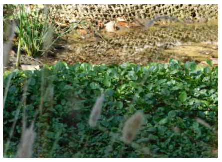
ES&H Division
SLAC-R-1149

Annual Site Environmental Report: 2020

September 2021



Prepared for the Department of Energy, Office of Science, under contract number DE-AC02-76-SF00515

SLAC National Accelerator Laboratory, Stanford University, Stanford, CA 94309

SLAC NATIONAL ACCELERATOR LABORATORY

Department of Energy
Office of Science
Bay Area Site Office

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September 22, 2021

Subject: 2020 Annual Site Environmental Report (ASER) for the SLAC National Accelerator Laboratory

This report, prepared by the SLAC National Accelerator Laboratory (SLAC) for the U.S. Department of Energy (DOE), SLAC Site Office (SSO), provides a comprehensive summary of the environmental program activities at SLAC for calendar year 2020. Annual Site Environmental Reports (ASERs) are prepared 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 summarizes the results of the 2020 environmental monitoring, compliance, and restoration programs at SLAC. This assurance can be made based on SSO and SLAC review of the ASER, and quality assurance protocols applied to monitoring and data analyses at SLAC.

Any questions or comments regarding this report may be directed to Mitzi Heard at (650) 926-5704.

Sincerely,

PAUL GOLAN Digitally signed by PAUL GOLAN Date: 2021.09.22 08:08:05 -07'00'

Paul Golan
Site Manager

Disclaimer

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Preface

To satisfy the requirements of the United States Department of Energy (DOE) SLAC Site Office approved Site Compliance Plan for DOE Order 231.1B (Change 1, 2012, "*Environment, Safety and Health Reporting,*" the Environment, Safety and Health Division (ES&H) of the SLAC National Accelerator Laboratory prepares an annual report describing its environmental programs and activities.

This *Annual Site Environmental Report: 2020* summarizes the SLAC National Accelerator Laboratory compliance with standards and requirements, describes the management and monitoring systems in place, and highlights significant accomplishments for the year.

Organization

The report is published in a single volume, organized into the following chapters:

- Chapter 1, "Site Overview", describes the environmental setting of the SLAC National Accelerator Laboratory and the activities conducted at the site
- Chapter 2, "Environmental Compliance", gives an account of the regulatory framework and results concerning the site's environmental programs
- Chapter 3, "Management Systems", outlines the organizational structure, methods, and responsibilities relevant to environmental programs
- Chapters 4, 5, and 6, respectively "Environmental Non-radiological Programs", "Environmental Radiological Programs", and "Groundwater Protection and Environmental Restoration", give more detailed accounts of the programs and their results for the year

An executive summary provides an overview of the report.

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Editing and Publishing

ES&H Division Publishing edited and published this report.

Acronyms

^3H	tritium
AB	Assembly Bill
AHJ	Authority Having Jurisdiction
ASER	Annual Site Environmental Report
ASTs	aboveground storage tanks
BAAQMD	Bay Area Air Quality Management District
BASO	Department of Energy, Bay Area Site Office
BDE	beam dump east
BMPs	best management practices
CCR	California Code of Regulations
C&D	construction and demolition
CACM	Contractor Assurance and Contract Management Office
CalARP	California Accidental Release Prevention Program
CAS	Contractor Assurance System
CARB	California Air Resources Board
CB	catch basin
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cf	cubic feet
CFR	Code of Federal Regulations
Ci	curie
CIWQS	California Integrated Water Quality System
CMS	chemical management system
COPCs	chemicals of potential concern
COVID 19	Corona Virus Deases 2019
CPR	cardiopulmonary resuscitation
CUPA	Certified Unified Program Agency
CWA	Clean Water Act
CY	calendar year
CX	categorical exclusion
DOE	United States Department of Energy
DPE	dual-phase extraction
DREP	dosimetry and radiological environmental protection
DWQ	Department of Water Quality

DWS	drinking water standard
EA	Environmental Assessment
EBR	Environmental Baseline Report
e.g.	for example
EIS	Environmental Impact Statement
EMS	environmental management system
EMT	emergency medical technicians
EO	Executive Order
EP	Environmental Protection Department
EPCRA	Emergency Planning and Community-Right-to-Know Act
ERT	emergency response team
ES&H	Environment, Safety & Health
FACET	Facility for Advanced Accelerator Experimental Tests
FHWSA	Former Hazardous Waste Storage Area
FMS	flow metering station
FS	Feasibility Study
FSUST	Former Solvent Underground Storage Tank
FY	fiscal year
GDF	gasoline dispensing facility
GHG	greenhouse gases
GIS	gas insulated switchgear
GSS	Government Scientific Source
GWP	global warming potential
HAPs	hazardous air pollutants
HPSB	high-performance sustainable building
HMBP	hazardous materials business plan
HSU	hydrodynamic sedimentation unit
i.e.	that is
IAS	Integrated Assessment Schedule
IDPE	interim dual-phase extraction
IGP	industrial general permit
IH	industrial hygiene
IR	Interaction Region
ISCO	in-situ chemical oxidation
ISEMS	Integrated Safety and Environmental Management System
ISM	Integrated Safety Management

ISO	International Organization for Standardization
KIPAC	Kavli Institute for Particle Astrophysics, and Cosmology
km	kilometer
L	liter
lbs.	pounds
linac	linear accelerator
LCLS	Linac Coherent Light Source
LLRW	low-level radioactive waste
LSY	lower salvage yard
M&O	management and operations
MAPEP	Mixed-Analyte Performance Evaluation Program
MSub	Master Substation
MEI	maximally exposed individual
mg/L	milligrams per liter
MFPF	metal finishing pre-treatment facility
MPMWD	Menlo Park Municipal Water Department
MPR	monitoring plan report
mrem	milli-rem
mSv	milli-Sievert
MSW	municipal solid waste
MTCO2e	metric tons of carbon dioxide (CO2) equivalent
na	not available
n/a	not applicable
NAL	Annual Numeric Action Level
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
No.	number
NOI	notice of intent
NOV	Notice of Violation
NPL	National Priorities List
OU	operable unit
PBR	permit by rule
PCBs	polychlorinated biphenyls
PCGs	Preliminary Cleanup Goals
pCi/L	pico-Curies per liter
PTO	permit to operate

ppm	parts per million
PSA	Plating Shop Area
PULSE	Photon Ultrafast Laser Science and Engineering Institute
QA	quality assurance
QC	quality control
RA	risk assessment report
RAP	remedial action plan
REP	Radiological Environmental Protection
RCRA	Resource Conservation and Recovery Act
RD	remedial design report
RI	remedial investigation
RMP	risk management plan
RNA	ribonucleic acid
RP	Radiation Protection Department
RWM	radioactive waste management
RWQCB	Regional Water Quality Control Board
RY	research yard
SAP	sampling and analyses plan
SARA	Superfund Amendments and Reauthorization Act
SB	State Bill
SF_6	sulfur hexafluoride
SIMES	Stanford Institute for Materials and Energy Sciences
SLAC	SLAC National Accelerator Laboratory
SMEs	subject matter experts
SMOP	synthetic minor operating permit
SMP	self-monitoring program
SPCC	spill prevention, control, and countermeasures plan
SPP	Strategic Partnership Program
SSMP	Sanitary Sewer Management Plan
SSO	sanitary sewer overflow
SSRL	Stanford Synchrotron Radiation Lightsource
SUNCAT	SUstainable eNergy through CATalysis
SVCW	Silicon Valley Clean Water
SVE	soil vapor extraction
SVOCs	semi-volatile organic compounds
SWPPP	Stormwater Pollution Prevention Plan

SWRCB	State Water Resources Control Board
T&IM	training and information management
TDS	total dissolved solids
TL/CL	Test Lab and Central Lab area
TPH	total petroleum hydrocarbons
TRI	toxic release inventory
TSCA	Toxic Substances Control Act
TSS	total suspended solids
US	United States
USEPA	United States Environmental Protection Agency
VOCs	volatile organic compounds
WBSD	West Bay Sanitary District
WM	Waste Management Group
WP	Work Plan
XW	extraction well
yr	year
ZWP	Zero Waste Program

Executive Summary

This report provides information on environmental programs during calendar year (CY) 2020 at the SLAC National Accelerator Laboratory (SLAC) in San Mateo County, California. Activities that overlap the calendar year - e.g., stormwater monitoring covering the winter season of 2019/2020 (October 1, 2019 through May 31, 2020) are also included.

Production of an annual site environmental report (ASER) is a requirement established by the United States Department of Energy (DOE) under DOE Order 231.1B (Change 1, 2012) for all management and operations (M&O) contractors throughout the DOE complex. SLAC is a federally funded research and development center managed and operated by Stanford University for the DOE.

Under Executive Order (EO) 13834, *Efficient Federal Operations*, and DOE Order 436.1, *Departmental Sustainability*, SLAC effectively implements and integrates the key elements of an Integrated Safety and Environmental Management System (ISEMS) to achieve the site's integrated safety and environmental management system goals. SLAC ensures the site is operated in a safe and environmentally responsible manner, and complies with applicable laws, regulations, standards, and other requirements. SLAC managers and supervisors are responsible for ensuring that policies and procedures are understood and followed so that:

- Worker safety and health are protected
- The environment is protected
- Compliance is ensured

Throughout 2020, SLAC continued to strengthen its management systems. These systems provided a structured framework for SLAC to implement programs required by EO 13834 and DOE Order 436.1. Overall, management systems at SLAC are effective, supporting compliance with all relevant statutory and regulatory requirements. The following are among SLAC's progress on key environmental goals in the areas of energy, sustainable buildings, fuel/fleet efficiencies, increases in recycling, and decreases in waste generated, greenhouse gases generated, and use of water in 2020:

- Approximately 270 tons of scrap metal were recycled
- There were no radiological impacts to the public or the environment from SLAC operations
- Zero Waste Program (ZWP) was expanded from eighteen to nineteen buildings. Over 85 percent of SLAC's staff now work in buildings that are participating in the program
- 94 percent of construction and demolition debris was diverted from disposal at a landfill
- 74.8 percent of municipal solid waste was diverted from disposal at a landfill
- SLAC reduced its hazardous waste generated by routine operations to 9 tons, a 94 percent reduction from the 1993 baseline of 147 tons
- 15 tons of electronic waste and universal waste combined was recycled

- Up to 34 percent of SLAC's total electric energy came from renewable sources such as wind and hydroelectric sources, avoiding generating 15,000 metric tons of greenhouse gases (GHGs)
- A reduction of Scope 1 and 2 emissions by 64 percent, and a 34 percent reduction in Scope 3 emissions
- Reduction of water usage by 65 percent from the 2007 baseline
- Disposal of 4,995 cubic feet of low-level radioactive waste

In 2020, there were no radiological impacts to the public or the environment from SLAC operations. The potential doses to the public were evaluated based on both calculation and measurements; the impacts are negligible and far below the regulatory and SLAC administrative limits. Potential exposure to the public from SLAC operations represents a very small fraction of the dose received from natural background radiation. No radiological incidents occurred that increased radiation levels to the public or released radioactivity to the environment. During CY 2020, SLAC disposed of 57 sealed sources, shipped 4,955 cubic feet of low-level radioactive water (LLRW) containing 22.7 Curie (Ci) of activity and weighing 219,820 kilograms to appropriately permitted and licensed treatment and disposal facilities for low-level radioactive waste

SLAC is regulated under a site cleanup and abatement order (Board Order) issued by the San Francisco Bay Area Regional Water Quality Control Board (RWQCB, Board Order number R2-2009-0072) on October 19, 2009, for the investigation and remediation of impacted soil and groundwater at SLAC. Risk-based preliminary cleanup goals for impacted soil and groundwater have been established for SLAC, and remediation efforts are designed and implemented to meet these established goals. The Board Order also lists specific tasks and deadlines for completion of remediation activities.

All deliverable submittals to the RWQCB in 2020 were completed and submitted on time. The final "one-time" deliverable required by the Board Order was submitted to and approved by the Water Board in 2020. In 2020, the SLAC Environmental Restoration Program continued remediation efforts in specific areas impacted by chemicals of potential concern (COPCs), including volatile organic compounds, semi-volatile compounds, and polychlorinated biphenyls (PCBs). Operating data indicate that the groundwater remediation systems have resulted in significant decreases in concentrations of COPCs in groundwater and soil vapor and are achieving hydraulic control of the groundwater plumes.

1 Site Overview

This chapter describes the environmental setting of SLAC and the activities conducted at the site.

1.1 Introduction

SLAC is a multi-program national laboratory operated by Stanford University under contract to the DOE. The lab is located in Silicon Valley, about halfway between San Francisco and San Jose, California (Figure 1-1).

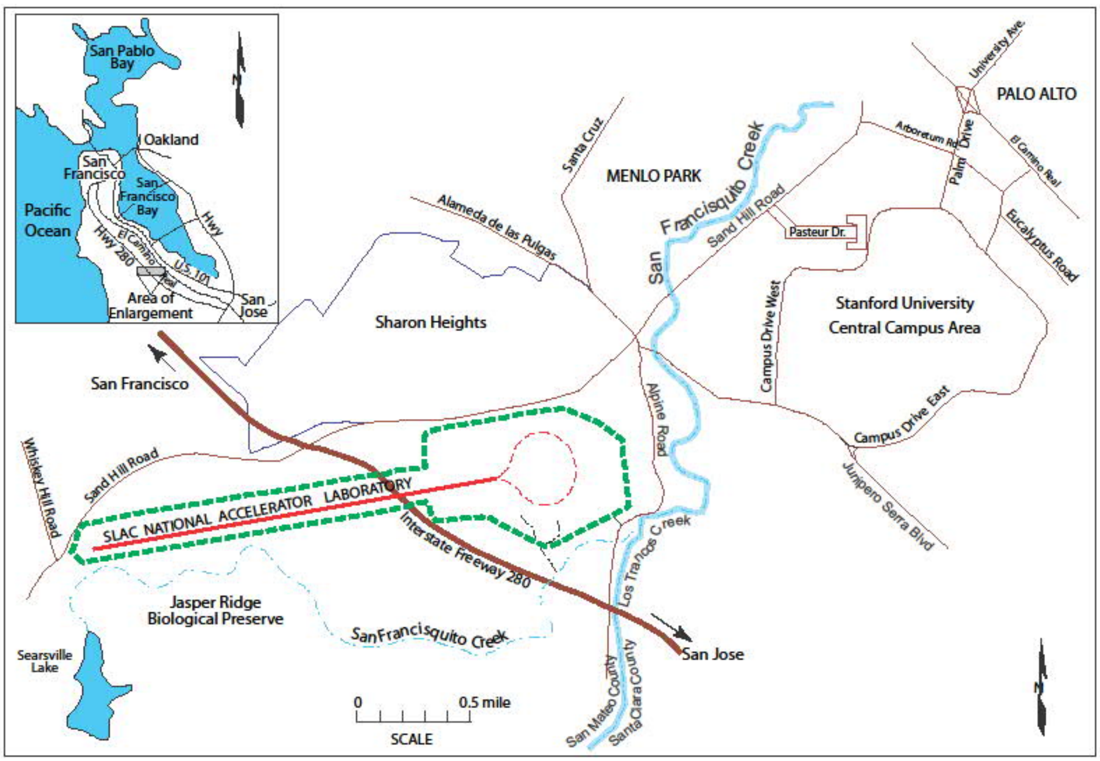

Figure 1-1 SLAC Site Location

1.1.1 SLAC Mission

As the world leader in X-ray and ultrafast science and a hub for cutting-edge research, SLAC's mission is to deliver scientific discoveries and develop research tools that help address the most challenging scientific and technological problems facing society and industry and transform our understanding of the universe. In support of this mission, SLAC has four laboratory goals:

1. Be the world leader in X-ray and ultrafast science and in our selected areas of accelerator science and high energy physics;

2. Expand and increase our impact in Office of Science mission areas by leveraging our world-leading core capabilities and expertise;
3. Broaden and strengthen our impact across critical national needs by using our position within Stanford and Silicon Valley; and
4. Be the “best-in-class” DOE lab for safe, efficient and innovative operations that align with and enable our research mission.

As a multipurpose national laboratory managed by Stanford for the Office of Science, SLAC supports the DOE mission, which is to ensure America’s security and prosperity by addressing its energy, environmental and nuclear challenges through transformative science and technology solutions.

1.1.2 Research Program

For more than 50 years, SLAC has stood at the forefront of scientific discovery. What started as home to the world’s longest particle accelerator, one of the largest scientific endeavors of its time, has over the years become the scene of transformative scientific research, where building blocks of matter have been discovered and life’s fundamental processes studied and better understood.

In its first 40 years of operation, the linear accelerator hosted pioneering experiments in particle physics including research that led to three Nobel Prizes. These were for the realization that protons in the atomic nucleus are composed of smaller entities called quarks; discovery of the J/psi particle, which implied the existence of the charm quark; and discovery of the tau lepton, the first of a new family of fundamental building blocks. The BaBar experiment offered important insights into the imbalance of matter and antimatter in the universe, providing experimental evidence that led to the award of the 2008 Nobel Prize in physics to the theorists who first explained the source of this imbalance. These and other particle physics discoveries reshaped our understanding of matter and inspired completely new areas of science.

In the early 1970s, researchers realized that X-ray light released by electrons circling in an accelerator could be harnessed for exploring matter at an atomic scale. This early research blossomed into the facility now called the Stanford Synchrotron Radiation Lightsource (SSRL), which continues to produce both fundamental insights into the natural world and discoveries with practical applications. SSRL experiments helped determine the structure of an important biomolecule, ribonucleic acid (RNA) polymerase, leading to the 2006 Nobel Prize in chemistry.

Today, SLAC is a multipurpose national laboratory, leveraging the lab’s historical strength in particle physics and accelerator research to power discoveries across an even greater range of scientific disciplines. The 2-mile-long particle accelerator is still the lab’s backbone, generating brilliant X-rays for the world’s first hard X-ray free-electron laser. At SSRL, companies use beams of X-ray to design better pharmaceuticals, stronger materials and more efficient sources of energy. SLAC continues to build on a solid foundation in particle physics to peer into the farthest reaches of the universe, using ever more sophisticated tools and techniques.

SLAC is home to three very large and sophisticated Office of Science user facilities that host thousands of scientists from the broader research community each year. They are the:

- Stanford Synchrotron Radiation Lightsource (SSRL), which produces bright X-ray light for probing matter at the atomic and molecular level, enabling advances in energy production, environmental cleanup, nanotechnology, new materials and medicine;
- Linac Coherent Light Source, whose brilliant X-ray laser pulses at unprecedented speed allow researchers to make stop-action movies of chemistry in action, explore proteins for new generations of pharmaceuticals and recreate extreme conditions in the hearts of faraway planets; and
- Facility for Advanced Accelerator Experimental Tests (FACET-II), the only facility in the world that provides high-energy electron beams for researching a vast array of revolutionary particle accelerator technologies. These approaches could make future accelerators 100 to 1,000 times smaller and a lot more capable for applications in basic research, medicine, industry and other areas important to society.

SLAC now has core capabilities in large-scale user facilities and advanced instrumentation; accelerator science and technology; chemical and molecular science; condensed matter physics and materials science; particle physics; and plasma and fusion energy science. SLAC is building additional capabilities in advanced computer science, visualization and data, including an initiative in machine learning.

SLAC jointly operates three institutes, a research center and a bio-imaging facility with Stanford:

- Kavli Institute for Particle Astrophysics and Cosmology (KIPAC)
- Stanford Institute for Materials and Energy Sciences (SIMES)
- Stanford Photon Ultrafast Laser Science and Engineering Institute (PULSE) Institute
- SUNCAT Center for Interface Science and Catalysis
- Stanford-SLAC Cryo-EM (cryogenic electron microscopy)

1.2 Location

SLAC is located in a belt of low, rolling foothills between the alluvial plain bordering San Francisco Bay to the east and the Santa Cruz Mountains to the west. The site varies in elevation from 175 to 380 feet above sea level. The alluvial plain to the east lies less than 151 feet above sea level and the mountains to the west rise abruptly to over 2,000 feet.

The site occupies 426 acres of land owned by Stanford University. The property was originally leased by Stanford University in 1962 to the United States (U.S.) Atomic Energy Commission, the predecessor to the DOE, for purposes of research into the basic properties of matter. The DOE and Stanford University signed a new lease in 2010, which extends through 2043. The land is part of Stanford's academic preserve, and is located west of the university and the city of Palo Alto in an unincorporated portion of San Mateo County.

The site lies between Sand Hill Road and Alpine Road, bisected by Highway 280, on an elongated parcel roughly 2.75 miles long, oriented in an east-west direction. The parcel widens to about 0.6 miles at the target (east) end to allow space for buildings and experimental facilities. The south side of much of the western end of the parcel is bordered by Stanford University's Jasper Ridge Biological Preserve, which includes part of the San Francisquito Creek riparian channel, the last channel of its kind between San Jose and San Francisco still in its natural state. San Francisquito Creek is seasonal (dashed line, Figure 1-1) with sections of its streambed drying up during warmer months. Los Trancos Creek typically has water flowing year-round (Figure 1-1).

1.3 Climate

The climate in the SLAC area is Mediterranean. Winters are cool and moist, and summers are mostly warm and dry. Daily mean temperatures are seldom below 32 degrees Fahrenheit or above 86 degrees Fahrenheit. Rainfall typically averages about 22 inches per year. The distribution of precipitation is highly seasonal. Approximately 75 percent of the precipitation, including most of the major storms, occurs during the four-month period from December through March of each year. Most periods of winter storms last from two days to a week in duration. The storm centers are usually characterized by relatively heavy rainfall and high winds.

1.4 Land Use

The SLAC site is located on an unincorporated portion of San Mateo County and is zoned in the San Mateo County General Plan as a residential estate. Approximately 30 percent of the property is developed with buildings and pavement, mostly in the core campus area.

Land use to the immediate west is commercial (office buildings and a hotel), and farther west is agricultural and the Jasper Ridge Biological Preserve. Land use to the north is mostly commercial, residential, and recreational (a golf course), with a school and office buildings located north of the central campus. Land use to the east is residential, recreational (another golf course), and educational (the Stanford campus). Land use to the south is agricultural (including a horse boarding and training facility), preserved open space, and residential.

1.5 Water Supply

Domestic water for SLAC is supplied by the Menlo Park Municipal Water Department (MPMWD). The source is the City of San Francisco-operated Hetch Hetchy aqueduct system, which is fed from reservoirs located in the Sierra Nevada. SLAC, the neighboring Sharon Heights development (to the north), and the Stanford Shopping Center all receive water service from an independent system within the MPMWD. This separate system taps the Hetch Hetchy aqueduct and pumps water up to a 268,391cubic-feet reservoir north of Sand Hill Road, approximately 1.5 miles from SLAC.

Drinking and process water are transported throughout the SLAC site by a distribution system protected by backflow prevention devices. Water at SLAC is primarily utilized (as high as 80 percent usage) to support cooling of high-energy experimental equipment, buildings and associated processes. The remainder of water supply supports SLAC office buildings/grounds and the Stanford facilities on the SLAC campus that include the Guest House, Arrillaga athletic field, Stanford Research Computing Facility, and Kavli building.

1.6 Geology

The SLAC site is underlain by sandstone, with some basalt at the far eastern end. In general, the bedrock on which the western half of the SLAC linear accelerator (linac) rests is the Whiskey Hill Formation (Eocene age), and the bedrock under the eastern half is the Ladera Sandstone (Miocene age). On top of this bedrock at various places along the accelerator alignment is the Santa Clara Formation (Pleistocene age), where alluvial deposits of sand and gravel are found. At the surface is a soil overburden of non-consolidated earth material ranging from 0.3 to 3 feet in depth. Figure 1-2 shows the general geographic and geologic setting of the area.

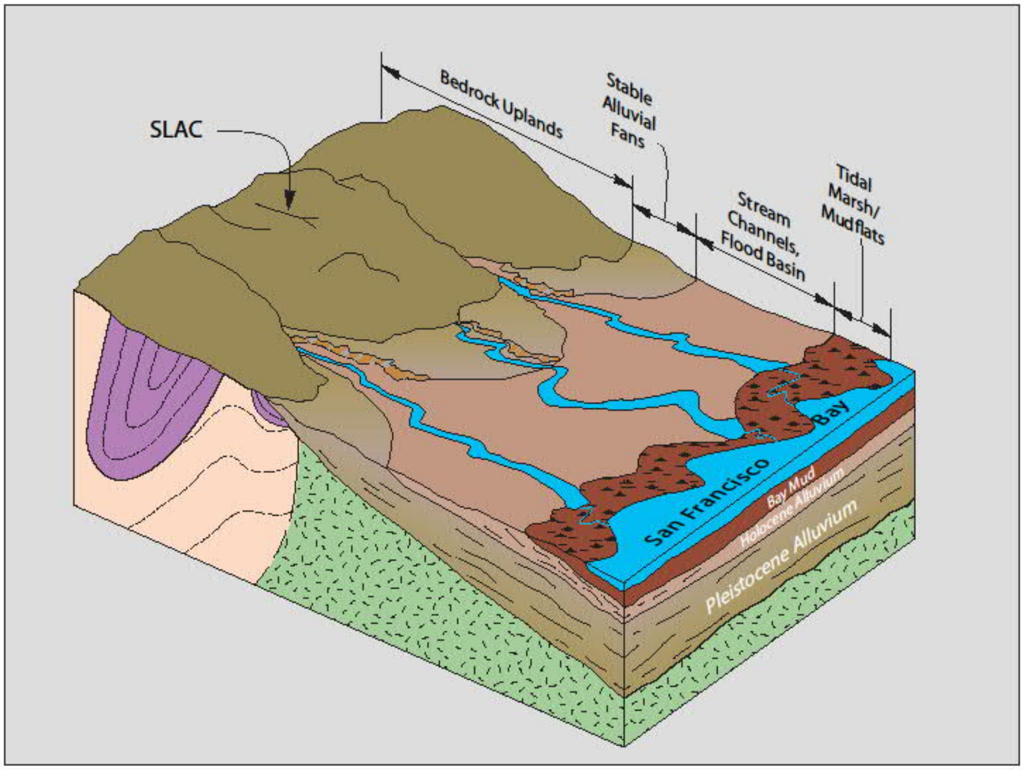

Figure 1-2 Site Area General Geographic and Geologic Setting

1.7 Demographics

SLAC has a daytime population of more than 1,500 full-time employees, including scientists, engineers, technicians and specialists in a wide range of operational support areas, from human resources and business services to facilities, security and maintenance. In addition, several hundred undergraduate students, graduate students and postdoctoral researchers work at SLAC. As stewards of renowned user facilities, SLAC hosts, supports and collaborates with more than 4,000 U.S. and international researchers, including many at SSRL, LCLS and FACET-II, as well as in laboratory-hosted science programs.

The populated area around SLAC is a mix of offices, schools, single-family housing, apartments, condominiums, and Stanford University. SLAC is surrounded by five communities: the city of Menlo Park; the towns of Atherton, Portola Valley, and Woodside; and the unincorporated community of Stanford University, which is located in Santa Clara County. Nearby unincorporated communities in San Mateo County, include Ladera and two neighborhoods located in western Menlo Park. Two public and two private schools with elementary and/or middle school students are located within one mile of SLAC's perimeter.

2 Environmental Compliance

2.1 Introduction

This chapter provides a summary of the regulatory framework within which the environmental programs of SLAC operate, and compliance with those regulations for CY 2020.

2.2 Regulatory Framework

The SLAC External Requirements Management Dataset cites the environmental protection and safety requirements and standards that are applicable to the Laboratory.

2.3 Environmental Permits and Notifications

The permits held by SLAC in 2020 are shown in Table 2-1 below.

Table 2-1 General Permits Held by SLAC

Issuing Agency	Permit Type	Description	Number
BAAQMD	Air quality	per Title V of the Clean Air Act	1
		Encompasses 44 sources of air emissions - 35 permitted SMOP issued, 2 registered and 7 permit-exempt. After initial permitting, individual sources integrated into SMOP	1
		Separately, SLAC has a PTO for an onsite above-ground GDF from the BAAQMD	
California Department of Toxic Substances Control	Hazardous waste treatment	Unit 1A – Building 025, PBR for cyanide treatment tanks	1
		Unit 1B – Building 038, PBR for metal finishing pretreatment facility	1
		Unit 1C – Building 038, PBR for batch hazardous waste treatment tank	1
		Unit 2 – Building 038, PBR for sludge dryer	1
Silicon Valley Clean Water and West Bay Sanitary District	Wastewater discharge	Mandatory Wastewater Discharge Permit	1
Regional Water Quality Control Board	Stormwater	General Permit for Stormwater Discharges Associated with Industrial Activities	1

Issuing Agency	Permit Type	Description	Number
San Mateo County/CUPA	CUPA programs	PBR; Above-Ground Tank/SPCC plan; Hazardous Material Storage > 32,000 gallons, 224,000 lbs., 11,2000 cf.; Hazardous Waste Generator 51-250 tons; CalARP	1
United States (US) Environmental Protection Agency	Hazardous waste	90-day hazardous waste generator	1

Notes:
BAAQMD - Bay Area Air Quality Management District
CalARP – California Accidental Release Prevention Program
CUPA – Certified Unified Program Agency
GDF – gasoline-dispensing facility
lbs. – pounds
cf. – cubic feet
PBR – permit by rule
PTO – permit to operate
SMOP - synthetic minor operating permit
SPCC - Spill Prevention, Control and Countermeasures Plan
> - greater than

2.4 Environmental Incidents

2.4.1 Non-radiological Incidents

No incidents of a non-radiological nature occurred at SLAC during CY 2020.

2.4.2 Radiological Incidents

During CY 2020, no radiological incidents occurred that would have increased radiation levels above natural background to the public or released radioactivity to the environment; SLAC was compliant with all radiological requirements related to the environment and the public.

2.5 Assessments, Inspections, and Quality Assurance

The environmental programs at SLAC are subject to routine assessments, inspections, and quality assurance measures conducted by SLAC, DOE and external regulators. Those conducted during CY 2020 are reported here.

2.5.1 Assessments

External assessments conducted by regulators occur periodically and include quarterly radiation monitoring of the SLAC perimeter by the California Department of Health Services. Currently, monitoring results are not available to SLAC for CY 2020.

2.5.2 Inspections

Periodic inspections of the environmental programs are performed at SLAC by federal, state and local environmental regulatory agencies. Table 2-2 lists the inspections conducted in CY 2020 by these agencies.

Table 2-2 Environmental Inspections

Regulatory Agency	Inspection Title	Date	Violations (Y/N)
Silicon Valley Clean Water	Annual Compliance Inspection	December 2, 2020	Y
San Mateo County CUPA	Tiered Permit Inspection PBR	September 10, 2020	N
San Mateo County CUPA	Hazardous Waste Inspection	November 19 to 24, 2020	N

2.5.3 Quality Assurance

The SLAC Quality Assurance (QA) program is consistent with the DOE Bay Area Site Office (BASO) approved Site Compliance Plan for DOE Order 414.1D, Quality Assurance, and includes documented roles, responsibilities, and authorities for implementing the QA criteria in the plan. The SLAC prime contract also includes an H clause that requires SLAC to implement a Contractor Assurance System (CAS) as outlined in the SLAC Contractor Assurance Description approved by the DOE BASO. Both the QA and CAS programs at SLAC require the performance of risk and compliance-based self-assessments and the management of associated issues. Environmental Program Assessments of program elements are conducted by SLAC and DOE based on past performance, management discretion or regulatory drivers and are tracked in the Integrated Assessment Schedule (IAS). Issues from assessments and regulatory inspections are managed according to the SLAC Issues and Improvements Program and tracked in the SLAC Issues and Improvements Management System (SIIMS). The IAS and SIIMS are maintained by the SLAC Contractor Assurance and Contract Management (CACM) Office.

The SLAC CACM Office is responsible for:

- Ensuring that risk and compliance-based self-assessments or regulatory inspections are routinely performed for Environment, Safety and Health (ES&H) programs and documented in the SLAC IAS
- Ensuring that issues from ES&H Program assessments or regulatory inspections are managed in the SLAC Issues and Improvements Management System (SIIMS)
- Providing direction for implementation of the SLAC CAS and QA criteria from BASO-approved Site Compliance Plan for DOE Order 414.1D as they apply to ES&H program implementation

2.5.3.1 Environmental Non-radiological Program

The Environmental Protection Department uses the *Quality Assurance Project Plan for the Environmental Protection Program* [1] for data quality review of analytical laboratory results of solid and liquid samples. This document includes all components required of quality assurance project plans and is consistent with United States Environmental Protection Agency (USEPA), Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or Superfund), and DOE guidance documents. The components include defining required laboratory and field QA, and quality control (QC) procedures and corrective actions, along with data validation and reporting.

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1 SLAC National Accelerator Laboratory, Environment, Safety, and Health Division, Environmental Protection Department, *Quality Assurance Project Plan for the Environmental Protection Program* (SLAC-I-750-2A17M-003 R008, July 2019)

2.5.3.2 Environmental Radiological Program

Programmatic QA/QC is governed by the SLAC Radiological Environmental Protection (REP) program manual. Specific radioanalysis laboratory procedures and data validation as well as reporting for environmental samples are governed by the SLAC Radioanalysis Laboratory Quality Assurance Manual. SLAC has been participating in the DOE Mixed Analyte Performance Evaluation Program (MAPEP) on a biannual testing cycle. In CY 2020, due to Covid-19 impacts, SLAC participated and passed one cycle of the MAPEP performance tests with excellent results - less than 10 percent biases for both water and soil mixed analyte samples. In addition, duplicate environmental samples (mainly well water samples) are biannually analyzed by both SLAC and an off-site, California State certified radioanalysis laboratory. The two sets of results are then compared and documented to identify any discrepancies. For CY 2020, the results of these inter comparisons were consistent with each other, supporting the high level of QA/QC standards of the SLAC data and analysis protocols.

3 Management Systems

3.1 Introduction

This chapter provides an overview of the SLAC organizational structure, management approach, and Environmental Management System (EMS) implementation used to protect the environment. The results for the various measures and reviews discussed below are contained in Chapter 2, "Environmental Compliance".

3.2 SLAC Organization

SLAC is organized as follows: Accelerator Directorate, Fundamental Physics Directorate, LCLS Directorate, Energy Sciences Directorate, SSRL Directorate, Technology Innovation Directorate, and Mission Support. SLAC's customers include the DOE, the many users who participate in experiments at SLAC using the laboratory's unique experimental facilities, and the sponsors of work conducted under the Strategic Partnership Program (SPP).

3.2.1 ES&H Division Organization

The ES&H Division is part of Mission Support and consists of seven departments and a Division Office. The Division Office is tasked with overall strategic planning and management. The shared goal is to ensure that SLAC operates in compliance with applicable federal, state, and local laws and regulations, as well as DOE directives.

3.2.1.1 Occupational Health

The Occupational Health Center (OHC), which is associated with the Division Office, provides on-site medical services including treatment of minor injuries such as cuts, minor abrasions and burns, sprains/strains, and removing splinters and ticks. The OHC also provides a medical surveillance program for employees who may be potentially exposed to chemical and physical hazards.

3.2.1.2 Environmental Protection

The Environmental Protection (EP) Department has two primary functional areas, Environmental Compliance and Environmental Restoration. The EMS, which is an overarching management system that SLAC uses for identifying and managing environmental aspects, is managed by the EP Department. SLAC's EMS is further described in Section 3.5. The EP Department also develops and implements the following programs: pollution prevention, stormwater and industrial wastewater, air quality, toxic substances control, wildlife protection, National Environmental Policy Act (NEPA), the National Historic Preservation Act, and spill prevention, as well as groundwater protection and oversees work to restore soil and groundwater impacted with chemicals from historical operations.

3.2.1.3 Chemical and Waste Management

The Chemical and Waste Management Department consists of the Chemical Management Group, and Waste Management (WM) Group. The Chemical Management Group is multifaceted and addresses chemical safety at every point in the chemical lifecycle from transportation, procurement, use, storage, inventory management, and implements the Toxic and Hazardous Material Reduction Plan. The WM Group is responsible for coordinating the management and off-site disposal of regulated and hazardous wastes, and for developing and implementing hazardous waste minimization plans.

3.2.1.4 Health and Safety Services

The Health and Safety Services Department consists of two groups – the Industrial Hygiene (IH) Group and the Safety Specialist Group. The IH Group is responsible for assisting with the management of SLAC's safety and health programs, and keeping SLAC workers safe by anticipation, recognition, evaluation, prevention, and control of environmental hazards. The Safety Specialist Group is responsible for operations, maintenance, construction and subcontractor safety oversight, safety program ownership, and for providing safety training to SLAC personnel. This includes safety programs such as confined space, hoisting and rigging, fall protection and excavation safety.

3.2.1.5 Security and Emergency Management

The Security and Emergency Management Department provides oversight of two intertwined site safety functions - SLAC Site Security and Emergency Management. The SLAC Site Security is led by the Security Manager and staffed by contract security professionals, who are responsible for providing site-wide security services and emergency assistance 24 hours a day, seven days a week. The SLAC Security team includes Certified Emergency Medical Technicians (EMT). Emergency response oversight is led by the Security Manager and Assistant Fire Marshal, who is also SLAC's Emergency Management Coordinator. The SLAC emergency management organization includes the SLAC Emergency Response Team (ERT) and SLAC Site Security. The ERT team is made up of SLAC employees who have been trained in basic cardiopulmonary resuscitation (CPR), Medical Aid and emergency response. As of May 1, 2012, SLAC has been supported by the County of San Mateo Fire Department through a Memorandum of Agreement with the Menlo Park Fire Protection District.

3.2.1.6 Radiation Protection

The SLAC Radiation Protection (RP) Department is responsible for the radiation safety and radiological programs that protect the workers, the general public, and the environment. The RP Department includes five technical groups: Radiation Physics Group, Dosimetry and Radiological Environmental Protection (DREP) Group, Field Operations Group, Radioactive Waste Management (RWM) Group, and Laser Safety Group. The Radiation Physics Group provides support for safety analysis and control, which includes shielding calculations and radiation safety system design, as well as providing authorization and oversight for the safe operation of the accelerator, the beam line and experiments. The DREP Group provides dosimetry services (external, internal, area, environment and high-dose) assessment and/or monitoring of radiological impacts to the public and environment (see Chapter 5). The DREP group also operates the in-house Radioanalysis Laboratory and operates the instrumentation program. The Field Operations Group oversees radiological workplace monitoring, management of radioactive materials and sources, training, radiological control and work support. The RWM Group is responsible for radioactive waste management at SLAC such as low-level radioactive waste disposal (see Chapter 5). The Laser Safety Group develops and implements SLAC's Laser Safety Program.

3.2.1.7 Code Compliance and Authorities Having Jurisdiction (AHJ) Services

The ES&H Code Compliance and AHJ Services Department includes the Building Inspection Office (BIO) led by the Building Code Official and two Safety Officers/AHJs - the Electrical Safety Officer and the Fire Marshal. BIO provides review, oversight, and authorization for construction, modification, renovations, demolition, use, occupancy, and alteration of all buildings, structures, and areas at SLAC. During construction, the BIO performs on-site inspections to ensure conformance to the authorized design. Upon completion of construction, the BIO issues a certificate of occupancy. In addition to their BIO duties, the Electrical Safety Officer provides assistance to site personnel on electrical safety and control of hazardous energy matters, and the Fire Marshal provides assistance to site personal on fire protection and life safety matters.

3.2.1.8 Training and Information Management

The Training and Information Management (T&IM) Department serves all essential functions in the implementation of SLAC's safety and health programs. The department manages a catalog of approximately 125 ES&H courses and coordinates the provision of classroom and availability of computer-based training that affects all workers at SLAC. It collaborates with the Human Resources office, which manages all SLAC training, to ensure the training system supports the assignment, provision and tracking of all formal training. Additionally, the T&IM Department manages the periodic review coordination, updating and publishing of the approximately 50 chapters in the ES&H Manual and ES&H web and business applications resources.

3.3 Integrated Safety and Environmental Management System

SLAC's commitments to protecting the health and safety of on-site personnel, the public, and the environment are embodied in the SLAC Environment, Safety and Health Policy[2]. SLAC ensures the site is operated in a safe and environmentally responsible manner, and complies with applicable laws, regulations, standards and other requirements through implementation of an ISEMS. The ISEMS integrates the key elements of effective safety and environmental management systems into the mission and everyday operations of the site.

3.3.1 Integrated Safety and Environmental Management System

The 'plan, do, check, and improve' approach of ISEMS[3] has been formally adopted by SLAC, and has been incorporated into the SLAC Worker Safety and Health Program[4]. Work at SLAC 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):

- Define the scope of work

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2 SLAC Environment, Safety and Health Policy, http://www-group.slac.stanford.edu/esh/about_esh/eshpolicy.htm

3 SLAC Environment, Safety, and Health Division, "Integrated Safety and Environmental Management Systems", http://www-group.slac.stanford.edu/esh/general/isems/

4 SLAC National Accelerator Laboratory, Environment, Safety, and Health Division, SLAC Worker Safety and Health Program, (SLAC-I-720-0A21B-001-R011), http://www-group.slac.stanford.edu/esh/general/wshp/

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

3.3.2 Requirements Management System

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

- The DOE/Stanford University prime contract for SLAC
- DOE approved site compliance plans for contractual DOE Directives
- SLAC program documentation (ES&H Manual)
- SLAC subject matter experts (SMEs)

SLAC's External Requirements dataset contains laws and regulations not specifically cited in the prime contract in DOE Directive site compliance plans

3.3.3 Environmental Performance Measures

In addition to complying with external requirements, SLAC evaluates its performance against measures and metrics. Specific performance objectives, measures and targets are jointly developed by DOE and SLAC and are approved and formally incorporated into the M&O contract each fiscal year. DOE uses the contract performance measures and results of ongoing field observations, surveillances and routine assessments of SLAC operations and construction activities to formally evaluate contractor performance in all areas, including ES&H.

In fiscal year (FY) 2020, SLAC established environmentally relevant performance goals to ensure protection of the environment. Measures were initiated to ensure the effective development, implementation, and maintenance of an efficient Environmental Management System.

SLAC received a grade of A from DOE for its environmental performance. In particular, the following accomplishments were noted for FY 2020:

- West Bay Sanitary District (WBSD) is building a local wastewater treatment plant at the Sharon Heights Golf Course and SLAC's wastewater will be diverted to the plant. SLAC supported the development of this plant by working with WBSD to develop practical and cost-effective alternatives to achieving a reduction in total dissolved solids (TDS) in SLAC's wastewater that will ultimately be treated at this plant.
- Improvements to the stormwater best management practices (BMPs) resulted in stormwater sampling results below applicable regulatory action levels for the last two years. Based on this, SLAC qualified for a reduction in sampling frequency for the CY 2019/2020 wet season.

3.3.4 Training

To ensure workers are both aware and capable of fulfilling their responsibilities safely, SLAC maintains an extensive catalog of classroom and computer-based environmental and health and safety training. 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 SLAC's training program are available online.[5] Workers are required to have all appropriate environmental, health and safety training prior to performing any work assigned to them. Training is documented in SLAC's Safety Training Assessment database for every worker receiving training, which is formally reviewed and approved by the worker's supervisor annually.

3.4 Environmental Management System

The EMS portion of the ISEMS is essentially a systematic approach for ensuring environmental improvement – a continual cycle of planning, implementing, reviewing and improving to ensure protection of the air, water, land, and other natural resources that may be potentially impacted by operational activities. SLAC's EMS program is described in detail in the *EMS Description* [6] document.

The Office of Management and Budget issues an annual Environmental Stewardship scorecard for the federal agencies and an EMS Report Card is one of four elements. SLAC achieved a score of "green" on its EMS Report Card, indicating that all elements of the EMS are in place and working. Despite receiving a score of "green", SLAC continually strives to improve its EMS.

SLAC's EMS is consistent with International Organization of Standardization (ISO) 14001:2015. The EMS was formally in place on December 21, 2005, following a DOE assessment and declaration, and has been assessed and revalidated by DOE every three years. SLAC's EMS was last assessed in August 2018 by a qualified outside party who determined the EMS to be fully implemented and in conformance with the ISO 14001:2015 standard for EMS. Based on the assessment results and DOE's routine oversight of the EMS, SLAC's EMS was formally revalidated by the DOE in September 2018.

The annual review and update of environmental aspects and determination of significance was completed during the year by SLAC's EMS Advisory Group. Four new objectives and targets were established for 2020. For each objective and target, a work plan, also referred to as an Environmental Action Plan (EAP), was completed. These EAPs addressed the following environmental aspect categories:

- Air emissions
- Conservation of resources

A notable accomplishment achieved during FY 2020 for the EAPs include the following:

5 SLAC National Accelerator Laboratory, *SLAC Training*, http://www-group.slac.stanford.edu/esh/training/

6 SLAC National Accelerator Laboratory, *EMS Description*, SLAC-750-0A03H-002 R7, September 2018

- Options for improving portal-to-portal transport between SLAC and Stanford Campus were developed

Recommissioning efforts in Buildings 041, 028, and 023 were completed resulting in respective electrical energy reductions up to 15 percent. Additionally, SLAC's progress on the DOE's sustainability goals, including those related to GHGs, energy, water, fuel reduction and high-performance sustainable buildings is provided in Section 4.7, *Sustainability*. SLAC's GHGs inventory work is discussed in Section 4.2.2.9.

4 Environmental Non-radiological Programs

4.1 Introduction

During the course of providing state of the art research equipment and support for national and international research programs, SLAC manufactures, uses, maintains and runs one-of-a-kind research equipment, which requires the use and management of various industrial chemicals, gases and metals, and utilizes resources such as energy and water. SLAC also has environmental management issues typical of any employer with more than 1,500 full-time staff. In addition to the regular population, during typical years SLAC hosts several hundred undergraduate students, graduate students, and postdoctoral researchers as well as more than 4,000 U.S. and international researchers. These include in laboratory-hosted science programs. Calendar year 2020 was unusual however, with all on site activity curtailed to a minimum due to the Corona Virus Disease 2019 (COVID 19) pandemic.

SLAC has focused considerable efforts to minimize potential environmental impacts including working to eliminate the generation of waste and emissions. Additionally, SLAC continually strives to improve its environmental performance.

Recognition of SLAC's environmental performance accomplishments is provided in Table 4-1.

Table 4-1 Recent Environmental Awards

Year	Organization	Award/Recognition Program	Description
2016	Silicon Valley Water Conservation Awards Coalition	Silicon Valley Water Conservation Award for a Government Agency	Reducing potable water usage
2018	Stanford University	Sustainable Stanford Award for staff member	Spearheading the BeWell SLAC Active Commuting Health Work Environment Group to encourage more commuters to walk, bike, use public transportation and carpool to/from work to reduce Single Occupancy Vehicles (SOVs)
2020	Department of Energy	Sustainability Award – Honorable Mention	Organizing a swap meet of over 330 lab and office equipment and supplies

This chapter provides an overview of the non-radiological environmental programs SLAC 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 non-hazardous waste. The sections in this chapter are organized by environmental protection programs, which describe the regulatory framework and program status for CY 2020, and relevant performance trends. The environmental radiological program is discussed in Chapter 5, and programs covering the monitoring and remediation of groundwater, soil, and sediment are discussed in Chapter 6.

4.2 Air Quality Management Program

SLAC operates various sources of regulated air emissions, including a plating shop, a paint shop, several machine shops, boilers, solvent degreasers, emergency generators, and a vehicle fueling station, as well as diesel trucks and several types of off-road equipment. In addition, GHGs, which are generated indirectly through electricity use and used in electrical substations as well as research equipment, are being actively managed per Assembly Bill (AB) 32, the California Global Warming Solutions Act of 2006. This section describes the regulatory framework to which SLAC is subject for the purpose of air quality protection, and presents the status of SLAC's air quality protection program during CY 2020.

4.2.1 Regulatory Framework

In the San Francisco Bay Area, most federal and state air regulatory programs are implemented through the rules and regulations of Bay Area Air Quality Management District (BAAQMD). Included in the BAAQMD roles and responsibilities is the implementation of Title V (Operating Permits) of the Clean Air Act. SLAC's Title V SMOP was issued by the BAAQMD on July 26, 2002. The SMOP stipulates limits on facility-wide emissions of volatile organic compounds (VOCs), total hazardous air pollutants (HAPs), and individual HAPs, along with various other requirements. At the state level, the California Air Resources Board (CARB) is responsible for administering AB 32, the implementation of which was completed in 2012. Additionally, CARB has several regulations applicable to SLAC, including those governing diesel-fueled equipment and vehicles, large spark ignition equipment and sources of sulfur hexafluoride, a potent greenhouse gas (GHG).

Finally, SLAC is subject to two federal air quality programs, both of which are administered through the Air Division of USEPA Region 9:

- National Emission Standards for Halogenated Solvent Cleaning, under Title 40, Code of Federal Regulations (CFR), Part 63.460
- Protection of Stratospheric Ozone, under 40 CFR 82

4.2.2 Program Status

All air quality deliverables were submitted to regulators on time during CY 2020.

4.2.2.1 Biennial Facility Inspection

BAAQMD inspects SLAC biennially. SLAC was last inspected by the BAAQMD in 2019, there was no inspection during CY 2020.

4.2.2.2 New Source Permits

SLAC submitted two permit applications for new stationary emissions sources during CY 2020. Both of these sources are stationary diesel-powered generators, intended for back-up and planned maintenance power for a subset of the SLAC campus. At the end of CY 2020, under the SMOP SLAC managed 44 sources of air emissions, 35 of which were permitted sources, two were registered sources, and seven were exempt sources (Chapter 2, Table 2-1). Separately, SLAC manages an onsite aboveground gasoline dispensing facility (GDF) under a separate BAAQMD operating permit.

4.2.2.3 Annual Update for Permit-to-Operate and Annual Title V SMOP Emissions Report

SLAC has two overarching annual deliverables to the BAAQMD, as well as other deliverables described in subsequent sections. The first overarching annual deliverable is an annual information update requested by BAAQMD for selected permitted sources. This report was submitted to the BAAQMD in April 2020. The BAAQMD permit to operate is renewed annually, and spans two years, from July 1 to June 30 of the following year. SLAC's permit-to-operate renewal for year 2020 /2021 went into effect on July 1, 2020, and is valid through June 30, 2021.

The other overarching annual BAAQMD deliverable is the Title V annual emissions report for all onsite sources included in the SMOP, covering the period of July 1, 2019 through June 30, 2020. SLAC submitted the Title V annual emissions report in July 2020.

4.2.2.4 Annual Adhesives Usage Report

In April 2020, SLAC submitted its CY 2019 adhesives usage report to the BAAQMD to satisfy BAAQMD Regulation 8-51-502.2c.

4.2.2.5 Annual Air Toxics Report

SLAC reviewed the annual air toxics report covering CY 2019 that was prepared by BAAQMD, in accordance with AB 2588, and found no errors.

4.2.2.6 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, SLAC is required to provide advance notice to the BAAQMD. During CY 2020, demolition projects were evaluated by the SLAC Air Quality Program Manager for the purpose of air quality protection. Based on the projects' scope and the results of pre-work asbestos surveys, two asbestos demolition/renovation notifications were submitted to BAAQMD for these projects.

4.2.2.7 National Emission Standards for Hazardous Air Pollutants

SLAC owns and operates emissions sources that report under 40 CFR 63, Subpart T "National Emission Standards for Halogenated Solvent Cleaning", which is part of the National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations. None of these solvent cleaners and degreasers were in service during CY 2020. The NESHAP deliverables required by the USEPA is comprised of one annual performance report and two semi-annual exceedance reports. For the CY 2019 annual report, the report was consolidated with the second semi-annual report, and submitted to the USEPA in January 2020. The report included information on three degreasers. The first semi-annual report for CY 2020 was submitted to USEPA in July 2020.

4.2.2.8 Vehicle Fleet Management and Source Testing

SLAC operates, fuels, and maintains a diverse fleet of cars, trucks, and specialized pieces of heavy equipment to support its daily operations. Vehicles are provided by one of two federal agencies: the DOE or the United States General Services Administration. SLAC continues to replace and upgrade its service fleet as resources allow. SLAC submitted its CY 2019 On-Road Diesel (also known as the Truck and Bus Regulation) annual report to CARB in January 2020. Both the CY 2019 annual Off-Road Diesel Report and the CY 2019 annual Large Spark Ignition Report were submitted to CARB in February 2020 and June 2020, respectively.

The permit for SLAC's onsite GDF requires annual source testing of the gasoline dispensing system to ensure proper functioning. The GDF has two tanks, each with its own dispensing nozzle: a larger 1,500-gallon tank and a smaller 500-gallon tank. SLAC renewed the GDF permit - the renewal for 2020 - 2021 went into effect on September 1, 2020, and is valid through August 31, 2021. A routine source test was performed on the GDF on January 16, 2020; all results were within regulatory limits.

4.2.2.9 Greenhouse Gas Inventory and Baseline

GHG emissions are divided into 3 categories, or scopes. Scope 1 emissions are generated onsite and are under the direct control of the facility, such as those produced by combustion of natural gas in a boiler. Scope 2 emissions are associated with onsite use, but are generated by an offsite entity, such as electrical power. The majority of SLAC's GHG emissions are Scope 2, due to its high demand for electricity. Scope 3 emissions are business-related but generated offsite. Employee commuting and business travel account for the majority in this category.

Executive Order EO 13834 revoked the GHG reduction goals outlined in the prior EO13693. SLAC continues to track GHGs. In 2020, SLAC achieved a cumulative reduction in Scope 1 and 2 emissions of 64 percent, a reduction from 92,000 to 33,000 of metric tons of carbon dioxide (CO2) equivalent (MTCO2e). Scope 3 emissions reduced by 34 percent relative to the 2008 baseline, a reduction from 12,000 to 8,000 MTCO2e. The reduction is attributed to SLAC shutting down the majority of accelerator operations during the LCLS II construction and reduced on-site activity during the pandemic.

As part of its GHG management program, CARB established a program that specifically addresses gas-insulated switchgear (GIS), electrical equipment filled with sulfur hexafluoride (SF_6). This compound is the most powerful GHG known, having a Global Warming Potential (GWP) of 23,900 relative to carbon dioxide, which has a GWP of 1. SLAC monitors all purchase and use of SF_6 closely; explores less potent GHG alternatives; and emissions, if any, are tracked and reported to CARB. Both the annual SF_6 GIS inventory report and the annual SF_6 Research Report were submitted to CARB by the March 2020 and June 2020 deadlines, respectively.

4.3 Industrial and Sanitary Wastewater Management Program

SLAC discharges industrial wastewater and sanitary sewage to the wastewater collection system operated by the WBSD. The sewage is then conveyed via the WBSD's collection system to the Sharon Heights Golf Club recycled water plant, located in Menlo Park, California. During the hours of 12 am to 2 am, wastewater is bypassed by the recycled water plant and sent to the treatment plant operated by the Silicon Valley Clean Water (SVCW) in Redwood City, California.

4.3.1 Regulatory Framework

The Federal Water Pollution Control Act, now referred to as the Clean Water Act (CWA), was enacted into law in 1972 to halt the degradation of our nation's waters. The CWA established the National Pollutant Discharge Elimination System, which regulates discharges of wastewater from point sources such as a publicly owned treatment work facilities and categorically regulated industrial facilities, such as electroplating and metal finishing shops.

SLAC operates its industrial and sanitary wastewater programs under mandatory wastewater discharge permits, negotiated jointly with the WBSD and SVCW and covering the entire SLAC facility. The permits are for the duration of one year, with automatic renewal annually for successive one-year terms, up to 5 years. SLAC's Mandatory Wastewater Discharge Permit number WB 161215 will expire on December 15, 2021. SLAC also has a contractual relationship with the WBSD, which specifies the total industrial and sanitary water flow volumes allowed to be discharged into the municipal wastewater collection system.

Industrial and sanitary monitoring locations at SLAC are shown in Figure 4-1. SLAC's Sand Hill Road flow metering station (Sand Hill Road flow metering station (FMS)) is located immediately upstream of SLAC's sewer system connection to WBSD's Sand Hill Road trunk line, located just to the north of the SLAC main gate.

SLAC also has four wastewater flow monitoring stations located on the south side of the facility, which collectively monitor the flow SLAC discharges to the WBSD's Alpine Road trunk line. The four locations are Master Substation (MSub), Alpine Gate (Alpine), Interaction Region 8 (IR08) and IR06 Adit, as shown on Figure 4-1.

SLAC is required to submit a semi-annual self-monitoring report, which includes the results of its monitoring of the metal finishing pre-treatment facility (MFPF) and Former Hazardous Waste Storage Area (FHWSA) treatment system. The report also contains certification of a solvent management plan for approximately 100 solvents selected by SVCW. The Radiation Protection Department submits quarterly self-monitoring reports for discharges of radioactivity in industrial wastewater (see Section 5.5.1).

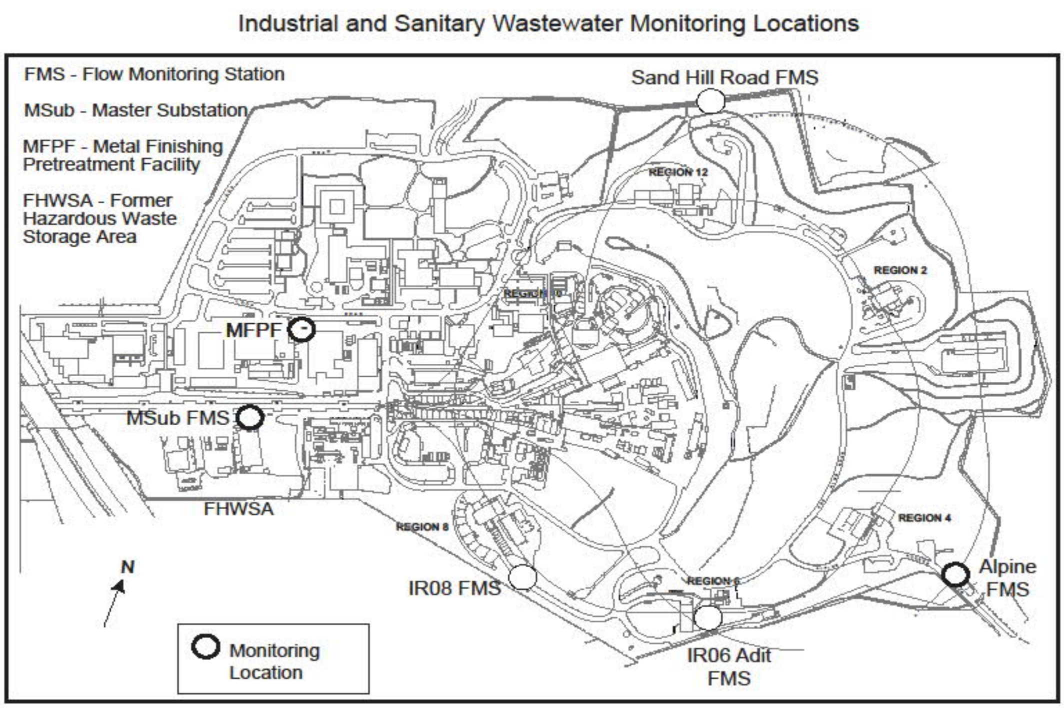

Figure 4-1 Industrial and Sanitary Wastewater Monitoring Locations

4.3.2 Program Status

4.3.2.1 Annual Facility Enforcement Inspection

The SVCW conducted the annual facility enforcement inspection of SLAC on December 2, 2020. SLAC was found to be in compliance and no issues were noted by the SVCW.

4.3.2.2 Water Quality Monitoring Results

SLAC collects water quality samples semi-annually from the MFPF and FHWSA monitoring locations, and, SVCW collects samples quarterly at the Sand Hill Road FMS and annually at both the MFPF and FHWSA. Compliance with the water quality parameters contained in the permit is determined at the Sand Hill Road FMS and FHWSA by comparing the mass discharge limit with the daily maximum mass limit. During 2020, the FHWSA groundwater treatment system was shut down for a multi-year rebound test and not discharging to the sanitary sewer, so no samples were collected from this location. SLAC was within compliance for all permitted discharge limits at the MFPF and Sand Hill Road FMS monitoring locations.

4.3.2.3 Sanitary Sewer Overflow Management

SLAC registered with the State Water Resources Control Board (SWRCB) and the San Francisco Bay RWQCB sanitary sewer overflow reporting systems in October 2008[7]. All spills from the sanitary sewer system are reported to the SWRCB using the sanitary sewer overflow reporting system. A Category 1 sanitary sewer overflow (SSO) is a spill of any volume from the sanitary sewer, which reaches surface water and/or enters a storm drain channel tributary to surface water. Category 1 spills equal to or greater than 1,000 gallons must be reported within two hours of discovery to the California Office of Emergency Services. A Category 2 SSO is any spill of 1,000 gallons or greater that does not reach surface water or a drainage channel tributary to surface water. Category 2 spills require that a draft report must be submitted electronically to the California Integrated Water Quality System (CIWQS) within three business days. A Category 3 SSO is any spill less than 1,000 gallons that does not reach surface water or a drainage channel tributary to surface water. Category 3 spills are reported electronically via CIWQS within 30 calendar days after the end of the month in which the overflow occurred. A no-spill certification must be completed and certified via CIWQS within 30 days of a month in which no spills occur.

In 2020, SLAC had no Category 1, 2 or 3 SSOs to report. However, there were two indoor private sewer lateral SSOs of 1 gallon each that occurred on February 12 and 27, 2020, at B082 due to a clogged sewer line. Private sewer lateral SSOs are not required to be reported in CIWQS. All no-spill certifications were submitted on schedule.

SLAC's Sanitary Sewer Management Plan (SSMP) was last updated in April 2019. The Plan includes descriptions of SLAC's sanitary sewer operations and maintenance activities, spill response, and reporting procedures.

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7 *Statewide General WDRs for Sanitary Sewer Systems, WQO No. WA 2013-0058-EXE.* Available at https://www.waterboards.ca.gov/

4.4 Surface Water Management Program

Stormwater flows out of the 426-acre SLAC site through 25 drainage channels. Many of the channels drain areas where the stormwater has little or no potential of exposure to industrial activities. As defined in Attachment A of the SWRCB's Industrial General Permit (IGP) Order 2014-0057- Department of Water Quality (DWQ) (amended by Order 2015-0122-DWQ and Order 20XX-XXXX-DWQ [8]), stormwater has the potential to come into contact with support activities or facilities. Such activities or facilities include SLAC's Transportation Department at Building 81 (B081), the Lower Salvage Yard, the IR-8 Salvage Yard, and the Research Yard. Based on the permit requirements of the IGP and SLAC's Stormwater Pollution Prevention Plan (SWPPP), revised in December 2019, five locations representative of stormwater discharges associated with support activities are monitored. These locations are listed below and shown in Figure 4-2.

- IR-8 Channel at the E003 outfall;
- IR-6 channel downstream of the Hydrodynamic Sedimentation Unit (HSU);
- Stormdrain catch basin (CB) number CB27E-34, located downstream of the SLAC Transportation Department;
- Stormdrain catch basin number CB31G-7 adjacent to the Lower Salvage Yard; and
- IR-8 Stormdrain sump at the IR-8 Salvage Yard

8 Order 2014-0057-DWQ as amended by Order 2015-0122-DWQ expired on June 30, 2020. Order 20XX-XXXX-DWQ went into effect on July 1, 2020; however, due to COVID-19 related concerns, the Clerk to the Board has not yet assigned a final order number to the permit.

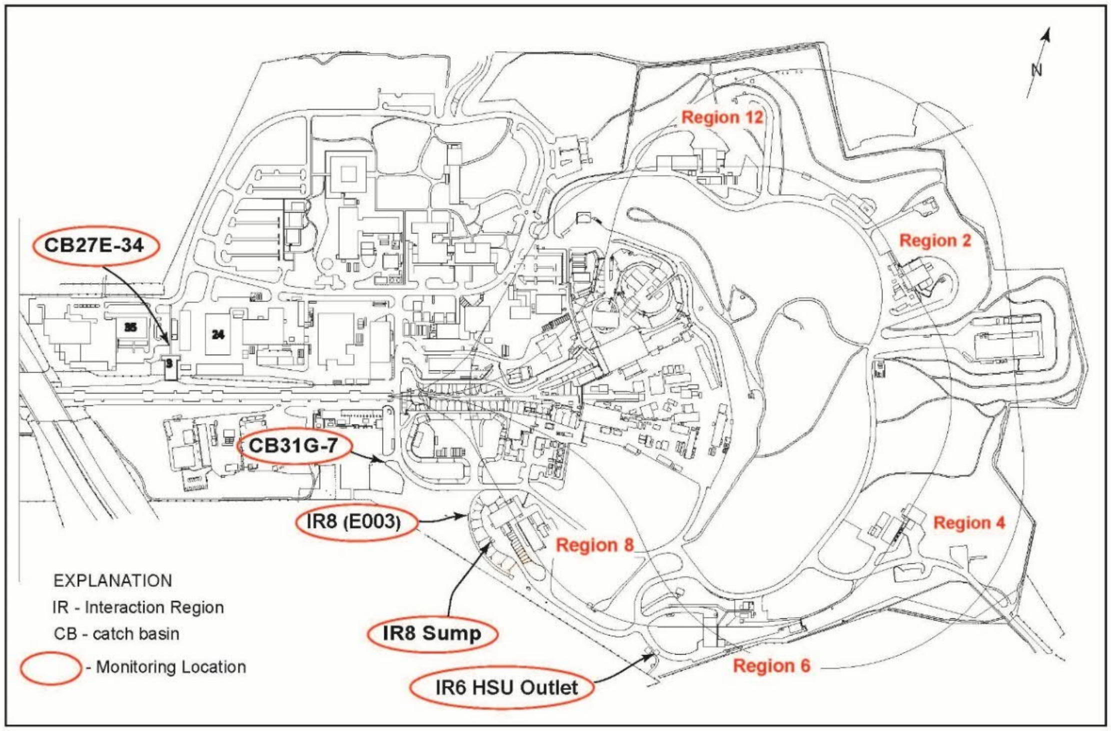

Figure 4-2 Surface Water Monitoring Locations

4.4.1 Regulatory Framework

In 1987, the CWA was amended to include non-point source discharges such as storm water run-off from industrial, municipal, and construction activities. Federal regulations allow authorized states to issue general permits to regulate industrial storm water or non-point source discharges. California is an authorized state; and in 1991, the SWRCB adopted the industrial activities storm water general permit, with the goal of reducing water pollution by regulating storm water discharges associated with industrial activities.

From 1997 through June 26, 2015, SLAC's storm water was regulated under IGP Order 97-03-DWQ. On July 1, 2015, a new State IGP Order, 2014-0057-DWQ, came into effect. SLAC filed a Notice of Intent (NOI) for coverage under the new IGP Order 2014-0057-DWQ and submitted a revised SWPPP. On July 1, 2020, the SWRCB adopted Order 20XX-XXXX-DWQ amending Order 2014-0057-DWQ.

The SWPPP has two main components: a Monitoring Plan and BMPs. The Monitoring Plan describes the rationale for sampling, lists the sampling locations, and specifies the analyses to be performed. The BMPs include a list of 18 generic and site-specific practices that serve to minimize the impact on storm water from SLAC's industrial activities (see Section 4.4.2).

4.4.2 Program Status

The reporting period for IGP Order 2014-0057-DWQ runs from July 1 through June 30 of the following year. Since the IGP's period of coverage spans two calendar years the period for monitoring water quality during the wet season of 2019 - 2020 was July 1, 2019 through June 30, 2020.

The IGP requires that stormwater samples be analyzed for the following three parameters: pH, total suspended solids (TSS), and oil/grease; as well as potential pollutants that could result from support activities and operations (identified by Standard Industrial Code in Attachment A of the IGP). The samples are also to be analyzed for any additional parameters related to receiving waters with 303(d) listed impairments or approved total maximum daily load. During the wet season of 2019 - 2020, stormwater samples were analyzed for the three required parameters as well as seven additional parameters – five metals and one non-metal (Table 4-2). The additional parameters were selected after a review of SLAC's support activities and operations.

Table 4-2 Stormwater Parameters Analyzed

Metals	Non-Metals
Aluminum	Total Suspended Solids *
Copper	pH *
Iron	Oil and Grease *
Lead	Chemical Oxygen Demand
Zinc	

* Required parameter under Industrial Stormwater General Industrial Permit Order 2014-0057-DWQ

SLAC compares its stormwater analytical results to the SWRCB-developed Annual Numeric Action Levels (NALs), in particular those for the parameters listed in Table 4-3. A comparison is also made with the Instantaneous NAL values, as applicable. During the 2019 - 2020 wet season, none of the analyzed parameters had exceedances of the Instantaneous or Annual NALs. Since there were no exceedances, SLAC was able to remain at Baseline status under the IGP on July 1, 2020.

Table 4-3 Average NALs and Average Concentrations in 2019 - 2020 Wet Season

Metals	SWRCB Annual NAL (mg/L)	SLAC Annual Average Concentration (mg/L)
Aluminum	0.75	0.44
Copper	0.0332	0.016
Iron	1.0	0.55
Lead	0.262	0.001
Zinc	0.26	0.18
Non-Metals	**SWRCB Annual NAL (mg/L)**	**SLAC Annual Average Concentration (mg/L)**
TSS	100	13
pH	6 - 9	7.52
Oil and Grease	15	< 5.1
Chemical Oxygen Demand	120	33

mg/L – milligrams per liter

4.5 Hazardous Materials Management

SLAC uses hazardous materials as part of its experimental programs including the manufacturing and maintenance of experimental devices, as well as in conventional facilities operations, maintenance and construction projects. Examples of hazardous materials managed at SLAC include the following:

- Cryogens
- Compressed gases
- Acids and bases
- Solvents
- Oils and Fuels, including Propane
- Adhesives
- Paints and epoxies
- Metals

Hazardous materials management encompasses numerous programs at SLAC, but the primary goal remains the same, to ensure the safe handling of hazardous materials in order to protect the workers, community, and the environment.

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

Important drivers at the state level generally date back to the mid-1980s and include a Hazardous Materials Business Plan (HMBP), the California Accidental Release Prevention Program (CalARP), the underground and aboveground storage tank programs, and pollution prevention and waste minimization programs.

In general, the local implementing agency for hazardous materials regulation in California is the Certified Unified Program Agency (CUPA). The Environmental Health Division of the San Mateo County Health Services Agency is the CUPA responsible for overseeing hazardous materials and waste management at SLAC. A CUPA has broad enforcement responsibilities, which include the SWPPP, the Spill Prevention, Control, and Countermeasures (SPCC) plan, and the Waste Tire Survey and Inspections, as well as the following four hazardous material subject areas:

- Hazardous Materials Business Plan (HMBP), /Emergency Response Plan
- Hazardous Waste/Tiered Permitting/Waste Minimization and Pollution Prevention
- California Accidental Release Prevention Program (CalARP)
- California Fire Code Hazardous Materials Management Plan (Section 2701.5.1 and 2701.5.2)

4.5.2 Program Status

Discussed in the following sections are the status of SLAC's 2020 programs related to hazardous materials life cycle management, including the hazardous materials business plan, the Toxics Release Inventory (TRI), and the CalARP program.

On March 16, 2020, SLAC notified workers that they would be sheltering in place in compliance with San Mateo County's Public Health Order related to the COVID 19 Pandemic. Only essential workers were allowed on site with a phased approach to bringing workers back on site. This resulted in a reduction in both chemical use and waste generation in 2020.

4.5.2.1 Annual Facility Enforcement Inspections

A HMBP inspection was conducted on December 11, 2020. During the inspection, the CUPA inspector noted stains, residues and debris in a secondary containment in the Plating Shop and cited SLAC with a Notice of Violation (NOV) under 22 CCR 12 66262.34(a)(4); 22 CCR 15 66265.31 for failure to inspect and clean.

4.5.3 Hazardous Materials Business Plan Program

EPCRA, passed in 1986 as Title III of SARA, establishes requirements for emergency planning, notification, and reporting. In California, the requirements of SARA Title III are incorporated into the state's HMBP program.

For the 2020 reporting year, SLAC's HMBP was updated and submitted in March 2020 to the San Mateo County CUPA and was accepted.

The HMBP includes the Hazardous Materials Inventory Statement. The inventory consists of all hazardous materials present at SLAC in amounts exceeding the state's aggregate threshold quantities (55 gallons for liquids, 500 pounds (lbs.) 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. A portion of the hazardous materials inventory is based on procurement data generated through the chemical management system (CMS). The hazardous waste inventory is based on the database maintained by the WM Group. Mixed waste and radioactive materials data are provided by the RP Department. Inventory of process and bulk tanks are part of the SLAC property and building databases.

The plan also includes the SLAC Emergency Management Plan. This plan combines the emergency response requirements for the following programs:

- HMBP
- Hazardous Waste Contingency Plan
- SPCC
- Risk Management Plan (RMP)

4.5.4 Toxics Release Inventory Program

DOE requires its facilities to comply with Toxic Chemical Release Reporting and Community Right-to-Know requirements (40 CFR 372), more commonly referred to as the TRI program. SLAC provides the required information annually to the DOE, which reviews, approves, and sends the TRI information to the USEPA and the state of California.

The TRI report is submitted to USEPA by June 30 of each year and reports quantities from the previous calendar year. The TRI report for SLAC submitted online to USEPA and the state of California in June 2020 covered the CY 2019 reporting year. Of the more than 400 chemicals listed in the TRI, only lead is used at SLAC above its regulatory threshold for reporting. As a result, SLAC prepared a TRI Form R for lead and submitted it to the DOE BASO for review and approval in June 2020. TRI data are available to the public via the USEPA website.[9]

4.5.5 California Accidental Release Prevention Program

Under the CalARP program, SLAC has only one regulated chemical that is used in a process above its threshold: potassium cyanide, which is used only in the Plating Shop complex. For this usage, a RMP was originally prepared and submitted to the CUPA in 2006. As part of the RMP, worst-case scenarios were modeled for a catastrophic release of potassium cyanide, but none of the scenarios led to offsite consequences. Since the impact of such a release would be limited to the immediate area of use, SLAC qualified for a Program 1 RMP (the lowest level), whereby a more detailed process hazard assessment and an offsite consequence analysis were not required. The final Program 1 RMP for SLAC was finalized in 2008 following a public comment period. It is required that the RMP be reviewed and updated every 5 years. It was reviewed, updated and submitted to the CUPA in both April of 2012 and April of 2017. The CUPA last conducted a routine CalARP inspection on March 7, 2019. Everything was found to be in order, there were no Notices of Violations issued.

4.5.6 Aboveground Storage Tank Program

Aboveground storage tanks (ASTs) are regulated under the authority of the CWA and California's Aboveground Petroleum Storage Act. Table 4-4 lists the active and regulated ASTs containing petroleum products at SLAC during CY 2020. SLAC does not have any underground storage tanks. All of the petroleum tanks at SLAC are constructed of steel with secondary containment. The SLAC SPCC plan was last updated in 2018.

Table 4-4 Aboveground Petroleum Tanks

Petroleum Product	Property Control Number	Location	Number of Tanks	Capacity (gallons)
Diesel	19683	B112 Master Substation	1	2,000
Gasoline	21443	B035 Vehicle Refueling Station	1 *	1,500/ 500
Diesel	21287	B007 MCC Generator	1	500
Diesel	22658	B 081 Maintenance yard	1	500
X-ray Oil	15192	B044 Klystron Test Lab	1	414
Diesel	NA	PSPS, B. 280 Parking lot	2	2000

* There are two sections within the tank

[9] https://enviro.epa.gov/triexplorer/tri_release.chemical

4.5.7 Toxic Substances Control Act Program

The objective of TSCA is to minimize the exposure of humans and the environment to chemicals introduced by the manufacturing, processing, and commercial distribution sectors. One portion of TSCA regulates equipment filled with oil or other dielectric fluids that contain PCBs.

TSCA regulations are administered by the USEPA; there were no USEPA inspections of SLAC during CY 2020.

TSCA defines transformers containing oil with PCBs as follows. Transformers containing oil with PCB concentrations of 500 parts per million (ppm) and greater are defined as PCB transformers. Transformers with PCB concentrations equal to or greater than 50 ppm but less than 500 ppm are defined as PCB-contaminated transformers, and transformers containing PCBs at concentrations of less than 50 ppm are defined as non-PCB transformers. At the end of CY 2020, SLAC had 100 plus transformers on site, none of which are PCB transformers. Six of the transformers are PCB-contaminated. All other transformers are free of PCBs.

4.5.8 Chemical Management System

SLAC has been purchasing chemicals through Government Scientific Source (GSS) since 2017, which provide sourcing, purchasing, expediting, and vendor support for all non-radioactive chemicals and gases purchased. The use of GSS is to provide support for SLAC's chemical management system. The key objectives of the CMS program at SLAC are to:

- Reduce SLAC's chemical and gas cost through vendor-leveraged buying power
- Reduce SLAC's risk and space requirements associated with storing, managing and handling chemicals
- Reduce time spent by SLAC researchers and other personnel on sourcing, ordering and tracking chemicals
- Generate chemical usage and compliance reports directly from procurement data

By the end of calendar year 2020, the program had achieved the following:

- Maintained excellent safety performance in the CMS program; no illnesses/injuries or reportable chemical spills in CY 2020
- Ensured contractors have met their training requirements
- Achieved the availability of eight vendor punch out catalogs and 81 static catalogs providing options for thousands of active chemicals available to requestors.
- Identified approved chemical requestors of the CMS program and 220 approved work areas

4.6 Waste Management and Minimization

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

4.6.1 Hazardous Waste Management and Minimization

4.6.1.1 Regulatory Framework

SLAC is a 90-day hazardous waste generator and as such, is not required to obtain a Resource Conservation and Recovery Act (RCRA) Part B permit that would allow the treatment, storage and/or disposal of hazardous waste onsite (i.e. a treatment, storage, and disposal facility permit) under the federal RCRA regulations. However, SLAC does have permits to treat a few RCRA-exempt and non-RCRA (i.e. California-only) hazardous waste streams (see Section 4.6.1.2 regarding the state-level tiered permit program).

The USEPA has delegated authority for implementing the federal RCRA program to the state of California. In turn, the state has delegated its authority on certain aspects of hazardous waste program oversight to the local CUPA. The San Mateo County Health Services Agency, Environmental Health Division serves as the CUPA with delegated authority to oversee SLAC's hazardous waste management activities.

4.6.1.2 Hazardous Waste Treatment: Tiered Permitting Program

The five tiers of California hazardous waste permits, presented in order of decreasing regulation, are the *full permit*, *standard permit*, *permit by rule*, *conditional authorization*, and *conditional exemption*. SLAC operates four hazardous waste treatment units, all under permit by rule (Table 4-4). These units are authorized to treat listed or characteristic hazardous wastes.

Table 4-5 Hazardous Waste Treatment Units Subject to Tiered Permitting

Tiered Permit Level	Unit Number	Location/Description
Permit by rule	Unit 1A	Cyanide Treatment Tanks
Permit by rule	Unit 1B	Metal Finishing Pre-treatment Facility
Permit by rule	Unit 1C	Batch Hazardous Waste Treatment Tank
Permit by rule	Unit 2	Metal Finishing Pre-treatment Facility – Sludge Dryer

4.6.1.3 Hazardous Waste Tracking

This section does not include radioactive waste. SLAC utilizes a site-specific computerized hazardous waste tracking system. Hazardous wastes are tracked from the time they are generated to final appropriate disposal off-site. The waste tracking system includes fields that generate information required for the SARA Title III, TRI, State Bill (SB) 14 and TSCA PCB reports.

4.6.1.4 Hazardous Waste Minimization

SLAC hazardous waste generation rates have been reduced through a combination of waste minimization and pollution prevention techniques, and processes including the following:

- Reducing generation of excess chemicals through CMS
- Converting non-hazardous empty metal containers and drums to scrap metal
- Exchanging chemicals with other users
- Reclassifying waste streams to reduce hazardous waste volumes
- Re-using chemicals
- Returning unused material to the vendor or manufacturer
- Sending electrical equipment offsite for re-use by other organizations

SLAC continues to make progress in reducing hazardous waste generated from routine operations. Routine wastes are those wastes associated with SLAC's routine operations and maintenance processes. For FY 2020, SLAC reduced its hazardous waste generated by routine operations from the 1993 baseline of 147 tons to 4.8 tons, a 97 percent reduction. This quantity was also a 45 percent reduction from the previous year's quantity of 8.7 tons, which is attributed to COVID 19 impacts on operations. Measures will continue to be taken to further reduce hazardous waste by helping smaller generators increase their awareness of waste reduction opportunities, helping them procure less hazardous chemicals, and helping them learn to develop for themselves more focused waste reduction measures for their work areas.

4.6.2 Non-Hazardous Waste Management and Minimization

Non-hazardous waste can be grouped into non-hazardous industrial waste, municipal solid waste, and, construction and demolition (C&D) debris.

4.6.2.1 Non-hazardous Industrial Waste Management

SLAC's WM Group manages industrial waste resulting from SLAC's laboratory operations and remediation operations that, while not classified as hazardous, is not sufficiently "clean" to be disposed of in a municipal or sanitary solid waste landfill. Examples of industrial wastes include soils containing low levels of petroleum hydrocarbons, PCBs or metals that are classified as non-hazardous but are not acceptable for disposal at municipal landfills. In California, industrial wastes are generally termed *Class 2* waste since they are specifically required to be disposed of at Class 2 landfills (these provide an intermediate level of protection to the environment between *Class 1*, hazardous waste landfills and *Class 3*, municipal solid waste landfills).

4.6.2.2 Municipal Solid Waste Management

The term *municipal solid waste* (MSW) refers to the following waste streams generated at SLAC:

- Beverage containers (glass, aluminum, plastic)
- Paper
- Cardboard
- Scrap wood (non-treated)
- Scrap metal
- Garden/landscaping waste
- Salvage sales and transfers
- Food wastes
- Tires
- Trash (non-recyclable waste)

SLAC's Facilities & Operations Department operates a MSW management program that collects a variety of recyclable and compostable materials as well as regular dumpster refuse (i.e., trash). SLAC's Property Control Department operates a salvage operation that sells metal, equipment, and other salvageable commodities for their cash value or makes them available to the site and others for reuse. SLAC recycled approximately 270 tons of scrap metal in FY 2020. These programs help SLAC minimize disposal of MSW in landfills.

SLAC also has programs in place to manage other wastes including C&D wastes, electronic wastes (e-wastes), and universal wastes, as described in Sections 4.6.2.3 and 4.6.3.

SLAC continues to strive for MSW waste reduction through expansion of zero waste programs in SLAC office buildings. SLAC's zero waste program utilizes a model developed by the City of San Francisco for commercial office buildings, which includes centralized waste, recycling, and compost collection areas, and compost collection of paper towels in the restrooms. The program was first instituted in 2008 at the SLAC cafeteria, and in FY 2012, SLAC began expanding this program to office buildings. Through FY 2020, the program has been implemented in nineteen buildings, which include a large majority of the higher occupancy buildings at the facility. SLAC's MSW diversion from landfill is shown in Table 4-6 and Figure 4-3. The tonnage of MSW generated was lower in FY 2020 compared to previous years due to COVID 19 curtailments to working onsite. Included in the MSW diverted was approximately 270 tons of scrap metal that was recycled. SLAC continues to exceed the DOE's MSW diversion rate of greater than 50 percent diversion with a 74.8 percent diversion rate in FY 2020.

Table 4-6 Breakdown of Municipal Solid Waste (MSW) Diversion Quantities, FY 2016 to FY 2020
(Excluding C&D, E-Waste, and Universal Waste)

Year (FY)	MSW Disposed (all Offsite) (tons)	MSW Diverted (1) (tons)	MSW Composted (2) (tons)	Waste to Energy (3) (tons)	MSW Diversion Percentage Rate (%)
2016	301.1	505.4	190.3	51.6	71.3
2017	321.9	624.5	326.6	89.5	76.4
2018	305.0	461.3	193.4	92.5	71.0
2019	315.3	283.1	187.3	93.3	64.1
2020	181.5	351.6	90.9	95.7	74.8

(1) " MSW Diverted" includes materials recycled including paper, cardboard, scrap metal, scrap wood, equipment sold or transferred (i.e., reuse), and tires, and does not include C&D, e-waste, or universal wastes.

(2) " MSW Composted" includes composted green waste such as garden and landscape trimmings and food waste.

(3) Waste to Energy includes those materials diverted from landfill and used for energy, such as scrap wood sent as fuel to boilers.

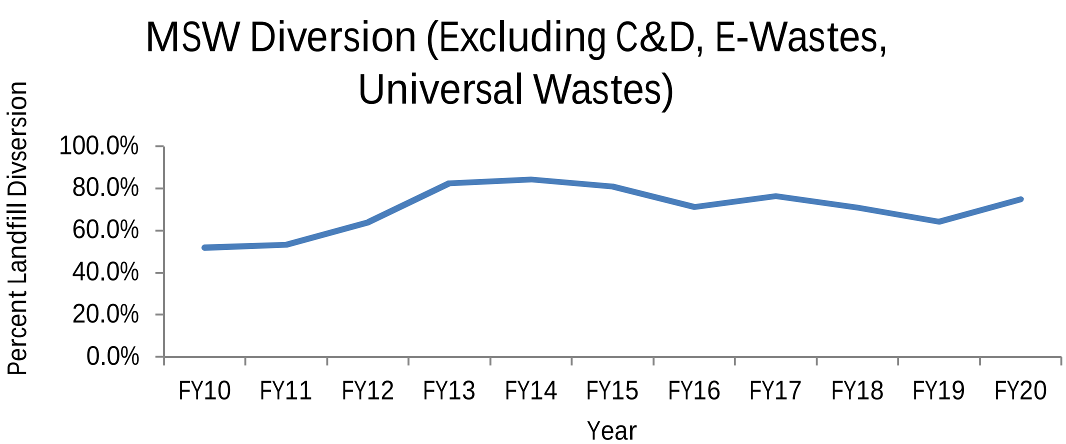

Figure 4-3 Municipal Solid Waste Diversion Rates 2010 – 2020 (Excluding C&D, E-Waste, and Universal Wastes)

Additional information on SLAC's MSW diversion program and data are provided in SLAC's *Site Sustainability Plan.* [10]

4.6.2.3 Construction and Demolition Debris

C&D debris include a variety of non-hazardous materials generated as a result of construction projects, and may include concrete, wood, metal, gypsum board, and other materials. SLAC's major construction and renovation contracts include requirements for recycling of C&D wastes and as a result, SLAC achieves high landfill diversion rates for C&D materials, as illustrated in Table 4-7.

Table 4-7 Breakdown of Construction and Demolition Diversion Quantities, FY 2016 to FY 2020 (Excluding Soil Reuse)

Year (FY)	C&D Disposal (tons)	C&D Diverted (tons)	Diversion (%)
2016	107	4,579	98
2017	86	704	89
2018	54	287	84
2019	27	88	76
2020	14	220	94

% - percentage
FY – fiscal year

4.6.3 Other Waste Management Activities

SLAC has programs in place to recycle electronic waste (e-waste) and universal wastes (e.g., bulbs and batteries). In FY 2020, approximately 15 tons of these wastes were recycled, and all of SLAC's electronic wastes were recycled through electronics recyclers that were certified under either the e-Stewards or Responsible Recycling programs, helping to ensure proper disposition of these materials.

SLAC generates a small quantity of low-level radioactive waste every year; this waste stream is discussed in Chapter 5. In addition, SLAC generates a small quantity of medical waste from the on-site Medical Department. In California, the state Medical Waste Management Act requires proper storage, treatment, and disposal of medical waste. The state program is administered by the California Department of Health Services.

4.7 Sustainability

SLAC's *Site Sustainability Plan 202*1, which was published in 2020,[11] summarizes SLAC's planned actions and performance status on the sustainability goals derived from EO 13834, as adopted by DOE in their *Fiscal Year 2021 Site Sustainability Plan Guidance.*

A core part of SLAC's Environment, Safety and Health Policy is to "wisely use and conserve natural resources and conduct our activities in a sustainable manner". The EO and DOE goals complement SLAC's

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10 SLAC National Accelerator Laboratory, *Site Sustainability Plan 2019*, December 2018

11 SLAC National Accelerator Laboratory, *Site Sustainability Plan FY 2021*, December 2020.

values on sustainability and provide quantifiable objectives and timeframes, consistent across the federal complex.

Included below is a summary of progress on key sustainability goals, in the areas of energy, GHG, water, sustainable building, and waste, as reported in SLAC's *Site Sustainability Plan 2021*.

Table 4-8 Progress against Select Sustainability Goals of EO 13834 and the DOE Strategic Sustainability Performance Plan through FY 2020

Category	EO 13834/DOE Goal	Progress
Energy Reduction	30% energy intensity (BTU per gross square foot) reduction by FY 2015 from the FY 2003 baseline value and 1.0% YOY thereafter (2020 target: 1%).	SLAC met the target by achieving a 62% reduction in energy intensity compared with FY 2015. FY 2003 building metering not available to baseline. Year-to-year comparison of electrical energy shows minor deviations in annual consumption on most buildings indicating consistent performance. An increase of 1.5% was measured compared with the previous year attributed to the Arrillaga Science Laboratory building (B057) commencing operations, a resulting increased load on the central plant (B023) and increased energy usage in the Data Center building (B050).
Renewable Energy	Renewable electric energy shall account for 30% of total electric consumption (new target replacing the former target of 7.5%).	Renewable energy accounted for 34% of electric consumption. SLAC offsets power through renewable energy purchases from a combination of wind and hydroelectric sources, and through on-site solar generation.
Water Reduction	Greater than 20% potable water intensity (gallons per gross square foot) reduction by FY 2015 from the FY 2007 baseline and 0.5% year over year thereafter (2020 target: 0.5%).	SLAC achieved a 65% reduction compared with the FY 2007 baseline. Water consumption was minimal for cooling towers supporting science due to Linac shutdown for construction upgrades.
Sustainable Building	15% of buildings larger than 5,000 gross square feet to be compliant with the HPSB by FY 2025, with annual progress thereafter.	SLAC's goal is nine HPSB buildings. SLAC has seven HPSB compliant buildings. The new Cryo-Plant building was HPSB certified FY 2020. SLAC has plans to convert existing buildings and add new construction by FY 2025. SLAC completed retro-commissioning the energy consuming systems in the HPSB buildings in order to maintain efficiency.
Waste Reduction	Divert at least 50% non-hazardous solid waste (excluding C&D debris) by FY 2020.	SLAC met the target and has exceeded the MSW diversion goal for the last several years, with a 66% diversion rate for FY 2020 (excluding C&D debris). Similarly, the C&D diversion goal was exceeded, with a 94% diversion rate for FY 2020.

BTU – British thermal BTU – British thermal units
C&D – construction and demolition
FY – fiscal year
GHG – greenhouse gases
HPSB – high-performance sustainable building
MSW – municipal soil waste

4.8 National Environmental Policy Act

SLAC's mission has expanded to a multi-program laboratory conducting research in the areas of photon science, particle physics, cosmology, structural biology and medicine, material science, and emerging technologies. SLAC continues to upgrade the original linear accelerator and its associated machines and hardware in response to its evolving programs, and ensures that the NEPA requirements are followed on a project-by-project basis for all new construction projects.

NEPA, the goal of which is to protect, restore and enhance the environment, was enacted into law in 1970. SLAC developed its formal NEPA program in 1992, which is jointly administered by the DOE and SLAC's EP Department. Under this program, proposed SLAC projects and actions are reviewed to evaluate NEPA documentation requirements. The three categories of NEPA documentation in increasing order of complexity are:

- Categorical exclusion (CX)
- Environmental assessment (EA)
- Environmental impact statement (EIS)

SLAC staff provides information and technical support to DOE to be used in determining whether proposed federal actions will have a significant effect on the environment. The completed NEPA documents are forwarded to the DOE BASO for review, concurrence, and/or approval by the DOE NEPA Compliance Officer located at the DOE Office of Science Integrated Support Center in Oak Ridge, Tennessee.

Environmental aspects that must be considered when conducting the environmental analysis and preparing NEPA documentation commonly include: potential increases in air emissions, hazardous materials usage, and waste generation, impacts on wetlands, sensitive species and critical habitats, increases in water consumption and wastewater discharge, and impacts to historical and cultural resources.

To be consistent with the DOE NEPA Openness Policy, SLAC's CX determinations are available to the public at the link provided below.[12] All of the projects reviewed for NEPA purposes in 2020 were relatively minor in scope and impacts, and were classified as CXs.

[12] NEPA Page (slac.stanford.edu)

5 Environmental Radiological Program

5.1 Introduction

All members of the public receive radiation doses from natural background radiation and from various human activities. This chapter describes sources of radiation and radioactivity at SLAC and provides an overview of how SLAC's REP program assesses radiation and radioactivity in the environment (e.g. air, soil and water) to determine the potential radiation dose to the public and any impacts to the environment.

DOE Order 458.1, *Radiation Protection of the Public and the Environment (Change 3)*, requires that radiation and radioactivity from SLAC do not cause any member of the public to receive a radiation dose greater than 100 milli-rems (mrem, a unit used to quantify radiation dose to humans) in a year.[13]

As in past years, the potential dose that members of the public received due to SLAC operations in CY 2020 was a very small fraction of the dose received from natural background radiation. In addition, the potential dose to the public and the radiation-related impacts to the environment from SLAC operations were significantly below all DOE and USEPA regulatory limits and SLAC administrative limits.

5.2 Sources of Radiation and Radioactivity

The long linac at SLAC is located inside a concrete tunnel 25 feet beneath the ground surface. Through this underground tunnel, electron beam particles are accelerated to nearly the speed of light up to giga-electron volt levels.

Some beam particles strike accelerator components during the acceleration process. When that happens, the decelerating particles may emit secondary radiation in the form of high-energy photons and neutrons. This secondary radiation is present whenever beam particles are accelerated then lost, but it ceases as soon as power to the accelerator is terminated.

The secondary radiation may also make the substances they strike become radioactive. Table 5-1 lists the predominant radioactive elements produced in water or air, and their half-lives (the time required to reduce the radioactivity by half).

Facilities at SLAC are designed to meet all applicable safety and environmental requirements. Nearly all of the direct radiation is stopped by the combined shielding on the accelerator structure and the ground, and by the thick concrete walls of the tunnel that surround the accelerator itself. SLAC monitors the small fraction of photons and neutrons that pass through the accelerator components, through the surrounding earth or walls, to reach areas outside of the accelerator housing. This direct-radiation evaluation and monitoring is described in Section 5.3.

SLAC also assesses, measures, and reports on radioactivity potentially produced and released to the environment as required by SLAC's policies and by state or federal regulations. Sections 5.4 through 5.6

13 United States Department of Energy, DOE O 458.1, *Radiation Protection of the Public and the Environment.*

and 5.9 describe SLAC's programs designed to assess and control radioactivity that have the potential to be released into the different types of environmental media. All potential releases of radioactive materials are included in tables within those sections.

Section 5.8 provides a summary of how the calculated potential maximum doses compare with natural background radiation. Table 5-6 summarizes annual doses to the maximally exposed individual (MEI) from both direct radiation (0.4 mrem) and airborne radioactivity released (2.77E-02 mrem), and shows that the doses are much smaller the regulatory limits and the natural background radiation.

Table 5-1 Activation Products in Water or Air

Radioactive Element	Half-life	Primarily Produced In
Oxygen (^{15}O)	123 seconds	Water or air
Nitrogen (^{13}N)	10.0 minutes	Air
Carbon (^{11}C)	20.3 minutes	Water or air
Argon (^{41}Ar)	1.8 hours	Air
Beryllium (^{7}Be)	53.6 days	Water
Hydrogen (tritium (^{3}H))	12.3 years	Water

5.3 Monitoring for Direct Radiation

The maximum dose that could have been received by a member of the public due to direct radiation from SLAC was 0.4 mrem [0.004 milli-Sievert (mSv) - the International System of units for dose equivalent]. [14] This is 0.4 percent of the 100 mrem regulatory limit.

During CY 2020, SLAC measured direct radiation at 43 locations around the SLAC site boundary to determine the potential radiation dose to a member of the public. Readings from these site-boundary dosimeters used to measure radiation were recorded each calendar quarter. The annual doses from these dosimeters were used to estimate the doses to the MEI based on continuous occupancy of 24 hours a day, 365 days per year. Landauer Incorporated, accredited by the DOE's Laboratory Accreditation Program and National Voluntary Laboratory Accreditation Program as a dosimeter supplier, provided and processed the dosimeters.

Results from these dosimeters were also used to calculate the collective dose to the population (about 5.3 million based on year 2000 census data) that live within 80 kilometers (km) (equivalent to approximately 50 miles) of SLAC; the collective dose was 1.53 person-rem for CY 2020.

[14] Radiation Protection Department Memo. CY 2020 SLAC Site Boundary Environmental Monitoring Results & Public MEI Dose Calculations from Direct/Skysine Radiation, RP-DREP-20210504-MEM-01

5.4 Assessment of Airborne Radioactivity

As required by 40 CFR 61, Subpart H, SLAC files an annual report to the USEPA that describes the possible sources, types, and quantities of airborne radioactivity released into the atmosphere. [15] As detailed below, the potential maximum dose to the MEI of the general public (onsite or off site) from CY 2020 releases of airborne radioactivity was calculated to be 2.77E-02 mrem (2.77E-04 mSv). Approximately 1.88E-02 mrem (68 percent of the MEI dose) can be attributed to ^{13}N radioisotope. The MEI location that corresponds to the highest calculated effective dose equivalent for releases in CY 2020 is at the onsite Building 082 (leased by a private company). This MEI dose is well below the regulatory limit, which requires airborne radionuclide releases to be limited so that no member of the public receives a dose in excess of 10 mrem (0.1 mSv) in any one year.

About 99.6 percent of the total MEI dose (2.76E-02 mrem) can be attributed to emissions from the Beam Switch Yard (BSY) operations in CY 2020. Additionally, there was no individual release point within SLAC exceeding the 0.1 mrem/year (0.001 mSv/year) value that requires to be continuously monitored. The maximum value from a single effluent point was 2.76E-02 mrem/year (yr) from the BSY release point.

The collective effective dose equivalent to the population within 80 km of SLAC's site boundary (estimated at 5.3×10^6 persons) due to releases of airborne radioactivity at SLAC in CY 2020 was calculated to be 5.55E-02 person-rem.

As detailed in the annual National Emission Standards for Hazardous Air Pollutants (NESHAPs) report, the released airborne radioactivity was calculated based on conservative information from the SLAC accelerator operations during CY 2020. Table 5-2 summarizes the estimated radioactivity released in CY 2020, showing the quantities in Ci. Potential doses to members of the public due to the released radioactivity were determined using the USEPA-approved software code CAP-88 version 2.

15 SLAC National Accelerator Laboratory, Environment, Safety & Health Division. Radiation Protection Department, *Radionuclide Air Emissions Annual Report – CY 2020* (June 2020)

Table 5-2 Airborne Radioactivity Released CY 2020

Category	Radioactive Element	Activity (Ci)
Tritium	Hydrogen (^{3}H)	n/a
Krypton-85	Krypton (^{85}Kr)	n/a
Noble gases ($T_{1/2}$ < 40 days)	Argon (^{41}Ar)	0.22
Short-lived activation products ($T_{1/2}$ < 3 hr)	Oxygen (^{15}O)	3.94
	Nitrogen (^{13}N)	7.35
	Carbon (^{11}C)	0.79
Other activation products ($T_{1/2}$ > 3 hr)	n/a	n/a
Total radioiodine	n/a	n/a
Total radiostrontium	n/a	n/a
Total uranium	n/a	n/a
Plutonium	n/a	n/a
Other actinides	n/a	n/a
	Total	12.29

n/a – not applicable
$T_{1/2}$ – half life
< - less than
> - greater than

5.5 Assessment of Radioactivity in Water

Three types of water are monitored for radioactivity at SLAC: industrial wastewater, stormwater, and groundwater. This section summarizes the CY 2020 monitoring and results for each water type.

5.5.1 Industrial Wastewater

Federal and state regulations (10 CFR 20.2003 and 17 California Code of Regulators 30253) limit the radioactivity in industrial wastewater that SLAC releases to the sanitary sewer system. In CY 2020, SLAC released 0.0004 percent of the applicable limits (only 2.17×10^{-5} Ci for tritium). There were no other gamma/beta emitters releases to the sanitary sewer system.

Throughout CY 2020, SLAC sampled and analyzed wastewater discharges for tritium. Total activity released during CY 2020 is summarized in Table 5-3.

As required by regulations, at the end of each calendar quarter of CY 2020, SLAC reported the results of wastewater monitoring and discharge to the SVCW.[16]

[16] SLAC, ES&H Division, Radiation Protection Department, *Radioactivity in Industrial Wastewater for the Period of 1 October 2020 to 31 December 2020.*

Table 5-3 Radioactivity in Wastewater Released into Sanitary Sewer CY 2020

Category	Radioactive Element	Activity (Ci)	Annual Release Limit (Ci)
Tritium	Hydrogen (^{3}H)	2.17×10^{-5}	5
Activation products ($T_{1/2}$ > 3 hr)	Cobalt (^{60}Co)	0	1 *
	Beryllium (^{7}Be)	0	
Total radioiodine	n/a	0	
Total radiostrontium	n/a	0	
Total uranium	n/a	0	
Plutonium	n/a	0	
Other actinides	n/a	0	

* Combined. Excluding ^{3}H (for which there is a 5 Ci annual limit), there is a 1 Ci limit for the combined activity of all radioactive elements released during the calendar year

n/a – not applicable

Table 5-4 summarizes the historical results of wastewater monitoring for CY 2010 through CY 2020. The final column of the table compares the radioactivity discharged by SLAC into the sanitary sewer with the annual limit for such discharges set by federal and state regulation. Each year, the quantities and types of radioactivity in wastewater discharged depend on past accelerator operations and on details of wastewater handling.

Table 5-4 Summary of Radioactivity in SLAC Wastewater, CY 2010 to 2020

Year	Radioactive Element	Activity (Ci)	Percentage of Annual Limit
2010	Hydrogen (^{3}H)	1.2×10^{-2}	0.24
2011	Hydrogen (^{3}H)	2.08×10^{-4}	0.004
2012	Hydrogen (^{3}H)	1.1×10^{-4}	0.002
2013	Hydrogen (^{3}H)	4.63×10^{-5}	0.0009
2014	Hydrogen (^{3}H)	4.86×10^{-4}	0.01
2015	Hydrogen (^{3}H)	1.36×10^{-5}	0.0003
2016	Hydrogen (^{3}H)	6.23×10^{-5}	0.0013
2017	Hydrogen (^{3}H)	1.13×10^{-4}	0.0023
2018	Hydrogen (^{3}H)	3.95×10^{-5}	0.0008
2019	Hydrogen (^{3}H)	7.32×10^{-5}	0.0015
2020	Hydrogen (^{3}H)	2.17×10^{-5}	0.0004

^{3}H – tritium
Ci - Curie

5.5.2 Stormwater

The stormwater monitoring program is described in Section 4.4 of this report. As in all previous years, in CY 2020, no radioactivity above natural background was found in any storm water or storm drain sediment samples.

5.5.3 Groundwater

Throughout CY 2020, SLAC performed in-house analysis of water samples from monitoring wells for the presence of radioactivity each time the wells were sampled under SLAC's groundwater Self-Monitoring Program (SMP) as described in Chapter 6. The groundwater SMP includes a groundwater Sampling and Analyses Plan (SAP) that outlines the frequency at which the wells are sampled and the constituents for which the samples are analyzed. Groundwater samples collected as part of the SMP and analyzed for tritium are sent to a California-certified analytical laboratory for independent tritium analysis. Splits of these samples are also analyzed by SLAC's RP Department. The results from the in-house laboratory are in agreement with the results of the external laboratory.

SLAC has over one hundred groundwater wells (see Chapter 6), 19 of which are sampled for tritium and other radionuclides at least once a year, per the groundwater monitoring program's SAP. Tritium has historically been detected above the analytical method's reporting limit (SLAC's RP Department data) in only the five wells listed in Table 5-5. These data were also reported quarterly in the SLAC Memorandum Quarterly Summary of Tritium Concentrations Measured in Monitoring Wells. No other radionuclides were detected.

Table 5-5 Summary of Tritium Concentrations from Five Monitoring Wells CY 2020

Period (Month)		Jan. to March	April to June	July to Sept.	Oct. to Dec.
EXW-4	Avg ^{3}H (pCi/L)	2622	1854	1473	1101
	percent of DWS [1]	13	9	7	6
	No. of Samples		1	1	1
MW-30	Avg ^{3}H (pCi/L)	< 500 [2]	< 500 [2]	< 500 [2]	512
	percent of DWS	na	na	na	
	No. of Samples	1	1	1	3
MW-81	Avg ^{3}H (pCi/L)	< 500 [2]	< 500 [2]	< 500 [2]	< 500 [2]
	percent of DWS	na	na	na	na
	No. of Samples	1	1	1	1
MW-82	Avg ^{3}H (pCi/L)	<500 [2]	<500 [2]	< 500 [2]	581
	percent of DWS	na	na	na	3
	No. of Samples	1	1	1	1
MW-94	Avg ^{3}H (pCi/L)	1317	1962	1561	1390
	percent of DWS	7	10	8	7
	No. of Samples	1	1	1	1

[1] DWS – Drinking Water Standard: 20,000 pCi/L for tritium
[2] 500 pCi/L was the minimum tritium concentration that was detectable by SLAC in CY 2020
na – not available
No.- number
pCi/L – pico-curies per liter
XW – extraction well

Other than groundwater from these five wells, no radioactivity above natural background levels has ever been detected in samples from any of the other wells. The detected concentrations of tritium in the water samples summarized in Table 5-5 were below federal and state limits set for tritium in drinking water, which is 20,000 pCi/L under 22 California Code of Regulations (CCR) 64443 and 40 CFR 141.66. In addition, groundwater beneath SLAC is not used for any purpose because of its very low well yields, and because of the water's naturally high content of TDS.

To support the future LCLS II operations, two new groundwater monitoring wells were constructed in October 2019 in the vicinities of the LCLS II End Beam Dump and one was installed in the Beam Switch Yard to gather baseline data prior to the future start of the LCLS II experiment. Groundwater samples were collected after the wells' installation and analyzed for tritium, all CY 2020 results were below the detection limit of 500 pCi/l for tritium.

5.6 Assessment of Radioactivity in Soil

During CY 2020, SLAC collected over 100 soil samples to support the LCLS II construction project, and analyzed them by gamma ray spectroscopy. Results of all the soil samples were all within Naturally Occurring Radioactive Material (NORM) background levels.

5.7 Release of Property Potentially Containing Residual Radioactive Material

All property, both real and personal, exposed to any process at SLAC that could cause the property to have the potential for surface or volumetric radiation contamination has to be measured using appropriate instruments with sufficient detection capabilities before release. In addition to radiological surveys, SLAC uses process knowledge to ensure that the material meets the release criteria for recycled metals. The materials are verified to have no detectable radioactivity before they are cleared and permitted to be released from the radiological controlled areas. At SLAC, property that has any detectable radioactivity is identified as radioactive, and either is retained for appropriate reuse on site or is disposed of as radioactive waste. Only material which does not have detectable radioactivity can be released from radiological controlled areas. Therefore, property releases at SLAC do not add to the potential public dose.

The SLAC material release program has been benchmarked with other similar DOE laboratories and peer-reviewed. The protocols and the releases for certain batches of metals have also been validated and verified by the DOE BASO. A radiation portal-gate monitor is in operation at SLAC, which is used as a final screening by SLAC of trucks full of metal that has been tentatively released and is ready to be transported to the appropriate recycling center. During 2020, there were no significant recycling efforts due to the Covid 19 pandemic and the requirement to shelter in place.

5.8 Potential Dose to the Public

The maximum dose to members of the public due to SLAC operations are very small compared with doses from natural background radiation and are well below all regulatory limits.

Table 5-6 summarizes the dose results for the two modes that were the potential contributors to public radiation dose in CY 2020, namely direct radiation (0.4mrem) and airborne radioactivity (2.77E-02 mrem). Releases of radioactivity into water and property were too small to result in a radiation dose to a member of the public under any credible scenario. Table 5-6 also compares the CY 2020 dose results with regulatory limits and natural background.

The MEI due to airborne radioactivity is located at the onsite Building 82 (leased to a private company).

Table 5-6 Summary of Potential Annual Doses due to SLAC Operations CY 2020

	Maximum Dose to General Public : Direct Radiation	Maximum Dose to General Public : Airborne Radioactivity	Maximum Dose to General Public : Airborne + Direct	Collective Dose To Population within 80 km of SLAC
Dose from SLAC	0.4 mrem	2.77E-02 mrem	0.43 mrem	1.53 (direct) + 5.55E-02 (air) = 1.59 person-rem
DOE Radiation Protection Standard	100 mrem	10 mrem	100 mrem	n/a
SLAC Maximum Dose as Percentage of DOE Standard	0.40 %	0.28%	0.43 %	n/a
Dose from Natural Background[17]	100 mrem	200 mrem	300 mrem	1,667,000 person-rem
SLAC Maximum Dose as Percentage of Natural Background	0.04%	0.014 %	0.14%	9.5E-05

Notes
mrem – milli-rem
n/a - not applicable
% - percent

Table 5-7 presents the maximum dose potentially received by a member of the public from both direct radiation and airborne radioactivity due to SLAC operations in CY 2010 through CY 2020, and compares it with the average dose due to natural background radiation and radioactivity.

17 National Council on Radiation Protection and Measurement, NCRP Report No. 94, *Exposure of the Population in the United States and Canada from Natural Background Radiation*

Table 5-7 Potential Annual Dose * (mrem/yr) to Maximally Exposed Individual, CY 2010 to 2020

Year	SLAC Direct and Airborne Radiation (mrem)	Average, Total Natural Background Radiation (mrem)	Percentage of SLAC Dose to Natural Background %
2010	0.13	300	0.04
2011	0.42	300	0.14
2012	0.53	300	0.18
2013	0.04	300	0.013
2014	0.045	300	0.015
2015	0.045	300	0.015
2016	0.052	300	0.017
2017	0.031	300	0.010
2018	0.041	300	0.014
2019	0.0001	300	0.0001
2020	0.43	300	0.14

* Starting with the 2003 calculations, the effects of air attenuation were taken into account.

5.9 Biota Dose

The DOE technical standard, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE-STD-1153-2002), indicates DOE facilities are to protect plants and animals by assuring the following dose rates due to “exposure to radiation or radioactive material releases” into the applicable environment are not exceeded:

- Aquatic animals: should not exceed 1 rad/day
- Terrestrial plants: should not exceed 1 rad/day
- Terrestrial animals: should not exceed 0.1 rad/day
- Rad, instead of rem, is used in this report, as rad is the unit to quantify radiation dose in a material, in this case animal and plants.

5.9.1 Dose to Biota from Direct Radiation

In CY 2020, SLAC monitored radiation dose and dose rate at approximately 300 onsite locations (most of which are outside accelerator shielding housing, the rest are inside shielding housing) using passive radiation dosimeters posted for six-month periods. For each period, the average dose rate of these dosimeters was found to be less than 0.0005 rad/day[18] (dominated by those inside shielding housing), and the maximum dose rate was less than 0.03 rad/day (inside shielding housing). Based on these results, and the fact that the animal population could only have had access to areas with low dose rates (outside shielding housing), doses to plant and animal populations at SLAC were well within the above-mentioned limits of the DOE standard throughout CY 2020.

[18] Monitoring Results for Integrated Area Dose around SLAC for the period from January 2020 through June 2020, and Monitoring Results for Integrated Area Dose around SLAC for the period from July 2020 through December 2020.

5.9.2 Dose to Biota from Activation Products

In CY 2020, SLAC tested water samples for the presence of radioactivity above natural background levels, as described in Sections 5.5 and 5.6. Tritium was occasionally found in industrial wastewater, but plants as well as animal populations have no path by which they would come into contact with industrial wastewater at SLAC. Since the radioactivity concentrations in these sampled media are much lower than from direct radiation, there is no possibility that plants or animals will have received dose rates from radioactive activation products at SLAC that exceed the standard radiation limits.

In CY 2020, all groundwater samples analyzed for tritium were reported as either non-detects (i.e. below the reporting limit 500 pCi/L) or, if tritium was detected, the concentration was well below the human drinking water standard of 20,000 pCi/L. This value is set by the USEPA regulation. Section 5.5.3 summarizes the CY 2020 results of monitoring for radioactivity in groundwater and it shows that the levels of tritium in the groundwater have been decreasing over time. There is no potential that plants or animals will have received dose rates from activation products in groundwater at SLAC that exceed the limits of the standard.

5.10 Low-level Radioactive Waste Management

SLAC generates low-level radioactive waste (LLRW) and mixed waste from its routine operations, repairs, experiments and special projects such as decommissioning. The total waste generated during CY 2020 was 1839 cubic feet. Eighty seven cubic feet of the total was from routine operations (ion exchange resins). SLAC employs waste generator training, careful planning of work operations, thorough survey and characterization of materials, segregation, reuse, and volume reduction to meet waste minimization goals.

SLAC continues to manage its LLRW in compliance with all applicable laws and regulations and DOE directives. During CY 2020, SLAC disposed of 57 sealed sources, shipped 4,955 cubic feet of LLRW containing 22.7 Ci of activity and weighing 219,820 kilograms to appropriately permitted and licensed treatment and disposal facilities for low-level radioactive waste.

6 Groundwater Protection and Environmental Restoration

6.1 Introduction

This chapter describes the groundwater protection and environmental restoration programs at SLAC, including the regulatory framework, site cleanup objectives, an overview of potential chemical impacts, summary of most recent restoration activities, and SLAC's groundwater monitoring program.

6.2 Background Conditions

The document *The Geology of SLAC* [19] provides a detailed description of the geology of SLAC. Based on many tests in exploratory borings and wells, the hydraulic conductivity of SLAC's bedrock is overall much less than the range of that generally accepted as representing natural aquifer material. The groundwater at SLAC is not used as a drinking water source because of low yield as well as naturally occurring high TDS content.

6.3 Areas with Potential Impact from Chemicals

The *2006 Environmental Baseline Report* [20] (EBR) provided an inventory of facilities and areas at SLAC that were considered to have the potential to have chemical impacts, and summarized the results of the environmental investigations and remediation activities that had occurred. The EBR identified COPCs, defined Investigation Areas (IAs), and provided a decision process for determining which areas still required additional actions. At that time, The *Work Plan for the Remedial Investigation and Feasibility Study* [21] (RI/FS WP) provided additional description and updated the status of IAs, defined the four OUs at SLAC, and described the framework for completing the environmental investigations and remedial actions at the facility. Subsequent to the EBR, numerous investigations and clean-ups have been conducted, as discussed in Section 6.5.

6.4 Strategies for Controlling Potential Sources of Chemicals

Strategies for chemical source control include measures to control known soil and groundwater impacts (as are discussed in this chapter), and required procedures that are meant to prevent practices that could

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19 Stanford Linear Accelerator Center, *The Geology of SLAC* (SLAC-I-750-3A33X-002, November 2006) http://www-group.slac.stanford.edu/esh/groups/ep/geology/geologicreport.pdf

20 Sapere Consulting, *Stanford Linear Accelerator Center Environmental Baseline Report* (February 2006)

21 Stanford Linear Accelerator Center, *Work Plan for the Remedial Investigation and Feasibility Study* (SLAC-I-750-A17M-008, May 2006)

adversely affect soil and groundwater (as discussed in Chapter 4). These procedures include the site's SWPPP,[22] which discusses BMPs for preventing adverse impacts from spills and operations at SLAC.

6.5 Restoration Activities

SLAC first began environmental investigation and restoration activities in the mid-1980s and by 1991 had developed a comprehensive environmental restoration program. Program activities range from discovery and characterization to remediation and long-term monitoring or maintenance where required.

The general restoration approach at SLAC is to accomplish the following steps:

1. Identify sites with actual or potential impacts (involving soil, soil vapor, groundwater, surface water, and/or air)
2. Prioritize impacted sites based on site complexity, nature of chemical impacts, associated risks, remaining data needs, and projected remedy
3. Investigate sites and identify remedies that protect human health and the environment, beginning with the highest-priority sites
4. Implement remedies and monitor for effectiveness

SLAC has reached and continues to work towards completion of the fourth step. In 2020, SLAC's Environmental Restoration Program continued remediation efforts in specific areas impacted by COPCs. Remediation work conducted to date generally consists of two categories, extraction and treatment of solvent-impacted soil vapor and groundwater, and soil excavation to remove localized areas of chemically impacted soils. There have been four main areas impacted with COPCs in groundwater: the FHWSA, the Former Solvent Underground Storage Tank Area (FSUST), the Test Lab and Central Lab (TL/CL) area, and the Plating Shop Area (PSA). Current operating data of soil vapor and groundwater extraction at these areas indicate that the remediation systems have resulted in a significant decrease in concentrations of COPCs in soil vapor and groundwater and are achieving hydraulic control of the groundwater plumes; and, in the case of the FHWSA, is thought to have achieved clean-up levels. Each of the groundwater areas is described in Section 6.7, along with a description of sites where soil removal has recently been conducted.

6.6 Regulatory Framework

In October 2009, the RWQCB (Water Board) issued an updated Board Order (No. R2-2009-0072) for SLAC for the investigation and remediation of impacted soil and groundwater resulting from historical spills and leaks that occurred during the course of operations at SLAC. The Board Order addresses release sites at SLAC and consolidates the investigation and cleanup activities at the facility. It also rescinds the Board Order issued in May 2005. In January 2006, the Water Board was designated by the State of California the Administering Agency (i.e., lead agency) for the environmental cleanup work at SLAC.[23] As the lead agency, the Water Board has the responsibility to determine the adequacy and extent of cleanup, issue necessary authorizations and permits, and following the determination that an approved remedy has

[22] SLAC National Accelerator Laboratory, Environment, Safety, and Health Division, Environmental Department, *SLAC Stormwater Pollution Prevention Plan* (SLAC-I-750-0A16M-002, 2019)

[23] California Environmental Protection Agency, *Site Designation Committee Resolution No. 06-01* (January 2006)

been accomplished, issue a certificate of closure. The Water Board has specified site cleanup to standards for unrestricted land use, [24] consistent with how the SLAC property is zoned.

In accordance with the Board Order and the RI/FS WP, the framework for ongoing cleanup activities parallels as practicable the CERCLA RI/FS Process, whereby a sequential series of documents are prepared for accessible areas within each of the four OUs established at SLAC. These OUs include: 1) the Groundwater VOC OU, 2) the Tritium OU, 3) the West SLAC/Campus Area/IR-8 Drainage Channel OU (WSLAC OU), and 4) the Research Yard-SSRL/IR-6 Drainage Channel OU (RY OU). However, it should be noted that while SLAC follows the CERCLA RI/FS process, SLAC is not listed in the National Priorities List (NPL) as a Superfund site because the USEPA determined that the conditions at the site did not warrant inclusion on the NPL.

All of the RI/FS documents required under the Board Order for each OU have been completed and approved by the Water Board. These documents include a detailed summary of the nature and extent of the impact (RI reports), baseline human health and ecological risk assessments (Risk Assessment (RA) Reports), followed by a thorough review of remedial options (FS Reports) to address any remaining soil and groundwater remediation issues at the site. The reports take into consideration the removal actions already implemented and incorporate, in accordance with DOE guidance, an assessment of the NEPA values for the interim actions planned for the OU. Remedial alternatives were evaluated in the FS reports against a number of criteria including effectiveness, ease of implementation, cost, and community acceptance. Upon the Water Board's approval of the RI, RA, and FS reports, as applicable, Remedial Action Plans (RAP) and Remedial Design (RD) reports were prepared for each OU. The RAPs outline the steps required to implement the proposed remedial actions required to achieve the cleanup objectives for the site and the RD reports provide the engineering design details for the remedial action. Upon completion of the remedy, a RAP Implementation Report, Operation and Maintenance Plan, and Risk Management Plan were prepared for each OU, as applicable.

The following bullets, and Table 6-1, summarize the Water Board Order deliverables and other documents submitted to, or approved by the Water Board during CY 2020:

- The *Winter Self-Monitoring Report* was uploaded onto GeoTracker and submitted to the Water Board on June 9, 2020.
- The *FHWSA Shallow Soil Excavation Implementation Report* was approved by the Water Board in a letter received on September 4, 2020.
- The final updated *Self-Monitoring Program Sampling and Analysis Plan, Revision 4* was approved by the Water Board in a letter dated September 30, 2020.
- The final *Risk Management Plan,* a Board Order Deliverable for the Research Yard and West SLAC OUs was approved in a letter from the Water Board dated October 2, 2020.
- The *Rebound Testing Report for the Former Hazardous Waste Storage Area, Through February 2020* was provided to the Water Board for information on October 8, 2020.
- The *Summer 2020 Self-Monitoring Report* was finalized and submitted to the Water Board on December 2, 2020.
- The *FSUST Area Soil Investigation Report* was submitted to the Water Board on September 3, 2020 for review. Based on a Water Board email dated December 18, 2020 indicating that the

[24] Regional Water Quality Control Board, *Approval of Stanford Linear Accelerator Center Long Range Redevelopment Plan* (November 18, 2005)

responses were acceptable, the report would be finalized for formal approval in 2021.

- As part of permit requirements, the *Environmental Cleanup of IR-6 and IR-8 Drainages- Year 3 (2020) Vegetation Monitoring Report* was prepared and submitted electronically to the permitting agencies (RWQCB, California Department of Fish and Game, and the US Army Corps of Engineers) on December 21, 2020.

Table 6-1 Regional Water Quality Control Board Order Deliverables Status

Operable Unit / Deliverable	GW VOC OU	Tritium OU	West SLAC Campus Area IR-8 OU	Research Yard/ SSRL/ IR-6 OU
RI Report	Complete	Complete	Complete	Complete
Baseline Human Health & Ecological Risk Assessment	Complete	n/a [1]	Complete	Complete
FS Report	Complete	n/a [1]	Complete	Complete
RAP	Complete	n/a [1]	n/a [3]	Complete
Remedial Design Report	Complete	n/a [1]	n/a [3]	Complete
O&M Plan	Complete	n/a [2]	n/a [3]	Complete
RAP Implementation Report	Complete	n/a [1]	n/a [3]	Complete
Risk Management Plan	Complete	n/a [1]	Complete [4]	Complete [4]
West SLAC OU RI Compliance Schedule	n/a	n/a	Complete	n/a
5-Year Review Report	1st Report: Complete 2nd Report: Due 6/29/2022			
Protocol for Newly Discovered Sites, Deferred Areas, and Land Use Changes	Complete			

FS - Feasibility Study
IR – Interaction Region
MCL – maximum contaminant level
n/a – not applicable
O&M – operation and maintenance
OU – operating unit
RAP – Remedial Action Plan
RI – Remedial Investigation
SSRL – Stanford Synchrotron Radiation Lightsource

Notes:
1) The Final RI Report for the Tritium OU, approved June 12, 2009, identified remaining low levels of tritium in groundwater below the MCL and concluded that no remedial action is necessary at this time other than continuing long term monitoring to assess any changes to current conditions.
2) Based on the findings of the Tritium OU RI report, the submittal consists of a Monitoring Plan (completed) only.
3) For the West SLAC/ Campus Area/ IR-8 OU, not applicable based on the findings of the FS.
4) The Risk Management Plan will be combined for the West SLAC Campus Area IR-8 OU and the Research Yard/SSRL IR-6 OU.

Regular Core Team meetings regarding site cleanup status continued through 2020. The Core Team is a decision-making body consisting of representatives from the Water Board, DOE, Stanford University, and SLAC. As needed, members of the technical team are present at these meetings.

6.7 Groundwater Monitoring and Characterization Network

As part of the Board Order, SLAC implements a groundwater SMP that includes a groundwater SAP outlining the frequency at which wells are sampled, the constituents for which the samples are analyzed and a schedule for collecting groundwater samples from extraction and monitoring wells, surface water samples, and sediment samples from select catch basins and drainage channels. Figures 6-1 through 6-3 show the areas where wells are used for monitoring.

The six locations where plume monitoring is performed are listed below and shown on Figures 6-2 and 6-3.

- Former Hazardous Waste Storage Area (FHWSA)
- Former Solvent Underground Storage Tank (FSUST) Area
- Test Lab and Central Lab Area (TL/CL)
- Plating Shop Area (PSA)
- Lower Salvage Yard (LSY)
- Beam Dump East (BDE)

As of the end of 2020, of the 172 wells used by the Restoration Program at SLAC (Table 6-2), 112 wells are used for monitoring groundwater quality, general site-wide surveillance, COPCs, and/or water level measurements. Fifty five of the 172 wells are extraction wells located at four groundwater remediation systems, two wells at the FSUST Area are infiltration wells, and three of the wells are inactive soil vapor extraction (SVE) wells.

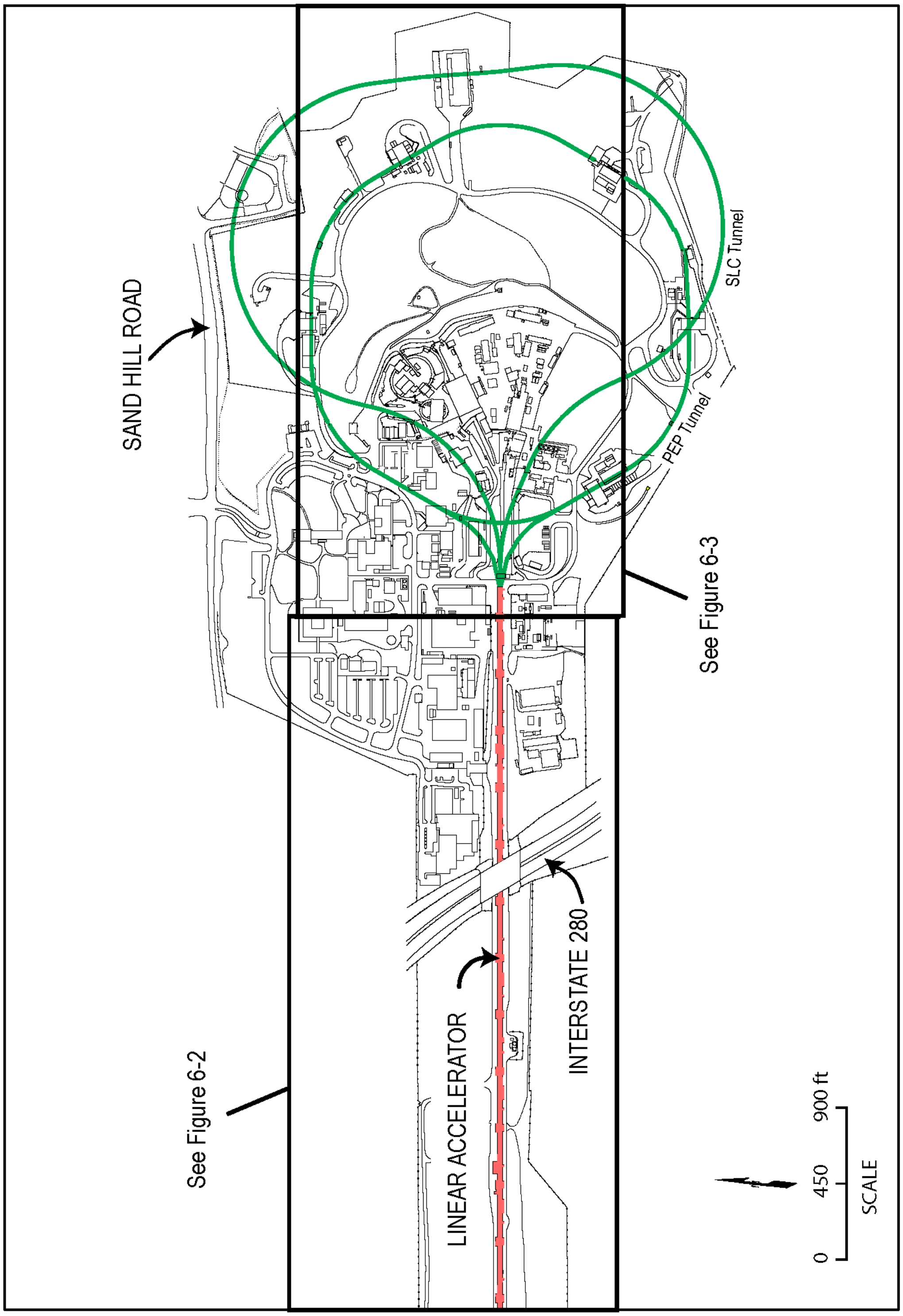

Figure 6-1 Groundwater-Impacted Well Network

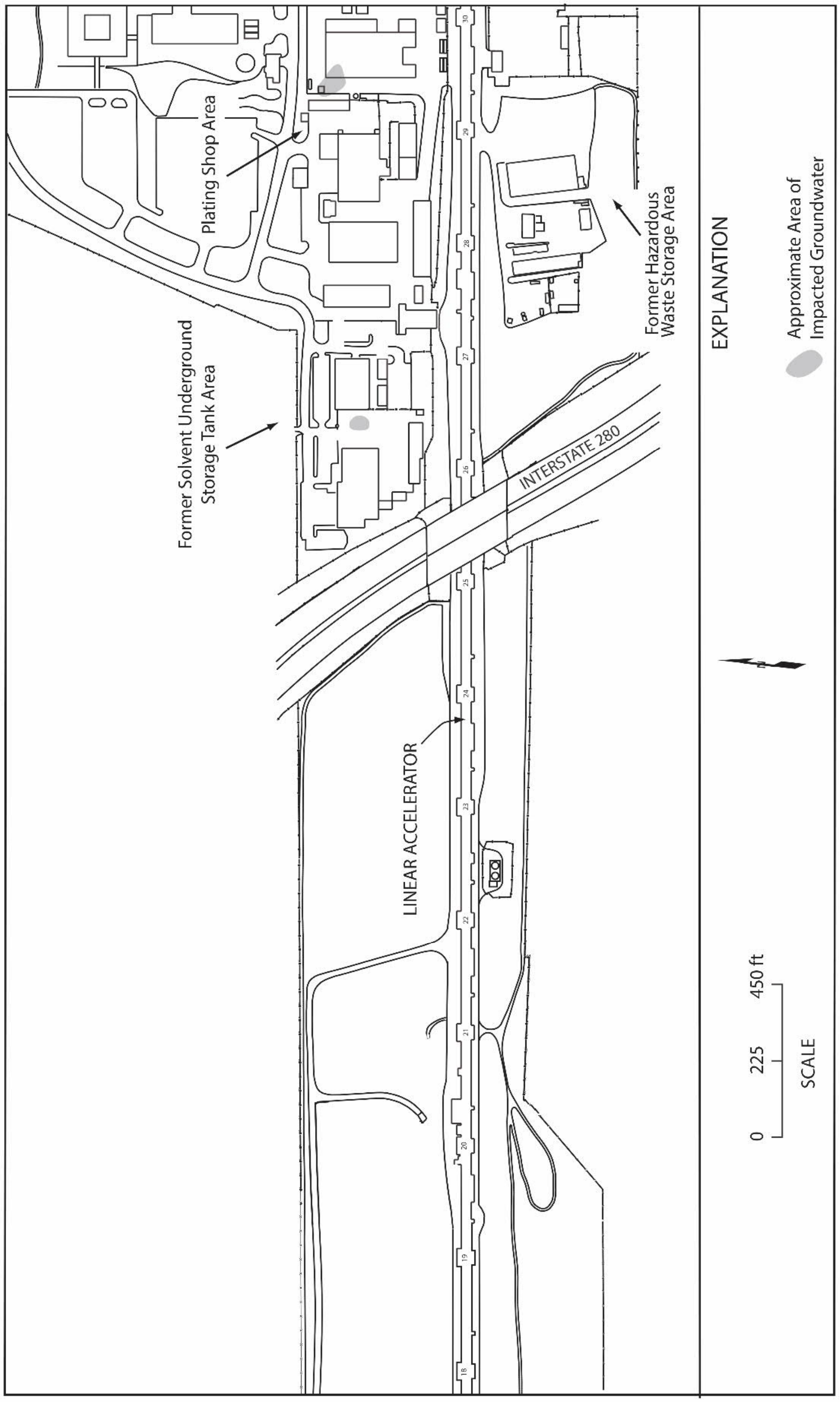

Figure 6-2 Areas in West SLAC where Groundwater is Impacted

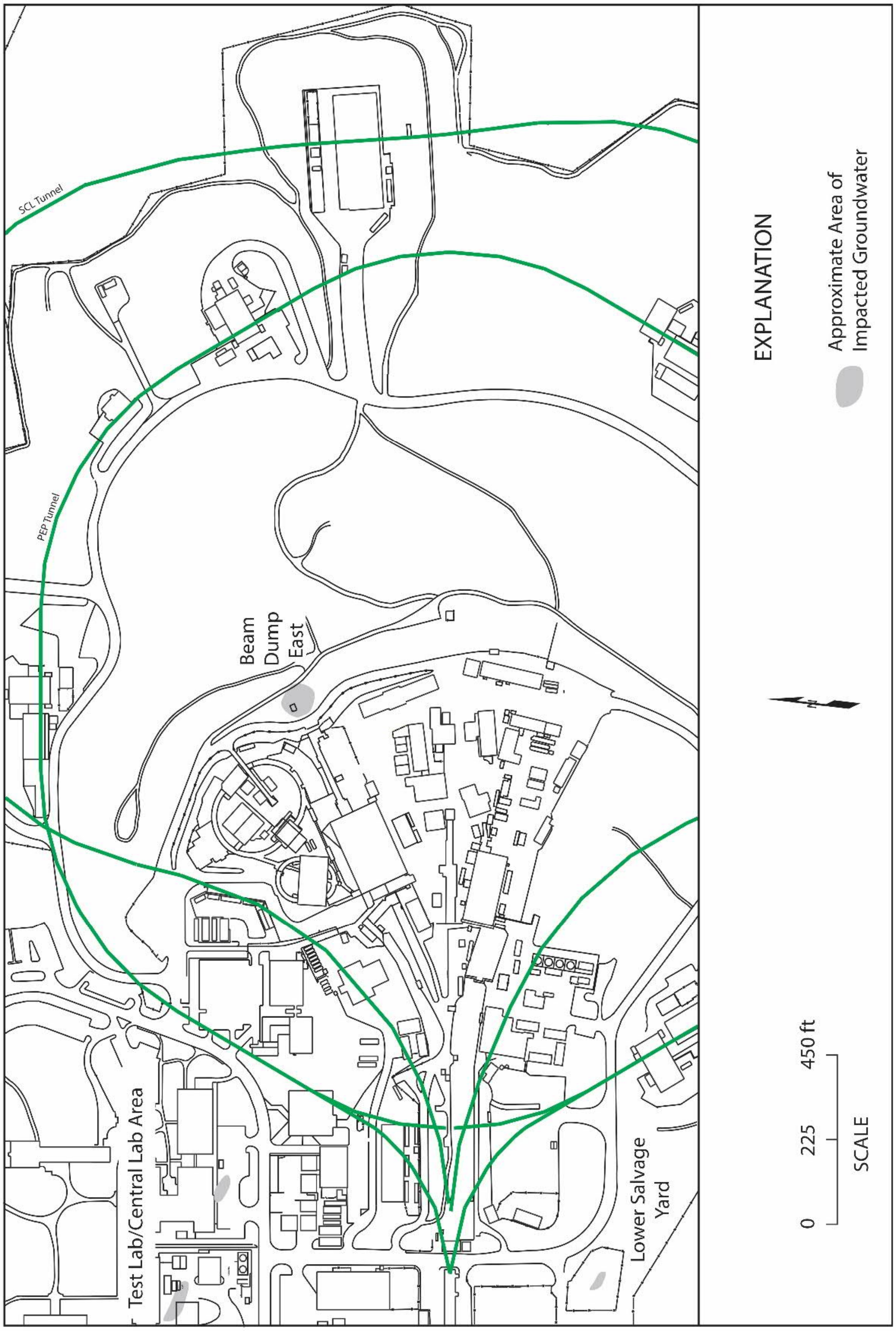

Figure 6-3 Areas in the Main Campus and East End of SLAC where Groundwater is Impacted

Table 6-2 summarizes the wells at SLAC by location, number of wells per location, and purpose of the wells.

Table 6-2 Locations, Use and Number of Wells

Location and Well Type		Number of Wells
Plume Monitoring		
Beam Dump East		9
Former Hazardous Waste Storage Area		21
Former Solvent Underground Storage Tank		22
Lower Salvage Yard		4
Plating Shop Area		26
Test Lab and Central Lab		7
	Subtotal	*89*
Environmental Surveillance		
Site Wide	*Subtotal*	*16*
Piezometer		
Plating Shop Area		4
Former Hazardous Waste Storage Area		3
	Subtotal	*7*
Extraction		
Former Solvent Underground Storage Tank		12
Former Hazardous Waste Storage Area *(inactive)*		10
Plating Shop Area		26
Test Lab and Central Lab		7
	Subtotal	*55*
Infiltration		
Former Solvent Underground Storage Tank	*Subtotal*	*2*
Inactive Soil Vapor Extraction Wells		
Former Solvent Underground Storage Area	*Subtotal*	*3*
	TOTAL	*172*

Groundwater samples were collected from monitoring wells at least once from 101 wells in 2020 and analyzed for a variety of constituents. Results of groundwater samples collected from the monitoring wells were reported to the Water Board in the semi-annual self-monitoring report for Winter 2020 [25] and Summer 2020.[26]

Groundwater analytical results were generally within each well's historical range of concentrations. Samples were analyzed for one or more of the following:

- Total petroleum hydrocarbons (TPH)
- Metals
- Polychlorinated biphenyls (PCBs)
- Tritium
- Volatile organic compounds (VOCs)
- Semi-volatile organic compounds (SVOCs)

The COPCs in groundwater at SLAC are primarily VOCs and to a lesser extent SVOCs. Four of the locations listed above, the FHWSA, FSUST, TL/CL and PSA, had/have remediation systems that extract soil vapor and groundwater. As of the end of 2020, the remediation system at the FHWSA was not operating and the dual phase extraction system (DPE) system was partially dismantled in accordance with the Curtailment Request Report approved by the Water Board. The FHWSA area is undergoing rebound testing. At the TL/CL, groundwater has met clean-up goals and is no longer being extracted. Soil vapor in a small area at the CL continues to be extracted; soil vapor at the TL has met clean-up goals. Preliminary Cleanup Goals (PCGs) at SLAC were n established for groundwater and soil vapor. The systems at the FSUST and FHWSA, PSA and TL/CL were designed with the goal of achieving these PCGs. Operating and monitoring data from these locations indicate that the remediation systems have resulted in significant decreases in concentrations of COPCs in both groundwater and soil vapor, and are achieving hydraulic control of the plumes. At the FHWSA and the TL/CL, the Water Board has accepted alternative groundwater clean-up criteria related risks that are based on potential vapor intrusion risk.

6.8 Site Descriptions and Results

The groundwater IAs are described below, including four VOC-impacted areas (TL and CL are combined) and one low-level tritium-impacted area. Under the Board Order, the formal FS and RAP reports for the four VOC-impacted groundwater IAs were prepared by SLAC and approved by the Water Board in January 2010 and August 2010, respectively. The Remedial Design report for the Groundwater VOC Operable Unit,[27] which includes the four VOC-impacted plume areas, was approved by the Water Board in March 2011, and construction of the selected remedy (DPE at the four VOC-impacted areas) was completed by December 2010. Performance Evaluation Reports for all DPE systems are prepared biennially as part of the approved RAP and subsequent Core Team discussions. These reports are provided to the Water Board for informational purposes.

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25 SLAC National Accelerator Laboratory, *Semi-annual Self-Monitoring Program Report, Winter 2019* (SLAC-I-750-2A15H-054, June 2019)

26 SLAC National Accelerator Laboratory, *Semi-annual Self-Monitoring Program Report, Summer 2019* (SLAC-I-750-2A15H-055, December 2019)

27 C/P/E, *Remedial Design Report for the Groundwater VOC Operable Unit*, (C/P/E SL-22GW-RPTS-CD000001 R0, November 2010)

6.8.1 Former Solvent Underground Storage Tank Area

A chemical plume in groundwater associated with the FSUST is located adjacent to the SLAC plant maintenance building in the northwestern portion of the main SLAC campus (Figure 6-2). The FSUST was used to store organic solvents from 1967 to 1978. A pressure test performed on the FSUST in 1983 indicated the presence of a leak. The FSUST and accessible chemically impacted soil were removed in December 1983. A network of 21 monitoring wells and 10 extraction wells were subsequently installed, and groundwater is monitored for VOCs and SVOCs.

An interim groundwater extraction and treatment system was installed in 2001 and upgraded to include a soil vapor extraction component in 2007. The DPE operations, which started at the FSUST on October 18, 2007, increased the mass removal rate of VOCs and SVOCs from an average of 0.14 lbs. per day to an average of 2.2 lbs. per day for the remainder of 2007. The average mass removal rate has since declined, as anticipated, as the more concentrated sources are removed in the soil vapor. In 2014, two DPE wells (extraction well (XW- 9 and XW-10) were brought online to improve overall mass removal, bringing the total number of DPE wells to ten.

In September 29, 2015, the first phase of a two-phase pilot study using in-situ chemical oxidation (ISCO) at the FSUST was conducted. The objective of the pilot study was to determine if infiltration of an oxidant solution into the residual chemically impacted soil source zone could accelerate the VOC and SVOC removal rates from both soil and groundwater. The second phase of the ISCO pilot study was conducted in April 2016. The 2016 and 2017 monitoring results for the pilot study indicated a temporary reduction of VOC concentrations in the monitoring wells installed in the source and nearby areas followed by a gradual rebound of VOC concentrations in the same monitoring wells to near pre-pilot study concentrations.

Since 2018, when the DPE system at the FSUST is operating, DPE wells XW-9 and XW-7 remained selectively off in an effort to optimize mass removal conceptually by flushing the source area with cleaner up-gradient groundwater and capturing with downgradient DPE wells. The system was shut down in February 2019 and has effectively remained off as of the end of 2020 to allow for the passive groundwater sampling and boring soil sampling investigation projects; DPE well conversion; system upgrades; and replacement of one of the groundwater granular activated carbon treatment vessels (ongoing as of the end of 2020). The FSUST sub-slab vapor extraction system in B035 remained operational. The soil investigation project was completed in August-September 2019 and involved the collection of soil samples from eight soil borings to evaluate the extent of (if any) of residual chemicals that may exceed soil cleanup goals. Two of the soil borings installed within the footprint of the gravel pit were converted into monitoring wells (which may be operated as additional focused remediation extraction wells). The analytical results indicated that the soil met cleanup goals and a report was prepared in December 2020 and is under review by the Water Board.

Since the startup of the remediation system at the FSUST in August 2001 and through December 2020, the DPE system has removed approximately 881 lbs. of VOCs and SVOCs from the subsurface (soil vapor and groundwater combined), and treated approximately 1,544,245 gallons of extracted groundwater. Hydraulic and analytical data collected from the monitoring wells indicate a capture zone encompassing the entire plume has been established and chemical data indicate that the plume continues to shrink in size. In addition, the monitoring data show that significant progress has been made to reduce soil vapor VOC concentrations to below remedial action goals for all the groundwater VOC-impacted areas.

6.8.2 Former Hazardous Waste Storage Area

The FHWSA was in use as a storage area from approximately 1973 to 1982. Following cessation of its use as a storage area, PCBs were found in shallow soils. As a result, several inches of topsoil were removed. A monitoring well was installed in this area in 1990, and VOCs were detected in the groundwater. Since then, two passive soil gas surveys have been performed, 24 monitoring wells, 23 DPE wells, and 18 soil gas probes have been installed, and more than 50 soil borings have been drilled at this site. Figure 6-2 shows the current extent of VOCs in the groundwater. At present, there are 21 monitoring wells, 10 inactive DPE wells, and 13 soil vapor probes at the FHWSA.

In 2002, a DPE pilot test performed at the FHWSA proved promising as a treatment method for soil and groundwater that were impacted by COPCs, and was recommended as a suitable remediation technology. Two DPE wells were installed at the FHWSA in 2003 as part of an interim dual-phase extraction (IDPE) system. The IDPE system was in operation from December 2003 to March 2006. The design of an interim full-scale DPE system for the FHWSA was finalized in 2004[28] and the installation of the system was completed in March 2006 after six months of construction. The full-scale system utilized 19 groundwater/soil vapor combined extraction wells and four vacuum-enhanced groundwater extraction wells. Groundwater extraction and treatment began on March 6, 2006. Soil vapor extraction began on April 3, 2006.

In 2016, the FHWSA DPE operated in a cyclic mode, allowing groundwater to be cyclically extracted (DPE system on) and recharged (DPE system off) in an attempt to increase mass removal through flushing. In 2017, the DPE system largely remained off, with the exception of localized focused DPE well groundwater extraction. Analytical data showed that significant progress was made in reducing the concentrations of VOCs in groundwater and in soil vapor, and that clean-up goals were met for groundwater and deeper soil vapor. The data also showed that DPE had been unable to reduce VOCs concentrations in shallow soil vapor, characterized by very low permeability shallow clayey soils. This area was further evaluated in 2015 to 2017 and the lateral and vertical extent was established. Alternative remedial options for this area were evaluated in the Five-Year Technology Review Report, which requires review and reevaluation of a remedial action after a period of five years from the beginning of the RAP implementation. The five-year review report recommendation specified excavation of the low permeability shallow clayey soils as the remedial action. The excavation fieldwork was implemented between July and November 2018. Between the startup of the DPE system in December 2003 and May 2018 when DPE operations ceased prior to the excavation work, the FHWSA interim and full-scale systems had removed approximately 2,437,164 gallons of groundwater and 41.3 lbs. mass of total VOCs and SVOCs. Prior to the excavation work, a Curtailment Request Report was approved by the Water Board via letter in April 2018. The report requested the cessation and partial dismantling of the DPE system at the FHWSA such that shallow soil excavation can be performed. A total of 13 DPE wells, 5 soil vapor probes, and 3 monitoring wells located within the footprint of the planned excavation were destroyed using California State well removal standards. In 2020, the FHWSA site continues to undergo rebound testing (second year of two years of soil vapor monitoring and second of three years of groundwater monitoring).

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40 Erler & Kalinowski, *Technical Specifications and Drawings for the Dual Phase Extraction and Treatment System at the Former Hazardous Waste Storage Area* (2004)

6.8.3 Plating Shop Area

In 1990, three monitoring wells were installed down-gradient of the plating shop at the PSA. COPCs were detected in all three wells, and an investigation began that included the installation of additional monitoring wells, performance of a passive soil gas survey, and remediation beneath a steam-cleaning pad. Twenty-six monitoring wells are currently located at the PSA (Figure 6-2). Groundwater sampling analytical data indicate that chemicals are present in groundwater.

Twenty-six DPE wells make up the treatment system at the PSA, in operation since November 2010. Between the start-up of the system and December 31, 2020, approximately 5,765,203 gallons of groundwater were extracted by the PSA DPE system and 15.13 lbs. mass of total VOCs and SVOCs were removed by the system. Analytical data collected from the monitoring wells thus far indicate that a capture zone encompassing the entire plume has been established and that the plume appears to be shrinking in its vertical and lateral extent. In addition, the data show that significant progress has been made in reducing soil vapor VOC concentrations and that groundwater and soil vapor remedial goals were being attained in most areas of the PSA. Beginning in April 2019, the PSA DPE system was operated using four select DPE wells in two focused remediation areas as approved by the Core Team. Focused DPE operations were shut were restarted on January 22, 2020 after the SLAC winter break. Operations were again shut down on March 16, 2020 due to the Covid-19 shelter-in-place requirements and restarted on August 17, 2020 after which focused operations continued for the remainder of the fiscal year. In November 2020, five additional soil vapor probes were installed to refine lateral extent for the remaining PSA areas of concern related to soil gas.

6.8.4 Test Lab and Central Lab Area

Analytical data from previous investigations, including a passive soil gas survey, soil borings and monitoring wells installed in the TL/CL helped delineate the sources of groundwater and soil vapor impacts. Results of the investigation indicated three possible source areas for VOCs, including one adjacent to the TL, and two adjacent to the CL. The final remedial design specified two separate DPE systems at the TL/CL.

Construction of separate DPE well systems at the TL and at the CL with additional soil vapor probes and monitoring wells was completed and started in November 2010. Between the startup of the system in November 2010 and the last day of operation in December 2012, when the system was shut down for initial rebound testing (see below) approximately 200,261 gallons of groundwater was extracted by the TL DPE systems and 682,572 gallons of groundwater was extracted by the CL DPE system. In addition, 0.77 lb. of total VOCs and SVOCs mass were removed by the TL system, and 3.6 lbs. of total VOCs and SVOCs mass were removed by the CL system. Based on the remediation progress, the Water Board approved turning off the DPE system for rebound testing in December 2012. The fourth year of the rebound test period (initially planned to be a 3-year rebound period) was completed in December 2016. The four-year rebound testing and monitoring results indicated remediation goals were met, with the exception of one newly identified localized shallow soil vapor zone at the CL. Per recommendations provided in the 5-Year Review Report, the CL DPE system was restarted in January 2017 to evaluate if continued operations would be effective in meeting the soil vapor remediation goals in the localized shallow soil vapor zone. By November 2918, the total volume groundwater extracted from the CL area was 1,298,218 gallons. In August 2019, based on SVP monitoring results, the SVE component only of the CL system started limited operation (at three DPE wells only). The focused SVE operation is intended to reduce localized soil vapor COPCs to below risk-based levels. This operational approach was concurred by the Core Team members. An apparent electrical short in the SVE control panel shut down the operation of the system on December 9, 2019. By March 12, 2020, the SVE operation at the CL resumed after repairs were made. The CL system was shut down on March 16, 2020 due to the Covid-19 shelter-in-place and was restarted on August 10, 2020, with operations continuing through the remainder of the year.

6.8.5 Beam Dump East

The BDE was used as a subsurface high-energy beam termination point for the End Station A beamline operations and is located in the hillside along the northeastern edge of the research yard. Groundwater is monitored in nine wells and sampled at least two times per year. In 2020, as in previous years, the monitoring of groundwater indicates that tritium is localized to two wells in the area of the beam dump at levels far below the drinking water standards (see Section 5.9). The BDE is part of the Tritium OU, for which a formal RI report has been prepared by SLAC under` the Board Order and approved by the Water Board in June 2009. In addition, a Monitoring Plan Report (MPR) was prepared by SLAC under the Board Order and approved by the Water Board in December 2009. The MPR specifies continued groundwater monitoring at the BDE with contingent actions in the unlikely event that monitored tritium levels exceed any established threshold concentrations.

6.8.6 Lower Salvage Yard

Low levels of TPH continue to be detected in groundwater samples collected at the LSY during 2020. Based on the West SLAC OU Baseline Risk Assessment, the detected levels do not represent a human health or ecological risk.

6.8.7 Removal and Remedial Actions

Since CY 2008, soil removal actions have been completed in advance of the formal FS or RAP reports for the West SLAC and RY OUs based on an Engineering Evaluation and Cost Analysis. Soil removal actions since CY 2008 have resulted in the removal of over 48,000 cubic yards of impacted soil and debris from 27 areas. As of the end of 2018, all targeted and requisite known soil removal actions had been completed at SLAC; there were no soil removal and remedial actions in 2020.

6.9 Excavation Clearance Program

The excavation clearance program continued to support SLAC-wide projects to ensure proper disposal of excavated soil. An excavation permit form must be completed and approved by multi-reviewers for activities that involve excavation or relocation of soil within SLAC. The excavation clearance program addresses potential worker exposure hazards associated with underground utility lines, chemical contamination, and radiological hazards. The program also ensures proper management and disposal of excavated materials. During 2020, 32 projects were supported by this program.

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