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ERNEST ORLANDO LAWRENCE BERKELEY NATIONAL LABORATORY

1995 Site Environmental Report

Environment, Health and
Safety Division

July 1996

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1995 Site Environmental Report

July 1996

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To Our Readers:

Each annual Site Environmental Report publishes the results of environmental monitoring at the Ernest Orlando Lawrence Berkeley National Laboratory and documents our compliance with federal, state, and local environmental regulations. Our goal is to give our readership—whether regulators, scientists, or the public—a clear accounting of the range of environmental activities we undertake, the methods we employ, the degree of accuracy of our results, the status of our programs, and significant issues affecting programs. A second volume of the report has been prepared that contains the environmental monitoring data used to support the summary data in the report. Volume I contains all the information of interest to most of our readers, and can be read without reference to Volume II. Due to its size, Volume II will only be sent upon request. Please complete Part I to request a copy of this volume.

It is also important that the information we provide is easily understood, of interest, and communicates Berkeley Lab's effort to protect human health and minimize our impact on the environment. We would appreciate a few moments of your time to complete the reader survey in Part II as a way for us to determine whether we are successful in achieving these goals. Completion of this part is not a prerequisite for receiving a copy of Volume II.

A business reply envelope has been attached for returning this page to Berkeley Lab. Laboratory staff may send their forms through internal mail to Patrick Thorson, Mailstop B75B-101.

Part I: Request for Volume II — Data Appendix

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Acknowledgments

The 1995 Site Environmental Report for Ernest Orlando Lawrence Berkeley National Laboratory is prepared for the U.S. Department of Energy under the requirements of DOE Order 5400.1. The report is intended to present the status of Berkeley Lab's compliance programs and environmental surveillance activities, as well as an assessment of the impacts of its operations on the environment for calendar year 1995. The report uses the International System of Units (SI) as the primary means of presenting data.

The report was prepared under the direction of Patrick Thorson of the Environmental Protection Group. The primary authors of the report listed by section of responsibility include:

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Environmental monitoring and sampling data represent an important element for determining the impact of Berkeley Lab operations on the environment. David Balgobin, Tom Donovan, Ginny Lackner, Vic Montoya, Ron Pauer, Charles Smith, Patrick Thorson, Henry Tran, and Randy Yow were responsible for designing, coordinating, collecting, and maintaining environmental monitoring and sampling programs. Angela Davi, Tanya Ebermann, and David Yaeger completed the onsite portion of the sample analysis. Finally, Doug Finley, Jean Marie Walker and Steve Wyrick managed the variety of data collected by the environmental surveillance program.

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Section 1. Executive Summary

Introduction and Purpose

The 1995 Site Environmental Report summarizes environmental activities at the Ernest Orlando Lawrence Berkeley National Laboratory (Berkeley Lab or LBNL) for the 1995 calendar year. The report strives to present environmental data in a manner that characterizes the performance and compliance status of the Laboratory's environmental management programs, measured against applicable regulatory standards and DOE requirements. The report also discusses significant highlights and plans of these programs. The format and content of the report satisfy the requirements set forth in U.S. Department of Energy (DOE) Order 5400.1, *General Environmental Protection Program*.¹ Readers are encouraged to share feedback on this report by completing the survey card located at the inside cover page.

For more than 60 years, Berkeley Lab has maintained a strong tradition of outstanding research. Since its early years as a particle physics accelerator facility, LBNL has evolved into a multiprogram institution that pursues research in additional areas such as chemistry, the bio- and life sciences, environmental and earth sciences, advanced materials, and energy resources and energy efficiency. Berkeley Lab has an infrastructure of operational divisions designed to provide support for its research programs. While conducting research in a highly competitive environment challenged by an ever-changing climate of national scientific priorities, LBNL is committed to conducting activities "with full regard for the environment, health, and safety"² of its workers and the public.

Environmental Compliance Programs and Performance

The Environmental Protection and Waste Management Groups of the Environment, Health, and Safety Division's Services Department are primarily responsible for overseeing environmental compliance

activities at the Laboratory. Both groups provide integrated, full service environmental compliance support to the Laboratory community in the areas of environmental protection, environmental restoration, and waste management. Areas of environmental compliance include air quality, water quality, hazardous materials, hazardous waste, waste minimization, pollution prevention, and soil and groundwater characterization and remediation. Compliance services offered include regulatory compliance oversight and technical assistance (standards of operation), permitting, audits and inspections, regulatory liaison, training, reporting, corrective action, environmental monitoring and sampling, and spills and accidental release emergency response. More information on program events highlighted in this summary can be found in Chapter 3, *Environmental Compliance Programs*. Results on environmental monitoring and surveillance activities are presented in chapters 4 through 12.

Under the Laboratory's operating contract³ between DOE and the University of California (UC), LBNL is required to objectively measure its effectiveness at managing environmental excellence. These measures, called performance criteria measures, are prepared quarterly, but submitted once each year to UC and verified by DOE. The criteria measures were jointly developed by LBNL, UC, and DOE, and are reviewed annually for possible improvements.

The purpose of the performance measures is to encourage continual improvement in managing environmental programs. 1995 marked the second full year of using criteria measures at Berkeley Lab. Several measures were in place to evaluate environmental programs in four performance objective areas: protection and prevention, compliance, integration and accountability, and customer focus. LBNL achieved at least a *Meets Expectations* rating in all the graded criteria measures, with five receiving *Far Exceeds Expectations* evaluations.

1 — Executive Summary

Each group is also involved in program planning. The principle mechanism for achieving this planning is through the DOE 5-year *Environment, Safety and Health (ES&H) Management Plan*. This process identifies the magnitude of effort, prioritizes deficiencies, and determines funding needed to bring DOE-facilities into full compliance with all environment, safety, and health laws and regulations. Environmental planning documents request the level of resources necessary to maintain or improve compliance within program areas. Documents are updated annually. In early 1995, LBNL prepared 25 planning documents for environmental protection, environmental restoration, and waste management programs and projects. The funding period requested by these documents is Fiscal Year (FY) 1996 through FY 2000.

Environmental Permitting

At the end of 1995, Berkeley Lab had 53 environmental operating permits issued by regulatory agencies for air emissions, hazardous waste handling and treatment operations, stormwater and wastewater discharges, and underground storage tanks. Table 3-2 summarizes the permits held by Berkeley Lab.

The Bay Area Air Quality Management District (BAAQMD) issues operating permits for stationary sources of air pollutant emissions. These permits are renewed annually; LBNL renewed 37 operating permits for various facility-wide activities in 1995. There were no new sources permitted, although BAAQMD approved two permit modification requests from the Laboratory. The Laboratory also has 76 minor sources registered with BAAQMD under exempt status. LBNL's operating permits cover a wide range of equipment and operations, such as gasoline dispensing, surface coating (painting, epoxy mixing, and vacuum coating), surface preparation and cleaning

(sandblasting and solvent cleaning), and semiconductor research, as well as abatement equipment to control emissions from lead pouring, material machining, and sulfur hexafluoride discharges.

LBNL's Hazardous Waste Handling Facility (HWHF) operates under a full Resource Conservation and Recovery Act (RCRA) permit issued by the California Environmental Protection Agency's (Cal/EPA) Department of Toxic Substances Control (DTSC) for the U.S. Environmental Protection Agency (US/EPA). The permit for both the existing and proposed replacement HWHF was issued in 1993 and is valid until 2003. In May, LBNL requested a modification to the permit for proposed changes in storage locations and storage capacities. DTSC immediately granted a temporary authorization to this request, provided that Berkeley Lab would submit additional information by a later date. The additional information was submitted to DTSC in January 1996, along with further proposed changes in treatment methods, storage capacity, training requirements, and HWHF operating requirements. A final decision by DTSC is expected after all public and agency concerns have been addressed.

LBNL has five fixed treatment units (FTUs) located around the facility; these units fall into the "Permit By Rule" and "Conditional Authorization" permit categories under the State's Tiered Permitting program for hazardous waste treatment and storage units. The Laboratory's FTUs are designed to treat inorganic acids, aqueous waste containing metals and inorganic acids, and oil mixed with water. Permits under this program are renewed annually through DTSC, with the City of Berkeley (COB) also receiving a copy of the renewal package. Work on a sixth FTU began in 1995. The upgraded unit will treat wastewater from the new Ultra High Vacuum Cleaning Facility at Building 77. The unit is expected to come on line in 1996.

Water discharges are categorized as either stormwater or wastewater. Stormwater runoff

from the entire site is authorized under a general State permit issued by the State Water Resources Control Board (SWRCB), and enforced by the Regional Water Quality Control Board (RWQCB) and the City of Berkeley. The permit requires a *Storm Water Pollution Prevention Plan* and a *Storm Water Monitoring Program*. These documents present LBNL's plan and procedures for identifying, monitoring, and preventing contamination in its stormwater discharges.

Discharge limits for wastewater effluent are established under a permit program administered by the East Bay Municipal Utility District (EBMUD). LBNL maintains three separate EBMUD wastewater permits: one general site-wide permit, and two source-specific permits for treatment units at metal finishing operations in Buildings 25 and 77. These permits are renewed annually. The permits include monitoring and reporting requirements, which have stayed the same as the previous year because LBNL has had no exceedances of the permitted discharge limits since 1992.

Permits for LBNL's underground storage tanks (USTs) are issued by the COB. At the end of 1995, there were ten permitted USTs containing diesel, gasoline, or transformer oil. All tanks meet the State's requirements for leak protection and monitoring. Seven of the USTs are double-walled tanks. The remaining three will be upgraded from a single-wall design to meet new regulatory standards set for December 1998. No tanks were removed during the year. One tank, storing diesel fuel for the emergency generator at the new HWHF, was installed during the year. A permit for this tank is expected from the City of Berkeley prior to the startup of the new building later in 1996.

Violations, Findings, and Environmental Incidents

Regulatory agencies and various entities of DOE conducted a total of 47 audits and inspections of LBNL's environmental programs during 1995. This number included

13 self-monitoring inspections performed by the Laboratory under requirements of its EBMUD wastewater discharge permits. Agencies performing these inspections included BAAQMD, COB, California Department of Health Services (DHS), DTSC, EBMUD, RWQCB, SWRCB, and US/EPA. In 1995, LBNL did not receive any violation citations. Table 3-3 lists the environmental audits and inspections for the year. Table 3-4 identifies these environmental incidents that triggered formal notification within the DOE Occurrence Reporting Program. Additional information on each inspection and incident is found throughout specific program discussions in Chapter 3.

The first environmental incident happened during the first week of January when construction activity on a floor drain connection in the basement of Building 71 revealed mercury in the drain pipe. A small amount of mercury fell onto the soil when a section of the pipe was removed. Contaminated soil was extracted into sealed drums until instrumentation could no longer detect the presence of mercury. Further discussion on this and other environmental cleanup efforts on site are found in the *Resource Conservation and Recovery Act* section of Chapter 3, and the *Groundwater Protection* section of Chapter 4, *Environmental Monitoring and Surveillance*.

The first inspections of the year began in January with the first of six BAAQMD inspections of nonradiological air emissions activities. The reviews were completed in February. US/EPA came on site in June to conduct an inspection of the documentation generated by Berkeley Lab for the Federal Facilities Compliance Agreement that was established after a 1991 Notice of Violation (NOV) with the Laboratory's radionuclide NESHAPs (*National Emission Standard for Hazardous Air Pollutants*) program.⁴ No violations resulted from either the BAAQMD or US/EPA inspections.

No violations for exceeding permitted wastewater discharge limits were issued to Berkeley Lab in 1995 as a result of 11

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EBMUD and 13 LBNL self-monitoring inspections. These inspections focused on effluent discharge at the site's two outfalls, Hearst and Strawberry, and the site's two metal finishing treatment units. An incident involving a series of methylene chloride exceedances at the site's Strawberry sanitary sewer monitoring station in March and April initially led EBMUD to cite the University of California at Berkeley (UCB). EBMUD later rescinded the violation after extensive investigation and interaction between LBNL, EBMUD, and UCB failed to conclusively identify the cause of the exceedances, as this discharge line is shared by both Berkeley Lab and UCB facilities. The initial finding of the methylene chloride resulted in the filing of the second DOE occurrence report of 1995 for an environmental incident.

The waste management program often receives considerable scrutiny by either regulatory agencies, DOE, or DOE-affiliates because of the stringent hazardous waste regulations that apply to the site. The Hanford facility in Richland, Washington, which normally receives Berkeley Lab's mixed waste for treatment, storage, and disposal, raised two separate issues on waste management practices. The first issue, raised in February, involved the chemical compatibility of certain mixed waste streams included in two shipments from the site during the previous year. The concentration of one of the incompatible substances was later found to be below U.S. Department of Transportation oxidizer threshold levels, and therefore, not the potential problem as originally suspected. In April, Hanford raised a second issue when it discovered differences between the number of containers within two drums listed on the shipping documents compared to the actual number packaged. This incident led to the third and final environmental occurrence report for LBNL in 1995. In response to these two developments, Hanford took two significant steps: 1) deciding that increased quality assurance and quality control procedures were needed for waste shipments of this nature to their site,

and 2) suspending receipt of Berkeley Lab's mixed waste until the new procedures were completed.

Also within the waste management program, DTSC conducted four inspections during the year; in January, February, March, and August. The agency did not issue any violations from its review of the Hazardous Waste Handling Facility, fixed treatment units, waste accumulation area, or satellite accumulation area programs at the time of the inspections. However, in October, DTSC issued an inspection report alleging three violations for mixed waste shipments to the Hanford disposal facility. The allegations, tied to the Hanford findings described above, concerned incompatibility of waste, inaccuracy of inner-container counts, and labeling of non-RCRA containers. By the end of the year, Berkeley Lab requested that DTSC drop all alleged violations, providing justification for each claim. At this time, DTSC has neither issued a Report of Violation nor dropped the charges.

The City of Berkeley inspected the installation activities at the site of the new HWHF UST on three occasions. There were no findings from any of these inspections. COB also inspected the Laboratory's stormwater compliance program in November. No violations or concerns resulted. Lastly, COB performed several inspections of Berkeley Lab's hazardous materials management program. Again, no violations were found.

Berkeley Lab's environmental programs also undergo periodic review by external agencies that are not considered regulatory in nature. The two most prominent from 1995 were DOE oversight responsibilities under the operating contract between DOE and UC, and the Agreement-in-Principle (AIP)⁶ between DOE and the State of California. DOE oversight consists of two parts: day-to-day interaction with staff, and formal review of programs.

One formal review occurred over a multi-week period in November, and was directed jointly by the Berkeley Site Office and the Oakland Operations Office of DOE. The review, entitled Pilot ES&H Oversight Appraisal, represented a new approach taken by DOE in their oversight efforts that was more cost-effective and performance-based than previous efforts. Goals of the pilot appraisal were to implement the review in parallel with DOE's necessary and sufficient compliance strategy, and to integrate with the performance objectives established in the UC/DOE contract. Reliance upon the Laboratory's self-assessment program and familiarity with program status from routine interactions shaped the scope of the review, and therefore excluded several topics from formal review. As a whole, EH&S programs were rated as satisfactory. The report⁵ recognized the soundness of programs not reviewed, and noted the effective management in areas of environmental protection, packaging and transportation, and underground storage tanks, stating that key attributes in each program included established goals, adequate staffing, and training. A smaller fraction of all EH&S programs received a rating of not strong based on the appraisal team's observation of opportunities for improvement in implementing programs. The areas included conduct of operations, fire protection, occupational safety, occurrence reporting, quality assurance, radioactive waste management, self-assessment, and training. In spite of this rating, each area was recognized for the presence of the basic framework of a sound program and for its noteworthy practices. The DOE appraisal identified 17 findings. No finding was considered major, life-threatening, or a significant noncompliance issue.

In the second external review, the five-year Agreement-in-Principle between the state's Department of Health Services and Water Quality Control Board and DOE ended as 1995 came to a close. The AIP program provided technical support from the state for evaluating environmental monitoring efforts at Berkeley Lab and five other DOE facilities in California. At LBNL, collaborative efforts

during the year took place in three areas of monitoring: direct radiation, surface water, and groundwater sampling. The groundwater sample analysis included both radiological and nonradiological assessments, while the other two were limited to radiological elements. Results from AIP sampling were comparable to analytical results from the Laboratory's own programs. Reports were released in October 1995⁷ and May 1996⁸ by the Department of Health Services and Water Quality Control Board, respectively.

Environmental Monitoring

The Berkeley Lab's environmental monitoring program serves as a means of verifying that radiological and nonradiological impacts from site activities remain within permit and compliance requirements. The *Environmental Monitoring Plan*,⁹ which characterizes the type and extent of annual monitoring activities, as well as the justification behind the program, underwent a triennial review and revision at the end of the year. Full implementation of the modified plan will take effect in 1996. Outside the routine monitoring program, a preoperational study in the vicinity of the new Hazardous Waste Handling Facility continued in 1995. The objective of this study is to establish background or baseline levels of both radiological and nonradiological substances prior to the startup of this new facility.

Radiological

The radiological monitoring portion of the program includes elements needed to gather information from several media: air, water, soil, sediment, and vegetation. External direct penetrating radiation (gamma and neutron), is also included. Water sampling is categorized as rainwater, surface (creek) water, groundwater, and wastewater. The regulatory standards of comparison differ among media, with the key parameter of interest being the dose received by members of the public. A dose represents the cumulative exposure to a concentration over a period of time.

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Dose equivalents in 1995 were a small fraction of the relevant US/EPA and DOE radiological standards, and of the total natural radiation background of approximately 3 millisieverts per year (mSv/yr) or 300 millirem per year (mrem/yr). The total estimated dose due to direct penetrating radiation from accelerator operations and airborne radionuclide releases, compared to typical radiation doses received by the general public, is summarized in Figure 1-1. LBNL's maximum dose to an individual member of the public for 1995 was 0.023 mSv (2.3 mrem). The location of this maximum dosage is about 100 meters west of Building 88, the source of the direct penetrating radiation from accelerator activities that is the primary contributor to this dosage. This value is 2.3% of the DOE limit of 1 mSv/yr (100 mrem/yr) set forth in DOE Order 5400.5 and less than 1% of the background radiation received by each member of the public during the same period. Also of note, this dose value assumes that the maximally exposed individual (MEI) resides at the high dose location 100% of the time during the year. The purpose of this conservative assumption is for the dosage to represent an upper-bound value in compliance reporting. Actual dosages to the public are considerably less than this value.

To monitor external penetrating radiation, Berkeley Lab has installed a network of direct reading measurement devices spaced around the perimeter of the site. This includes five real-time instruments and 27 time-integrated dosimeters. Results from these locations are used to calculate the dosage at the site of the maximally exposed individual from penetrating radiation.

For dispersible particulate radionuclides, LBNL must comply with requirements of 40 CFR 61 Subpart H, the *National Emission Standard for Hazardous Airborne Pollutants Other Than Radon From DOE Facilities* (NESHAPs).¹⁰ The NESHAPs dose standard from all exposure pathways resulting from airborne releases of radionuclides is 0.1 mSv/yr (10 mrem/yr). This dose standard is calculated at an area where non-LBNL personnel work or reside.

Dose calculation is based in part on emissions from a source. Dispersion of these emissions is based on meteorological conditions. The radionuclide information used in the dose assessment modeling is gathered by monitoring airborne effluent at building stacks, or for smaller sources, estimated using US/EPA-accepted methods. LBNL also monitors atmospheric ambient air at on site and offsite locations for comparison with modeling results. Environmental air samples were analyzed for tritium, carbon-14, gamma emitters, gross alpha, and gross beta radioactivities.

Figure 1-1. Typical Radiation Doses Received by the General Public and the Maximum Contribution From LBNL

Tritium accounted for 80% of LBNL's total airborne radionuclide emissions (Table 11-5). Nearly 20 other radionuclides comprise the remaining emissions. Radionuclides are used in designated research areas across the Laboratory. During 1995, about 1.96 terabecquerels (TBq), or 53 curies (Ci), of tritium in the form of tritiated water vapor and elemental tritium were released to the atmosphere, primarily from the National Tritium Labeling Facility (NTLF). The projected overall dose, or effective dose equivalent, from all airborne radionuclides was 0.0016 mSv (0.16 mrem) to a hypothetical maximally exposed individual, who is located offsite about 110 meters northwest of LBNL's Building 75. This dose is about 1.6% of the NESHAPs limit. Tritium accounted for about 80% of this dose.

An additional assessment of LBNL radiological impact is the population dose, or collective effective dose equivalent (CEDE). CEDE is defined as the sum of the "doses" delivered to all individuals within an 80-kilometer (50-mile) radius of the Laboratory. The collective effective dose equivalent for LBNL's operations in 1995 was estimated to be 0.118 person-Sv (11.8 person-rem).

Nonradiological

Nonradiological monitoring is performed for wastewater, stormwater, groundwater, and soils and sediment. Wastewater and groundwater sampling make up the majority of this portion of the program.

Under the requirements of the Laboratory's three wastewater discharge permits issued by EBMUD, LBNL is required to perform sampling of the sanitary sewer system on specific dates during the year. Twelve samples were taken during 1995 and analyzed for metals and toxic organics. All wastewater discharge levels were below the limits established in the three permits.

Stormwater discharges at LBNL are authorized under a general permit issued by SWRCB. Stormwater discharges are regulated in a manner different from that for wastewater in that there are no specific discharge limits cited in the general permit. References in the permit to the RWQCB *Water Quality Control Plan* (Basin Plan)¹¹ for the San Francisco Bay Basin are intended as guidelines at this time. Constituent levels presented in the Basin Plan are water quality targets, not measures of compliance for stormwater discharges. The recent US/EPA

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benchmark levels for metals are also used for comparison.

Stormwater samples are analyzed for an extensive suite of possible contaminants, depending upon the location of the sample. Samples were collected from 10 sites during 1995. Levels of the metals chromium, copper, lead, and zinc often exceeded guidance levels in the Basin Plan,¹ but were consistent with levels of metals in other urban runoff areas. The Laboratory has a series of best management practices, identified in its *Stormwater Pollution Prevention Plan*,¹² in place to minimize contamination in stormwater runoff. A survey of prevailing site conditions was reported as part of the annual report submitted to the RWQCB on July 1.

The Laboratory's groundwater monitoring program included quarterly analyses of water samples from its network of monitoring and slope stability wells for a variety of potential contaminants, including organic compounds, metals, and tritium. The total number of monitoring wells now stands at 109, with twenty-five wells added in 1995. Groundwater monitoring results have identified seven groundwater contamination plumes on site. These plumes can be categorized into four types with the number in each class in parentheses: volatile organic compounds (3), fuel (2), freon (1), and tritium (1). Contaminant levels of numerous pollutants and plume movements are reported to agencies on a quarterly basis, along with other program developments and upcoming program workplans.

Soil and sediment samples, taken on site and in the area surrounding the Laboratory, were also analyzed for metals and a suite of toxic organics, including polychlorinated biphenyls (PCBs), diesel, kerosene, and oil. All analyses indicated levels of contaminants which are below regulatory concern.

Significant Corrective Actions

The combination of being a research-based organization with evolving programs, a facility with an aging infrastructure, and ever-changing regulatory requirements creates a need to constantly upgrade or improve site operations to meet environmental management requirements. In recent years, this element of the program has shown significantly increased activity and importance in site corrective action projects. In 1995, Berkeley Lab completed several important corrective action projects before regulatory-mandated deadlines, namely:

- aboveground storage tank modifications
- radiological NESHAPs stack monitoring upgrades
- sanitary sewer monitoring
- sitewide radiological ambient air monitoring
- storm drain connection repairs

The NESHAPs project was the result of a Finding of Violation issued by US/EPA in April 1991 for not adequately evaluating all potential emissions sources. US/EPA and DOE signed a Federal Facilities Compliance Agreement in August 1993 that established a schedule for bringing LBNL's program into full compliance with the NESHAPs for radionuclides by February 1995 through a series of stack emissions monitoring projects. Over 50 stacks were modified to some extent by this project. LBNL completed this project in January; as stated earlier, US/EPA confirmed completion through a June inspection of project documentation.

The storm drain connections project faced a March 30, 1995 regulatory deadline. The statewide general permit for stormwater discharges associated with industrial activities required the elimination of non-stormwater discharges into storm drain systems. Non-stormwater discharges include flows of

process water that should go to sanitary rather than storm sewers. LBNL's upgrade project began in 1992 with a sitewide survey that identified the improper connections. With completion of the remaining two connections at Building 71 in March, the project was completed ahead of the regulatory deadline.

Conclusion

A major goal of Berkeley Lab is to continue the long tradition of outstanding research that has made the facility a premier national and international multi-program laboratory. Through seamless integration of research programs with operational support, activities are intended to be conducted with full regard to environment, health, and safety laws and regulations. Berkeley Lab maintains environmental compliance programs that offer expertise to the entire Laboratory community. As an added measure of protection to show that site activities comply with applicable environmental regulations and have a minimal impact on the environment, Berkeley Lab performs cross-media environmental monitoring of both radiological and nonradiological parameters. Results from 1995 confirm that no environmental standards were exceeded by Laboratory activities. Specifically in the more sensitive radiological area, radionuclide emissions dropped by over 50% from the previous year. The estimated dose to the public from these emissions, as well as from the direct radiation from accelerator sources, remained comparable to the previous year, due to improved evaluation methods. More importantly, the total radiological dosage was a small fraction of the applicable environmental standard and background radiation; slightly above 2% and below 1%, respectively.

In addition to a complete discussion of environmental compliance programs and monitoring results in the chapters that follow and the accompanying data appendix Volume II, the 1995 Site Environmental Report can be found on the World Wide Web, off the LBNL Environment, Health, and Safety Division's home page. The URL address for this home page is <http://ehssun.lbl.gov/ehsdiv/ehswww.html> and the URL address for Berkeley Lab's home page is <http://www.lbl.gov>.

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Section 2. Introduction

Origin

Berkeley Lab began as an accelerator laboratory in 1931, when Ernest O. Lawrence established the Radiation Laboratory with the construction of the 27-Inch Cyclotron on the University of California at Berkeley (UCB) campus. In 1939, the need for higher-energy accelerators resulted in the construction of the 184-Inch Cyclotron on a hill overlooking the campus and the City of Berkeley. The 1940s were a period of rapid growth in response to national defense needs. Further development during the 1950s was more carefully planned, with the construction of permanent concrete and steel-frame structures east and west of the earlier construction.

Over the past decades, Berkeley Lab has evolved into a multiprogram national research laboratory with a history of distinguished achievement, including the discovery of many elementary particles and all of the named transuranium elements. Nine Berkeley Lab scientists have won Nobel prizes for their work, and countless others have been honored by awards such as MacArthur Foundation grants and election to the various national science academies. From an initial emphasis on high-energy and nuclear physics, the Laboratory has diversified to include materials sciences, chemistry, earth sciences, the biosciences, and energy conservation research. It is the oldest of the DOE national laboratories, and the only one located adjacent to a major university.

Mission

Berkeley Lab is operated under contract by the University of California (UC) for the U.S. Department of Energy (DOE). The Laboratory's fundamental mission is to provide national scientific leadership and technological innovation to support the DOE's objectives. The mission consists of four goals:

- Perform leading multidisciplinary research in the energy sciences, general sciences, and biosciences in a manner that

ensures employee and public safety and protection of the environment.

- Develop and operate unique national experimental facilities for use by qualified investigators from throughout the world, including the Advanced Light Source (ALS), the 88-Inch Cyclotron, the National Center for Electron Microscopy, and the National Tritium Labeling Facility (NTLF).
- Educate and train future generations of scientists and engineers. Hundreds of graduate and undergraduate students pursue research each year, gaining useful experience for their future careers and contributing greatly to the Lab's achievements. Through the Center for Science and Engineering Education, precollege programs are conducted for students, and various outreach programs are directed at students and science educators.
- Transfer knowledge and technological innovations, and foster productive relationships between LBNL research programs, universities, and industry to promote national economic competitiveness. The Technology Transfer Program strives to make technology transfer an integral part of all LBNL programs and provides services to the research divisions in support of efforts for licensing or collaboration with industry.

Location

San Francisco Bay Area

Berkeley Lab is located 8 kilometers (5 miles) east of San Francisco Bay on the slopes of the Coast Range within 479 hectares (1,183 acres) of land owned by the University of California (Figure 2-1). The Lab's 54-hectare (134-acre) site is under long-term lease to DOE.

The Laboratory lies in Alameda County with the eastern portion of the site in Oakland and the western portion in Berkeley, largely a university and residential community.

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Figure 2-1. San Francisco Bay Area Map

Research is also conducted in buildings on the adjacent UCB campus (student population 31,500), and some research and other functions are also carried out at leased space in various commercial buildings in Berkeley.

Berkeley Lab is served by a network of state, county, city, University, and LBNL roadways, as well as public, University, and Laboratory transit services. The Laboratory is within commuting distance to the Lawrence Livermore National Laboratory, Sandia National Laboratory at Livermore, and the Stanford Linear Accelerator Center.

The San Francisco Bay Area is a cosmopolitan region consisting of nine counties with a total land area of 1.9 million hectares (4.6 million acres) and a population of 6.0 million. Although the metropolitan

areas are highly developed, only 12% of the total land has been developed as residential, commercial, or industrial area. The highly diversified technology- and service-oriented labor force of the region totals 3.3 million people. Aerospace, computers, electronics, scientific instruments, and communications equipment comprise more than 50% of all manufacturing jobs.

Alameda County, with an area of 189,950 hectares (469,400 acres), has major educational, research, industrial, and agricultural resources, including six colleges and universities, large private and public research laboratories, heavy and light industry, and extensive nursery and viticulture acreage. Important industries include electronics, automobile assembly, biotechnology, and food processing. The estimated population of

Alameda County at the beginning of 1995 was 1,356,000, making it the seventh most populous county in California. The civilian labor force is approximately 600,000.

Cities of Berkeley and Oakland

Berkeley Lab is located within the communities of Berkeley and Oakland. Berkeley is a residential, university, and industrial city encompassing 2,720 hectares (6,720 acres). The city is best known for the presence of the University of California at Berkeley (Figure 2-2). Industries include major biotechnology companies, chemical and pharmaceutical companies, and service industries such as restaurants. The population of Berkeley, estimated at 106,000 in 1995, has not changed significantly during recent years.

To the south and east of Berkeley is the urban hub of the East Bay, Oakland. Ranked as the sixth largest city in the state, Oakland is one of the most ethnically diverse cities in the United States. Oakland is a cultural, commercial, and transportation center having a population of approximately 387,000 (1995). As a transportation center, Oakland serves as headquarters for the Bay Area Rapid Transit and the Metropolitan Transportation Commission, and has one of the fastest growing international airports in the nation and a thriving industrial port. Its industrial and professional base includes major corporate headquarters in the food, health care, household, and building materials fields. Recreational opportunities include three major professional sports franchises and 24,300 hectares (60,000 acres) of community parkland. Oakland is also the location of many of Alameda County's government offices.

Figure 2-2. Vicinity Map

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Figure 2-3. LBNL Buildings

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1	Donner Laboratory	54	Cafeteria
2	Advanced Materials Laboratory (AML & Center for X-Ray Optics (CXRO))	55	Research Medicine/Radiation Biophysics
3	Chemical Biodynamics Laboratory	55A	Nuclear Magnetic Resonance (NMR)
4	Magnetic Fusion Energy (MFE)	56	Biomedical Isotope Facility
5	Magnetic Fusion Energy (MFE)	58	Accelerator Research & Development
6	Advanced Light Source (ALS)	58A	Accelerator Research & Development Addition
7	Central Stores & Electronics Shops	60	High Bay Laboratory
10	Cell & Molecular Biology Research & Photography	61	Standby Propane Plant
14	Accelerator & Fusion Research & Earth Sciences	62	Materials & Chemical Sciences
16	Magnetic Fusion Energy Laboratory	63	Accelerator & Fusion Research
17	EH&S/Applied Sciences Lab	64	Accelerator & Fusion Research
25	Mechanical Technology	65	Data Processing Services
25A	Electronics Shops	66	Surface Science & Catalysis Lab
26	Medical Services	68	Upper Pump House
27	High Voltage Test Facility & Cable Shop	69	Business Services, Materiel Management, Mail Room & Purchasing
29	Electronics Engineering, Research Medicine/Radiation Biophysics Offices	70	Nuclear Science, Applied Science & Earth Sciences
31	Chicken Creek Maintenance Bldg.	70A	Nuclear Science, Materials & Chemical Sciences & Earth Sciences
36	Grizzly Substation Switchgear Bldg.	71	Heavy Ion Linear Accelerator (HILAC)
37	Utilities Service	71A	HILAC Rectifier
40	Electronics Development Lab	71B	HILAC Annex
41	Magnetic Measurements Lab	72	National Center for Electron Microscopy (NCEM)
42	Salvage	72A	High Voltage Electron Microscope (HVEM)
43	Compressor Bldg.	72B	Atomic Resolution Microscope (ARM)
44	Indoor Air Pollution Studies	72C	ARM Support Laboratory
45	Fire Apparatus	73	Atmospheric Aerosol Research
46	RTSS, ALS, Accelerator Development	74	Research Medicine/Radiation Biophysics, Cell & Molecular Biology Laboratory
46A	Real Time Systems Section (RTSS)	74B	Research Medicine/Radiation Biophysics, Cell & Molecular Biology Laboratory Annex
47	Advanced Accelerator Study	75	Radioisotope Service & National Tritium Labeling Facility (NTLF)
48	Fire Station	75A	Compactor, Processing & Storage Facility
50	Physics, Accelerator & Fusion Research & Nuclear Science	76	Construction & Maintenance & Craft Shops
50A	Director's Office, Environment & Laboratory Development, Administration Division, Patents	77	Mechanical Shops
50B	Physics, Computer Center, IRD & ICSD	77A	Ultra High Vacuum Assembly Facility (UHV)
50C	PID, Physics	78	Craft Stores
50D	MCSD & Nuclear Science	79	Metal Stores
50E	Earth Sciences	80	Electronics Engineering
50F	Computing Services, IRD	80A	Office Building
51	Bevalac/Bevatron	81	Liquid Gas Storage
51A	Bevatron Experimental Area	82	Lower Pump House
51B	External Particle Beam (EPB) Hall	83	Lab Cell Biology
52	Magnetic Fusion Energy Laboratory	88	88-Inch Cyclotron
53	SuperHILAC Development	90	Applied Science, Employment, Engineering, Occupational Health, Personnel, Protective Services

Figure 2.3. (p. 2) Key to LBNL Buildings Shown on the Previous Page

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The Laboratory

Berkeley Lab (Figure 2-3) is sited on the ridges and draws of Blackberry Canyon, which forms the central part of the site, and Strawberry Canyon, which generally forms the southern boundary. The area to the south, which is University land, is maintained largely in a natural state and includes UCB recreational facilities and the University Botanical Garden. Above and to the east of the Laboratory are the University's Lawrence Hall of Science, the Space Sciences Institute, and the Mathematical Sciences Research Institute. LBNL is bordered on the north by predominantly single-family homes and on the west by multi-unit dwellings, student residence halls, and private homes. The area to the west of Berkeley Lab is highly urbanized.

The eastern section of the main Laboratory site is located in the northeast portion of the City of Oakland. This area is undeveloped and provides LBNL with a backdrop of botanical gardens, a regional park, and open space that preserves the rural character of the foothills.

Berkeley Lab also has space in six offsite leased buildings. The following four are considered local offsite leased buildings because the space can be used by any division at the Laboratory. All four are located in Berkeley (Figure 2-2).

- 903 - warehouse and receiving, Carleton Street
- 934 - Dymo Building, a leased laboratory building primarily used by Life Sciences, near Aquatic Park
- 936 - Hink's Building, housing LBNL's financial services (accounting and budgeting), on Shattuck Avenue
- 938 - Promenade Building, housing Human Resources and Information Systems and Services, between University Avenue and Addison Street.

The other two leased buildings are considered "remote" because they have been leased for specific purposes and are available only to their users.

- 940 - Cholesterol Research Center on Telegraph Avenue in Berkeley. The Life Sciences Division does research in this building in conjunction with Children's Hospital of Oakland.
- 960 - The Portals in Washington, D.C., office space used by the Energy and Environment Division.

Laboratory Programs

To support the national infrastructure for fundamental science and engineering research, LBNL provides a range of unique research facilities and centers to investigators from industry, universities, and government. The major national facilities available to qualified users include:

- The Advanced Light Source, which generates photon beams of unprecedented brightness in the far ultraviolet and soft x-ray regions of the spectrum. This synchrotron radiation source is used for basic and applied research across a broad spectrum of scientific and technological disciplines. The facility began operation in the fall of 1993.
- The 88-inch Cyclotron, which provides light ions, polarized protons and deuterons, and intense and high-charge-state beams of heavy ions (up to krypton) at energies up to about 35 MeV per nucleon. The cyclotron facility has experimental areas for conducting nuclear science experiments, as well as research in other areas such as biomedicine, atomic physics, and radiation damage in semiconductors.
- The National Center for Electron Microscopy, which consists of the High Voltage Electron Microscope, operating at up to 1.5 MeV (the highest energy in the U.S.); the Atomic Resolution Microscope, offering 1.5-Å resolution; and analytical

LBNL Peak Population—FY1995, Total 5,069

Figure 2-4. LBNL Population, 1995

microscopes and support facilities. The Electron Beam Microcharacterization Facility, with resolution down to 1.0 Å, is planned as an upgrade of the facility.

- The National Tritium Labeling Facility, which provides advanced instrumentation to investigators needing high specific activities of tritiated compounds as tracers in chemical and biomedical research.
- The National Energy Research Scientific Computing Center, which supplies production high-performance computing and networking services to the nation's energy research community.

The Laboratory has established many other programmatic research centers with specific objectives of fostering collaborative research with industrial and educational institutions. These include, among others, the Center for Advanced Materials, the Center for Beam Physics, the Human Genome Center, the Center for X-Ray Optics, the Center for Computational Seismology, the Center for Functional Imaging, the Center for Building Science, and the Center for Isotope Geochemistry.

Laboratory Population

The most recent population figures for the Laboratory show over 3,200 full- and part-time employees. In addition, in 1995 Berkeley Lab provided facilities for approximately 1,800 guests who worked at the site for varying lengths of time. Over 700 of these guests were on site at any one time, giving an estimated population base at the Laboratory of about 3,900. A breakdown of the population by category is presented in Figure 2-4. About 250 scientists are also faculty members at UC Berkeley or UC San Francisco. They and other researchers provide guidance and opportunities for hundreds of undergraduate, graduate, and post-doctoral students who pursue research at the Laboratory each year. In addition, approximately 50,000 visitors tour the Berkeley Lab each year. DOE maintains an onsite office for about 15 staff members.

Land Use

The Laboratory's hillside location, with elevations ranging from 200 to 330 meters (650 to 1,000 feet) above sea level, affords

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Figure 2-5. Adjacent Land Use

dramatic views of nearby San Francisco Bay and its surrounding urban areas. The hillside topography and vistas are both an amenity and a constraint to construction and add an important dimension to site planning at Berkeley Lab.

Adjacent land use consists of residential, institutional, and recreation areas (Figure 2-5). Development within the Laboratory site is governed by guidelines that state that operations must be compatible with the surrounding community. Visually the Laboratory is associated by the public with the UCB campus, and the Laboratory works with municipal, county, and university planning staffs to coordinate development plans.

Infrastructure

Facilities

Berkeley Lab research and support activities are conducted in structures totaling 181,000 gross square meters (1.95 million gross square feet), including 154,000 gsm (1.66 Mgsf) on the main site, 9,000 gsm (0.10 Mgsf) on the UC Berkeley campus, and 18,000 gsm (0.19 Mgsf) leased off site. The first onsite building was constructed in 1940. There are 78 permanent buildings and 120 trailers and temporary buildings on the main site. The average age of the main-site buildings is slightly over 30 years. Nearly sixty percent of the permanent buildings are over 30 years old.

Figure 2-6. 1995 LBNL Space Distribution

Figure 2-6 shows the 1995 LBNL space distribution.

Water Supply

All of the Laboratory's water is supplied continuously by the East Bay Municipal Utility District (EBMUD). There are no drinking water wells on site. The primary water supply is EBMUD's Shasta Reservoir, located in the Berkeley hills to the north of LBNL. The Laboratory's high-pressure fire and domestic system is supplied from this reservoir. A secondary source is EBMUD's Berkeley View tank, with a capacity of approximately 11.4 million liters (3.0 million gallons), connected by EBMUD piping.

Domestic water distributed at the site is of the highest quality. It originates in 1,494 square kilometers (577 square miles) of Sierra Nevada watershed lands that are largely untouched by human activity. Water is brought to the Bay Area and ultimately to LBNL through a system of lakes, aqueducts, and treatment stations. EBMUD tests for contaminants and meets disinfection standards as required by the Safe Drinking Water Act. All EBMUD-supplied drinking water meets

both primary (health-related) and secondary (aesthetic) standards as defined by federal and state maximum contaminant levels.

The Laboratory's water distribution system contains several backup safety distribution loops and is valved to provide control in case of emergency. The system normally operates by gravity flow, requiring no pumps or energy consumption for operation within the Laboratory. Berkeley Lab has two 760,000-liter (200,000-gallon) fire-protection storage tanks. One is located behind Building 75 near the Shops and Support Facilities Area, and the other is near Building 71. Automatically starting diesel-powered pumps will maintain a reliable flow for the fire-protection system during emergencies.

The piping system that distributes the EBMUD water within the site consists of an extensive layout providing domestic water and fire-protection water to all installations. The system also supplies makeup water for cooling towers, irrigation water, and water for other miscellaneous uses. The system includes fire hydrants and fire department connections and sprinkler services to almost all buildings. Berkeley Lab has also completed a project to install backflow

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preventers at all buildings in accordance with recent building code regulations.

Because of the differences in elevation at the site, there are two main pressure zones, both of which operate at the nominal pressure of about 480,000 pascals (70 pounds per square inch). Most of the existing pipe is either cement-lined and coated steel pipe with welded joints or cast iron and/or ductile iron pressure pipe with mechanical joints. Much of the pipe has been designed and installed to resist forces caused by earth movement due to slides and/or earthquakes. All of the newer lines have been located to avoid potentially unstable earth areas.

The water system has a high degree of reliability for both domestic use and emergency purposes. This reliability exists by virtue of the two separate connections to EBMUD's Shasta and Berkeley View sources, the two 760,000 liter (200,000-gallon) storage tanks, and the high quality of both the Berkeley Lab and EBMUD systems. The system has sufficient capacity to meet the flow-rate and duration requirements for fire protection; in the case where EBMUD service is not available, the capacity is currently limited to 1.5 million liters (400,000 gallons). There is no restriction on the volume of water available from EBMUD. The only limitations are due to the capacity of the existing pipes.

Figure 2-7. Sanitary Sewer System

Sanitary Sewer Systems

The western portion of the Laboratory's sanitary sewer system (Figure 2-7) connects to the City of Berkeley sewer main at Hearst Avenue. On the south side of the Laboratory, a second connection is made to University-owned piping and then to the City of Berkeley system at Centennial Drive.

The sanitary sewer system consists of pipe, manholes, and two monitoring stations. Pipe in the system is cast iron or ductile iron. The system is entirely gravity flow and discharges through either a monitoring station at Hearst Avenue or one located adjacent to Centennial Drive in Strawberry Canyon. The Hearst Avenue monitoring system receives discharges from over half of the buildings on the hill. Those buildings that lie within the eastern and southern Strawberry Canyon watershed discharge to the Strawberry monitoring station, along with effluent from several UCB campus facilities, mainly the Lawrence Hall of Science, the Space Sciences Laboratory, the Mathematical Sciences Research Institute, and the Botanical Gardens.

Several of the main sewer lines have been in service since before 1950, and some are as small as 15 centimeters (six inches) in diameter. The system is over 50 years old, and portions have deteriorated or failed for a variety of reasons. Video survey results revealed sewer breaks, offsets, obstructions, and undulations caused by ground movement and settling. These conditions result in excessive maintenance, sewer line cleaning problems, and possible soil contamination. As a result, in 1995, Berkeley Lab funded the sanitary sewer restoration project, which will replace approximately 1,000 meters of underground sanitary sewer lines at various locations within the Laboratory. The project is currently in the design phase, and construction is scheduled to begin in FY 1997. Further surveys will be conducted as needed.

Effluent from the Hearst monitoring station flows to a manhole located at the intersection of Cyclotron Road and Highland, where it

enters the City of Berkeley pipe system and is transported to the EBMUD North Interceptor sewer. The EBMUD North Interceptor carries the effluent to the District's wastewater treatment plant south of the Bay Bridge toll plaza. Here, the wastewater undergoes primary and secondary treatment before it discharges to the San Francisco Bay.

Effluent from the Strawberry monitoring station flows through a campus sewer that ties in to the City of Berkeley system at a manhole near the intersection of Rimway Road and Canyon Road, just south and east of UCB Memorial Stadium. The City system then delivers the sewage to the EBMUD North Interceptor.

The Hearst and Strawberry monitoring stations continuously measure the volume of the wastewater effluent. Grab and composite samples of the sewage are also taken at regular intervals and analyzed for various parameters, including pH, metals, chlorinated hydrocarbons, and radioactivity. Monitoring is also performed at the Building 25 and 77 fixed treatment units, where periodic samples are analyzed for pH, metals, total toxic organics, and cyanide.

The measured total wastewater discharge volume for the year at the two stations was approximately 161,000,000 liters (43,000,000 gallons) per day; about 60% of this discharge flows through the Strawberry outfall, and the rest flows through the Hearst outfall. This was approximately 95% of the water purchased from EBMUD during this period. The remaining 5% was lost to various processes such as landscape irrigation and cooling tower evaporation. There is more discharge through the Strawberry

than through Hearst because of the campus facilities in Strawberry Canyon, which also discharge to this line.

Storm Drainage System

The Laboratory lies within the Strawberry Creek watershed, which in total contains about

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Figure 2-8. Stormwater Drainage in the Strawberry Creek Watershed

354 hectares (874 acres). There are two main creeks in the watershed, namely Strawberry Creek and the North Fork of Strawberry Creek. This watershed also includes other University of California property, public streets of both the cities of Oakland and Berkeley, and private property. In the vicinity of Berkeley Lab, the Strawberry Creek watershed is further subdivided into the Blackberry Canyon and Strawberry Canyon watersheds (Figure 2-8).

Because of its hillside location and moderate annual rainfall, surface runoff at Berkeley Lab is a prevalent feature. An inclusive storm drain system, designed and installed in the 1960s, discharges into the North Fork of Strawberry Canyon in the Blackberry Canyon watershed on the north side of LBNL and the south fork of Strawberry Creek in the Strawberry Canyon watershed on the south side (Figure 2-8). This system provides for

runoff intensities expected in a 25-year maximum-intensity storm.

Stormwater runoff from the Laboratory and from the upper parts of the Blackberry Canyon watershed discharges into a 1.5-meter (60-inch) concrete culvert at the head of LeConte Avenue in Berkeley. The drainage facilities in this watershed have proven to be adequate during the heavy rains of the mid 1980s and the 1994/95 rainy season.

Grounds and buildings in the Strawberry Canyon watershed area were heavily damaged during storms in October 1962. Subsequently, extensive improvements were made by Berkeley Lab and UCB. These improvements included additional pipe and culvert capacity, a retention basin, trash racks, and hardening of stream channels. Current drainage facilities have been able to

Figure 2-9. 1995 Temperature Summary by Month

accommodate all runoff since the improvements have been made.

Environment

Meteorology

The Bay Area has a Mediterranean climate with cool, dry summers and relatively warm, wet winters. The proximity of the Pacific Ocean and the maritime air that flows through the Golden Gate moderate local weather to keep seasonal temperature variations small. The mean annual temperature at LBNL during 1995 was about 14°C (57°F). The average temperatures during the summer (June through September) and winter (November through February) periods measured 17°C (62°F) and 12°C (53°F), respectively (Figure 2-9). The maximum temperature at the site was 34.4°C (94°F), while the minimum temperature was 2.8°C (37°F). Generally comfortable outdoor conditions prevail throughout the year, although occasional hard

freezes in mid-winter and heat waves in summer can occur.

Annual average relative humidity values range from 85–90% in the early morning, when ocean fog often blankets the site, to between 55–65% in the afternoon. Annual insolation ranges from 65% to 75% of that which is theoretically available, and the average daytime cloudiness is about the same in summer and winter. Heating degree-days number about 2,600 and cooling degree-days about 150. Winds are generally light and from the southeast or west-northwest (Figure 2-10). During 1995, wind speeds were less than 1.5 meters per second (3.5 miles per hour) about 40% of the time. Over 95% of the time, winds were less than 5 meters per second (11 miles per hour). Predominant wind patterns have winds blowing from the southeast during nighttime hours and from a westerly direction during the daytime. These patterns are consistent with those from previous years. Drought periods of several years' duration are not uncommon, and neither are abnormally

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Figure 2-10. 1995 Wind Summary

wet winters. The annual average precipitation at the site over the past five years is roughly 80 centimeters (31 inches). About 95% of this total occurs from October through April, the winter rainy season. Calendar year 1995 produced a considerably greater than normal rainfall year, with over 100 centimeters (39 inches) of precipitation falling. See Figure 2-11 for a monthly breakdown of precipitation totals over the past five years.

Biological Resources

Vegetation

The majority of the vegetation within the site is located around the periphery, away from the centrally developed portion. The site was largely grassland until the 1940s. Since cattle-grazing operations ceased in the 1940s, *Baccharis* brushland has re-established itself

on some open slopes. Introduced trees, especially eucalyptus, oak, and evergreens, have been planted in dense stands. Without management intervention or occasional wildfires, open areas of the site will continue the transition to an oak-bay woodland.

Vegetation can be broadly categorized into four types: native woodland, eucalyptus plantations, a hillside habitat of grasses and brush, and mixed introduced species (which include ornamental plantings near buildings). Only the remnant stands of oak-bay woodland consist of species native to the site. The most common and widespread vegetation types on the Laboratory site are the hillside habitat, the eucalyptus plantations, and mixed introduced species. The open grassy slopes of the hillside habitat occur primarily in the eastern portion of the Laboratory, while the western portion of the site is more heavily forested (Figure 2-12).

Yearly Rainfall, by Month

	Total (cm)		Accumulated (cm)	
	1995	5-year avg.	1995	5-year avg.
Jan	30.1	9.1	30.1	9.1
Feb	8.2	12.1	38.3	21.2
Mar	29.5	16.0	67.7	37.2
Apr	0.0	1.3	67.7	38.5
May	9.5	5.0	77.2	43.5
Jun	3.4	0.9	80.7	44.4
Jul	0.0	0.0	80.7	44.4
Aug	0.0	0.1	80.7	44.5
Sep	0.0	0.0	80.7	44.5
Oct	0.0	1.8	80.7	46.3
Nov	0.2	13.3	80.9	59.6
Dec	20.0	19.7	100.9	79.3
Total	100.9	79.3		

Figure 2-11. 1995 Berkeley Rainfall

Native Woodland

A mix of Coast Live Oak (*Quercus agrifolia*) and California Bay (*Umbellularia californica*) occurs naturally in those ravines and drainages that retain moisture during the long dry season. The understory can be quite open under the spreading canopies or dense with tangled underbrush. The trees grow relatively

slowly, reaching a height of up to 15 meters (50 feet) in about 25 years.

Eucalyptus Plantations

The Berkeley Hills have been widely planted with introduced eucalyptus, primarily *Eucalyptus globulus*, the Blue Gum eucalyptus. The Laboratory has extensive stands of this tree both on the site and surrounding its borders. Several other

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Figure 2-12. Vegetation Types

eucalyptus species also occur singly or in small clusters. The Blue Gum eucalyptus grows tall, easily reaching a height of 24 to 30 meters (80 to 100 feet). Fruit drop, leaf debris, and large pieces of exfoliated bark from the trees present maintenance and fire management concerns.

Hillside Habitat

Several types of grassy, brushy vegetation share the open slopes on and around the Laboratory. Coyote Brush (*Baccharis pilularis*) occurs in sporadic clumps until it spreads sufficiently to form a dense shrub mass about 2 meters (6 feet) tall. Coastal scrub areas on south- and west-facing slopes host sparse, low shrubs up to 1 meter (3 feet) tall that sometimes include California Sagebrush (*Artemisia californica*). Introduced annual grasses have naturalized in open areas and on most disturbed sites. The major grass species present are Soft Chess (*Bromus mollis*), wild oats (*Avena* spp.), and wild

barley (*Hordeum* spp.) Low broad-leaved plants commonly associated with annual grassland include Rabbit-foot Clover (*Trifolium arvense*), Cut-leaved Geranium (*Geranium dissectum*), and English Plantain (*Plantago lanceolata*). Recent hydroseeding operations to control surficial erosion have used native grass seeds (*Stipa pulchra* and *Stipa sernua*) for their deep rooting and drought-resistant characteristics.

Mixed Introduced Species

Introduced species include trees native to the state, but not naturally occurring on the site, such as Monterey Pine (*Pinus radiata*), Knobcone Pine (*Pinus attenuata*), Canary Island Pine (*Pinus canariensis*), and Coast Redwood (*Sequoia sempervirens*). The conifers are fast-growing trees with a generally sparse understory.

A variety of other introduced ornamental species of trees, shrubs, and perennials has

been planted around existing facilities. Many are not Mediterranean-type species and so have not evolved to withstand a long annual dry season. These introduced species require regular supplemental irrigation to maintain health and appearance.

Landscape Buffers

Berkeley Lab manages its landscape for a variety of objectives:

- provision for future development needs
- site amenity for employees and visitors
- scale and context for development
- separation of adjacent uses, internal and external
- visual and sound screening, internal and external
- microclimate modification
- erosion control
- wildlife habitat
- slope stability.

An important feature of the landscape is the ability to blend the developed Laboratory areas and future developed sites with the surrounding hillside context. Except on the western edge, perimeter landscape buffers merge with adjacent open space beyond the site fence line.

Erosion Control

The steepness of the site makes protection from wind and water erosion a serious concern. Vegetation provides the best control of surficial erosion by reducing the impact of rain on soil, while plant roots stabilize and hold topsoil.

In 1992, Berkeley Lab developed a hydroseed project to revegetate bare soil areas on the site. The seeding operation depends on winter rains sufficient to produce germination without washing the seed away. Variable weather can require repeated applications for success. Other means to control surficial erosion

include retaining walls, slope terracing, and paving of footpaths.

Fire Management

Within the site fence line, most of the Laboratory's north perimeter is managed as a fuel or fire break. Fire protection along the south and east perimeters is complicated by limited landscape space within the fence line and proximity to less-managed University lands.

Since the fire of October 1991, which devastated the Berkeley/Oakland Hills south of the site, LBNL has updated and intensified its fire management efforts. The primary objective of the renewed effort remains to reduce and control fire hazards in landscaped areas. The basic strategy involves reducing fuel loads and fire "laddering" capabilities.

Revegetation plans are currently being developed in order to assure long-term continuity in LBNL's landscape value. They will provide a flexible framework for reducing fire hazards, while at the same time integrating aesthetic considerations such as screening Berkeley Lab buildings from public view through tree height planning, blending the site with the hillside, maintaining the view of the Cyclotron as an historical landmark, and preserving bay views. It is planned to maintain mature trees while encouraging and revegetating with native species to preserve the site's wildland park appearance.

A first step in the vegetation management program was the initiation of eradication of the highly invasive French broom, a non-native pea family shrub originally from the Canary Islands. This plant had spread aggressively at LBNL, competing with native vegetation and presenting a high fire hazard due to its open form and high resin content. Because it resprouts easily and produces a large reservoir of seeds with long viability, eradication will require a determined effort over an extended period of time. During 1995, French broom was cut down throughout the site and controlled burns set as one measure to control

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seed germination in areas where broom had proliferated. The areas will be replanted with grasses and, later, native shrubs.

A long-term routine maintenance strategy to control vegetation has been implemented, emphasizing reduction of fuel and risk to buildings. In conjunction with the East Bay Hills Vegetation Management Consortium and UCB, Berkeley Lab is currently investigating improvement of fire defense at the site's perimeter. Computer modeling of wildfire scenarios predicts how revegetation, clearing, and other strategies may be optimized for fire safety and a sustainable landscape.

Wildlife

In general, the site supports habitats and associated wildlife that are typical of disturbed portions of the Berkeley-Oakland hills. Approximately 79 species of birds, 20 mammal species, and 19 reptile and amphibian species, none rare or endangered, occur on or near the site.

The most significant wildlife habitats at the site occur in lower Blackberry Canyon. This supports a relatively intact oak-bay woodland, but it is completely surrounded by development, so the habitat is small and limited.

The *Baccharis* brushland provides cover, food, and breeding sites for a variety of common birds, reptiles, and small mammals of the region, the dominant mammals of which are brush rabbits and mule deer. The Laboratory's tree stands offer nesting sites for many bird species; during the flowering season, the eucalyptus provide food for nectar-eating birds. In general, the sparse tree understory offers poor wildlife habitat.

Geology

Berkeley Lab occupies the west- and south-facing slopes of the Berkeley hills immediately east of the main UCB campus. Elevations range from approximately 200 meters (650 feet) to 330 meters (1,000 feet) above sea level (Figure 2-3). The LBNL site is underlain by sedimentary and volcanic rocks whose interbedding, faulting, and folding have created a complex geological structure. In general, the bedrock is relatively weak and has weathered deeply, forming soils several meters thick.

Three major geologic formations have been identified at the site. The western and southern parts are underlain by moderately to well-consolidated upper Cretaceous marine sediments. These rocks consist of shales, siltstones, sandstones, and conglomerates. The upper Miocene or lower Pliocene Orinda formation overlies the Cretaceous rocks and underlies most of the property. It consists of poorly consolidated claystones, siltstones, sandstones, and conglomerates of relatively low strength and hardness. These rocks are blanketed by clay soils having high shrink-swell characteristics. The volcanic Moraga formation underlies most of the higher elevations of the Laboratory as well as much of the "Old Town" area around the Advanced Light Source. The Moraga formation overlies the Orinda formation. However, in some areas the volcanic rocks of the lower Moraga are interbedded with sedimentary rocks similar to the Orinda. The Moraga formation consists of basalt and andesite flows and pyroclastic tuffs.

Several other formations underlie the easternmost portion of the site. These include siltstones of the Sobrante formation and siltstones and cherts of the Claremont formation. These rocks are separated from the three main formations underlying the site by the Wildcat Fault complex (Figure 2-13).

Due to the hilly terrain, extensive grading and filling has been necessary to provide suitable

Figure 2-13. Mapped Seismic Faults

building sites. Consequently, cuts up to tens of meters deep have been made in some of the ridges and high ground, and fills up to tens of meters thick are present in some of the original ravines and depressions.

Landslide deposits have been encountered in numerous locations within the site. Many of these slides are related to the contact between the Orinda and the Moraga formations and/or to cutting and filling of the original topography. A soft clay bed up to 0.3 meter (one foot) thick typically exists at the Orinda/Moraga contact. Slide planes develop readily in this material. During the past 20 years, the Laboratory has carried out a program of slope stabilization, including shallow dewatering wells, vegetation cover, and soils management, to reduce the risk of property damage due to soil movement. In 1995 Phase II of a project to stabilize slopes behind Building 51 and Building 77 was completed; the project involved placing piers deep into the soil in both areas, installation of

drainage systems, and replacement of unstable material. Phase I had addressed installation of the piers and subsurface corrective measures, while Phase II stabilized the surface area.

Hydrogeology

The hydrogeology at LBNL is complex. Year-round springs, annual surface seeps, and variable water levels in observation wells indicate discontinuous and localized aquifers. These conditions are due to a number of factors. The different rock units underlying the site have contrasting permeabilities. Volcanic rocks are typically fractured, while the sedimentary rocks consist of interbedded impervious claystones and siltstones and include moderate-permeability sandstones. Orinda formation sandstones are discontinuous, and probably exist primarily as channel fillings in the claystones and siltstones. The relation between the high-permeability volcanic rocks and the low-

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permeability sedimentary rocks is complex due to paleotopography, interbedding, faulting, and folding.

Groundwater is a concern because of its potential effect on slope stability. The fractured bedrock underlying the Laboratory allows percolation that augments groundwater. Faults that cut through bedrock tend to drain groundwater, whereas clay layers impede or direct flow. LBNL's complex geology includes both elements. Across the site, water-table depths vary from less than 3 meters (10 feet) to more than 27 meters (90 feet).

During the winter rainy season, groundwater levels and hydrostatic pressures increase, intensifying slide dangers. The Laboratory has installed an extensive system of monitoring wells, hydraugers, and storm drainage lines (Figure 2-8) to maintain slope stability. Using data from this system, the Laboratory's Environment, Health and Safety Division has also initiated a program that characterizes and remediates groundwater contaminants (see Chapter 6, *Groundwater Protection*).

Seismicity

Berkeley Lab is located in a seismically active region (Figure 2-13). The Hayward Fault, a branch of the San Andreas Fault System, trends northwest-southeast along the base of the hills at the Laboratory's western edge. It has the potential to produce an earthquake of approximately Richter magnitude 7.5. Traces of the Wildcat Fault, also part of the San Andreas system, traverse the site on the east, but analysis indicates no evidence that the fault is active in this area. Shorter, apparently inactive, subsidiary faults also transect the Laboratory.

The San Andreas Fault zone, which has potential for a magnitude 8.3 earthquake, lies about 32 kilometers (20 miles) west of Berkeley Lab, offshore beyond the Golden Gate. The Calaveras Fault, another branch of the San Andreas, lies about 24 kilometers (15 miles) east of the site. For an earthquake of any given magnitude, the Hayward Fault would produce the most intense ground shaking at LBNL because of its proximity. No buildings or building additions are sited across the fault.

To reduce the potential for damage from seismic activity, the Laboratory has carried out a comprehensive earthquake safety program since 1971. All new facilities have been designed and constructed to resist the maximum credible earthquake estimated for the site. All existing buildings have been reviewed, and 34 have been strengthened to meet current risk criteria. Building 90 underwent seismic strengthening in 1993 and 1994.

Section 3. Environmental Compliance Programs

3 — Environmental Compliance Programs

This chapter consists of two main sections. The first section describes Berkeley Lab's organizational structure for meeting environmental compliance requirements. This includes a brief description of the roles and responsibilities of the main groups assigned to oversee compliance. The second section summarizes the compliance status during 1995 with major federal and state environmental statutes and federal executive orders. Included in the summary are the status of compliance activities and any corrective actions, overview of noteworthy regulatory developments, identification of environmental permits, and review of regulatory inspections or other audits, including descriptions of any notices of violation or findings. This section also reports on other noteworthy practices or highlights in environmental programs at the Berkeley Lab.

Organizational Overview

General Environmental Responsibilities

The Environment, Health, and Safety Division (EH&S) is responsible for administering the majority of environmental compliance programs at LBNL. The EH&S Division is organized into two branches, the Field Support and Services Departments (see Figure 3-1). In general, the Field Support Department provides front-line guidance and support to Laboratory research and operations programs in the areas of industrial hygiene, occupational safety, hazard assessment, worker radiation protection, and fire protection, while the Services Department provides essential services to the entire Laboratory in areas such as medical services, analytical laboratory services, environmental protection and restoration, and waste management.

Many of the environmental regulatory programs described in this chapter are managed exclusively by either the Environmental Protection or Waste Management Groups. An overview of the primary responsibilities of each group follows. In addition to this general outline,

each year each group participates in programmatic planning that is presented at the end of this chapter. In nearly all cases, EPG and WMG interface with agencies at either the state, regional, or local level in California. Agencies can receive authority to administer specific programs by developing programs at least as stringent as that of the agency having the power to delegate downward through the regulatory hierarchy. For example, the U.S. Environmental Protection Agency (US/EPA) delegates Resource Conservation and Recovery Act responsibilities to the Department of Toxic Substances Control (DTSC), which is an agency within the California Environmental Protection Agency (Cal/EPA). The regulatory compliance programs at LBNL implement the various requirements from applicable federal, state, and local laws, regulations, and ordinances.

The operating contract between DOE and the University of California for the Berkeley Lab reiterates the compliance objectives required by DOE orders, namely that contractor-managed facilities comply with applicable federal, state, and local environmental laws, regulations, ordinances, and the DOE orders. The University of California has established a series of measures to track EH&S performance at LBNL. Measures that track environmental protection and waste management performance will be discussed later in this chapter, after the Compliance Summary.

Environmental Protection Group

The Environmental Protection Group (EPG) is responsible for overseeing compliance efforts and providing technical assistance at Berkeley Lab with respect to environmental regulations. EPG is divided into two functional entities: environmental protection and environmental restoration.

Environmental Protection

The main responsibilities of the environmental protection program center around regulatory

3 — Environmental Compliance Programs

Environment, Health & Safety Division

Figure 3-1. LBNL Environment, Health and Safety Division Organization

compliance and environmental monitoring activities. Monitoring efforts support compliance requirements stated in regulations and DOE orders.

Compliance

This section consists of a diverse professional and technical staff trained to address the various permitting, operating, monitoring, and reporting requirements in regulations protecting air, water, and soil. All staff are responsible for actions intended to maintain sitewide compliance with regulatory standards of operation for individual environmental protection programs. This goal is achieved by providing on site compliance oversight information and training to Berkeley Lab personnel and interfacing with regulatory agencies on compliance issues. Staff also take a lead role in obtaining necessary environmental operating permits, coordinating inspections of facilities by regulatory agencies, maintaining appropriate inventory records, preparing necessary operating procedures, reports, and plans, conducting environmental risk assessments, overseeing sampling strategies, and interacting with agencies during

the rule-development phase for regulations potentially impacting site activities. In the event of an accidental release or spill, staff report to necessary agencies, and investigate appropriately.

Environmental Monitoring

Environmental monitoring involves two main areas of effort: (1) monitoring effluents and emissions from Laboratory operations, and (2) surveillance (i.e., the measurement, monitoring, and calculation) of the effects of those operations on the environment and public health. These efforts are dictated by environmental permits and compliance requirements in the areas of radiological and nonradiological air emissions, penetrating radiation, meteorology, surface wastewater and stormwater discharges, soil/sediment and vegetation, and groundwater. Staff coordinate program activities to ensure that time-dependent obligations involving routine monitoring and surveillance are satisfied. Staff maintain data management systems to support the diverse set of monitoring and analytical information generated, and to assist in preparing environmental monitoring reports

3 — Environmental Compliance Programs

to regulatory agencies and DOE. Additionally, staff initiate investigations and conduct sampling to determine the extent and type of accidental environmental releases should such an incident occur. Environmental monitoring personnel interface with other EH&S and LBNL organizations in conducting sampling and monitoring efforts.

The *Environmental Monitoring Plan* is the foundation document for the program. This plan identifies the monitoring needs for the facility, and details the existing and planned monitoring activities designed to satisfy these needs. The *Environmental Monitoring Plan* underwent a triennial update during the second half of 1995. DOE approved the new version of this plan in early 1996. Current elements of the environmental monitoring program are presented in Table 3-1. The monitoring plan focuses considerable attention on the importance of quality assurance in all aspects of environmental monitoring. More discussion on quality assurance is found in Chapter 12, *Quality Assurance*.

Environmental Restoration

The environmental restoration program (ERP) oversees site and groundwater characterization and cleanup activities. The primary goal of the program is to ensure that the risk to human health and the environment from past releases of hazardous and/or radioactive materials is either reduced to allowable levels or eliminated. Professional and technical staff perform functions necessary to characterize the extent of contamination to the soil and groundwater of the site, and to determine appropriate corrective measures.

As mentioned later in the *Compliance Summary* section of this chapter, Berkeley Lab's site-wide soil and groundwater characterization and restoration activities are conducted under the RCRA Corrective Action Program. ERP interacts with several state and local agencies in conducting its program; the RWQCB, SWRCB, Department of Health Services, DTSC, and the City of Berkeley. DOE and local community groups are also included in program updates. The RCRA

permit for the Laboratory's Hazardous Waste Handling Facility (HWHF) identifies requirements related to site restoration activities. ERP produces progress reports, and planning documents such as the *RCRA Facility Investigation Workplan*.¹³

ERP consists of two distinct sections: planning and geotechnical support. Planning establishes goals and objectives in all four major phases of the program: site assessment, field investigation, data evaluation, and site remediation. Geotechnical support primarily provides field support services to the program.

Waste Management Group

The Waste Management Group (WMG) manages hazardous, medical, radioactive, and mixed (hazardous and radioactive) waste generated at LBNL. The Waste Management Group is divided into five operational teams, which are staffed by professional and technical personnel: Certification, Compliance, Operations, Waste Minimization and Generator Support, and Budget and Planning.

The hazardous waste regulations in California are among the most stringent and complicated in the nation. They consist of both the federal and state requirements under RCRA and the California Hazardous Waste Control Law, respectively, as well as DOE requirements. DTSC has received delegated authority to implement the federal program in California. The City of Berkeley, through a Memorandum of Understanding with Cal/EPA, administers the requirements of RCRA and HWCL at hazardous waste generator sites.

LBNL's HWHF is a RCRA-permitted storage facility designed to manage the large number, although in relatively small quantities, of waste chemicals classified as hazardous. The HWHF permit is valid through 2003. LBNL is presently constructing a new HWHF on site. The current schedule estimates completion of construction activities for the new facility in June 1996, with operational activities starting near the end of 1996.

3 — Environmental Compliance Programs

Table 3-1. Environmental Monitoring Program Elements at End of 1995.

Type of Monitoring	Description
Air – ambient	Continuous sampling of ambient air at five on site and two offsite locations. Particulate matter and tritiated water are individually sampled at five sites; three of the seven locations house instrumentation for both sampling media.
Direct radiation	Monitoring of penetrating radiation (gamma and neutron) using two methods: real-time and time-integrated. Real-time sampling at five perimeter stations and in each major accelerator complex. Data are telemetered from the stations to a central location and collected by a computerized data acquisition system. Time-integrated sampling at 25 perimeter stations and one background location. Sample media exchanged quarterly.
Air – stack	Sampling of stack emissions in all areas where significant quantities of radionuclides are handled. Three type of sampling methods for radiological parameters: direct reading, continuous sampling, and periodic sampling. Sampling conducted at 24 locations on site.
Meteorology	Continuous information collected for all meteorological parameters. Wind speed and direction monitored at three locations. Temperature, humidity, barometric pressure, rainfall, and solar radiation data collected at one site. Rainfall samples are analyzed for tritium and gross alpha and beta emitters.
Soil/Sediments	Sampling of soils and sediments take place once each year after the beginning of the dry season (approximately May 1). Soil sampling is conducted at locations that coincide with the five ambient air particulate matter stations. Sediments are sampled at two locations down-gradient from the site; North Fork of Strawberry Creek and Chicken Creek.
Stormwater	Samples collected during two significant stormwater events between October 1 and March 31 at four locations: two influent, two effluent. Samples analyzed for gross alpha and beta emitters, tritium, metals, organics, oil/grease, gasoline, and diesel. Visual observations are made at least twice at all sites during dry season for non-stormwater discharges.
Surface Water	Sampling by collecting grab samples at six hydraugers and five creeks that drain the site's watershed. The samples are analyzed for tritium and gross alpha and beta emitters.
Vegetation	Annual sampling following the spring growth period at sites that will be selected based on active farms or gardens, known or suspected LBNL-induced contamination, proximity to site, potential for being affected by site operations, and representative of background site. Laboratory analyses will be specified but will consider a review of effluent and past year's data.
Wastewater	Two types of periodic sampling occurs at the two LBNL sewer outfalls and the two metal finishing shops. Grab samples are analyzed for pH, cyanide, and organics. Composite samples are analyzed for metals at all sites. Composite samples are analyzed for radiological activity, solids, and oxygen demand at the outfalls. Outfall flow is continuously measured at the outfalls.

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Certification Team

The Certification Team evaluates all incoming waste pickup requisition forms for proper waste characterization on hazardous, radioactive, and mixed wastes. Generators provide the necessary information for their waste pickup. Waste characterization requirements are described in the *Guidelines for Hazardous, Radioactive, and Mixed Waste Generators at LBNL*.¹⁴

Compliance Team

The Compliance Team reviews the completed waste requisition forms to determine acceptability of particular waste streams requested by the generators under the Part B permit for the HWHF. Other duties performed by the team include the following: administering a QA/QC sampling program on all wastes received by the HWHF; conducting self-assessments on the HWHF operations; administering a comprehensive training program for all HWHF staff; updating HWHF operations procedures and related waste management plans; conducting root cause analyses on non-conformances and implementing corrective actions; performing offsite audits of treatment, storage, and disposal facilities; reviewing newly proposed hazardous waste management laws and regulations; completing regulatory reports; and maintaining waste management records.

Operations Team

The Operations Team manages the day-to-day activities of the Hazardous Waste Handling Facility. Duties associated with this responsibility include overseeing and arranging for pickup, packaging, transport, and disposal of hazardous, radioactive and mixed wastes; treating and storing hazardous, radioactive, and mixed wastes in accordance with RCRA permit conditions and DOE orders; and arranging for sampling and analysis of wastes as required by quality assurance/quality control and DOE Moratorium procedures. The Operations Team also supervises on site contractors that

provide hazardous, radioactive, and mixed waste support.

Waste Minimization and Generator Support Team

The Waste Minimization and Generator Support Team provides assistance to the Laboratory community on issues raised by hazardous waste generators, with particular emphasis on finding solutions that incorporate opportunities for pollution prevention or waste minimization. As more attention has been placed on pollution prevention and waste minimization by DOE and regulatory agencies, LBNL has established several resourceful means of reducing waste, such as developing a Laboratory-wide Chemical Exchange Database and a solid waste disposal contract that requires increased and measurable recycling efforts.

Budget and Planning Team

The Budget and Planning Team is responsible for developing work plans and planning documents required by DOE, including the group's contribution to the 5-year *ES&H Management Plan*. This section also tracks overall program progress, generates performance measures, and performs budget analysis and review.

Compliance Program Summary

This section discusses the status of environmental compliance programs at Berkeley Lab. It begins with summary tables of environmental permits, audits and inspections, environmental incidents, and environmental corrective action projects from 1995.

3 — Environmental Compliance Programs

Summary of Environmental Permits

Berkeley Lab's environmental compliance programs have obtained a number of operating permits from administering agencies for various Laboratory activities. Table 3-2 lists the different categories of permits and the number held by category, as well as the issuing agency and the section of this chapter that more fully describes the permits, and any permit-related developments during the course of the year, such as permit modification or renewal.

Summary of Audits and Inspections

Each year, stakeholder regulatory agencies visit LBNL to conduct inspections of environmental compliance programs. Table 3-3 lists the visits for 1995. Also included in the list are appraisals performed by DOE, as well as self-monitoring events required by

EBMUD wastewater discharge permits; self-monitoring events have the potential for a regulatory violation. Not included on the list were agency visits involving only on site informational meetings.

Summary of Environmental Incidents

LBNL filed three reports for environmental incidents in 1995 under the DOE occurrence reporting program.¹⁵ Two other reports have been submitted in early 1996 for additional incidents. Each of these incidents will be discussed in greater detail later in the program compliance section of this chapter. Table 3-4 summarizes these incidents and refers to the section that contains the detailed discussion.

Table 3-2. Summary of Environmental Permits Held by LBNL During 1995

Type of Permit	Issuing Agency	Description	Number of Permits	Section for More Information
Air Quality	BAAQMD	Variety of individual activities with atmospheric emissions	37	Air Quality - Nonradiological
Hazardous Waste	DTSC	Hazardous Waste Handling Facility operations and hazardous waste treatment units	2	RCRA, Hazardous Waste
Stormwater	SWRCB	Sitewide stormwater discharges	1	Water Quality - Clean Water Act
Underground Storage Tank	City of Berkeley	Underground storage tanks containing petroleum products	10	RCRA, Underground Storage Tanks
Wastewater	EBMUD	Sitewide and operation-specific wastewater discharges to sanitary sewer	3	Water Quality - Clean Water Act

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Table 3-3. Environmental Audits, Inspections, and Appraisals at LBNL During 1995

Organization	Inspection Title	Start Date	Duration (days)	Violations
BAAQMD	Annual Inspection by BAAQMD (10 Permitted and 27 Registered-Exempt Sources)	1/11/95	1	0
	Annual Inspection by BAAQMD (4 Permitted and 10 Registered-Exempt Sources)	1/17/95	1	0
	Annual Inspection by BAAQMD (12 Permitted and 19 Registered-Exempt Sources)	1/25/95	1	0
	Annual Inspection by BAAQMD (3 Permitted and 5 Registered-Exempt Sources)	1/27/95	1	0
	Annual Inspection by BAAQMD (6 Permitted and 14 Registered-Exempt Sources)	2/2/95	1	0
	Annual Inspection by BAAQMD (2 Permitted Sources)	2/8/95	1	0
City of Berkeley	Water Treatment Unit - Building 25	3/15/95	1	0
	Inspection of Plating Separation	3/21/95	1	0
	Hazardous Materials Management Plan	7/21/95	1	0
	Hazardous Materials Management Plan	10/26/95	1	0
	Hazardous Materials Management Plan	12/8/95	1	0
	Satellite Accumulation Areas Walkthrough	12/14/95	1	0
City of Berkeley/ DTSC	Satellite Accumulation Areas Inspection	2/21/95	1	
DHS	DHS Onsite Inspection of Analytical Chemistry Laboratory	11/16/95	1	0
DOE	FY95 Environment, Safety, and Health Pilot Appraisal	11/6/95	12	0
DTSC	Waste Accumulation Areas (WAA)	1/27/95	1	0
	Inspection of HWHF and Hazardous Waste Management Program, Fixed Treatment Units (5), and Satellite Accumulation Areas	2/22/95	1	0
	Tiered Permitting Waste Treatment Units (5)	8/16/95	1	0
	Waste Accumulation and Satellite Accumulation Areas	8/17/95	2	0
EBMUD	Wastewater Monitoring Inspection at B25 Treatment Unit	1/17/95	1	0
	Wastewater Monitoring Inspection at Hearst and Strawberry Outfalls	1/18/95	1	0
	Wastewater Monitoring Inspection at Hearst and Strawberry Outfalls	3/29/95	1	0
	Wastewater Monitoring Inspection at B25 Treatment Unit	5/1/95	1	0
	Wastewater Monitoring Inspection at Hearst Outfall	6/19/95	1	0
	Wastewater Monitoring Inspection at B77 Treatment Unit	6/21/95	1	0

(Table continued on following page)

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Table 3-3. (continued)

Organization	Inspection Title	Start Date	Duration (days)	Violations
EBMUD (continued)	Wastewater Monitoring Inspection at B25 Treatment Unit	7/7/95	1	0
	Wastewater Monitoring Inspection at Hearst Outfall and B77 Treatment Unit	7/10/95	1	0
	Wastewater Monitoring Inspection at Hearst Outfall and B77 Treatment Unit	7/31/95	1	0
	Wastewater Monitoring Inspection at Hearst and Strawberry Outfalls	11/17/95	1	0
	Wastewater Monitoring Inspection at B77 Treatment Unit	12/5/95	1	0
LBNL	EBMUD Self-Monitoring Inspection at Hearst and Strawberry Outfalls	1/10/95	1	0
	EBMUD Self-Monitoring Inspection at B77 Treatment Unit	1/18/95	1	0
	EBMUD Self-Monitoring Inspection at Hearst and Strawberry Outfalls	3/15/95	1	0
	EBMUD Self-Monitoring Inspection at B77 Treatment Unit	4/20/95	1	0
	EBMUD Self-Monitoring Inspection at Hearst and Strawberry Outfalls	5/9/95	1	0
	EBMUD Self-Monitoring Inspection at B25 Treatment Unit	5/17/95	1	0
	EBMUD Self-Monitoring Inspection at Hearst Outfall	6/13/95	1	0
	EBMUD Self-Monitoring Inspection at Strawberry Outfall	6/20/95	1	0
	Annual Stormwater Site Inspection	6/23/95	1	
	EBMUD Self-Monitoring Inspection at Hearst and Strawberry Outfalls, and B77 Treatment Unit	7/17/95	1	0
	EBMUD Self-Monitoring Inspection at Hearst and Strawberry Outfalls	11/7/95	1	0
	EBMUD Self-Monitoring Inspection at B77 Treatment Unit	11/9/95	1	0
	EBMUD Self-Monitoring Inspection at B25 Treatment Unit	12/5/95	1	0
RWQCB	Review of Storm Water Data	3/14/95	1	0
SWRCB	Groundwater Monitoring Well Sampling Comparison	5/11/95	1	0
	Groundwater Monitoring Well Sampling Comparison	6/7/95	1	0
US/EPA	Federal Facility Compliance Agreement Verification	6/29/95	1	0

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Table 3-4. Summary of Environmental Incidents at LBNL During 1995

Reporting Date	Reporting Number	Description	Section for More Information
1/13/95	SAN--LBL-EHS-1995-0001	Mercury contamination of soil at Building 71	RCRA — Environmental Restoration
4/11/95	SAN--LBL-EHS-1995-0003	Wastewater discharge violation in Strawberry Canyon	Water Quality — Clean Water Act
4/25/95	SAN--LBL-EHS-1995-0004	Packing and shipping errors of mixed waste shipments to Hanford	RCRA — Hazardous Waste

Summary of Corrective Action Projects

As the need arises, LBNL's environmental compliance programs become involved with projects designed to correct an environmental compliance finding or violation, or address pending regulatory changes. Table 3-5 identifies the corrective action projects involving these programs in 1995 and the section in the compliance summary where more information can be found.

Summary of Program Compliance

Air Quality

Clean Air Act (CAA)

Enacted initially as the Air Quality Act of 1967, the Clean Air Act¹⁶ was most recently amended in 1990 in a multipurpose effort to

- protect and enhance the nation's air quality through more stringent standards and control methodologies,
- increase research into prevention and control of air pollution,
- assist state and local governments in developing their air pollution programs, and
- establish a new goal of promoting pollution prevention.

The Clean Air Act is the key statutory reference for federal, state, and local air pollution control programs. It classifies air pollutants into several main classes, including

Table 3-5. Summary of Environmental Corrective Action Projects at LBNL During 1995

Description	Status	Section for More Information
Aboveground Storage Tank Modifications	Completed	Water Quality — Clean Water Act
NESHAPs Federal Facilities Compliance Agreement	Completed	Air Quality — Radiological
Sanitary Sewer Monitoring Upgrade	Completed	Water Quality — Clean Water Act
Sitewide Radiation Monitoring and Sampling	Completed	DOE Orders
Storm Drain Connection Repairs	Completed	Water Quality — Clean Water Act

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- air pollutants (e.g., carbon monoxide, nitrogen oxides, particulate matter),
- hazardous air pollutants (e.g., volatile air toxics, radionuclides), and
- ozone-depleting substances (e.g., chlorofluorocarbons or "freons").

The State of California has its own statutory air pollution control program,¹⁷ which was updated significantly in 1988. This Act gives the state additional powers to control sources of air emissions. In complying with the federal and state requirements, air quality protection activities at LBNL are divided into two main categories: radiological and nonradiological.

Radiological

The radiological air-emissions compliance

program at LBNL must follow the standards found in 40 CFR 61, Subpart H, *National Emissions Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities*,¹⁸ as well as DOE Orders 5400.1 and 5400.5.¹⁹ Subpart H is part of the National Emission Standards for Hazardous Air Pollutants (NESHAPs)¹⁹ program. NESHAPs regulations are administered by US/EPA, while the requirements of the DOE orders are overseen by DOE. See the discussion later in this section (DOE Orders) for an update on a pending change with DOE orders that will affect the Laboratory's environmental radiological compliance program, including air.

NESHAPs-regulated radionuclides may be released to the atmosphere from research activities at LBNL. These research activities

Table 3-6. Summary of LBNL NESHAPs Compliance Strategy

Category	Annual Effective Dose Equivalent (AEDE) (millirem/year)	Sampling/Monitoring Strategy	Number of Sources (1995)
Non-compliance	AEDE $\geq$ 10.0	Reduce or relocate source term and reevaluate prior to authorization.	0
I	10.0 > AEDE $\geq$ 0.1	US/EPA Application to Construct or Modify required, along with <u>continuous</u> isokinetic sampling. Analytical differences associated with half-life of radionuclide. <ul style="list-style-type: none"> • Half-life greater than 100 hours: <u>weekly</u> analysis. • Half-life less than 100 hours: <u>hourly telemetry</u> to central location. 	5
II	0.1 > AEDE $\geq$ 0.05	Continuous isokinetic sampling with <u>weekly</u> analysis.	0
III	0.05 > AEDE $\geq$ 0.01	Continuous isokinetic sampling with <u>monthly</u> analysis.	1
IV	0.01 > AEDE $\geq$ 0.001	Sampled <u>annually</u> during project activity (continuous two-week sampling run). Isokinetic sample probe design, with sample mass flow set for average stack velocity.	8
V	0.001 > AEDE	No monitoring required. Inventory controlled by <u>administrative</u> methods (Radiation Work Permit) and annual reconfirmation.	55

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are dynamic. Research projects often have a fixed duration, and new projects may occur at new locations and emit a different set of radionuclides. These changes affect both the sampling strategy and sampling devices. To track compliance and continually assess stack monitoring requirements, LBNL reviews all activities that may release radionuclides through the LBNL *Radiological Work Authorization* program. This program tracks the use and inventory of all radionuclides on site. An assessment based on the nature of the work being proposed and the state of the radionuclide provides part of the basis for determining the dose to the nearest offsite member of the public. Adhering to US/EPA regulations and DOE EH-1073T,²⁰ this assessment is performed with the assumption that no portion of the release is collected by emission controls even if controls are in place. Berkeley Lab's NESHAPs compliance program uses a sampling and monitoring strategy formulated from regulatory requirements and site-specific estimated dose impacts generated by US/EPA-approved dispersion methods as internal guidance in determining the minimum degree of sampling/monitoring or administrative controls necessary to maintain compliance.

This strategy has been approved by US/EPA, and is summarized in Table 3-6. The current summary of the actual sampling/monitoring methods in place at NESHAP sources is presented in Table 3-7. The actual methods provide a higher level of measurement than required by the compliance strategy, which accounts for any variance between individual numbers in the two tables.

Berkeley Lab achieved a significant milestone by fulfilling its final obligations under a Federal Facilities Compliance Agreement (FFCA). The FFCA resulted from a 1991 Finding of Violation issued by US/EPA for not performing evaluations on some of the Laboratory's smaller radiological air-emission sources, as required in Subpart H of NESHAPs. Final radiological stack monitoring upgrades were completed in early 1995. LBNL submitted a final report to US/EPA on February 1, 1995, to inform the agency that it had completed all milestone and contractual obligations of the FFCA on schedule, including stack upgrades. On June 29, US/EPA conducted a final evaluation of compliance projects and documentation relative to NESHAPs requirements. The agency sent DOE written confirmation on

Table 3-7. NESHAPs Point Source Compliance Sampling/Monitoring Summary

Type	Sampling/Monitoring Method	Sampling Location
Real-time	Real-time monitoring of HT and HTO	Bldg. 75 NTLF exhaust
	Real-time monitoring of ¹¹ C, ¹³ N, ¹⁵ O	Bldg. 88 accelerator exhaust
	Real-time monitoring of ¹¹ C, ¹³ N, ¹⁵ O, ¹⁸ F	Bldg. 56 Biomedical Isotope Facility accelerator exhaust
	Real-time monitoring of particulates and iodine	Bldg. 75 mixed and radioactive waste handling area
Continuous	Isokinetic sampling of HT and HTO	Bldg. 75 NTLF exhaust
	Isokinetic sampling of particulates and iodine	Bldg. 75 waste compactor
	Isokinetic sampling of particulates and iodine	Bldg. 75 mixed and radioactive waste handling area
	Isokinetic sampling of particulates, iodine, tritium, and sulfur	17 stacks located on 13 on site and offsite buildings
No monitoring	Inventory control	45 locations

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November 8 that LBNL had satisfactorily completed all requirements of the FFCA. DOE was the recipient of this letter, as the FFCA was an agreement between US/EPA and DOE to bring the Laboratory into full radiological NESHAPs compliance by February 1995.

To put the size of this corrective action into perspective, it covered three projects that individually embodied a significant undertaking. One project upgraded stacks to allow emission measurements with either a portable or fixed sampling device. These stacks represent the least significant potential radionuclide emission sources at the Laboratory. This project upgraded 47 stacks for periodic monitoring (portable sampler) and 17 stacks for fixed, non-isokinetic, continuous-sampler capability. In 1995, two other fixed monitoring systems unrelated to the corrective action project were installed, one each in Buildings 55 and 934.

The other two projects upgraded the stacks with the greatest potential to emit radionuclides at LBNL. Both projects include real-time monitoring capability. One project consisted of installing real-time, isokinetic monitoring systems for radionuclide emissions at Buildings 75 and 75A. This included the emissions from the National Tritium Labeling Facility and the existing Hazardous Waste Handling Facility. The other project concentrated on real-time non-isokinetic monitoring of air-activation emissions from accelerator activities in Buildings 56 and 88. Building 56 is the location of LBNL's new Biomedical Isotope Facility. Building 88 is the location of the 88-Inch Cyclotron. Isokinetic sampling means that the stack flow velocity and the sampling velocity are equal. This ensures that the same particle distribution in the effluent stream are being sampled and collected. The criteria for this requirement is stated in the NESHAPs regulation.

There were no US/EPA inspections of the LBNL radiological program in 1995, other

than the June 29 visit mentioned above. Also, DOE eliminated its requirement for a quarterly NESHAPs update report from Laboratories, which had previously submitted completed questionnaires on program activities. There was no change in the requirement under NESHAPs for an annual report. The 1995 NESHAPs report for LBNL is attached as an appendix.

Nonradiological

The Bay Area Air Quality Management District (BAAQMD) is the implementing agency for federal and state air quality requirements for air-emission activities that fall outside of NESHAPs. BAAQMD issues operating permits for stationary sources of air pollutant emissions. Sources exempt from permit but for which operating information has been provided to BAAQMD in a permit application are classified as registered-exempt. Operating permits are renewed annually, with new permits effective July 1. BAAQMD also requests information on the state's Air Toxics "Hot Spots" Information and Assessment Act of 1987 (AB2588)²¹ during the annual permit renewal process. LBNL renewed a total of 37 operating permits and 77 registered-exempt sources in 1995. This represented a decrease by one operating permit and an increase by one registered-exempt source from the 1994 renewal. The change in the number of sources occurred in late 1994. The diversity of research and support activities on site corresponds to a wide range of equipment or activities that are subject to BAAQMD emission source category requirements. Categories affecting LBNL include

- casting and molding,
- chemical processing,
- furnaces, ovens, and kilns,
- gasoline dispensing,
- general combustion,
- liquid storage and loading,
- material working and handling,

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- miscellaneous equipment (e.g., vacuum devices, welding tools, wastewater separators),
- semiconductor manufacturing,
- surface coating and printing, and
- surface preparation and cleaning.

See Table 3-8 for a complete listing of permitted sources.

LBNL submitted two permit modification requests with BAAQMD in 1995: increasing the usage limit at a solvent wipe-cleaning source, and adding a non-ozone-depleting substance as an allowable material used in a vapor degreasing system. The solvent increase in the wipe-cleaning permit at Building 77 was in response to a consolidation of work efforts across the site. The Laboratory submitted the application on April 12, and BAAQMD approved the increase on July 25. To address future operational changes in the distribution of workplace activities, Berkeley Lab will submit a request in 1996 for BAAQMD to consolidate the present 14 building-wide permits into a single facility-wide wipe-cleaning permit.

LBNL filed the second permit modification on November 14 and BAAQMD approved on December 12. This application requested that one of LBNL's smaller vapor degreasing systems, BAAQMD source 140, be allowed to use a non-ozone-depleting substance as the cleaning agent. The previous permit limited the source to use 1,1,1-trichloroethane, an ozone-depleting substance that was banned from production as of December 31, 1995. Berkeley Lab's larger and only other remaining vapor degreasing system, source 92, will undergo a similar permit modification request in 1996 for the same reason. The actual permit modification timetable depends on completing the evaluation of test results from source 140. A full discussion on the results will be presented in next year's report. LBNL did not file any permit applications for new sources during 1995.

Sources 92 and 140 also played a role in the project to convert the Building 77 Plating

Shop into an Ultra-High Vacuum Cleaning Facility (UHVCF). When this project entered the construction phase in May 1994, source 92 became unavailable for an extended period. As mentioned in last year's report, LBNL received a variance from BAAQMD to increase solvent usage at source 140 by 475 liters (125 gallons) of 1,1,1-trichloroethane until March 5, 1995. Although the UHVCF project remains in progress, the project was sufficiently completed to allow LBNL to bring source 92 back into service by the end of the variance period. LBNL notified BAAQMD on March 2, 1995, that it had successfully completed the variance period.

Although permits are not required for asbestos-removal projects, prior notification to the BAAQMD is required. There were four removal projects in 1995 meeting BAAQMD notification requirements for larger-sized jobs. Separate asbestos notices were submitted by LBNL's asbestos-removal contractor for removal projects in March and April. Smaller jobs do not need notification unless the cumulative total from this class of effort exceeds BAAQMD thresholds (i.e., individual projects below 30.5 meters [100 feet], 9.4 square meters [100 square feet], or 1 cubic meter [35 cubic feet]). LBNL did not submit a cumulative notification in 1995.

BAAQMD conducted six separate inspections in January and February, 1995 of permitted and registered-exempt sources. There were no violations from any of these inspections. LBNL modified record keeping logs for certain permitted sources at the suggestion of the BAAQMD inspector. The modifications make it easier to compare cumulative emissions against permitted emissions.

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Table 3-8. BAAQMD Permitted Air Emission Sources Renewed in 1995

BAAQMD Source Category	BAAQMD Source #	Description	Building	Permit Conditions	Abatement Device	Abatement Type
Furnaces, Ovens, and Kilns	104	Paint drying oven	77			
	145	Crystal Growth Furnace	2	X	X	Mist Eliminator
	148	Epoxy Curing Oven	53			
	149	Epoxy Curing Oven	53			
	150	Epoxy Curing Oven	53			
Gasoline Dispensing	76	Gasoline Pumps	76		X	Vapor recovery
Material Working and Handling	64	Sawdust collector	74		X	Cyclone, Simple
	73	Machine shop tools	76		X	Cyclone, Dynamic
	116	Machine shop tools	79		X	Cyclone, Simple
Miscellaneous	124	Sulfur hexafluoride chamber	58A		X	Refrigeration
	159	Vacuum coating chambers	25	X	X	Baghouse, Simple
Semiconductor Manufacturing	168	Instrument Support Laboratory	70A	X		
	186	Semiconductor Fabrication Area	70A	X		
Surface Coating and Printing	74	Paint spray booth	76	X	X	Liquid Separator
	96	Paint spray booth	77		X	Dry Filter
	147	Epoxy Mixing Hood	53	X		
Surface Preparation and Cleaning	38	Ultrasonic cleaner	53	X		
	92	Vapor/spray degreaser	77	X	X	Refrigeration
	97	Sandblast booth	77		X	Baghouse, Shaking
	130	Solvent cleaning, 60 gal/yr. net	77			
	140	Vapor degreaser	52	X		
	141	Ultrasonic degreaser	76	X		
	166	Sandblast booth	71B	X	X	Baghouse, Simple
	172	Wipe-cleaning	52	X		
	173	Wipe-cleaning	58	X		
	174	Wipe-cleaning	62	X		
	175	Wipe-cleaning	77	X		
	176	Wipe-cleaning	80	X		
	177	Wipe-cleaning	88	X		
	178	Wipe-cleaning	16	X		
	179	Wipe-cleaning	25	X		
	180	Wipe-cleaning	46	X		
	181	Wipe-cleaning	53	X		
	182	Wipe-cleaning	2	X		
	183	Wipe-cleaning	66	X		
	184	Wipe-cleaning	70A	X		
	185	Wipe-cleaning	1	X		

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BAAQMD continued the ongoing task of modifying its rules to implement federal and state laws and regulations. In 1995, the BAAQMD Board of Directors approved changes to 25 existing rules and dropped one rule from its list.²² The list included three permitting rules: general requirements, new source review, and major facility review. The changes in permitting were the result of streamlining efforts. Four changes in this group will have impact on permitting activities at LBNL:

- An exemption added for sources not subject to other rules, provided emissions remain below specified limits. At a research facility where many operations or equipment do not fall into well-defined source categories, this can serve as a catch-all exemption.
- An exemption added for laboratory buildings provided they contain less than 25,000 square feet of total laboratory floor space or less than 50 fume hoods, and follow what BAAQMD defines as Responsible Laboratory Management Practices. All of LBNL's buildings are below the space thresholds. The responsible practices defined in the regulation include closing containers of volatile toxic organic compounds when not in use, training of laboratory employees, posting with reminders on fume hoods, and periodic testing of a fume hood's face velocity.
- Reduced permit review time from 30 to 21 days for completeness determinations and from 60 to 49 days for issuance of Authority-to-Construct permits.
- Additional clarification on the major facility review or Title V permit requirements. This issue will be discussed in a separate section below.

Most of the other modified rules were in the District's organic compound regulation. The most significant change was the shift in designation class for two substances, acetone and parachlorobenzotrifluoride, from precursor organic compound to that of non-precursor organic compound. This change

came in response to a determination made by US/EPA in June that these substances had negligible effect on the formation of photochemical smog or ozone.²³ Acetone is used in various activities at LBNL, including permitted sources with conditional limitations on precursor and non-precursor organic compound usage.

Transportation Programs

1995 represented the last year for mandated employer trip reduction regulations in the Bay Area in their present form. BAAQMD's Regulation 13-1, and similar rules adopted by air quality management districts across the state to meet state air quality standards, were declared illegal with the passage of Senate Bill 437 during the 1995 California legislative session. The effective date under the new law for terminating such trip reduction regulations was January 1, 1996. Prior to SB437,²⁴ the BAAQMD rule targeted companies with more than 100 employees, requiring them to designate an Employee Transportation Coordinator and an Employer Program Manager, conduct surveys of employee commuting styles, and develop a trip reduction plan if survey results fell short of performance values.

LBNL satisfied its 1995 regulatory obligations for the transportation control measure by submitting an Employer Trip Reduction Plan for the site on July 18. The need to prepare this plan was initiated by the results of an employee transportation survey of November 1994 required by the regulation. The survey's calculated vehicle-to-employee ratio of 0.84 did not meet the targeted performance value of 0.79 for employees arriving on site during normal commute hours. BAAQMD approved Berkeley Lab's plan on August 23. Berkeley Lab does not face any further requirements under this regulation. As of this writing, BAAQMD has not yet proposed an alternative trip reduction rule.

In a separate transportation control program arising from the 1991 passage of Assembly Bill 434,²⁵ the Laboratory applied for and received a matching grant for its shuttle bus

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program under the BAAQMD's Transportation Fund for Clean Air program. This program is intended to fund transportation projects that effectively achieve emission reductions from motor vehicles. Funds for the program come from a surcharge on motor vehicle registration fees. The portion of the LBNL shuttle bus service covered under the funding includes the connector services to the City of Berkeley Downtown and City of Oakland Rockridge Bay Area Rapid Transit stations. The duration of the grant is for two years, starting in January 1996, and will cover about 30% of the cost of the shuttle bus program.

Title V Operating Permit

Efforts to improve implementation of the Title V operating permit requirements created by the Clean Air Act Amendments of 1990 continued in 1995, with even more changes expected in 1996. As the local administering agency of most federal and state air quality laws for stationary sources, BAAQMD has attempted to integrate Title V's new facility-wide permitting requirement with their long-standing permitting system. BAAQMD has worked closely with US/EPA to develop a single permit system that meets federal and state requirements.

BAAQMD approved an updated *Major Facility Review* regulation in April. The present regulation includes two permitting tiers: major facility and synthetic minor facility. Major facilities are those having the potential-to-emit more than 9,100 kilograms (10 tons) per year of a single hazardous air pollutant, more than 23,000 kilograms (25 tons) per year of all hazardous air pollutants, or more than 91,000 kilograms (100 tons) per year of any regulated air pollutant. Synthetic minor facilities are major facilities that accept facility-wide federally-enforceable permit conditions that keep emissions below these levels. Potential-to-emit is one of the key terms in both the regulation and the law. It has also been highly controversial, because the permit programs in effect for many years

throughout California are designed around a source's actual emissions. Potential-to-emit is defined as the maximum capacity to emit a pollutant based on physical and operational design. Typically, this assumes around-the-clock operation for the entire year at full operational capacity. In January, US/EPA and the state reached an agreement to let California air districts use actual emissions as a substitute for potential-to-emit.²⁶ This agreement characterizes facilities as major if actual emissions exceed 50% of the limits stated earlier. Facilities exceeding the Title V permitting thresholds generally have until November 1997 to prepare and submit this application. The facility-wide air emissions inventory for the Laboratory prepared for the 1995 BAAQMD permit renewal and presented in Table 3-9, estimates the following quantities of pollutants, all of which are below the thresholds for filing a Title V permit.

In other Title V developments, US/EPA released two policy papers designed to ease both the permitting requirements and the permitting process. The two papers provided interpretation and guidance on issues raised by administering agencies and the regulated community. The first US/EPA White Paper,²⁷ issued on July 10, had a national market for its policies, provided the agency's opinion on issues such as identifying insignificant sources, grouping activities, testing of emissions, and identifying applicable requirements in relevant State Implementation Plans. In March 1996, US/EPA issued a second guidance document, the California White Paper,²⁸ intended to address the unique characteristics created by the state's pre-existing permit program, and was designed to further simplify the Title V process. The California White Paper offers relief to BAAQMD as the reviewer of Title V permits, and to facilities preparing these permits. BAAQMD has yet to modify its Major Facility Review rule in light of these developments. However, BAAQMD has announced a tentative schedule to consider a Title V exclusion rule during the second quarter of 1996. It is anticipated that this new

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Table 3-9. Comparison of Annual Emissions from LBNL with Title V Major Source Requirements.

Pollutant	Title V Major Source Threshold (kg)	LBNL Estimated Emissions (kg)
<i>Regulated Air Pollutants</i>		
Carbon Monoxide	91,000	2,300
Nitrogen Oxides	91,000	9,100
All Organic Compounds	91,000	1,500
Particulate Matter	91,000	160
Class I Ozone-Depleting Substances	91,000	1,230
<i>Hazardous Air Pollutants</i>		
All Hazardous Air Pollutants	23,000	3,200
1,1,1-trichloroethane	9,100	1,225

rule will add a third permit tier. The new prohibitory permit category will set *de minimis* levels below which a facility is exempt from any Title V requirements. Initial indications are that the *de minimis* levels would be set at 50% of the potential-to-emit values. Whichever permitting option LBNL elects to pursue, the facility will be required, at a minimum, to keep additional sitewide records to justify the selected category.

Adhesive and Sealant Products

Changes in the BAAQMD adhesive and sealant products rule, Regulation 8-51, took effect at the beginning of 1995. This rule called for stricter limitations on volatile organic compounds (VOC) emissions from a wide range of adhesive and sealant products. The rule also required monthly facility-wide use records, unless a facility had an approved alternative plan. In February 1995, LBNL submitted an alternative record keeping plan to BAAQMD. LBNL proposed that it would integrate its record keeping obligations into the site's Chemical Inventory Database. This database is a comprehensive sitewide hazardous material tracking system that is now capable of serving air quality, waste minimization, and other environmental needs as well. Additional details on this system can be found in the *Hazardous Materials* section later in this chapter. BAAQMD approved the

LBNL alternative plan on April 4, 1995. Key requirements in the LBNL plan include reporting adhesive and sealant usage with the annual renewal of BAAQMD permitted sources, determining average monthly usage using the Chemical Inventory Database, and maintaining VOC information on adhesive and sealant products purchased. Berkeley Lab made changes to the structure of this database in 1995 to adapt to these additional requirements.

Ozone-Depleting Substances

The Clean Air Act Amendments of 1990 also established a timetable for the production phaseout of ozone-depleting substances (ODSs). The amendments allow for the purchase and use of ODSs beyond the production phaseout deadlines. ODSs are divided into two categories based on a substance's ozone-depletion potential: Class I and Class II. The production phaseout date for Class I was the end of 1995. Class II products have staggered phaseout dates beginning in 2005. LBNL established an aggressive program for eliminating or reducing its ODS usage in solvent cleaning, packaging materials, refrigeration and air conditioning, and fire suppression operations in response to requirements of Title VI and other mandated requirements (see Executive Order 12843 later in this section). LBNL's

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Figure 3-2. Total Class I ODS Usage from Active Sources

ODS reduction program is designed to comply with US/EPA's Significant New Alternatives Policy (SNAP)²⁹ program for ODSs. Using 1991 as a baseline, LBNL has reduced its Class 1 ODS usage by about 70% (see Figure 3-2). Usage refers to both reductions in emissions from open systems such as vapor degreasing systems and inventory contained in closed systems such as building-wide centrifugal chillers. Usage does not include the approximately 3,200 kilograms of halons from fire suppression systems that are currently in surplus storage or in critical systems for which cost-effective alternatives do not yet exist. DOE has had a moratorium in effect since 1990 on new halon installations. Another 35% drop from the 1991 baseline usage is linked to three projects with expected completion dates in 1996.

Since the progress reported in the 1994 *Site Environmental Report*, the Laboratory has accomplished the following:

- Purchased a replacement cleaning system for the largest vapor degreasing system on site. The replacement system is presently being manufactured. It is designed to

handle a variety of aqueous and semi-aqueous cleaning products, all considered non-ODS.

- Received funding for fiscal year 1996 to replace an additional operational vapor degreasing system on site.
- Converted the remaining centrifugal chiller in Building 2 to an acceptable alternative refrigerant.
- Funded conversion of one of the two remaining centrifugal chillers on site, both in the Building 50 complex, for fiscal year 1996.
- Funded conversion, also in fiscal year 1996, of the contained ODS gas serving as the dielectric constant in a large research electron microscope to a non-ODS alternative.

The new accomplishments, along with earlier ones (replacing solvent cleaning systems, converting centrifugal chillers and research equipment, installing and converting refrigeration and freezer systems, and installing leak detection sensors in key workrooms on site), have significantly

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reduced the Laboratory's pending compliance obligations under the stratospheric ozone depletion regulations, as well as the risk of ozone depletion to the environment.

Executive Order 12843, "Procurement Requirements and Policies for Federal Agencies for Ozone-Depleting Substances"

This Executive Order³⁰ was signed in early 1993. It focuses on a limited aspect of the ozone-depleting substance regulations derived from the Clean Air Act Amendments. This order required that each federal agency submit a report to the Office of Management and Budget (OMB) on its plan to reduce and phase out both the procurement and use of substances that cause stratospheric ozone depletion. DOE's report, submitted in November 1993, identified efforts in four main usage areas: refrigeration and air conditioning, fire protection, solvent cleaning, and miscellaneous uses. Concurrently, DOE distributed a document entitled *Refrigerant Management Plan for Department of Energy Facilities*³¹ to all DOE sites; the document provided guidance on the largest usage area affected by this order: refrigeration and air conditioning. LBNL's refrigerant management program, first started in early 1993, is consistent with DOE guidance. The LBNL program prioritizes operations based on quantity of ODS, age of unit, and unit-specific maintenance history. LBNL has also implemented purchase restrictions on certain classes of ozone-depleting substances.

DOE Orders

DOE Order 5400.1, "General Environmental Protection Program"

This DOE Order sets environmental protection program requirements that assure compliance with appropriate federal, state, and local environmental laws and regulations. Codification of the radiation protection aspect of this order and DOE Order 5400.5 into pending regulation 10 CFR 834, *Radiation*

Protection for the Public and Environment,³² began in 1993. Delays have set back the targeted promulgation date until later in 1996. The most recent delay was caused by addition of a new section to the rule, *Radiation Protection of Terrestrial Animals and Plants*. DOE was still receiving public comments on this section in early 1996. When promulgated, this regulation will create additional impact on environmental radiological protection activities at LBNL. The most notable new requirement is the preparation of an *Environmental Radiological Program Plan* (ERPP). This plan will serve as a key reference resource for all program-related materials, such as specific procedures and planning documents. LBNL will have a year to develop this plan after the effective date of the rule, and another six months to have the plan approved by DOE and implemented on site. In anticipation of this change, LBNL has prepared an Activity Data Sheet under the 5-year ES&H Management Plan to address the new requirements. LBNL has also worked closely with the DOE Oakland office and other DOE laboratories to exchange information and share resources for the preparation and implementation of the ERPP. It is anticipated that this strategy will lead to a cost-effective and consistent interpretation and implementation of the regulation across the entire DOE system.

Under the DOE Order, LBNL submitted all reports in 1995 as required. Included in this list are the 1994 *Site Environmental Report* (annual) and the *Environmental Monitoring Plan* (triennial).³³ DOE approved the 1994 *Site Environmental Report* by the June 1, 1995, deadline. DOE completed its review and approval of the significantly modified *Environmental Monitoring Plan* in January 1996. This plan identifies point source sampling for radiological and nonradiological parameters, and site and offsite ambient air samples for radiological parameters, as well as sampling programs for creeks, hydraugers, rainwater, sanitary sewer, soil, and sediment. This plan was redesigned based on historical measurement results, changes to potential sources, and risk determinations. No monitoring activity was completely eliminated; however, frequency of monitoring

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and locations were reduced in some cases. On the other hand, monitoring surface water from nearby lakes and vegetables from nearby community gardens was added.

Also under this order was a Berkeley Lab corrective action project stemming from a 1991 Tiger Team finding that cited deficiencies in the distribution and number of ambient air monitoring stations. The *Sitewide Radiation Monitoring and Sampling Project* was completed in March 1995. The project added seven new high-volume air samplers strategically located to measure the highest expected concentrations of particulate releases from the Laboratory. Two new gamma and neutron monitoring stations were positioned to detect direct radiation and backscatter from the 88-Inch Cyclotron and the Advanced Light Source.

Environmental Cleanup

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)

CERCLA³⁴ was passed in 1980 for the purpose of regulating actual or threatened releases into the environment. Actions under CERCLA and related statutes include removal and/or remedial action where the release may present an imminent danger, as well as remedial investigations and feasibility studies that determine site cleanup options. Based on information provided by LBNL in 1991, US/EPA determined that site restoration activities at LBNL should not be conducted under CERCLA, but rather under the Corrective Action Program of the Resource Conservation and Recovery Act (RCRA).³⁵ See Chapter 7 of this report for a discussion of LBNL's site restoration efforts in 1995.

CERCLA also has implications for offsite incidents associated with LBNL activities. In 1995, two incidents from previous years

continued to move closer to resolution, while one new incident developed.

The first CERCLA incident involves 13 drums of polychlorinated biphenyl (PCB) waste that had been transported to the North American Environmental, Inc. (NAE) site in Clearfield, Utah, in violation of an agreement between NAE and an LBNL subcontractor. LBNL removed its reported waste from the site following US/EPA protocol prior to the site's official designation as a Superfund site in September 1992. LBNL reported to US/EPA that the removed drums showed no evidence of any release while at the site. According to US/EPA, inventory and removal actions subsequent to the Superfund designation date have been completed, as have all other actions required of the Defense Logistics Agency and Freeport Center under an Administrative Order on Consent. US/EPA's involvement with the NAE site is therefore over, with no further action taken against Berkeley Lab since it removed its reported waste.

The second incident involved the Bay Area Drum (BAD) site, a former drum recycling and reconditioning facility in San Francisco. LBNL's involvement with this site also began in 1992. After the site owners and operators declared bankruptcy, Cal/EPA's Department of Toxic Substances Control (DTSC) targeted former customers of the site to bear the cleanup costs. A Potentially Responsible Parties (PRP) group, including several University of California (UC) campuses, began negotiating with DTSC over the scope of the cleanup. DTSC and the PRP group attributed a number of drums at the site to LBNL, based on oral testimony from a BAD truck driver. LBNL believes that the pickup location described by the driver was actually a University of California at Berkeley campus storehouse. The campus agreed to take responsibility for those drums. During 1995, the UC Office of the President (UCOP) obtained a release and indemnity agreement from the *non-de minimis* PRPs for LBNL and other involved University entities. More

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recently, UCOP signed a consent order with the state Attorney General's Office; UCOP expects the *non-de minimis* PRPs to perform, pursuant to the release and indemnity agreement, anything required of the University entities, including LBNL.

An additional offsite incident involving the Berkeley Lab occurred in December 1995, when LBNL received a *Proposed Finding of Potential Liability Status* letter from the state of Washington Department of Ecology related to a hazardous substances release at the Cameron-Yakima portion of the Yakima Railroad Area site in Yakima. Berkeley Lab recently provided the Department of Ecology with information on eight used carbon drums it had sent to Cameron-Yakima for recycling prior to May 5, 1995. LBNL disputed any contribution to contamination at the site, based on the nature of the material sent and associated shipment dates. These carbon drums, which were used to treat groundwater contaminated with low levels of the solvent perchloroethylene, contained a total of approximately 28.8 grams (0.06 pounds) of this solvent. These shipment dates were after the Department of Ecology became involved in the Cameron-Yakima site and during a period when the Department of Ecology itself sent used carbon to the site, according to Cameron-Yakima records. Nevertheless, the Department of Ecology named LBNL as a Potentially Liable Party in March 1996. This incident will be updated in next year's Site Environmental Report.

Environmental Reviews

California Environmental Quality Act (CEQA)

The California Environmental Quality Act (CEQA)³⁶ is an environmental review process at the state level that, in general terms, is similar to the federal-level requirements presented by the National Environmental Policy Act (NEPA). CEQA's objectives are to help agency officials make decisions that are based on an understanding of environmental consequences of those decisions, and to take actions that protect,

restore, and enhance the environment. Similar to NEPA, it requires the preparation of specific types of documentation for projects proposed, funded, or approved by state agencies or located on state-owned lands.

Under CEQA, a project is classified under one of three levels:

- exempt,
- not exempt; may result in significant adverse environmental effects (prepare an Initial Study or IS), or
- would result in significant adverse environmental effects (prepare Environmental Impact Report or EIR).

During 1995, LBNL conducted CEQA reviews for 400 small-scale research proposals and construction projects. Most of these projects consisted of renewals of ongoing research, and small-scale interior building modifications or routine maintenance activities. These were determined to fall within the scope of the 1992 Supplemental EIR, or were determined to be statutorily or categorically exempt from CEQA. In addition, preparation of an Initial Study was begun for proposed modifications to waste operations at the Laboratory's Hazardous Waste Handling Facility.

Also, the Laboratory continued to implement its mitigation monitoring program for the construction of the Human Genome Laboratory, which was established in conjunction with approval of the 1994 Human Genome Laboratory EIR. During 1995, a total of 23 construction-related mitigation measures were implemented, verified, and documented.

Endangered Species Act (ESA)

The Endangered Species Act³⁷ of 1973 provides a means to protect endangered and threatened species and their ecosystems. LBNL did not conduct any studies in 1995 related to this Act.

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Executive Order 11988, "Floodplain Management"

Under this Executive Order,³⁸ which was last amended in 1979, Berkeley Lab assesses whether or not a proposed project involving DOE-owned or leased facilities, including those on the University of California at Berkeley campus, will occur in a designated floodplain. The last required floodplain assessment was completed in 1994.

Executive Order 11990, "Protection of Wetlands"

Reviewing proposed projects for potential impacts on wetlands is required by this 1977 Executive Order.³⁹ LBNL's main site is not located in a designated wetland area. No new wetlands assessments were performed in 1995. Berkeley Lab conducts wetland reviews for all offsite projects having potential impacts on wetlands. Work on offsite projects proceeds after approval by the sponsoring agency.

Berkeley Lab reviewed two projects of this nature in 1995. The first review was for an Energy and Environment Division project that is investigating whether dredging or sediment disturbance from contamination cleanup activities at Mare Island Naval Shipyard in Vallejo could cause toxic effects in marine organisms. Sponsoring agencies include the Department of Defense, the Office of Naval Resources, and US/EPA.

The second project reviewed concerned an Earth Sciences Division project that is researching the fate and transport of refinery-discharged selenium in the northern portion of San Francisco Bay, and the bioaccumulation of selenium in algae and other plant and animal species. The San Francisco Bay Regional Water Quality Control Board is the sponsoring agency for this project.

National Environmental Policy Act (NEPA)

The main objectives of the National Environmental Policy Act⁴⁰ of 1969 are to help officials of the federal government make decisions that are based on an understanding of environmental consequences of those decisions, and to take actions that protect, restore, and enhance the environment. It requires the preparation of specific types of documentation for activities proposed or funded by federal agencies. Under NEPA, a project is classified as either:

- categorically excluded,
- not categorically excluded but may result in significant adverse environmental effects (prepare an Environmental Assessment or EA), or
- would result in significant adverse environmental effects (prepare an Environmental Impact Statement or EIS).

In 1995, Berkeley Lab conducted NEPA reviews for 400 small-scale research and building modification projects. All but two were determined to be categorically excluded from preparation of an EA or EIS, or were determined to be within the scope of previously-approved EAs. One EA was prepared for modification to Building 51B to install and conduct experiments on a new project called the Induction Linear Accelerator System. DOE issued a Finding of No Significant Impact for the project on September 8.

The second EA was prepared for construction and operation of a genome sequencing facility in the Laboratory's existing Building 64. This project involved modification of 14,900 square feet of Building 64 and construction of laboratory and office space to house human genome sequencing and research on human genetics. During the 45-day comment period on the EA, the California Department of Conservation and the City of Berkeley each submitted comments. The Department of

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Conservation recommended that the document provide geotechnical information of sufficient detail to allow confirmation of conclusions reached regarding the significance of potential impacts from seismically-induced landslides in the project vicinity, and on the seismic performance of the building. In response, Berkeley Lab both provided the requested information in writing to the DOE and revised the EA to include additional detail on these subjects. DOE issued a Finding of No Significant Impact for the project on April 17, 1995.

To address comments from the City of Berkeley, the Laboratory committed to conducting traffic counts at the three Lab gates: once during project construction and once after project construction was complete. The first gate count was conducted over a three-day period in June. The results showed that traffic counts at the gates are well below the 1997 projections established in the Lab's 1992 Supplement to the 1987 Long Range Development Plan EIR (SEIR)⁴¹. For example, the total gate count projection in the SEIR for 1997 is 9,763; the 1995 actual total was 7,115. The results for the peak-hour volumes are also below projections for 1997. The next gate count is planned for February 1996.

National Historical Preservation Act (NHPA)

During 1995, the Berkeley Lab intensified its efforts to complete inventories of its buildings for purposes of determining whether any buildings were eligible for listing in the National Register of Historic Places. Meetings and tours took place with representatives from the California Office of Historic Preservation and the National Park Service. The Laboratory completed historic architectural inventories for six Berkeley Lab buildings, including Building 10 (Accelerator Support Building), Buildings 51 (the External Particle Beam Hall), and 51A (the Bevatron Buildings), and Buildings 74 and 74B (Life Sciences Research Buildings).

Of this list, Buildings 51 and 51A have been found by DOE to meet registry criteria because of their association with the lives of persons significant in the Laboratory's past (National Register Criteria C). Building 51 contained the Bevatron, a high-energy particle accelerator constructed in 1954. Building 51A contained the circular magnet room, shops and offices, and an experimental area. The Bevatron was considered the most productive accelerator in the world during the 1950s and 1960s. Four Nobel Prizes were awarded for particle physics research conducted in whole or in part at the Bevatron during this period

- 1957: Tsung-Dao Lee and Chen Ning, for their work on particle parity.
- 1959: Emilio Segre and Owen Chamberlain, for their work on the antiproton.
- 1968: Luis Alvarez, for his work on particle resonances.
- 1969: Murray Gell-Mann, for his work on "strange" particles.

The scientific careers of Alvarez, Chamberlain, and Segre in particular are associated with the Bevatron. The experiments that led to their Nobel Prize awards were performed at this facility. Lee, Ning, and Gell-Mann were not directly affiliated with the Bevatron; however, experiments conducted by other researchers at the Bevatron contributed significantly to the Nobel prize-winning work of these three physicists.

Formal concurrence of the state Historic Preservation Officer with this finding is currently being sought by DOE.

Hazardous Materials

Emergency Planning and Community Right-To-Know Act (EPCRA)

This Act was passed in 1986 as Title III of the Superfund Amendments and Reauthorization Act (SARA).⁴² The two general areas of the Act establish requirements for emergency

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planning and notification, as well as reporting. These sections of SARA Title III are incorporated into requirements of the California Hazardous Materials Release Response Plans and Inventory Law.⁴³ SARA Title III Section 302 requires notification from facilities handling greater than threshold amounts of extremely hazardous materials. Section 304 requires emergency notifications in the event of certain hazardous-material releases. Section 311 requires that material safety data sheets (MSDSs) be available for all hazardous substances on the site. Section 312 requires that facilities subject to MSDS requirements prepare an annual emergency and hazardous chemical inventory form (Hazardous Materials Management Plan) and an acutely hazardous materials registration form. Finally, Section 313 requires facilities that use, handle, or store more than specified amounts of certain toxic chemicals to report annual emissions. Compliance activities under these sections of the law are summarized in the following sections: *Toxic Release Inventory*, *Hazardous Materials Management Plan*, and *Risk Management and Prevention Plan*.

Toxic Release Inventory

A 1992 DOE Memorandum and Executive Order 12856, *Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements*,⁴⁴ subjected LBNL to the Toxic Release Inventory (TRI) reporting requirements of EPCRA. LBNL and other DOE facilities must submit their completed TRI reports for the previous calendar year to DOE by July 1 of the following year (e.g., the 1994 report was due July 1, 1995). TRI reporting can be separated into two stages: determining usage, and submitting US/EPA Form R. In preparing for the 1995 submission, LBNL determined from site visits and record searches that no TRI chemical use during 1994 exceeded the 4,536-kilogram (10,000-pound) criterion under the law, and thus, no Form R preparation was needed. Four chemicals, each with aggregate sitewide use of more than 454 kilograms

(1,000 pounds), were identified. This was down from seven chemicals exceeding this threshold the previous year. Table 3-10 compares the highest usage levels of the chemicals from the Laboratory's TRI assessment over the last several years. The 1993 assessment only reviewed usage for the seven major chemicals listed. Data for the 1995 report were not available at the time of this writing.

Hazardous Materials Management Plan

The City of Berkeley is the local administering agency for certain hazardous materials regulations pursuant to state law. Although federal sovereign immunity from such regulations has not been waived, Berkeley Lab voluntarily submits a *Hazardous Materials Management Plan*⁴⁵ to the City of Berkeley prior to July 1 of each year. The 1995 Plan included a detailed inventory of containers present on site in various hazardous or regulatory areas of concern (i.e., reproductive toxins, carcinogens, extremely hazardous substances, OSHA hazardous materials equal to or in excess of state threshold levels, and ozone-depleting substances), and annotated floor plans and corresponding hazard lists by LBNL building. Business plan documentation (i.e., emergency plans and procedures and training) was not updated with this year's report; such documentation must be updated every two years, or sooner if significant changes occur. The inventory must be revised annually.

To prepare this inventory, LBNL maintains a sitewide container tracking system using bar-coding technology. Approximately 50,000 individual containers are accounted for in the inventory report, representing in excess of 1,000 individual or aggregate chemicals. Also included in the system is detailed information on physical and regulatory attributes of the chemicals. Prior to preparing the 1995 *Hazardous Materials Management Plan*, EH&S program leads met with LBNL divisions to ensure consistency with regard to

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Table 3-10. Trends in Highest Quantities of EPCRA Toxic Release Inventory Reporting

Substance	1993 (kg)	1994 (kg)
Acetone	475	495
CFC-11	1035	45
CFC-12	180	15
CFC-113	<90	— ²
HCFC-22	— ¹	70
Hydrochloric Acid	— ¹	205
Isopropyl Alcohol	— ¹	315
Methanol	— ¹	145
Nitric Acid	525	645
Sulfuric Acid	4265	2195
1,1,1-Trichloroethane	1715	1565

¹Only seven major TRI chemicals reviewed in 1993

²Usage no longer reported

accuracy and completeness of chemical inventory records. Also, program administrators expanded quality assurance routines to identify discrepancies between database and field inventories, with subsequent efforts to improve and update discrepant information. In related developments that represent how the chemical inventory aspect of HMMP has evolved past its original strict regulatory compliance objective, output reports have been developed that are geared more toward utility, such as hazard reports for specific users, listings of surplus materials for review, and abbreviated emergency response hazard reports for response personnel, as well as uses for other environmental compliance purposes. LBNL has worked closely with the City of Berkeley to increase the functionality and availability of hazard and emergency reports for use on a more routine basis.

The City conducted three inspections in 1995 under the hazardous materials program. No violations were issued from any of the visits. On July 21, the inspector looked at Buildings 46, 53, and 58. Minor issues centering around availability of spill cleanup materials and personnel notification of emergency procedures were reported. These issues were mitigated prior to and verified during the next

City inspection on October 26. This visit included an introductory tour of the upgraded Ultra-High Vacuum Cleaning Facility (UHVCF) in Building 77. Lastly, on December 8, the inspector reviewed issues associated with Building 25, and was given a demonstration of the sitewide chemical inventory program. No issues were noted.

Risk Management and Prevention Plan

Under state hazardous materials management requirements, the City of Berkeley requires a *Risk Management and Prevention Plan* (RMPP) for on site facilities using acutely hazardous materials above certain thresholds. When first addressed by the City in 1992, LBNL exceeded the planning thresholds at the Building 77 Plating Shop for nitric acid, sulfuric acid, sodium cyanide, and potassium cyanide. Subsequent to this initial review, this shop began a major conversion project from a plating operation to a UHVCF, beginning in May 1994. The RMPP was written in the context of the temporary UHVCF, which significantly reduced or eliminated most of the acutely hazardous materials inventory. The permanent UHVCF is expected to have a similar inventory. Once construction is complete and the permanent facility becomes

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operational, LBNL will revise the RMPP as necessary.

Berkeley Lab voluntarily submitted a draft RMPP for the new UHVCF to COB in late 1994. COB and its consultant conducted an inspection of operations covered by the RMPP in November 1994. In response to comments on the draft RMPP and the inspection, LBNL conducted a hazard operability study to identify potential scenarios of consequence from operations at the new facility, as well as an offsite consequence analysis to quantify these scenarios. The results indicated that the worst-case bounding scenario would involve release of a 208-liter (55-gallon) drum of nitric acid, with the concentration at the nearest Laboratory boundary estimated at 33 milligrams per cubic meter (mg/m^3) of air. This is well below the National Institute for Occupational Safety and Health's immediately dangerous to life or health concentration of $262 \text{ mg}/\text{m}^3$ (100 parts per million). LBNL submitted the finalized RMPP in June, with the City of Berkeley certifying this plan as complete on July 14. COB inspected the UHVCF in late October 1995. There were no findings or recommendations generated from this visit.

The last remaining activity required under initial implementation of the RMPP is the need for training of facility staff on the various aspects of the plan. A suitable schedule and mechanism for provision of this training is currently being developed between EH&S and UHVCF staff. The RMPP program will then have advanced from the development phase to the maintenance level.

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

Passed by Congress in 1972, FIFRA's⁴⁶ purpose is to restrict the registration, sale, use, and disposal of pesticides. LBNL has not applied pesticides to the site for several years. The Laboratory initiated a composting program in the summer of 1995, using newly

purchased equipment, a chipper and two mulchers, to produce an estimated 3,060 cubic meters (4,000 cubic yards) of vegetation. Most of the vegetation was French broom that came from the Laboratory's *Maintenance Program for a Fire-Safe Sustainable Landscape*. As a result of this new composting program, LBNL has also stopped using herbicides. The mulch generated by the program is used for on site activities such as weed screening and landscaping, where herbicides were previously used. Use of insecticides is limited to as-needed application in and near buildings by a licensed contractor.

Toxic Substances Control Act (TSCA)

TSCA⁴⁷ became law in 1976. Like many key environmental laws, it has been amended several times since first passage. TSCA is designed to minimize the exposure of human beings and the environment to the many chemical substances and mixtures found in manufacturing, processing, commercial distribution, or disposal activities. TSCA establishes a means of evaluating these products before they are introduced into the marketplace and controlling their use once they are approved for manufacturing. The most prominent substance at LBNL affected by the TSCA regulations is polychlorinated biphenyls.

Under TSCA, regulated PCBs are defined as substances with a concentration greater than 500 parts per million (ppm) of PCBs. In the case of capacitors, only those in excess of 4.1 kilograms (9 pounds) are considered regulated PCBs. Other lesser categories of PCB concentrations are PCB-containing and PCB-contaminated. PCB-containing is defined by TSCA as having a measurable amount of PCB up to 50 ppm, while PCB-contaminated refers to PCB concentrations between 50 and 500 ppm. For comparison, the State of California regulates waste PCBs to less than 5 ppm (for liquids) and for disposal, less than 2 ppm.

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Since the US/EPA program began, LBNL has inventoried and removed all identified as regulated PCB transformers. In-use transformers currently are nonregulated PCB, following an aggressive transformer-oil retrofit program. The remaining sources of PCBs are primarily large, low- and high-voltage capacitors. Approximately 50 of these capacitors are still in use or storage, containing an estimated 192 kilograms (424 pounds) of PCBs. The estimated volume of PCBs in electrical transformers is less than 1 kilogram. Figure 3-3 displays the results of the Laboratory's efforts to eliminate the presence of regulated-PCB transformers and capacitors from the site.

LBNL has a written plan for the management of PCBs on the site. Initial approval of the document and implementation of its provisions were completed in June 1994. As required by TSCA, LBNL prepared an *Annual PCB Activity Document*, which reported inventories and documented PCB-related activities at the site for the previous calendar year. LBNL is not required to submit the document to US/EPA, but it is available to the agency if requested.

In March 1995, the Department of Energy's Oakland Operations Office and Berkeley Site Office conducted a PCB surveillance review of LBNL's PCB management practices and procedures. The review included visits to several buildings on site and an examination of documentation on the program. Several recommendations were made, which LBNL then implemented. These recommendations included creation of a closeout list documenting LBNL's building inspections, and a list of transformers containing between 5 and 50 parts per million of PCBs.

Finally, there were no new inspections by US/EPA in 1995. However, in May, LBNL received confirmation from US/EPA that inspections conducted in 1990 and 1994 were officially closed. Later, in October, LBNL was notified that Cal/EPA, specifically DTSC would conduct future PCB inspections while acting as US/EPA's lead agency.

Hazardous Waste

Resource Conservation and Recovery Act (RCRA) and California Hazardous Waste Control Law

The primary goal of the Resource Conservation and Recovery Act of 1976 is to assure that hazardous waste management practices are conducted in a manner that protects human health and the environment. RCRA established a large and comprehensive structure of regulatory authority for waste disposal activities in several key areas. The three areas most notably affecting LBNL include hazardous waste, medical waste, and underground storage tanks. RCRA also created a mechanism for establishing viable partnerships between federal and state agencies for carrying out the requirements of the Act. In California, DTSC has received authority from US/EPA to administer the RCRA program. California's regulations in these three areas are also dictated by state statutes.

Hazardous Waste

In addition to administering the requirements for hazardous waste under RCRA, DTSC is responsible for overseeing the regulations originating from the State's Hazardous Waste Control Law.⁴⁸ The California law was initially established in 1973, prior to federal action under RCRA. The California program incorporates the provisions of both the federal and state hazardous waste laws.

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Figure 3-3. Trends in Regulated-PCB Capacitors and Transformers Based on Annual Surveys

The California program includes permitting and enforcement elements. The state's current permitting program for hazardous waste treatment and storage units was last modified in 1993. This Tiered Permitting program consists of five tiers. These tiers, listed in decreasing order of regulatory complexity, are:

- 1) Full permit
- 2) Standardized permit
- 3) Permit-by-rule
- 4) Conditional authorization
- 5) Conditional exemption

LBNL's Hazardous Waste Handling Facility operates under the "full permit" tier of the

program. The permit for the HWHF⁴⁹ was approved by DTSC for US/EPA, under authority granted by the state's Hazardous Waste Control Law. The permit, which allows storage and simple treatment of certain hazardous and mixed (radioactive and hazardous) wastes at the HWHF, was issued on May 4, 1993, and is valid for ten years. Simple treatment includes neutralization, consolidation, solidification, and desensitization. Occasionally, the need arises to modify the permit as a result of the dynamic nature of research activities. Berkeley Lab submitted a request to modify the permit on May 8, 1995, which was approved as a temporary authorization by DTSC on May 17. The modifications requested the following seven provisions:

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- Expand the storage capacity of mixed waste storage unit B75A-7 from 1,666 liters (440 gallons) to 13,325 liters (3520 gallons).
- Increase the maximum storage height of containers in this same storage unit to 2.7 meters (9 feet).
- Convert two storage lockers, units B75M and B75N, from classification as hazardous waste storage lockers to that of mixed waste storage lockers. Unit B75M had stored oxidizers while unit B75N had stored corrosive acids.
- Allow for storage of hazardous wastes (corrosive bases and oxidizers) in unit B75. Corrosive bases had been stored in unit B75G.
- Reclassify unit B75G from storage of corrosive bases to corrosive acids. Corrosive bases would be stored in unit B75F (see above).
- Clarify the description of mixed waste streams stored in units B75A-1 and B75A-2 to include flammable liquids with corrosive bases and flammable liquids with corrosive acids, respectively.
- Allow for storage of corrosive acid oxidizers with radionuclides in units B75A-4 and B75M, and storage of oxidizers with radionuclides in units B75A-5 and B75A-6. Also allow for storage of air- and water-reactive wastes with radionuclides in unit B75A-3.
- Improve the effectiveness of the training plan by eliminating redundancies and modifying frequencies of refresher classes.
- Allow handling and storage from an additional waste stream; elemental mercury and devices containing elemental mercury from LBNL research programs and decommissioning activities. This new waste stream would require no additional or different management practices from those already authorized in the existing permit.
- Remove the high efficiency particulate air (HEPA) requirement for filtered hood exhaust systems at the existing HWHF, because these units do not require HEPA filtration under exposure limits set in federal regulations.
- Modify the waste analysis sampling plan for both the existing and replacement facilities to reflect the use of nonrandom selection methods for certain waste stream samples used to verify generators' waste characterization and comply with land disposal restriction requirements.
- Permit storage of Class 9 (other health hazards) wastes in hazardous waste and mixed waste unit. Class 9 wastes are compatible with and a lower hazard than the other wastes permitted for such units.
- Add the following new mixed waste treatment methods: desensitization (e.g., of air-reactive or water-reactive wastes), filtration, precipitation, phase separation, UV/ozone oxidation, UV/peroxide oxidation, reduction of Class 1 - 3 oxidizers, air-stripping and steam stripping of volatile organic compounds from dilute aqueous solutions, absorption, adsorption, ion exchange, metallic replacement, plating of metal onto an electrode, evaporation, distillation of organics from dilute aqueous solutions, rinsing of empty containers, and mixing of multicomponent resins.
- Add the waste treatment methods described above, but for hazardous wastes, to allow testing of these methods for mixed wastes without the presence of

Originally, the May 17 approval was valid for 180 days, contingent upon the submission by Berkeley Lab of a Class 2 permanent permit modification to DTSC, no later than September 1, 1995. During this period, LBNL identified additional changes that would expand the scope of its Class 2 permanent permit modification application. DTSC agreed to an extension of the temporary authorization for another 180 days, allowing the Laboratory to resubmit the permit modification application as a single package in January, 1996; the package was submitted on January 11. The expanded scope of the permit included the following fourteen requests:

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radionuclides. These treatment tests are necessary for process efficiency and mixed waste management, given the lack of available offsite mixed waste treatment and disposal facilities.

- Add treatment method of neutralization for corrosive liquid mixed wastes for process efficiency and personnel safety reasons at existing Mixed Waste Treatment Unit 131E.
- Modify language in the permit to make it internally consistent and to allow efficient use of the HWHF's permitted mixed waste storage capacity.
- Increase storage capacity for ignitable liquids with radionuclides in unit MW4, at the replacement facility only, from 5000 liters (1320 gallons) to 8325 liters (2200 gallons), given the lack of available offsite treatment and disposal facilities.
- Increase storage capacity for "other health hazards" with radionuclides, at the replacement facility only, in unit MW5 from 4920 liters (1300 gallons) to 8325 liters (2200 gallons), given the lack of available offsite treatment and disposal facilities.
- Eliminate the 415-liter (110-gallon) capacity mixed waste storage unit for highly toxic mixed wastes, at the replacement facility only, and replace with a 275-gallon capacity prefabricated hazardous materials storage building for highly toxic, toxic, and other health hazard mixed wastes. This change is necessary to accommodate mixed waste inventory, given the lack of available offsite treatment and disposal facilities.
- Increase the treatment capacity for neutralization, desensitization, and consolidation in units 131FH and HW7 and consolidation and neutralization in units 131AFH and MW6 from one gallon to 6 gallons per treatment to allow greater operational efficiency while keeping maximum daily treatment capacities for

these methods in these units at presently permitted levels.

- Delete the existing HWHF closure requirement to fully close all of the hazardous and mixed waste storage units presently permitted at the existing facility to improve the efficiency of the transition to the replacement facility. Certain units would be inspected for contamination and relocated to the replacement facility for further use without full closure if they are not contaminated.

Since the permit modification request was submitted to DTSC, a required public meeting on the permit modifications and a public hearing under CEQA took place. Originally, DTSC expected to grant a decision on the permit modification request by May 12, 1996, when the extended temporary authorizations expired. However, DTSC has requested additional time to comment on the public comments received from the public meeting and public hearing. As a result, DTSC issued a consent order that allows the HWHF to operate outside of its existing permit conditions. The consent order outlines operating conditions for the Laboratory's HWHF between May 12, 1996 and the time when DTSC makes a decision on LBNL's modification request.

LBNL has additional hazardous waste authorization to operate five fixed treatment units (FTU) (Table 3-11) that support various programs at the Laboratory. Each of these treatment units is located outside the HWHF. Three of these FTUs are authorized for operation under the "conditional authorization" tier. Two FTUs are authorized to operate under the "permit-by-rule" tier. LBNL renews this permit with DTSC for these units annually by March 1. The Laboratory submitted the 1995 renewal package to both DTSC and the City of Berkeley. LBNL identified only one process change in the renewal. Specifically, the Building 77 fixed treatment unit (FTU 001) discontinued treating cyanide rinse water,

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Table 3-11. LBNL's Fixed Treatment Units Subject to Tiered Permitting During 1995

Building	FTU	Description	Permit Tier
77	001	Aqueous waste containing metals and inorganic acid	Permit-by-Rule
25	002	Aqueous waste containing metals and inorganic acid	Permit-by-Rule
76	003	Oil mixed with water	Conditional Authorization
70A/70F	004	Inorganic acid	Conditional Authorization
2	005	Inorganic acid	Conditional Authorization

since cyanide was eliminated from the upstream process.

Additionally, construction work began in 1995 on upgrading a separate, inactive treatment unit at Building 77. This other unit will be capable of processing wastewater at 227 liters per minute (60 gallons per minute). The source of the process wastewater will be the Ultra High Vacuum Cleaning Facility. Startup of this treatment unit is expected in 1996. LBNL will file a permit amendment prior to the startup date of the new FTU. The present FTU at Building 77 is expected to remain operational, serving as a backup to the new treatment unit.

DTSC conducted two separate inspections of the Laboratory's hazardous waste management program in 1995. The first inspection occurred on February 22; the agency reviewed HWHF operations and several of the waste management programs, including fixed treatment unit and satellite accumulation area programs. DTSC reported no violations for this inspection. Later in the year, DTSC again inspected LBNL's hazardous waste management program during the three-day period in August. DTSC also reported no violations in hazardous waste programs after inspecting the five fixed treatment units and various waste and satellite accumulation areas. This marked the third consecutive inspection by DTSC with no violations in the hazardous waste program. However, on October 27, DTSC issued an inspection report alleging three violations for mixed waste shipments to disposal facilities in

Richland, Washington. DTSC had been contacted by the Washington State Department of Ecology regarding the alleged incidents. The three alleged violations include: 1) incompatible storage of wastes in mixed waste lab-packed drums; 2) inaccurate inner container counts in mixed waste lab-pack drums; and 3) failure to label containers of non-RCRA mixed waste. On December 11, the Laboratory requested that DTSC drop all three alleged violations, noting that all three issues concerned mixed waste, the management of which is still evolving because of the regulatory and technical complexities involved in managing concurrently both the hazardous and radioactive components. The Laboratory also requested a meeting with DTSC to discuss the inspection report. The meeting took place in January 1996. LBNL has submitted additional information on the three alleged violations. Discussions continue, but as of this writing, no final report had been issued by DTSC on the alleged mixed waste violations.

The Hanford facility normally receives LBNL's mixed waste for treatment, storage, and disposal. Several incidents during the year involved Hanford-related activities. In February 1995, Hanford raised an issue on chemical compatibility with respect to certain mixed waste streams shipped from LBNL in May and September of 1994. An area of the Hanford facility had been shut down because of waste chemical compatibility concerns on four Berkeley Lab lab-pack mixed waste drums. In two drums, inner bottles containing an oxidizer, nitric acid, were packaged with

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other inner bottles containing organics such as ethyl ether and isopropyl alcohol. Later, the concentration of nitric acid was found to be below the Department of Transportation oxidizer definition. Therefore, there appeared to be no issue with respect to the potential incompatibility of an oxidizer (nitric acid) with organics. The remaining two drums contained mineral acids. The lab packs within the drums held containers of single mineral acid solutions that included hydrofluoric, hydrochloric, nitric and perchloric acids. The dilute nature of the acids indicated that gas generation and the resultant pressure buildup due to generation of aqua regia (three parts concentrated hydrochloric acid and one part concentrated nitric acid) was not an issue. None of the containers of individual acid solutions nor the containers of acid mixtures contained the required concentrations for formation of aqua regia.

In April 1995, Hanford raised a separate issue on a discrepancy involving two drums of mixed waste shipped from LBNL. The discrepancy centered on the number of inner bottles shipped and the number recorded on the shipping papers. A drum of lab-packed mixed waste acids was found to have fifteen inner containers, while the packing slip listed nine. Another drum of lab-packed mixed waste acids was found to contain 39 inner containers, instead of 42 listed on the packing slip. LBNL issued occurrence report SAN--LBL-EHS-1995-0004 on April 25 in response to the findings referenced in an occurrence report submitted by Hanford on February 20 (RL--WHC-SOLIDWASTE-1995-0004; potential storage of incompatible mixed waste). At the time, LBNL could not resolve the discrepancy between the packing slips and the container count. As a first and immediate corrective action taken by Berkeley Lab, the Hanford facility will review shipment paperwork much more extensively prior to a shipment. Berkeley Lab also enhanced its waste characterization program, and established a system of greater accountability from the generator to the final treatment, storage, and disposal facility. Finally, in May,

Hanford informed LBNL that they would perform increased quality assurance and quality control (QA/QC) procedures on certain mixed waste shipments transported to their facility. Furthermore, Hanford would not accept LBNL mixed waste shipments until the QA/QC process is complete. This entire process was expected to take approximately eight months. Thereafter, LBNL submitted an application to DTSC for the temporary authorization, described above, to allow LBNL to store increased amounts of mixed waste during the temporary shipping moratorium. As of this writing, the shipping moratorium remained in effect.

As a result of the Hanford incidents, there were three external audits of the hazardous waste management program by non-regulatory affiliations in 1995. Between April 19 and 21, LBNL requested assistance from Los Alamos National Laboratory (LANL) and Lawrence Livermore National Laboratory (LLNL) to conduct an independent review of apparent noncompliance issues associated with the shipment of RCRA mixed waste drums to Hanford. The LANL/LLNL team reached a consensus that the root causes of the cited discrepancies were inadequate planning that did not allow adequate time to accomplish tasks correctly, inadequate oversight resulting in a lack of formality of operations, and inadequate quality assurance in operations. A contributing causal factor that should be considered was inadequate regulatory training. The LANL/LLNL team found no indication of intentional, willful misconduct. From April 26 to May 2, the DOE Oakland Operations Office conducted a review of LBNL's waste management operations. DOE/OAK submitted a review report on May 17. In response to this report, LBNL prepared a corrective action plan, addressing all of DOE/OAK's concerns on waste traceability, waste characterization, and personnel training. Finally, as part of the November DOE Pilot ES&H Oversight Appraisal (see *Updates on Non-Regulatory, Multiprogram Reviews* later in this chapter), DOE/OAK evaluated LBNL's radioactive waste management program. The

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review raised issues on instrument calibration, design control, non-conformance reporting, quality assurance, waste characterization, packaging, procedures, sampling, and document control. As of this writing, LBNL's efforts in completing corrective actions in response to both DOE reviews are continuing. Completion of all corrective actions is expected by June 1, 1996.

The Waste Management Group has made several organizational structure changes since these mixed waste incidents. The main change was bolstering its mixed waste certification efforts by increasing the number of full-time staff from 1 to 3.5. The new staffing level now constitutes the Certification Team.

LBNL prepared the *Annual Hazardous Waste Report for 1994*⁵⁰ in March 1995. The report was submitted to DTSC, with a copy to RWQCB. It contains specific generator and transport information for all activities at the Hazardous Waste Handling Facility during the reporting year. The Waste Management Group also submitted quarterly reports to DTSC on the Laboratory's mixed waste inventory, as a compliance requirement of LBNL's HWHF permit. The group prepared the *Mixed Waste Site Treatment Plan* (STP),⁵¹ which DTSC approved on October 6. Henceforth, LBNL will be bound by the procedures and conditions outlined in the STP in managing its mixed waste streams. LBNL also prepared the *Annual Waste Reduction Report*⁵² for the previous calendar year. This report was submitted to DOE. It contains a detailed analysis of waste minimization efforts

made by waste generators.

During 1995, the HWHF received and shipped for offsite disposal over 210 metric tons of total hazardous waste. Just over 0.1 metric ton of hazardous mixed waste was shipped during the year. The HWHF received about 6.25 metric tons of radioactive waste, of which less than 0.9 metric ton was in the form of mixed radioactive waste.

Table 3-12 shows the total radioactivity content of radioactive and mixed (hazardous and radioactive) waste generated at Berkeley Lab in 1995, as well as the total inventory of radioactive and mixed wastes in storage at the HWHF at the end of 1995. The radioactive isotopes are subdivided into two categories: tritium and other isotopes.

Several regulatory developments in 1995 at both the federal and state levels affect the LBNL waste management program. In federal actions, beginning in May, US/EPA published the final rule on universal waste.⁵³ This rule lessens the regulatory restraints on batteries, certain recalled/unused pesticides, and mercury-containing thermometers and thermostats. In August, US/EPA teamed with the Nuclear Regulatory Commission (NRC) to jointly publish draft guidance on the storage of mixed waste.⁵⁴ The purpose of this draft guidance is to assist mixed waste generators forced to store their mixed waste on site, pending the development of adequate treatment and disposal capacity for commercially generated mixed waste, and to point out areas of flexibility within NRC and US/EPA regulations that relate to the storage

Table 3-12. Radioactive and Mixed Waste Generated in 1995 and in HWHF Inventory

	Radioactive Waste (Bq ¹)		Mixed Waste (Bq ¹)	
	Inventory	1995 Generation	Inventory	1995 Generation
Tritium	1.95 x 10 ¹⁴	1.95 x 10 ¹⁴	6.44 x 10 ¹³	6.18 x 10 ¹³
Other isotopes	3.20 x 10 ¹⁰	1.48 x 10 ⁹	5.25 x 10 ⁹	8.51 x 10 ⁸

¹ 1 Becquerel (Bq) = 2.7 x 10⁻¹¹ curies (Ci)

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of mixed waste. Finally, in early December, US/EPA proposed the Hazardous Waste Identification Rule (HWIR),⁵⁵ to be incorporated into 40 CFR parts 260, 261, 266, and 268. As proposed, this rule would establish regulatory thresholds for 400 hazardous waste constituents, helping to remove "low risk" waste from RCRA regulation. There are two major components to this rule. First, the process waste component would replace the current "mixture" and "derived from" rules pertaining to solid waste. Second, the contaminated media component proposes a bright line regulatory threshold above which the contaminated media is regulated as RCRA hazardous waste to be treated by specific technologies; contaminated media below the "bright line" thresholds would be exempt. Any impact on LBNL from this proposed HWIR is at least two years away, as the final rule, when promulgated, must first be adopted by DTSC into its regulatory program.

At the state level, DTSC commenced its Regulatory Structure Update (RSU)⁵⁶ in June. The purpose of the RSU is to update DTSC's non-RCRA hazardous waste management policies and regulations that are overly restrictive or burdensome and do not provide additional protection of public health and the environment. The RSU process is organized to ensure public input, but it is not a public decision or consensus-building process. The RSU has a two-year time frame and will conclude by June 1997. In September, Cal/EPA proposed regulations based on SB 1082, the final Certified Unified Program Agency (CUPA) legislation.⁵⁷ Under this program, by January 1, 1997, each California regulated entity will receive oversight from only one regulatory agency in six major environmental program areas:

- Hazardous waste generator program and hazardous waste generator on site treatment activities authorized under permit-by-rule, conditionally authorized, and conditionally exempt tiers,
- Aboveground storage tank program,

- Underground storage tank program,
- Hazardous Materials Release Response Plans and Inventory Programs,
- Risk Management and Prevention Program, and
- Hazardous Materials Management Plans and Hazardous Materials Inventory Statement requirements.

As written, the proposed regulations may result in increased fragmentation at regulated entities that have a facility physically located within the jurisdictional boundaries of more than one CUPA, such as Berkeley Lab. The City of Berkeley and the City of Oakland have applied for CUPA designation.

On October 15, 1995, the California Assembly and California Senate passed the Hazardous Waste Management Reform Act of 1995 (SB 1222).⁵⁸ This Act consisted of many changes. It narrowed the definition of non-RCRA hazardous waste, by eliminating a number of chemicals, ranging from acetic acid to sodium carbonate, from regulation as non-RCRA hazardous waste due solely to the characteristic of acute oral toxicity. Also, the broader definition of hazardous waste in the California Health and Safety Code was replaced with a definition that centered on specific tests, procedures, and thresholds. Other significant changes involved tier permitting facilities', Phase I environmental assessment requirement, and reduction in hazardous waste disposal and permit modification fees.

RCRA Corrective Actions Program — Site Environmental Restoration

The environmental restoration program (ERP) at LBNL is conducted under the RCRA Corrective Action Program. Requirements for this program are included in the RCRA permit for the Hazardous Waste Handling Facility. The *RCRA Facility Investigation (RFI) Work Plan*, first submitted to DTSC in November 1992, outlined the planned scope of work for site investigation and specified (1) areas

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requiring further site characterization to define the extent of contamination and identify sources, and (2) areas where no further action was needed. LBNL submits *RFI Workplan Addenda* to regulatory agencies prior to the initiation of specific site activities. LBNL submitted three *Workplan Addenda* in 1995 to the City of Berkeley for monitoring well construction, and abandonment or upgrading of slope stability wells.⁵⁹ Four *Workplan Addenda* were submitted to DTSC during the year for soil investigation activities.⁶⁰

ERP maintains a proactive interaction with community relations and program stakeholders. Stakeholder agencies include the State Water Resources Control Board (SWRCB), the Regional Water Quality Control Board (RWQCB), the Environmental Management Branch of the California Department of Health Services (DHS), the City of Berkeley, and DTSC. The program holds quarterly meetings with regulators where the status of performed and planned environmental restoration activities are discussed. Quarterly meetings were held in February, April, July, and October. Representatives of DTSC, SWRCB, RWQCB, the City of Berkeley, DHS, University of California, and DOE attended. Quarterly progress reports were sent to DTSC, DHS, SWRCB, RWQCB, and the City of Berkeley. The ERP also holds technical working group meetings with RWQCB, SWRCB, DTSC, and the City of Berkeley. The meetings give the agencies a detailed description of results from program field investigations, and facilitate agency involvement in planning upcoming activities. Nine meetings occurred in 1995: March, April (2), May, June, July, August, October, and December. LBNL updated program activities at the City of Berkeley's Community Environmental Advisory Commission meeting on August 3, and presented the draft environmental health risk assessment on tritium released by the NTLF at the October 5 meeting. This risk assessment⁶¹ was submitted to regulatory agencies for their review and comment also on October 5.

The program prepared several other reports in 1995 for agencies involved in the program.

The Laboratory submitted a proposed protocol to DTSC for determining background concentrations of metals in soil at LBNL on August 1. The *Draft RCRA Facility Investigation Phase II* progress report⁶² was submitted to DTSC, RWQCB, and City of Berkeley for review in November. The Report documents ERP activities from July 1994 through June 1995. The *Draft Final RCRA Facility Investigation Workplan (Phase III)*⁶³ was submitted to regulatory agencies (DTSC, RWQCB, City of Berkeley) for review in October 1995. The workplan specified investigations planned for the period October 1995 through September 1996.

The following paragraphs describe some of the ERP's highlighted activities from the past year.

Trenching activities between Buildings 51 and 64 on November 18, 1994 unearthed an area of soil contaminated with elemental mercury. Trenching work was halted, the area cordoned off, and cleanup efforts begun. LBNL contacted the City of Berkeley, the state Office of Emergency Services, DTSC, and the National Response Center about this discovery. During cleanup activity in 1994, 21 drums of contaminated soil were removed from the area until instrumentation could no longer detect the presence of mercury. Additional investigations at the site were temporarily halted because the heavy rainfall could potentially spread contaminants if more soil were exposed. In May 1995, the west side of a buried catch basin was uncovered, and an additional 60 drums of contaminated soil were removed until instrumentation could no longer detect the presence of mercury. Based on agreement from DTSC, the site was backfilled with clean soil and covered. LBNL's investigation concluded that the mercury apparently entered the soil between a 20-centimeter-thick (8-inch) concrete slab and the wall of the buried catch basin. This area was designated an area of concern under the RCRA Corrective Action Program and a request has been made to DTSC for a determination of no-further-investigation (NFI) status.

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On January 6, 1995, while correcting a floor drain connection in the basement of Building 71, mercury was detected in the drain pipe. A small amount of mercury was released from the pipe to the soil when a section of pipe was removed. This resulted in the removal of approximately 16 drums of contaminated soil from the area until instrumentation could no longer detect the presence of mercury. The remaining mercury in the pipe was collected by flushing the pipe with water. Sampling and excavation took place between January 20 and March 13, 1995. This area was designated an area of concern under the RCRA Corrective Action Program, and NFI status for the area has been requested from DTSC. This incident was filed under the DOE occurrence reporting program as SAN--LBL-EHS-195-0001.

Also in January, when replacing an emergency electrical generator on the northeast side of Building 77, LBNL detected soil contaminated with diesel under the generator's concrete pad. Low concentrations of TPH-D (110 mg/kg and 14 mg/kg) were detected in two of the seven samples collected beneath and adjacent to the generator pad after the base rock was excavated. A total of 17 drums of contaminated soil was excavated and disposed. This area was designated an area of concern under the RCRA Corrective Action Program, and a request has been made to the City of Berkeley for a determination of NFI status.

On August 12, a sump that was responsible for soil and groundwater contamination in the Old Town area of LBNL was removed. Perchloroethylene (PCE) was detected at a maximum concentration of 14,000 mg/kg in a soil sample collected from a boring at the sump site in June. Highly contaminated soil was removed from an area of about 2.0 meters (6.5 feet) wide by 2.9 meters (9.5 feet) long by 5.2 meters (17 feet) deep. Soil samples collected from the base of the excavation contained concentrations of PCE ranging from 3.2 to 1000 mg/kg. The depth of the excavation was limited, since the

saturated soil below the excavation depth would have made further excavation difficult and a deeper excavation would have threatened the structural integrity of nearby buildings. Approximately 54 cubic meters (70 cubic yards) of contaminated soil were removed and disposed at a Class I landfill. LBNL is planning to install a groundwater collection trench in 1996 to further remediate the site and restrict further plume migration.

A pump located in Room 181 (Hydraulic Gate Unit Pump Room) of Building 88 is used for the hydraulic main vault doors of this building. In June 1994, three concrete samples were obtained from holes cored in the floor of the Building 88 Hydraulic Gate Unit pump room. PCBs (Aroclor-1254) and oil and grease were detected in all three samples. In August 1994, three additional samples were collected at the same locations from construction sand/gravel immediately beneath the concrete floor. PCBs, including both Aroclor-1254 and Aroclor-1242, and oil and grease were detected in all three samples. In February 1995, the concrete slab was removed from an area of approximately 1.1 square meters (12 square feet) in the area of the initial samples, and additional samples were collected. The subsurface profile consisted of concrete, base sand, base rock, and native soil. The base sand and base rock were separated by plastic sheeting. PCB concentrations in the base sand varied between 5000 and 11,000 mg/kg, and the maximum concentration of oil and grease detected was 48,000 mg/kg. The PCB concentrations were 27 mg/kg in the base rock, 5.9 mg/kg in the native soil at a depth of 0.3 meters (1 foot), and 3.3 mg/kg at a depth of 0.6 meters (2 feet). In order to characterize the horizontal extent of contamination, three additional samples were collected in March 1995 from the sand beneath the concrete at distances of between 8 and 30 feet from the removed slab. PCBs were not detected at two of the locations, and the PCB concentration was 0.07 mg/kg at the third location. Oil and grease were detected at two of the sample locations at concentrations of 64 mg/kg and 72 mg/kg, respectively. All

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accessible contaminated sand was removed (3 drums), and the concrete slab was repaired. In April 1995, an additional sample was collected in the pump room near the wall of the gate unit room to the west. The gate unit room itself was active and not accessible for sampling. PCBs (5,700 mg/kg Aroclor 1242 and 430 mg/kg Aroclor 1254) and oil and grease (21,000 mg/kg) were detected. With the building housing an active accelerator, appropriate corrective action will be taken when the accelerator is decommissioned. Since all contaminated material could not be removed from the actions to date, signs have been posted indicating the presence of PCBs beneath the concrete floor.

Medical Waste

The definition of medical waste includes biohazardous waste (e.g., blood and blood-contaminated materials), "sharps" waste (e.g., needles), and other waste produced in research relevant to the diagnosis, treatment, or immunization of human beings or animals, or in the production of biological products used in medicine. No federal regulations govern the management of medical waste at generator sites such as Berkeley Lab. Regulatory authority at these sites has been passed on to individual states. In California, the state's Medical Waste Management Act,⁶⁴ first promulgated in 1991, contains requirements designed to ensure the proper storage, treatment, and disposal of medical waste. LBNL does not treat any medical waste; this is done at offsite vendor facilities. The state program is administered by DHS. There were no significant changes in regulations affecting medical waste management in 1995.

Under the state's program, LBNL is considered a large-quantity generator, since it generates more than 91 kilograms (200 pounds) of medical waste each month. Registration is renewed annually with the state. LBNL completed its annual renewal in November. The new registration number for this permit is 1-423. There were no audits or inspections of the program by outside regulatory agencies in 1995.

The most significant change in the program in 1995 was the implementation of a contract with a new medical waste hauler. The new hauler implemented a bar coding system that provided better tracking of waste back to the specific generator. The hauler offered a more favorable pricing structure that allowed Berkeley Lab to consolidate waste pickup from 13 to 8 sites.

LBNL generates medical waste at about 100 different locations distributed over 12 buildings, including four offsite buildings. In 1995, LBNL shipped about 17,020 kilograms (37,524 pounds) of medical waste off site for treatment either through incineration or steam sterilization. The majority of the waste was treated via steam sterilization prior to disposal at a landfill. About 5% of the waste total underwent incineration. In October, LBNL updated its *Medical Waste Management Plan*⁶⁵ to reflect minor changes in the waste generation quantities, consolidation of pickup sites, and information on the new disposal contractor.

In spite of an approximately 16% increase in the amount of waste sent off site for disposal over the previous year, the disposal costs for medical waste decreased by about 25%. The primary factors for the cost reduction were using a more favorable pricing structure and consolidating pickup sites to avoid minimum pickup charges where possible. Several factors contributed to the increased generation rates: an increased level of research in the Life Sciences Division, and possibly different methods of weighing and reporting waste weights between the new and previous contractors. With the startup of the new Human Genome Sequencing Facility expected in March 1996, an additional increase in generation of medical waste is expected in 1996. On the other hand, this operation is "factory-like" and may present significant opportunities for waste minimization evaluation.

Underground Storage Tanks

In the early 1980s, the State of California first began addressing the serious threat to

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groundwater posed by underground storage tanks (USTs) by establishing a rigorous regulatory and remediation program.⁶⁶ The state requirements for USTs that contain hazardous materials include permitting, construction design, monitoring, record keeping, inspection, accidental releases, financial responsibility, and tank closure. The state program underwent modifications after US/EPA adopted federal regulations for USTs in late 1988 under the provisions of RCRA.⁶⁷ These modifications were needed for the state program to obtain federal approval. The City of Berkeley is the local administering agency for the UST regulations affecting LBNL.

At the beginning of 1995, there were 10 USTs on site (see Table 3-13), all of which were permitted by the City of Berkeley. The operating permits apply to tanks containing diesel fuel, gasoline, or transformer oil. One new UST was installed during this period at the new HWHF (Building 85) site to store diesel fuel for an emergency generator. LBNL has initiated the permit process with the City of Berkeley and is expected to have the permit in place when the building becomes

operational in 1996.

Of the ten permitted tanks operating on site, seven are double-walled and meet the pending December 1998 regulatory standards for construction, monitoring, leak containment, and design of operating tanks. The remaining three tanks have single steel or fiberglass walls and require upgrades to meet the 1998 standards.

The City of Berkeley meets monthly with EH&S staff. Occasionally, UST-related items are discussed, including visits to a UST site. In 1995, the City visited and inspected the new HWHF tank on three occasions from August through October, to witness precision testing and tank construction work. There were no findings during these inspections. There were no other inspections of the UST program during the year.

No tank removal projects were initiated or performed during 1995. One tank removed near Building 74 in November 1994 led to the discovery of contaminated soil, as reported in last year's report. Cleanup efforts required for

Table 3-13. Underground Storage Tank Operating Permits from City of Berkeley for 1995

Registration Tank ID #	LBNL Building #	Stored Material	Capacity liters (gallons)	Construction	Year Installed
Fiberglass tanks, double-walled					
2-1	2	Diesel	15,200 (4,000)	Fiberglass	1988
2-2	2	Diesel	3,800 (1,000)	Fiberglass	1988
[pending]	85	Diesel	9,500 (2,500)	Fiberglass	1995
Double-walled steel with fiberglass plastic corrosion protection					
55-1	55	Diesel	3,800 (1,000)	Glasteel	1986
66-1	66	Diesel	15,200 (4,000)	Glasteel	1987
66-2	66	Diesel	7,600 (2,000)	Glasteel	1987
76-1	76	Unleaded gasoline	38,000 (10,000)	Glasteel	1990
76-2	76	Diesel	38,000 (10,000)	Glasteel	1990
Single-walled tanks					
6	70	Diesel	2,300 (600)	Steel	1953
7	70A	Diesel	3,800 (1,000)	Fiberglass	1975
11	58	Transformer oil	7,600 (2,000)	Steel	1978

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site closure, including groundwater monitoring and reporting, will be performed under the RCRA Corrective Actions Program. Further discussion on this effort is included in the groundwater section or can be found in the detailed quarterly reports published by the ERP.

Pollution Prevention and Waste Minimization

Executive Order 12873, "Federal Acquisition, Recycling, and Waste Prevention"

A key objective of this Executive Order⁶⁸ is to integrate recycled materials into the procurement and acquisition process. The original list of product categories targeted by the order included

- building insulation materials,
- cement and concrete containing fly ash,
- lubricating oils containing refined oil,
- paper and paper products, and
- retread tires.

Berkeley Lab purchased nearly \$280,000 of non-GSA paper products in 1995. Considerably smaller amounts of products were sold in the other categories

This list was amended on May 1 by a Recovered Materials Advisory Notice⁶⁹ published in the Federal Register. The notice added 19 new categories, with recommended recovered materials content levels. The new product categories included paper and paper products, vehicular products, construction products, transportation products, park and recreation products, landscaping products, and non-paper office products. These changes are effective May 1, 1996.

In addition to regular purchases of products of recycled components, the Executive Order mandates that all federal agencies buy printing and writing paper consisting of at least 20% post-consumer material by December 31,

1994, and at least 30% post-consumer material by December 31, 1998. No increase in federal spending on paper products will be allowed under the order. Instead, agencies must compensate for price increases by reducing paper use and waste.

To assist the Laboratory in identifying areas of possible paper use reduction, LBNL completed a study in late 1995 that evaluated patterns in paper use and potential cost savings opportunities. Significant findings of the report included the following:

- identified paper-related costs at Berkeley Lab exceeded \$2 million per year,
- copying remained the dominant office paper use,
- duplexing (double-sided copying) rates at LBNL were significantly higher than national rates, and increased during the study, and
- costs for paper varied widely depending on the paper type.

Hazardous Waste Source Reduction and Management Review Act (SB14).

The California State Legislature passed the Hazardous Waste Source Reduction and Management Review Act⁷⁰ in 1989 (SB14). Although this act is found in the State's Hazardous Waste Control Law, the main emphasis of SB14 is on waste minimization and pollution prevention. In particular, the goals of SB14 are to

- reduce hazardous waste at its source,
- encourage recycling wherever source reduction is not feasible or practicable,
- where it is not feasible to reduce or recycle, treat hazardous waste in an environmentally safe manner to minimize the present and future threat to health and the environment, and
- document hazardous waste management information and make that information available to state and local government.

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LBNL maintains and certifies a two-part report for SB14 compliance: (1) *Source Reduction Evaluation Review Plan and Plan Summary*,⁷¹ and (2) *Hazardous Waste Management Report Summary*.⁷² LBNL updated both parts of the report by the September 1, 1995, deadline. The Plan established a timetable for performing process waste assessments (PWAs) on waste streams that exceeded 5% of the total waste stream from the site. Those waste streams included

- aqueous wastewater treatment effluent,
- waste oil (nonautomotive),
- waste liquids with pH ≤ 2 ,
- spent empty drums larger than 30 gallons capacity,
- waste machining and grinding coolant/water,
- waste mercury (extremely hazardous).

Two of the PWAs were completed prior to 1994. Three were completed in 1995. The PWA for waste mercury has not been done, but the closure of the Bevatron has greatly reduced the volume of mercury. The section later in this chapter that summarizes process waste minimization efforts under the UC/DOE contract performance measures provides additional information on these assessments. The *Hazardous Waste Management Report Summary* assesses changes in the initial process waste assessments.

Other plans or reports prepared for waste minimization and pollution prevention efforts included the *Draft LBNL Mixed Waste Reduction Plan*, DOE Annual Waste Reduction Report, a paper reduction report, and revising the *Waste Minimization and Pollution Prevention Awareness Plan* to address Site Restoration waste reduction goals.

LBNL's program had considerable success in other areas in 1995, as the list below highlights. The section found later in this

chapter on the performance measures required by the UC/DOE contract quantifies these efforts. For example, Berkeley Lab has reduced the shipped quantity of routine hazardous waste by 48% compared to 1994 and 60% versus 1993, while reducing the amount of nonhazardous waste sent to landfill by 8% from 1994 and 25% from 1993. The program either met, exceeded, or greatly exceeded all hazardous waste reduction goals under the contract.

- Initiated solid waste recycling program that included cardboard, white paper office source separation and recycling, and waste recycle boxes for demolition and new construction projects.
- Switched from Tyvek to coveralls for gardeners and Site Restoration technicians.
- Managed facility-wide vegetation through eradication, composting, chipping, and mulching of 3,060 cubic meters (4,000 cubic yards).
- Sold timbers from the Bevatron to a lumber company for reuse.
- Reused shielding blocks from the Bevalac at Brookhaven National Laboratory.
- Switched main photographic shop over to digital technology.
- Installed a closed-loop deionized water treatment system at the Building 25 Photofabrication shop.
- Purchased equipment to evaporate water from coolant at Building 77 shop, reducing offsite shipment.
- Implemented spent-abrasive waste reduction program.
- Carried out first year of complex-wide project to disseminate Total Cost Assessment methods to justify Waste Minimization and other projects on the basis of their cost effectiveness.
- Joined in Program Research and Development Agreement, aimed at showing that radioactive Bevatron

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shielding blocks can be used as aggregate for concrete radioactive waste containers.

- Trained several dozen key LBNL generators and DOE staff in Pollution Prevention Opportunity Assessment methods.
- Hosted a national waste minimization workshop in October that focused on waste from shop operations.
- LBNL staff received 5 awards from DOE and the White House for Waste Minimization Accomplishments.

Pollution Prevention Act of 1990 (PPA)

The Pollution Prevention Act⁷³ of 1990 declares that source reduction is a national policy and directs US/EPA to study and encourage source reduction policies. LBNL's levels of pollution remain below the *de minimis* numbers identified in the Act and are not subject to its reporting requirements.

Water Quality

Clean Water Act (CWA)

Water programs at the Berkeley Lab in general are based on the Clean Water Act (CWA).⁷⁴ This 1977 Act amended the Federal Water Pollution Control Act of 1972, which itself was a consolidation of the original Federal Water Pollution Control Act of 1948 and several other amendments over the intervening years. The Act's purpose is to control the discharge of pollutants to the waters of the United States from both point and nonpoint sources using various means, including development of pollutant discharge standards and limitations, and a permit and licensing system to enforce such standards. The US/EPA has broad authority to implement this system nationwide, and may delegate all or parts of this authority, upon application, to states that enforce standards at least as stringent as those of the CWA. California is an authorized state and administers the principal components of the federal water quality management program.

The Porter-Cologne Water Quality Control Act (the Porter-Cologne Act)⁷⁵ established a comprehensive statewide system for the regulation of water pollution in California. This 1969 act provided for the three-tiered system that regulates water use in California today: the State Water Resources Control Board (SWRCB), the nine Regional Water Quality Control Boards (RWQCB), and local governments. In the case of Berkeley Lab, the regional authority is the San Francisco Bay RWQCB, and the local authority is the City of Berkeley for stormwater, while the East Bay Municipal Utility District (EBMUD) is the local authority for water supply and wastewater.

Regulatory programs administering stormwater regulations and effluent guidelines and standards for wastewater are independent of one another; however, each program integrates federal requirements with state regulations found in Titles 22 and 17 of the California Code of Regulations, along with any plans promulgated by the SWRCB. Regional guidelines are found in the San Francisco Bay RWQCB's Basin Plan. Finally, on a local level, Berkeley Lab is also subject to the City of Berkeley's Stormwater Ordinance (No. 6906)⁷⁶ and EBMUD's Wastewater Control Ordinance (No. 311).⁷⁷

During 1995 there were no major regulatory changes in water quality laws and regulations that impacted the Berkeley Lab. A revision of the Basin Plan in June did not affect storm water programs, although Table 4-3, Effluent Limitations for Selected Toxic Pollutants Discharged to Surface Waters, was revised to indicate that it applied to effluent discharges from POTWs and process water discharges from industrial facilities, not stormwater runoff.

On both the federal and state levels, future changes are expected that may affect the Lab's stormwater permit. During 1996, the SWRCB is planning to renew the state general industrial stormwater permit.⁷⁸ A statewide task force of interested parties has been working on this issue for some time in preparation for the November renewal date. The Laboratory will continue tracking activity

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at both levels and assess the need for any changes in its plans or programs at a more appropriate time.

EBMUD issued wastewater discharge permits for three LBNL activities in September 1995: one sitewide (Acct. No. 066-00791), and one each for discharge from treatment units at metal finishing operations in Building 25 (Acct. No. 502-38911) and Building 77 (Acct. No. 502-38921). The three permits are renewed annually. The permits incorporate standard terms and conditions, as well as individual discharge limits, provisions, and reporting requirements. Monitoring and reporting requirements for the sitewide and Building 77 permits remained the same as the previous year, while similar requirements for Building 25 decreased. The past compliance record for this treatment unit created an opportunity to reduce sampling costs.

All LBNL wastewater effluent is discharged through two sanitary sewer outfalls. The effluent is monitored from vaults located near the LBNL boundary of each drainage area. The Hearst vault is located in Blackberry Canyon east of the end of Hearst Avenue, and the Strawberry vault is located on Centennial Drive, south of the site. In recent years, LBNL has embarked on a project to upgrade sanitary sewer monitoring at each vault. The objective of the upgrade was to make reliable and efficient measurement of the wastewater flow possible, to reduce maintenance costs, improve access to the flume vault, allow for expansion with monitoring instruments, and provide for telemetry access to these instruments. These improvements were completed in May 1995.

Onsite inspections of LBNL's sanitary sewer discharge activities are performed occasionally by EBMUD without prior notification of Berkeley Lab personnel. During 1995, no notifications of any concerns raised by such inspections were received. There was one significant event related to sanitary sewer discharge activities in 1995.

Self-monitoring performed on March 16, 1995, at the Strawberry Canyon sampling station revealed levels of methylene chloride (0.990 mg/L) exceeding permit levels (0.5 mg/L). LBNL verbally reported this information to EBMUD in accordance with reporting requirements upon receipt of the laboratory analysis on March 30th, following up with the required 5-day written report in early April. The Laboratory filed occurrence report SAN--LBL-EHS-1995-003 on April 11 to formally notify DOE. Follow-up samplings by LBNL in an attempt to pinpoint the source were inconclusive: samples of no methylene chloride mixed with samples showing high levels. The Laboratory kept EBMUD informed of all sampling results.

LBNL expanded its investigation to include the involvement and cooperation of the University of California at Berkeley (UCB) campus, which also has some facilities discharging into the affected sewer line. Berkeley Lab staff conducted an in-house investigation using the site chemical inventory and physical inspections of buildings and laboratories where researchers were known to use methylene chloride. Concurrently, University facilities were inspected, but no laboratories were found where methylene chloride was used in a fashion where a discharge to a sanitary drain was likely. EBMUD personnel brought a portable gas chromatograph (GC) to the site for a day of investigating and cooperated with LBNL staff in sampling at various points on the sewer line in an attempt to trace the source of the methylene chloride. The GC did not detect any methylene chloride in this effort.

On May 5th, EBMUD issued a Notice of Violation to the University of California at Berkeley as the owner and user of the sewer line where the violation had occurred. Around the same time, LBNL conducted a walkthrough of Building 62, where a laboratory was found operating a rotary evaporator with an aspirator discharging to a sink. The solvent in use was methylene chloride. Analytical results of samples taken

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during operations the next morning revealed levels of methylene chloride in the sink discharge ranging from 230 to 1200 mg/L. Operation of this experimental configuration was immediately discontinued. LBNL notified the University of California of the discovery by letter on May 18th. In that letter Berkeley Lab identified Building 62 as a suspected source of the elevated levels of methylene chloride, but cautioned that no specific correlation could be made between operation of the experimental equipment and the dates that the elevated levels were found in self-monitoring samples at the Strawberry monitoring station. UCB included this information as a technical reference to their subsequent request for reconsideration to EBMUD on May 25. UCB also informed EBMUD that the Regents of the University of California were the actual owner of the sewer line. EBMUD ultimately withdrew the violation and did not issue it to any of the parties involved or assess any violation fees. However, in the interim EBMUD revised Berkeley Lab's sitewide permit to exclude Strawberry Sewer because of the ownership issue. LBNL continued to monitor at Strawberry station as usual in order to provide for completeness of the data and records.

UCB and LBNL agreed that it was in the interest of both parties that Berkeley Lab continue monitoring at Strawberry Sewer as before, since it is the main user of the line. UCB pledged to institute administrative controls on its facilities that discharge to this line. In August, during the annual renewal phase for the sitewide permit, Berkeley Lab requested that EBMUD again include Strawberry monitoring station and attendant monitoring requirements in the permit. EBMUD complied with this request. The only change made was that the permit is now officially in the name of the Regents of the University of California, with LBNL, as the primary user, having responsibility for the implementation of the permit and any monitoring requirements. In January 1996, Berkeley Lab completed the last link in the chain of signature delegation from the Regents that enables EH&S staff to sign correspondence and documents that implement the permit and permit applications.

Corrective actions in the wake of this incident included several measures to raise the awareness level of the Laboratory community on such issues. An article appeared in *Currents*, Berkeley Lab's newspaper, on May 19th. An informational memorandum detailing the incident and giving tips on the use of rotary evaporators, plus a copy of a safety bulletin dealing with LBNL's prohibition against disposal of hazardous materials to the sanitary sewer, was distributed to all building managers and division safety coordinators. These were also posted and distributed within the divisions. An informational talk was also given to the safety committee of the affected division on the issue of drain disposal of hazardous materials and LBNL's wastewater permit. No further exceedances, of methylene chloride or any other parameters, were discovered in LBNL's wastewater discharge during the rest of 1995.

Elsewhere in the water quality compliance program, the Laboratory is required under the terms of its annual wastewater discharge permits for Buildings 25 and 77 to implement a current Toxic Organic Management Plan (TOMP) for these facilities. The plans outline facility management practices to ensure that toxic organics are not released to the sewers or external environment. The requirement is based in federal pretreatment regulations and pertains to facilities that hold categorical permits under the terms of 40 CFR Subchapter N. The plans require updating if a change in operations occurs. During 1995, changes at the former plating shop, now the Ultra High Vacuum Cleaning Facility at Buildings 77 and 77H, precipitated the need for review and changes to the TOMP's. Updated TOMP's for both Buildings 25 and 77 were finished in September to reflect current conditions. EBMUD was notified of the updates by letter on October 11.

Also under the terms of its wastewater discharge permits, LBNL must maintain an *Accidental Spill Prevention and Containment Plan* (ASPCP) for areas where spills have the greatest potential to occur. EBMUD leaves selection of such sites to the discretion of the permit holder. Previously, Berkeley Lab included areas with photoprocessing activity,

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Building 25, Building 77, and the motor pool at Building 76. In 1995, the Laboratory expanded this scope to include the fixed treatment units at Buildings 2 and 70A. In another change designed to make the ASPCP more functional for the user, the document was divided into separate ASPCPs for each relevant area. Under this new strategy, new and updated ASPCPs were written in April. EBMUD does not require that these documents be submitted, but they are posted in the relevant areas. They are one of the things that the EBMUD inspector would look for when conducting a compliance inspection.

In accordance with compliance requirements in its wastewater discharge permit, Berkeley Lab submitted a Report on Alternative Cleaning Materials to EBMUD on June 21 and a copy of the site environmental report for 1994 in September. It also submitted a semi-annual report of groundwater sampling activities on June 1, 1995. The permit issued in September for the 1995-96 permit year relaxed the frequency of submittal of this report to annual; thus the next submittal will occur in June of 1996.

In November, the Oakland Operations Office of the Department of Energy conducted an Environment, Health, and Safety Pilot Oversight Appraisal at the Berkeley Lab. The water quality program was involved in a portion of this appraisal dealing with environmental radiological protection. No findings or concerns with the Water Quality Program resulted from this appraisal, and the final report concluded that "LBNL has an effective program in place to demonstrate compliance with limits for radiation exposure to the public by documentation of an appropriate combination of measurements and calculations."

LBNL's stormwater releases require a permit under the California-wide *General Permit for Stormwater Discharges Associated With Industrial Activity* (No. 2-01S002421). The California-wide permit is issued by the State Water Resources Control Board and

administered and enforced by the Regional Water Quality Control Board as a National Pollutant Discharge Elimination System permit for discharges of stormwater under the Clean Water Act. Under the permit, LBNL has implemented a *Stormwater Pollution Prevention Plan* (SWPPP) and a *Stormwater Monitoring Program* (SWMP). Together, these documents represent LBNL's plan and procedures for identifying, monitoring, and reducing pollutants in its stormwater discharges. The General Permit was promulgated by the state in 1991 and will be in effect for five years, after which it is subject to renewal or revision by the SWRCB.

In accordance with the sitewide stormwater permit, LBNL submitted its third Annual Report on June 29 to the Regional Water Quality Control Board and the City of Berkeley. This report addresses stormwater activities undertaken by LBNL. Results are discussed in the Chapter 5, *Surface Water*.

As reflected in LBNL's SWPPP, the Laboratory identified non-stormwater discharges at the facility that could not be eliminated prior to implementing the SWPPP in 1992. LBNL submitted a letter to the RWQCB on June 4, 1993, detailing the Laboratory's intent to eliminate these discharges by the regulatory deadline of March 30, 1995. Survey work to identify these discharges began in 1992, during which LBNL had found 38 old connections of industrial or sanitary wastewater discharges to the storm sewer system: 31 within buildings and 7 at exterior locations. Corrective actions to eliminate these connections progressed during 1993 and 1994 as funding allowed. LBNL completed its *Storm Drain Corrective Action Project* ahead of the regulatory deadline by eliminating the last connection, at Building 71, in March 1995. On March 23, LBNL informed the RWQCB in a letter that it had eliminated all such connections in accordance with the terms of the permit and the commitment that LBNL had made in 1992.

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The City of Berkeley performs stormwater inspections of the Berkeley Lab. In 1995, one inspection took place in November. No violations or concerns resulted. Also, no unusual discharge incidents occurred in 1995.

Requirements for the SWRCB's *General Construction Activity Storm Water Permit*⁷⁹ state that such a permit is necessary if more than 20,200 square meters (five acres) of a site are under construction. Since the total construction acreage on site falls below this acreage criterion, Berkeley Lab has not needed to file an application for this construction activity permit. However, LBNL does institute best management practices at all construction sites and seeks to avoid impact to the storm drain system from soil erosion or construction material. Examples of LBNL's practices include covering excavation piles with weighted plastic, protecting storm drains from soil or other materials by covering or blocking them, practicing general good housekeeping on a site, and storing hazardous materials in containers and away from storm drains.

The Clean Water Act and the state's Aboveground Petroleum Storage Act⁸⁰ outline the regulatory requirements for aboveground storage tanks. Nonpetroleum (i.e., chemical or hazardous) ASTs consist of FTU tanks, drum storage at Waste Accumulation Areas, and drum storage at product distribution areas. FTU tanks are inspected each operating day by operators of the FTU. WAAs are inspected weekly by EH&S staff. Product distribution areas contain petroleum and non-petroleum drums. Both types of drums are inspected during routine petroleum drum inspections.

In 1995, LBNL completed an aggressive program, begun in 1993 and associated with the *Spill Prevention, Control, and Countermeasures* project, to reduce the risk of environmental releases from aboveground storage tanks (ASTs) containing petroleum products. At the beginning of the program, a survey of the nearly 70 petroleum storage areas on the site, including transformers, engine generators, and petroleum drum storage areas, identified AST areas in need of repair or modification of secondary

containment. Twenty-four AST areas received upgrades in 1994. A second survey in 1994 assessed the condition of 90 aboveground storage tank areas on site. To complete the project in 1995, LBNL installed or repaired secondary containment at seven remaining AST locations from the two surveys.

In December 1995, a new 15,150-liter (4,000-gallon) AST was installed at Building 83 to support the energy generator located at Building 74. The new AST is a double-walled tank provided with a leak detection system. This AST was installed to replace a 37,850-liter (10,000-gallon) underground storage tank which was removed in late 1994.

Safe Drinking Water Act (SDWA)

The Safe Drinking Water Act⁸¹ was originally passed in 1974 and was last updated in 1988. This act concerns the protection of underground sources of drinking water and sets primary drinking water standards for public water systems. Berkeley Lab has no drinking water wells on site. The drinking water provided to LBNL comes from EBMUD's supply and distribution system.

EH&S's Industrial Hygiene (IH) Group conducts sampling of drinking fountains, while Facilities' Maintenance & Operations (M&O) performs any repairs, maintenance, or upgrades on either the fountains or the distribution system. IH has had a formalized drinking water program since 1994. The program was approved by IH and M&O in early 1995.

After initial sampling of all drinking water fountains on site for the presence of copper and lead in 1994, the sampling program has settled into a maintenance activity. Five drinking fountains and 12 sinks were sampled for copper during 1995 because of concerns about water quality. One fountain exceeded the drinking water standard for copper and was taken out of service.

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Additionally, there were two unusual incidents. The first involved the discovery of lead strips in a main water line serving Building 46 during the flushing of a fire water system. The strips were removed during the flushing. Apparently, these strips were inadvertently left during original construction many years ago. Historical test results and a subsequent test of the building water supply indicated that the drinking water did not exceed the drinking water standard for lead.

The second incident involved an uncured, epoxy-lined hot water heater that was installed by an outside contractor in Building 70. This resulted in the hot water having a "solvent" odor. A volatile organic scan indicated that although the water met drinking water standards, significant amounts of xylene were present. IH took six bulk samples, and worked closely with Facilities during the flushing and cleaning process until the xylene concentration was at a background level.

Other LBNL Environmental Programs

Training

In 1995, EH&S offered 61 different courses for the Laboratory's permanent, temporary, and visiting staff. These courses are required or recommended by regulation and/or Laboratory policy. In 1995 alone, over 550 different training sessions were held, with total enrollment exceeding 4,250. Eight environmentally-related courses exist, covering topics such as hazardous waste generators, radioactive and mixed waste generators, biohazardous and medical waste, waste accumulation areas, and hazardous waste operators and emergency response. Over 2,150 Laboratory employees have been trained in this last group of courses since their inception, and the number of current staff who have taken any one of these classes in 1995 was 337.

Training courses are offered to employees with varying frequency, from every other

week to once a year. On-demand training, designed to meet the needs of a particular division or group, is also available and is becoming increasingly common. Video training, self-study courses, challenge exams, and computer-based training are all experiments that are in different stages of evaluation.

The Job Hazards Questionnaire (JHQ) has now been completed by more than 3200 Berkeley Lab employees and participating guests. Review of the JHQ and completion of required EH&S training has been included in instructions for the annual employee performance progress review. In addition, sections with questions to identify job-specific training have been added for the Advanced Light Source and EH&S' Waste Management Group. In 1996, the JHQ will undergo a major revision to improve clarity and efficiency, and reflect changes in training requirements. Completed JHQs are available on line for widespread access by employees.

Self-Assessment

Berkeley Lab's self-assessment program provides a formal process for identifying, prioritizing, and correcting environment, health, and safety issues as they apply to all phases of Laboratory operations. The program satisfies the requirements of DOE Order 5700.6C,⁸² *Quality Assurance*, for worker, management, and independent assessments. The Office of Assessment and Assurance (OAA) oversees the self-assessment program at the Laboratory. OAA prepared the *FY 95 Berkeley Laboratory Self-Assessment Report*, which describes LBNL's self-assessment activities and summarizes the results of the divisions' self-appraisals. It also describes opportunities for improving environmental protection and occupational safety and health at LBNL, discusses root causes, and presents the status of corrective action strategies. This report fulfills the requirement in the 1992 SEIR for LBNL to implement Mitigation Measure IV-K-1 relating to Hazardous Materials.

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The report characterized the LBNL self-assessment program as an effective tool for line management based on the absence of significant unauthorized releases into the environment and occupational exposures above action levels in the research community, and no regulatory violations or fines were issued in FY95. The report identified areas of uneven implementation by management, namely calibration of toxic and flammable gas monitors, activity hazard reviews, division self-appraisals and reporting, chemical inventory maintenance, emergency team training, ES&H training, radiological materials work practices, and characterizing of hazardous, mixed, and radioactive waste. With several of these issues, the report noted the Berkeley Lab's continued progress on correcting the root causes of earlier opportunities for improvement. Finally, the report recognized the success of the satellite accumulation areas in complying with Laboratory procedures.

Updates on Non-Regulatory, Multiprogram Reviews

Necessary and Sufficient

DOE and various National Laboratories began field testing a "necessary and sufficient" program in 1994 and 1995. The objective of the necessary and sufficient program is to establish a mutually agreed-upon set of standards of performance between DOE and individual laboratories for a program's operations. The criteria for creating such a set of standards are two-fold: 1) sources of standards include federal, state, and local laws and regulations; DOE orders; DOE Technical Standards; nationally and internationally recognized consensus standards; and industry standards; and 2) the set of standards identified must be sufficient to ensure appropriate compliance. Berkeley Lab's National Tritium Labeling Facility participated in the pilot program. A Necessary and Sufficient Standards Set (LBL-37440)⁸³ for the NTLF was reached between LBNL and the DOE Berkeley Site Office in September 1995.

DOE is expected to evaluate the results of the entire field pilot test to determine the feasibility of implementing such a program across the DOE system.

The NTLF pilot established a set of standards in the area of environment, safety, and health. Goals of the program were to seek out compatible industry practices that have proven successful at maintaining safe, efficient, and cost-effective compliance programs while eliminating inapplicable, unnecessary, or duplicative standards. The pact is comprehensive, identifying potentially hazardous radiological and nonradiological activities with reference to safety issues such as radiation dose limits, instrument calibration, waste disposal, record keeping, training, ventilation, electrical safety, fire and seismic safety, and environmental protection. The team of LBNL and DOE personnel compiling the pact agreed that the necessary and sufficient closure process should not be designed to support minimal compliance. As a result, the standards set for the NTLF include nonmandatory standards believed to add cost-effective safety protection. The plan also addressed administrative requirements such as implementing changes with standards, using standards rather than implementation plans, and use of management systems as an effective tool to document necessary and sufficient program implementation. The NTLF is presently operating under the direction of this closure process.

Pilot ES&H Oversight Appraisal (1995)

In response to DOE internal reviews, feedback from national laboratory directors, and recommendations of the Galvin Report,⁸⁴ DOE modified its EH&S oversight program so that such appraisals would be performed in a more cost-effective and performance-based manner. DOE established a pilot program affecting various national laboratories, including Berkeley Lab, to evaluate the results of the restructured line oversight program. Key goals of the restructured program were to: 1) implement it in parallel with the necessary and sufficient pilot program; 2)

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limit the amount of time spent annually on appraisals; 3) rely more on a Laboratory's self-assessment and performance measure programs, and inputs from routine interactions with Laboratory staff; and 4) create a more fully integrated DOE approach to Laboratory management.

The pilot appraisal of LBNL under this new structure took place between November 6 and 22. The appraisal was conducted jointly by DOE's Oakland Operations Office and Berkeley Site Office. The scope of this multidisciplinary appraisal was linked to performance objectives in Appendix F of the UC/DOE contract. These performance objectives included Integration and Accountability, Protection and Prevention, and Compliance. Within each objective were functional areas at the Laboratory, such as self-assessment, training, fire protection, environmental radiological protection, and radiological waste management. The scope of the appraisal did not include functional areas that were rated as good performance by the most recent performance measures, previous DOE appraisal reports, or regulatory agencies; or familiar to DOE from self-assessment reports or routine interactions with LBNL staff.

The appraisal report separated results into three general categories: 1) programs achieving satisfactory performance through review 2) programs achieving satisfactory performance through daily oversight or previous reviews and 3) programs not considered strong although basic systems are in place.

The overall conclusion by the appraisal team on the soundness of environment, safety, and health programs at Berkeley Lab based on performance is one rated as satisfactory. Many of the ES&H programs have performed well, as measured by ongoing daily interaction of Laboratory personnel with DOE local counterparts, and were excluded from the pilot review, although mentioned in summary report. Similarly, the areas of environmental

protection, packaging and transportation, and underground storage tanks were found to be managed effectively and performing satisfactorily. Commitment through stated goals, adequate staffing, and training were essential attributes of these programs.

This left a much smaller set of programs that the appraisal team classified as not strong. The team recognized certain noteworthy practices and the existence of the basic framework in each of these remaining area, but identified opportunities for improvements primarily through better program implementation. The functional areas affected include conduct of operations, fire protection, occupational safety, occurrence reporting, quality assurance, radioactive waste management, self-assessment, and training.

The noteworthy practices recognized in this last set of programs included

- streamlining efforts of the self-assessment process to simplify reporting procedures,
- shifting to more quantifiable self-assessment criteria,
- using the JHQ for new employees in the new employee training, and
- hosting an awards dinner for safe truck drivers.

The DOE report identified 17 findings in these areas. The area classified as conduct of operations received the largest number of findings with five. None of these findings were considered major, nor did they pose immediate life-threatening or significant noncompliance issues. The findings covered issues that included

- improving the process for collecting and validating self-assessment data for reporting on EH&S issues,
- implementing the existing self-assessment program,
- adding a means to evaluate the effectiveness of the EH&S safety program under self-assessment,

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- improving line-management enforcement of required training for employees,
- eliminating discrepancies between procedures and processes,
- developing adequate waste characterization controls,
- providing sufficient document control procedures, and
- increasing adherence to procedures.
- program evaluation, reporting, and corrective action
- quality assurance
- staff resources, training, and development
- surface water
- waste management

In each of these areas considered not strong by the appraisal team, DOE recognized that the foundation of an adequate program has been established.

In early 1996, a joint working group consisting of the three parties in the appraisal completed a root cause analysis on findings in four of the areas identified by the appraisal team. Results of this analysis will be combined with the remaining findings into a corrective action plan for the Laboratory. This corrective action plan is expected later in 1996.

DOE EH-24 Environmental Audit (1994)

A DOE-led audit team evaluated the Laboratory's environmental programs in November 1994, with emphasis on the management systems designed to ensure effective development and implementation of such programs. The scope and results of the audit were reported in extensive detail in the *1994 Site Environmental Report*. In summary, the audit concentrated on the following thirteen areas:

- air
- environmental commitment
- environmental planning and risk management
- environmental protection programs
- formality of environmental programs
- inactive waste sites and releases
- internal and external communication
- organizational structure

The audit team identified nine findings in their report; seven in environmental management systems and two in specific technical disciplines. Six findings applied to LBNL's environmental management programs, while three findings applied to either DOE/OAK or DOE/BSO oversight duties. The audit recognized three strengths in LBNL programs: staff dedication, proactive external communication, and progress on air monitoring systems. The key finding of the audit team was DOE's interprogram effectiveness in cross-program communication, oversight, and planning and funding of environmental activities affecting LBNL. The structure at the time of the audit reduced DOE's effectiveness in carrying out basic environmental management functions impacting activities at LBNL.

The ensuing corrective action plan developed by LBNL included 28 tasks and 98 milestones affecting Laboratory programs. DOE approved the corrective action plan in April 1995. By January 1996, LBNL had closed 18 of these tasks and 75 of the milestones.

DOE Functional Appraisal (1993)

LBNL completed the corrective action plan developed in response to a DOE/OAK functional appraisal of the Laboratory's environmental programs during April 1993. The appraisal reviewed management systems that had been developed or improved since previous appraisals or audits. The functional appraisal report⁸⁵ identified six compliance findings and eight best management practice observations. LBNL developed a corrective action plan consisting of 14 tasks with 48 milestones to address these findings and observations. The last task in this plan was

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completed in the first quarter of 1995 with the final installation of monitoring sites in the Sitewide Radiological Ambient Air Monitoring project. See the discussion on DOE Order 5400.1 for more information on this last project.

Tiger Team Activities (1991)

LBNL also completed its corrective activities for the Laboratory-wide audit in 1991 by the DOE Tiger Team.⁸⁶ This extensive corrective action plan took four years to complete. The corrective action plan established 375 tasks and 1,397 milestones to resolve the findings of this audit. Milestones for the last nine tasks were completed in early 1995. Of the overall total, 107 tasks and 455 corresponding milestones concerned environmental issues.

Agreement in Principle (1990-1995)

The oversight agreement between the State of California and DOE, known as the Agreement in Principle (AIP), drew to a close as 1995 ended. The AIP program had been established in late 1990 as a means of funding technical support from the state for its efforts in environmental monitoring at LBNL and five other DOE facilities in California. The agreement ended in early March 1996 due to budget restrictions.

Prior to its end, the AIP program saw several changes in 1995. The California Department of Health Services relinquished its role as lead agency as of October 1, and was no longer a part of the program. The State Water Resources Control Board took over the lead agency role for approximately five months until the agreement expired. Quarterly progress meetings were held on site prior to the change in roles in October. In addition, the annual AIP meeting involving all DOE facilities in the program was held in April. AIP agencies also participated in the quarterly meetings hosted by the Laboratory's environmental restoration program.

DHS submitted its annual report to DOE in October after completing its participation in the program. The report covered LBNL-related AIP activities for the period January through September. The report summarized environmental monitoring results in the areas of direct radiation, surface water, groundwater, and stable isotopes. DHS results in all areas were consistent with those monitored by LBNL.

The direct radiation project reported ongoing monitoring of thermoluminescent dosimeters (TLDs) by DHS at six LBNL perimeter monitoring stations and one at a DHS control site in Sacramento. Dosimeters were changed on a quarterly basis by DHS, occurring on January 3, April 3, and July 5. Comparison of TLD results showed good agreement and were within normal background radiation. The DHS TLD network remains in place even though the AIP program has been discontinued. Operation of this network is now performed by DHS' Radiologic Health Branch. DHS had no new recommendations for LBNL's direct radiation network.

Surface water monitoring activities in 1995 consisted of two sampling events. Surface water samples from five creeks in and around LBNL were collected on February 23 and June 15. Samples were split and then analyzed for metals, gross alpha, gross beta, gamma, and tritium. Results among the respective analytical laboratories and an outside laboratory used for QA purposes were comparable. Minor amounts of radioactive constituents and certain metals were seen, but most were an order of magnitude below drinking water levels. See the surface water discussion in Chapter 4 for more information.

Likewise, comparative groundwater sampling consisted of two sampling events in 1995; May 11 and June 6. DHS and SWRCB staff both participated in these split sampling events. Samples were collected from six wells in May and two wells in June. All samples were tested for organic compounds and general minerals. The results showed

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very good agreement between LBNL and the AIP program. The DHS report had no further comments on the LBNL groundwater monitoring program, referring to the SWRCB for possible additional comments in their annual report. As of the writing of this report, the SWRCB has not issued their final report for 1995.

Finally, 1995 marked the first year where the AIP program conducted a comprehensive stable isotope sampling program. The intent of this segment of the program was to gather information useful to evaluating groundwater models and better understanding the complex hydrogeology of the site. Natural variations in stable, or nonradiogenic, isotopes of hydrogen and oxygen can be used to provide some clue to the sources of bodies of water and assist with hydrogeologic assessment of a site. For example, using stable isotopes analyses, it is possible to discern differences between rain that falls in Berkeley and rain that falls in the Sierra. This knowledge can help identify leaks from the EBMUD water supply system that travel into the local groundwater, since this would change the stable isotope value of the groundwater. The AIP program collected stable isotope samples from numerous LBNL groundwater wells in May and June, and from surface water sources on June 15. The groundwater samples indicated little change in stable isotope ratios since LBNL sampling in July 1992. However, the results did show areas of possibly significant breaches in the site's municipal water, sanitary sewer water, or low-conductivity water systems, and recommended that LBNL repair these breaches and continue monitoring these anomalies. The only unusual observation from the surface water results of June was the sample from the North Fork of Strawberry Creek. Results of this sample show signs that the water had been subject to evaporation, such as that found in a cooling tower.

Summary of Program Performance — UC/DOE Contract 98 Performance Measures

The present five-year operating contract for LBNL between the University of California and the Department of Energy requires performance-objective-criteria measures in many areas of management, including environmental compliance. All performance objectives are developed by representatives of the University's Office of the President, the three laboratories managed by the University, and DOE. Individual criteria-measure gradients, also called measure control levels, are site-specific and are negotiated with the local DOE office annually. In general, the objective of the environmental measures is to provide an incentive toward lowering the laboratories' impacts on the environment. Criteria-measure gradients are usually linked to a downward trend of a particular environmental parameter, such as public dose or the number of environmental releases that exceed regulatory levels. Such a downward trend would symbolize an improvement in managing of that parameter. There is a mechanism for recognizing significant changes in work levels that may effect the criteria measure results.

The five performance objectives, along with the relevant environmental criteria measures, are listed in the Table 3-14. There are a total of nine criteria measures that relate to environment protection management. The rating of each criteria measure consists of several factors established prior to the evaluation period. First, each measure is given a weighting factor relative to the others. Then, a set of relevant assumptions is identified, such as the evaluation period or changes in workload that would initiate a formal adjustment in rating values. Finally, gradients are established that define the quantifiable mark needed to receive a rating of meets, exceeds, or far exceeds expectations. In 1995, there were no data available for two of these criteria measures. Under operational exceptions, there were no environmental

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Table 3-14. UC/DOE Contract 98 Performance Objectives and Associated Criteria Measures for LBNL

Performance Objectives	Applicable Environmental Criteria Measures	Expectation Rating
1 Protection and Prevention The Laboratory will conduct operations in a safe manner that protects human health, the environment, the public, and prevents adverse impacts thereon.	<ul style="list-style-type: none"> • Radiation protection of the public • Process waste minimization • Solid waste minimization • Source reduction and pollution prevention 	<ul style="list-style-type: none"> • Far Exceeds • Far Exceeds • Meets • Far Exceeds
2 Compliance: The Laboratory will comply with applicable federal, state and local ES&H laws, regulations, and ordinances, and with applicable and accepted DOE directives.	<ul style="list-style-type: none"> • Tracking and trending of findings and violations • Tracking and trending of environmental releases • Regulatory commitments 	<ul style="list-style-type: none"> • Far Exceeds • Far Exceeds • Meets
3 Integration and Accountability The Laboratory and line management is accountable for integration of EH&S programs into all programs and conduct of operations.	<ul style="list-style-type: none"> • Operational exceptions 	<ul style="list-style-type: none"> • NA
4 Risk Management and Resources Allocation The Laboratory will ensure that EH&S risks are analyzed and risk reduction resources are allocated appropriately for its programs and operations.	<ul style="list-style-type: none"> • There are no applicable environmental criteria measures for this objective 	<ul style="list-style-type: none"> • —
5 Customer Focus: The Laboratory will conduct its business in a manner that meets or exceeds expectations and, through continuous communications, will foster customer and stakeholder mutual trust and credibility.	<ul style="list-style-type: none"> • Regulator satisfaction 	<ul style="list-style-type: none"> • NA

occurrence reports where the contributing or root causes were due to inadequate planning or failure to adequately implement plans, inadequate training, or inadequate understanding or acceptance of EH&S roles, responsibilities, or authorities. Also, under regulatory satisfaction, there were no regulator surveys in 1995. The last survey was completed in 1994, and the next survey is

scheduled for 1996. Results for the remaining seven measures are discussed below.

Radiation Protection of the Public

The intent of this criteria measure is to provide a strong incentive to reduce the radiological dose to the public and the environment from

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Figure 3-4. Cumulative Public Dose for 1995 at Maximally Exposed Individual Locations

all LBNL activities to levels that are as low as reasonably achievable. The current control level for the site is 0.03 mSv (3 mrem), a dose value established by LBNL, UCOP, and DOE in 1994. In December 1995, the annual review of this control level left this value unchanged.

Methods used to minimize radiological impacts to the public and environment include engineering controls (e.g., absorber and filter installations in fume hoods and glove boxes), administrative controls (e.g., radiation work permits, beamline schedules), and inventory controls (e.g., limit on annual possession quantity of radioisotopes, central control of radioisotope ordering and purchasing). Achieving this goal of a minimum impact is verified through real-time and periodic environmental monitoring.

During 1995, the dose that a maximally exposed individual could receive from Laboratory operations was determined to be 0.021 mSv (2.1 mrem). For LBNL, this value represents an upper bound dose to the public, because this maximum dose is calculated at the site boundary, rather than in the surrounding areas. This dose level is

below the established Berkeley Lab control level and about 2.1% of the allowable federal limit (1 mSv or 100 mrem). The comparable value reported in 1994 was 0.015 mSv (1.5 mrem). The cause for this small increase is due to an increase in the beam schedule for light ion runs in the 88-Inch Cyclotron during 1995. Figure 3-4 shows the cumulative public dose for 1995 at the maximally exposed individual location. The figure also indicates both the DOE reporting limit and LBNL's control level. For 1995, the appropriate assessment of this measure was *Far Exceeds Expectations*.

Process Waste Minimization

The intent of this measure is to provide an incentive toward minimizing the quantity of process waste. DOE and LBNL selected three of five process waste streams that were the highest generators of waste for 1993. The three waste streams were acids, contaminated solids, and coolants. The performance measure requires that the Laboratory reduce the waste generated annually by 5% from the previous year. Recycling is considered a means of waste minimization. In 1995, two additional waste streams were added to the

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Acid Waste Minimization

Figure 3-5. Trends in Acid Waste Minimization for 1995 Compared to Preceding Years

list. These include routine liquid and solid mixed wastes. Tracking of these new waste streams will begin in 1996.

After the institution of this performance measure in 1994, LBNL focused its efforts on developing the tracking capabilities required to provide accurate evidence of the Laboratory's progress in waste minimization and pollution prevention efforts. With regard to this performance measure, the graphs shown in Figures 3-5 through 3-7 demonstrate the Laboratory's considerable continued success in 1995.

Acids

LBNL has greatly exceeded the waste reduction goals for acids, having accomplished a 77% reduction in 1994 and a further 90% reduction in 1995. In total, the Laboratory has reduced its routine acid waste generation rate by more than 98% in the past two years (Figure 3-5). This accomplishment

is due, in part, to the implementation of recommendations found in a process waste assessment for acid wastes, prepared in 1995 by the Laboratory's Waste Management Group. Waste minimization staff will begin neutralizing acids with no underlying hazardous constituents in 1996 at the Hazardous Waste Handling Facility, which will result in a near-zero routine acid generation rate. The acid generation rate will continue to be tracked and reported as a performance measure to ensure that unanticipated increases in this waste stream do not occur.

Contaminated solids

LBNL has greatly exceeded the waste reduction goals for contaminated solids, having accomplished a 28% reduction in 1994 and a further 39% reduction in 1995. In total, the Laboratory has reduced its routine contaminated solids waste generation rate by more than 56% in the past two years (Figure

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Figure 3-6. Trends in Contaminated Solids Waste Minimization for 1995 Compared to Preceding Years

3-6). This accomplishment is due, in part, to the implementation of recommendations found in a pollution prevention opportunity assessment for hazardous abrasive wastes, prepared in 1995 by waste management staff. The recommendations included testing of abrasive waste for nonhazardous designation and investing in newer abrasive blasting equipment. The testing options have been implemented, with abrasives designated as nonhazardous now used as fill material where appropriate, or sent to sanitary landfill. Berkeley Lab expects to continue tracking the routine contaminated solids generation rate as a performance measure for at least one additional year to provide an incentive for implementing additional reduction methods to contaminated solid streams that remain relatively large, such as metal-contaminated deionization resins.

Coolants

LBLN has greatly exceeded the waste reduction goals for coolants, having accomplished a 45% reduction in 1994 and a further 78% reduction in 1995. In total, the Laboratory has reduced its routine coolant waste generation rate by more than 88% in the past two years (Figure 3-7). Essentially all of the Laboratory's remaining routine coolant waste is Trimsol contaminated with up to 80% water, generated at the Building 77 shops. With the installation of a water evaporator unit in Building 77 in 1995, this stream will be further reduced in 1996, and all of the treated Trimsol will be recycled. Although this is anticipated to result in zero generation in 1996, this performance measure will continue to be tracked and reported to ensure that unanticipated increases in coolant waste generation do not occur.

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Coolant Waste Minimization

Figure 3-7. Trends in Coolant Waste Minimization for 1995 Compared to Preceding Years

The program for process waste minimization has met all of the performance measure requirements as well as those of the success criteria. Combined with the proactive management strategy in place, the assessment for this measure was *Far Exceeds Expectations* for 1995.

Solid Waste Minimization

The goal for this performance measure is a 10% per year reduction in the total aggregate weight of nonhazardous, hazardous, radioactive, mixed, and biohazardous wastes shipped offsite for disposal, compared to the total aggregate weight shipped in the previous year. In this case, 1994 solid waste shipments are used for comparison.

LBNL has initiated a variety of programs to reduce the total aggregate weight of wastes

shipped offsite for disposal. The Laboratory has focused its efforts on the non-hazardous waste stream, since hazardous waste makes up less than 15%, and radioactive and biohazardous waste streams comprise less than 2%, of the total aggregate weight. Foremost among these efforts was the broadening of LBNL's paper recycling program, in which generators separate paper waste into white, mixed colored, and wet cans. This segregation has led to significant reductions in paper waste disposal. LBNL has also provided for similar recycling of cardboard waste in 1995. In addition, several LBNL operations have switched to electronic data dissemination systems, reducing the amount of paper used in routine LBNL communications. The Laboratory conducted a pollution prevention opportunity assessment for paper waste in 1995, to search for additional methods to reduce this important waste stream. The investigation attempted to

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Figure 3-8. Trends in Aggregate Total Waste Minimization for 1995 Compared to Preceding Years

document patterns of paper use, efforts to reduce use, and the costs and savings involved. Key discoveries of the report were that copying remains the dominant office paper use despite increases in laser print output, duplexing (front-to-back copying) rates at LBNL are significantly higher than national averages, imaging costs range from \$4,700 per ton for accounting reports to \$390,000 per ton for international fax calls, and finally, total paper-related costs exceed \$1.7 million per year, with several significant costs yet to be determined. One such cost is that associated with printer cartridges and mail.

In addition to these paper waste reduction efforts, LBNL began a sitewide "Yard Waste Reduction" program in 1995 that included the purchase of a shredder and several mulchers to be used for recycling most of the Laboratory's yard waste. This new activity reduced the total aggregate weight of LBNL wastes by an estimated 3100 cubic meters (4000 cubic yards) in 1995 and produced a considerable amount of mulch for on site landscaping use. Additional information on

this program is presented earlier under Federal Insecticide, Fungicide, and Rodenticide Act compliance.

Other highlights of the aggregate waste reduction program include the following recycling measures:

- For the first time, subcontractors are using recycling bins for debris generated during the HWHF and Human Genome construction projects.
- LBNL and Brookhaven National Laboratory arranged for reuse of approximately 15,000 tons of slightly radioactive concrete shielding blocks, with an estimated savings to DOE of approximately \$35 million.
- Berkeley Lab's environmental restoration program developed qualitative goals for minimizing waste resulting from remediation efforts. These goals have been added to the LBNL *Waste Minimization and Pollution Prevention Awareness Plan*.

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- As shown in Figure 3-8, the Laboratory has reduced its aggregate waste stream by 25% in the past two years, with an 8% reduction in 1995 after a 17% decrease in 1994. The reduction in 1995 is below the goal of 10%, as several extenuating circumstances came into play, including the following:
- The extremely heavy rains in the first quarter of 1995 precluded the recyclers from working for much of this quarter. This resulted in a 28% recycling rate for LBNL paper waste, compared to recycling rates of 55% to 68% for the remaining three quarters.
- The new NERSC initiative in Building 50 resulted in approximately 600 LBNL staff being moved in the fourth quarter of 1995. This resulted in a net increase in the generation rate of solid waste to 549.2 metric tons, compared to the average of 336.9 metric tons for the first three quarters. This represents a temporary increase in the non-hazardous waste generation rate of 63% compared to the previous three quarters.

The appropriate assessment for this measure in 1995 was *Meets Expectations*.

Source Reduction and Pollution Prevention

1995 represented the first year of reporting on this performance measure. The Laboratory surveyed its operations for opportunities related to source reduction and pollution prevention in 1995. The survey could not include opportunities identified in the *Process Waste Minimization* performance measure. Based on survey results, LBNL and DOE reached agreed-upon specific milestones, which the Laboratory implemented. The performance rating for the Laboratory in this category depends on measured progress against the funded portion of these milestones. Table 3-15 identifies the milestones that met this criteria. Berkeley Lab has met milestones on substantive opportunities with a mutually

agreed-upon aggressive schedule. Consequently, all success criteria as well as the performance measure criteria have been met. The appropriate assessment for this measure is *Far Exceeds Expectations*.

Annually, effective with fiscal year 1996, the Laboratory will continue to survey on site operations for opportunities to eliminate, reduce, recover, or recycle potential pollutants to all media, including air, water, soil, sediments, and biota. Also annually, Berkeley Lab will evaluate and prioritize a site-specific number of pollution prevention opportunities and establish milestones/metrics that allow the measurement of progress for each opportunity.

The majority of funding for LBNL's pollution prevention programs come from two DOE offices, Energy Research (ER) and Environmental Management (EM). Both ER- and EM-funded activities require 5-year plans. Both the ER 5-year plan, called the ES&H Management Plan, and the EM 5-year plan include risk assessment and prioritization information for environmental activities. This risk prioritization system integrates public and employee safety and health, environmental concerns, regulatory and contractual compliance, as well as programmatic concerns such as LBNL mission and public perception. Requests for project funding are reviewed by the LBNL Project Coordination Committee. Recommendations for ER funding are forwarded to LBNL executive management where the final priorities are established. For EM funding, risk-ranking prioritization is determined by EM, based on its perception of need across the entire DOE organization. In future years, EM will adopt a risk prioritization model similar to that used in the ES&H Management Plan.

Tracking and Trending of Findings and Violations

The goal with this performance measure is simply a downward trend in findings and violations. It does not have a target or control

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Table 3-15. Process Waste Minimization Milestones for 1995

Description	Original Due Date	Current Due Date	Completion Date
Award contract for B25 closed-loop FTU.	7/31/95	7/31/95	7/31/95
Complete installation of LBNL yard waste mulching system.	7/31/95	7/31/95	7/31/95
Revise subcontractor WMin/PP compliance policy for LBNL.	8/1/95	8/1/95	8/1/95
Complete feasibility study of abrasives alternatives.	8/15/95	8/15/95	8/15/95
Initiate transfer of LBNL Bevatron shielding blocks to BNL.	9/1/95	9/1/95	9/1/95
Assess opportunities for LBNL nonhazardous dumpster waste.	9/1/95	9/1/95	9/1/95
Complete installation of B25 closed-loop FTU.	9/30/95	9/30/95	12/1/95
Complete acidic wastes PPOA.	9/30/95	9/30/95	9/30/95
Implement LBNL abrasive wastes reduction program.	9/30/95	9/30/95	9/30/95
Complete installation of B25 closed-loop FTU.	9/30/95	9/30/95	12/1/95
Complete LBNL office waste reduction training materials.	12/31/95	12/31/95	12/31/95
Approve subcontractor WMin/PP compliance policy for LBNL.	1/31/96	1/31/96	
Complete installation of B77 Alternative Cleaning System.	3/1/96	10/1/96	
Remove B70 UST and replace with compliant system.	6/30/96	6/30/96	
Remove B58 UST and replace with compliant system.	9/30/96	9/30/96	
Complete purchase of vapor/degreaser replacement.	10/30/96	10/30/96	
Replacement of 50B ODS Chiller	6/1/96	6/1/96	
Replacement of Electron Microscope ODS operating fluid	10/1/96	10/1/96	

level below which annual findings and violations are considered negligible. The basis for evaluating this measure in 1995 was the 55 regulatory inspections and permit-required self-monitoring events (37 for BAAQMD and 18 for EBMUD). In this case, each source reviewed was treated as a separate inspection when referencing the list of inspections in Table 3-3. As mentioned earlier in the water quality compliance discussion, a March self-monitoring analysis of wastewater at the Strawberry Canyon outfall indicated levels of volatile organics above the discharge limitation. However, EBMUD did not issue a violation as it was unclear from subsequent

investigation whether UC or LBNL was responsible for the release. As a result of this decision and the other inspection results, Berkeley Lab did not receive any violations or findings in 1995. The gradient for this measure is assessed as *Far Exceeds Expectations* for 1995.

Tracking and Trending of Environmental Releases

A downward trend is expected in the tracking of reportable occurrences of environmental releases that exceed regulatory or permitted

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levels. Releases that are abnormal but do not exceed regulatory requirements will not be included in this performance measure. The metric being used with this performance measure is the mean time between environmental releases. The base year for comparison purposes is 1993. However, for a historical perspective, the mean time between environmental releases in 1992 was 6.5 weeks (8 occurrences). The mean time value for base year 1993 was 26 weeks. In 1994 and 1995, there were no environmental releases resulting in violations to Berkeley Lab.

From this performance the gradient for this measure was assessed as *Far Exceeds Expectations*.

Regulatory Commitments

This performance measure assesses the Laboratory's ability to meet all funded regulatory consent agreement milestones.

A stack emissions-monitoring upgrade project was managed within schedule to ensure compliance with the NESHAPs Federal Facilities Compliance Agreement. This compliance action was successfully completed in February 1995. In November, US/EPA notified the Laboratory that it had confirmed the successful completion of this FFCA.

The Federal Facilities Compliance Act⁸⁷ passed by Congress on October 6, 1992, requires each DOE site to prepare a plan that identifies the treatment of its mixed waste that meets land disposal restrictions. On October 6, 1995, the DOE and the state DTSC signed a consent agreement establishing site treatment plan milestones for Berkeley Lab. There were no milestones in 1995, although a number of treatment technologies were developed for mixed transuranic wastes. These were submitted on time to satisfy the first milestone in January 1996.

Since all milestones were met, the assessment for this measure was *Meets Expectations*.

Environmental Program Planning

Since late 1992, DOE facilities have developed ES&H five-year plans at the request of the Secretary of Energy. The objectives of this planning activity are to identify the magnitude of effort, prioritize the deficiencies, and determine the funding required to bring DOE programs into full compliance with all environment, safety, and health laws and regulations. There are three categories of activities under the plan: core, compliance, and improvement. Core activities are those deemed essential to maintain current levels of risk and compliance. Compliance activities are those required to move a facility toward full compliance. Improvement activities raise the level of ES&H performance while lowering the ES&H risk. The fiscal year for which the 5-year period funding is requested begins two years from the fiscal year during which the plans are prepared. For example, the Activity Data Sheets (ADSs) prepared in late 1994 and early 1995 are for the funding period FY 1997 through FY 2001. The ADS structure includes a breakdown by costs, resources, and traceable milestones, as well as a narrative justification for the funding request. Environmental planning ADSs are categorized below as Environmental Protection, Environmental Restoration, or Waste Management. Since preparation of the plans crosses over the calendar year, only the most recently submitted ADSs have been included in the lists below.

Environmental Protection

Beginning in January 1993, LBNL prepared a series of ADSs for six core and ten compliance activities in the environmental functional areas of air quality, water quality, solid waste generation and control, toxic substances control, and management of environmental activities. Later in 1993, the ES&H Five-Year Plan was renamed the ES&H Management Plan and was broadened

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to provide complete coverage of all A-106 environmental projects and pollution prevention activities. The ADSs prepared in early 1995 cover the period from FY 1997 through FY 2001. The requested level of support for the core and compliance activities totals \$8.9 million and \$7.0 million, respectively. Environmental protection core ADSs are as follows:

- Protection of Water Quality
- Protection of Air Quality
- Solid/Hazardous Waste Generation and Control
- Environmental Management, Oversight, and Reporting
- Control of Toxic Substances

Environmental compliance ADSs include requests for supplemental resources to work on lower-risk areas of compliance, as well as funding for construction and renovation needed to minimize the impacts of LBNL operations on environmental quality. A notable emphasis in the 1995 submission is waste minimization and pollution prevention programs and projects, reflecting the recent focus on these areas by the US/EPA, DOE, and many other agencies and interested parties. The complete list of compliance ADSs prepared for the ES&H Management Plan in early 1995 is as follows:

- Strawberry Sanitary Sewer Sampling Upgrade
- Radiation Protection of the Public and Environment
- Wastewater Zero-Discharge Process at Building 77
- Groundwater Protection Management Plan Implementation
- Environmental Monitoring Database Development
- Hearst Sewer Monitoring Equipment Installation
- Waste Minimization and Pollution Prevention

- Waste Minimization and Pollution Prevention Implementation
- Environmental Monitoring Plan Implementation
- Underground Storage Tank Removals/Replacements
- Ozone-Depleting Substances Reduction Program
- Ion-Exchange Resin Reduction and Regeneration Process
- NPDES/Best Available Technologies Upgrades
- Waste Coolant Reduction at the Building 77 Machine Shop

Environmental Restoration

LBNL's environmental restoration program has prepared and maintained ADSs since the beginning of 1992 for ERWM Five-Year Plan activities. ERWM programs have required this planning activity for an additional year, compared to the environmental ADS described above. The structure of the ADSs in either program is similar. The three environmental restoration ADSs completed in early 1995 are listed below:

- Closure of the Existing Hazardous Waste Handling Facility
- Environmental Restoration Program Management
- Soil and Groundwater Environmental Assessment and Remediation

With the exception of *Environmental Restoration Program Management*, these activities share two common tasks: an initial assessment or characterization of the situation, followed by surveillance and/or remediation efforts.

Waste Management

Three ADSs were prepared by LBNL for ERWM Five-Year Plan activities in waste management in early 1995, covering the fiscal year period 1997 through 2001. These ADSs are:

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- Facility Operations and Maintenance
- New Hazardous Waste Handling Facility
- EM Waste Minimization and Pollution Prevention

The facility operations and waste minimization ADSs are similar to the programmatic ADSs prepared for environmental programs in that they describe the elements required to maintain or improve compliance programs. This waste minimization ADS is principally directed at end-of-stream activities within the HWHF, but it includes support for the Laboratory's sitewide pollution prevention program as well. The new HWHF ADS requests support for construction of the new HWHF, which is presently underway.

In addition to the ADSs for facility operations and waste minimization, Waste Management completed a FY95 Work Plan in September 1994 that detailed FY95 work scope and cost estimates in these activity areas.

Section 4. Air Quality

Introduction

The environmental monitoring and surveillance program of Berkeley Lab is designed to demonstrate the commitment of the Laboratory to protecting public health and the environment, while ensuring compliance with federal, state, local, and DOE environmental requirements. This program is divided into numerous elements for which monitoring and surveillance activities are carried out during the course of the year by Laboratory personnel. This chapter summarizes the results of these activities for 1995. Results are presented in separate sections by program element, which include:

- Air
- Surface Water
- Groundwater
- Sanitary Sewer
- Soil and Sediment
- Vegetation and Foodstuffs
- Special Studies
- Radiological Dose Assessment
- Quality Assurance

The *Data Appendix for Environmental Monitoring and Surveillance Results* in Volume II of the 1995 Site Environmental Report contains tables of supporting data referenced in the summary discussions.

The *Environmental Monitoring Plan* for the Berkeley Lab details the strategies used to fulfill monitoring and surveillance obligations. The EMP identifies regulatory and DOE requirements for effluent monitoring, environmental surveillance, and preoperational studies. In addition to guidance stated in regulations, this plan incorporates guidance from DOE orders and DOE/EH-0173T. This plan is revised every three years. The Laboratory began updating the EMP in late 1995, with DOE approving the revised plan in early 1996. The discussions that follow describe results from activities conducted under the earlier EMP, although noteworthy

changes in the revised EMP are included in certain sections.

Air

Three key requirements drive the Laboratory's air monitoring program: 1) 40 CFR Part 61, Subpart H (NESHAPs), 2) DOE Order 5400.1 (General Environmental Protection Program), and 3) DOE Order 5400.5 (Radiation Protection of the Public and the Environment). NESHAPs and DOE Order 5400.5 only address monitoring requirements for radiological air emissions, while DOE Order 5400.1 considers monitoring requirements for both radiological and nonradiological air emissions. However, the types of sources and quantities released from Laboratory operations compared with the monitoring requirements limit the air monitoring program at Berkeley Lab to one that is designed for only radiological emissions. Estimations of nonradiological air emissions and their impact are satisfied through alternative means such as engineering calculations, record keeping, and dose modeling when such information is required for regulatory purposes.

The air monitoring program consists of two elements: direct radiation, stack emissions, and ambient air. Descriptions and results of the stack emissions monitoring programs is presented along with direct radiation results in Chapter 11, *Radiological Dose Assessment*. The remainder of this chapter will concentrate on ambient air monitoring results from 1995.

The ambient air monitoring network is designed to collect data representative of the impacts from Laboratory activities and to serve as a quality assurance comparator for radiological dose assessment modeling. The number and placement of monitoring stations, as well as the parameters monitored and their frequency, is periodically evaluated in response to changes in LBNL operations or external requirements.

As a research facility, Berkeley Lab employs a wide variety of regulated radionuclides in its radiochemical and biomedical research

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programs. In addition, radioactive materials are a resultant byproduct from the operations of the charged-particle accelerators such as the 88-Inch Cyclotron. The most commonly and widely used radionuclides at the site are hydrogen-3, carbon-14, fluorine-18, phosphorus-32, sulfur-35, and iodine-125. Table 11-4 lists the names of the more predominant airborne radionuclides used at LBNL, along with certain physical characteristics. A reference table on radionuclides and their symbols is given in the glossary.

Radionuclides are primarily released from onsite stacks in the form of vapors and gases. Particulate materials are normally filtered from effluent streams such that measurable radioactivities of this type are rarely observed. The dominant radionuclide emissions from Berkeley Lab in 1995 were in the form of hydrogen-3 as tritiated water vapor (HTO). Table 11-5 provides a listing of the atmospheric emissions of radionuclides from site activities for the year.

To assess the environmental impact of these radiological emissions, the LBNL network collected data to analyze five radiological parameters in 1995: gross alpha, gross beta, carbon-14, iodine-125, and tritium. Table 4-1 lists the parameters, along with the number of sites data was collected for this parameter in 1995.

Tritium Monitoring

Historically, and again in 1995, tritium, in the form of tritiated water vapor, accounted for the vast majority of radionuclide releases from Berkeley Lab activities. See Chapter 11, *Radiological Dose Assessment* for more information on these releases. During 1995, approximately 1.96×10^{12} Bq (53 Ci) of tritium emission were measured, with nearly all discharged from the Building 75 (National Tritium Labeling Facility and Hazardous Waste Handling Facility) stacks. To assess the environmental impact of these tritium releases, a network of eight sampling locations collected samples for atmospheric tritium analysis in 1995. Three sampling locations were on site and five were off site, as seen in Figure 4-1. Table 4-2 describes these locations.

The sampling methodology captures HTO by pumping air through a column containing silica gel. At the beginning of 1995, the silica gel HTO samples were changed weekly at each station. When changes were made in the EMP later in the year, the sampling frequency was reduced to a monthly schedule. This change accounts for the number of samples in Table 4-3 being less than 52. The analytical process, referred to as US/EPA Method 9, starts with adding a known amount of distilled water to the silica gel sample, and allowed to come into equilibrium. At that point, a 10-milliliter aliquot is drawn from the liquid

Table 4-1. Number of Monitoring Locations by Parameter

Parameter	Number of Locations ¹
Alpha/beta	18
¹⁴ C	1
¹²⁵ I	4
Tritium (in form of HTO)	8

¹does not include preoperational monitoring study sites

Figure 4-1. Ambient Air Monitoring Network for Tritium and Particulate Matter

Table 4-2. Monitoring Locations for Atmospheric Tritium.

Station ID	General Location	Specific Location
ENV-69A	LBL	Northwest of Building 69
ENV-B13A	LBL	West of Building 88
ENV-B13B	LBL	Northwest of Building 90
ENV-3	UCB	Roof of Building 3
ENV-LHS	UCB	Public area of the Lawrence Hall of Science
ENV-MRI	UCB	Public area of the Mathematical Science Research Institute
ENV-B13C	UCB	South ridge of Strawberry Canyon
ENV-B13D	UCB	Northwest of the Lawrence Hall of Science

sample and placed into a liquid scintillation counting instrument for 200 minutes. This methodology results in a nominal atmospheric detection limit of 0.00116 Bq/L (0.0312 pCi/L).

The minimum detection limit for tritium and all other radionuclides is based on the sample counting time and the counts of the representative background samples. The gross analytical result from a sample is then

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Table 4-3. Summary of ^3H Concentrations from Ambient Monitoring Network

Station ID	Number of Samples	Average (Bq/L)**	Average as Percent of Standard*	Maximum (Bq/L)**
ENV-B13A	24	0.0033	0.0001	0.0236
ENV-B13B	19	0.0033	0.0001	0.0211
ENV-B13C	24	0.0033	0.0001	0.0280
ENV-B13D	18	0.0045	0.0002	0.0183
ENV-3	18	0.0050	0.0002	0.0210
ENV-69A	22	0.0240	0.0009	0.0770
ENV-LHS	23	0.0053	0.0002	0.0253
ENV-MRI	17	0.0068	0.0003	0.0313

* Standard of comparison = 2.7×10^3 Bq/L (source: DOE Order 5400.5)

** 1 Bq = 27 pCi

Table 4-4. Summary of ^{125}I Concentrations from Ambient Monitoring Network

Station ID	Number of Samples	Average (Bq/L)**	Average as Percent of Standard*	Maximum (Bq/L)**
ENV-B13A	22	$< 2.0 \times 10^{-7}$	$< 1.5 \times 10^{-6}$	$< 3.0 \times 10^{-7}$
ENV-B13B	27	$< 2.0 \times 10^{-7}$	$< 1.5 \times 10^{-6}$	1.2×10^{-6}
ENV-B13C	27	$< 2.0 \times 10^{-7}$	$< 1.5 \times 10^{-6}$	2.9×10^{-6}
ENV-B13D	22	4.0×10^{-7}	3.0×10^{-6}	4.4×10^{-6}

* Standard of comparison = 1.35×10^4 Bq/L (source: DOE Order 5400.5)

** 1 Bq = 27 pCi

subtracted from the background counts to determine the net result.

Atmospheric tritium concentrations measured by the network of stations for 1995 are presented in Table 4-3. Average concentration values are all significantly less than 1% of the allowable DOE standard for tritium, which is 2,700 Bq/L. This standard is based on an annual exposure frequency, but the comparison also holds true when considering the maximum monitored levels. Of particular interest in the results is the rapid dropoff in tritium levels from ENV-69A and other sites as the distance from the main source on site increases. ENV-69A is located near the base of the NTLF's tritium stack.

Radioiodine Monitoring

Radioiodine is a common nuclide used in medical and life science research. In past years, radioiodine has consistently been reported in annual release summaries, although the release quantity remains an insignificant fraction of the total released from the site (less than 1% of total; see Table 11-5). Iodine-125 has been included in the Laboratory's environmental sampling network at four locations.

The sampling strategy for radioiodine uses filter paper containing 55% activated carbon. Samples were collected weekly from the monitoring sites. Radioiodines in air, specifically iodine-125, are assayed by analyzing the activated-carbon filters with a thin-window Geiger-Muller detector. The

detection limit for iodine-125 in stack effluents is 7.4×10^{-9} Bq/L (2.0×10^{-7} pCi/L). Table 4-4 contains a summary of the iodine-125 sampling results for 1995. See Table APP-1-1 in *Volume II, Data Appendix for Environmental Monitoring and Surveillance Results*, for raw sampling data. Like tritium discussed above and the other nuclides discussed below, these ambient concentrations represent a very small fraction of the appropriate DOE standard.

Carbon-14 Monitoring

Similarly, carbon-14 is a commonly used in medical and life science research, including Berkeley Lab programs. Its annual releases have been quantified, but are also an insignificant fraction of the total of all radionuclides released from the site (less than 1% of total; see Table 11-5). Also like radioiodine, the analytical technique used to determine carbon-14 is relatively straightforward compared with other nuclides. Sampling for carbon-14 occurred at one location in early 1995 before sampling was discontinued based on an assessment of releasable quantities and associated risk. The average and maximum concentrations of atmospheric carbon-14 for 1995 are given in Table 4-5. See Table APP-1-1 in *Volume II, Data Appendix for Environmental Monitoring and Surveillance Results*, for the raw sampling data.

Atmospheric carbon-14 is estimated by analyzing for $^{14}\text{CO}_2$, and assuming that the resulting value is entirely carbon-14. The sampling methodology passes (bubbles) atmospheric air through a jar containing 30 milliliters of 0.2-molar sodium hydroxide (highly diluted) and thymol blue as a pH

indicator. A 5-milliliter aliquot of the sodium hydroxide is added to a liquid scintillation "cocktail" and counted in a liquid scintillation counter. The detection limit for $^{14}\text{CO}_2$ is 7.4×10^{-3} Bq/L (0.2 pCi/L). The sampling media are changed weekly.

Gross Alpha/Beta Monitoring

Radiological particulate matter may be released by some of the Berkeley Lab research programs. The effluent stacks with the greatest potential for particulate release exists have in-line sampling instrumentation. On the remaining stacks, radionuclide inventories are strictly controlled and techniques are used to estimate particulate releases. Many of these stacks have filtration on the effluent stream, which further reduce the small amount of particulate material that is released. The dose impact from these releases is discussed Chapter 11, *Radiological Dose Assessment*.

As a means of verifying the particulate emissions and determining their environmental impact, the Laboratory has a network of ambient radiological particulate sampling stations. Consistent with stack effluent monitoring, the particulate material is analyzed for gross alpha and beta levels. An upgrade to this network was completed in early 1995 to address deficiencies in coverage identified during the 1991 DOE Tiger Team appraisal. The resultant network added or upgraded seven new high-volume air samplers in strategic locations where the highest impacts from Laboratory particulate releases were expected. Sampling at previous stations in the network was discontinued after the upgrade, although results from these

Table 4-5. Summary of ^{14}C Concentrations from Ambient Monitoring Network

Station ID	Number of Samples	Average (Bq/L)**	Average as Percent of Standard*	Maximum (Bq/L)**
ENV-3	2	0.0023	1.7×10^{-7}	0.0034

* Standard of comparison = 1.35×10^4 Bq/L (source: DOE Order 5400.5)

** 1 Bq = 27 pCi

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Table 4-6. Monitoring Locations for Gross Alpha and Beta Particulate

Station ID	General Location	New or Existing Site	Sampler Type
ENV-B13A	LBNL	Existing	Simple Vacuum
ENV-B13B	LBNL	Existing	Simple Vacuum
ENV-B13C	UCB	Existing	Simple Vacuum
ENV-B13D	UCB	Existing	Simple Vacuum
ENV-1	UCB	Existing	High-volume
ENV-10	LBNL	Existing	Simple Vacuum
ENV-15	LBNL	Existing	Simple Vacuum
ENV-17	LBNL	Existing	Simple Vacuum
ENV-50	UCB	Existing	Simple Vacuum
ENV-69P	LBNL	Existing	High-volume
ENV-71	LBNL	Existing	Simple Vacuum
ENV-72	LBNL	New	High-volume
ENV-74	LBNL	Existing	High-volume
ENV-75	LBNL	Existing	Simple Vacuum
ENV-78	LBNL	New	High-volume
ENV-80	LBNL	New	High-volume
ENV-81	LBNL	New	High-volume
ENV-90	LBNL	New	High-volume

stations are included in this section, as well as the data appendix. Sampling at some of the upgraded stations was suspended later in 1995 due to operational constraints.

While the previous instrumentation provided acceptable sampling results for gross atmospheric particulate alpha and beta, the newer instrumentation is more sensitive. The previous sampling instrumentation consisted of an unregulated pump drawing air through a fiberglass-polyester filter sampling media of dimensions 10 centimeters x 23 centimeters (4 inches x 9 inches) at an estimated rate of 113 liters per minute (4 cubic feet per minute). The new high-volume air samplers consist of a pump that draws air through a smaller fiberglass-polyester filter sampling media (10-centimeter or 4-inch diameter) at a constant rate of 170 liters per minute (6 cubic feet per minute). Although the filter on the newer sampler is smaller, this has no effect on the analytical technique used by the laboratory when processing the results.

During 1995, gross atmospheric particulate alpha and beta activities were measured at 18 air sampling points shown in Figure 4-1. Table 4-6 lists the stations in the particulate sampling network and the corresponding sampler type.

Samples are collected weekly for radioanalyses. Before being counted, they are set aside for five days to allow short-lived radon and thoron daughters (naturally occurring airborne radionuclides) to decay. The filters are loaded into an automatic counter that determines gross alpha activity by means of a large-area 0.25-mil Mylar-window gas-proportional counter. Gross beta activity is counted with Geiger-Muller detectors with 30 milligram per square centimeter windows. The detection limit for alpha emitters is 1.1×10^{-4} Bq/L (3×10^{-3} pCi/L). The detection limit for beta emitters is 4.4×10^{-3} Bq/L (1.2×10^{-1} pCi/L). To ensure accuracy of all counting results, each group of samples counted includes at least one NIST-traceable reference

Table 4-7. Summary of Gross Alpha and Beta Concentrations from Ambient Monitoring Network

Station ID	Number of Samples	Alpha			Beta		
		Average (Bq/L)***	Percent of Standard	Maximum (Bq/L)***	Average** (Bq/L)***	Percent of Standard	Maximum (Bq/L)***
ENV-B13A	16	$< 8.0 \times 10^{-7}$	< 0.42	$< 1.0 \times 10^{-6}$	1.0×10^{-6}	$< 7.4 \times 10^{-5}$	1.5×10^{-6}
ENV-B13B	16	$< 8.0 \times 10^{-7}$	< 0.42	$< 1.0 \times 10^{-6}$	1.0×10^{-6}	$< 7.4 \times 10^{-5}$	1.5×10^{-6}
ENV-B13C	21	$< 8.0 \times 10^{-7}$	< 0.42	$< 1.0 \times 10^{-6}$	9.0×10^{-7}	$< 6.7 \times 10^{-5}$	1.5×10^{-6}
ENV-B13D	15	$< 8.0 \times 10^{-7}$	< 0.42	$< 1.0 \times 10^{-6}$	1.1×10^{-6}	$< 8.2 \times 10^{-5}$	2.2×10^{-6}
ENV-1	3	$< 2.0 \times 10^{-7}$	< 0.11	$< 5.0 \times 10^{-6}$	4.0×10^{-7}	$< 3.0 \times 10^{-5}$	5.0×10^{-7}
ENV-10	1	2.0×10^{-7}	< 0.11	2.0×10^{-7}	4.0×10^{-7}	$< 3.0 \times 10^{-5}$	4.0×10^{-7}
ENV-15	1	$< 4.0 \times 10^{-8}$	< 0.03	$< 4.0 \times 10^{-8}$	1.0×10^{-7}	$< 7.4 \times 10^{-6}$	1.0×10^{-7}
ENV-17	1	$< 4.0 \times 10^{-8}$	< 0.03	$< 4.0 \times 10^{-8}$	1.0×10^{-7}	$< 7.4 \times 10^{-6}$	1.0×10^{-7}
ENV-50	4	$< 4.0 \times 10^{-8}$	< 0.03	$< 7.0 \times 10^{-7}$	6.0×10^{-7}	$< 4.4 \times 10^{-5}$	1.2×10^{-6}
ENV-69P	16	$< 2.2 \times 10^{-7}$	< 0.11	$< 7.0 \times 10^{-7}$	6.0×10^{-7}	$< 4.4 \times 10^{-5}$	9.0×10^{-7}
ENV-71	1	$< 1.0 \times 10^{-7}$	0.05	1.0×10^{-7}	2.0×10^{-7}	1.5×10^{-5}	2.0×10^{-7}
ENV-72	3	$< 2.0 \times 10^{-7}$	< 0.11	$< 2.0 \times 10^{-7}$	4.0×10^{-7}	3.0×10^{-5}	5.0×10^{-7}
ENV-74	12	$< 4.0 \times 10^{-7}$	< 0.21	$< 8.0 \times 10^{-7}$	1.1×10^{-7}	$< 8.2 \times 10^{-5}$	1.5×10^{-6}
ENV-75	1	2.0×10^{-7}	0.11	2.0×10^{-7}	3.0×10^{-7}	$< 2.2 \times 10^{-5}$	3.0×10^{-7}
ENV-78	10	$< 2.0 \times 10^{-7}$	< 0.11	$< 8.0 \times 10^{-7}$	6.0×10^{-7}	$< 4.4 \times 10^{-5}$	8.0×10^{-7}
ENV-80	9	$< 2.0 \times 10^{-7}$	< 0.11	$< 3.0 \times 10^{-7}$	5.0×10^{-7}	$< 3.7 \times 10^{-5}$	8.0×10^{-7}
ENV-81	4	$< 2.0 \times 10^{-7}$	< 0.11	$< 3.0 \times 10^{-7}$	4.0×10^{-7}	$< 3.0 \times 10^{-5}$	5.0×10^{-7}
ENV-90	1	2.0×10^{-7}	0.11	2.0×10^{-7}	5.0×10^{-7}	3.7×10^{-5}	5.0×10^{-7}

* Standard of comparison = 1.9×10^{-4} Bq/L (source: DOE Order 5400.5)

** Standard of comparison = 1.35 Bq/L (source: DOE Order 5400.5)

*** 1 Bq = 27 pCi

standard and a number of background samples.

Gross alpha and gross beta concentrations for these particulate air samples are presented in Table 4-7. See Table APP-1-1 in *Volume II, Data Appendix for Environmental Monitoring and Surveillance Results*, for raw sampling data on these parameters. Since DOE Order 5400.5 makes no provision for evaluating unidentified radionuclides, such as the general classification of alpha and beta particles, unidentified radionuclides are assumed to be thorium-232 if they are alpha-emitting material or strontium-90 if they are beta-emitting material. This is a conservative approach because these assigned radionuclides represent the most restrictive alpha and beta emitters listed in DOE Order 5400.5 by several orders of magnitude. The ambient results are still below these more restrictive

comparitors. An inspection of the diversity in both the inventory of radionuclide sources and the summary of annual release information confirm that this is an overly conservative assumption.

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Section 5. Surface Water

Introduction

Surface water at Berkeley Lab, for environmental monitoring purposes, consists of rainwater, creeks, lakes, hydraugers, and stormwater. The first four surface water types are monitored for alpha, beta, and tritium activity, based solely on DOE orders which prescribe the monitoring of radioisotope activity. Stormwater monitoring is undertaken pursuant to the California General Industrial Activities Stormwater Permit, and includes monitoring for metals and other constituents. The monitoring programs for each type of surface water are further described below.

Sample analyses of surface water are performed by Berkeley Lab's Radiation and Analytical Measurement Laboratory. Tritium analysis of water samples is accomplished by liquid scintillation counting. Water samples are prepared for gross alpha and beta analysis by acidification (nitric acid) and evaporation into 5-centimeter (2-inch) diameter stainless steel planchettes. Organic residues not wet-ashed by the nitric acid treatment are oxidized by flaming the planchettes. A similar method (US/EPA Method 906) is employed by the outside laboratory to which some split samples are sent for QA purposes.

At the end of 1995, LBNL reassessed the surface water sampling program as part of the triennial revision of the *Environmental Monitoring Plan*. Some of the monitoring programs were reduced in scope to achieve a greater cost-effectiveness based on the usefulness of information. For example, the creeks, which had been monitored weekly, will now be monitored quarterly. On the other hand, lakes, which were not monitored before, will now be sampled annually. Most changes went into effect during the last quarter of 1995, so any anomalies in sampling frequency can often be ascribed to the program change.

Rainwater

During the rainfall season, generally October through April, rainwater is collected monthly or whenever there is significant rainfall.

During 1995, April, October, and November were dry months, and no samples were collected (see Figure 2-11). Rainwater was collected at six locations on site and analyzed for tritium and gross alpha and beta activity; the north side of Building 75, the roof of Building 4, and at stations ENV-B13A through ENV-B13D (see Figure 5-1). Alpha and beta activity were in general not detected, although normal low amounts of beta were seen at stations ENV-B13B and ENV-B13C. Alpha was seen infrequently, and, when present, was always less than 0.04 Bq/L (1 pCi/L). For comparison, federal and state maximum contaminant levels (MCLs) for drinking water are 0.6 Bq/L (15 pCi/L) for alpha and 1.9 Bq/L (50 pCi/L) for beta.

Tritium was detected once at ENV-B13D at extremely low levels (52 Bq/L or 1400 pCi/L). At Building 75 tritium was always detected, in varying amounts. These amounts ranged from low (77 Bq/L or 2,080 pCi/L) up to a maximum of 496 Bq/L (13,400 pCi/L), or about two-thirds of the US/EPA drinking water limits for tritium (740 Bq/L or 20,000 pCi/L). Most values lay in the mid-range between these two extremes. Tritium was not detected at ENV-B13A, ENV-B13B, or ENV-B13C.

With the switch to the new monitoring program, samples will now be collected only monthly. Analysis of historical and wind data revealed that the stations at Building 4 and ENV-B13A, ENV-B13B, and ENV-B13D were not useful indicators of radioisotope activity, and they were dropped from the program. The remaining rainwater sampling locations are Building 75 and ENV-B13C. Building 75 houses the National Tritium Labeling Facility; ENV-B13C, a station nearly one kilometer south of the NTLF, is useful as an indicator of background levels of activity. Table 5-1 summarizes the levels of alpha, beta, and tritium seen in rainwater samples taken during 1995.

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Figure 5-1. Rainwater Sampling and Hydrauger Locations

Table 5-1. Rainwater Radiological Monitoring Results

Location:	Alpha, Bq/L		Beta, Bq/L		Tritium, Bq/L	
	Average	High	Average	High	Average	High
Building 4	< 0.019*	0.020	< 0.026*	ND	< 11.1*	23.7
Building 75	< 0.019*	ND	< 0.026*	ND	289	496
ENV 13A	< 0.019*	ND	< 0.022*	ND	< 11.1*	ND
ENV 13B	< 0.019*	0.022	0.078	0.14	< 11.1*	ND
ENV 13C	< 0.019*	0.019	0.11	0.19	< 11.1*	ND
ENV 13D	< 0.019*	0.037	< 0.022*	0.030	24.1	51.9

* Average concentration was less than the MDA for the sample aliquot

Creeks

Given Berkeley Lab's location in the hills of the Strawberry Creek watershed, there are many streams and creeks in the Laboratory's vicinity which flow to varying degrees at various times of the year. When flowing, they are sampled and analyzed weekly for alpha, beta, and tritium activity by means of a 1-liter (1-quart) grab sample. Creeks sampled during 1995 were Botanical Garden Creek, Chicken Creek, Claremont Creek, Lower Strawberry Creek (on campus), the North Fork of Strawberry Creek, No Name Creek, Ravine Creek, Upper Strawberry Creek (on campus), also referred to as Strawberry Creek (UC), Ten-Inch Creek, and Wildcat Creek (see Figure 5-2 for locations). The Haas Upper and Lower Pools (campus swimming facilities in Strawberry Canyon) were also sampled twice. Data summaries for creek sampling are shown in Table 5-2.

In general, alpha activity was non-detect at all sampling sites. Similarly, beta activity was also generally not detected, but was occasionally seen in the larger creeks (Chicken, Claremont, Strawberry (2 locations on campus), and Wildcat) in small amounts. A small peak for beta seems to have occurred in early June, when beta was detected at all five sampling locations in amounts ranging from 0.18 Bq/L (4.9 pCi/L) in Wildcat Creek to 0.27 Bq/L (7.2 pCi/L) at Lower Strawberry on campus, still far below the MCL. These levels may be attributable to low water flow in

the creeks, or possibly samples in which sediment was inadvertently included.

Tritium was not seen at the smaller creeks (Botanical Garden, Cafeteria, Ten-Inch, No-Name, and Ravine) sampled twice during the year by the Environmental Restoration Program.

Results from the six larger creeks vary somewhat, although levels never exceeded one-quarter of the drinking water MCL of 740 Bq/L (20,000 pCi/L), and in most cases never exceeded 37 Bq/L (1,000 pCi/L). Results from Claremont Creek, with two exceptions, were non-detect. Wildcat Creek also showed generally non-detect levels. Upper and Lower Strawberry sites on campus showed generally non-detect levels, with some low levels (under 37 Bq/L or 1,000 pCi/L) throughout the year. The North Fork of Strawberry Creek was also mainly non-detect, with results of under 37 Bq/L (1,000 pCi/L) scattered throughout the year, and one result of 70 Bq/L (1,890 pCi/L).

Chicken Creek exhibited the highest results, both in number of samples in which tritium was detected, and in terms of levels detected. The highest level of tritium seen in the creeks during 1995 was 179 Bq/L (4,840 pCi/L) in Chicken Creek on January 4.

LBNL discharges no effluents directly to the ground, surface impoundments, injection wells, or other sources that would directly impact surface water. Neither Strawberry Creek, nor any of its tributaries, is known to be used as a source of drinking or irrigation

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Figure 5-2. Creek Sampling Locations

water. Therefore, in the revised monitoring program, the creek monitoring frequency was reduced to quarterly. The Lower Strawberry sampling point on campus was also dropped, since this was redundant with Upper Strawberry for purposes of monitoring Berkeley Lab radioisotopes. The sampling point at Upper Strawberry has been re-named "Strawberry Creek (UC)," and, along with Chicken, Claremont, the North Fork of Strawberry, and Wildcat creeks, will make up the five sampling points that will now be monitored quarterly for alpha, beta, and tritium activity.

Some creeks were also sampled and analyzed randomly for nonradiological parameters. Twice during the year (January 3-4 and July 6) certain creeks were sampled for volatile

organic compounds (VOCs) by US/EPA method 8260. All results were non-detect. During the sampling of July 6, Ravine and Botanical Garden Creeks were also sampled for metals, with nothing detected above method limits. On August 9, four creeks (Chicken, No Name, Ten-Inch, and Ravine) were sampled for metals. Three of these showed barium at approximately 110 $\mu\text{g/L}$ (about two orders of magnitude below the MCL of 1 mg/L). Trace amounts of zinc and molybdenum were also present.

On February 23 and June 15, DHS took surface water samples at five main creek sites (Claremont, Wildcat, North Fork of Strawberry, and Upper and Lower Strawberry (on campus) under the auspices of the Agreement in Principle (AIP) Program (see

Table 5-2. Creek Radiological Monitoring Results

Location:	Alpha, Bq*		Beta, Bq*		Tritium, Bq*	
	Average	High	Average	High	Average	High
Botanical Garden Creek	—	—	—	—	< 14.8**	ND
Cafeteria Creek	—	—	—	—	< 14.8**	ND
Chicken Creek	< 0.11**	ND	< 0.11**	0.26	< 11.7**	179
Claremont Creek	< 0.15**	ND	< 0.11**	0.20	< 9.93**	20.0
Haas Lower Pool	—	—	—	—	< 14.8**	52.2
Haas Upper Pool	—	—	—	—	< 14.8**	47.4
Lower Strawberry Creek	< 0.07**	ND	< 0.07**	0.27	< 9.44**	37.4
North Fork Strawberry Creek	< 0.07**	ND	< 0.11**	0.033	< 14.0**	33.0
No Name Creek	—	—	—	—	< 14.8**	ND
Ravine Creek	—	—	—	—	< 14.8**	ND
Strawberry Creek (UC)	< 0.15**	ND	< 0.15**	0.22	< 11.5**	31.8
Ten-Inch Creek	—	—	—	—	< 14.8**	ND
Wildcat Creek	< 0.07**	ND	< 0.07**	0.18	< 7.18**	58.2

* 1 Bq = 27 pCi

** Average concentration was less than the MDA for the sample aliquot

Chapter 3, *Compliance Summary*). These samples were analyzed for gross alpha, gross beta, and tritium, as well as the list of Title 22 metals. Tritium-spiked samples were included in this batch for quality assurance purposes. A sample was also taken from one influent point near Building 69. This sample was analyzed only for Title 22 metals. For quality control purposes, de-ionized water with a metal spike and a field blank were also analyzed with the samples analyzed for metals.

Results from split sampling received from the AIP sampling can be found in Table APP-5-2 in the Volume II data appendix. Results were consistent with those provided by DHS and SWRCB, and with those seen throughout the year in routine samplings.

Lakes

Lake sampling is a new program that will commence in 1996. The first report on lakes will be in next year's site environmental report.

Hydraugers

Hydraugers are essentially perforated pipes inserted into a hillside in order to increase and improve the drainage of unstable slopes. Because of its location on some very steep hillsides, Berkeley Lab has many of these hydraugers. See Chapter 6, *Groundwater Protection*, for additional information.

Six hydrauger sites (HYG77-0101, HYG77-0103, HYG77-0104, HYG77-02XX, HYGCC1, and HYGCC2) are monitored as a means of keeping track of any known or suspected plumes of contamination. See Figure 5-1 for locations of monitored hydraugers. HYG77-02XX is a manifold of several hydraugers, and is sampled at the point where all of them discharge together. Hydraugers prefixed with HYG77 are located behind Building 77, while the HYGCC prefix refers to a location near Chicken Creek further down the hillside. These six sites are monitored quarterly for alpha, beta, and tritium.

During 1995, the hydrauger at Building 71 was sampled three times as part of the historical program, before being eliminated.

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Alpha and beta activity was generally non-detect, with one low exception, and tritium was found just at method detection limits.

Hydrauger flow is dependent upon rainfall and several other factors; not all of the hydraugers flow all the time, and sometimes they cannot be sampled for that reason. At the hydraugers which could be sampled during 1995 (HYG77-0101, HYG77-02XX, HYGCC1, and HYGCC2), alpha was always non-detect, except for one result just at detection limit (0.04 Bq/L, or 1 pCi/L, at HYGCC2), while beta was occasionally seen, again generally near detection limits. Tritium was either non-detect or at very low levels at the Chicken Creek hydraugers, while it is usually present at less than half of US/EPA drinking water levels at HYG77-0101, and less than one-quarter of US/EPA drinking water levels at HYG77-02XX. The area behind Building 77 contains a known plume of tritium. These results both track its presence and help to establish the level of contamination.

Stormwater

Under the State of California's authorized NPDES program, which is administered by the SWRCB, Berkeley Lab has held General Industrial Activities Stormwater Permit No. 2 01S002421 since October of 1992. Permit holders are required to develop and maintain a *Storm Water Monitoring Plan* (SWMP) and a *Storm Water Pollution Prevention Plan*. These are the guiding documents for the Lab's compliance with stormwater regulations. Additional discussion on this compliance program is found in the water quality section of Chapter 3.

Berkeley Lab's SWMP details the rationale for sampling, sampling locations, and the kinds of analyses to be performed. The sampling points are shown in Figure 5-3 and the sampling design is summarized in Tables 5-3 and 5-4. Two tables are presented because LBNL changed its sampling design after the 94/95 stormwater season. In accordance with a provision of the General Permit that allows a

facility to eliminate a certain pollutant from sampling if that substance is not detected in significant quantities after two consecutive samplings, LBNL reduced the number of substances for which it analyzes. These substances were volatile organic compounds and cyanide, which had not been detected in three years of monitoring. Samples taken in late 1995, during the 95/96 stormwater season, were taken according to the revised sampling design (Table 5-4).

In August, LBNL notified the RWQCB and the City of Berkeley that, subject to regulatory approval, it intended to delete the six minor creeks (StW5 through StW10 on Figure 5-3) from its sampling program. Among other reasons given was the fact that, during three years of analysis by whole effluent toxicity, no samples had ever been analyzed as toxic to fish. These creeks are also very small streams and their flow is intermittent, even during rainstorms, making it difficult to sample them. Thus samples taken in late 1995, during the 1995-96 stormwater season, were taken only from sampling points 71 - Storm Drain Manhole (formerly StW1), 69 - Storm Drain Manhole (formerly StW3), N. Fork Strawberry Creek (formerly StW2), and Chicken Creek (formerly StW4), shown on Figure 5-3.

Two of the monitoring points, 71 - Storm Drain Manhole and 69 - Storm Drain Manhole, are actually influent points, where stormwater comes onto the LBNL site from residential areas, roads, and other campus facilities located above it. These points were chosen as a basis of comparison and to increase the possibility of locating a source should contaminants be found. The 71 - Storm Drain Manhole was brought on line for the beginning of the 95/96 stormwater season.

Under the terms of the General Permit, sampling must take place twice per year under specific conditions (for example, for a sample to be valid, the discharge must be preceded by 72 hours of dry weather). Monitoring also includes visual observation of one storm per

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Table 5-3. Previous Stormwater Sampling Design

Monitoring Locations	Parameters of Concern ¹							
	Metals	VOCs	PCBs	CN	TPH/BTEX	TPX/Extractable	Gross Alpha & Beta	Tritium
StW 1	•	•	•	•	•	•	•	•
StW 2	•	•	•		•	•		
StW 3	•	•	•	•	•	•	•	•
StW 4	•	•	•	•	•	•	•	•
StW 5			•		•	•		
StW 6	•	•				•		
StW 7								
StW 8		•				•		
StW 9								
StW 10						•		

¹ All samples are tested for pH, Total Suspended Solids (TSS), Specific Conductance, and Total Organic Carbon (TOC) or Oil & Grease.

Table 5-4. Current Stormwater Sampling Design

Monitoring Locations	New Name	Parameters of Concern ¹					
		Metals	PCBs	TPH/BTEX	TPX/Extractable	Gross Alpha & Beta	Tritium
StW 01	71 - Storm Drain Manhole	•	•	•	•	•	•
StW 02	N. Fork Strawberry Creek	•	•	•	•	•	•
StW 03	69 - Storm Drain Manhole	•	•	•	•	•	•
StW 04	Chicken Creek	•	•	•	•	•	•

¹ All samples are tested for pH, Total Suspended Solids (TSS), Specific Conductance, and Total Organic Carbon (TOC) or Oil & Grease.

month. All sampling points must be monitored for the following:

- pH, total suspended solids, specific conductance, and total organic carbon (TOC). Oil and grease may be substituted for TOC.
- toxic chemicals and other pollutants that are likely to be present in stormwater discharge in significant quantities.

The pH was always near neutral, and PCBs, BTEX (benzene, toluene, ethylbenzene, and xylenes) and cyanide were never detected. Total petroleum hydrocarbons (diesel) and oil

and grease, both tests for gas or oil, often detected insignificant amounts. Specific conductance, usually a measure of the degree of mineralization of water, was low and within the range of domestic drinking water. Total suspended solids, in this case mostly a measure of water clarity, refers to the portion of solids retained on a filter of 2.0 µm (or smaller) when analyzed by a laboratory. This was also in general quite low, indicating clear water.

Metals occasionally seen included arsenic, chromium, copper, lead, selenium, vanadium, and zinc. The General Permit does not contain

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Figure 5-3. Stormwater Sampling Locations

specific discharge limits for these metals. Dischargers are prohibited from contributing to a violation of any applicable water quality standards, such as a regional Basin Plan. For General Permit purposes, the limits set in such plans or standards are intended as a guide to indicate when constituent levels seen in an individual facility's monitoring results should become a cause for concern. At this stage, the Regional Boards consider monitoring results to be part of the information-gathering phase of stormwater regulation. Results at Berkeley Lab are consistent with levels of urban runoff which could be expected to be present at a site such as LBNL, with traffic and roads on site and runoff from roads and residential areas above.

For comparison purposes, Table 4-3 of the Water Quality Control Plan (Basin Plan) promulgated by the San Francisco Bay Regional Water Quality Control Board gives effluent limitations for selected toxic pollutants discharged to surface waters. These limitations are applicable to Publicly Owned Treatment Works, like EBMUD, and industrial effluent. Table 5-5 compares these limits to the average levels of metals seen in Berkeley Lab's stormwater samples for 1995. Also given for comparison are US/EPA's benchmark levels for metals, recently promulgated as part of its national multisector stormwater permit.

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Table 5-5. 1995 Average Stormwater Results for Metals

Analyte*	STW 2	STW 3	STW 4	Basin Plan (RWQCB)	Benchmark (EPA)
Antimony	ND	ND	ND	—	0.636
Arsenic	0.0045	ND	0.0054	0.02	0.16854
Barium	.06	ND	ND	—	—
Beryllium	ND	ND	ND	—	0.13
Cadmium	ND	ND	ND	0.01	0.0159**
Chromium	0.024	ND	0.021	0.011	—
Cobalt	ND	ND	ND	—	—
Copper	0.038	0.017	0.033	0.02	0.0636**
Lead	0.022	0.017	0.025	0.0056	0.0816**
Mercury	ND	ND	ND	0.001	0.0024
Molybdenum	ND	ND	ND	—	—
Nickel	ND	ND	ND	0.0071	1.417**
Selenium	ND	ND	ND	—	0.2385
Silver	ND	ND	ND	0.0023	0.0318**
Thallium	ND	ND	ND	—	—
Vanadium	ND	ND	ND	—	—
Zinc	0.18	0.073	0.244	0.058	0.117**

*All results are given in mg/L

**Hardness dependent

Another useful comparison is with the results from the preoperational monitoring study at Building 85, the new Hazardous Waste Handling Facility. This preoperational study is discussed later in the chapter. Metals analyses exhibited low levels of arsenic, barium, cadmium, chromium, cobalt, copper, lead, nickel, vanadium, and zinc. Since this is a portion of the site that had not been in use previously and was undisturbed ground prior to construction, the presence of metals in stormwater runoff there may either point to the kind of urban runoff from construction and vehicles as alluded to above, or be an

indication of the background levels of metals present in general at the LBNL site.

Routine stormwater samples are also analyzed for the presence of alpha and beta emitters and tritium. Alpha was in general non-detect, while beta ranged from 0.04 to 0.11 Bq/L (1 to 3 pCi/L). Tritium values were also low, ranging from non-detect at the North Fork of Strawberry Creek to 103 Bq/L (2,780 pCi/L) at 69 - Storm Drain Manhole, an influent site near the National Tritium Labeling Facility. Summaries of alpha, beta, and tritium for stormwater sampling during 1995 are shown in Table 5-6.

Table 5-6. Average Stormwater Radiological Analysis Results

Location	Yearly Average Concentration (Bq*/L)		
	Alpha	Beta	Tritium
STW 2	ND	0.052	ND
STW 3	ND	0.088	73.7
STW 4	ND	0.082	31.9

*1 Bq = 27 pCi

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Section 6. Groundwater Protection

Responsibilities

Berkeley Lab seeks to ensure that the protection of groundwater benefits the overall environmental quality. The *Groundwater Protection Management Program Plan*⁸⁸ provides a framework for preventing future groundwater contamination and for remediating existing contamination at the site. This plan stresses the integrated nature of all environmental activities and seeks to ensure that protection of groundwater results in a net benefit to overall quality. Berkeley Lab strives to protect groundwater by preventing future groundwater contamination, monitoring to ensure that present groundwater quality is preserved, remediating contamination to prevent the degradation of uncontaminated groundwater, and to improve groundwater quality. The Laboratory involves local and state government agencies in its protection and remediation programs, and informs the public of efforts to protect groundwater quality.

Under the RCRA Corrective Measure Process, the Laboratory areas of soil and groundwater contamination are identified that may have resulted from past releases of contaminants to the environment, determines the sources and extent of the contamination, and develops and implements plans to remediate contaminated areas. LBNL protects groundwater quality by containing and remediating areas of contamination and preventing the degradation of uncontaminated groundwater.

Activities are closely coordinated with the oversight regulatory agencies, including the California Department of Toxic Substances Control, State and Regional Water Quality Control Boards, and the City of Berkeley. These agencies approve the work plans that are prepared for all activities. In addition, each quarter Berkeley Lab writes a progress report and meets with the regulatory agencies to review results of previous activities. Further, Berkeley Lab informs the public of efforts made to protect groundwater quality through Community Relations Fact Sheets and the information repositories where program

documents are available for public review. The documents in the information repositories include the quarterly progress reports, which contain all groundwater monitoring data, site maps showing monitoring well locations and contaminant concentrations, and graphs showing changes in contaminant concentrations over time.

Hydrogeologic Characterization

This section discusses the hydrogeological setting of Berkeley Lab and includes: a review of the hydrogeologic units, a discussion of groundwater flow, and a description of the hydrologic properties of the shallow water-bearing zones. More detailed information on the hydrogeology is provided in the 1994 *LBNL RCRA Facility Investigation Progress Report*.

Hydrogeologic Units

There are five geological bedrock units at the site. Moraga formation volcanic rocks, Orinda formation sediments, and Great Valley Group sediments constitute the major rock units at the site. The Claremont formation and the San Pablo Group crop out only in the easternmost area and are of limited extent. The hydrogeological characteristics of the three main units are discussed below. Values of hydraulic conductivity, a coefficient that controls the rate at which groundwater can move through rock or soil, for the rock units have been determined through single-well and multiple-well hydraulic tests. Interpretation of these test results has shown a wide range of hydraulic conductivity at LBNL.

The Moraga formation consists mainly of lava flows, flow breccias, and agglomerates. The lavas are typically highly fractured, jointed, or brecciated. Due to the presence of open fractures and low-matrix permeability, groundwater flow is primarily through fractures. The hydraulic conductivity of these rocks is relatively high at 10^{-4} to 10^{-6} meters per second (3.3×10^{-4} to 3.3×10^{-6} feet per second), and they constitute the main water-

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bearing unit at Berkeley Lab. The presence of low-permeability interbeds of clay and other sediments as well as zones with little fracturing create multiple-perched water conditions at many locations. As a result, differences in measured water levels of as much as 8 meters (26 feet) can be observed over short distances.

The Orinda formation consists primarily of low-permeability siltstones, sandstones, mudstones, and conglomerates. The Orinda formation generally has a lower hydraulic conductivity, ranging between 10^{-7} to 10^{-9} meters per second (3.3×10^{-7} to 3.3×10^{-9} feet per second) and underlies the Moraga formation, constituting a relatively impermeable boundary for groundwater flow. Zones of coarser-grained, more permeable sandstone, and conglomerate channel fills occur locally in the Orinda formation. The sandstones and conglomerates may form confined aquifers, especially where they are fractured. A review of archived geological logs of boreholes indicates that the water table was seldom encountered in the Orinda formation during drilling.

The Great Valley Group consists primarily of low-permeability shales, mudstones, and sandstones and crops out along the western and southern parts of the site. Most of the borings drilled into this formation have encountered groundwater. Due to the presence of moderately spaced open fractures and low-matrix permeability, groundwater flow is primarily through fractures. The hydraulic conductivity varies between approximately 10^{-5} and 10^{-7} meters per second (3.3×10^{-5} and 3.3×10^{-7} feet per second).

Groundwater Flow

The direction and the velocity of groundwater flow are controlled primarily by the hydrogeologic characteristics of the geologic units (i.e., distribution of hydraulic conductivity) and the distribution of hydraulic head. Representative values of hydraulic conductivity for the primary hydrogeologic units were described above. A groundwater piezometric map indicating the hydraulic head

distribution at LBNL, based on water levels measured in wells, is given in Figure 6-1. The groundwater piezometric surface indicates that the direction of groundwater flow generally follows the topography. In the western part of the site, groundwater generally flows to the west; over the rest of Berkeley Lab, flow is generally toward the south. The velocity of the groundwater varies widely from approximately 0.001 meter per year (0.003 feet per year) to 1 meter per day (3.3 feet per day). The depth to groundwater ranges from approximately 0 to 30 meters (0 to 98 feet).

Groundwater Fluctuations

Fluctuations in groundwater elevation generally show a good correlation with rainfall data, as illustrated by comparison of site rainfall amounts with groundwater elevation changes in well 7-92-19 in the "Old Town" area (Figure 6-2). Generally there is a fairly rapid response (i.e., days) of water levels in most site wells after rainfall occurs. Fluctuations as much as 4.2 meters (14 feet) are common in wells in the Old Town area.

Groundwater Quality

Groundwater samples from monitoring wells include tests for total dissolved solids (TDS), cations, and anions. TDS concentrations measured in groundwater monitoring wells vary from 105 to 2,750 mg/L. Water in the Orinda formation typically has a high total dissolved solids concentration, indicating a long resident time. Average mineral concentrations for the three primary geologic units are listed in Table 6-1.

Figure 6-1. Groundwater Piezometric Map at LBNL

Groundwater Monitoring Program

The groundwater monitoring program began in 1991 at the Laboratory. The purpose of monitoring is to characterize the extent and magnitude of contaminants in groundwater and to evaluate the potential for future contaminant migration. Groundwater monitoring wells serve three main purposes: 1) monitor groundwater quality near the site perimeter, 2) characterize the magnitude and extent of groundwater contamination, and 3) evaluate the impact to groundwater of possible past releases from units that stored hazardous materials or hazardous waste, including underground storage tanks. Three categories of contaminants are monitored under the

program: Hydrocarbons, metals, and tritium. The extent of monitoring within each category is influenced by the historical findings to date.

Currently, the program has 16 monitoring wells installed close to the site boundary and two wells installed off site, downgradient from the site. Figure 6-3 shows the approximate locations of these wells. With the exception of MWP-7 and MW74-94-7, no volatile organic compounds (VOCs) were detected in any of these wells in 1995. Trace concentrations of VOCs (approximately 1 µg/L or less) were detected in MW74-94-7 in only one of the seven quarters in which the well has been sampled (February 1995). Low concentrations of trichloroethylene (TCE), perchloroethylene (PCE), or chloroform were detected in MWP-7 during all four quarters of 1995. MWP-7 monitors the Building 37

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Figure 6-2. Groundwater Fluctuations in Well 7-92-19 Compared to Rainfall

Table 6-1. Water Quality in Different Formations

Parameter	Federal or California Maximum Contaminant Level (MCL)	Orinda Formation	Average Concentration (mg/L)	
			Moraga Formation	Great Valley Group
TDS	500 *	925	473	640
Nitrate (as NO ₃)	45	32	12	2.6
Sulfate	500	128	28	124
Chloride	250 *	132	26	42
Bicarbonate		502	413	430
Potassium		3.6	2.2	4.2
Sodium		276	60	127
Magnesium		20	31	26
Calcium		35	68	61
pH	6.5 to 8.5	8.0 pH units	7.4 pH units	7.7 pH units

* indicates secondary maximum contaminant level (aesthetic standard)

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Figure 6-3. Approximate Location of Monitoring Wells Close to the LBNL Property Line

VOC plume; this well is part of an interim corrective measure, as discussed in the following section. Concentrations of total VOCs detected in MWP-7 decreased from 27.6 $\mu\text{g/L}$, before the interim corrective measure was applied in January 1994, to 14.6 $\mu\text{g/L}$ in November 1995.

The groundwater monitoring program consists of semi-annual sampling and analysis for VOCs by US/EPA method 8260 at selected sites, and annual sampling for Title 22 metals in all site monitoring wells and two offsite wells. Samples from monitoring wells in the Corporation Yard (Building 75 and 69 area) and those close to the property boundary are sampled approximately quarterly for tritium. Wells associated with underground fuel storage tanks or areas of known petroleum hydrocarbon contamination are also analyzed for petroleum hydrocarbons, approximately quarterly.

The number of installed groundwater monitoring wells is shown below. The program has a total of 109 monitoring wells. Twenty-five of these wells were installed in 1995. Of the total number of wells, 3 are considered multi-level, in that they allow monitoring activities to occur at several tiers. One of the multi-level wells was installed in 1995.

A summary of groundwater monitoring results for 1995 is presented in Tables 6-2 through 6-4. Tables 6-2 and 6-3 show the metals and hydrocarbon analytes detected in groundwater monitoring wells, respectively, along with the drinking water maximum contaminant level for the analyte, the number of monitoring wells sampled, the number of wells in which the analyte was detected, and the ranges in concentrations detected. Table 6-4 presents quarterly tritium results from monitoring wells located across the site. The discussion on the tritium plume later in this

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Table 6-2. Metals Detected in Groundwater Samples from Monitoring Wells in 1995

Metal	Number of Wells	Number of Samples	Number of Samples Detected	Range of Concentrations (µg/L)	California Maximum Contaminant Level for Drinking Water (µg/L)
Antimony	62	83	2	4 - 11	6
Arsenic	62	83	45	2 - 120	50
Barium	62	83	36	10 - 360	1000
Beryllium	62	83	1	2	4
Cadmium	62	83	1	6	5
Chromium	62	83	11	10 - 40	50
Cobalt	62	83	2	9 - 40	NS*
Copper	62	83	3	11 - 17	1000**
Lead	62	83	0	—	15***
Mercury	62	83	1	0.2	2
Molybdenum	62	83	29	10 - 360	NS*
Nickel	62	83	2	10 - 40	100
Selenium	62	83	19	2.4 - 62	50
Silver	62	83	0	—	100**
Titanium	62	83	0	—	2
Vanadium	62	83	13	6 - 82	NS*
Zinc	62	83	10	10 - 73	5000**

* NS: Not Specified

** Secondary MCL

*** Action Level

chapter summarizes the extent of this plume in more detail.

Groundwater Contamination

Based on groundwater monitoring results, seven principal groundwater contamination plumes have been identified on site. The plume locations listed below are shown in Figure 6-4:

VOC Plumes

- Old Town
- Building 71
- Building 37

Freon Plume

- Building 71

Tritium Plume

- Building 75

Fuel Plume

- Building 7
- Building 74

Contamination has also been detected in groundwater in other areas of the site. These areas are indicated by the small circles in Figure 6-4. However, based on the present information, the extent of contamination in these areas is limited.

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Table 6-3. Analytes Detected in Groundwater Samples from Monitoring Wells in 1995

Method 8260 Analytes	Number of Wells Sampled	Number of Samples	Range of Concentrations (µg/L)	Federal or California Max. Contaminant Level (MCL) (µg/L)
<u>Aromatic or Non-halogenated Hydrocarbons</u>				
Benzene	109	8	0.63 - 76	1
Bromobenzene	109	1	1.1	
sec-Butylbenzene	109	3	0.63 - 3.1	
ter-Butylbenzene	109	2	1.2 - 1.6	
Isopropylbenzene	109	3	0.51 - 2.1	
Naphthalene	109	4	0.57 - 26	
n-Propylbenzene	109	2	1 - 3	
Toluene	109	9	0.55 - 32.3	150
1,2,4-Trichlorobenzene	109	1	0.76	70
1,2,3-Trichloropropane	109	1	1.1	
1,2,4-Trimethylbenzene	109	2	1.7 - 18	
1,3,5-Trimethylbenzene	109	3	0.82 - 11	
Xylenes, total	109	1	1	1750
<u>Halogenated Hydrocarbons</u>				
Bromodichloromethane	109	5	0.94 - 6.6	100
Carbon Tetrachloride	109	19	0.53 - 8100	0.5
Chloroethane	109	1	0.7 - 0.96	
Chloroform	109	39	0.52 - 108	100
Dibromomethane	109	1	4.5	
Dichlorodifluoroethane (Freon 12)	109	1	0.66	
1,1-Dichloroethane	109	32	0.51 - 21.5	5
1,2-Dichloroethane	109	4	0.53 - 4.6	0.5
1,1-Dichloroethene	109	36	0.51 - 525	6
cis-1,2-Dichloroethene	109	33	0.5 - 556	6
trans-1,2-Dichloroethene	109	15	0.56 - 75	10
1,3-Dichloropropane	109	1	3.7	
1,1-Dichloropropene	109	1	3.2	

(continued on following page)

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Table 6-3. (continued)

Method 8260 Analytes	Number of Wells Sampled	Number of Samples	Range of Concentrations (µg/L)	Federal or California Max. Contaminant Level (MCL) (µg/L)
Halogenated Hydrocarbons (Continued)				
cis-1,3-Dichloropropene	109	1	4.4	
trans-1,3-Dichloropropene	109	1	4	
Methylene Chloride	109	2	1 - 11.5	5
1,1,1,2-Tetrachloroethene	109	3	30.9 - 329	
Tetrachloroethene	109	53	0.5 - 190,000	5
1,1,1-Trichloroethane	109	20	0.51 - 213	200
1,1,2-Trichloroethane	109	4	1.6 - 5.1	5
Trichloroethene	109	50	0.47 - 100,000	5
Trichlorofluoromethane (CFC 11)	109	2	0.53 - 3.9	
1,1,2-Trichlorotrifluoroethane (CFC 113)	109	21	0.4 - 610	1200
Vinyl Chloride	109	15	0.51 - 50.9	0.5

Figure 6-4. Groundwater Contamination Plumes, December 1995

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Table 6-4. Tritium Detected in Groundwater Sampling from Monitoring Wells in 1995
(Concentrations in Bq/L)

Well Number	Jan-Mar 95	Apr - June 95	Jul - Sep 95	Oct - Dec 95
MCL:	741	741	741	741
MW76-1	< 14.8		30.3 ± 12.9	
MW91-4	38.1 ± 7.2	35.5 ± 7.7	22.4 ± 8.2 < 14.8	37.6 ± 7.5
MW91-5	66.3 ± 9.9		68.7 ± 15.1	37.7 ± 10.9
MW91-6	150.9 ± 16.7		175.1 ± 19.3	158.7 ± 17.1
75-92-23	41.1 ± 11.0		44.5 ± 13.8	163.6 ± 16.0 157.0 ± 15.7
75B-92-24	248.5 ± 17.3	249.8 ± 18.1	255.4 ± 20.9 273.3 ± 22.0	277.7 ± 20.2
CD-92-28	< 14.8	< 14.8	< 14.8	< 14.8
76-93-6	118.9 ± 14.7 121.5 ± 14.8 (D) 130 ± 15 (S)	136.0 ± 14.5	132.7 ± 17.6	119.7 ± 15.9
53-93-16		< 14.8		
MWP-1	< 14.8	< 14.8	< 14.8	< 14.8
MWP-2	< 14.8	< 14.8	< 14.8	< 14.8
MWP-4	< 14.8	< 14.8	< 14.8	< 14.8
MWP-5	< 14.8	< 14.8	< 14.8	< 14.8
MWP-6	< 14.8	< 14.8	< 14.8	< 14.8
MWP-7	< 14.8	< 14.8	< 14.8	< 14.8
MWP-8	< 14.8	< 14.8	< 14.8	< 14.8
MWP-9	< 14.8	< 14.8	< 14.8	< 14.8
MWP-10	< 14.8	< 14.8	< 14.8	< 14.8
OW3-225	< 14.8	< 14.8	< 14.8	< 14.8
85-95-1			< 14.8	< 14.8
85-95-2			< 14.8	

MCL = Maximum contaminant level for drinking water determined by California DTSC

D = Duplicate Sample

S = Split

VOC Plumes

The Old Town VOC Plume is the most extensive plume at Berkeley Lab and covers the area of Buildings 7, 53, 27, 58A, and the slope west of Building 53. The plume is defined by the presence of perchloroethene (PCE) and trichloroethene (TCE), and by lower concentrations of other halogenated hydrocarbons, including 1,1-dichloroethene (1,1-DCE), cis-1,2-dichloroethene, 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane, 1,1,1-trichloroethane (1,1,1-

TCA), 1,1,2-trichloroethane, carbon tetrachloride, and vinyl chloride, several of which are products of PCE and TCE degradation. The maximum concentration of total halogenated hydrocarbons detected in wells monitoring the Old Town VOC plume in 1995 was 298,100 µg/L, which primarily consisted of PCE (190,000 µg/L), TCE (100,000 µg/L), and carbon tetrachloride (8,100 µg/L). Figure 6-5 shows the areal extent of VOCs in groundwater in the Old Town area. Figure 6-6 shows the time variation of contaminant concentrations in monitoring well MW7-92-19. MW7-92-19 is located close to the plume source area.

Figure 6-5. Groundwater Contamination in the Old Town Area, December 1995

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MW7-92-19

Figure 6-6. Time Variation of Contaminant Levels at Monitoring Well MW7-92-19

The primary source of the plume was apparently leakage and/or overflow from an abandoned sump located between Buildings 7 and 7B. The sump was discovered and its contents removed in 1992. Other less significant source areas are indicated by relatively high concentrations of halogenated hydrocarbons detected in groundwater samples from monitoring wells west of Building 16, northeast of Building 52, and west of Building 25A. The sources of the contamination detected in these wells have not been identified. The contaminated groundwater from these sources flows westward, where it intermixes with the main Old Town plume.

Other VOC plumes have been identified in the area south of Building 71 (Building 71 VOC plume) and south of Building 37 (Building 37 VOC plume). These plumes cover less area than the Old Town plume, and the number of contaminants detected and magnitude of contamination are also much less. The Building 71 VOC plume is defined by the presence of halogenated hydrocarbons, predominantly PCE, TCE, cis-1,2-DCE, 1,1-DCA, 1,1,1-TCA, and vinyl chloride. The maximum concentration of total halogenated hydrocarbons detected in wells monitoring the plume in 1995 was 73.8 µg/L. There has been a general decrease in the concentration of total VOCs detected in Well MW90-3 since December 1992. The Building 37 VOC plume is defined by the presence of

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halogenated hydrocarbons, primarily TCE and PCE in monitoring wells MWP-7 and MW37-92-6. There has been a decreasing trend in VOC concentrations detected in the two wells after January 1994 when pumping groundwater for plume management was initiated.

Freon Plume

High concentrations of Freon-113 were detected in groundwater south of Building 71 in 1993 and 1994 (The Building 71 freon plume). The source of Freon-113 is most likely past spills from the Building 71 Linear Accelerator Cooling Unit, which is no longer operational. Concentrations of Freon-113 increased to a maximum concentration of 8,984 µg/L in August 1994, and then decreased to 260 µg/L in December 1995. The MCL for Freon-113 is 1200 µg/L. The decrease in the Freon-113 concentration is believed to be source depletion due to the recent extensive groundwater recharge.

Tritium Plume

The tritium plume is limited to the vicinities of Buildings 75, 76, 77, and 78. The source of the tritium is emissions from the NTLF stack west of Building 75. The maximum concentration of tritium detected in monitoring wells in 1995 was 277 Bq/L (7,497 pCi/L), which is well below the drinking water standard of 740 Bq/L (20,000 pCi/L). Tritium has not been detected in groundwater samples from monitoring wells near the site boundary. There appear to be decreasing trends in the concentration of tritium in two wells in the Corporation Yard near Buildings 75A and 69 (MW91-4 and MW91-6) since September 1992. No consistent trend is evident in the variations of tritium concentration in other wells.

Fuel Contamination and Fuel Plumes

Monitoring wells have been installed at, or downgradient from, two decommissioned and

four removed UST sites. Figure 6-7 shows approximate locations of these wells. The ranges in concentrations of total petroleum hydrocarbons (TPH) detected at these sites in 1995 are listed in Table 6-5.

Trace concentrations of aromatic hydrocarbon (common components of fuels) of approximately 1 µg/L or less, including benzene, ethylbenzene, and xylenes were detected in groundwater at the Former Building 76 UST site (south of Building 76) in 1995. Aromatic hydrocarbons were also detected in the three wells at the former Building 7E UST site; however no BTEX components (i.e., benzene, toluene, ethyl benzene, xylene) were detected. This removed tank is the largest plume of fuel-related contamination. The plume is located north of Building 6. A thin layer of free product has been detected on the water table at this site and LBNL is evaluating potential interim corrective measures for soil and groundwater remediation. No aromatic hydrocarbons have been detected at the other UST sites.

Interim Corrective Measures

Interim corrective measures are used to remove contaminated media or prevent movement of contamination once it is identified, especially where the presence or movement of contamination poses an immediate risk to human health or the environment. Throughout the RCRA corrective actions process, Berkeley Lab has conducted interim corrective measures in consultation with regulatory agencies. These measures include

- removing sources of contamination,
- stopping discharge of contaminated water to surface waters,

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Figure 6-7 Approximate Locations of Monitoring Wells Associated With Underground Storage Tanks

Table 6-5. Total Petroleum Hydrocarbon Concentrations at UST Sites

UST Location	Status	Previous Contents	TPH Detected in 1995 ($\mu\text{g/L}$)
Building 7E	Removed	Fuel	TPH-D* = 390 to 1,400,000
Building 76	Removed	Diesel	TPH-D* = 100 to 1100
Building 76	Removed	Gasoline	TPH-G** = 70
Building 74	Removed	Diesel	TPH-D* = 240 to 530
Building 62	Removed	Diesel	TPH-D* = 58 to 400
Building 88	Abandoned	Diesel	TPH-D* = 78
Building 46A	Abandoned	Gasoline	Trace oil range hydrocarbon

* TPH-D = TPH quantified as diesel range hydrocarbons

** TPH-G = TPH quantified as gasoline range hydrocarbons

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- eliminating potential pathways that could contaminate groundwater, and
- preventing further migration of contaminated groundwater.

Source Removal

Berkeley Lab has identified potential sources of contamination by reviewing site records, conducting visual site inspections, and sampling soil, soil gas, and groundwater at solid waste management units and areas of concern. Where the contaminant concentrations pose a threat to human health or leaching of contaminants from the soils can impact groundwater, the need for interim corrective measures is evaluated. In 1995, the following sources of contamination were removed:

- the abandoned Building 7 sump, the primary source of the Old Town groundwater plume,
- PCB-contaminated material at the Building 88 hydraulic gate unit,
- mercury-contaminated soil and sludge associated with the Buildings 51/64 buried catch basin,
- diesel-contaminated soil at the Building 77 diesel generator pad, and
- mercury contaminated soil and sludge at the Building 71 storm drain.

A brief discussion for each of the contaminated source removals is provided below.

Abandoned Building 7 Sump

In 1992, an abandoned sump was discovered north of Building 7 in the Old Town area. The sump was located next to a former plating shop and is believed to be the major source of soil and groundwater contamination in the Old Town area. Over 35 years ago, the sump was backfilled with soil and covered with a concrete slab with its contents (PCE contamination) left in place. The interim corrective action conducted in 1992 included

removing the concrete slab which was covering the sump and its contents. However, due to nearby underground utilities such as sanitary sewers and storm drains, the sump could not be removed. In the summer of 1995, utilities were relocated and the sump was removed. Highly contaminated soil in the area of the sump was excavated to a maximum depth of approximately 5.2 meters (17 feet) from an area of about 2.1 by 3.1 meters (7 by 10 feet). Approximately 55 cubic meters (70 cubic yards) of contaminated soil were excavated and disposed of in accordance with regulatory requirements.

Building 88 Hydraulic Gate Unit

As part of visual inspections conducted in 1992, an oil stain approximately 3.1 meters (10 feet) long was observed on the concrete floor of the Building 88 hydraulic gate unit. The stain was believed to be the result of occasional drips of oil from a pump associated with the unit. Oil containing PCBs were used in the pump from 1962 to 1976, at which time the oil was changed to non-PCB oil. Detailed sampling activities were performed at the unit from 1994 to 1995 in an attempt to define the vertical and horizontal extent of PCB, oil, and grease contamination, which was found to be mostly contained within the shallow construction backfill materials. The interim corrective action conducted in 1995 included the removal of a 1.1 square meter (12 square foot) concrete slab and subsurface material (base rock and sand) to an approximate depth of 0.3 meters (1 foot). Three 208-liter (55-gallon) drums of PCB-contaminated concrete and subsurface material were removed and disposed of in accordance with regulatory requirements. Since the entire area of contamination was not accessible, appropriate corrective actions will be taken when the building is decommissioned.

Buildings 51/64 Catch Basin

In 1995, while performing excavation of soil for a utility relocation, maintenance and operations staff discovered mercury

contaminated soil in and around a buried catch basin near Buildings 51 and 64. Interim corrective actions included the removal of mercury-contaminated soil to a depth of approximately 2.4 meters (8 feet) around the catch basin, removal of the mercury contaminated sludge, and the repair of a broken concrete pipe connected to the catch basin. Sixty-one drums, or approximately 12 cubic meters (16 cubic yards), of soil and sludge were recycled or disposed of in accordance with regulatory requirements.

Building 77 Diesel Generator Pad

In 1995, while replacing the concrete pad for a diesel generator, maintenance and operations staff encountered soil that had a detectable odor and was stained beneath the generator pad. A sample was obtained and laboratory analysis confirmed the presence of diesel contaminated soil. The interim corrective action, conducted in 1995, included the removal and recycling of sixteen drums, or approximately 3.4 cubic meters (4.4 cubic yards), of diesel contaminated soil in accordance with regulatory requirements.

Building 71 Mercury Contamination

In 1995, while performing storm drain repairs in the basement of Building 71, maintenance and operations staff discovered mercury in the sludge at the bottom of the pipe and adjacent soil. Interim corrective measures included removal of the mercury-contaminated sludge and adjacent soil, and repair of the storm drain. Approximately sixteen 208-liter (55-gallon) drums, or 3,328 liters (880 gallons) of non-RCRA hazardous soil were recycled or disposed of in accordance with regulatory requirements.

Preventing Further Migration of Contaminated Groundwater and Preventing Discharge of

Contamination to Surface Waters

As noted above, several groundwater contamination plumes have been identified. As an interim corrective measure to control groundwater plumes that could migrate off site or contaminate surface water, LBNL is using extraction wells and subdrains to capture groundwater plumes. The extracted water is treated by granular activated carbon treatment systems prior to being recycled for industrial use on site or released to the sanitary sewer in accordance with the site's EBMUD permit.

In addition, the program has installed free-flowing subhorizontal drains (hydraugers) to lower groundwater levels and to reduce the risk of landslides. To prevent the discharge of contaminated groundwater to surface water, a system to collect and treat VOC-contaminated hydrauger discharge is in place.

In 1995, a collection system was installed in an electrical utility access port east of Building 6 as an interim corrective measure. The purpose of the system is to prevent the potential migration of contaminants through the electrical conduits. Water pumped from the access port is treated at the Building 37 treatment system.

Table 6-6 lists the volumes of contaminated water treated by the four installed systems.

Eliminating Potential Contaminant Pathways to Groundwater

To further reduce the risk of landslides, Berkeley Lab has installed numerous large-diameter slope-stability wells. The well casings are slotted to near the surface and the exterior of the casings backfilled with gravel to allow the maximum volume of groundwater to be extracted. The backfill is a potential conduit for the migration of contaminated water from the surface to groundwater due to the lack of a surface seal. Three approaches

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Table 6-6. Treatment of Contaminated Groundwater

Source of Contamination	Treatment System	Volume of Water Treated in 1995 (liters)	Total Volume Treated (liters)
Building 37 VOC Plume	Building 37	493,337	1,053,441
Old Town VOC Plume	Building 46	4,444,835	9,372,572
Water Collected From Purging Monitoring Wells	Building 51 Firetrail	31,041	177,422
VOC Contaminated Hydrauger Effluent	Building 51 Hydraugers	3,404,399	5,096,294
Total Volume Treated		8,373,612	15,699,729

have been selected as interim corrective measures to prevent these wells from acting as potential contaminant pathways to groundwater:

1. If a slope-stability well is needed for slope-stability purposes, its construction is modified by redrilling the well and installing at least 6.1 meters (20 feet) of an impermeable cement seal in the annular space from the ground surface to the screened interval. To date, nine slope-stability wells have been modified.
2. If a slope-stability well is not needed, it is abandoned in accordance with regulatory requirements. To date, six slope-stability wells have been abandoned.
3. If a slope-stability well is needed to monitor groundwater contamination, then the well is reconstructed into a monitoring well. To date, five slope-stability wells have been reconstructed into monitoring wells.

Another step to protect the groundwater was to survey the majority of sanitary sewer lines with a video camera. Several problem areas in the sewer line have been identified. Some of them have been repaired and a plan is being prepared to replace other damaged lines.

Section 7. Sanitary Sewer

Sanitary sewer discharge monitoring is divided into two major areas, based on regulatory and DOE requirements. What is generally termed self-monitoring is mandated by the wastewater discharge permits granted to Berkeley Lab by the East Bay Municipal Utility District. In general, samples are analyzed for pH, total suspended solids, and chemical oxygen demand. Analyses for volatile organic compounds and metals are included when required by permit conditions. Analysis is performed by a state-certified outside contract laboratory. Results are compared against the discharge limits for each parameter given in the permits, and self-monitoring reports are submitted to EBMUD.

Other monitoring performed at the two sanitary sewer discharge outfalls is driven by DOE guidance and orders, but also ensures compliance with the radiological limits given in 17 CCR 30287, as cited in the EBMUD permit. Analysis is confined to radioisotope activity, normally gross alpha, gross beta, iodine-125, and tritium. Gross alpha and gross beta measurements are used as a screening mechanism to determine if specific radionuclide measurements are required. Until changes were made in the *Environmental Monitoring Plan* (see discussion under Surface Water), this monitoring had been performed weekly. Currently it is performed biweekly, and split samples are analyzed by both LBNL's in-house Radiation Assessment and Measurement Laboratory and by an outside laboratory as a quality control measure.

Monitoring of sanitary sewer discharge occurs at one of the two site outfalls, Hearst or Strawberry (see Figure 2-7 in Chapter 2 for locations). These two locations capture all wastewater leaving the site, although the discharge from Strawberry Sewer also includes effluent from certain UCB facilities in Strawberry Canyon. Details of the sewage system are given in the *Sanitary Sewer Systems* section of Chapter 2, *Introduction*. Self-monitoring of wastewater discharge within the lab also occurs at Buildings 25 and 77, according to the terms of their respective EBMUD permits.

Wastewater Discharge Permit Self-Monitoring

Berkeley Lab currently has three Wastewater Discharge Permits issued by EBMUD; one for discharges from the site as a whole, and two for so-called categorical discharges from the two metal finishing facilities on site, Building 25 and Building 77. As the local Publicly Owned Treatment Works, EBMUD regulates all industrial discharges to its treatment facilities. As part of the terms and conditions of the permit, EBMUD mandates that LBNL perform self-monitoring for certain constituents in its discharges at certain prescribed intervals. In addition, EBMUD often performs monitoring at the site concurrently with Laboratory self-monitoring efforts as a check on methods and analyses.

A permit prescribes self-monitoring dates during the permit year. EBMUD annually renews the site's wastewater discharge permits in September. The self-monitoring dates for 1995 as listed in the September 1994 and September 1995 permits are presented in Table 7-1.

The next three sections present the results from the self-monitoring program required by the EBMUD wastewater permits. Figures 7-1 through 7-3 show annual trends in various effluent contaminants as monitored at the sitewide outfalls, Hearst and Strawberry.

Operational changes in metals finishing and implementation of programs designed to reduce pollution discharges may account for any downward trends seen in these figures. The actual self-monitoring results for the site, Building 77, and Building 25 are given in Table APP-7-1 in *Volume II, Data Appendix for Environmental Monitoring and Surveillance Results*.

In addition to self-monitoring, the wastewater discharge permits mandate other tasks and reports. The Toxic Organic Management Plans for Buildings 77 and 25 were revised in September of 1995 to reflect present conditions at those facilities. A separate Accidental Spill Prevention and Containment

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Table 7-1. Weeks for Required LBNL Wastewater Self-Monitoring in 1995

Hearst and Strawberry Outfalls	Building 77	Building 25
1/9/95	1/16/95	5/15/95
3/13/95	4/17/95	11/6/95
5/8/95	7/17/95	12/4/95
6/12/95		
7/17/95		
11/6/95		

Plan was created for the fixed treatment units at Buildings 2 and 70A, joining those for Buildings 25, 77, 76 Motor Pool, and photoprocessing facilities.

A semiannual effluent meter calibration report was submitted to EBMUD on May 30, 1995. For this report, each of the flow meters at the Hearst and Strawberry outfalls was calibrated at several different levels. All parameters passed calibration, and no adjustments to the flow meters were made. Although Berkeley Lab still calibrates the meters, reports are no longer required by the permit, and were not submitted to EBMUD during the latter half of 1995.

Semi-annual sewage meter reading reports were submitted on January 6 and July 6. For this report, sewer flows are measured at the Hearst and Strawberry outfalls for the site. The Strawberry outfall is shared with some offsite UCB buildings. The flow meters are read weekly; the results given in this report are the sum of fifty-two weekly readings. The flows measured at these outfalls for 1995 were 58,244,000 liters (15,386,608 gallons) and 102,688,000 liters (27,127,223 gallons) respectively. The estimated average flow per week is calculated to be 2,184,000 liters

(577,000 gallons) for Hearst and 2,566,000 liters (678,000 gallons) for Strawberry.

Since the latter half of 1993, Berkeley Lab has had permission from EBMUD to discharge to the sanitary sewer treated groundwater that had been contaminated with volatile organic compounds and tritium. The treatment process consists of passing the contaminated groundwater through a double-filtered carbon adsorption system. Presently, this treatment activity occurs at Buildings 51, 46, and 37, although discharge takes place only at Building 51. One of the conditions for this discharge was a semiannual report on the volumes discharged and any contaminants found. The 1995 report was submitted to EBMUD on May 26. In the current permit, the reporting requirement was reduced to annual, so that the next report will be in June, 1996. Tests employing US/EPA method 8260 were run on treated groundwater to determine levels of volatile organic compounds; all results were non-detect. Total volume treated and discharged for the six months prior to the report was estimated at 2,316,000 liters (612,000 gallons), substantially more than during the same period in the previous year. Flow from the hydraugers that collect this groundwater varies widely throughout the year, depending on

rainfall and various other factors. A more detailed discussion on results from the groundwater protection program is presented in Chapter 6, *Groundwater Protection*.

Building 25 Photofabrication Shop

The Building 25 fixed treatment unit has been successfully operating in batch mode since December 1993. With an eye toward waste minimization, the operators at Building 25 had asked that their developer rinsewater be characterized. Analysis of this rinsewater showed that it was not hazardous waste and did not have to be processed by the treatment unit. It also was well within all EBMUD permit limits, and thus could be discharged to the sanitary sewer. On July 13, 1995, Berkeley Lab notified EBMUD that Building 25 would begin discharging the developer rinsewater to the sanitary sewer, saving an estimated 18,900 liters (5,000 gallons) per year of wastewater from being processed through the FTU.

There was also a slight change at Building 25 in the sequence of events prior to discharging the batch effluent. On September 29, 1995, Berkeley Lab sent notice to EBMUD that Building 25 would no longer have samples of its treated effluent analyzed by an outside laboratory before releasing it to the sanitary sewer. The reason behind this discontinuation was two-fold; Building 25's excellent discharge record over the past several years, and the cost-effectiveness of this analysis. In its place, the FTU operators instituted internal methods to confirm the sewerability of the treated wastewater before discharge. Building 25 discharges one to two times per week, depending on production volume.

Within the framework of both waste minimization and ensuring that discharge is within permit limits, in November Berkeley Lab notified EBMUD that Building 25 had installed a reverse osmosis and ion exchange system. This is a closed-loop recycling system which will reduce FTU wastewater 50 - 90%, while generating less than 7.5 liters (20

gallons) of reject and exhausted acid per month. The system allows re-use of rinsewater and removes some of the contaminant load from the treatment unit. A photospectrometer is planned for the Building 25 operations in the near future, which will allow even more accurate testing for metals in wastewater prior to discharge.

Two self-monitoring samples were taken from the Building 25 FTU during 1995. None of the sample analyses exceeded any of the discharge limits set by EBMUD. Complete data tables reside in Table APP-7-1, *Volume II, Data Appendix for Environmental Monitoring and Surveillance Results*.

Building 77 Fixed Treatment Unit

During 1995, the plating shop in Room 156 at Building 77 remained closed for a complete rebuilding of the facility. A temporary Ultra High Vacuum Cleaning Facility in Building 77H functioned as a replacement to meet Berkeley Lab's interim cleaning and coating demands. In July, the vapor degreaser in Room 156 was returned to service. A small, portable vapor degreaser had temporarily been used in the interim UHVCF during the rebuilding project. A purchase order has been placed for an ultrasonic cleaner for Building 77. The new cleaner is expected in the second half of 1996. More in-depth evaluation testing will be undertaken once the system comes on line to determine the range of its cleaning abilities compared to the exacting specifications required by onsite customers of the UHVCF.

The upgraded Room 156 is expected back in service during the second quarter of 1996. Pilot tests of a new, 227-liter per minute (60-gpm) FTU, which will treat waste from Room 156, are scheduled to commence at the end of April, and will be reported on in next year's site environmental report. Cleaning and coating activities in 77H will be discontinued.

Four self-monitoring samples were taken from the Building 77 FTU during 1995.

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Figure 7-1. Hearst and Strawberry Monitoring Stations: Effluent Trends for Cadmium, Chromium, Copper, and Lead

None of the sample analyses exceeded any of the discharge limits set by EBMUD.

Hearst and Strawberry Sewer Outfalls

Hearst and Strawberry Monitoring Stations both underwent minor construction modifications during 1995, which were intended to make sampling easier and more accurate. A new sampling port and other

Figure 7-2. Hearst and Strawberry Monitoring Stations: Effluent Trends for Mercury, Nickel, Silver, and Zinc

equipment were installed at Hearst inside the sampling shed, and meters were moved inside for ease of reading. A new ultrasonic flow meter has been installed as a backup for the bubble flowmeters which historically have measured sewage flow. A similar meter is planned for the Strawberry monitoring station at some future date. A gate was also provided

in the flume to allow adjustment of the flow and make meter calibration more accurate.

Six self-monitoring samples were taken from the Hearst and Strawberry outfalls during 1995. Figures 7-1 through 7-3 present trends in effluent analyses for metals and hydrocarbons at these outfalls for the past five

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Figure 7-3. Hearst and Strawberry Monitoring Stations: Effluent Trends for Chlorinated Hydrocarbons

years. Samples taken during the week of March 13 and follow-up samples exceeded discharge limits for Total Identifiable Chlorinated Hydrocarbons set by EBMUD. A complete discussion of this incident is presented in Chapter 3, *Environmental Compliance Programs and Summary*. All other measurements were well within discharge limits.

Wastewater Monitoring for Radiation

Hearst and Strawberry sewer outfalls are sampled continuously by means of automatic samplers which collect 50-mL samples at 30-minute intervals at Hearst and 20-minute intervals at Strawberry. Composite samples are collected by technicians. During most of 1995, this occurred weekly, but under the revised *Environmental Monitoring Plan*, samples were collected biweekly for approximately the last quarter of the year. Analysis for iodine-125, gross alpha, gross

beta, and tritium was performed by the in-house laboratory, with splits occasionally also being analyzed by a state-certified outside contract laboratory.

Regulatory guidelines used to evaluate radioactive sewer discharge data are not concentrations, as they are with surface water, but rather total amounts per year, as given in 10 CFR 20 and 17 CCR 30287. For tritium, this amount is 1.85×10^{11} Bq (5 curies) per year; for Carbon-14 the limit is 3.7×10^{10} Bq (1 curie) per year, and the limit for all other radioisotopes is 3.7×10^{10} Bq (1 curie) per year total. Radioanalyses of Berkeley Lab's sewer wastewater for 1995 are summarized in Table 7-2. Detailed monitoring data may be found in Table APP-7-1 in Volume II, *Data Appendix for Environmental Monitoring and Surveillance Results*.

The total discharge of tritium for 1995 was 4.8×10^{10} Bq (1.3 Ci), and the total for other radioisotopes was 5.9×10^{10} Bq (0.16 Ci),

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Table 7-2. Radionuclide Analyses of Sewer Water Samples

Parameter:	Concentration, Bq*/L	
	Hearst Station	Strawberry Station
Alpha		
Average	<0.11**	<0.11**
Maximum	<0.11**	<0.11**
No. of Samples	39	41
Beta		
Average	<0.11**	<0.11**
Maximum	<0.11**	<0.11**
No. of Samples	39	41
Iodine 125		
Average	2.8	2.6
Maximum	5.22	7.36
No. of Samples	39	41
Tritium		
Average	15.9	83.7
Maximum	407	809
No. of Samples	33	33

* 1 Bq = 27 pCi

** represents minimum detectable activity for sample aliquot

well below allowable limits. Alpha, which comes from transuranic and heavy element research, is in general non-detect at both sewers. Beta, including iodine-125 from biomedical research, is seen at consistently low levels in both sewers. Tritium is often less than the minimum detectable activity. When present, it is seen in very low amounts at Hearst, with greater concentrations at Strawberry. This result is consistent with the fact that the National Tritium Labeling Facility discharges to the Strawberry sewer line. Wash water from this facility is strictly monitored, and is discharged only if analysis by liquid scintillation counting has shown it to be below 7.4 Bq (2,000 μ Ci) per day. This threshold has been determined by employing an LBNL-imposed administrative limit of 10% of the strictest limit. The strictest limit is the 1.85×10^{11} Bq (5 Ci) per year mentioned above; 10% of that, assuming 21 working days per month, determines the 7.4 Bq (2,000 μ Ci) per day limit.

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Section 8. Soil and Sediment

Soil and sediment provide an integrating medium that can account for the release of contaminants to air or water. The retention properties of soil create a potential source of continued contamination after the release of contaminants has ceased. DOE EH-0173T, *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance*, establishes the framework and provides the basis for environmental sampling, monitoring, and analysis of various media by incorporating and expanding the requirements of DOE Orders 5400.1 and 5400.5. The guidance recommends a graded approach to radiological surveillance of this media. No specific regulations or guidance have been identified for nonradiological assessment, although this element is included in the Berkeley Lab's soil and sediment program. Further, this guidance describes the varying usefulness of soil and sediment analyses (e.g., trend evaluation to assess long-term buildup, projection of future plant uptake, contaminant inventory, and comparison with applicable standards).

The *Environmental Monitoring Plan*, revised in late 1995, details the soil and sampling activities designed to comply with regulatory and DOE requirements. Consistent with DOE guidance, annual soil and sediment sampling is performed on a periodic schedule. In 1995, sampling was done in October, prior to the wet season. Future soil and sediment sampling will be scheduled for the end of the spring runoff. These sampling events will help document and establish baseline ecological values and environmental profiles against which future sampling results can be measured.

Soil Sampling

During 1995, soil samples were taken from three sampling locations around LBNL buildings and at one offsite environmental monitoring station. These samples were analyzed for gross alpha and beta, and tritium (Table 8-1). With respect to radionuclides, no unusually high level of contamination was seen in any location. Analyses for Title 22

metals indicated that all were below regulatory levels (Table 8-2). Other soil analyses included pH and semi-volatile organics compounds (US/EPA Method 8270).

Samples from the top 2 to 5 centimeters of surface soils were taken at four locations (see Figure 8-1). Locations were chosen to coincide with the areas of ambient air samples.

Soil analyses results are presented in Table APP-8-1 in *Volume II, Data Appendix for Environmental Monitoring and Surveillance Results*.

Sediment Sampling

Sediment samples in 1995 were taken from the continually flowing creeks; the North Fork of Strawberry Creek (STW2) and the Chicken Creek (STW4) streambeds. Samples were analyzed for Title 22 metals and a suite of toxic organics, including PCBs, diesel, oil and grease, and for gross alpha, beta, and tritium. Tables 8-1 and 8-2 also include radiological and nonradiological analytical results, respectively, for both creek sampling locations. The complete set of sediment sampling results are presented in *Volume II*.

Sediment analyses for semi-volatile organic compounds (US/EPA method 8270), were either "none detected" or insignificant for all locations. Analysis for oil and grease at the creek outfalls revealed minor sedimentation, 250 mg/kg, for the North Fork of Strawberry Creek, and 76 mg/kg at Chicken Creek. Again, analyses for metals were not indicative of contamination.

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Figure 8-1. Soil and Sediment Sampling Sites

Table 8-1. Soil and Sediment Sampling Results for Radionuclides in 1995.

Sampling Location	Matrix	Tritium (Bq*/g)	Gamma (Bq*/g)
B13C	Soil	0	0.67
B50	Soil	0.0026	0.67
B69	Soil	0.0030	0.41
Chicken Creek	Sediment	0.044	.026
N. Fork Strawberry Creek	Sediment	0.0026	0.41

* 1 Bq = 27 pCi

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Table 8-2. Soil and Sediment Sampling Results for Metals and pH from 1995.

Sample Location								
	Soils			Sediment				
Analyte	B13C	B50	B69	Chicken Creek	N. Fork Strawberry Creek	MDA*	Regulatory Criteria (TTLC**)	Units
Antimony	ND***	ND***	ND***	ND***	ND***	5	500	mg/kg
Arsenic	7.5	7.2	6.3	2.6	5.1	0.5	500	mg/kg
Barium	131	149	114	117	30	0.5	10,000	mg/kg
Beryllium	ND***	0.52	ND***	ND***	ND***	0.5	75	mg/kg
Cadmium	0.63	0.75	4.1	0.75	0.93	0.5	100	mg/kg
Chromium	27	34	70	46	57	0.5	2,500	mg/kg
Cobalt	7.8	11	15	8.8	3.9	2	8,000	mg/kg
Copper	25	39	48	30	33	0.5	2,500	mg/kg
Lead	64	17	42	61	283	2	1,000	mg/kg
Mercury	ND***	ND***	ND***	ND***	ND***	0.2	20	mg/kg
Molybdenum	ND***	ND***	ND***	ND***	ND***	2	3,500	mg/kg
Nickel	27	36	80	44	15	2	2,000	mg/kg
Selenium	ND***	ND***	ND***	ND***	ND***	0.5	100	mg/kg
Silver	ND***	ND***	ND***	1.5	ND***	1	500	mg/kg
Thallium	ND***	ND***	ND***	ND***	ND***	0.5	700	mg/kg
Vanadium	34	37	50	35	23	0.5	2,400	mg/kg
Zinc	96	86	340	179	308	2	5,000	mg/kg
pH	4.9	6.15	5.21	7.85	7.91	0.01	2 - 12.5	S.U.

* Minimum Detectable Amount

** Total Threshold Limit Concentration

*** Non-detectable

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Section 9. Vegetation and Foodstuffs

Introduction

Surveillance of vegetation is sometimes performed because edible vegetation can be a source of radiation dose to offsite residents. Ingestion of radionuclides could occur via the following pathways:

- liquid effluent → marine species → human
- airborne effluent → vegetable crop → human
- airborne effluent → forage crop → meat (milk) animal → human
- airborne effluent → exchange to surface water body → aquatic species → human
- airborne effluent → surface or groundwater → vegetable crop → human.

DOE/EH-0173T recommends that if the annual effective dose equivalent from ingestion of foods is 0.05 millisieverts (5 mrem) or greater, then sampling of the foods and radionuclides contributing 90% of the dose should be carried out. Where the dose is less than 0.01 millisieverts (one mrem), guidance also recommends that periodic sampling and analysis of indicator materials, such as soil or vegetation should be performed to determine if there is a long term buildup of radionuclides in the terrestrial environment. At LBNL, the actual offsite dose from these pathways is much less than 1 mrem; therefore only a minimal surveillance program is required. There are no state or local regulations requiring the sampling of foodstuff or vegetation for pollutants.

Berkeley Lab reviewed various categorical sources of pollutants on their potential to enter into food chain pathways. Sources which could fall into this category are airborne emissions of non-volatile or semi-volatile pollutants, such as metals or semi-volatile organics. Only radionuclides sources were identified as potential contributors through the vegetation or foodstuffs pathways. The remainder of this chapter will identify the radionuclides of interest, the potential

pathways of concern, and the Berkeley Lab sampling strategy for the radionuclides.

Tritium

Tritium is released primarily in the form of tritiated water vapor. As such, it is susceptible to washout by rain or fog, and to vapor exchange with leaf surfaces and surface bodies of water. Tritiated water vapor behaves chemically and biologically in a manner very similar to normal water, and follows the same pathways in the food chain, becoming easily incorporated into plant and animal tissues.

Carbon-14

Carbon-14 is released primarily in the form of carbon dioxide. As such, it may enter into local food chains by being incorporated into organic molecules through the photosynthetic action of plants. The chemical behavior of carbon-14 is identical to that of non-radioactive carbon.

Radioiodine

The most common radioactive isotope of iodine released by at Berkeley Lab is iodine-125. No data on the specific chemical forms of the iodine released are available. Radioiodine released to the air would primarily enter into the food chain by surface deposition on plants, which would then be ingested by grazing animals, and would be incorporated into the meat or milk. This pathway is not of concern in the vicinity of LBNL as long as iodine-125 releases remain low, and results of onsite air sampling for radioiodine show acceptable levels. Also, no meat or milk animals are raised commercially in the area.

Sulfur-35

Sulfur-35, in the form of $^{35}\text{SO}_2$ is released to the atmosphere by LBNL. This chemical form is gaseous, stable, and not a nutrient or compound important in the metabolism of plants or animals. As such, it is not

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considered to be a high risk radionuclide for incorporation into food chain pathways.

Alpha Emitting Radionuclides

LBNL uses various types of alpha emitting radionuclides. Most of the uses involve very small quantities. Any source which is considered to have a potential for significant emissions of particulate radionuclides is fitted with high efficiency particulate air filters and sampled. Particulate radionuclides are primarily metals, and therefore are not highly susceptible to incorporation into food chain pathways. Exposure could come from deposition on the surfaces of leafy vegetables and subsequent ingestion by man or food animals.

Methods

There was no routine sampling of vegetation in 1995. Future samplings of this type, which Berkeley Lab is considering for 1996, would be carried out following the spring growth period. Choices of vegetation sampling locations will be made prior to sampling, based on the following criteria:

- Locations of active farms or gardens
- Areas of known or suspected LBNL-induced contamination
- Proximity to and potential for being affected by Berkeley Lab operations
- Background locations with vegetation similar to that near LBNL, but unlikely to be affected by its operations

In the vicinity of Berkeley Lab, there are a few small vegetable farms which are the only known commercial produce growers. However, it may be assumed that small kitchen gardens do exist. There are no known farms in this vicinity which produce agricultural products such as milk, eggs, or meat. Laboratory analyses will be specified following a review of effluents, consideration of prior years' data and consultation with the appropriate LBNL personnel.

Section 10. Special Studies

Special Studies — Building 85 Preoperational Monitoring

Background

The new Hazardous Waste Handling Facility, presently under construction and designated as Building 85, will replace the existing waste facility located in Buildings 75 and 69. The Department of Energy, under DOE Order 5400.1, requires that an environmental study be conducted prior to startup of a new site, facility, or process to assess the effect of new activities on the environment. The preoperational study for the HWHF will be used for site characterization in establishing chemical and radiological background levels at the new site, and to provide a baseline for operational environmental monitoring and surveillance and closure of the facility in the future.

This section summarizes preoperational monitoring activities and sampling performed in 1995 for the new facility. It is not intended to provide the complete preoperational report here as it is beyond the scope of the Site Environmental Report; a complete preoperational report will be drafted separately in late 1996 and references made to this report in next year's site environmental report.

The HWHF Preoperational Sampling and Analysis Plan (SAP)⁸⁹ was written in February 1995. This plan outlined the objectives of the sampling to be performed, specified the sampling locations and frequency, and established a schedule to fulfill the requirements of the DOE order. As part of the SAP, a *Quality Assurance Project Plan*⁹⁰ was also prepared in February 1995, outlining the quality assurance/quality control measures that would be taken to ensure sampling and data were representative and valid.

The SAP stated that sampling would occur for radiological and nonradiological constituents in air, stormwater, sanitary sewer, sediments, groundwater, and soil. A separate study would be conducted for tritium in the biota. Another study was later added that involved a gamma survey of the soil at the site. Modifications to the SAP have been necessary due to changing conditions. These modifications have been noted and will be attached to the SAP as an amendment at the completion of the project.

1995 Sampling Results

The following sections briefly outline information pertinent to the sampling, including modifications that were made to the SAP, and sampling results from 1995.

AIR

Methodology

Figure 10-1 shows the two sample locations for ambient air sampling: AA-A and AA-B.

Sampling for nonradiological analyses was done using an evacuated chamber. Analysis was done in accordance with US/EPA Method TO14, which analyzes for common volatile organic compounds. Radiological analyses included gross alpha, beta, and gamma activity, iodine-125 and -129, carbon-14, and tritium.

Two samples were taken at AA-A for nonradiological analyses, while four samples were taken at AA-B for nonradiological analyses in 1995. Six samples were taken at AA-B for radiological analyses. No radiological samples were taken at AA-A. Sampling results for both nonradiological and radiological analyses are presented in Table 10-1. All toxic organic results are in parts per billion by volume (ppbv). Radiological analyses at AA-B are in units of becquerels per cubic meter of air.

Figure 10-1. Building 85 Preoperational Monitoring Sampling Sites

Analytical Results

No data exist at this time for comparison with the Building 85 preoperational monitoring data. The organics found in the air samplers are typical of those found in laboratories, including the vent/hood systems at Building 74 and Building 83. The most common air contaminants are acetone, toluene, xylenes and ethanol. It appears that these four organics, as well as benzene, ethyl benzene, and the trimethylbenzenes, are being emitted on a somewhat regular basis and will be found during most sampling events. Organic substances were found during one of the two sampling events at AA-A. The highest

organic concentration detected was 7.9 ppbv for hexane. Several common organic compounds were found during the four sampling events at AA-B. Acetone and toluene were detected during each event, ranging from 5.6 ppbv to 47 ppbv for acetone and 1.6 ppbv to 11 ppbv for toluene. Ethanol and m,p-xylene were detected in three of the four sampling events. Organics detected in at least two events were methylene chloride, benzene, ethyl benzene, o-xylene, 1,3,5-trimethylbenzene, and 1,2,4-trimethylbenzene. The highest concentration detected was 47 ppbv for acetone.

No alpha emitters were detected at location AA-B. No radiological iodine (125/129) was detected. Gross beta emitters were detected in four of six sampling events. The

Table 10-1. Air Sampling Results at New HWHF Site

Parameter	Sample Size	Number of Times Detected	Maximum	Minimum
AA-A Nonradiological				
— Toxic Organic (units = ppbv)				
Acetone	2	1	4.6	ND
Toluene	2	2	2.5	1.5
m,p-Xylene	2	1	2.7	ND
o-Xylene	2	1	2.7	ND
Styrene	2	1	2.8	ND
Chloromethane	2	1	1	ND
Hexane	2	1	7.9	ND
AA-B Nonradiological				
— Toxic Organic (units = ppbv)				
Acetone	5	5	4.7	5.6
Toluene	5	5	11	1.6
m,p-Xylene	5	4	6.7	ND
Ethanol	5	4	2.4	ND
Methylene chloride	5	2	3	ND
1-1-1, Trichloroethane	5	1	1.3	ND
Benzene	5	3	4.7	ND
Tetrachloroethene	5	1	12	ND
Ethyl benzene	5	3	1.7	ND
o-Xylene	5	3	3.1	ND
2-Propanol	5	1	5.3	ND
Hexane	5	1	8.1	ND
1,3,5-Trimethylbenzene	5	3	1.1	ND
1,2,4-Trimethylbenzene	5	3	4.5	ND
4-Ethyltoluene	5	1	4.2	ND
Radiological (units = Bq/m³)				
Alpha	6	0	ND	ND
Beta	6	4	0.0026	ND
Gamma	3	2	0.0026	ND
Tritium	5	1	0.34	ND
I	4	0	ND	ND
C	1	1	1.51	--

source of these beta emitters may be due to point source releases from Buildings 74 and 83, or from naturally occurring uranium-238 and uranium-235 found in soil. Concentrations of naturally occurring uranium-238 and uranium-235 would be expected to skew the concentrations upwards due to the amount of dust created during construction. Most probable radionuclides that are beta emitters from Building 74 and Building 83 are thorium-232, fluorine-18, nickel-63, sulfur-35 and strontium-90. The maximum concentration of 0.0026 Bq/m³ is well below the maximum particulate values

collected from the routine sitewide ambient air sampling network (see Table 4-7).

One carbon-14 sample at 1.5 Bq/m³ is below sitewide levels reported as 2300 Bq/m³ average and 3400 Bq/m³ maximum. One air sample detectable tritium at 0.34 Bq/m³. This level is below the reported sitewide averages that ranged from 3,300 Bq/m³ to 24,000 Bq/m³.

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STORMWATER

Methodology

Four surface drainage points were included in stormwater sampling: STW-A, STW-B, STW-C, and STW-D. See Figure 10-1 for the location of these points.

Stormwater samples were analyzed for radiological and nonradiological constituents. The radiological analyses included gross alpha and beta activity, and tritium. The nonradiological analyses included Title 22 metals, volatiles (purge and trap, US/EPA Methods 8260 or 624), semivolatiles

(US/EPA Methods 8270 or 625), total petroleum hydrocarbons as diesel and gasoline (TPH-D and TPH-G, US/EPA modified Method 8015), BTEX (benzene/toluene/ethyl benzene/xylene), US/EPA modified Method 8015), oil and grease (US/EPA Method 413.1), total suspended solids (US/EPA Method 160.2), total dissolved solids (US/EPA Method 160.1), electrical conductivity (US/EPA Method 9050), and pH (US/EPA Method 9040).

STW-A was sampled three times during 1995. STW-B and STW-C were each sampled once, while STW-D was sampled twice for the year. Analytical results are shown in Tables 10-2 to 10-5.

Table 10-2. Stormwater Sampling Results from Location STW-A at New HWHF Site.

Type	Parameter	Sample Size	No. of Times Detected	Maximum	Minimum
Nonradiological — Metals (units = mg/L)	Antimony	3	0	ND	ND
	Arsenic	3	3	0.0038	0.002
	Barium	3	2	0.17	ND
	Beryllium	3	0	ND	ND
	Cadmium	3	0	ND	ND
	Chromium	3	3	0.082	0.01
	Cobalt	3	2	0.021	ND
	Copper	3	2	0.034	ND
	Lead	3	2	0.018	ND
	Mercury	3	0	ND	ND
	Molybdenum	3	0	ND	ND
	Nickel	3	2	0.073	ND
	Selenium	3	0	ND	ND
	Silver	3	0	ND	ND
	Thallium	3	0	ND	ND
	Vanadium	3	2	0.11	ND
	Zinc	3	2	0.097	ND
Nonradiological — Volatiles (units = µg/L)	Total Volatiles (Acetone)	3	1	11	ND
	Total Semivolatiles (Bis(2-ethylhexyl)phthalate)	3	1	12	ND
	PCBs	1	0	ND	ND
Nonradiological — Other (units = µg/L, unless stated otherwise)	TPH-Diesel	3	1	100	ND
	TPH-Gasoline	3	0	ND	ND
	Oil and Grease, mg/L	3	2	2	ND
	Total Susp. Solids, mg/L	3	3	572	4.8
	Elect. Conduct. µmhos/cm	3	3	675	1
	BTEX	1	0	ND	ND
	pH, S.U.	1	1	8	--
Radiological (units = Bq/L)	Alpha	2	2	0.016	0.010
	Beta	2	2	0.064	0.031
	Tritium	2	0	ND	ND

Table 10-3. Stormwater Sampling Results from Location STW-B at New HWHF Site.

Type	Parameter	Sample Size	Number of Times Detected	Maximum	Minimum
Nonradiological	Antimony	1	0	ND	--
— Metals (units = mg/L)	Arsenic	1	1	0.0036	--
	Barium	1	1	0.16	--
	Beryllium	1	0	ND	--
	Cadmium	1	0	ND	--
	Chromium	1	1	0.085	--
	Cobalt	1	1	0.019	--
	Copper	1	1	0.036	--
	Lead	1	1	0.019	--
	Mercury	1	0	ND	--
	Molybdenum	1	0	ND	--
	Nickel	1	1	0.071	--
	Selenium	1	0	ND	--
	Silver	1	0	ND	--
	Thallium	1	0	ND	--
	Vanadium	1	1	0.099	--
	Zinc	1	1	0.11	--
Nonradiological	Total Volatiles (Acetone)	1	1	11	--
— Volatiles (units = µg/L)	Total Semivolatiles (Bis(2-ethylhexyl) phthalate)	1	1	11	--
Nonradiological	TPH-Diesel	1	0	ND	--
— Other (units = µg/L, unless stated otherwise)	TPH-Gasoline	1	0	ND	--
	Oil and Grease, mg/L	1	1	1	--
	Total Suspended Solids, mg/L	1	1	702	--
	Elect. Conduct. µmhos/cm	1	1	332	--
Radiological (units = Bq/L)	Alpha, pCi/L	1	1	0.024	--
	Beta, pCi/L	1	1	0.038	--
	Tritium, pCi/L	1	0	ND	--

Analytical Results

There presently are no specific discharge limits for contaminants found in stormwater, although the RWQCB has established target contaminant levels in its Basin Plan for the San Francisco Bay Region. A discussion on this plan, and the new US/EPA benchmark levels, can be found earlier in Chapter 5, *Surface Water*. Metals were all within the ranges found at other Berkeley Lab stormwater sampling locations, also reported

in the *Surface Water* discussion. Arsenic was found at each sampling point during every sampling event. Arsenic ranged from 0.002 to 0.0052 mg/L across all sampling points. Other metals detected in the stormwater were barium, chromium, cobalt, copper, lead, mercury, nickel, vanadium, and zinc. The maximum concentration of an individual metal was found at STW-D with a reading for zinc of 0.14 mg/L. A duplicate sample for metals analysis was taken at STW-D for quality assurance and quality control purposes; the result was within

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Table 10-4. Stormwater Sampling Results from Location STW-C at New HWHF Site

Type	Parameter	Sample Size	Number of Times Detected	Maximum	Minimum
Nonradiological	Antimony	1	0	ND	--
— Metals (units = mg/L)	Arsenic	1	1	0.0026	--
	Barium	1	0	ND	--
	Beryllium	1	0	ND	--
	Cadmium	1	0	ND	--
	Chromium	1	1	0.026	--
	Cobalt	1	0	ND	--
	Copper	1	0	ND	--
	Lead	1	1	0.008	--
	Mercury	1	0	ND	--
	Molybdenum	1	0	ND	--
	Nickel	1	0	ND	--
	Selenium	1	0	ND	--
	Silver	1	0	ND	--
	Thallium	1	0	ND	--
	Vanadium	1	0	ND	--
	Zinc	1	1	0.051	--
Nonradiological	Total Volatiles	1	0	ND	--
— Volatiles (units = µg/L)	Total Semivolatiles	1	0	ND	--
Nonradiological	TPH-Diesel	1	0	ND	--
— Other (units = µg/L, unless stated otherwise)	TPH-Gasoline	1	0	ND	--
	Oil and Grease, mg/L	1	1	1	--
	Total Suspended Solids, mg/L	1	1	94	--
	Elect. Conduct. µmhos/cm	1	1	200	--
Radiological (units = Bq/L)	Alpha	1	1	0.014	--
	Beta	1	1	0.035	--
	Tritium	1	0	ND	--

acceptable error for the analytical technique used.

No total petroleum hydrocarbons in the form of gasoline were detected at either sampling location. Diesel was detected in very small amounts (100 µg/L) during one sampling event. Testing for BTEX was performed on one sample; no BTEX was detected. Minor levels of oil and grease were detected at all locations, with a maximum of 2 mg/L at STW-A. The likely source of oil and grease was residue washed from the roadways.

Acetone was the only volatile substance detected from sampling at two separate events. The reported level at each location was 11 µg/L. This chemical is a common solvent used at LBNL. Its presence may be due to solvent vapors being scrubbed out from rainfall since acetone has been consistently detected as an air emission. The semivolatiles detected, bis(2-ethylhexyl)phthalate and di-n-butyl phthalate, at 12 µg/L and 19 µg/L, respectively, are probably due to lab contamination. Both chemicals are common plasticizers and

Table 10-5. Stormwater Sampling Results from Location STW-D at New HWHF Site

Type	Parameter	Sample Size	No. of Times Detected	Maximum	Minimum
Nonradiological	Antimony	3	0	ND	ND
— Metals (units = mg/L)	Arsenic	3	2	0.0052	0.0022
	Barium	3	1	0.11	ND
	Beryllium	3	0	ND	ND
	Cadmium	3	0	ND	ND
	Chromium	3	1	0.041	ND
	Cobalt	3	0	ND	ND
	Copper	3	1	0.018	ND
	Lead	3	1	0.013	ND
	Mercury	3	0	ND	ND
	Molybdenum	3	0	ND	ND
	Nickel	3	1	0.058	ND
	Selenium	3	0	ND	ND
	Silver	3	0	ND	ND
	Thallium	3	0	ND	ND
	Vanadium	3	2	ND	ND
	Zinc	3	3	0.14	0.82
Nonradiological	Total Volatiles	2	0	ND	ND
— Volatiles (units = µg/L)	Total Semivolatiles (Di-n-butyl phthalate)	2	1	19	ND
	PCBs	1	0	ND	ND
Nonradiological	TPH-Diesel	2	0	ND	ND
— Other (units = µg/L, unless stated otherwise)	TPH-Gasoline	2	0	ND	ND
	Oil and Grease, mg/L	2	1	1	ND
	Total Susp. Solids, mg/L	2	2	226	19.4
	Elect. Conduct. µmhos/cm	2	2	185	120
Radiological (units = Bq/L)	Alpha	2	2	0.022	0.0055
	Beta	2	2	0.091	0.017
	Tritium	2	0	ND	ND

contaminants in sampling containers. No PCBs were detected for the one sampling event at two locations.

The levels of total suspended solids will vary with the conditions of the drainage pathway and the force of the previous rainfall. Levels such as those found during sampling are not unusual. The maximum level was found at STW-B, with a concentration of 702 mg/L.

No tritium was detected in any of the stormwater samples from the four sampling

locations. The concentrations of gross alpha and beta detected at the four sampling points are within the analytical range at other stormwater and creek sampling locations around the Laboratory, including the Upper Strawberry Creek area.

GROUNDWATER

Methodology

The boreholes, BS-85-95-1 and BS-85-95-2, were converted to monitoring wells designated as GW-A and GW-B

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respectively. Locations of the wells are shown in Figure 10-1.

Both wells were sampled in 1995 for radiological and nonradiological constituents. The radiological analyses included gross alpha, beta, and gamma activity, and tritium. The nonradiological analyses included Title 22 metals, volatiles (purge and trap, US/EPA Methods 8260a and 8260), semivolatiles (US/EPA Method 8270), total petroleum hydrocarbons as diesel and gasoline (TPH-D and TPH-G, US/EPA

modified Method 8015), total suspended solids (US/EPA Method 160.2), total dissolved solids (US/EPA Method 160.1), electrical conductivity (US/EPA Method 9050), and pH (US/EPA Method 9040).

Well GW-A was sampled twice, while well GW-B was sampled once. A summary of analytical results is shown in Tables 10-6 and 10-7.

Table 10-6. Groundwater Sampling Results from Well 85-95-1 at New HWHF Site.

Type	Parameter	Sample Size	No. of Times Detected	Maximum	Minimum
Nonradiological	Antimony	3	0	ND	--
— Metals (units = mg/L)	Arsenic	3	2	0.003	0.002
	Barium	3	0	ND	--
	Beryllium	3	0	ND	--
	Cadmium	3	0	ND	--
	Chromium	3	0	ND	--
	Cobalt	3	0	ND	--
	Copper	3	0	ND	--
	Lead	3	0	ND	--
	Mercury	3	0	ND	--
	Molybdenum	3	0	ND	--
	Nickel	3	0	ND	--
	Selenium	3	0	ND	--
	Silver	3	0	ND	--
	Thallium	3	0	ND	--
	Vanadium	3	0	ND	--
	Zinc	3	3	0.073	0.016
Nonradiological	Total Volatiles	2	0	ND	--
— Volatiles (units = µg/L)	Total Semivolatiles	2	0	ND	--
Nonradiological	TPH-Diesel	2	0	ND	--
— Other (units = µg/L, unless stated otherwise)	TPH-Gasoline	2	0	ND	--
	Total Suspended Solids, mg/L	2	2	1980	181
	Total Dissolved Solids, mg/L	1	1	2840	--
	Elect. Conduct. µmhos/cm	1	1	3350	--
Radiological	Alpha	1	0	ND	--
(units = Bq/L)	Beta	1	0	ND	--
	Gamma	1	0	ND	--
	Tritium	1	0	ND	--

Table 10-7. Groundwater Sampling Results from Well 85-95-2 at New HWHF Site.

Type	Parameter	Sample Size	No. of Times Detected	Maximum	Minimum
Nonradiological	Antimony	2	0	ND	--
— Metals (units = mg/L)	Arsenic	2	0	ND	--
	Barium	2	1	0.07	--
	Beryllium	2	0	ND	--
	Cadmium	2	0	ND	--
	Chromium	2	0	ND	--
	Cobalt	2	0	ND	--
	Copper	2	0	ND	--
	Lead	2	0	ND	--
	Mercury	2	0	ND	--
	Molybdenum	2	0	ND	--
	Nickel	2	0	ND	--
	Selenium	2	1	0.005	--
	Silver	2	0	ND	--
	Thallium	2	0	ND	--
	Vanadium	2	1	0.013	--
	Zinc	2	1	0.03	--
Nonradiological	Total Volatiles	1	0	ND	--
— Volatiles (units = µg/L)	Total Semivolatiles	1	0	ND	--
Nonradiological	TPH-Diesel	1	0	ND	--
— Other (units = µg/L, unless stated otherwise)	TPH-Gasoline	1	0	ND	--
	Total Susp. Solids, mg/L	1	1	6.7	--
	Total Dissolved Solids, mg/L	1	1	540	--
	Elect. Conduct. µmhos/cm	1	1	822	--
Radiological	Alpha, pCi/L	1	0	ND	--
(units = Bq/L)	Beta, pCi/L	1	0	ND	--
	Gamma, pCi/L	1	0	ND	--
	Tritium, pCi/L	1	0	ND	--

Analytical Results

Metals found within the groundwater are below the US/EPA benchmark levels for all metals, and below the Basin Plan levels for all but one sample of zinc (0.073 mg/L). Most metals were below detectable limits. No organics of any type (i.e., volatiles, semivolatiles, total petroleum hydrocarbons, and oil and grease) were detected in groundwater samples.

Due to the low recharge and the extent of development of each well, total dissolved and total suspended solids will vary. Electrical conductivity as a measure of the total ionic concentration within the groundwater will vary with total dissolved solids. Both wells indicated that pH in the groundwater was about neutral (7.1 and 7.4; neutral = 7.0).

No radiological constituents were found in the groundwater at either well.

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SANITARY SEWER

Sanitary sewer samples are taken as a normal part of the Berkeley Lab's sitewide monitoring program. Analytical results from the Strawberry Creek sewer line would be considered part of the preoperational monitoring for Building 85 and were presented in Chapter 7, *Sanitary Sewer*.

SOIL — Surface Topsoil

Methodology

One surface soil sample, 5 to 10 centimeters below the surface, was taken in 1995. This sample was a composite from two areas around the new building: one from the roadway just past Building 83 (SL-B) and Building 74B on the route to Building 85; and the second between the storm drain culvert and pipe (SL-A). Both locations are shown in Figure 10-1.

These samples were analyzed for semivolatiles (US/EPA Method 8270), Title 22 metals, and radiological constituents that included tritium and gross gamma. Radiological and nonradiological results are presented in Table 10-8.

Analytical Results

All analytical results for metals and radiological analytes are below regulatory levels and consistent with results from other soil sampling locations at Berkeley Lab (see Tables 8-1 and 8-2, respectively). The table above also indicates that the metals results are within the range of the maximum value considered to represent background for each metals. Only one semivolatile organic was found in the composite sample: bis(2-ethylhexyl)phthalate at 0.43 mg/kg.

Soil Low-Background Gamma Survey

An additional component of the preoperational study involving soil is a two-

part program underway at the Low Background Facility of Berkeley Lab that will provide a detailed characterization for the preoperational radiometric setting of the new Hazardous Waste Handling Facility. The first phase, sampling and laboratory analyses of soils and rocks keyed to the local geology and topography, has now been completed. A set of 52 samples has been collected and analyzed at the Low Background Facility for concentrations of the natural radionuclides (uranium, thorium, and potassium) and manmade isotopes such as cesium-137. See Table APP-10-3 in Volume II, *Data Appendix for Environmental Monitoring and Surveillance Results*, for a listing of the data from this phase.

A set of 52 samples was collected from the Building 85 site during the first phase, which has been keyed to the local geology and topography. All samples have been analyzed quantitatively by high-resolution germanium-crystal gamma-spectrometry for natural terrestrial radionuclides (uranium, thorium, potassium); other naturally occurring radionuclides, such as beryllium-7, and manmade radionuclides from nuclear weapons testing, such as cesium-137. Searches were made for other long-lived manmade radionuclides (such as cobalt-60 or sodium-22) that could have been produced during operation of high-energy particle accelerators. None were found, and upper limits were established for their presence at levels of less than 0.037 Bq per kilogram (0.45 pCi per pound) of sample material (soil or rock).

The natural radioactivities (uranium, thorium, potassium) in these samples are appropriate to the geologic formations to which they belong, and are consistent with results from an earlier (1970s) survey that encompassed the entire Berkeley Lab site and some adjacent areas.

Table 10-8. Top Soil Sampling Results at New HWHF Site.

Type	Parameter	Sample Size	No. of Times Detected	Maximum	Minimum	Considered Background
Nonradiological	Antimony	1	0	ND	--	5.5
— Metals	Arsenic	1	1	3.4	--	19.1
(units = mg/kg)	Barium	1	1	96	--	323.6
	Beryllium	1	0	ND	--	1
	Cadmium	1	1	1.1	--	2.7
	Chromium	1	1	58	--	99.6
	Cobalt	1	1	15	--	22.2
	Copper	1	1	35	--	69.4
	Lead	1	1	3.7	--	16.1
	Mercury	1	0	ND	--	0.4
	Molybdenum	1	0	ND	--	7.4
	Nickel	1	1	50	--	119.8
	Selenium	1	0	ND	--	5.6
	Silver	1	0	ND	--	1.8
	Thallium	1	0	ND	--	27.1
	Vanadium	1	1	69	--	74.3
	Zinc	1	1	54	--	106.1
Nonradiological	Total Semivolatiles	1	0	0.43	--	
— Volatiles	(Bis(2-ethylhexyl) phthalate)					
(units = mg/kg)						
Radiological	Gamma	1	1	0.23	--	
(units = Bq/g)	Tritium	1	1	0.0030	--	

The range of (uranium, thorium, potassium) contents of surficial materials at the Building 85 site is narrower than was observed in the site wide survey. Dose rates in the interval 3-4 $\mu\text{rem/hr}$ dominate over most of the site, providing a relatively uniform radiation field against which to identify the small increments due to accidental releases of radioactivity during facility operation.

A second phase of this preoperational survey will be undertaken upon completion of the facility, when the various imported surface materials are in place. A detailed database for the preoperational radiometric environment of the Building 85 site will then be complete, to be available in evaluation of any changes in the radiometric environment that may be associated with operation of the facility. Surveillance techniques are outlined that make effective use of this database, to

provide a methodology for making accurate quantitative assessment of suspected or actual radiological spills.

SOIL — Borings

Methodology

Two boreholes, BS-85-95-1 and BS-85-95-2, were drilled in 1995 and later converted to monitoring wells GW-A and GW-B, respectively. The two wells are downgradient from Building 85, as shown in Figure 10-1.

During the boring of the monitoring wells, samples were taken at approximately 1.5 meter (5 foot) intervals and analyzed for radiological and nonradiological constituents. The first sample, at approximately 1.5 meters (5 feet) from the surface for each boring, was analyzed for Title 22 metals,

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volatiles (US/EPA Method 8240), base, neutral and acid extractables (semivolatiles, US/EPA Method 8270), total petroleum hydrocarbons as diesel and gasoline (TPH-D and TPH-G, US/EPA modified Method 8015), and pH (SW-9045). The holding time requirements were met for all analyses except pH. Subsequent samples at greater depths were analyzed for Title 22 metals and volatiles (8240) only. The surface sample for BS-85-95-1 (3.2 feet) was analyzed for oil and grease (US/EPA Method 413.1).

A summary of the analytical results for BS-

85-95-1 and BS-85-95-2 is shown in Tables 10-9 and 10-10, respectively.

Analytical Results

Metal analyses are within the maximum level considered to be background except for chromium, cobalt, and vanadium. Since these three metals were above the maximum background for each borehole at comparable depths, the values may be considered normal for the geology within the area. Higher than background levels were measured in the first 4.3 meters (14.2 feet) of the borings at BS-

Table 10-9. Soil Sampling Results from Boring BS-85-95-1 at New HWHF Site.

Type	Parameter	Sample Size	No. of Times Detected	Maximum	Minimum	Considered Background
Nonradiological	Antimony	3	0	ND	--	5.5
— Metals	Arsenic	3	3	6.7	1.2	19.1
(units = mg/kg)	Barium	3	3	123	91	323.6
	Beryllium	3	2	0.59	0.58	1
	Cadmium	3	0	ND	--	2.7
	Chromium	3	3	171	17	99.6
	Cobalt	3	3	45	17	22.2
	Copper	3	3	68	24	69.4
	Lead	3	1	8	ND	16.1
	Mercury	3	0	ND	--	0.4
	Molybdenum	3	0	ND	--	7.4
	Nickel	3	2	57	37	119.8
	Selenium	3	2	0.95	0.52	5.6
	Silver	3	0	ND	--	1.8
	Thallium	3	0	ND	--	27.1
	Vanadium	3	3	113	75	74.3
	Zinc	3	3	72	34	106.1
Nonradiological	Total Volatiles	1	0	ND	--	
— Volatiles	Total	1	0	ND	--	
(units = mg/kg)	Semivolatiles					
Nonradiological	TPH-Diesel	1	1	20	--	
— Other	TPH-Gasoline	1	0	ND	--	
(units = mg/kg unless noted)	Oil and Grease, mg/L	1	1	22	--	
	pH, SU	1	1	7.2	--	
Radiological	Alpha	1	0	ND	--	
(units = Bq/g)	Beta	1	1	0.26	--	
	Gamma	1	2	0.44		
	Tritium	1	1	0.012	--	

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Table 10-10. Soil Sampling Results from Boring BS-85-95-2 at New HWHF Site.

Type	Parameter	Sample Size	No. of Times Detected	Maximum	Minimum	Background
Nonradiological — Metals (units = mg/kg)	Antimony	4	0	ND	--	5.5
	Arsenic	4	3	2.9	0.79	19.1
	Barium	4	4	91	61	323.6
	Beryllium	4	2	0.56	0.5	1
	Cadmium	4	0	ND	--	2.7
	Chromium	4	4	112	51	99.6
	Cobalt	4	4	24	13	22.2
	Copper	4	4	58	34	69.4
	Lead	4	2	4	3.6	16.1
	Mercury	4	0	ND	--	0.4
	Molybdenum	4	0	ND	--	7.4
	Nickel	4	4	90	53	119.8
	Selenium	4	0	ND	--	5.6
	Silver	4	0	ND	--	1.8
	Thallium	4	0	ND	--	27.1
	Vanadium	4	4	107	39	74.3
	Zinc	4	4	57	45	106.1
Nonradiological — Volatiles (units = mg/kg)	Total Volatiles	1	0	ND	--	
	Total Semivolatiles	1	0	ND	--	
Nonradiological — Other (units = mg/kg unless noted)	TPH-Diesel, mg/kg	1	1	20	--	
	TPH-Gasoline, mg/kg	1	0	ND	--	
	pH, SU	1	1	8.1	--	
Radiological (units = Bq/g)	Alpha, pCi/g	1	0	ND	--	
	Beta, pCi/g	1	0	ND	--	
	Gamma, pCi/g	1	1	0.19		
	Tritium, pCi/g	1	1	0.016	--	

85-95-1 and the first 3.0 meters (10.1 feet) at the other boring.

No volatiles, semivolatiles, total petroleum hydrocarbons in the form of gasoline, or oil and grease was found in the samples taken during the drilling of the boreholes. Total petroleum hydrocarbons in the form of diesel was found in low concentration (20 mg/kg) in one borehole. The pH readings at

each boring site are similar to other pH values around the Laboratory.

Samples for radiological analyses were taken 0.9 meters (3 feet) from the surface. The radioactivity found in the gross alpha, beta or gamma scan were within the ranges found during sitewide sampling. Tritium levels were also within those found in sitewide sampling.

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SEDIMENT

Methodology

Two areas were identified for sediment sampling: SD-A and SD-B. These two areas are located in storm drainage pathways. These areas are shown in Figure 10-1.

Sediment samples were analyzed for radiological and nonradiological constituents. The radiological analyses included gross alpha, gross beta, and tritium analyses. The nonradiological analyses included Title 22 metals, volatiles (US/EPA Methods 8260), semivolatiles (US/EPA Methods 8270), total petroleum hydrocarbons as diesel and gasoline (TPH-D and TPH-G, US/EPA modified Method 8015), oil and grease (US/EPA Method 413.1), polychlorinated biphenyls (PCBs, US/EPA Method 8270) and pH (US/EPA Method 9040).

Each sampling area was sampled once during 1995. A summary of analytical results for SD-A and SD-B are shown in Tables 10-11 and 10-12, respectively. No further sampling of sediments will occur in 1996 because of the difficulty associated with this method of sampling. Soil sampling around Building 85 will be substituted.

Analytical Results

Metals analyses show that the samples taken from SD-A and SD-B are generally within those values found for sediment and soil throughout the site (see Tables 8-1 and 8-2).

No TPH-G was reported for the samples taken, while TPH-D was detected at the two sampling locations at 12 mg/kg and 18 mg/kg, respectively. No volatiles or semivolatiles were detected in the samples. Although pH is reported, the holding-time requirement for this measurement was exceeded for both samples.

No gross alpha or beta were detected in the sediment samples. Low levels of tritium were detected at both sample locations, and concentrations were within the range of sitewide sediment samples analyzed at Chicken Creek and North Fork Strawberry Creek. A duplicate of the SD-B sample was analyzed for quality assurance and quality control purposes.

VEGETATION

Methodology

Vegetation from the area surrounding Building 85 site was sampled and analyzed for tritium because of the site's proximity to the NTLF (Building 75). The tree general areas are indicated on Figure 10-1. Sampling was conducted in July and November. Foliage from eucalyptus, laurel, pine, oak, French broom and coyote brush were sampled. A total of 30 samples from 10 plants were taken.

Analytical Results

Results of the sampling and analyses are given in Table 10-13. The data indicate the concentrations of tritium in azeotropically-distilled water from fresh plant biomass samples, and are expressed in becquerels per liter of biomass. The data show slightly elevated tritium concentrations in the plant water. A marked seasonal difference is observed, with higher tritium levels in summer. The data provide a site background for tritium in vegetation.

The differences between species are not significant, nor are the differences in plant locations. Variability between samples taken from the same plant was generally less than $\pm 50\%$. However, replicate samples from one plant varied by as much as a factor of four. Analytical precision is typically $\pm 20\%$.

Table 10-11. Sediment Sampling Results from Location SD-A at New HWHF Site.

Type	Parameter	Sample Size	No. of Times Detected	Maximum	Minimum
Nonradiological	Antimony	1	0	ND	--
— Metals (units = mg/kg)	Arsenic	1	1	3.7	--
	Barium	1	1	94	--
	Beryllium	1	0	ND	--
	Cadmium	1	1	0.54	--
	Chromium	1	1	38	--
	Cobalt	1	1	10	--
	Copper	1	1	18	--
	Lead	1	1	9.4	--
	Mercury	1	0	ND	--
	Molybdenum	1	0	ND	--
	Nickel	1	1	30	--
	Selenium	1	1	0.5	--
	Silver	1	0	ND	--
	Thallium	1	0	ND	--
	Vanadium	1	1	46	--
	Zinc	1	1	49	--
Nonradiological	Total Volatiles	1	0	ND	--
— Volatiles (units = mg/kg)	Total Semivolatiles	1	0	ND	--
	PCBs	1	0	ND	--
Nonradiological	TPH-Diesel	1	1	18	--
— Other (units = mg/kg, unless stated otherwise)	TPH-Gasoline	1	0	ND	--
	Oil and Grease	1	1	26	--
	pH, SU	1	1	7.31	--
Radiological	Alpha	1	0	ND	--
(units = Bq/L)	Beta	1	0	ND	--
	Tritium	1	1	0.011	--

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Table 10-12. Sediment Sampling Results from Location SD-B at New HWHF Site.

Type	Parameter	Sample Size	No. of Times Detected	Maximum	Minimum
Nonradiological	Antimony	1	0	ND	--
— Metals (units = mg/kg)	Arsenic	1	1	2.8	--
	Barium	1	1	96	--
	Beryllium	1	0	ND	--
	Cadmium	1	1	1	--
	Chromium	1	1	22	--
	Cobalt	1	1	10	--
	Copper	1	1	12	--
	Lead	1	1	12	--
	Mercury	1	0	ND	--
	Molybdenum	1	0	ND	--
	Nickel	1	1	45	--
	Selenium	1	1	0.66	--
	Silver	1	0	ND	--
	Thallium	1	0	ND	--
	Vanadium	1	1	26	--
	Zinc	1	1	54	--
Nonradiological	Total Volatiles	1	0	ND	--
— Volatiles (units = mg/kg)	Total Semivolatiles	1	0	ND	--
	PCBs				
Nonradiological	TPH-Diesel	1	1	12	--
— Other (units = mg/kg, unless stated otherwise)	TPH-Gasoline	1	0	ND	--
	Oil and Grease, mg/L	1	1	22	--
	pH, SU	1	1	4.95	--
Radiological	Alpha	2	0	ND	--
(units = Bq/g)	Beta	2	0	ND	--
	Tritium	2	2	0.019	0.015

Table 10-13. Tritium Concentrations in Vegetation

Plant Type	Direction From Bldg. 85	Number of:		Average Value (Bq/L)	
		Samples	Plants	Summer	Winter
Eucalyptus	South	7	2	275	12
Eucalyptus	North	3	1	567	39
Laurel	North	3	1	671	25
Laurel	Southeast	3	1	90	23
Pine	South	7	2	224	34
Oak	Southeast	3	1	435	79
French Broom	Southeast	2	1	no sample	22
Coyote brush	Southeast	2	1	no sample	22
All	All	30	10	377	32

Section 11. Radiological Dose Assessment

Background

Radiation is a natural part of our environment. It has surrounded the planet since its formation. Natural radiation reaches earth from outer space and continuously radiates from the rocks, soils, and water on the earth. Natural radiation is called "background radiation" and makes up about 82% of the average person's exposure to ionizing radiation.

Man-made radiation is produced from various activities: medical sources, such as X-rays and accelerator, radionuclides used in medical researches, nuclear weapon testing activities, and nuclear power plants.

Before discussing the radiological monitoring program and its impact to the environment at LBNL, it is useful to introduce some basic concepts associated with radiation classifications and characteristics.

Radiation is defined as the emission and propagation of energy. There are three major types of radiation: electromagnetic, acoustic, and particle. The types of radiation associated with radioactive elements are particle radiation and electromagnetic radiation.

Particle radiation consists of particles that have been ejected from atoms. An alpha particle is a heavy particle composed of neutrons and protons. It can be stopped by a sheet of paper and is not likely to penetrate the outer layer of our skin. A beta particle is a high-speed electron. Beta particles are more penetrating than alpha particles. Depending on the energy of the beta particle, it can go through up to two centimeters of living tissue.

Electromagnetic radiation includes visible light as well as unseen radiation such as radio waves, x-rays, and gamma radiation. Certain radioactive elements give off gamma radiation. Gamma radiation travels at the speed of light and is extremely penetrating. Because of their ability to cause changes in the ionization (i.e., chemical bonding characteristics) of atoms and molecules, alpha,

beta, and gamma radiation are called ionizing radiation. Ionizing radiation can also cause chemical changes in cells through excitation, dissociation, and atom displacements. These chemical changes can lead to cancer, genetic defects, and developmental and reproductive effects.

An element is radioactive if its individual atoms are undergoing decay, releasing energy and matter from their nuclei in the form of ionizing radiation, and, in the process, changing into different element or a different isotope of the same element. This decay process goes on continuously, but at different rates for specific radioactive elements and isotopes. The decay rate of a radioactive element or isotope is expressed in terms of its half-life. A half life is the amount of time it takes for half the atoms in a quantity of an element or isotope to decay. The number of individual atomic decays that take place each second is called the activity, and is measured in either becquerels (Bq) or curies (Ci). A curie is equal to 37,000,000,000 (37 billion) becquerels.

The remainder of this chapter reports the results from two distinct monitoring programs; penetrating radiation and airborne radionuclides.

External Penetrating Radiation Monitoring

Radiation-producing machines (accelerators, x-ray machines, and irradiators) and various radionuclides are used at Berkeley Lab for high energy particle studies and biomedical research. External penetrating radiation is associated mainly with accelerator/irradiator operations at the Laboratory.

Historically, DOE facilities have reported "fence-post doses," which are measured or computed values reflecting the exposures to a hypothetical individual living 100% of the time at the perimeter of the facility. In keeping with the DOE trend toward presenting realistic assessments of exposures to actual individuals, this section will provide both maximum fence-post dose estimates and

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estimates of exposures to workplaces or dwellings of LBNL's nearest neighbors.

Accelerator-Produced Penetrating Radiation

To determine the environmental radiological impact of accelerator operations, LBNL maintains five permanent real-time environmental monitoring stations (EMSs) at various locations around the site's perimeter. Figure 11-1 displays the location of these stations. This figure also displays the thermoluminescent detector (TLD) monitoring locations, which will be discussed later in this section. The EMSs continuously detect and record direct gamma and neutron radiation. Each station contains sensitive neutron and gamma pulse counters. The neutron detector is mainly a 500-cubic centimeter cylindrical boron trifluoride gas-proportional counter housed in a 6-centimeter thick (2.5-inch thick) cylindrical paraffin moderator. The gamma detector is an energy-compensated Geiger-Muller chamber. The calibrated output pulses from these detectors are transferred electronically to a central storage computer in Building 75.

With the closure of the Bevalac in early 1993, Building 88 (88-Inch Cyclotron) contains the only remaining moderately high energy accelerator that could generate detectable radiation at nearby EMSs. This accelerator runs heavy ions during a significant fraction of its operating schedule. Successful work in beam development several years ago followed with an increase in beam currents led to a correspondingly slight increased dose equivalent at the Building 88 EMS.

Since early 1991, the 88-Inch Cyclotron has administratively controlled its use of light-ion runs which are the main contributors to the offsite exposure. Operations of the accelerator are limited to an offsite exposure of less than the established LBNL's environmental ALARA goal of 0.03 mSv in a year (3 mrem/yr). The former injection source that provided beam currents up to 100 milliamperes is no longer used. The new

source will only allow beam currents of less than 10 milliamperes. During 1995, light ion runs (hydrogen-1 and helium-3) in the 88-Inch Cyclotron averaged less than 30 percent (1200 hours) of all running time for the year. The gamma and neutron doses attributable to LBNL accelerator operations during 1995 are listed in Table 11-1, as derived from measurements at the five EMSs.

Accelerator-Produced Radiation

In 1976, LBNL developed a site-specific model to assess the population dose equivalent attributable to penetrating radiation.⁹¹ Population figures from the 1980 US census^{92,93} are used in this calculation. Although the population within 80 km (50 mi) of LBNL increased by about 20% during the 1970s and 1980s from 5 to 6 million, the populations of Berkeley and Oakland, the two cities immediately adjacent to LBNL, declined. Recomputing the population dose model with population statistics from the 1990 census produced no significant difference in dose.

In the LBNL model, population dose equivalent is computed from the maximum measured value of perimeter (fence-post) neutron dose. During 1995, the maximum annual fence-post dose, estimated at EMS 13A (near Building 88), was 0.021 mSv (2.1 mrem) (see Table 11-1). The model's expression relating population dose equivalent M (in person-rem) to maximum measured fence-post dose H_0 (in rem—a rem is 1,000 mrem) is:

$$M < 10^3 \times H_0.$$

Since H_0 was 0.021 mSv (2.1 mrem or 2.1×10^{-3} rem), the collective effective dose equivalent (CEDE) to the approximately 5 million people within 80 kilometers (50 miles) of LBNL attributable to penetrating radiation

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Table 11-1. 1995 Annual Penetrating Radiation Dose at LBNL Perimeter Due to Accelerators

Monitoring Station	Net Gamma Dose (mSv*/yr)	Net Neutron Dose (mSv*/yr)	Total Dose (mSv*/yr)
Station 13 A (Bldg. 88)	0.014	0.007	0.021
Station 13 B (Bldg. 90)	0.007	0.001	0.008
Station 13 C (Panoramic)	0.006	0.001	0.007
Station 13 D (Olympus Gate)	0.004	0.001	0.005
Station 13 H (ALS)	0.004	0.002	0.006

(*) 1 mSv = 100 mrem

from LBNL accelerator operation during 1995 was about 0.118 person-Sv (11.8 person-rem).

Irradiator-Produced Penetrating Radiation

For many years, Berkeley Lab has stored two shielded gamma irradiators in the Building 75 waste yard behind a large earth berm. This location minimizes the potential worker and offsite exposure. One unit contains about 20 trillion (10^{12}) Bq (543 Ci) of cesium-137, and the other unit contains 10×10^{12} Bq (270 Ci) of cobalt-60. The gamma radiation field attributable to these irradiators measured at the perimeter fence nearest to the devices was less than 2×10^{-5} mSv/hr (0.002 mrem/hr). This value was determined by a survey meter and extrapolated to give an annual fence-post dose of less than 0.18 mSv/yr (18 mrem/yr). However, the perimeter fence at this location is on UCB land. The nearest offsite workplace (40-hour/week occupancy) is the Lawrence Hall of Science, which is approximately 270 meters from the fence. The nearest residence is approximately 500 meters away. Both of these offsite locations are shielded by a hillside. Even if the hillside shielding is ignored, the predicted doses from these irradiators would be about 5×10^{-5} mSv/yr (0.005 mrem/yr) and 7×10^{-5} mSv/yr (0.007 mrem/yr) at the Lawrence Hall of Science and at the nearest home, respectively. These retired irradiators are clearly marked, barricaded, and cordoned off. The dose rate at the nearest accessible distance to these units is approximately 0.002 mSv/hr (0.2 mrem/hr).

In October 1995, both of these accelerators were removed from LBNL property and properly transferred to a commercial irradiator manufacturer for recycling.

Several other gamma irradiators of multicurie magnitude are being used at LBNL to carry out radiobiological and radiochemical research. The largest of these units is a cobalt-60 unit housed in an interlocked, massive, reinforced-concrete-covered labyrinth built as part of Building 74. This unit is also the irradiator closest to the LBNL perimeter. Routine surveys taken when the shielding for the irradiator was not in place confirmed that no area exceeded 0.01 mSv/hr (1 mrem/hr) at 1 meter from the outside walls or ceiling. The Building 74 irradiator is about 80 meters from the LBNL perimeter fence, 150 meters from the nearest offsite workplace (a UCB Botanical Garden building), and more than 700 meters from the nearest residence. The projected annual dose equivalents to members of the public are about 0.014 mSv/yr (1.4 mrem/yr) at the perimeter fence, 0.001 mSv/yr (0.1 mrem/yr) at the Botanical Garden building, and less than 2×10^{-4} mSv/yr (0.02 mrem/yr) at the nearest residence. The remaining smaller, well-shielded gamma irradiators pose considerably lesser environmental impact than the Building 74 irradiator. These irradiators are used in sealed containers, and located and monitored throughout the Laboratory. A summary of the 1995 penetrating radiation doses due to the most significant gamma irradiators is given in Table 11-2.

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Figure 11-1. Environment Monitoring Stations

Table 11-2. Estimated 1995 Annual Penetrating Radiation Dose due to Gamma Irradiators

Irradiator Location	Estimated Gamma Dose (mSv*/yr.)		
	Fence-Post	Nearest Residence	Nearest Workplace
Building 75	<0.15	<0.00007	<0.00005
Building 74	<0.012	<0.0002	<0.001

(*) 1 mSv = 100 mrem

Environmental TLD Program

LBNL expanded its sitewide environmental thermoluminescent monitoring program in December 1994 to cover a total of 27 locations near the site boundary (Figure 11-1) and six locations around two offsite facilities (Building 903 Warehouse and Building 934). The TLD network's objective is to confirm the estimated exposures from external penetrating radiation, and to ensure that public radiation exposure is kept well below allowable regulatory limits. The expanded TLD monitoring program uses aluminum oxide TLDs, which are designed to measure low-level gamma and photon radiation with a minimum detection level of 0.0001 mSv (0.1 mrem). Table 11-3 summarizes the quarterly and annual TLD gamma radiation dose equivalents from the environmental TLD monitoring program. The results indicate that the sitewide average dose equivalent from external direct radiation exposure at LBNL's perimeter is about the same as typical background radiation in the Bay Area (0.72 mSv or 72 mrem).

Dispersible Radiation

Airborne Radionuclides

LBNL employs a wide variety of radionuclides in its radiochemical and biomedical research programs. In addition, radioactive materials are inevitably produced by the operations of the charged particle accelerators, such as the 88-Inch Cyclotron. Table 11-4 characterizes the dominant radionuclides used/monitored at LBNL during 1995.

Of these radionuclides, the most commonly and widely used radionuclides in the research programs are: hydrogen-3, carbon-14, fluorine-18, phosphorus-32, sulfur-35, and iodine-135. Radioactive gases produced by the accelerator operations are mainly short-lived radionuclides such as carbon-11, nitrogen-13, oxygen-15, and argon-41. These

induced radioactive gases are normally produced in areas where the beam strikes beamline components.

Research operations occur in 18 laboratory buildings which have the potential to emit radionuclides into the atmosphere. Based on historical emissions activity, Berkeley Lab has identified four release points that are potentially subject to the continuous monitoring requirement of the radiological NESHAPs standard. Except for the Building 75 tritium stack, all other sources which were operational during 1995 are "small sources." That is, the effective dose equivalent (EDE) from each source is much less than 1.0×10^{-3} mSv/yr (0.1 mrem/yr), the NESHAPs threshold limit for continuous monitoring.

During 1995, discharge points with the most significant potential for routine or accidental release were continuously or periodically sampled, consistent with regulatory and DOE requirements. The 1995 airborne discharges from Laboratory accelerators were estimated using a model developed by Patterson and Thomas in 1973.⁹⁴ Very small sources, that is, sources with potential for routine annual off site EDE impacts of less than 1.0×10^{-4} mSv (1.0×10^{-2} mrem) are, in general, not sampled continuously.

The dose to the maximally exposed individual and the CEDE resulting from airborne releases of radionuclides for 1995 are 1.6×10^{-3} mSv (0.16 mrem) and 0.096 person-Sv (9.6 person-rem), respectively. The NESHAPs regulations in 40 CFR 61 Subpart H require that facilities releasing airborne radionuclides compute the impact of such releases using an approved code. In this report, CAP88-PC was used to compute the effective dose equivalent to a maximally exposed offsite person. CAP88-PC is a microcomputer radionuclide dispersion and dose-assessment code supplied and approved by US/EPA. This dose was calculated for the point of maximum offsite exposure and represents the cumulative exposure from all significant exposure pathways (inhalation, ingestion, air immersion, and surface exposure). The methods and parameters used

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Table 11-3. Results from the Environmental TLD Monitoring Program for 1995, Including Background Sources^(c)

TLD #	Location	QTR 1 (mSv*)	QTR 2 (mSv*)	QTR 3 (mSv*)	QTR 4 (mSv*)	Total (mSv*)
1	Main Entrance Gate	0.164	0.176	0.200	0.163	0.702
2	Strawberry Entrance Gate	0.173	0.148	0.170	0.150	0.640
3	Grizzly Peak Gate	0.163	0.179	0.198	0.144	0.683
4	ENV-13A	0.170	0.194	0.190	0.177	0.731
5	ENV-13B	0.173	0.181	0.205	0.163	0.721
6	ENV-13C	0.181	0.175	0.187	0.160	0.703
7	ENV-13D	0.169	0.178	0.174	0.167	0.689
8	ENV-13H	0.168	0.159	0.170	0.160	0.657
11	LBNL Site Boundary	0.170	0.212	0.184	0.189	0.755
12	LBNL Site Boundary	0.175	0.209	— ^(a)	0.237	0.829 ^(b)
13	LBNL Site Boundary	0.167	0.199	0.215	0.190	0.771
14	LBNL Site Boundary	0.168	0.148	0.164	0.154	0.633
15	LBNL Site Boundary	0.175	0.217	0.189	0.150	0.732
16	LBNL Site Boundary	0.186	0.168	0.204	0.168	0.726
17	LBNL Site Boundary	0.171	0.173	0.194	0.163	0.700
18	LBNL Site Boundary	0.169	0.184	0.170	0.178	0.702
19	LBNL Site Boundary	0.193	0.255	0.214	0.211	0.873
20	LBNL Site Boundary	0.186	0.211	0.173	0.212	0.782
21	LBNL Site Boundary	0.182	0.217	0.202	0.210	0.810
22	LBNL Site Boundary	0.171	0.192	0.198	0.175	0.736
23	LBNL Site Boundary	0.165	0.170	0.180	0.148	0.663
24	LBNL Site Boundary	0.195	0.195	0.203	0.204	0.797
25	LBNL Site Boundary	0.178	0.170	0.187	— ^(a)	0.714 ^(b)
26	LBNL Site Boundary	0.177	0.181	0.186	0.175	0.720
27	LBNL Site Boundary	0.177	0.177	0.169	0.166	0.689
28	LBNL Site Boundary	0.177	0.173	0.167	0.165	0.681
29	LBNL Site Boundary	0.166	0.179	0.176	0.185	0.705
30	Building 903 Warehouse (Off-site)	0.175	0.156	0.163	0.159	0.652
31	Building 903 Warehouse (Off-site)	0.179	0.171	0.158	0.163	0.671
33	Building 934 Perimeter (Off-site)	0.175	0.176	0.166	0.166	0.684
34	Building 934 Perimeter (Off-site)	0.179	0.169	0.169	0.190	0.706
35	Building 934 Perimeter (Off-site)	0.175	0.175	0.184	0.163	0.697
36	Building 934 Perimeter (Off-site)	0.176	0.181	0.169	0.190	0.717
AVERAGE:		0.175	0.183	0.184	0.175	0.717

(*) 1 mSv = 100 mrem

(a) Missing data due to lost TLD's

(b) Projected annual dose based on quarterly average of available data

(c) Average background is 0.72 mSv

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Table 11-4. Airborne Radionuclides Used and/or Monitored at LBNL During 1995

Nuclide Name (Atomic Number)	Radio-Nuclide Symbol	Principal Radiation Types	Principal Energy (MeV)	Half-Life
Americium (95)	²⁴¹ Am	a	5.40	432 years
		g	0.06	
Argon (18)	⁴¹ Ar	b	1.2	1.83 hours
		g	1.3	
Carbon (6)	¹¹ C	b ⁺ /g	0.511	20.5 minutes
Carbon (6)	¹⁴ C	b	0.156	5730 years
Curium (96)	²⁴⁸ Cm	a	5.08	3.39 x 10 ⁵ years
Cobalt (27)	⁶⁰ Co	b	0.318	5.27 years
		g	1.33	
Fluorine (9)	¹⁸ F	b ⁺ /g	0.511	109.7 minutes
Hydrogen /Tritium (1)	³ H	b	0.0186	12.28 years
Iodine (53)	¹²⁵ I	g	0.027	60.14 days
Nitrogen (7)	¹³ N	b ⁺ /g	0.511	9.97 minutes
Nickel (28)	⁶³ Ni	b	0.066	100.1 years
Oxygen (8)	¹⁵ O	b ⁺ /g	0.511	122 seconds
Phosphorus (15)	³² P	b	1.71	14.3 days
Rubidium (37)	⁸⁶ Rb	b	1.77	18.66 days
		g	1.08	
Sulfur (16)	³⁵ S	b	0.167	87.44 days
Strontium (38)	⁹⁰ Sr	b	0.546	28.6 years
Thorium (90)	²³² Th	a	4.01	1.4 x 10 ¹⁰ years
		b	0.04	
Uranium (92)	²³⁸ U	a	4.2	4.47 x 10 ⁹ years
		b	0.029	
Zinc (30)	⁶⁵ Zn	g	1.12	244 days
Zirconium (40)	⁹⁵ Zr	b	0.4	64 days
		g	0.757	

to calculate the dose are very conservative. For example, the model assumes that some portion of the food consumed by the hypothetical individual was grown within the assessed area. The individual was assumed to reside at this location continuously throughout the year. In addition, all of the tritium released was assumed to be the most hazardous form, tritium oxide. Consequently, this dose is not a dose actually received by anyone, but an upper-bound estimate.

In 1990 the NTLF began a program to reduce emissions of HTO from both planned and unplanned releases. This program has resulted in a very notable decrease in these emissions from a maximum of 2.13×10^{13} Bq (575 Ci) in 1988 to 1.85×10^{12} Bq (50 Ci) in 1995 (see Figure 11-2). The releases in 1991-1994 were in the range 3.15×10^{12} to 4.26×10^{12} Bq (85 to 115 Ci), and the further decrease in 1995 is attributable to several factors. First, there were no significant (greater than 9.26×10^{11} Bq or 25 Ci) unplanned releases in 1995. Second, a tritium

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Figure 11-2. Summary of Annual Tritium Releases from Building 75, 1986-1995

alarm was added that allowed off-hours monitoring by the LBNL Fire Department. Two significant engineering changes during 1995 included the addition of redundant valving on vacuum pumps close to the tritium source, and the replacement of the existing silica gel traps with broader traps which give the same flow, but higher HTO trapping efficiency. Many other minor engineering changes and procedural revisions were implemented during the year, and these all combined to markedly diminish HTO releases from the NTLF, especially during the latter half of the year. It is expected that the benefits of these changes will be realized in the future, and that releases for all of 1996 will be at the same low rate measured in the last half of 1995.

Until 1994, acceptable on site meteorological information was not available. Dose assessment modeling with CAP88-PC in prior years therefore used the Oakland airport dataset (OAK0319.WND) that was distributed by US/EPA with the model. These meteorological data were measured at

the Oakland airport. Use of the Oakland airport data had been formally approved by US/EPA Region IX, which serves California. In response to a finding by the DOE Tiger Team audit in 1991 regarding the adequacy of the onsite meteorological monitoring, siting, and quality assurance, Berkeley Lab recently completed a project to collect and use quality assured onsite meteorological data for performing dose assessments. The upgraded network began collecting data in early 1994. The 1995 radiological dose assessment calculations presented in this report are generated using the first full year of on site data collected by the meteorological tower. These data more accurately reflect the local wind directions and atmospheric stability categories in the US/EPA computer model. With this change to the site-specific meteorological input parameters, the CAP88-PC computer model yields an MEI dose by a factor of two higher than the model based on the Oakland airport meteorological data. This is mainly due to the fact that the average local wind speed at LBNL is lower by this factor of two compared to the Oakland airport (2 m/s

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vs. 4 m/s). Thus, even though there was a 50% reduction in tritium release during 1995 compared to 1994, the dose from CAP88-PC model remains the same as the last year value due to this refinement in modeling procedure.

Fourteen CAP88-PC individual modeling runs were executed to predict the impact of 14 single/grouped release points, as described in Section II of Appendix B, *NESHAPs*. As mentioned previously, the NTLF was identified as the major release point at LBNL. Therefore, the maximally exposed individual associated with this facility was also specified, with appropriate distances and directions, in each of these fourteen individual CAP88-PC

runs. The reported EDE to a MEI at LBNL includes contributions from all of these fourteen CAP88-PC models (see Table 11-6).

Collective population dose is calculated as the average radiation dose to an individual in a specified area, multiplied by the number of individuals in that area. One "population" CAP88-PC run was used to carry out this population dose assessment. This CAP88-PC model is based on the input parameters from the Building 75 computer run, with the source terms replaced by all the radionuclides listed in Table 11-5. The total collective dose from all radionuclides is given in Table 11-7.

Table 11-5. Total Air Effluent Radioactivities Released During 1995.

Nuclide	LBNL 1995 Total Air Effluent (Ci*/yr)	LBNL 1995 Total Air Effluent (Bq*/yr)	% of Total Effluent
H-3	5.30E+01	1.96E+12	80.17%
F-18	2.30E+00	8.51E+10	3.48%
N-13	4.88E+00	1.81E+11	7.38%
O-15	2.51E+00	9.29E+10	3.80%
C-11	3.20E+00	1.18E+11	4.84%
Ar-41	2.00E-01	7.40E+09	0.30%
C-14	1.29E-02	4.77E+08	0.02%
I-125	3.42E-05	1.27E+06	0.00%
P-32	3.03E-03	1.12E+08	0.00%
Sr-90	1.11E-03	4.11E+07	0.00%
Th-232	2.95E-04	1.09E+07	0.00%
U-238	2.50E-06	9.25E+04	0.00%
Co-60	3.40E-14	1.26E-03	0.00%
TOTAL:	6.61E+01	2.45E+12	100.00%

*

1 Ci = 3.7×10^{10} Bq

**

Estimated/calculated values

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Table 11-6. Summaries of Dose Assessment from All LBNL Airborne Release Points for 1995

Building Number	Building Name	Relative to the MEI of Building 75			
		75 MEI Distance (m)	75 MEI Dir.	75 MEI Dose (mSv*/yr)	% Total EDE
75	National Tritium Labeling Facility	110	NW	1.3×10^{-3}	79.53%
75-127 & 75A	Hazardous Waste Handling Facility	150	NW	1.2×10^{-4}	7.34%
74, 74B & 83	Buildings 74/74B/83 Research Med.	730	WNW	5.5×10^{-5}	3.36%
3	Calvin Lab at UCB	1,070	NE	5.3×10^{-5}	3.24%
88	88-Inch Cyclotron	670	ENE	5.1×10^{-5}	3.12%
75A (D)	Waste Storage Area (Diffuse)	150	NW	1.9×10^{-5}	1.16%
1	Donner Laboratory at UCB	980	ENE	1.3×10^{-5}	0.80%
55	Research Med & Rad Bio	490	E	1.2×10^{-5}	0.73%
934	Molecular & Cell Bio. (off site)	4,900	ENE	6.8×10^{-6}	0.42%
70 & 70A	Nuclear / Applied Science	510	NE	4.6×10^{-6}	0.28%
6	Advanced Light Source (ALS)	360	NE	2.6×10^{-7}	0.01%
62	Materials & Chem. Science	650	NW	3.5×10^{-8}	0.00%
2	Advanced Material Lab.	370	NE	2.1×10^{-15}	0.00%
26	Medical Services & Counting Lab.	240	N	0.0	0.00%
(*) 1 mSv = 1.0 x 100 mrem				TOTAL:	1.64 x 10⁻¹ 100.00%

Combined Dose Assessment

Radiological impact from accelerator operations and airborne radionuclides is minimal compared to applicable standards and nominal background radiation. As presented in Table 11-7 and Figure 11-3, the maximum effective dose equivalent to an individual due to 1995 LBNL operations is about 0.023 mSv (2.3 mrem) per year. This value is about 0.8% of the nominal background and less than 3% of the DOE-permitted annual limits. The estimated dose to the population within 80 kilometers of Berkeley Lab was 0.118 person-

mSv in 1995. This is estimated to be about one-thousandth of a percent of the dose that the population within this region received from background sources during the same period.

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Table 11-7. LBNL Radiological Impact

	Maximum Individual (Accelerators)	Maximum Individual (Airborne Nuclides)	Maximum All Sources	Collective Dose within 80 km of LBNL (All Sources) (person-Sv /yr)
Annual EDE (mSv/yr)	0.021	0.0016	0.023	0.0118
MEI Location	Residence (110m W of Bldg. 88)	Workplace (110m NW of Bldg. 75)	Residence (110m W of Bldg. 88)	Within 80 km of LBNL
DOE / EPA Standards (mSv /yr)	1	0.10	1	NA
LBNL impact as % of DOE/EPA Standard	2.1%	1.60%	2.3%	NA
Annual Background (mSv /yr)	1	2	3	1.50×10^4
LBNL Impact as % of Background	2.1%	0.07%	0.8%	0.00%

1 mSv = 100 mrem

Figure 11-3. LBNL Radiological Impact for 1995

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Section 12. Quality Assurance

General

For environmental programs, quality assurance (QA) consists of all activities conducted to ensure that data acquired provide a valid representation of actual conditions. Quality assurance is implemented through the Berkeley Lab's *Operating and Assurance Program* (OAP), PUB-3111. This document incorporates the guidance of DOE Order 5700.6C, *Quality Assurance*,⁹⁵ DOE Order 5480.19, *Conduct of Operations*,⁹⁶ and DOE Order 4330.4B, *Maintenance Management Program*.⁹⁷ Draft US/EPA guidance on QA (ANSI/ASQC E-4)⁹⁸ and US/EPA QA requirements from 40 CFR 61, Subpart H, Appendix B, method 114 were also used in creating the OAP.

Implementing the OAP is achieved through the creation of notebooks at all organizational levels within Berkeley Lab. There are three types of notebooks. Function notebooks provide guidance in the performance of support services such as environmental program activities. Facility notebooks are created to provide guidance in the operations of facilities to preclude operational incidents or environmental releases. Project notebooks provide guidance to researchers regarding their activities.

The function notebooks for the environmental programs (i.e., Environmental Protection, Waste Management, Environmental Restoration, Radiation and Analytical Measurement Laboratory) include provisions for documenting items such as:

- The organizational structure, functional responsibilities, levels of authority, and lines of communications for all activities related to the emissions measurement program.
- Administrative controls prescribed to ensure prompt response in the event that emission levels increase due to unplanned operations.
- Identification of sampling sites and number of sampling points, including the rationale for site selections.

- Sampling probes and representativeness of the samples.
- Any continuous monitoring system used to measure emissions, including the sensitivity of the system, calibration procedures, and frequency of calibration.
- Sample collection systems for each radionuclide measured, including frequency of analysis, calibration procedures, and frequency of calibration.
- Laboratory analysis procedures used for each radionuclide measured, including frequency of analysis, calibration procedures, and frequency of calibration.
- Vendor control practices, which provide the basis for selection of vendors and include verification activities related to the vendor calibration practices.
- Sample flow-rate measurement systems or procedures, including calibration procedures and frequency of calibration.
- Effluent flow rate measurement procedures, including frequency of measurements, calibration procedures, and frequency of calibration.
- Documented objectives of the QA program, which state the required precision, accuracy, and completeness of the emission measurement data, including a description of the procedures used to assess these parameters. Accuracy is the degree of agreement of a measurement with a true or known value. Precision is a measure of the agreement among individual measurements of the same parameters under similar conditions. Completeness is a measure of the amount of valid data obtained compared to the amount expected under normal conditions.
- A quality control program established to evaluate and track the quality of the emissions measurement data against preset criteria. The program includes, where applicable, a system of replicates, spiked samples, split samples, blanks, and control charts. The number and frequency of such quality control checks are identified.

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- A sample-tracking system established to provide for positive identification of samples and data through all phases of the sample collection, analysis, and reporting system.
- Sample handling and preservation programs to maintain the integrity of samples during collection, storage, and analysis.
- Periodic internal and external audits to monitor compliance with the QA program. These audits are performed in accordance with written procedures and conducted by personnel who do not have responsibility for performing any of the operations being audited.
- The corrective action program, including criteria for when corrective action is needed, what corrective actions will be taken, and who is responsible for taking the corrective action.
- Periodic reports prepared for management that describe the performance of the emissions measurements program. These reports include assessment of the quality of the data, results of audits, and descriptions of corrective actions.

limits, with the exception of three analyses. Evaluating the results of the analyses that did not pass indicate the following: 1) the June 9 cesium-134 in water analyses was attributed to peak summation error inherent to gamma spectroscopy analysis; 2) the July 21 beta in water analyses was attributed to a laboratory contamination problem discussed later in this text; 3) and the October 27 alpha in water is still under review by the US/EPA. Less than 80% of the US/EPA participants passed the October 27 alpha in water analyses. No trends were identified in the overall results. The root cause for each inability to pass was determined to be isolated and a review of previous or post same category analyses supported RAML's ability to perform the analyses within the acceptable US/EPA control limits.

Radiation and Analytical Measurements Laboratory

Radiochemical analyses of environmental samples are performed by LBNL's Radiation and Analytical Measurements Laboratory (RAML), which is under the direction of the EH&S Services Department. The RAML is accredited by the State Department of Health Services and is fully compliant with both DOE Order 5700.6c and US/EPA NESHAPs regulations in 40 CFR 61.

RAML participated in a total of 33 US/EPA interlaboratory comparison samples. Both the RAML and the comparison samples were reviewed by DHS in November. Table 12-1 summarizes RAML's US/EPA results. All results were within the listed US/EPA control

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Table 12-1. Summary Of Performance In US/EPA Intercomparison Study Samples, 1995

Sample Date,	Analyses	Medium	LBNL Mean	LBNL Std. Deviation, Bq/L*	US/EPA Value Bq/L*	US/EPA Control Limits	Deviation
1/13/95	Sr-89	Water	0.69	0.047	0.74 ± 0.19	0.42 to 1.06	-0.017
1/13/95	Sr-90	Water	0.47	0.022	0.56 ± 0.19	0.23 to 0.88	-0.030
1/27/95	Alpha	Water	0.37	0.025	0.19 ± 0.19	0.00 to 0.51	0.064
1/27/95	Beta	Water	0.28	0.006	0.19 ± 0.19	0.00 to 0.51	0.034
3/10/95	H-3	Water	312.0	12.5	275.4 ± 27.6	227.6 to 323.2	0.085
4/18/94	Alpha	Water	1.32	0.39	1.76 ± 0.44	1.00 to 2.52	-0.064
4/18/95	Beta	Water	3.13	0.19	3.21 ± 0.37	2.57 to 3.85	-0.014
4/18/95	Sr-89	Water	0.54	0.030	0.74 ± 0.19	0.42 to 1.06	-0.069
4/18/95	Sr-90	Water	0.47	0.036	0.56 ± 0.19	0.23 to 0.88	-0.030
4/18/95	Co-60	Water	1.06	0.058	1.07 ± 0.19	0.75 to 1.40	-0.004
4/18/95	Cs-134	Water	0.54	0.22	0.74 ± 0.19	0.42 to 1.06	-0.069
4/18/95	Cs-137	Water	0.38	0.14	0.41 ± 0.19	0.09 to 0.73	-0.009
6/9/95	Co-60	Water	1.26	0.39	1.48 ± 0.19	1.16 to 1.80	-0.077
6/9/95	Zn-65	Water	2.77	0.87	2.81 ± 0.30	2.30 to 3.33	-0.011
6/9/95	Cs-134	Water	1.46	0.42	1.85 ± 0.19	1.53 to 2.17	-0.137***
6/9/95	Cs-137	Water	1.01	0.32	1.30 ± 0.19	0.97 to 1.62	-0.099
6/9/95	Ba-133	Water	3.15	0.36	2.93 ± 0.30	2.43 to 3.44	0.059
7/14/95	Sr-89	Water	0.63	0.050	0.74 ± 0.19	0.42 to 1.06	-0.039
7/14/95	Sr-90	Water	0.23	0.014	0.30 ± 0.19	0.00 to 0.62	-0.021
7/21/95	Alpha	Water	0.83	0.074	1.02 ± 0.26	0.57 to 1.46	-0.047
7/21/95	Beta	Water	1.49	0.21	0.72 ± 0.19	0.40 to 1.04	0.268***
8/4/95	H-3	Water	167.4	17.4	180.4 ± 18.0	149.2 to 211.7	-0.047
8/25/95	Alpha	Air filter	0.92	0.037	0.93 ± 0.23	0.52 to 1.33	0.029
8/25/95	Beta	Air filter	2.87	0.057	3.21 ± 0.37	2.57 to 3.85	-0.059
8/25/95	Sr-90	Air filter	1.09	0.28	1.11 ± 0.19	0.79 to 1.43	-0.009
8/25/95	Cs-137	Air filter	0.70	0.12	0.93 ± 0.19	0.60 to 1.25	-0.077
10/17/95	Alpha	Water	3.21	0.22	**	**	**
10/17/95	Beta	Water	4.60	0.17	**	**	**
10/17/95	Sr-89	Water	0.54	0.049	**	**	**
10/17/95	Sr-90	Water	0.31	0.033	**	**	**
10/17/95	Co-60	Water	1.93	0.16	**	**	**
10/17/95	Cs-134	Water	1.22	0.10	**	**	**
10/17/95	Cs-137	Water	1.20	0.081	**	**	**
10/27/95	Alpha	Water	0.67	0.18	1.90 ± 0.47	1.07 to 2.72	-0.166
10/27/95	Beta	Water	0.71	0.12	0.92 ± 0.19	0.60 to 1.24	-0.074
11/3/95	Co-60	Water	2.28	0.67	2.22 ± 0.19	1.90 to 2.54	0.021
11/3/95	Zn-65	Water	4.84	1.52	4.56 ± 0.48	3.79 to 5.47	0.028
11/3/95	Cs-134	Water	1.44	0.32	1.48 ± 0.19	1.16 to 1.80	-0.013
11/3/95	Cs-137	Water	2.02	0.43	1.81 ± 0.19	1.49 to 2.14	0.034
11/3/95	Ba-133	Water	3.67	0.57	3.67 ± 0.37	3.03 to 4.31	0.000

Note: Units are becquerels per liter unless noted otherwise.

* The filter results were Bq/filter.

** Results for these studies not yet received from US/EPA.

*** Analysis Failed. See text for discussion.

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Figure 12-1. Environmental Monitoring Sample Analyses Performed by RAML

During 1995, RAML performed 5,139 various air, water, soil, and vegetation sample analyses for the environmental sampling and monitoring program. Figure 12-1 summarizes the total number of these analyses. The "other" category includes soil, vegetation, and goat's milk samples. Figure 12-2 summarizes the total number of all environmental monitoring samples analyzed on a monthly basis. On average, 20% of all samples analyzed were quality control samples. Figure 12-3 is an example of a common instrument control chart maintained by RAML. This particular control chart is called a Figure of Merit because it indicates the stability of an instrument at detecting a sample. In this case, it is for a tritium measuring instrument. This type of chart combines the sensitivity of the instrument with its efficiency. Each instrument produces a signal in the absence of any sample, called the background. Background arises from natural radiation sources such as cosmic rays and materials used to manufacture the instrument. As background lowers, the sensitivity of the instrument increases (i.e., able to detect a lower amount of radioactivity in a sample). Efficiency is the instrument's ability to convert the strength of the signal generated by radioactive material into a measured signal. As the efficiency increases,

a smaller amount of radioactivity in the sample can be detected. RAML checks the Figure of Merit parameter periodically, once a week in this case, to assure that the instrument is stable and within acceptable limits. Statistically, variations up to 2 standard deviations are expected routinely. Any variations over 2 standard deviations are checked and any variations over 3 standard deviations are investigated. The control chart will also reveal long term drift of the instrument.

Two incidents occurred in the analytical laboratory in 1995 which invalidated certain sample analyses for the environmental sampling and monitoring program. These incidents affected about 2% of all samples analyzed during the year. All sample analyses identified as potentially affected by the contamination incidents were jointly reviewed by EPG and RAML in order to validate the results published in this report. The first incident involved samples processed during January. The cause of the first contamination was attributed to a "hot" radiological sample received by RAML improperly labeled as a nonradiological environmental sample. During the analyses, the "hot" sample contaminated the environmental hood and additional samples. The full effect of the contamination incident was not identified until

Figure 12-2. RAML Analyses by Month

a later date. The second contamination incident occurred in early June. The cause of the second incident was identified as improper drying in an environmental hood of contaminated silica gel for recycling. Corrective actions were taken by both the laboratory and the monitoring groups to modify work practices. The main actions taken included: improved control on incoming samples, segregation of work areas, improvements in collection techniques, and timely review of data.

Environmental Protection Group

Quality assurance for the Environmental Protection Group is documented in the EPG function notebook and the NESHAP Quality Assurance Project Plan. It provides for self and independent assessments of environmental quality assurance programs, including those performed by environmental

monitoring personnel in this group. The rationale for all routine sampling and monitoring activities is described in the *Environmental Monitoring Plan*. The *Parameter Review Plan* describes the pathways, monitoring and sampling criteria, and action limits for all sample media and analytes.

All monitoring personnel are trained in the performance and execution of their duties. Since there are few specific formal environmental monitoring and sampling training courses, personnel are trained in areas and skills closely aligned with their specific duties. Training records are maintained, with periodic review conducted to ensure that training records are current.

Accuracy and precision requirements cited in the *Parameter Review Plan* form the basis of the data quality objectives (DQOs). Three data management procedures form the basis for quality improvement within the

Tritium Figure of Merit

Note: standard deviations less than ± 2 show better than expected sensitivity and efficiency

Figure 12-3. Instrument Sensitivity and Efficiency for Tritium Analyses

environmental sampling and monitoring program: *Data Quality Objectives*, *Data Validation And Verification*, and *Data Analysis*. These procedures have been in place since 1994. Data validation, verification, and statistical analysis procedures applied to analytical data determine the “goodness” of the sampling and analyses, and provide a statistically defensible means of demonstrating compliance with regulatory agency and DOE order requirements. Analytical data are assessed by applying the data validation and verification procedures with respect to the DQOs. If the precision and accuracy criteria set forth in the DQOs are met, then no further change in sampling/analytical procedure is required. If the DQOs are not met, then the sampling and analytical procedures will be reviewed to identify any required corrective actions.

Data Validation

In order to determine whether a stated sample analytical accuracy or precision is being met, duplicate and split sample are taken. Obtaining duplicates or splits is relatively simple when sampling surface waters, wastewater effluent, and radiological deposition. However, taking representative duplicate samples from air point sources (exhaust stacks) and ambient air poses significantly greater challenges. For this reason, the precision and accuracy procedures were applied only to surface water, sewer, and radiological deposition samples from 1995. Nonradiological data sets did not contain enough duplicate samples to allow precision or accuracy testing.

Environmental data are most commonly distributed either normally or log-normally. If the sample analysis is close to the instrument detection limit or MDA, the analytical standard deviation is quite large and the data distribution tends to be log-normal. If the sample analysis is far from the instrument MDA, the data tend to be distributed normally. Tests are applied to all the data to determine whether or not they are normally or log-normally distributed. There are other distribution modes whose analyses become increasingly complex. If other modes are observed in the data, then the procedures will be modified to accommodate the change. Knowledge of the distribution mode is important, as the statistical analysis procedures require a normally distributed data set. If the data are found to be log-normally distributed, a log transform is applied to transform them to a normally distributed data set.

Aqueous samples were taken weekly throughout most of 1995 and were analyzed for gross alpha, beta, and tritium. Figures 12-4 through 12-6 are comparison plots of actual versus expected aqueous analytical data, assuming a normal distribution. Figures 12-7 through 12-9 are comparison plots of the same parameters, assuming a log-normal distribution of the data. The degree of linearity is slightly better in the log-normally distributed plots so in the discussion of statistical analysis which follows data were assumed to be log-normally distributed.

Statistical Analysis

Data management procedures require performing a paired-sample t-test to determine if there are statistically significant differences between duplicate and routine samples whenever eight or more duplicate or routine data pairs exist. Tables 12-2 through 12-4 summarize the results of the paired-sample t-test applied to suites of aqueous alpha, beta, and tritium sample analyses. The statistical analysis tests the null hypothesis that there is no difference between sample and duplicate analyses against the alternate hypothesis that duplicate data differ statistically from the

sample data. Accepting the null hypothesis at a 95% confidence level indicates that the error introduced by either sampling or analytical methods is at an acceptable level. The null hypothesis is accepted if the absolute value of the calculated t statistic is less than the predicted t statistic. This is a function of the number of samples taken and is derived from tables. It should be noted that since a portion of the data sets has negative values, in testing the log of the data a large positive linear transform is applied (since the log of a negative number is undefined). This is allowable since, in the t-test, the shape of the distribution and not the absolute value of the data is what is important. For all three data sets, the absolute value of their t statistic is less than the predicted t statistic, or t critical two-tail. This means that the null hypothesis is accepted and that errors in sampling and analysis are acceptable at a 95% confidence level.

In addition, during the latter part of the year, the group began sending splits of all aqueous samples to an outside commercial laboratory for comparison testing with analyses done at the onsite RAML. Table 12-5 summarizes the results of paired-sample t-testing for the laboratory splits. Again the t statistic for the paired data is less than the predicted t statistic, so that errors in analytical procedure are acceptable at a 95% confidence level.

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Figure 12-4. Comparison Plots of Alpha from Aqueous Analytical Data, Assuming Normal Distribution.

Figure 12-5. Comparison Plots of Beta from Aqueous Analytical Data, Assuming Normal Distribution.

Figure 12-6. Comparison Plots of Tritium from Aqueous Analytical Data, Assuming -Normal Distribution.

Figure 12-7. Comparison Plots of Alpha from Aqueous Analytical Data, Assuming Log-Normal Distribution.

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Figure 12-8. Comparison Plots of Beta from Aqueous Analytical Data, Assuming Log-Normal Distribution.

Figure 12-9. Comparison Plots of Tritium from Aqueous Analytical Data, Assuming Log-Normal Distribution.

Table 12-2. t-Test, Paired Two Sample for Means (alpha field duplicates, transformed log values)

<i>Statistical Parameter</i>	<i>log(alpha transformed)</i>	<i>Log(alpha dup transformed)</i>
Mean	0.696848158	0.698157538
Variance	1.98219E-05	3.2148E-06
Observations	10	10
Pearson Correlation	0.34615053	
Hypothesized Mean Difference	0	
df	9	
t Stat	-0.989507525	
P(T<=t) one-tail	0.174134968	
t Critical one-tail	1.833113856	
P(T<=t) two-tail	0.348269936	
t Critical two-tail	2.262158887	

Table 12-3. t-Test, Paired Two Sample for Means (beta field duplicates, transformed log values)

<i>Statistical Parameter</i>	<i>log(transformed beta)</i>	<i>log(transformed beta dup)</i>
Mean	0.035303831	0.033976181
Variance	0.002344073	0.002649428
Observations	12	12
Pearson Correlation	0.805052096	
Hypothesized Mean Difference	0	
df	11	
t Stat	0.146838772	
P(T<=t) one-tail	0.44295796	
t Critical one-tail	1.795883691	
P(T<=t) two-tail	0.885915921	
t Critical two-tail	2.200986273	

Table 12-4. t-Test, Paired Two Sample for Means (tritium field duplicates, transformed log values)

<i>Statistical Parameter</i>	<i>log(transformed tritium)</i>	<i>log(transformed tritium dup)</i>
Mean	2.073961445	2.106126655
Variance	0.005621147	0.010815482
Observations	12	12
Pearson Correlation	0.529543885	
Hypothesized Mean Difference	0	
df	11	
t Stat	-1.23206317	
P(T<=t) one-tail	0.121806296	
t Critical one-tail	1.795883691	
P(T<=t) two-tail	0.243612592	
t Critical two-tail	2.200986273	

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Table 12-5. t-Test, Paired Two Sample for Means (laboratory splits, transformed tritium, non-detect pairs removed)

Statistical Parameter	RAML	Outside Commercial Laboratory
Mean	2.10019919	2.12123785
Variance	0.035471498	0.03200925
Observations	12	12
Pearson Correlation	0.972662062	
Hypothesized Mean Difference	0	
df	11	
t Stat	-1.65840816	
P(T<=t) one-tail	0.062723657	
t Critical one-tail	1.795883691	
P(T<=t) two-tail	0.125447314	
t Critical two-tail	2.200986273	

Environmental Restoration Program

The environmental restoration program prepared a function notebook in 1993, which is designed to comply with institutional quality assurance requirements. These requirements and procedures are further specified in the QAPP and ERP *Standard Operating Procedures*. The QAPP and the SOPs are applicable to all field and laboratory activities conducted in support of the ERP. Quality assurance requirements include definition and implementation of controls on accuracy, precision, completeness, comparability, and representativeness of sample data; and controls on data reduction and reporting.

The overall QA objective is to collect and analyze environmental samples in a manner that ensures that all technical data generated during site investigations withstand scientific scrutiny and are useful in planning environmental restoration activities at the site. The QAPP describes the organization structure and responsibilities of the

environmental restoration program, including an assigned quality assurance manager. The quality assurance manager conducts general oversight of the ERP QA program and is responsible for conducting and documenting annual assessment audits to ensure that requirements of the QAPP are fulfilled. The quality assurance manager also documents compliance with pertinent DOE and Berkeley Lab QA policies.

Sample collection, preservation, and custody activities are performed according to procedures specified in the QAPP and SOPs. All required sample analyses are completed by laboratories certified by the State of California Department of Health Services *Environmental Laboratory Accreditation Program*. Internal quality control checks for field operations include the collection of equipment (rinse) blanks, trip blanks, and sample duplicates or replicates. Table 12-6 lists the number of quality control samples that were collected during quarterly groundwater sampling in 1995.

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Table 12-6. Quality Control Samples from Groundwater Monitoring Wells

Analysis	Number of Samples	Duplicate Samples	Split Samples	Equipment Blanks	Trip Blanks
Volatile Organic Compounds	407	27	14	41	33
8270 Semi-Volatile Organic	3	0	0	0	0
Title 22 Metals	77	11	1	5	0
Minerals	22	6	1	1	0
Total Petroleum Hydrocarbons	88	12	14	13	0
Oil and Grease	3	1	1	1	0
Total Suspended Solids	3	0	0	0	0
Radionuclides/Tritium	75	3	2	7	0

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In addition, the Association of Bay Area Government's Web site (<http://www.abag.ca.gov/>) provided access to vital statistics on the Bay Area and its communities, including the latest population census figures.

Glossary

Acronyms and Abbreviations

A	Ampere
Å	Angstrom
ADS	Activity Data Sheet
AEDE	Annual Effective Dose Equivalent
AIP	Agreement in Principle
ALARA	As Low As Reasonably Achievable
ALS	Advanced Light Source
ANSI	American National Standards Institute
ASPCP	Accidental Spill Prevention and Containment Plan
AST	Aboveground Storage Tank
BAAQMD	Bay Area Air Quality Management District
BAD	Bay Area Drum
Bq	Becquerel
BTEX	Benzene, Toluene, Ethylbenzene, and Xylene
°C	degrees Celsius
CAA	Clean Air Act
Cal/EPA	California Environmental Protection Agency
CCR	California Code of Regulations
CEDE	Collective Effective Dose Equivalent
CEQA	California Environmental Quality Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
Ci	Curie
cm	centimeter
COB	City of Berkeley
CUPA	Certified Unified Program Agency
CWA	Clean Water Act
CY	Calendar Year
DHS	Department of Health Services
DOE	U.S. Department of Energy
DOE EH-24	U.S. Department of Energy, Office of Environmental Audit

Glossary

DOE EM	U.S. Department of Energy, Office of Environmental Management
DOE ER	U.S. Department of Energy, Office of Energy Research
DOE/BSO	U.S. Department of Energy/Berkeley Site Office
DOE/OAK	U.S. Department of Energy/Oakland Operations Office
DOT	U.S. Department of Transportation
DQO	Data Quality Objectives
DTSC	Department of Toxic Substances Control
EA	Environmental Assessment
EBMUD	East Bay Municipal Utility District
EDE	Effective Dose Equivalent
EH&S	Environment, Health, and Safety
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
EM	Environmental Management
EMP	Environmental Monitoring Plan
EMS	Environmental Monitoring Station
EPCRA	Emergency Planning and Community Right-to-Know Act
EPG	Environmental Protection Group
ERPP	Environmental Radiological Program Plan
ERP	Environmental Restoration Program
ERWM	Environmental Restoration and Waste Management
ES&H	Environment, Safety, and Health
ESA	Endangered Species Act
°F	degrees Fahrenheit
FFCA	Federal Facilities Compliance Agreement or Federal Facilities Compliance Act of 1992
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
ft	foot or feet
FR	Federal Register
FTU	Fixed Treatment Unit
FY	Fiscal Year

gpm	gallons per minute
gsf	gross square feet
gsm	gross square meters
HEPA	High Efficiency Particulate Air
HGL	Human Genome Laboratory
HTO	Tritium Oxide (Tritiated Water)
HWHF	Hazardous Waste Handling Facility
HWIR	Hazardous Waste Identification Rule
IH	Industrial Hygiene
in	inch
IS	Initial Study
JHQ	Job Hazards Questionnaire
kg	kilogram
km	kilometer
L	Liter
LANL	Los Alamos National Laboratory
LBL	Lawrence Berkeley Laboratory
LLNL	Lawrence Livermore National Laboratory
m	meter
M&O	Maintenance and Operations
MCL	Maximum Contamination Limit
MDA	Minimum Detectable Activity
MeV	Million Electron Volts
mg	milligram
Mgsf	Million gross square feet
MEI	Maximally Exposed Individual
mL	milliliter
mrem	millirem
MSDS	Material Safety Data Sheet
mSv	millisievert
MW	Mixed Waste
NAE	North American Environmental, Inc.
ND	non-detectable
NEPA	National Environmental Policy Act

Glossary

NERSC	National Energy Research Scientific Computer Center
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NFI	No Further Investigation
NHPA	National Historic Preservation Act
NIST	National Institute of Standards and Technology
NOV	Notice of Violation
NRC	Nuclear Regulatory Commission
NPDES	National Pollutant Discharge Elimination System
NTLF	National Tritium Labeling Facility
OAA	Office of Assessment and Assurance
OAP	Operating and Assurance Program
ODS	Ozone-Depleting Substance
OMB	Office of Management and Budget
pCi	picocurie (one billionth)
PCB	Polychlorinated Biphenyl
PCE	Perchloroethylene
PM	Performance Measure
POTW	Publicly Owned Treatment Works
ppbv	parts per billion by volume
ppm	parts per million
PRP	Potentially Responsible Party
PWA	Process Waste Assessment
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RAML	Radiation and Analytical Measurements Laboratory
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
RMPP	Risk Management and Prevention Plan
RSU	Regulatory Structure Update
RWQCB	Regional Water Quality Control Board
SAA	Satellite Accumulation Area

SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SEIR	Supplemental Environmental Impact Report
SI	Système Internationale or International System of Units (the metric system)
SNAP	Significant New Alternatives Policy
SOP	Standard Operating Procedure
STP	Site Treatment Plan
Sv	Sievert
SWMP	Storm Water Monitoring Program
SWPPP	Storm Water Pollution Prevention Plan
SWRCB	State Water Resources Control Board
TBq	Terabecquerel (one trillion)
TCE	Trichloroethylene
TDS	Total Dissolved Solids
TICH	Total Identifiable Chlorinated Hydrocarbons
TLD	Thermoluminescent Dosimeter
TOC	Total Organic Carbon
TOMP	Toxic Organic Management Plan
TPH	Total Petroleum Hydrocarbons
TPH-D	Total Petroleum Hydrocarbons, Diesel
TPH-G	Total Petroleum Hydrocarbons, Gasoline
TRI	Toxic Release Inventory
TSCA	Toxic Substance Control Act
TTO	Total Toxic Organics
UC	University of California
UCB	University of California at Berkeley
UCOP	University of California Office of the President
μCi	microcurie
μg	microgram
UHVCF	Ultra-High Vacuum Cleaning Facility
URL	Uniform Resource Locator
US/EPA	U.S. Environmental Protection Agency

Glossary

UST	Underground Storage Tank
UV	Ultraviolet
VOC	Volatile Organic Compound
WAA	Waste Accumulation Area
WMG	Waste Management Group
WMin/PP	Waste Minimization and Pollution Prevention

Technical Terms

accuracy	The closeness of the result of a measurement to the true value of the quantity measured.
air particulates	Airborne particles that include dust, dirt, and other pollutants that occur as particles, and any pollutants that may be associated with or carried on the dust or dirt.
aliquot	An exact fractional portion of a sample taken for analysis.
Angstrom	A unit of length equal to one ten-billionth (0.0000000001 or 1×10^{-10}) of a meter.
alpha particle	A charged particle, identical to the helium nucleus, comprising two protons and two neutrons that are emitted during decay of certain radioactive atoms. Alpha particles are stopped by several centimeters of air or a sheet of paper.
ambient air	The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures. It does not include the air next to emission sources.
aquifer	A saturated layer of rock or soil below the ground surface that can supply usable quantities of ground water to wells and springs. Aquifers can be a source of water for domestic, agricultural, and industrial uses.
background radiation	Ionizing radiation from sources other than LBNL. Background may include cosmic radiation; external radiation from naturally occurring radioactivity in the earth (terrestrial radiation), air, and water; internal radiation from naturally occurring radioactive elements in the human body; and radiation from medical diagnostic procedures.
becquerel (Bq)	Unit of radioactive decay equal to one disintegration per second (SI unit).

beta particle	A charged particle, identical to the electron, that is emitted during decay of certain radioactive atoms. Most beta particles are stopped by less than 0.6 centimeters of aluminum.
categorical process	An industrial process governed by federal regulation(s) of wastewater discharges.
collective effective dose equivalent	The sum of the effective dose equivalents of all individuals in an exposed population within a certain radius, usually 80 kilometers for NESHAPs compliance. This value is expressed in units of person-sievert (SI) or person-rem (conventional).
contaminant	Any hazardous or radioactive material present in an environmental medium, such as air, water, or vegetation.
controlled area	Any Laboratory area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.
cosmic radiation	High-energy particulate and electromagnetic radiation that originates outside the earth's atmosphere. Cosmic radiation is part of the natural background radiation.
discharge	A release of a liquid into an area not controlled by LBNL.
dose	The quantity of radiation energy absorbed during a given period of time.
dose, absorbed	The energy imparted to matter by ionizing radiation per unit mass of irradiated material. The unit of absorbed dose is the gray (SI) or rad (conventional).
dose, effective	The hypothetical whole-body dose that would give the same risk of cancer mortality and/or serious genetic disorder as a given exposure and that may be limited to just a few organs. The effective dose equivalent is equal to the sum of individual organ doses, each weighted by degree of risk that the organ dose carries. For example, a 1-millisievert dose to the lung, which has a weighting factor of 0.12, gives an effective dose that is equivalent to 0.12 millisievert (1×0.12).
dose, equivalent	A term used in radiation protection that expresses all types of radiation (alpha, beta, and so on) on a common scale for calculating the effective absorbed dose. It is the product of the absorbed dose and certain modifying factors. The unit of dose equivalent is the sievert (SI) or rem (conventional).

Glossary

dose, maximum boundary	The greatest dose commitment, considering all potential routes of exposure, from a facility's operation to a hypothetical individual who is in an uncontrolled area where the highest dose rate occurs. It assumes that the hypothetical individual is present 100% of the time (full occupancy), and it does not take into account shielding by obstacles such as buildings or hillsides.
dose, maximum individual	The greatest dose commitment, considering all potential routes of exposure, from a facility's operation to an individual at or outside the LBNL boundary where the highest dose rate occurs. It takes into account shielding and occupancy factors that would apply to a real individual.
dose, population	The sum of the radiation doses to individuals of a population. It is expressed in units of person-sievert (SI) or person-rem (conventional). For example, if 1000 people each received a radiation dose of 1 sievert, their population dose would be 1000 person-sievert.
dosimeter	A portable detection device for measuring the total accumulated exposure to ionizing radiation. See also thermoluminescent dosimeter.
downgradient	Commonly used to describe the flow of groundwater from higher to lower concentration. The term is analogous to downstream.
effective dose equivalent	Abbreviated EDE, it is the sum of the products of the dose equivalent received by specified tissues of the body and a tissue-specific weighting factor. This sum is a risk-equivalent value and can be used to estimate the health risk of the exposed individual. The tissue-specific weighting factor represents the fraction of the total health risk resulting from uniform whole-body irradiation that would be contributed by that particular tissue. The EDE includes the committed EDE from internal deposition of radionuclides and the EDE due to penetrating radiation from sources external to the body. EDE is expressed in units of sievert (SI) or rem (conventional).
effluent	A liquid waste discharged to the environment.
emission	A release of air to the environment containing gaseous or particulate matter having one or more contaminants.

environmental remediation	The process of restoring a contaminated area to a noncontaminated or safe condition.
exposure	A measure of the ionization produced in air by X-ray or gamma radiation. The unit of exposure is the coulomb per kilogram (SI) or roentgen (conventional).
external radiation	Radiation originating from a source outside the body.
extractable pollutants	Pollutants that can be removed from a contaminated sample by passing water through the sample.
gamma radiation	Short-wavelength electromagnetic radiation of nuclear origin that has no mass or charge. Because of its short wavelength (high energy), gamma radiation can cause ionization. Other electromagnetic radiation, such as microwaves, visible light, and radio waves, have longer wavelengths (lower energy) and cannot cause ionization.
groundwater	A subsurface body of water in a zone of saturated soil sediments.
half-life, radioactive	The time required for the activity of a radioactive substance to decrease to half its value by inherent radioactive decay. After two half-lives, one-fourth of the original activity remains ($1/2 \times 1/2$); after three half-lives, one-eighth ($1/2 \times 1/2 \times 1/2$); and so on.
hazardous waste	Waste exhibiting any of the following characteristics: ignitability, corrosivity, reactivity, or EP-toxicity (yielding toxic constituents in a leaching test). Because of its concentration, quantity, physical, or chemical characteristics, it may: 1) cause or significantly contribute to an increase in mortality rates or cases of serious irreversible illness; or 2) pose a substantial present or potential threat to human health or the environment when improperly treated, stored, transported, disposed of, or handled.
internal radiation	Radiation from a source within the body as a result of deposition of radionuclides in body tissues by processes such as ingestion, inhalation, or implantation. Potassium (^{40}K), a naturally occurring radionuclide, is a major source of internal radiation in living organisms.
nonattainment area	An area that does not meet the National Ambient Air Quality Standards.

Glossary

nuclide	A species of atom characterized by what constitutes the nucleus, which is specified by the number of protons, number of neutrons, and energy content; or, alternatively, by the atomic number, mass number, and atomic mass. To be regarded as a distinct nuclide, the atom must be able to exist for a measurable length of time.
organic compound	A chemical whose primary constituents are carbon and hydrogen.
Part B permit	The second, narrative section submitted by generators in the RCRA permitting process. It details the procedures followed at a facility to protect human health and the environment.
pH	A measure of hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH less than 7, basic solutions have a pH greater than 7, and neutral solutions have a pH of 7.
piezometer	Generally, a small-diameter, nonpumping well used to measure the elevation of the water table or potentiometric surface. The water table is an imaginary surface that represents the static head of groundwater and is defined by the level to which water will rise.
pollutant	Any hazardous or radioactive material present in an environmental medium, such as air, water, or vegetation.
pretreatment	Any process used to reduce a pollutant load before wastewater enters the sewer system.
pretreatment regulations	National wastewater pretreatment regulations (40 CFR 403) adopted by US/EPA in compliance with the 1977 amendments to the Clean Water Act, which required that US/EPA establish pretreatment standards for existing and new industrial sources.
priority pollutants	A set of organic and inorganic chemicals identified by US/EPA as indicators of environmental contamination
purgeable pollutants	Pollutants that can be removed from a sample by passing nitrogen gas through the sample.
radiation protection standard	Limits on radiation exposure regarded as necessary for protection of public health. These standards are derived based on acceptable levels of risk to individuals.
radiation	Energy emitted from the nucleus of an atom in the form of waves or particles.

radioactivity	The property or characteristic of a nucleus of an atom to spontaneously disintegrate accompanied by the emission of energy in the form of radiation.
radiological	Arising from radiation or radioactive materials.
radionuclide	An unstable nuclide. See nuclide and radioactivity.
recharge zone	An area of the ground in which surface water migrates to the groundwater.
remediation	See environmental remediation.
scintillation cocktail	A solution of organic compounds that emits light upon interacting with radiation. For the purposes of this report, it is used primarily for the analysis of tritium.
source	Any operation or equipment that produces, discharges, and/or emits pollutants (e.g., pipe, ditch, well, or stack).
terrestrial	Pertaining to or deriving from the earth.
terrestrial radiation	Radiation emitted by naturally occurring radionuclides, such as ^{40}K ; the natural decay chains ^{235}U , ^{238}U , or ^{232}Th ; or cosmic-ray induced radionuclides in the soil.
thermoluminescent dosimeter (TLD)	A type of dosimeter. After being exposed to radiation, the material in the dosimeter (lithium fluoride) luminesces upon being heated. The amount of light the material emits is proportional to the amount of radiation (dose) to which it was exposed. See also dosimeter.
tritium	A radionuclide of hydrogen with a half-life of 12.3 years. The very low energy of its radioactivity decay makes it one of the least hazardous radionuclides.
uncontrolled area	An area beyond the boundaries of a controlled area. See controlled area.
upgradient	Opposite of the direction of groundwater flow from a designated area of interest. Analogous to upstream.
uranium	A metallic element that is highly toxic and radioactive.
uranium, depleted	Uranium consisting primarily of ^{238}U and having less than 0.72 wt% ^{235}U . Except in rare cases occurring in nature, depleted uranium is man-made.

Glossary

uranium, total	The amount of uranium in a sample, assuming that the uranium has the isotopic content of uranium in nature (99.27 wt% ^{238}U , 0.72 wt% ^{235}U , and 0.0057 wt% ^{234}U)
vadose zone	The partially saturated or unsaturated region of the ground above the water table that does not yield water to wells.
wind rose	A diagram that shows the frequency and intensity of wind from different directions at a particular place.

Radiological Units

becquerel (Bq)	Unit of radioactive decay equal to one disintegration per second. (SI unit)
curie (Ci)	Unit of radioactive decay equal to 2.22×10^{12} disintegrations per minute. (conventional units)
mrem	millirem (10^{-3} rem). See rem.
person-rem	The unit of population dose, which expresses the sum of radiation exposures received by a population. For example, two persons, each with a 0.5-rem exposure, receive 1 person-rem, and 500 people, each with an exposure of 0.002 rem, also receive 1 person-rem.
rad	A unit of absorbed dose from ionizing radiation (0.877 rad/R).
rem	Stands for roentgen equivalent man; a unit of ionizing radiation, equal to the amount of radiation needed to produce the same biological effect to humans as 1 rad of high-voltage x-rays. It is the product of the absorbed dose (rad), quality factor (Q), distribution factor, and other necessary modifying factors. It describes the effectiveness of various types of radiation in producing biological effects.
roentgen (R)	A unit of radiation exposure that expresses exposure in terms of the amount of ionization produced by x or gamma rays in a volume of air. One roentgen (R) is 2.58×10^4 coulombs per kilogram of air.
sievert (Sv)	A unit of radiation dose equivalent. The sievert is the SI unit equivalent to the rem. It is the product of the absorbed dose (gray), quality factor (Q), distribution factor, and other necessary modifying factors. It describes the effectiveness of various types of radiation to produce biological effects; $1 \text{ Sv} = \text{Gy} \times \text{Q} \times \text{N} = 100 \text{ rem}$.

Units of Measure

Throughout this report, an attempt has been made to reference the International System of Units (SI) or metric system of measurements, where ever possible. Radiological quantities (activity—curies (Ci), exposure—roentgen (R), and dose—rad and rem) have also been reported in U.S. conventional units because current standards are written in terms of these units. The equivalent SI units are the becquerel (Bq), coulomb per kilogram (C/kg), gray (Gy), and sievert (Sv), respectively.

Table GLS-1 presents prefixes used with SI units of measurement. Table GLS-2 presents conversion factors for converting from SI units to U.S. conventional units.

Table GLS-1. Prefixes Used with SI (Metric) Units

Prefix	Factor	Symbol
exa	1,000,000,000,000,000,000 = 10^{18}	E
peta	1,000,000,000,000,000 = 10^{15}	P
tera	1,000,000,000,000 = 10^{12}	T
giga	1,000,000,000 = 10^9	G
mega	1,000,000 = 10^6	M
kilo	1,000 = 10^3	k
hecto	100 = 10^2	h ^A
deka	10 = 10^1	da ^A
deci	0.1 = 10^{-1}	d ^A
centi	0.01 = 10^{-2}	c ^A
milli	0.001 = 10^{-3}	m
micro	0.000001 = 10^{-6}	μ
nano	0.000000001 = 10^{-9}	n
pico	0.000000000001 = 10^{-12}	p
femto	0.000000000000001 = 10^{-15}	f
atto	0.000000000000000001 = 10^{-18}	a

^AAvoid where practical

Glossary

Table GLS-2. Conversion Factors for Selected SI (Metric) Units

To Convert SI Unit	to U.S. Conventional Unit	Multiply By
Area		
square centimeters	square inches	0.155
square meters	square feet	10.764
square kilometers	square miles	0.3861
hectares	acres	2.471
Concentration		
micrograms per gram	parts per million	1
milligrams per liter	parts per million	1
Length		
centimeters	inches	0.3937
meters	feet	3.281
kilometers	miles	0.6214
Mass		
grams	ounces	0.03527
kilograms	pounds	2.2046
kilograms	ton	0.00110
Pressure		
pounds per square foot	pascal	0.000145
Radiation		
becquerel	curie	2.7×10^{11}
gray	rad	100
sievert	rem	100
coulomb per kilogram	roentgen	3876
Temperature		
degrees Celsius	degrees Fahrenheit	1.8, then add 32
Velocity		
meters per second	miles per hour	2.237
Volume		
cubic meters	cubic feet	35.315
liters	gallons	0.2642

Appendix A – NESHAPs Annual Report

US Department of Energy
Radionuclide Air Emission Annual Report
(Subpart H of 40 CFR 61)
Calendar Year 1995

Site Name: **Lawrence Berkeley National Laboratory (LBNL)**

Operation Office Information

Office: Oakland Operations Office

Address: 1301 Clay St. Room 700 N
Oakland, CA 94612

Contact: Steven Lasell Phone: (510) 637-1602

Site Information

Operator: Lawrence Berkeley National Laboratory

Address: 1 Cyclotron Road
Berkeley, CA 94720

Contractor Contact: Henry Tran Phone: (510) 486-7623

DOE Site Contact: Carl Schwab Phone: (510) 486-4298

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Section I. Facility Information

Site Description:

Laboratory Operations

The Lawrence Berkeley National Laboratory (LBNL) is a multi-program national laboratory managed by the University of California (UC) for the US Department of Energy (DOE). LBNL's major role is to conduct basic and applied researches in biology, physics, chemistry, materials, and energy. LBNL, birthplace of the cyclotron, was founded by the late Nobel Laureate Ernest Orlando Lawrence in 1931.

LBNL also supports nationwide university-based research by providing national facilities, including:

- National Center for Electron Microscopy (Building 72)
- National Tritium Labeling Facility (Building 75)

Other LBNL facilities that are relevant to the radioactive air emission program governed by "National Emission Standard for Hazardous Airborne Pollutants other than Radon from DOE Facilities" (NESHAPs) include:

- 88-inch Cyclotron (Building 88)
- Advanced Light Source (Building 6)
- A number of radiochemical and radiobiological laboratories located in Buildings 1, 2, 3, 26, 55, 56, 62, 70, 70A, 71, 74, 74B, 83, 88, and 934.
- Hazardous Waste Handling Facility (Buildings 75 and 75A)

Figure 1 illustrates the LBNL general site configuration and locations of potential NESHAPs source terms. Table 1 identifies the buildings illustrated in Figure 1. Figure 2 identifies other LBNL off site locations (Buildings 1, 3, and 934) that potentially involve radioactive air emissions.

Radiochemical and radiobiological studies performed in many on site/off site laboratories at LBNL typically use millicurie quantities of a great variety of radionuclides. (One millicurie is equal to 3.7×10^7 Becquerel (Bq).)

HILL-SITE BUILDINGS

2	Advanced Materials Laboratory (AML) & Center for X-ray Optics (CXRO)
4	Magnetic Fusion Energy (MFE)
5	Magnetic Fusion Energy (MFE)
6	Advanced Light Source (ALS)
7	Central Stores & Electronics Shops
10	Cell & Molecular Biology Research & Photography
14	Accelerator & Fusion Research & Earth Sciences
16	Magnetic Fusion Energy Laboratory
17	EH&S/Applied Sciences Lab
25	Mechanical Technology
25A	Electronics Shops
26	Medical Services
27	High Voltage Test Facility & Cable Shop
29	Electronics Engineering, Research
Medicine/Radiation	Biophysics Offices
31	Chicken Creek Maintenance Bldg.
36	Grizzly Substation Switchgear Bldg.
37	Utilities Service
40	Electronics Development Lab
41	Magnetic Measurements Lab
42	Salvage
43	Compressor Bldg.
44	Indoor Air Pollution Studies
45	Fire Apparatus
46	RTSS, ALS, Accelerator Development
46A	Real Time Systems Section (RTSS)
47	Advanced Accelerator Study
48	Fire Station
50	Physics, Accelerator & Fusion Research & Nuclear Science
50A	Director's Office, Environment & Laboratory Development, Administration Division, Patents
50B	Physics, Computer Center, IRD & ICSD
50C	PID, Physics
50D	MCSD & Nuclear Science
50E	Earth Sciences
50F	Computing Services, IRD
51	Bevalac/Bevatron (decommissioned)
51A	Bevatron Experimental Area
51B	External Particle Beam (EPB) Hall
52	Magnetic Fusion Energy Laboratory
53	SuperHILAC Development
54	Cafeteria
55	Research Medicine/Radiation Biophysics
55A	Nuclear Magnetic Resonance (NMR)
56	Cryogenic Facility
58	Accelerator Research & Development
58A	Accelerator Research & Development Addition
60	High Bay Laboratory
61	Standby Propane Plant
62	Materials & Chemical Sciences
63	Accelerator & Fusion Research
64	Accelerator & Fusion Research

65	Data Processing Services
66	Surface Science & Catalysis Lab
68	Upper Pump House
69	Business Services, Materiel Management, Mail Room & Purchasing
70	Nuclear Science, Applied Science & Earth Sciences
70A	Nuclear Science, Materials & Chemical Sciences
&	Earth Sciences
71	Heavy Ion Linear Accelerator (HILAC)
71A	HILAC Rectifier
71B	HILAC Annex
72	National Center for Electron Microscopy (NCEM)
72A	High Voltage Electron Microscope (HVEM)
72B	Atomic Resolution Microscope (ARM)
72C	ARM Support Laboratory
73	Atmospheric Aerosol Research
74	Research Medicine/Radiation Biophysics, Cell & Molecular Biology Laboratory
74B	Research Medicine/Radiation Biophysics, Cell & Molecular Biology Laboratory Annex
75	Radioisotope Service & National Tritium Facility (NTLF)
75A	Compactor, Processing & Storage Facility
76	Construction & Maintenance & Craft Shops
77	Mechanical Shops
77A	Ultra High Vacuum Assembly Facility (UHV)
78	Craft Stores
79	Metal Stores
80	Electronics Engineering
80A	Office Building
81	Liquid Gas Storage
82	Lower Pump House
83	Lab Cell Biology
88	88-Inch Cyclotron
90	Applied Science, Employment, Engineering, Occupational Health, Personnel, Protective
Services	

SMALL BUILDINGS AND TRAILERS

B-13A	Environmental Monitoring West of 88
B-13B	Environmental Monitoring West of 90
B-13C	Environmental Monitoring South of UC Recreation Area
B-13D	Environmental Monitoring North of 71
B-13E	Sewer Monitoring Station, Hearst Avenue
B-13F	Sewer Monitoring Station, Strawberry Canyon
B-13G	Waste Monitoring Station, West of 70

Table 1. Key to LBNL Buildings Shown in Figure 1

Figure 2. LBNL Off site Laboratories & Vicinity Map

The Site

LBNL is situated upon a hillside above the main campus of UC. The 54-hectare (134-acre) site is located on the west-facing slope of the Berkeley Hills, at elevations ranging from 150 to 300 meters (500 to 1,000 feet) above sea level within the Cities of Berkeley and Oakland. It is located about five kilometers (three miles) east of San Francisco Bay and about 25 kilometers (fifteen miles) east of the City of San Francisco (Figure 3).

LBNL is located in an urban environment on land owned by UC. On all sides of the Laboratory is a buffer zone of UC land. In addition, the Laboratory maintains a landscape buffer zone between its facilities and the site boundary. Beyond the northern side of the buffer zone there are predominantly single-family homes and beyond the west side are multiunit dwellings, student residence halls, and commercial districts. The area to the east and south, which is part of the University lands, is maintained in a largely natural state and includes recreational facilities and the University Botanical Garden. The population within an 80-km (50-mi) radius of the Laboratory is approximately 5.1 million (1980 census).

The Laboratory's activities are conducted on site and off site. LBNL activities take place in structures totaling 180,000 gross square meters (gsm), or 1.97M gross square feet (gsf). The buildings are on the LBNL hillside site, plus additional facilities located on the University campus, notably the Donner Laboratory of Biology and Medicine (Building 1) and the Melvin Calvin Laboratory (Building 3). The on site space consists of 125,000 gsm in about 60 buildings: 121,000 gsm in DOE buildings and trailers, and 4,000 gsm in University-owned buildings. Off site space utilized by LBNL consists of 25,000 gsm in various University buildings on the UC at Berkeley (UCB) campus and 14,000 gsm in leased facilities in Emeryville and Berkeley.

The most recent population figures for the Laboratory show over 3,200 full- and part-time employees. In addition, Berkeley Lab provided facilities for approximately 1,800 guests who worked at the site for varying lengths of time. Over 700 of these guests were on site at any one time, giving an estimated population base at the Laboratory of about 3,900.

The Climate

The climate of the LBNL site is greatly influenced by its close proximity to the Pacific Ocean and its exposure to the maritime air that flows in from San Francisco Bay. Seasonal temperature variations are small, with a mean temperature difference between the summer 17°C (63°F) and winter 9°C (48°F) of only 8.5°C (15°F). Relative humidity ranges from 85%-90% in the early morning to 65%-75% in the afternoon. The average annual rainfall is 64 cm (25 inches). About 95% of the rainfall occurs from October through April, and intensities are seldom greater than 1.3 cm/hr (0.5 in/hr). Thunderstorms, hail and snow are extremely rare. Winds are usually light, but summer sea breezes range up to 9-13m/s (20-30 mph). Winter storm winds from the south or southwest have somewhat lesser velocities.

Figure 3. San Francisco Bay Area Map

Compliance Status of Lawrence Berkeley National Laboratory :

On April 23, 1991, LBNL received a Finding of Violation (FOV) from Region IX of the United States Environmental Protection Agency (EPA). The FOV was for the failure to evaluate *all* radionuclide release points and determine the monitoring requirements at LBNL in accordance with Section 61.93, 40 CFR 61 Subpart H of the National Emission Standard for Hazardous Air Pollutants: Radionuclides (NESHAP). Even though LBNL is fully in compliance with the exposure standard of 10 mrem to a maximally exposed off site individual (MEI), the laboratory was not in compliance with the monitoring requirements of the regulation. During CY91, LBNL identified all actual and potential sources of dispersible radionuclides, evaluated all release point discharges, and proposed monitoring strategies to EPA for each stack or vent (see Table 2).

During CY92 LBNL obtained funding and initiated 3 monitoring upgrade projects, completed preliminary designs for the proposed monitoring systems, and prepared bid documents for Project 1 (Project 1 included stacks subject to periodic confirmatory monitoring). Proposals were received and vendors hired for the remaining projects 2 and 3 by November 1993. A Federal Facilities Compliance Agreement (FFCA) with Region IX EPA was finalized and executed in August 1993. In accordance with the FFCA compliance schedule, LBNL completed the 3 NESHAPs monitoring upgrade projects in February 1995.

LBNL submitted a final report to US/EPA on February 1, 1995, to inform the agency that it had completed all milestones and contractual obligations of the FFCA, including stack upgrades. On June 29, US/EPA conducted a final evaluation of compliance projects and documentation relative to NESHAPs requirements. The agency sent DOE written confirmation on November 8, 1995 that LBNL had satisfactorily completed all requirements of the FFCA. DOE was the recipient of this letter, as the FFCA was an agreement between US/EPA and DOE aimed to bring the Laboratory into full radiological NESHAPs compliance by February 1995.

Table 2. Summary of NESHAPs Compliance Strategy for Monitoring Emissions in 1995

EDE Criteria [mrem/year]	Category	Descriptions	Number of Sources
$EDE \geq 10.0$	Non-compliant	Reduce or relocate source term and re-evaluate prior to authorization.	0
$10.0 > EDE \geq 1.0 \times 10^{-1}$	I	<ul style="list-style-type: none"> • <u>Continuous</u> sampling required • Telemetry for nuclides with half-lives < 100 hours • EPA Application to Construct or Modify required. 	5
$1.0 \times 10^{-1} > EDE \geq 5.0 \times 10^{-2}$	II	Continuous sampling with <u>weekly</u> analysis.	0
$5 \times 10^{-2} > EDE \geq 1.0 \times 10^{-2}$	III	Continuous sampling with <u>monthly</u> analysis.	1
$1.0 \times 10^{-2} > EDE \geq 1.0 \times 10^{-3}$	IV	Sampled <u>annually</u> during project activity.	8
$EDE < 1.0 \times 10^{-3}$	V	Inventory controlled by Radiation Work Permit and periodic evaluation. <u>No monitoring</u> required	55

Source Description:

LBNL employs a wide variety of radionuclides in its radiochemical and biomedical research programs. In addition, radioactive materials are inevitably produced by the operations of the charged particle accelerators, such as the 88-Inch Cyclotron. Table 3 characterizes most of the dominant radionuclides used/monitored at LBNL during CY95.

Table 3. Radionuclides Used/Monitored at LBNL During CY95

Nuclide Name (Atomic Number)	Radio - Nuclide Symbol	Principal Radiation Types*	Principal Energy (MeV)	Half-Life
Americium (95)	Am-241	α γ	5.4 0.059	432 years
Argon (18)	Ar-41	β γ	1.2 1.3	1.83 hours
Carbon (6)	C-11	β^+/γ	0.511	20.5 minutes
Carbon (6)	C-14	β	0.156	5730 years
Curium (96)	Cm-248	α	5.08	3.39E+5 years
Cobalt (27)	Co-60	β γ	0.318 1.33	5.27 years
Fluorine (9)	F-18	β^+/γ	0.511	109.7 minutes
Hydrogen /Tritium (1)	H-3	β	0.0186	12.28 years
Iodine (53)	I-125	γ	0.027	60.14 days
Nitrogen (7)	N-13	β^+/γ	0.511	9.97 minutes
Nickel (28)	Ni-63	β	0.066	100.1 years
Oxygen (8)	O-15	β^+/γ	0.511	122 seconds
Phosphorus (15)	P-32	β	1.71	14.3 days
Rubidium (37)	Rb-86	β γ	1.77 1.08	18.66 days
Sulfur (16)	S-35	β	0.167	87.44 days
Strontium (38)	Sr-90	β	0.546	28.6 years
Thorium (90)	Th-232	α β	4.01 0.04	1.4E+10 years
Uranium (92)	U-238	α β	4.2 0.029	4.47E+9 years
Zinc (30)	Zn-65	γ	1.12	244 days
Zirconium (40)	Zr-95	β γ	0.4 0.757	64 days

(*) α = Alpha Particles β = Beta Particles γ = Gamma Rays

Of these radionuclides, the most commonly and widely used radionuclides in the research program are: H-3, C-14, F-18, P-32, S-35, and I-125. Radioactive gases produced by the accelerator operations are mainly short-lived radionuclides such as C-11, N-13, O-15, and Ar-41. These induced radioactive gases are normally produced in areas where the beam strikes beamline components.

LBNL conducts operations in 18 laboratory buildings with the potential to emit radionuclides into the atmosphere. Based on past/historical emission experience, LBNL has identified 5 release points that are potentially subject to the continuous monitoring requirement of Section 61.93 of NESHAPs standard. Even though all five of these release points were continuously monitored during the most part of the CY95, only 1 of these release points, the National Tritium Labeling Facility (NTLF) stack in Building 75, was actually subject to the continuous monitoring requirement during CY95. All other LBNL's sources which were operational during CY95 are "small sources." That is, the effective dose equivalent (EDE) from each source is much less than 0.1 mrem/yr ($1.0\text{E-}3$ mSv/yr), the NESHAPs threshold limit for continuous monitoring.

During CY95, discharge points with the most significant potential for routine or accidental release were continuously or periodically sampled. The CY95 discharges from LBNL accelerators were conservatively estimated using a model developed in Patterson, H.W., and Thomas, R.H., *Accelerator Health Physics*, Academic Press, New York, NY, 1973, pp. 519-531. Very small sources, that is, sources with potential for routine annual off site EDE impacts of less than $1.0\text{E-}2$ mrem ($1.0\text{E-}4$ mSv) are, in general, not sampled continuously. As a part of the FFCA, LBNL formalized the foregoing process and proposed a graded strategy for performing the "periodic confirmatory monitoring" called for in Section 61.93 (b)(4)(i) of the 40 CFR 61. Monitoring requirements are based on dose modeling with no emission controls in place. Table 2 summarizes the NESHAPs compliance strategy for monitoring requirements at LBNL, which has been implemented since the beginning of 1995.

Research activities with low potential impact ($\text{EDE} < 0.01$ mrem ($< 10^{-4}$ mSv) in a year) are carried out in unfiltered fume hoods. Activities with higher potential impact are performed in systems with appropriate exhaust filters or absorbers in place.

Many of LBNL release points qualify as "grouped sources" as described in the DOE guidance for the preparation of this document. The following grouping criteria were used:

- The sum of the EDEs attributable to all stacks in the group must be < 0.1 mrem ($< 10^{-3}$ mSv).
- Sources must be in close proximity (same or nearby building), and/or similar operations with similar nuclides are carried out in the facilities.
- Sources grouped in the description section may not be grouped in the dose assessment section if the critical receptors are not the same.

As identified in Figure 2, Buildings 1, 3, and 934 are located outside of LBNL's main perimeter and should technically be labeled as three separate "facilities" since they are not on one "contiguous site." However, Building 1 and Building 3 are located on UC land and are within walking distance from the main LBNL site. Building 934 is about five kilometers from the main site. Annual radioactive air emissions from these offsite buildings are very small compared to other on site emission sources. In fact, the EDE for each local receptor due to local airborne releases associated with these offsite buildings is several orders of magnitude lower than the contribution due to the tritium release from the main LBNL site. Thus, it would be inappropriate and misleading to model and report these much lower EDEs separately. Therefore, for reporting and dose modeling purposes, all of these offsite buildings will be considered as being on one contiguous LBNL site.

For each release point, the EPA-approved atmospheric dispersion dose calculation computer code, CAP88-PC, was used to estimate the Effective Dose Equivalent (EDE) to an offsite maximally exposed individual (MEI). A total of fourteen CAP88-PC computer model assessments were separately performed to simulate five point sources, eight grouped sources, and one non-point (diffuse) source for dose assessment during CY95. These 14 release points are listed in Section II, and are discussed below:

1. Building 1 (Donner Laboratory): Cell and molecular biology studies are performed in this facility. The building is located on the University of California campus. The predominant nuclides used are H-3, C-14, P-32, S-35, and I-125 as labeled amino acids and DNA precursors. Many non-LBNL employees (i.e., UC) also share this building for various other research activities. Work is mostly done on bench tops and in hoods. Releases are from building vents and hoods (11 stacks). Four stacks in Building 1 are sampled periodically. A summary of the CAP88-PC source term input parameters and EDE results for this release point is presented in Table 4.

Table 4. Building 1 Release Point Characteristics

Release Height [meter]	Local MEI Distance [meter]	Local MEI Dir.	Local MEI Description	Radio Nuclide	Annual Release [Ci*/yr]	LOCAL MEI EDE [mrem** /yr]	% Total EDE
9	10	ESE	School	U-238	2.5E-06	9.0E-04	81.66%
				C-14	7.7E-03	1.2E-04	10.72%
				H-3	1.0E-01	6.9E-05	6.28%
				P-32	3.1E-04	1.3E-05	1.15%
				I-125	9.1E-07	2.2E-06	0.20%
(*) 1 Ci = 3.7E10 Becquerel					(**) 1 mrem = 1.0E-2 mSv		
					TOTAL:	1.1E-03	100.00%

(*) 1 Ci = 3.7E10 Becquerel

(**) 1 mrem = 1.0E-2 mSv

2. Building 2 (Advanced Material Laboratory & Center for X-ray Optics): One semiconductor research group uses germanium, which contains nanocurie (nCi) quantities (a nanocurie is 37 Bq) of activation impurities. A summary of the CAP88-PC source term input parameters and EDE results for this release point is presented in Table 5.

Table 5. Building 2 Release Point Characteristics

Release Height [meter]	Local MEI Distance [meter]	Local MEI Dir.	Local MEI Description	Radio Nuclide	Annual Release [Ci*/yr]	LOCAL MEI EDE [mrem**/yr]	% Total EDE
20	370	NE	School	Co-60	3.4E-14	2.1E-13	100.00%
(*) 1 Ci = 3.7E10 Becquerel (**) 1 mrem = 1.0E-2 mSv					TOTAL:	2.1E-13	100.00%

3. Building 3 (Calvin Laboratory): Cell and molecular biology studies are performed in this laboratory. As with Building 1, this building is also located on the University of California campus. The predominant nuclides used are H-3, P-32, S-35, and ¹⁴C as labeled amino acids and DNA precursors. ¹⁴CO₂ is also used in this laboratory as an "incubant." Building 3 is wholly occupied by LBNL personnel. Work is done on bench tops and in hoods. Releases are from building vents and hoods. One stack in Building 3 is sampled periodically. A summary of the CAP88-PC source term input parameters and EDE results for this release point is presented in Table 6.

Table 6. Building 3 Release Point Characteristics

Release Height [meter]	Local MEI Distance [meter]	Local MEI Dir.	Local MEI Description	Radio Nuclide	Annual Release [Ci*/yr]	LOCAL MEI EDE [mrem**/yr]	% Total EDE
15	60	S	Res. & Business	C-14	3.1E-03	2.4E-05	0.17%
				P-32	2.5E-03	4.8E-05	0.35%
				Th-232	2.8E-05	1.4E-02	99.46%
				I-125	2.0E-06	2.8E-06	0.02%
(*) 1 Ci = 3.7E10 Becquerel (**) 1 mrem = 1.0E-2 mSv					TOTAL:	1.4E-02	100.00%

4. Building 6 (Advanced Light Source): The Advanced Light Source (ALS) is an electron accelerator/storage ring designed to produce intense beams of soft X-rays. The ALS injector produces stray neutrons during its operation, which activate the air in the injector vault. As the ALS is a low power accelerator, compared to LBNL's other accelerators, its inventory of air activation products is substantially lower than the 88-inch Cyclotron. The maximum potential annual releases of N-13 and O-15 (the important air activation products of the ALS) are computed to be 0.084 Ci (3 x 10⁹ Bq) and 0.006 Ci (2 x 10⁸ Bq), respectively. Thus, the

ALS is a very small source and continuous monitoring is not necessary. A summary of the CAP88-PC source term input parameters and EDE results for this release point is presented in Table 7.

Table 7. Building 6 Release Point Characteristics

Release Height [meter]	Local MEI Distance [meter]	Local MEI Dir.	Local MEI Description	Radio Nuclide	Annual Release [Ci*/yr]	LOCAL MEI EDE [mrem**/yr]	% Total EDE
19	360	NE	School	N-13 O-15	8.4E-02 5.9E-03	2.5E-05 9.9E-07	96.2% 3.8%
(*) 1 Ci = 3.7E10 Becquerel (**) 1 mrem = 1.0E-2 mSv					TOTAL:	2.6E-05	100.00%

5. Building 26 (Medical Services & Bioassay/Radioanalytical Laboratory): The LBNL bioassay/radioanalytical laboratory is the only radionuclide user in this building. Only trace quantities of radionuclides are used in sample spiking and standards preparation. Therefore, the annual release rate was set at zero. A summary of the CAP88-PC source term input parameters and EDE results for this release point is presented in Table 8.

Table 8. Building 26 Release Point Characteristics

Release Height [meter]	Local MEI Distance [meter]	Local MEI Dir.	Local MEI Description	Radio Nuclide	Annual Release [Ci*/yr]	LOCAL MEI EDE [mrem**/yr]	% Total EDE
8	240	N	School	None	0	0	0
(*) 1 Ci = 3.7E10 Becquerel (**) 1 mrem = 1.0E-2 mSv					TOTAL:	0	0

6. Building 55 (Research Medicine & Radiation Biophysics): The primary radiological activities carried out in Building 55 are positron emission tomography (PET) using F-18, and metabolic studies using I-125. The radiological activities take place in 2 laboratories and a PET camera room. Operations with radioiodine are done in a HEPA and Tetraethylene Diamine (TEDA)-doped carbon-filtered enclosures. Two radioisotope hoods and the radioiodine box stacks are sampled continuously for radioiodine, which dominates the EDE (the contribution from F-18 is insignificant.) A summary of the CAP88-PC source term input parameters and EDE results for this release point is presented in Table 9.

Table 9. Building 55 Release Point Characteristics

Release Height [meter]	Local MEI Distance [meter]	Local MEI Dir.	Local MEI Description	Radio Nuclide	Annual Release [Ci*/yr]	LOCAL MEI EDE [mrem**/yr]	% Total EDE
9	170	N	Residence	I-125	8.4E-05	1.2E-03	100.00%
(*) 1 Ci = 3.7E10 Becquerel (**) 1 mrem = 1.0E-2 mSv					TOTAL:	1.2E-03	100.00%

7. Buildings 62 (Materials & Chemical Sciences): Building 62 has only a few small laboratories working with trace amounts of common radionuclides. A thorium aerosol study with milligram quantities of 0.1 μ Ci thorium spheres is performed in one lab in Building 62. Operations in Building 62 are carried out in enclosures whose exhaust streams are HEPA filtered. The 62 stack is sampled periodically. A summary of the CAP88-PC source term input parameters and EDE results for this release point is presented in Table 10.

Table 10. Building 62 Release Point Characteristics

Release Height [meter]	Local MEI Distance [meter]	Local MEI Dir.	Local MEI Description	Radio Nuclide	Annual Release [Ci*/yr]	LOCAL MEI EDE [mrem**/yr]	% Total EDE
13	240	E	Workplace	C-14	2.8E-05	1.6E-06	34.82%
				H-3	9.5E-04	2.2E-06	48.62%
				Sr-90	7.9E-8	7.5E-07	16.56%
(*) 1 Ci = 3.7E10 Becquerel (**) 1 mrem = 1.0E-2 mSv					TOTAL:	4.5E-06	100.00%

8. Buildings 70 & 70A (Nuclear, Materials, Chemicals, and Earth Sciences): Programs carried out in these facilities include super-heavy nuclear studies, waste migration studies (tracer amounts), and nuclear chemical studies. There are also two biological science groups in 70A. The radioactive works are carried out by five research groups in 14 of the many small laboratories within the two buildings. Discharges from the two stacks from the biology group's laboratories are controlled by inventory of the Radiation Work Authorization (RWA) and periodic evaluation. In addition, there is also a pit storage room where radionuclides are stored in a fireproof pit in closed containers. A summary of the CAP88-PC source term input parameters and EDE results for these release points is presented in Table 11.

Table 11. Buildings 70&70A Release Point Characteristics

Release Height [meter]	Local MEI Distance [meter]	Local MEI Dir.	Local MEI Description	Radio Nuclide	Annual Release [Ci*/yr]	LOCAL MEI EDE [mrem** /yr]	% Total EDE
13	330	W	Dormitory	Th-232	8.3E-07	4.9E-04	89.95%
				C-14	3.6E-04	3.4E-06	0.62%
				H-3	1.3E-01	4.8E-05	8.77%
				P-32	2.1E-05	5.0E-07	0.09%
				I-125	2.2E-06	3.2E-06	0.58%
(*) 1 Ci = 3.7E10 Becquerel					(**) 1 mrem = 1.0E-2 mSv		
					TOTAL:	5.5E-04	100.00%

9. Buildings 74/74B (Research Medicine) & 83 (Cell Biology): These buildings include a wide variety of cell biology, virology, research medicine, and human genome projects. Releases from 74 and 74B come from hoods and stacks that vent individual workplaces. The Research Medicine Group prepares ¹⁸Fluorodeoxyglucose (F-18) for administration to patients in Building 55. Building 83 vents are through HEPA-filtered biological cabinets. Research activities involving I-125 are normally carried out in TEDA-doped activated-carbon-filtered enclosures. A summary of the CAP88-PC source term input parameters and EDE results for these release points is presented in Table 12.

Table 12. Buildings 74/74B&83 Release Point Characteristics

Release Height [meter]	Local MEI Distance [meter]	Local MEI Dir.	Local MEI Description	Radio Nuclide	Annual Release [Ci*/yr]	LOCAL MEI EDE [mrem** /yr]	% Total EDE
7	120	S	School	Ni-63	2.6E-06	2.4E-08	0.00%
				I-125	5.9E-07	9.8E-07	0.02%
				F-18	2.0E+00	3.5E-03	72.27%
				Th-232	1.7E-06	1.4E-03	27.63%
				P-32	1.6E-04	3.9E-06	0.08%
(*) 1 Ci = 3.7E10 Becquerel					(**) 1 mrem = 1.0E-2 mSv		
					TOTAL:	4.9E-03	100.00%

10. Building 75 (National Tritium Labeling Facility): The NTLF is mainly used for activities in which a wide variety of molecules are labeled with tritium and purified for further use in chemical, biochemical, and radiopharmaceutical studies. There are two stack release points for these activities, both of which are continuously sampled. The radionuclide releases are in the form of gaseous tritium (HT, T₂) or tritiated water (HTO, T₂O). Gaseous tritium releases are quantified as tritiated water even though its impacts are 1/25,000 of those of comparable releases of tritiated water. Tritium release at LBNL mainly comes from the tall stack (tritium trunk) located in the northern hillside near Building 75. This stack is the

closest discharge point to the maximally exposed offsite individuals (MEI). Other discharge points from the Building 75 complex are further from offsite individuals and released less than 3% of the yearly discharge.

In 1990 the NTLF began a program to reduce both planned and unplanned releases of HTO. This program has resulted in a very notable decrease in stack emissions from a maximum of 575 Ci in 1988 to 46 Ci in 1995. The releases in 1991-1994 were in the range 85-115 Ci, and the further decrease in 1995 is attributable to several factors. First, there were no significant (>25 Ci) unplanned releases in 1995, and the off-hours monitoring of tritium alarms by the LBNL Fire Department was an important contributor to this improvement. Two significant engineering changes during 1995 included the addition of redundant valving on vacuum pumps close to the tritium source, and the replacement of the existing silica gel traps with broader traps that give the same flow, but give higher HTO trapping efficiency. Many other minor engineering changes and procedural revisions were implemented during the year, and these all combined to markedly diminish HTO releases from the NTLF, especially during the latter half of the year. It is expected that the benefits of these changes will be realized in the future, and that releases for all of 1996 will be at the same low rate measured in the last half of 1995.

For CAP88-PC modeling, all tritium releases from the NTLF (tall stack plus hood vents) are conservatively assumed to be originated from the tall stack. This release point is the only "major source" at LBNL that results in more than 1% of the NESHAPs EDE dose standard. For reporting purposes, the MEI of this release point is also identified as the MEI for the whole LBNL site during CY95. A summary of the CAP88-PC source term input parameters and EDE results for this release point is presented in Table 13.

Table 13. Building 75 Release Point Characteristics

Release Height [meter]	Local MEI Distance [meter]	Local MEI Dir.	Local MEI Description	Radio Nuclide	Annual Release [Ci*/yr]	LOCAL MEI EDE [mrem**/yr]	% Total EDE
10	110	NW	School	H-3	5.0E+01	1.3E-01	100.00%
(*) 1 Ci = 3.7E10 Becquerel					(**) 1 mrem = 1.0E-2 mSv		
					TOTAL:	1.3E-01	100.00%

11. Building 75A (Hazardous Waste Handling Facility / Point Source): The LBNL Hazardous Waste Handling Facility is located in Buildings 75A and part of Building 75. Radioactive waste from various laboratories is processed and stored in these buildings. During CY95, many waste drums of high-level tritium from the NTLF were taken out of the original metal containers and repackaged for offsite disposals. This project resulted in a substantial increase in tritium releases from this facility compared to last year's release. A summary of the CAP88-PC's source term input parameters and EDE results for this point source Building 75A is presented in Table 14.

Table 14. Building 75A Release Point Characteristics (Point Source)

Release Height [meter]	Local MEI Distance [meter]	Local MEI Dir.	Local MEI Description	Radio Nuclide	Annual Release [Ci*/yr]	LOCAL MEI EDE [mrem** /yr]	% Total EDE
8	150	NW	School	H-3	3.0E+00	1.2E-02	98.65%
				Sr-90	1.7E-07	2.4E-05	0.20%
				I-125	1.9E-06	1.3E-04	1.12%
				C-14	1.7E-03	3.6E-06	0.03%
(*) 1 Ci = 3.7E10 Becquerel					(**) 1 mrem = 1.0E-2 mSv		
					TOTAL:	1.2E-02	100.00%

12. Building 75A (Hazardous Waste Handling Facility / Diffuse Source): In addition, Building 75A is also considered as a diffuse source of HTO, as HTO waste is processed and stored in the building. A summary of the CAP88-PC's source term input parameters and EDE results for this diffuse source of Building 75A is presented in Table 15.

Table 15. Building 75A Release Point Characteristics (Diffuse Source)

Release Height [meter]	Local MEI Distance [meter]	Local MEI Dir.	Local MEI Description	Radio Nuclide	Annual Release [Ci*/yr]	LOCAL MEI EDE [mrem** /yr]	% Total EDE
1	150	NW	School	H-3	6.25-02	1.9E-03	100.00%
TOTAL:						1.9E-03	100.00%

(*) 1 Ci = 3.7E10 Becquerel (**) 1 mrem = 1.0E-2 mSv

13. Building 88 (88-inch Cyclotron): This building houses an 88-inch-diameter sector-focused cyclotron used in a wide variety of research applications. Beams of ions from H⁺ through uranium are accelerated onto targets used for nuclear studies. The primary airborne impact to an offsite individual from this facility is attributable to short-lived air activation radionuclides (mostly positron emitters) produced in the cyclotron vault during the fraction of the beam year when intense light ions are accelerated, approximately 23.1% of the time during CY95. Releases were estimated as described previously in this report. The CY95 releases were estimated at 23.1% of the theoretical maximum. The quantity of activation products is controlled by the fraction of the beam year spent running light ions, and limits on circulating beam current. Small amounts of actinide radionuclides and other radioactive targets are monitored at experimental cave, fume hood, and glove box discharges. A summary of the CAP88-PC source term input parameters and EDE results for this release point is presented in Table 16.

Table 16. Building 88 Release Point Characteristics

Release Height [meter]	Local MEI Distance [meter]	Local MEI Dir.	Local MEI Description	Radio Nuclide	Annual Release [Ci*/yr]	LOCAL MEI EDE [mrem** /yr]	% Total EDE
12	110	W	Residence	N-13	4.8E+00	4.8E-03	43.74%
				O-15	2.5E+00	1.7E-03	15.74%
				C-11	3.2E+00	3.5E-03	31.65%
				I-125	2.4E-06	4.4E-06	0.04%
				Ar-41	2.0E-01	2.8E-04	2.51%
				Th-232	9.7E-07	5.8E-04	5.27%
				Sr-90	7.1E-05	1.2E-04	1.06%
(*) 1 Ci = 3.7E10 Becquerel (**) 1 mrem = 1.0E-2 mSv					TOTAL:	1.1E-02	100.00%

14. Building 934 (Molecular and Cell Biology): This building is located off site, roughly 5 kilometers (3 miles) from LBNL. The radiological activities include cell and molecular biology research. Also, forensic DNA investigations are carried out by a group from the California Department of Justice. The research employs RNA and DNA precursors and amino acids labeled with H-3, C-14, P-32, S-35, and I-125. Metabolism of S-35 amino acids produces $^{35}\text{SO}_2$, which is released to the atmosphere. Previous studies indicated that less than 0.1% of the activity incubated is available for release. Currently, one stack is routinely sampled at this location. A summary of the CAP88-PC source term input parameters and EDE results for this release point is presented in Table 17.

Table 17. Building 934 Release Point Characteristics

Release Height [meter]	Local MEI Distance [meter]	Local MEI Dir.	Local MEI Description	Radio Nuclide	Annual Release [Ci*/yr]	LOCAL MEI EDE [mrem**/yr]	% Total EDE
4	38	N	Business	I-125	1.6E-05	9.3E-04	99.99%
				P-32	1.4E-07	1.2E-07	0.01%
(*) 1 Ci = 3.7E10 Becquerel					(**) 1 mrem = 1.0E-2 mSv		
					TOTAL:	9.3E-04	100.00%

Section II. Air Emissions Data

Point Source	# of Stacks	Type Control	Efficiency [%]	Distance to Nearest Receptor
Building 2	1	None	0	370 m (School)
Building 6	1	None	0	360 m (School)
Building 62	1	HEPA	> 99	240 m (Workplace)
Building 75A	1	TEDA-DAC HEPA ⁽²⁾	> 75	150 m (Lawrence Hall of Science - LHS)
Building 88 Vault	1	None ⁽¹⁾	0	110 m (Residence)

Grouped Source	# of Stacks	Type Control	Efficiency [%]	Distance to Nearest Receptor
Building 1 Stacks	11	None ⁽³⁾	0	10 m (School in the same Building)
Building 3 Stacks	3	None ⁽³⁾	0	60 m (Workplace)
*Buildings 26	2	HEPA	>99	240 m (LHS)
Building 55 Stacks	5	HEPA TEDA-DAC ⁽²⁾	>99 >75	170 m (Residence)
Buildings 70 & 70A ⁽⁴⁾ Stacks	20	HEPA (Manifolds) None (Hood)	>99 0	330 m (Dormitory)
Buildings 74, 74B & 83 Stacks	14	TEDA-DAC ⁽²⁾ None	>75 0	120 m (Workplace)
Building 75 (NTLF)	2	Silica Gel ⁽⁵⁾	>99	110 m (LHS)
*Building 934 Stacks	9	None ⁽³⁾	0	38 m (Business)

* Not monitored, emissions estimated.

Non-Point Source	Radionuclide	Annual Quantity
Building 75A (Waste processing Area)	HTO	0.06 Ci (2.0×10^9 Bq)

Notes:

- (1) The Radionuclides released from the accelerators are air activation products, which are impractical to control.
- (2) Tetraethylene Diamine (TEDA) -doped activated carbon traps.
- (3) The uncontrolled releases are from LBNL fume hoods, which are unfiltered.
- (4) The stacks included in this group source vent a number of laboratories whose research employs μCi and mCi (between 3.7×10^4 and 3.7×10^7 Bq) quantities of a number of actinides. The most conservative dose-equivalent representative of the actinides was used.
- (5) Silica gel traps are >99% efficient traps for HTO as long as they are changed before breakthrough. NTLF personnel regularly change traps when working in the facility.

Quantities of nuclides released from LBNL stacks contributing more than 10% of the EDEs from a release point during CY95 are given in Table 18. These data are used to calculate the collective population dose for CY95.

Table 18. Total Air Effluent Potentially released During CY95

Nuclide	Total Air Effluent [Ci/yr] [Bq/yr]		% Total Effluent
H-3	5.30E+01	1.96E+12	80.17%
F-18	2.30E+00	8.51E+10	3.48%
N-13	4.88E+00	1.81E+11	7.38%
O-15	2.51E+00	9.29E+10	3.80%
C-11	3.20E+00	1.18E+11	4.84%
Ar-41	2.00E-01	7.40E+09	0.30%
C-14	1.29E-02	4.77E+08	0.02%
I-125	3.42E-05	1.27E+06	0.00%
P-32	3.03E-03	1.12E+08	0.00%
Sr-90	1.11E-03	4.11E+07	0.00%
Th-232	2.95E-04	1.09E+07	0.00%
U-238	2.50E-06	9.25E+04	0.00%
Co-60	3.40E-14	1.26E-03	0.00%
TOTAL:	6.61E+01	2.45E+12	100.00%

Section III. Dose Assessments

Description of Dose Model

To meet DOE guidance, the EPA atmospheric dispersion/radiation dose calculation computer code, CAP88-PC version 1.0, was used to calculate the Effective Dose Equivalent dose to an individual within each population segment at various distances and from various release points. A total of fourteen CAP88-PC "individual" runs were executed to model 14 single/grouped release points as described in Section II. As mentioned previously, the NTLF (Building 75) was identified as the major release point at LBNL. Therefore, the Maximally Exposed Individual associated with this facility was also specified (with appropriate distances and directions) in each of these fourteen "individual" CAP88-PC runs. The reported EDE to an MEI at LBNL includes contributions from all of these fourteen CAP88-PC models (see Table 19).

Collective population dose is calculated as the average radiation dose to an individual in a specified area, multiplied by the number of individuals in that area. One "population" CAP88-PC run was used to carry out this population dose assessment. This CAP88-PC model is based on the input parameters from the Building 75 computer run, with the source terms replaced by all the radionuclides listed in Table 18. A summary of this collective dose assessment attributed to each radionuclides is given in Table 20.

Summary of Input Parameters

The CY95 radioactive air emissions were either measured or conservatively derived, and are shown in Table 18 in Section II.

Until 1994, acceptable onsite meteorological information was not available. Dose assessment modeling with CAP88-PC in prior years therefore used the Oakland airport dataset (OAK0319.WND), which was distributed by US/EPA with the model. These meteorological data were measured at the Oakland airport. Use of the Oakland Airport data had been formally approved by US/EPA Region IX, which serves California. In response to a finding by the DOE Tiger Team audit in 1991 regarding the adequacy of the onsite meteorological monitoring, siting, and quality assurance, Berkeley Lab recently completed a project to collect and use quality-assured onsite meteorological data for performing dose assessments. The upgraded network began collecting data in early 1994. The 1995 radiological dose assessment calculations presented in this report are generated using the first full year of onsite data collected by the meteorological tower. These data more accurately reflect the local wind directions and atmospheric stability categories in the EPA computer model. With this change to the site-specific meteorological input parameters, the CAP88-PC computer model yields an MEI dose by a factor of two higher than the model based on the Oakland Airport meteorological data. This is mainly due to the fact that the average local wind speed at LBNL is lower by this factor of two compared to the Oakland airport (2 meters/second vs. 4 meters/second). Thus, even though there was a 50% reduction in tritium release during 1995 compared to 1994, the dose from CAP88-PC model remains the same as the last year value due to this refinement in modeling procedure.

Table 19. Summaries of Dose Assessment from All LBNL Release Points

Building Number	Building Name	Relative to the Specified Building					Relative to the MEI of Building 75			
		Release Height [meter]	Local MEI Distance [meter]	Local MEI Dir.	Local MEI Description	Local MEI Dose [mrem*/yr]	BLD-75 MEI Distance [meter]	BLD-75 MEI Dir.	BLD-75 MEI Dose [mrem*/yr]	% Total EDE
BLD-1	Donner Laboratory @UCB	9	10	ESE	School	1.1E-03	980	ENE	1.3E-03	0.80%
BLD-2	Advanced Material Lab.	20	370	NE	LHS	2.1E-13	370	NE	2.1E-13	0.00%
BLD-3	Calvin Lab @UCB	15	60	S	Res. & Business	1.4E-02	1070	NE	5.3E-03	3.24%
BLD-6	Advanced Light Source (ALS)	19	360	NE	LHS	2.6E-05	360	NE	2.6E-05	0.01%
BLD-26	Medical Services & Counting Lab.	8	240	N	LHS	0.0	240	N	0.0	0.00%
BLD-55	Research Med & Rad Bio	9	170	N	Residence	1.2E-03	490	E	1.2E-03	0.73%
BLD-62	Materials & Chem. Science	13	240	E	Workplace	4.5E-06	650	NW	3.5E-06	0.00%
BLD-70 & 70A	Nuclear / Applied Science	13	330	W	Dormitory	5.5E-04	510	NE	4.6E-04	0.28%
BLD-74, 74B & 83	Buildings 74/74B/83 Research Med.	7	120	S	School	4.9E-03	730	WNW	5.5E-03	3.36%
BLD-75	National Tritium Labeling Facility	10	110	NW	LHS	1.3E-01	110	NW	1.3E-01	79.53%
BLD-75-127 & 75A	Hazardous Waste Handling Facility	8	150	NW	LHS	1.2E-02	150	NW	1.2E-02	7.34%
BLD-75A (D)	Waste Storage Area (Diffuse)	1	150	NW	LHS	1.9E-03	150	NW	1.9E-03	1.16%
BLD-88	88-Inch Cyclotron	12	110	W	Residence	1.1E-02	670	ENE	5.1E-03	3.12%
BLD-934	Molecular & Cell Bio. (off site)	4	38	N	Business	9.3E-04	4900	ENE	6.8E-04	0.42%
TOTAL:									1.64E-01	100.00%

(*) 1 mrem = 1.0E-2 mSv

Table 20. Summary of Collective (Population within 80 km of LBNL) EDE Assessment

Nuclide	Collective EDE [Person-rem* /yr]	% Total Collective EDE
H-3	1.18E+00	12.29%
F-18	8.73E-02	0.91%
N-13	4.59E-02	0.48%
O-15	6.38E-03	0.07%
C-11	4.96E-02	0.52%
Ar-41	8.89E-03	0.09%
C-14	5.31E-03	0.06%
I-125	1.29E-04	0.00%
P-32	2.10E-03	0.02%
Sr-90	4.37E-02	0.46%
Th-232	7.36E+00	76.64%
Ra-228	1.93E-04	0.00%
Ac-228	3.20E-01	3.33%
Th-228	9.02E-04	0.01%
Ra-224	3.56E-03	0.04%
Rn-220	1.77E-04	0.00%
Po-216	4.71E-06	0.00%
Pb-212	5.35E-02	0.56%
Bi-212	5.88E-02	0.61%
Tl-208	3.57E-01	3.72%
U-238	2.03E-02	0.21%
Th-234	0.00E+00	0.00%
Pa-234	0.00E+00	0.00%
U-234	0.00E+00	0.00%
Th-230	0.00E+00	0.00%
Ra-226	0.00E+00	0.00%
Rn-222	0.00E+00	0.00%
Po-218	0.00E+00	0.00%
Pb-214	0.00E+00	0.00%
Bi-214	0.00E+00	0.00%
Po-214	0.00E+00	0.00%
Pb-210	0.00E+00	0.00%
Bi-210	0.00E+00	0.00%
Po-210	0.00E+00	0.00%
Co-60	1.75E-11	0.00%
TOTAL:	9.6	100.00%

(*) 1 Person-rem = 1.0E-2 Person-Sv

Compliance Assessment

This compliance assessment uses the computer code CAP88-PC Version 1.0 to calculate the Effective Dose Equivalent to an off site Maximally Exposed Individual. This exposure represents the sum of impacts from all fourteen release points modeled to that location (the MEI of Building 75). Summaries of the dose assessment from each release point are presented in Table 20.

Effective Dose Equivalent: 0.16 mrem/year (1.6E-3 mSv/year)

Location of Maximally Exposed Individual: LHS at 110 meters Northwest of Building 75

Certification

I certify under penalty of law that I have personally examined and am familiar with the information submitted herein and based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant penalties for submitting false information including the possibility of fine and imprisonment. (See, 18 U. S. C. 1001).

Signature: David C. McGraw Date: 5/24/96
David C. McGraw
Division Director, Environment, Health and Safety

Signature: R. Nolan Date: 6/13/96
Richard H. Nolan
Director, DOE Berkeley Site Office

Section IV. Additional Information

Additions or Modifications

Building 56 (Biomedical Isotope Facility-BIF)

The BIF construction was completed and started its operation near the end of CY95. The facility is located between Buildings 63 and 51. The BIF will provide dedicated equipment and workplaces for radiopharmaceutical preparation. The BIF will possess a customized commercial accelerator for radionuclide production and a separate radiopharmaceutical preparation area with glove box enclosures. Radiopharmaceuticals will be transferred from Building 56 to Building 55 for positron emission tomography (PET) scan imaging and research uses.

Dose assessments for Building 56 were conducted during NEPA review and the Negative Declaration. Dose due to Building 56 emissions is anticipated to be less than 0.1 mrem/year. Radionuclide emissions will include F-18, N-13, O-15, and C-11 from accelerator targets and subsequent radiopharmaceutical preparation. Smaller quantities of accelerator air activation products (N-13, O-15, C-11, and Ar-41) will also be produced. Although the BIF is not a "major source," LBNL has provided for continuous positron monitoring in the NESHAPs Project 3 monitoring upgrade.

Unplanned Releases

During 1995, there were no unplanned releases to the atmosphere from LBNL.

Diffuse Emissions

Fugitive emissions from stored tritium waste are estimated at less than 0.06 Ci (2.2×10^9 Bq) during CY95. The fugitive release estimate is the product of the annual average workplace HTO concentration where the tritium waste is packaged and stored, times the number of air changes in the storage building per year. The estimated EDE to an offsite MEI from this diffuse emission was found to be about $1.9\text{E-}3$ mrem/yr. ($1.9\text{E-}5$ mSv/yr.). This estimate is based on the "area" source CAP88-PC model, which is highly conservative for the diffuse source (see the "BLD-75AD" CAP88-PC run).

Section V. Supplemental Information

- *Provide an estimate of collective effective dose equivalent (person-rem/yr.) for CY95 releases.*

The estimated collective effective dose equivalent (CEDE) to persons living within 80 km of LBNL is 9.6 person-rem/year ($9.6\text{E-}2$ person-Sv) attributable to CY95 LBNL airborne releases (see Table 21).

- *Provide information on the status of compliance with Subparts Q and T of 40 CFR Part 61 if applicable. Although exempt from Subpart H, provide information on Rn-220 emission from sources containing U-232 and Th-232 where emissions potentially can exceed 0.1 mrem/yr. (10^{-6} Sv/a) to the public or 10% of the non-radon dose to the public. Provide information on non-disposal/non-storage sources of Rn-222 emissions where emissions potentially can exceed 0.1 mrem/yr. (10^{-6} Sv/a) to the public or 10% of the non-radon dose to the public.*

Subparts Q and T of 40 CFR 61 are not applicable to LBNL, as the Laboratory does not process, manage or possess significant enough quantities of uranium mill tailings, Ra-226, U-232, or Th-232, to produce an impact of 0.1 mrem/yr. (10^{-7} Sv/a) to a member of the public.

- *For the purpose of assessing facility compliance with the NESHAPs effluent monitoring requirements of Subpart H under Section 61.93(b), give the number of emission points subject to the continuous monitoring requirements, the number of these emission points that do not comply with the Section 61.93(b) requirements, and if possible, the cost for upgrades. Describe site periodic confirmatory measurement plans. Indicate the status of the QA program described by Appendix B, Method 114.*

LBNL has identified 5 points subject to the continuous monitoring requirements of 40 CFR subpart H, Section 61.93(b). During CY95 only 1 of the 5 points produced discharges exceeding 0.1 mrem/yr ($1.0\text{E-}3$ mSv/yr), however all 5 were continuously monitored (sampled). The single Category I release point was the NTLF main stack whose EDE was modeled at 0.13 mrem/yr (1.3×10^{-3} mSv). LBNL has upgraded the monitoring and analytical methods to fully conform to Section 61.93(b) monitoring requirements. LBNL has identified: a) all emission points and evaluated releases, b) categorized stacks by EDE, and c) suggested suitable monitoring methodology for each point. The information developed in a - c above was sent to EPA region IX during CY91 and finalized in CY93.

Under its Tiger Team action plan, LBNL completed upgrading all monitoring and analytical QA procedures. The program meets or exceeds all provisions contained in Appendix B method 114. The current LBNL Environmental Monitoring Plan and Environmental Protection Group Procedures contain QA elements consistent with method 114. The LBNL site specific NESHAPs QA plan has been developed and approved in August 1994.

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Appendix B – Distribution List

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