U.S. Department of Energy

NNSA Service Center, Oakland, California

ANNUAL SITE ENVIRONMENTAL REPORT
CALENDAR YEAR 2004

for the

LABORATORY FOR ENERGY-RELATED HEALTH RESEARCH
UNIVERSITY OF CALIFORNIA, DAVIS

Submitted to:

United States Department of Energy
Oakland Environmental Programs
1301 Clay Street
Oakland, California 94612-5208

Prepared by:

Weiss Associates
5801 Christie Avenue, Suite 600
Emeryville, California 94608-1827

June 24, 2005
Rev. A

DOE Delivery Order No. DE-AD03-04NA99610

Weiss Associates
Environmental Science, Engineering and Management

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(Signed approval letter from DOE to be produced for final report.)

CERTIFICATION OF ACCURACY FOR:

ANNUAL SITE ENVIRONMENTAL REPORT, CALENDAR YEAR 2004, LABORATORY FOR ENERGY-RELATED HEALTH RESEARCH

I certify that the information submitted herein is true, accurate, and complete, based on my familiarity with the information and my inquiry of those individuals immediately responsible for obtaining the information.

Signature:_____ Date: _____
Robert O. Devany, Project Manager

ANNUAL SITE ENVIRONMENTAL REPORT
READER SURVEY

To Our Readers:

Each Annual Site Environmental Report publishes the results of environmental monitoring at the former Laboratory for Energy-Related Health Research (LEHR) and documents our compliance with environmental regulations. In providing this information, our goal is to give our readership—whether they are regulators, scientists or the public—a clear accounting of the range of environmental activities we undertake, the methods we employ and the degree of accuracy of our results.

It is important that the information we provide is easily understood, is of interest, and communicates the Department of Energy's effort to protect human health and the environment. We would like to know from you, our readers, whether we are successful in these goals. Your comments are welcome.

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ACRONYMS AND ABBREVIATIONS

µg/l	micrograms per liter
BEI	Bechtel Environmental Inc.
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
D&M	Dames & Moore
DOE	(United States) Department of Energy
E	east
EDE	effective dose equivalent
EPCRA	Emergency Planning and Community Right-to-Know Act
HSU	hydrostratigraphic unit
km	kilometer
LEHR	Laboratory for Energy-Related Health Research
m	meters
MEI	maximally exposed individual
mg/l	milligrams per liter
mrem/yr	millirem per year
MSDS	Material Safety Data Sheet
mSv	milliSievert
N	north
N/A	not applicable
NNE	north by northeast
NNW	north by northwest
No.	number
NW	northwest
PCD	Putah Creek, Downstream
PCU	Putah Creek, Upstream
rem	Roentgen equivalent man

S	south
SARA	Superfund Amendments and Reauthorization Act
SPRU	Separations Process Research Unit
STPO	waste water [sewage] treatment plant outfall
Sv	Sievert
TLD	thermoluminescent dosimeter
UC Davis	University of California, Davis
USCB	United States Census Bureau
US EPA	United States Environmental Protection Agency
W	west
WA	Weiss Associates

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EXECUTIVE SUMMARY

This Annual Site Environmental Report for the Laboratory for Energy-Related Health Research (LEHR) (the Site) at the University of California, Davis (UC Davis) summarizes the United States Department of Energy's (DOE's) environmental performance at the Site in 2004, including environmental compliance; environmental monitoring data for air, soil, ground water, surface water, storm water and ambient radiation; and environmental management programs. DOE operation of LEHR as a research facility ceased in 1989 after three decades of research on the health effects of low-level radiation exposure using primarily beagles as research subjects. Contamination from prior site use, including research activities, resulted in the addition of the Site to the National Priorities List in 1994. In 1997, DOE and UC Davis reached an agreement on the responsibilities for site clean up. During Calendar Year 2004, DOE continued activities at the Site in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) requirements.

Progress of Site Environmental Restoration

DOE site restoration activities are conducted in accordance with a 1999 Federal Facility Agreement entered into by DOE and the United States Environmental Protection Agency (US EPA), California Department of Toxic Substances Control, California Department of Health Services and the Central Valley Regional Water Quality Control Board. Under the Federal Facility Agreement, DOE is responsible for remediation of site facilities, including the Radium-226/Strontium-90 Treatment Systems, the DOE Disposal Box, on-site domestic septic systems, DOE disposal trenches, and the former Dog Pens (Figure 1-2). Under an Administrative Order on Consent with the US EPA, UC Davis is responsible for remediation of three landfills, disposal trenches located south and east of Landfill Number (No.) 2, a disposal trench located south of the Western Dog Pens, an old waste water treatment plant, and impacted ground water (Figure 1-2) (US EPA, 2000).

DOE activities at the Site in 2004 consisted primarily of shipment of low-level radioactive waste and radiologically-impacted materials generated during prior remediation and site research activities, and limited ground water investigation. Specific DOE activities in 2004 included:

- **Ground Water Investigation at Dry Wells A-E:** A limited ground water investigation was conducted in 2004 in the vicinity of former Dry Wells A-E (Figure 1-2). DOE installed monitoring well UCD1-54 near the former dry wells in 2004 and collected four rounds of ground water samples. Sample results from this well indicate that releases associated with former Dry Wells A-E are not currently impacting ground water.
- **Shipment of Gravel for Reuse:** DOE shipped approximately 1,660 cubic yards of gravel from the Western Dog Pens to the Nevada Test Site for reuse.

- **Transfer of Surplus Material to DOE Separations Process Research Unit (SPRU) Site:** A significant amount of surplus materials including unused lift liners and radiological counting instruments were transferred to the DOE SPRU site during 2004.

Having completed all planned removal actions, DOE is in the process of determining a final remedy for the Site that is protective of human health and the environment. The following documents were in the process of being prepared in 2004:

- **Feasibility Study:** A draft feasibility study was expected to be completed in early 2004; however, delays associated with the issuance and approval of a UC Davis site-wide human health and ecological risk assessment have delayed the development of the DOE areas feasibility study. A draft feasibility study is now expected to be issued to the regulatory agencies in late 2005.

- **Draft Site-Wide Risk Assessment Volume I: Human Health Risk Assessment (Part B – Risk Characterization for DOE Areas):** Preparation of this document began in late 2004. The approval of the final risk characterization document will be the final step in the human health risk assessment process for DOE areas.

Overview of 2004 Water and Air Environmental Monitoring Results

Per the Memorandum of Agreement with DOE (DOE, 1997), UC Davis is responsible for conducting ground water monitoring at LEHR. A report developed by Brown & Caldwell for UC Davis (Brown & Caldwell, 2005) provides a complete description of the ground water monitoring program and analytical results for 2004. Based on the findings presented by UC Davis, the 2004 ground water monitoring results were consistent with previous years.

UC Davis also reported that storm water and surface water samples collected and analyzed in 2004 were consistent with previous years, and no new trends or concerns were identified.

Radiological Impact Assessment of the LEHR Environmental Restoration Project

The 2004 radiological air and ambient data all indicate that detected radionuclide activities were near or below natural background levels, and do not pose a risk to site workers or the general public.

1. INTRODUCTION

This Annual Site Environmental Report describes Calendar Year 2004 United States Department of Energy's (DOE's), environmental restoration and waste management activities at the Laboratory for Energy-Related Health Research (LEHR) (the Site) at the University of California, Davis (UC Davis) (Figure 1-1). This report was prepared according to the requirements of DOE Order 231.1A, Environmental Safety and Health Reporting. The purpose of this report is to summarize environmental data, confirm compliance with environmental standards and requirements, and highlight significant programs and efforts. This report describes activities conducted by DOE during 2004 in support of the Site environmental restoration efforts, and provides information about the impact of these activities on the public and the environment. A ground, surface and storm water monitoring program performed by UC Davis includes information important to the overall environmental restoration of the Site and is briefly summarized herein.

1.1 Site History

The Atomic Energy Commission first sponsored radiological studies on laboratory animals at UC Davis in the early 1950s. Initially situated on the main campus, LEHR was relocated to its present location in 1958 (Figure 1-1). Research at LEHR through the late 1980s focused on health effects from chronic exposure to radionuclides, primarily strontium-90 and radium-226, using beagles as research subjects. Other related research was conducted at the Site concurrent with these long-term studies. In the early 1970s, a cobalt-60 irradiator facility was constructed at the Site to study the effects of chronic exposure to gamma radiation on humans, again using beagles.

A campus landfill with two waste burial units that were used from the 1940s until the mid-1960s is located at the Site (Figure 1-2). Several low-level radioactive waste burial areas were also present at the Site, and campus and LEHR research waste was buried in these areas until 1974 in accordance with regulations in effect at the time. These radioactive burial areas have been remediated during several removal actions conducted at the Site since 1996.

In 1988, pursuant to the Memorandum of Agreement between DOE and the University of California, DOE's Office of Energy Research initiated activities to close out the research program at LEHR. In 1997, a second Memorandum of Agreement divided the responsibility for environmental remediation between DOE and UC Davis (DOE, 1997).

Under the Federal Facility Agreement effective in December 1999, DOE is responsible for remediation of the Radium/Strontium Treatment Systems, a waste burial area known as the DOE Disposal Box, on-site domestic septic tanks and associated leach fields and dry wells, DOE disposal trenches, and the former Dog Pens (Figure 1-2). UC Davis is responsible for remediation of three

landfills, disposal trenches located south and east of Landfill Number (No.) 2, 49 waste holes, an old waste water treatment plant, ground water impacted by the Site, and surface and storm water runoff impacted by UC Davis.

DOE activities at the Site in 2004 were limited, consisting of a ground water investigation, environmental surveillance monitoring, property disposition, the shipment of material generated during prior removal actions and radiological surveys of selected LEHR facilities.

1.1.1 Environmental Restoration

The DOE Oakland Operations Office manages the environmental restoration of the DOE-impacted areas of the Site. From October 1989 through February 1990, an interim contract with UC Davis was implemented to begin site restoration. From 1990 to 1996, Battelle Environmental Management Operations managed the LEHR remediation project. In 1996, the project was transferred to Weiss Associates (WA) of Emeryville, California.

In May 1994, the United States Environmental Protection Agency (US EPA) added the Site to the National Priorities List. A site Remedial Investigation and Feasibility Study work plan was developed to ensure that investigation and remediation were conducted in accordance with applicable regulatory requirements. Remedial Project Manager meetings are held every four to six weeks to evaluate the progress of remediation and identify actions needed to facilitate the process.

Primary DOE restoration/remediation activities that have been performed at the Site include: soil and ground water characterization; building assessment; decontamination and decommissioning of above-ground structures; removal of contaminated underground tanks, trench structures, and contaminated soil; chemical and radiological risk assessment; preparation of Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) documents; and waste management. In 2002, DOE completed all removal actions planned for the Site and, in 2004, shipped the remaining waste generated during these removal actions for disposal.

In 2004, UC Davis issued a final Remedial Investigation report and developed draft human heath and ecological risk assessments.

1.2 Site Description

The Site is a 15-acre parcel owned by the Regents of the University of California. It is 1.5 miles south of the main UC Davis campus in a rural agricultural area (Figure 1-1), and is presently occupied by the UC Davis Center for Health and the Environment. Research at the Center for Health and the Environment includes toxicology, epidemiology, radiation biology and radiochemistry.

Site facilities currently consist of 15 buildings, including a main administration and office building, two former animal hospitals, a laboratory and support buildings (Figure 1-2). Former

facilities include: radioactive waste water treatment systems, an indoor/outdoor cobalt-60 irradiator, a radioactive waste burial area and outdoor dog pens. Inactive campus landfill units and numerous inactive campus disposal sites (i.e., trenches and holes) were used to dispose low-level radioactive and chemical waste, and are being evaluated and/or remediated by UC Davis. Figure 1-2 shows areas that have potentially impacted the environment at the Site and those areas where DOE removal actions have been completed.

1.3 Population Data

1.3.1 Site Population

The UC Davis Center for Health and the Environment conducts ongoing research in toxicology, epidemiology, radiation biology and radiochemistry with a staff of approximately 200 researchers and support personnel. Center for Health and the Environment staff have varying schedules and are not all present at the Site at the same time.

In 2004, the LEHR remediation project had no full time workers at the Site. LEHR personnel conducted periodic site inspections, collected storm water and environmental radiation samples, performed radiation surveys of LEHR facilities and coordinated the shipment of remaining gravel for reuse at the Nevada Test Site. During these scheduled site activities, DOE contractors may have deployed up to ten workers to conduct and oversee site work.

1.3.2 Local Population

The Site is located in a rural area in northeastern Solano County on the UC Davis South Campus (Figure 1-1). The UC Davis campus has a student population of 30,065 and employs approximately 28,230 full-time faculty and staff (UC Davis, 2005).

The estimated 2004 population of the city of Davis is approximately 60,308 and the estimated total population of Yolo County is about 180,856. The more densely populated and metropolitan Sacramento area is approximately 12 miles east of the Site. The current population of Sacramento County is about 1,305,082, and approximately 407,018 people live in the city of Sacramento (USCB, 2000).

1.4 Environmental Setting

The Site is located on a relatively flat plain bordered on the south by Putah Creek. The Site is mostly open, slopes gently to the east, and has a few trees and bushes. The Site lies outside the Putah Creek 100-year floodplain.

1.4.1 Land Use

The land within a one-mile radius of the Site is owned both privately and by UC Davis. It is used for animal research, agriculture and recreation (i.e., fishing and swimming). Privately owned lands south and east of the Site are used to produce wheat, tomatoes, corn, barley and oats, and include permanent residences. The South Fork of Putah Creek separates private property to the south from the Site, and private property to the east is adjacent to non-LEHR, UC Davis-owned research facilities. The property immediately west, north and south of the Site (Putah Creek Reserve) is owned by UC Davis and is currently used for various types of animal, agricultural and health research.

1.4.2 Hydrogeology

Unconsolidated Pliocene and Pleistocene sedimentary deposits are the major ground water sources for public and private water supplies in the Sacramento Valley (DWR, 1978), in which the Site is located. Both unconfined and confined fresh water aquifers are present in the uppermost 3,000 feet of the valley subsurface. Ground water generally flows from the valley sides toward the valley axis. In the Site vicinity, regional ground water generally flows east from the Coast Ranges toward the Sacramento River (D&M, 1993).

At various depths beneath the valley floor, saline water is present as a result of entrapment during the deposition of sediments in a marine environment. The depth to the base of fresh water in the Sacramento Valley varies from 400 feet to over 3,000 feet, and is 2,600 feet to 3,100 feet below ground surface in the Davis area (DOG, 1982).

Previous investigations identified five hydrostratigraphic units (HSUs) beneath the Site (D&M, 1999). These include the vadose (unsaturated) zone and HSUs 1 through 4. The vadose zone extends from the ground surface to the top of ground water, which has historically ranged from 15 feet to 55 feet below ground surface. The vadose zone consists primarily of unsaturated clay and silt with lesser amounts of interbedded sand and gravel. HSU-1 extends from the bottom of the vadose zone to depths of approximately 76 feet to 88 feet below ground surface. This unit is lithologically similar to the vadose zone and consists primarily of silt and clay, with lesser amounts of sand and gravel. HSU-2 extends from the bottom of HSU-1 to depths of approximately 114 feet to 130 feet below ground surface. This unit is composed primarily of sand in the upper portion of the unit and gravel in the middle to lower portions. HSU-3, investigated in off-site areas, extends from the bottom of HSU-2 to a depth of about 250 feet below ground surface and is approximately 120 feet thick. The unit consists primarily of relatively fine-grained sediments varying from very fine-grained sandy silt to clayey silt and silty clay. HSU-4, also investigated in off-site areas, extends from the bottom of HSU-3 to a depth of about 280 feet below ground surface and is approximately 32 feet thick. This unit consists of coarse sand and gravel. Beneath HSU-4, a sharp contact with a bluish, dark gray silt was encountered 282 feet below ground surface in wells UCD4-41 and UCD4-43 (Figure 3-1). The bottom of this unit has not been penetrated in any of the Site borings (D&M, 1999).

The uppermost distinct aquifer beneath the Site consists of two HSUs (HSU-1 and HSU-2), based on the stratigraphy of the sediments at the Site and the associated ground water flow and contaminant migration characteristics. Well drillers' logs indicate that a 90-foot-thick clay unit separates HSU-2 from a second aquifer below (D&M, 1994).

Irrigation water, rainfall and Putah Creek recharge ground water in the site vicinity (D&M, 1997). The main component of ground water recharge, however, has been identified as irrigation water infiltration (WA, 1998b). Ground water pumping associated with agriculture is responsible for the great majority of ground water withdrawal. Locally, UC Davis extracts ground water from HSU-2 and re-injects treated ground water near the southwest corner of the Site as part of its interim remedial action.

Generally, there is a 20- to 30-foot seasonal fluctuation in the water table beneath the Site caused predominantly by the lack of surface recharge and nearby agricultural pumping in the summer. Vertical gradients vary both temporally and spatially. The magnitude of the vertical gradient is greatest when ground water elevations are rising or falling sharply. Short-term activities, such as local agricultural pumping, can produce downward vertical gradients during periods of an otherwise rising water table.

The HSU-1 lateral gradient across the Site typically ranges from 0.01 foot/foot to 0.04 foot/foot, and the direction of ground water flow is predominantly northeastern. Representative values of HSU-1 horizontal hydraulic conductivity are between 1×10^{-4} and 1×10^{-7} centimeters per second (D&M, 1999). The lateral gradient across the Site within HSU-2 typically ranges from 0.005 foot/foot to 0.015 foot/foot. The direction of flow appears to be predominantly to the northeast, although it can occasionally be to the east-southeast. Based on pumping tests, hydraulic conductivity in HSU-2 ranges from 0.26 centimeters per second to 0.43 centimeters per second (D&M, 1997).

Ground water in HSU-1, HSU-2 and HSU-4 has been impacted by site activities. Based on investigations to date (WA, 1997c and WA, 1999a), significant ground water impacts appear to be associated only with the UC Davis disposal areas.

1.4.3 Ground Water Supply and Quality

Ground water at depths of between approximately 100 and 500 feet in the Site vicinity is used for agricultural and domestic supply. Shallow ground water quality, at depths above 100 feet, has been impacted by nitrates, probably from agricultural sources, and has insufficient yield that precludes its extraction for domestic or agricultural use.

1.4.4 Sanitary Sewer Systems

The Site discharges its sanitary waste water to the UC Davis Waste Water Treatment Plant. UC Davis operates the plant under the conditions specified in its National Pollutant Discharge

Elimination System permit, granted by the Central Valley Regional Water Quality Control Board under agreement with the US EPA.

1.4.5 Storm Drainage System

Storm water runoff from the DOE areas at the Site is mainly collected in an underground drainage system. Storm water from the paved area in the western part of the Site and around the southern buildings in the western area is collected in a storm water drainage system. This system drains to the Site storm water lift station (LS-1 shown on Figure 3-1), and then to an outfall along the west side of Old Davis Road. Storm water in the northwestern area of the Site drains into a ditch along Old Davis Road. Storm water in the eastern and non-paved southern portions of the Site percolates into the ground, except for a section of the former Cobalt-60 Field where dog pens were once located and where drainage is connected to the sanitary sewer. Water ponds in some areas of the Site during and after heavy rains.

1.4.6 Biological Resources

A number of sensitive biological resources were identified in an Ecological Scoping Assessment (WA, 1997b) as potentially occurring in the vicinity of the Site. These species include the Giant Garter Snake, the Northern Harrier, the Coopers Hawk, the California Horned Lark, the Great Egret, the Burrowing Owl and the Valley Elderberry Longhorn Beetle, which lives in elderberry bushes. Although elderberry bushes are present at the Site, a focused biosurvey (IT Corp, 1998) found no sensitive species actually present on site and concluded that the on-site elderberry bushes are not currently hosting the Valley Elderberry Longhorn Beetle.

A draft ecological risk assessment evaluating the impact of residual site contamination on ecological resources was issued in 2004.

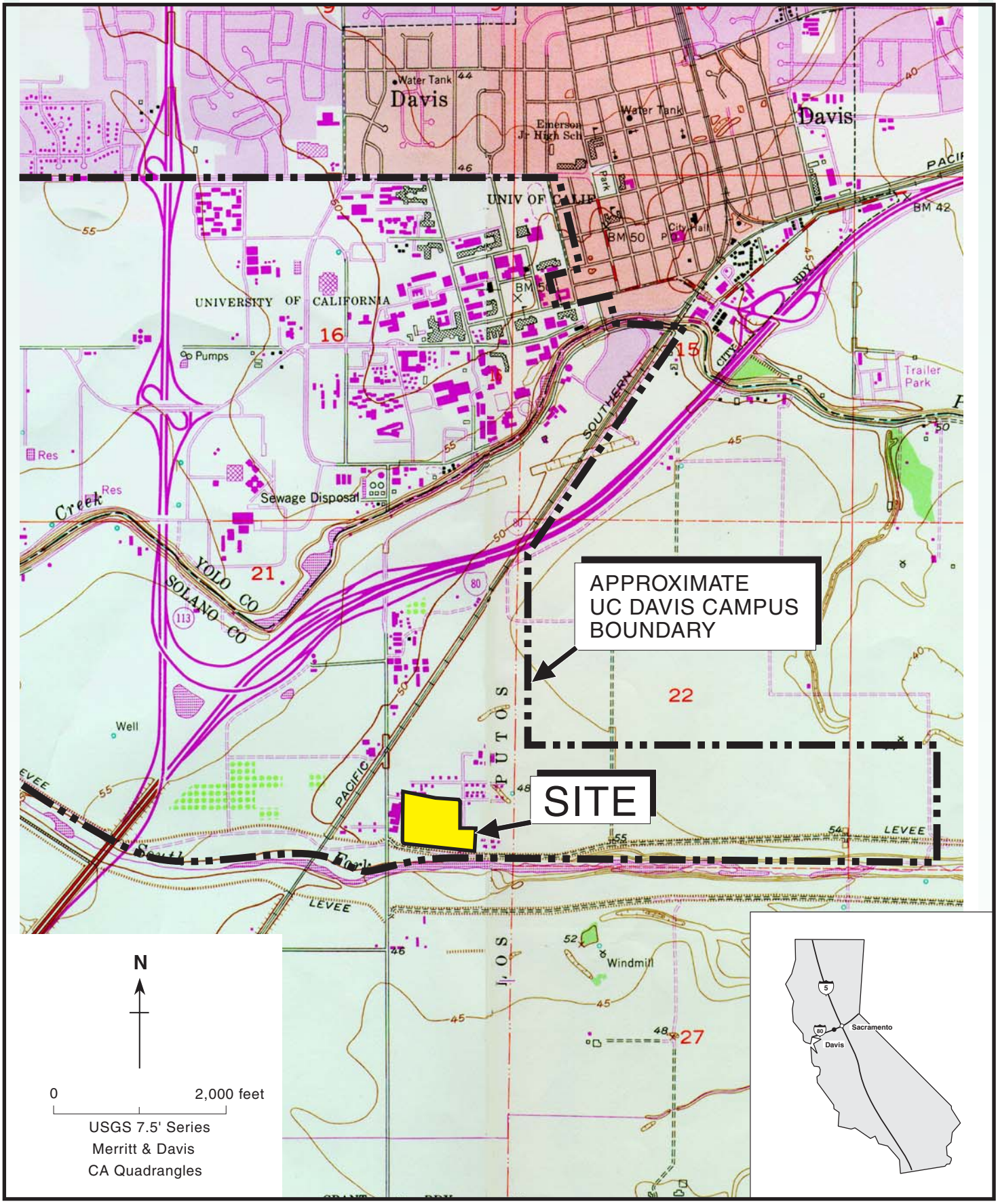

Figure 1-1. Location of the LEHR Site, UC Davis, California

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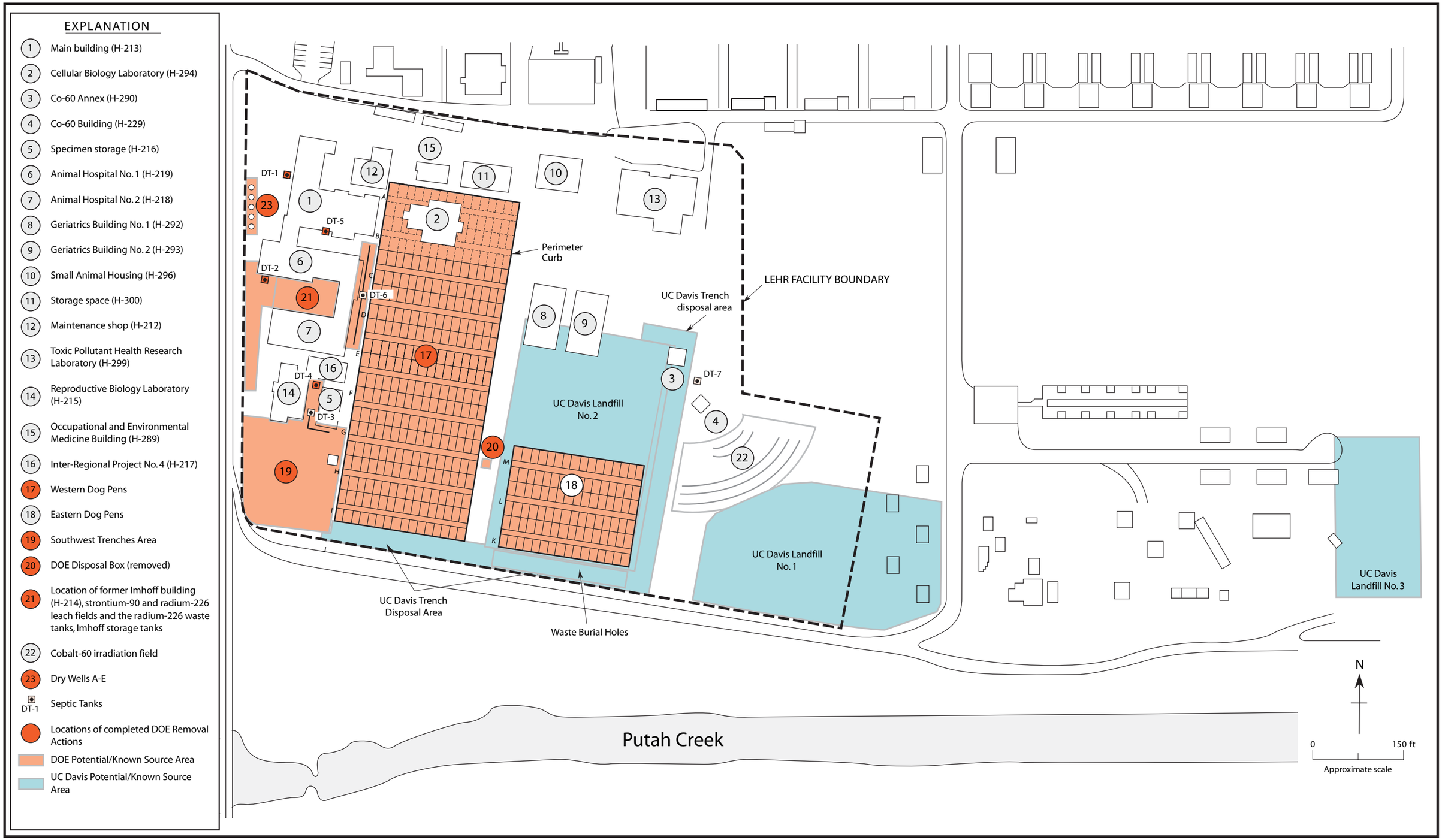

Figure 1-2. Site Features and Areas of Potentially Known Contamination Source Areas

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2. COMPLIANCE SUMMARY

This section summarizes the LEHR site's environmental regulatory compliance status during the environmental restoration and waste management activities conducted in Calendar Year 2004. No violations, fines or penalties were issued for the Site in 2004.

2.1 Environmental Restoration and Waste Management

Environmental restoration and waste management activities at LEHR were conducted in compliance with CERCLA and the National Contingency Plan, and include compliance with applicable or relevant and appropriate requirements and DOE Orders, as described below.

2.1.1 Comprehensive Environmental Response, Compensation and Liability Act as Amended by the Superfund Amendments and Reauthorization Act

In 1995, a streamlined remediation process was initiated at the Site using the CERCLA non-time critical removal action approach. This approach enables expedited response to contamination problems without requiring the time-consuming investigations and preparation of lengthy documents required otherwise. By 2003, DOE had finished all removal actions planned for the LEHR site.

In 2004, UC Davis issued a draft human health and ecological risk assessment. Findings from this risk assessment are needed to determine the contaminants of concern to be evaluated in the DOE Area Feasibility Study Report. Substantial comments from the US EPA required major revisions to the document. A draft site-wide risk assessment, comprising the human health and the ecological risk assessments, was issued on August 20, 2004. To shorten the project's completion schedule, DOE took on the responsibility of preparing the human health risk characterization of the risk assessment. Work on risk characterization began in late 2004. A final risk characterization document is expected to be issued before September 2005. The approval of the final human health risk characterization document will be the final step in the human health risk assessment process for DOE areas.

The ecological risk assessment is undergoing significant revision and is not expected to be finalized until early 2006. The delays associated with the issuance of a risk assessment have delayed the development of a feasibility study for both the DOE and UC Davis areas of the Site.

2.1.2 Resource Conservation and Recovery Act

No hazardous waste requiring compliance with the Resource Conservation and Recovery Act was generated, managed, shipped or disposed in 2004.

2.1.3 Federal Facilities Compliance Act

The Federal Facilities Compliance Act amends the Solid Waste Disposal Act and states that all federal agencies are subject to all substantive and procedural requirements of federal, state, and local solid and hazardous waste laws in the same manner as any private party. The act requires that a site treatment plan be prepared for each DOE site that generates or stores mixed radioactive waste. A final site treatment plan for LEHR was approved and issued in October 1995. No revisions have been made to this plan. The Site continues to be in compliance with the Federal Facilities Compliance Act.

2.1.4 National Environmental Policy Act

Consistent with DOE policy and guidance, environmental considerations for proposed removal actions and alternatives are evaluated during an engineering evaluation/cost analysis process, allowing integration of National Environmental Policy Act requirements with the CERCLA process, thereby eliminating the need for a separate National Environmental Policy Act analysis and streamlining the cleanup process.

Shipments of waste gravel completed in 2004 were categorically excluded from National Environmental Policy Act requirements, under Title 10 Code of Federal Regulations (CFR) 1021.410(b)(2).

2.1.5 Toxic Substances Control Act

Concern over the toxicity and persistence in the environment of polychlorinated biphenyls led Congress in 1976 to enact Section 6(e) of the Toxic Substances Control Act that included, among other things, prohibitions on the manufacture, processing, and distribution in commerce of polychlorinated biphenyls. The Toxic Substances Control Act legislates management of polychlorinated biphenyls from manufacture to disposal. No polychlorinated biphenyl-containing material or waste was generated, managed or disposed in 2004.

2.1.6 Federal Insecticide, Fungicide and Rodenticide Act

The US EPA, under the Federal Insecticide, Fungicide and Rodenticide Act, regulates the sales, distribution, and use of pesticides by requiring their registration. Registration includes

approval by the US EPA of the pesticide's label, which must give detailed instructions for its safe use. The US EPA must classify each pesticide as either "general use," "restricted use," or both. Only registered general use herbicides are applied at the Site by the UC Davis Agricultural Services Department to control weeds. The herbicides are used in accordance with the safe use instructions and in compliance with UC Davis campus requirements, and local, state and federal laws.

2.2 Radiation Protection

In 2004, all activities at the Site were conducted in compliance with Title 10 CFR Part 835, Occupational Radiation Protection, and applicable DOE Orders, as discussed below.

2.2.1 DOE Order 5400.5, Radiation Protection of the Public and the Environment

The *Final Report on the Radiation Protection of the Public and the Environment* (WA, 2001h) was developed in 2001. The purpose of this report was to evaluate LEHR operations and document their compliance with DOE Order 5400.5, Radiation Protection of the Public and the Environment. LEHR operations continued to be in compliance with DOE Order 5400.5 in 2004.

2.2.2 DOE Order 450.1, Environmental Protection Program

In 2001, the *Final Environmental Protection Program* (WA, 2001e) was developed, which defines environmental protection activities and monitoring conducted at LEHR, including radiological controls and monitoring requirements. This program complies with DOE Order 5400.1, which was subsequently replaced by DOE Order 450.1, Environmental Protection Program. Activities conducted at LEHR in 2004 were in compliance with the Environmental Protection Program.

2.2.3 Atomic Energy Act of 1954, as Amended

Under the Atomic Energy Act of 1954, as amended, DOE has the responsibility of controlling the activities of its contractors and operations in a manner that protects the public and the environment from radiation hazards associated with its operations.

All work at LEHR is performed in compliance with the *Final Radiological Protection Program* (WA, 1999b) and the *Final As-Low-As-Reasonably-Achievable Plan* (WA, 2001a), which comply with Title 10 CFR Part 835. The Radiological Protection Program and As-Low-As-Reasonably-Achievable Plan require that all work performed at LEHR be conducted in a manner that protects the public and the environment from radiological hazards.

In addition to the Radiological Protection Program and the As-Low-As-Reasonably-Achievable Plan, the LEHR Quality Assurance Project Plan (WA, 2000b) requires that environmental monitoring aspects of all operations and activities at LEHR be addressed in the work plans developed for specific activities. All activities at LEHR complied with the Radiological Protection Program, the As-Low-As-Reasonably-Achievable Plan and the LEHR Quality Assurance Project Plan in 2004.

2.2.4 DOE Order 435.1, Radioactive Waste Management

The comprehensive Radioactive Waste Management Basis (WA, 2001g) and Radioactive Waste Management Plan (WA, 2001d) were developed and approved in 2001, and at that time existing standard operating procedures for waste management were updated to meet the requirements of DOE Order 435.1. All waste management activities in 2004 were carried out in compliance with these documents and were conducted in a manner that protects the public, the workers and the environment from radiological hazards.

2.3 Air Quality and Protection

2.3.1 Clean Air Act

Under the Clean Air Act, the US EPA defined six criteria pollutants: carbon monoxide, nitrogen dioxide, lead, ozone, particulate matter, and sulfur dioxide, and set National Ambient Air Quality Standards for these pollutants. Of these, the only air pollutant emitted at the Site is particulate matter with aerodynamic size less than or equal to 10 micrometers from uncovered soils in the Eastern and Western Dog Pens. The Site is not a major source of air emissions.

In 2004, the Site was in compliance with all Clean Air Act requirements administered by the Yolo-Solano Air Quality Management District. Ambient air monitoring was routinely conducted between 1995 and 2001 by DOE. This prior data and current post-removal action site conditions indicate that surface soil contamination does not impact air quality at the Site.

2.3.2 National Emission Standards for Hazardous Air Pollutants

Subpart H of Title 40 CFR Part 61 protects the public and the environment from the hazards of radionuclide emissions, other than radon, from DOE facilities. It sets a limit on the emission of radionuclides that ensures that no member of the public in any year receives an effective dose equivalent of more than 10 millirem per year (mrem/yr).

The National Emission Standards for Hazardous Air Pollutants requirements primarily target point-source/stack emissions. There are currently no point sources of radionuclide emissions at the

Site. However, the Memorandum of Understanding between DOE and the US EPA (DOE, 1995) applies the point-source criteria to potential diffuse area sources at the Site.

The 2004 estimated dose to the public from the Site's diffuse area sources was calculated using surface soil radioactive contamination concentrations and assuming that wind-blown fugitive dust from the Western and Eastern Dog Pens, including re-entrainment and dispersion of surface soil dust, was the only potential sources of emissions. The analysis of potential diffuse airborne radiological effluent sources at the Site is included in the 2004 Calendar Year Radionuclide Air Emission Annual Report (under Subpart H of Title 40 CFR Part 61) (WA, 2005). Emissions modeling indicated that the maximum annual credible dose equivalent to a member of the public from residual site contamination was 8.7×10^{-7} mrem/yr for an off-site exposure, and 1.6×10^{-3} mrem/yr for an on-site exposure, far below the 10 mrem/yr effective dose equivalent limit. This analysis is discussed in more detail in Section 4 of this report.

2.4 Water Quality and Protection

2.4.1 Clean Water Act

As authorized by the Clean Water Act, the National Pollutant Discharge Elimination System permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States. The Site discharges its sanitary waste to the UC Davis Waste Water Treatment Plant, which is subject to the conditions in National Pollutant Discharge Elimination System Permit CA0077895, issued to UC Davis, and Waste Discharge Requirement Order No. 92-040, granted by the Central Valley Regional Water Quality Control Board. No waste water, other than sanitary waste, was discharged from LEHR to the waste water treatment plant in 2004.

Under the Clean Water Act, the US EPA also controls polluted storm water runoff. In California, this function is delegated to the California Regional Water Quality Control Board, under state-wide National Pollutant Discharge Elimination System General Permits for Storm Water Discharges Associated with Industrial and Construction Activities. A storm water sampling program described in the Revised Field Sampling Plan (D&M, 1998) is implemented at the Site and meets the state General Permit requirements. Best management practices are also used at the Site to mitigate any potential contamination in storm water runoff.

Under the Revised Field Sampling Plan (D&M, 1998), storm water samples are usually collected twice a year, once near the beginning of the rainy season, after the first significant storm of the season, and once near the end of the season. Surface water samples are also collected and analyzed in accordance with the Revised Field Sampling Plan. Details of the sampling and analyses are provided in the *Draft 2004 Comprehensive Annual Water Monitoring Report* (Brown & Caldwell, 2005) and are summarized herein in Section 3.

2.4.2 Drinking Water Requirements

Under the Safe Drinking Water Act, the US EPA sets standards to protect drinking water quality and drinking water sources, including rivers, lakes, reservoirs, springs and ground water wells. The California Porter-Cologne Water Quality Act authorizes the State Water Quality Board and Regional Water Quality Control Boards to coordinate and control water quality in the state. The regional boards establish and enforce water quality standards for both surface and ground water by issuing permits for discharges of waste water into state water bodies. The Safe Drinking Water and Toxics Enforcement Act prohibits discharge or release of chemicals known to the State of California to cause cancer or reproductive toxicity into water, or onto or into land where such chemical passes, or probably will pass, into any source of drinking water.

Historically, contaminated liquid waste was discharged from DOE research activities to the Imhoff Treatment Facility, the Domestic Septic Systems and the Radium/Strontium Treatment Systems and associated leach fields, which resulted in hazardous releases to site soils. These structures and associated contaminated soils have been removed and shipped off-site for disposal, with the final shipment of pipe joints shipped in 2003. Current DOE activities at LEHR do not discharge contaminants to any drinking water sources.

According to the Memorandum of Agreement between UC Davis and DOE (DOE, 1997), potential impacts to ground water from past site activities are to be addressed by UC Davis. UC Davis is conducting a ground water interim remedial action. Quarterly ground water and surface water monitoring has been conducted since November 1990. Monitoring activities conducted in 2004 are summarized in Section 4.

2.5 Other Environmental Statutes

2.5.1 Endangered Species Act

In 1997, an Ecological Scoping Assessment (WA, 1997b) was conducted to support the Draft Final Determination of Risk-Based Action Standards for DOE Areas (WA, 1997a). The Ecological Scoping Assessment identified special status species that have a high potential to exist in or near Putah Creek, including two plant species, five invertebrates, nineteen birds, two reptiles, one amphibian and four mammals.

Habitat for the Valley Elderberry Longhorn Beetle, a threatened species under the Endangered Species Act, was identified in the Western Dog Pens, Eastern Dog Pens and the former Cobalt-60 Field. LEHR staff are trained to recognize the habitat of this threatened beetle species and are required to protect the habitat from any interference or damage. No habitat modifications or adverse effects on the species resulted from the 2004 site activities.

The Draft Ecological Risk Assessment was developed by UC Davis and a final assessment will be issued in 2005.

2.5.2 National Historic Preservation Act

All areas affected by activities conducted at the Site in 2004 involved existing structures located on previously graded and developed land. An archeological evaluation was conducted during the Phase II Soil and Ground Water Characterization of the Site (DOE, 1992a). No evidence of cultural resources, historical or archeologically sensitive areas was encountered in 2004.

2.5.3 Migratory Bird Treaty

The Migratory Bird Treaty Act governs the taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts and nests. No activities resulting in taking of any migratory birds, their eggs, parts or nests occurred at the Site in 2004.

2.6 Executive Orders

2.6.1 Executive Order 13148, "Greening the Government through Leadership in Environmental Management"

Executive Order 13148 requires compliance with the Emergency Planning and Community Right-to-Know Act (EPCRA), also known as the Superfund Amendment and Reauthorization Act (SARA) Title III. SARA Title III requires facilities to provide information on the presence of hazardous chemicals and on the releases, both accidental and routine, of such chemicals into the environment. This information is used by state and local emergency agencies, hospitals, police and fire departments, and emergency response teams in responding to chemical emergencies, and is also available to the public to inform them of chemical hazards present in their neighborhood. The toxic release inventory requirements of SARA apply to facilities that use large amounts of certain chemicals.

The amounts of chemicals stored and used at LEHR are minimal and include such items as gasoline and propane fuels, paints and thinners. The storage, use, handling, and emergency response activities associated with these chemicals were covered by the following LEHR program documents which meet the EPCRA requirements:

- Project Health and Safety Plan (WA, 2001f), which contains a hazard communication program, including requirements for maintaining a chemical inventory and Material Safety Data Sheets;

- Contingency Plan and General Emergency Response Procedures (WA, 2001i), which cover planning, notification requirements and release notification procedures; and
- Occurrence Reporting Plan (WA, 2000a), which addresses the release notification process.

Since only small amounts of chemicals are used at the Site, LEHR is not required to submit a toxic release inventory under EPCRA Section 313, Toxic Release Inventory Reporting. The Site compliance with EPCRA reporting requirements is summarized in Table 2-1.

Table 2-1. Status of Emergency Planning and Community Right-to-Know Act Reporting

EPCRA Section	Description of Reporting	Status
e	Planning Notification	Compliant
304	Extremely Hazardous Substance Release Notification	Compliant
311-312	MSDS/Chemical Inventory	Compliant
313	Toxic Release Inventory Reporting	Not Applicable

Abbreviations
EPCRA Emergency Planning and Community Right-to-Know Act
MSDS Material Safety Data Sheet

2.6.2 Executive Order 11988, "Floodplain Management"

The Site is not on a 100-year floodplain as defined by the Federal Emergency Management Agency.

2.6.3 Executive Order 11990, "Protection of Wetlands"

No portion of the Site is designated as a wetland.

2.7 Other Major Environmental Issues and Actions

A total of 1,660 cubic yards of gravel from the Western Dog Pens were shipped to the Nevada Test Site for reuse as landfill cover. A significant amount of surplus materials including unused lift liners and radiological counting instruments were transferred to the DOE Separations Process and Research Unit (SPRU) site during 2004.

No violations, compliance orders or negative audit findings were issued to LEHR in 2004.

No new environmental programs and procedures were developed, approved, or implemented in 2004.

2.8 Continuous Release Reporting

In accordance with CERCLA, non-permitted hazardous substance releases in quantities exceeding the CERCLA reportable quantity must be reported to the National Response Center. No such releases occurred at the Site in 2004.

2.9 Unplanned Releases

No unplanned releases occurred at the Site in 2004. No reports of unusual or off-normal occurrences under DOE Order 232.1 were made in 2004.

2.10 Summary of Permits

DOE is not required to obtain any environmental permits for remediation and waste management activities conducted under CERCLA at LEHR.

3. ENVIRONMENTAL PROGRAM INFORMATION

Each year, DOE monitors the air, water and soil conditions at the Site by collecting environmental samples and evaluating relevant sample data obtained from UC Davis. This section describes the LEHR environmental monitoring program and summarizes the environmental monitoring activities conducted in 2004. The analytical results generated by this monitoring program are discussed in Sections 4, 5 and 6.

3.1 Environmental Management

In 2004, the LEHR environmental management was integrated into the overall management framework of site environmental restoration and waste management activities. It included evaluation of applicable environmental requirements, incorporation of these requirements into the CERCLA process, implementation of defined environmental controls, ongoing environmental compliance monitoring, corrective action and self-assessment procedures, and an annual management audit of the overall effectiveness of the LEHR environmental restoration and waste management program. The LEHR Quality Assurance Project Plan (WA, 2000b) defines this management and program approach, and explicitly incorporates the protection of the environment into site activities.

3.2 Environmental Protection and Monitoring Programs

The 2004 LEHR environmental management system included the following programs and documents designed to ensure environmental protection:

- Environmental Protection Program (WA, 2001e);
- Report on Radiation Protection of the Public and the Environment (WA, 2001h);
- Radiological Protection Program (WA, 1999b);
- As-Low-As-Reasonably-Achievable Plan (WA, 2001a);
- Radioactive Waste Management Plan and Standard Operating Procedures (WA, 2001d);
- Hazard Category Evaluation (safety basis documentation) (WA, 2001c);
- Standard Operating Procedure 42.1, Environment, Safety and Health Reporting (WA, 2001j);
- Occurrence Reporting Plan (WA, 2000a);

- National Environmental Policy Act Environmental Assessments (WA, 1998a and WA, 2001b); and
- Revised Field Sampling Plan (D&M, 1998) implemented by UC Davis for ground water, surface water, soil, sediment, air and biota monitoring.

With the decrease in scope of site activities, the scope of environmental and other compliance programs implemented at the Site has been scaled back proportionately.

3.3 Environmental Monitoring and Surveillance

In 2004, most environmental monitoring at LEHR was managed and performed by New World Technology and Weiss Associates and their subcontractors, with the exception of ground and surface water monitoring, which was performed by UC Davis. Environmental monitoring conducted in 2004 was conducted in accordance with DOE Order 5400.1, as described in Section 7 of the *Final Environmental Protection Program* (WA, 2001e).

Environmental monitoring at LEHR is composed of two activities: effluent monitoring and environmental surveillance. Effluent monitoring involves the collection and analysis of liquid and gaseous effluent samples to characterize and quantify contaminants released to the environment. These data are used to assess the exposure of and risk to the public, and to demonstrate compliance with applicable regulations. Environmental surveillance involves the collection and analysis of air, water, soil, terrestrial foodstuffs, biota and other media on or near DOE sites, and the measurement of external radiation. These data are used to assess potential exposure to the public, evaluate impacts on the environment and demonstrate compliance with applicable regulations. Because activities at the Site are conducted under Superfund requirements, water, soil and biota monitoring is integrated into the Superfund process, as discussed in the following sections.

3.3.1 Pre-Operational Monitoring

In accordance with the LEHR Environmental Protection Program (WA, 2001e), an environmental study must be conducted prior to start of any new process, which has the potential for significant adverse environmental impact. The study should be not less than one year, and preferably two years, before the start of any new process to evaluate seasonal changes and be consistent with National Environmental Policy Act requirements. The study shall:

- Characterize existing physical, chemical and biological conditions that could be affected;
- Establish background levels of radioactive and chemical components;
- Characterize pertinent environmental and ecological parameters;
- Identify potential pathways for human exposure or environmental impact; and

- Provide a basis for developing routine operational and emergency effluent monitoring and environmental surveillance programs.

No activities with potential for significant adverse environmental impacts were conducted at the Site in 2004. All transportation and disposal activities completed in 2004 were categorically exempt from environmental analysis.

3.3.2 Surface and Storm Water Monitoring

There are currently no active process-based effluent discharges from LEHR facilities to the environment that would require effluent stream monitoring. Surface and storm water runoff are the only potential liquid effluent sources of contamination.

Certain storm drains on the LEHR site are directed into the UC Davis combined storm and sanitary sewer system and subsequently treated by the UC Davis Waste Water Treatment Plant. The plant operates under National Pollutant Discharge Elimination System Permit No. CA0077895, which contains the waste water discharge requirements for the facility. Environmental monitoring and surveillance of the UC Davis Waste Water Treatment Plant is conducted by UC Davis, and is discussed in Sections 4.4 and 5.3 of this report.

Surface water monitoring is conducted by UC Davis in accordance with a Revised Field Sampling Plan (D&M, 1998) developed to comply with US EPA and DOE requirements for chemical and radiological analyses, respectively. Samples are collected at three locations along the South Fork of Putah Creek (Figure 3-1). The Putah Creek Upstream (PCU) monitoring point is located upstream of the LEHR site. The Putah Creek Downstream (PCD) monitoring point is located downstream of the LEHR site and UC Davis property. The waste water treatment plant outfall (STPO) monitoring station is located at the outfall of the UC Davis Waste Water Treatment Plant, which discharges into the South Fork of Putah Creek between PCU and PCD (Figure 3-1).

Surface water runoff samples are collected quarterly to coincide with ongoing LEHR project activities, and are analyzed for radioactive and hazardous materials. The types of analyses are based upon those contaminants historically present at the LEHR site and are monitored as part of ongoing LEHR activities.

In accordance with the Memorandum of Agreement between DOE and UC Davis (DOE, 1997), DOE collects storm water samples from a lift station located on the western border of the Site (LS-1 on Figure 3-1), and UC Davis collects samples from the UC Davis areas of the Site (LF-1 and LF-3 on Figure 3-1). The LS-1 collection point is a lift station located on the western side of the Site, which pumps runoff to a ditch along the west side of Old Davis Road. All of the storm water monitoring data collected by UC Davis and DOE are included in an annual report prepared by UC Davis. In accordance with the Revised Field Sampling Plan (D&M, 1998), sampling is conducted for two separate rainfall events: (1) the first significant storm event of the rainy season to sample runoff that may carry material that accumulated on the ground surface during the summer months; and (2) a large storm event late in the rainy season. Storm water samples are analyzed for

the following possible contaminants: selected radionuclides (tritium, carbon-14, strontium-90, radium-226), metals, chromium, nitrate, acute aquatic toxicity, alkalinity, other cations and anions, volatile organic compounds, chloroform, semi-volatile organic compounds, pesticides, polychlorinated biphenyls, total oil and grease, suspended and dissolved solids, and total organic carbon.

In 2004, UC Davis performed all surface water monitoring and monitored storm water runoff from the UC Davis areas of the Site. DOE monitored storm water runoff from the DOE areas only. The surface water monitoring results are discussed in detail in Sections 4.4 and 5.3.

3.3.3 Ground Water Monitoring

DOE and UC Davis signed a Memorandum of Agreement (DOE, 1997) to divide responsibility for site areas of contamination according to historical site use and operation. UC Davis has assumed responsibility for ground water monitoring and remediation activities. The locations of ground water monitoring wells are shown on Figure 3-1.

In 2004, UC Davis performed all site ground water monitoring. The ground water monitoring results are discussed in Section 6.

3.3.3.1 Ground Water Protection

In addition to ground water remediation conducted by UC Davis, ground water protection in 2004 was achieved through spill prevention measures implemented during waste management activities, such as covering stockpiles and minimizing the dispersion of dust by water suppression.

3.3.4 Air Monitoring

There are currently no point sources of radionuclide or chemical emissions at LEHR. The only potential sources of air emissions in 2004 were areas with exposed soil, such as the Eastern and Western Dog Pens, and soil/gravel stockpiles in the Western Dog Pens and the Southwest Trenches. Under realistic conditions, airborne effluent from these sources does not require sampling for hazardous materials, because there are no appreciable quantities of uncontained hazardous materials in the surface soil (D&M, 1992; BEI, 1991).

Radioactive and non-radioactive materials in air had been monitored at a number of locations at and near the Site since August 1995 through 2002, during site remediation activities. The majority of radionuclide analytical results for samples collected during this period were close to or below the minimum detectable activity for the laboratory analysis methods. Due to the completion of remediation activities DOE discontinued air monitoring at the Site at the end of 2002.

Airborne emissions of radioactive and hazardous materials from DOE-controlled facilities are subject to US EPA regulations. The primary regulatory driver for air monitoring programs at DOE

facilities is Title 40 CFR Part 61, Subpart H, National Emission Standards for Hazardous Air Pollutants for Emissions of Radionuclides from DOE Facilities. Subpart H of the National Emission Standards for Hazardous Air Pollutants requirements primarily target point-source/stack emissions. However, a Memorandum of Understanding between the DOE and the US EPA (DOE, 1995) applies the same criteria to potential diffuse area sources that are required of point sources. The National Emission Standards for Hazardous Air Pollutants regulations require that radionuclide emissions not exceed levels that would result in an effective dose equivalent of 10 mrem/yr. Measurement of emission rates is required for all release points with the potential to release radionuclides into the air that would cause an effective dose equivalent in excess of 1% of the standard (i.e., an effective dose equivalent >0.1 mrem/yr) and all radionuclides which could contribute to >10% of the potential effective dose equivalent for a release point. A discussion of compliance with Subpart H of the National Emission Standards for Hazardous Air Pollutants is provided in Section 4.1.1.

3.3.5 Environmental Dosimetry

Thermoluminescent dosimeters were used to quantify the exposure of on- and off-site personnel to penetrating gamma radiation (Figure 3-2). Thermoluminescent dosimeters were placed near perimeter fence lines, radioactive waste storage areas and various work areas around the Site. The thermoluminescent dosimeters were analyzed quarterly, and an annual gamma radiation dose is calculated for each location. The thermoluminescent dosimeter data are normalized by subtracting the site background activity from each location. The results of the ambient radiation monitoring program are discussed in Section 4.5. The thermoluminescent dosimetry program was discontinued at the end of 2004.

3.4 Site Environmental Training

Site-specific environmental training has been conducted annually to instruct project personnel on environmental policies, programs and procedures; project-specific environmental controls; pollution prevention goals and waste minimization requirements. This training is normally conducted as part of the site orientation. Additional training is provided prior to any new activity that could potentially impact the environment. Daily safety meetings reinforce this training and specify the steps needed to assure adequate environmental protection during that day's activities.

Before a worker is allowed to begin hazardous site work, he or she must complete a 40-hour Occupational Safety and Health Administration hazardous waste operations training. In addition, each worker receives hazard communication training. This training ensures that the worker is aware of proper handling, usage and disposal of chemicals used on the job. It covers spill prevention and control, as well as proper storage and chemical disposal methods. Workers are also trained in radiological control methods to prevent the spread of radioactive contamination to the environment, and emergency response and reporting procedures to ensure proper response in the event of an incident.

3.5 Waste Minimization and Pollution Prevention

The LEHR waste management program is committed to minimizing waste volumes by giving preference to source reduction, material substitution, decontamination and recycling. Applicable waste minimization activities include:

- Avoiding the use of porous materials that cannot be decontaminated;
- Minimizing personal protective equipment waste through effective planning;
- Using real-time analyses to delineate the extent of contamination;
- Optimizing waste container utilization and recycling;
- Removing surface contamination from subsurface structures and pipes; and
- Reusing uncontaminated soil and materials on site.

3.5.1 Recycling

A recycling program instituted in 2001 continued at LEHR in 2004. To the extent practicable, all paper, plastic, and cardboard waste generated by the project were recycled. All remaining gravel generated during the Western Dog Pens removal action in 2001 was shipped to the Nevada Test Site for reuse at the Site in lieu of landfill disposal.

A significant amount of surplus materials including unused lift liners and radiological counting instruments were transferred to the DOE SPRU site during 2004.

3.6 Protection of Biota

DOE Order 5400.5 and the interim DOE Technical Standard, *A Graded Approach for Evaluating Radiation Dose to Aquatic and Terrestrial Biota* (DOE, 2000), provides guidance on monitoring aquatic biota and terrestrial foodstuffs, a broad category that includes vegetation and fauna. Surveillance of terrestrial foodstuffs is required to quantify radioactive materials and chemicals, and to demonstrate that radioactive and hazardous materials are not accumulating in the environment. Currently, no sampling of terrestrial foodstuffs is planned at LEHR. A draft site-wide ecological risk assessment evaluating the site ecological risks was developed by UC Davis in 2004. A final risk assessment is expected to be issued in 2005. Surveillance requirements will be evaluated and/or developed based on the information obtained in this risk assessment.

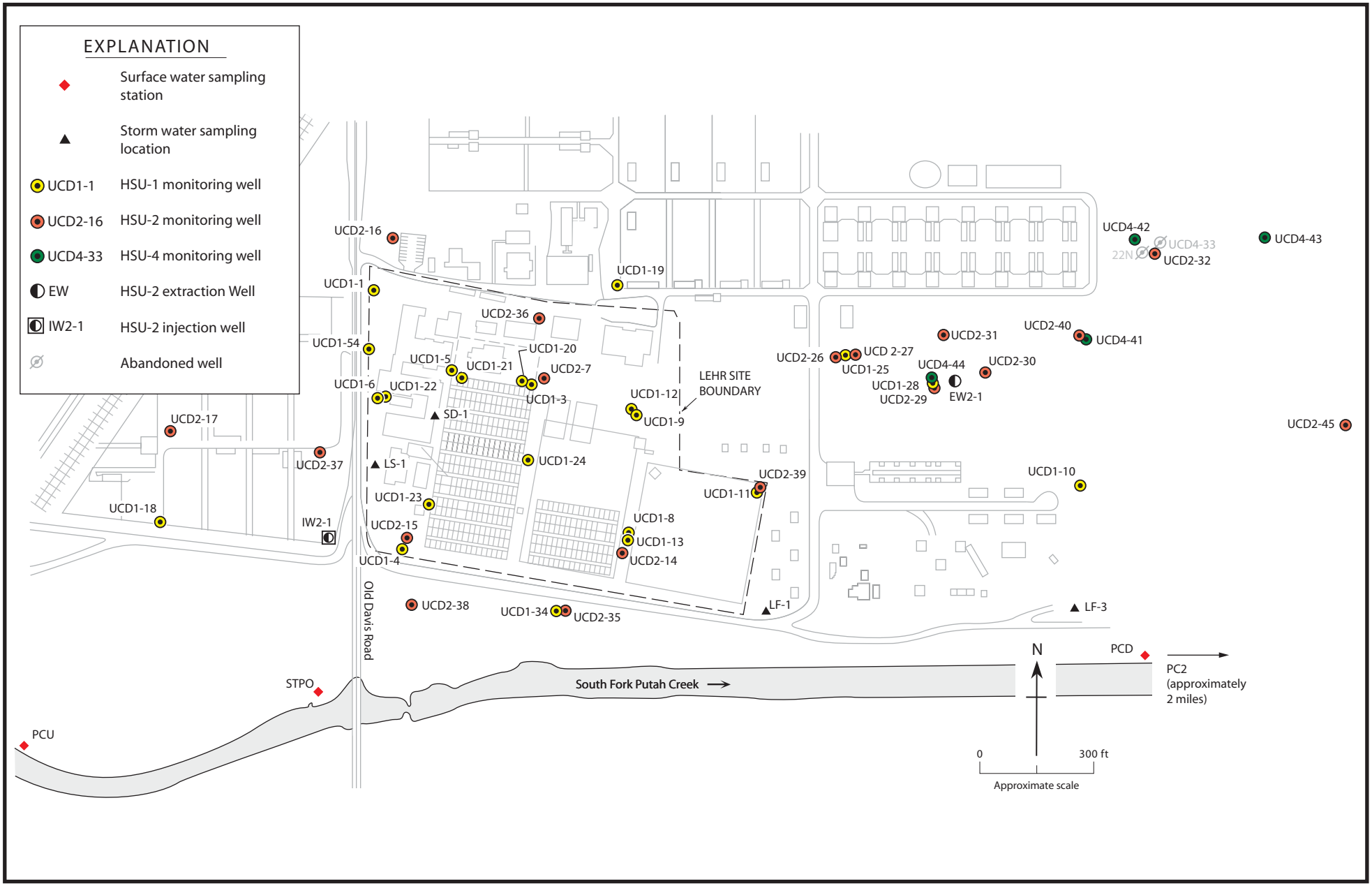

Figure 3-1. Ground Water, Storm Water and Surface Water Monitoring Locations

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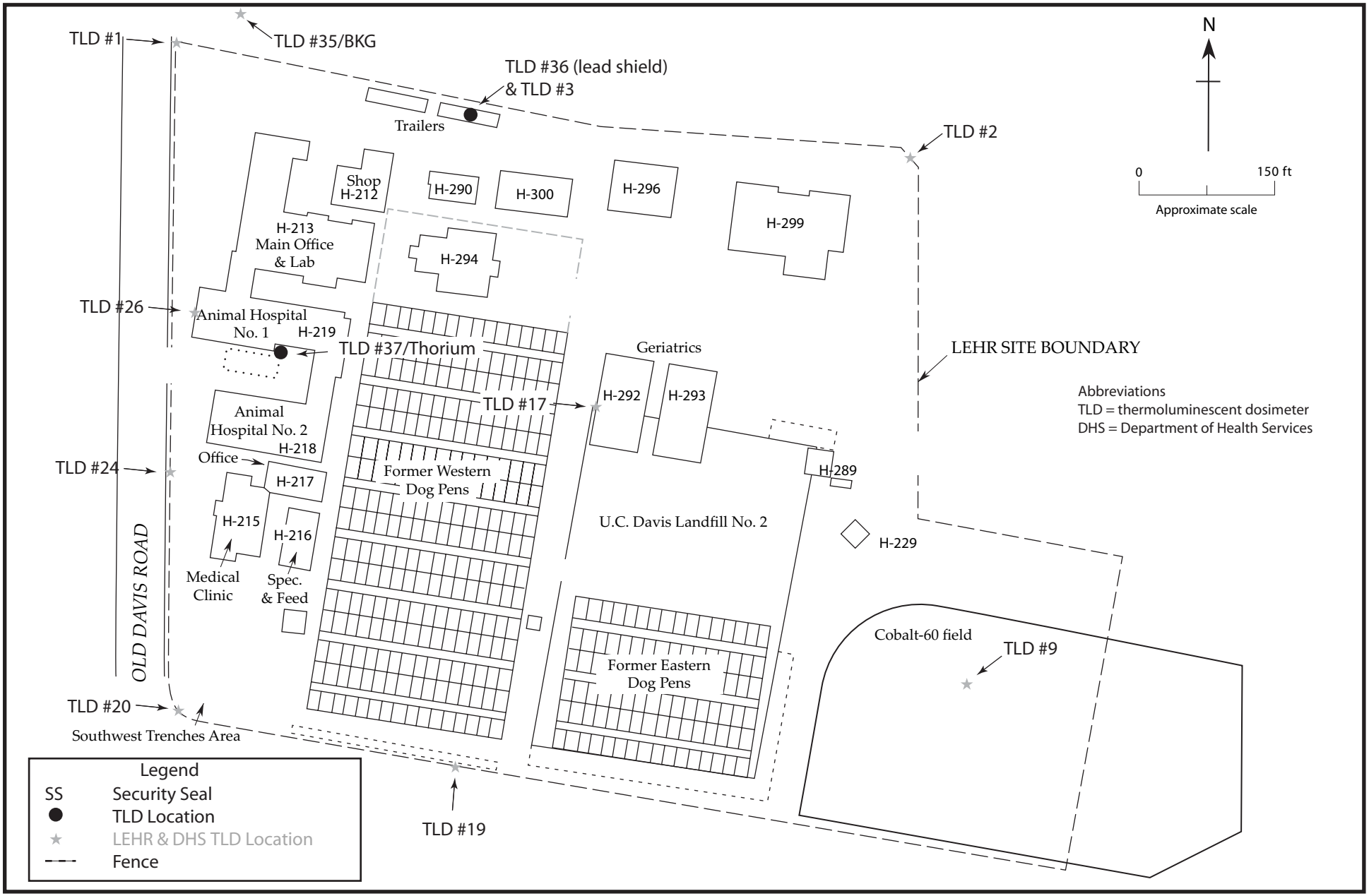

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Figure 3-2. Thermoluminescent Dosimeter Location Map

4. ENVIRONMENTAL RADIOLOGICAL PROTECTION PROGRAM INFORMATION

This section summarizes significant results and trends in radiological air, soil and water monitoring data for 2004. The majority of radionuclide sample results for samples collected at the Site in 2004 were close to or below the minimum detectable activity for the laboratory analysis methods. Table 4-1 provides a summary of public radiological dose exposure from DOE activities at the Site.

4.1 Radiological Discharges and Doses

Inhalation of site air emissions constitutes the only major exposure pathway for radiological dose at LEHR. There is no exposure to drinking water at the Site and occupational exposures to contaminated soil are managed in accordance with the CERCLA process and DOE Orders discussed Section 2.

Radioactive and non-radioactive materials in air have been monitored at a number of locations at and around the Site since August 1995 through 2002 during remediation activities. This monitoring indicated that all of the maximum concentrations of air contaminants of concern were well below their respective derived concentration guide values and did not pose any health risks to site workers or laboratory personnel at LEHR. The concentrations only marginally exceeded the concentrations at the background monitoring station. Since the completion of removal actions in 2002, air monitoring at the Site was discontinued.

4.1.1 National Emission Standards for Hazardous Air Pollutants Dose Estimation Calculations

Calculations were performed to determine the estimated radiation dose from site sources to the public. During 2004, the Western and Eastern Dog Pens were identified as the only remaining potential sources of non-point, diffuse radionuclide emissions. Radionuclide air emissions could potentially by generated by wind-blown, fugitive dust containing residual radioactivity above the site background concentrations.

Compliance with the National Emission Standards for Hazardous Air Pollutants requirements for diffuse, non-point source emissions was assessed using the US EPA atmospheric dispersion/radiation dose calculation computer code, CAP88-PC Version 1.0. This code was used to calculate the effective dose equivalent to individual receptors at various distances from the Western

and Eastern Dog Pens. "Individual receptor" CAP88-PC runs were executed for each non-point source area to model the fugitive dust emission sources. For each of the potential radionuclide emission non-point sources, a human receptor was identified in each of the north, south, east and west quadrants relative to the source.

The CAP88-PC computer code was then used to calculate the effective dose equivalent to individual receptors at various distances and from each of the potential LEHR facility radionuclide emission sources. The reported effective dose equivalent to a maximally exposed individual at the LEHR facility includes contributions from the two potential radionuclide emission non-point sources. Based on the combined non-point source exposures, the maximally exposed individual at the LEHR facility is located in the Specimen Storage Building (Building H-216) (Figure 1-2). The results of the assessment are shown in Table 4-2.

Conservative radionuclide emission rates in fugitive dust were estimated using maximum soil radionuclide activities above the Western and Eastern Dog Pens backgrounds and were used to calculate the total estimated contribution to the effective dose equivalent. The total contribution to the effective dose equivalent for an on-site maximally exposed individual resulting from non-point source emissions was estimated to be 1.6×10^{-3} mrem/yr (1.6×10^{-5} milliSieverts per year), far below the 10 mrem/yr standard. The results are presented in Table 4-2.

The CAP88-PC computer code was also used to calculate the collective population dose as required by DOE Order 5400.5. The collective dose equivalent to Davis residents was 5.1×10^{-5} person-Roentgen equivalent man per year, and the effective dose equivalent for the off-site maximally exposed individual was 8.7×10^{-7} mrem/yr, as estimated by CAP88-PC. The calculated effective dose equivalent for the off-site maximally exposed individual is several orders of magnitude below the 10 mrem/yr standard, as required by Title 40 CFR Part 61, Subpart H.

4.2 Radiological Soil Measurements

No soil sampling for radiological analyses was performed in 2004.

4.3 Release of Property Containing Residual Radioactive Material

In 2004 Buildings H-292 and H-219 (Room 202 and sample counting area), and the Co-60 Field were surveyed for radiological contamination according to survey protocols consistent with the MARSSIM guidance. These surveys are documented in the final status survey report approved by US EPA and California Department of Health Services (NWT, 2004a; NWT, 2004b; NWT, 2005).

4.4 Radiological Surface and Storm Water Monitoring

Quarterly surface water sampling has been conducted at the Site since 1990 for an extensive list of analytes. In 1997, in accordance with the Memorandum of Agreement (DOE, 1997), responsibility for surface water sampling was transferred to UC Davis. DOE retained responsibility for storm water runoff sampling in the DOE areas of the Site. Trends and conclusions drawn from the surface and storm water monitoring results are briefly discussed below. A detailed discussion of results, including tables summarizing the analytic data, can be found in the Draft 2004 Comprehensive Annual Water Monitoring Report (Brown & Caldwell, 2005).

4.4.1 Surface Water Monitoring

In 2004, UC Davis collected surface water samples from three locations: PCU, STPO, and PCD (Figure 3-1). Samples were collected during two rainfall events on February 18, 2004 and December 8, 2004. The samples that were collected were analyzed for carbon-14, radium-226, strontium-90 and tritium. None of these radionuclides were detected above the contract-required detection limits.

4.4.2 Storm Water Monitoring

Storm water samples were collected from two locations at the Site: LF-1 and LS-1 (Figure 3-1). UC Davis collected samples at location LF-1 on February 17, 2004 and November 11, 2004. The samples were analyzed for carbon-14, radium-226, strontium-90 and tritium. All of the sample results were below the contract-required detection limits.

DOE collected samples at location LS-1 on March 8 and 9, and October 26, 2004. These samples were analyzed for actinium-228, americium-241, bismuth-212, bismuth-214, carbon-14, cesium-137, cobalt-60, lead-210, lead-212, lead-214, plutonium-241, potassium-40, radium-226, sodium-22, strontium-90, thallium-208, thorium-234, tritium, uranium-235, uranium-238, gross alpha and gross beta. Of these, only gross alpha and beta exceeded the contract-required detection limits in the March 2004 sample. All other radionuclides, including tritium and carbon-14, were below the contract-required detection limits.

4.5 Ambient Radiation Monitoring Program

The LEHR ambient radiation monitoring program uses passive thermoluminescent dosimeters to monitor gamma radiation throughout the Site. During the first quarter of 2004, calcium sulfate dosimeters were used. During the remaining quarters, x-ray beta gamma neutron dose dosimeters were used. The thermoluminescent dosimeters are placed near perimeter fence lines, radioactive waste storage areas and various work areas around the Site (Figure 3-2). The thermoluminescent dosimeters are collected quarterly and an annual gamma radiation dose is calculated for each location. In 2004, thermoluminescent dosimeters and analyses were provided by

Radiation Detection Company, which is certified by the National Voluntary Laboratory Accreditation Program. TLD-35, located at the equine center to the north of the Site, is used to monitor ambient background activity.

The annual background dose near the Site measured by TLD-35 was 92 mrem/yr, which is consistent with previous years. The annual dose at the Site slightly exceeded background at two locations, TLD-1 and TLD-19, by 2 and 1 mrem, respectively. The total dose measurements from these locations are well below the DOE limit of 100 mrem/yr for public exposure. Table 4-4 shows that ambient radiation detected at the Site is either at background levels or well below the DOE dose limit for the general public.

Table 4-1. LEHR Radiological Dose Reporting Table for Calendar Year 2004

Pathway	Dose to Maximally Exposed Individual [1]		% of DOE 100- mrem/yr Limit	Estimated Population Dose		Estimated Population within 80 km
	(mrem)	(mSv)	%	(person-rem)	(person-Sv)	
Air	1.6E-03	1.6E-05	0.0016	5.1E-05	5.1E-07	3,554,000
Water[2]	-	-	-	-	-	-
Other Pathways[3]	N/A	N/A	N/A	N/A	N/A	N/A
All Pathways	1.6E-03	1.6E-05	0.0016	5.1E-05	5.1E-07	3,554,000

Notes

[1] The maximum total dose is the sum of effective dose equivalents modeled for each maximally exposed individual receptor from potential radionuclide fugitive dust emission non-point sources. The location of the receptor modeled is 132 meters west of the Eastern and Western Dog Pens, which is the approximate location of UC Davis research facilities. Additional information may be found in the 2004 National Emission Standards for Hazardous Air Pollutants Report (WA, 2005)

[2] The water pathway dose was not estimated but is assumed to be negligible.

[3] There are no other exposure pathways contributing to a radiological dose at LEHR.

Abbreviations

km	kilometer
LEHR	Laboratory for Energy-Related Health Research
mrem	millirem
mSv	milliSievert
N/A	not applicable
rem	Roentgen equivalent man
Sv	Sievert
yr	year

Table 4-2. On-Site Effective Dose Equivalent to Maximally Exposed Individual Resulting from Radionuclide Emissions from Each Potential Fugitive Dust Emission Non-Point Source

Receptor Location	Western Dog Pens Area (mrem/yr)[1]	Western Dog Pens Area Location[2]	Eastern Dog Pens Area (mrem/yr)[1]	Eastern Dog Pens Area Location[2]	Maximum Total Dose (mrem/yr)[3]
Specimen Storage Building (Building H-216)	1.4E-03	48 m W	2.2E-04	132 m W	**1.6E-03**
UC Davis Building E of LEHR Site	7.8E-05	300 m E	3.4E-05	180 m E	1.1E-04
Off-Site Receptor S of Putah Creek	6.9E-05	1,200 m S	3.4E-06	1,000 m S	7.2E-05
Off-Site Receptor W of LEHR Site	8.9E-05	400 m W	1.7E-05	500 m W	1.1E-04
Animal Hospital Building No. 1 (Building H-219)	8.4E-04	65 m W	1.4E-04	165 m W	9.8E-04
Inter-Regional Project No. 4 Building (Building H-217)	1.2E-03	52 m W	1.9E-04	143 m W	1.4E-03
Animal Hospital Building No. 2 (Building H-218)	8.4E-04	65 m W	1.4E-04	165 m W	9.8E-04
Cellular Biology Laboratory (Building H-294)	1.1E-03	65 m N	2.6E-04	150 m NNE	1.4E-03
Clinical Pathology (H-215)	4.0E-04	99 m W	1.7E-04	150 m W	5.7E-04
Main Office (H-213)	1.1E-03	65 m NW	1.5E-04	187 m NW	1.3E-03

Notes

[1]The EDE to the MEI is taken as the maximum modeled dose within a 45° sector in the direction and at the distance indicated in the "Location" column. For example, the dose 65 m north of the Western Dog Pens Area would be the maximum modeled dose within the sector bounded by 65 m NNE and 65 m NNW.

[2]The distance from an area source to a receptor is defined by CAP88-PC as the distance from the centroid of the area source to the receptor (US EPA, 1992). For the LEHR facility CAP88-PC modeling, the distance from an area non-point source to a receptor is measured as the approximate distance from the centroid of the non-point source to the centroid of the building assumed to house the receptor.

[3]The maximum total dose is the sum of the EDEs modeled for each MEI receptor from the two potential radionuclide fugitive dust emission non-point sources. Value in **boldface** is the maximum total dose for the Site.

Abbreviations

EDE	effective dose equivalent	NNW	north by northwest
E	east	NW	northwest
m	meters	No.	number
MEI	maximally exposed individual	S	south
mrem/yr	millirem per year	UC Davis	University of California, Davis
N	north	W	west
NNE	north by northeast		

Table 4-3. Summary of Estimated Collective Population Dose Resulting from Radionuclide Emissions from Each Fugitive Dust Emission Non-Point Source

Potential Emission Source	**Off-Site Maximally Exposed Individual**		**Collective Population Dose**[1]
	(mrem/yr)	**Location**	**(person-rem/yr)**
Western Dog Pens Area	6.4E-05	250 m north[2]	2.1E-04
Eastern Dog Pens Area	7.8E-05	250 m north[2]	2.5E-04
Total LEHR Site	**1.4E-04**		**4.5E-04**

Notes
Source of data: CAP88-PC Version 1.0 modeling output files.
[1]The collective population dose is for receptors within a 10-km radius.
[2]The approximate location of UC Davis research facilities.

Abbreviations

km	kilometer(s)
m	meter(s)
mrem/yr	millirem per year
person-rem/yr	person-Roentgen equivalent man per year
UC Davis	University of California, Davis

Table 4-4. LEHR Thermoluminescent Dosimeter Monitoring Results for Calendar Year 2004

Location [1]	Total Annual Dose (mrem)	Dose Associated with DOE Activities[2] (mrem)
TLD-1	94	2
TLD-2	91	-1
TLD-3 [3]	86	-6
TLD-9	88	-4
TLD-17	87	-5
TLD-19	93	1
TLD-20	92	0
TLD-24	86	-6
TLD-26	88	-4
TLD-35[6]	92	0
TLD-36 [3]	84	-8
TLD-37	90	-2

Notes
[1] Location corresponds to Figure 3-2.
[2] Measured dose in millirems, less background.
[3] Data for the third quarter (July 1, 2004 to September 30, 2004) is not available. The maximum reported dose for the third quarter was used to calculate the total annual dose for these locations.
[4] Background is collected at TLD-35.

Abbreviations

DOE	United States Department of Energy
TLD	thermoluminescent dosimeter
mrem	millirem

5. ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INFORMATION

This section summarizes significant results and trends in 2004 non-radiological LEHR site air, soil and water monitoring.

5.1 Non-Radiological Air Monitoring

No air monitoring for non-radiological constituents was performed during 2004.

5.2 Non-Radiological Soil Monitoring

No soil monitoring for non-radiological constituents was performed in 2004.

5.3 Non-Radiological Surface and Storm Water Monitoring

In 2004, surface water sampling was conducted and reported by UC Davis. Trends and conclusions drawn from the surface and storm water monitoring results are discussed briefly below. A detailed discussion of results and tables summarizing the analytical data can be found in the *Draft 2004 Comprehensive Annual Water Monitoring Report* (Brown & Caldwell, 2005).

5.3.1 Surface Water Monitoring

In 2004, UC Davis collected surface water samples from three locations: PCU, STPO, and PCD (Figure 3-1). Samples were collected during two rainfall events on February 18, 2004 and December 8, 2004. The samples that were collected were analyzed for chronic aquatic toxicity, metals, nitrate, pesticides, polychlorinated biphenyls, total dissolved solids and volatile organic compounds. Only metals, nitrate, one pesticide and total dissolved solids were detected above the contract-required detection limits. Nitrate was detected in concentrations ranging from 0.162 milligrams per liter (mg/l) at PCU to 7.07 mg/l at STPO. Total dissolved solids were detected in concentrations ranging from 176 mg/l at PCU and PCD to 557 mg/l at STPO. These concentrations are similar to concentrations detected in 2002. The pesticide detected was delta hexachlorocyclohexane. It was detected in one sample collected at PCD in December and was not detected in the duplicate of that sample. The metals detected were arsenic, barium, boron, copper,

chromium (total), iron, lead, manganese, molybdenum, nickel, vanadium and zinc. There are no significant differences between the upstream (PCU) and downstream (PCD) metal concentrations.

With the exception of the selenastrum species (algae), aquatic toxicity results for all three surface water locations did not demonstrate any toxicity during 2004. In the February 2004 selenastrum species analysis, samples collected both upstream and downstream of the Site indicated some toxicity, although results indicated that this toxicity was to due to site influence. The results for the PCD sample had a higher cell count than the results in the PCU sample. In both samples, cell counts were higher in the non-diluted sample than in the 50-percent dilution. The December 2004 selenastrum species analysis (as well as all tests for pimephales and ceridophania) indicated no toxicity in either PCU or PCD sample.

5.3.2 Storm Water Monitoring

All storm water samples were collected at two monitoring locations, LF-1 and LS-1 (Figure 3-1), during numerous storms throughout the rainy season in 2004. Monitoring location LF-1 was sampled on February 17, 2004 and November 11, 2004 by UC Davis; and monitoring location LS-1 was sampled by DOE on March 8 and 9, and October 26, 2004.

The sample collected from LF-1 was analyzed for field parameters, acute aquatic toxicity, metals, nitrate, oil and grease, pesticides, polychlorinated biphenyls, radionuclides (discussed in Section 4), total dissolved solids, total organic carbon, total suspended solids and volatile organic compounds. The following constituents were detected above the contract-required detection limits: acetone, metals, nitrate, total organic carbon and total dissolved solids. All of the compounds were within the historical ranges.

Aquatic toxicity results for the LF-1 sample collected in February 2004 indicated no toxicity for the pimephales species. The November sample indicated some toxicity in the non-diluted sample, although the toxicity criteria defined in the Field Sampling Plan (D&M, 1998) were met.

The samples collected from LS-1 were analyzed for metals, cations, nitrate, pesticides, polychlorinated biphenyls, radionuclides (discussed in Section 4), total dissolved solids, total organic carbon, total suspended solids and volatile organic compounds. With the exception of toluene, analytical results were similar to previous years. Toluene was detected slightly above the historical ranges at 20.4 micrograms per liter (µg/l) in March 2004; however, it was not detected in the October sample. Neither tritium nor carbon-14 was detected above the contract-required detection limit.

An additional sample was collected on February 26, 2004 and tested for aquatic toxicity. Aquatic toxicity results for the LS-1 stormwater location did not report any toxicity during 2004.

5.3.3 National Pollutant Discharge Elimination System Data

The Site discharges its sanitary waste to the UC Davis Waste Water Treatment Plant according to National Pollutant Discharge Elimination System permit requirements. Current DOE activities do not contribute to hazardous discharges.

6. WATER MONITORING AND PUBLIC DRINKING WATER PROTECTION PROGRAM

Ground water monitoring has been conducted at the Site since November 1990 and has been the responsibility of UC Davis since 1997. UC Davis submits quarterly and annual reports on ground water monitoring to DOE for review and comment.

6.1 Uses of Ground Water in the LEHR Vicinity

As discussed in Section 1.4.3, local ground water is utilized for both domestic supply and agricultural purposes. The major ground water sources for both public and private water supplies in the Sacramento Valley are unconsolidated deposits of Pliocene and Pleistocene age, and older alluvium (DOE, 1992b). Water from the first HSU is not used for drinking or irrigating purposes due to inadequate yield. A number of domestic and irrigation wells in the Site vicinity produce water from HSU-2.

6.2 Potential Sources of Ground Water Pollution

Sources contributing to ground water pollution at the Site include the UC Davis Landfill No. 2 (apparent source of volatile organic compounds) and the UC Davis Waste Burial Holes (Figure 1-2) (apparent source of tritium and carbon-14 contamination). UC Davis landfills and the former animal handling facilities at LEHR may be potential sources of nitrate contamination in the site ground water.

6.3 Ground Water Monitoring

UC Davis continued to monitor ground water at the Site. Of 46 wells used in the program, 22 are completed within HSU-1, 19 are completed within HSU-2, and five are completed within HSU-4.

The ground water monitoring program and the 2004 sampling results are discussed in detail in the *Draft 2004 Comprehensive Annual Water Monitoring Report* (Brown & Caldwell, 2005). UC Davis reported no significant changes in the ground water contaminant concentrations in monitoring samples collected from DOE areas in 2004. Increased nitrate concentrations were noted in the area of the UC Davis Eastern Trenches. Notable ground water monitoring results include:

- Chloroform was detected above the contract-required detection limit in 22 of 45 wells monitored at concentrations ranging from 0.58 µg/l to 3,140 µg/l.
- Acetone; 1,1-dichloroethane; 1,1-dichloroethylene; 1,2-dichloroethylene; 1,2-dichloropropane; perchloroethene; 1,1,2-trichoroethane and trichloroethene were detected above their respective contract-required detection limits.
- Carbon-14 and tritium concentrations continue to decrease.

In addition to continued ground water monitoring by UC Davis, DOE conducted a limited ground water investigation in 2004 in the vicinity of former Dry Wells A-E (Figure 1-2). DOE installed monitoring well UCD1-054 near the former dry wells in 2004 and collected four rounds of ground water samples. Sample results from this well indicate that releases associated with former Dry Wells A-E are not currently impacting ground water.

Well UCD1-054 has been incorporated into the ground water monitoring program conducted by UC Davis and will be sampled on a periodic basis in accordance with regulatory requirements.

6.4 Off-Site Supply Well Sampling

Private wells south, north, and east of the Site have been sampled since 1989. Monitoring of radiological constituents in private wells ceased in 1996 after adequate monitoring wells and hydrologic information had been established to ensure that no radioactive materials were migrating off site in ground water. UC Davis continues to monitor off-site wells for non-radiological constituents, including chloroform and nitrates, among others contaminants. Results of this monitoring are reported annually by UC Davis to the Regional Water Quality Control Board. This information is considered confidential based on the agreements between UC Davis and the private well owners.

7. QUALITY ASSURANCE

Quality assurance is a key element of the environmental protection program for the Site. A Quality Assurance Project Plan (WA, 2000b) that describes the requirements for all quality-related work on the LEHR project has been prepared and is fully implemented. The Quality Assurance Project Plan and other quality-assuring documents, such as standard quality procedures, standard operating procedures and task-specific work plans, govern all phases of the LEHR program, including site characterization, investigation, risk assessments, decontamination and decommissioning, waste management and site restoration. The purpose of the Quality Assurance Project Plan and the other documents is to identify the specifications and methods employed to establish technical accuracy, precision and validity of measurements and statistics; and to provide a sound basis for management decisions based on environmental information collected from the Site. The Quality Assurance Project Plan for the LEHR project was prepared in accordance with US EPA QA/R-5 (US EPA, 2001) and National Quality Assurance specifications. It also conforms to DOE Order 414.4a, the Nuclear Safety Management Quality Assurance Requirements in Title 10 CFR, Part 830, and incorporates requirements of DOE Order 5400.1, General Environmental Protection, to ensure that DOE quality and environmental goals are met.

Environmental samples collected by DOE that are discussed in this report were collected, analyzed, reviewed and validated according to the Quality Assurance Project Plan and other relevant standard operating procedures and/or task-specific work plans. To assure quality, quality control is integrated into all aspects of environmental sampling. Included in the Quality Assurance Project Plan and related documents are sections identifying quality control for sample collection requirements and specific quality assurance objectives for the measurement data. Quality control samples are run with each sample batch at the analytical laboratory to validate the method of analysis and the proficiency of the analyst. Because holding times are important to sample quality, they are carefully controlled. To ensure comparability of analytical data, all samples are analyzed by US EPA-approved methods, when available. When analytical results are received, they are reviewed according to the appropriate data quality objectives and data review procedures. All of the 2004 site air, soil and water monitoring data have been presented in other reports. The specific review and validation process for each data set are presented in these reports, and are not discussed in detail here.

7.1 Field Quality Assurance

Quality assurance for field sampling is accomplished by collecting field duplicates, decontamination rinseates, trip blanks and field blanks, as appropriate. For each round of sampling, duplicate samples are collected from a selected sample point at the same location as the original sample to check for consistency in the sampling process. The duplicate sample serves as a check on the precision of the sampling and analytical procedures. Decontamination rinseates are analyzed

whenever the potential exists for cross-contamination from sampling equipment. Trip blanks are sent with each shipment of water samples requiring analysis for volatile organic compounds. Field blanks are collected to check for contamination during the water sampling process. Calibration records for each field instrument are maintained in the project files.

7.2 Laboratory Quality Assurance

Contracted laboratories providing analytical services for the LEHR project were evaluated by Weiss Associates, New World Technology or UC Davis to ensure compliance with the quality assurance program requirements. Laboratory quality assurance is analyzed externally by submitting split samples, spiked samples and blanks to the laboratories analyzing environmental samples. Laboratories must submit their analytical procedure for review if it differs from standard procedures. Each contract laboratory is required to maintain participation, as applicable, in DOE, State of California, and/or US EPA-approved inter-laboratory quality assurance programs such as DOE's Environmental Measurement Laboratory Inter-Laboratory Comparison Program or US EPA's Water Pollution/Water Supply Program.

7.3 Summary of Quality Control Data Validation

The overall LEHR quality assurance objective is to collect and analyze environmental samples from the Site in a manner that ensures technical data are accurate and representative, are able to withstand scientific and legal scrutiny, and are useful for evaluating site conditions and remedial actions. The criteria used to specify quality assurance goals are precision, accuracy, representativeness, completeness and comparability for evaluation of quality control data. These parameters are evaluated through data validation. Table 7-1 summarizes the components used to monitor and evaluate the quality of LEHR environmental data.

Table 7-1. Components of the LEHR Quality Control Program in Support of Data Quality Objectives

Data Quality Objective	Quality Control Component	Evaluation Criteria
Precision	• Field duplicate • Matrix spike • Matrix spike duplicate	Relative percent difference
Accuracy	• Matrix spike • Matrix spike duplicate • Surrogate spikes	Percent recovery
Representativeness	• Trip blanks • Field duplicate • Method blanks	Qualitative degree of confidence
Completeness	• Holding time • Valid data points	Percent valid data
Comparability	• Analytical methods • Field duplicates	Qualitative degree of confidence

8. DEFINITIONS

The following definitions are adapted from DOE Order 5400.5 and the US EPA.

Term	Definition
absorbed dose	The energy imparted to matter by ionizing radiation per unit mass of irradiated material at the place of interest in that material. The absorbed dose is expressed in units of rad (or gray) (1 rad = 0.01 gray).
as-low-as-reasonably-achievable (ALARA)	A phrase (acronym) used to describe an approach to radiation protection to control or manage exposures (both individual and collective to the work force and the general public) and releases of radioactive material to the environment as low as social, technical, economic, practical, and public policy considerations permit. As used in United DOE Order 5400.5, ALARA is not a dose limit, but rather it is a process that has as its objective the attainment of dose levels as far below the applicable limits of the DOE Order as practicable.
collective dose equivalent and collective effective dose equivalent	The sums of the dose equivalents or effective dose equivalents of all individuals in an exposed population within an 80-kilometer (km) radius, for the purposes of DOE Order 5400.5, expressed in units of person-Roentgen equivalent, man (rem), (or person-Sievert). When the collective dose equivalent of interest is for a specific organ, the units would be organ-rem (or organ-Sievert). For purposes of DOE Order 5400.5, the 80-km distance shall be measured from a point located centrally with respect to major facilities or DOE program activities.
committed dose equivalent	The predicted total dose equivalent to a tissue or organ over a 50-year period after a known intake of a radionuclide into the body. It does not include contributions from external dose. Committed dose equivalent is expressed in units of rem (or Sievert).

Term	Definition
committed effective dose equivalent	The sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem (or Sievert).
confirmation samples	Analysis for metals, nitrate, pesticides/polychlorinated biphenyls, semi-volatile organic compounds, volatile organic compounds and hexavalent chromium.
Curie (Ci)	A unit of radioactivity equal to 3.7×10^{10} disintegrations per second.
derived concentration guide	The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in an effective dose equivalent of 100 millirem (1 milliSievert). Derived concentration guides do not consider decay products when the parent radionuclide is the cause of the exposure (derived concentration guide values are presented in Chapter III of DOE Order 5400.5).
designated level	Cleanup levels for specific constituents of a waste that provide a site-specific indication of the water quality impairment potential of the waste. Designated levels are calculated by first determining the bodies of water that may be affected by a waste and the present and probable future beneficial uses of these waters. Next, site-specific "water quality goals" are selected, based on background water quality or accepted criteria and standards, to protect those beneficial uses. Finally, these water quality goals are multiplied by factors that account for environmental attenuation and leachability. The result is a set of Soluble and total designated levels that are applicable to a particular waste and disposal site and which, if not exceeded, should protect the beneficial uses of waters of the State. Wastes having constituent concentrations in excess of these designated levels are assumed to pose a threat to water quality and are, therefore, classified as 'designated wastes' and directed to waste management units that isolate these wastes from the environment.
DOE Orders	DOE directives intended to direct, guide, inform and instruct DOE employees in the performance of their jobs, and enable them to work effectively within the DOE and with agencies, contractors, and the public.

Term	Definition
dose equivalent	The product of absorbed dose in rad (or gray) in tissue and a quality factor. Dose equivalent is expressed in units of rem (or Sievert).
effective dose equivalent	The summation 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-effects 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 effective dose equivalent includes the committed effective dose equivalent from internal deposition of radionuclides and the effective dose equivalent due to penetrating radiation from sources external to the body. Effective dose equivalent is expressed in units of rem (or Sievert).
effluent monitoring	The collection and analysis of samples or measurements of liquid and gaseous effluents for purposes of characterizing and quantifying contaminants, assessing radiation exposures of members of the public and demonstrating compliance with applicable standards.
environmental surveillance	The collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media from DOE sites and their environs, and the measurement of external radiation for purposes of demonstrating compliance with applicable standards, assessing radiation exposures of members of the public, and assessing effects, if any, on the local environment.
hazard index	The health impact of the non-carcinogenic compounds is quantified through the hazard index, which is the ratio of the expected concentration of a compound to the acceptable concentration of the compound. When more than one toxic compound is emitted, the hazard indices of the compounds are summed to give the total hazard index. A total hazard index of 1.0 or less is considered to be not significant and the resulting impact on public health is deemed acceptable.
maximally exposed individual	The maximally exposed individual is the representative member of the public who receives the highest estimated effective dose equivalent based on the sum of the individual pathway doses.

Term	Definition
members of the public	Persons who are not occupationally associated with a DOE facility or operations (i.e., persons whose assigned occupational duties do not require them to enter the DOE site). Also see: public dose.
picoCurie (pCi)	A unit of radioactivity equal to 1 x 10^{-12} Curies or 2.2 disintegrations per minute.
preliminary remediation goal	Initial cleanup goals that (1) are protective of human health and the environment and (2) comply with applicable or relevant and appropriate requirements. Preliminary remediation goals are developed early in the remedy selection process based on readily available information and are modified to reflect results of the baseline risk assessment. They also are used during analysis of remedial alternatives in the remedial investigation/feasibility study.
public dose	The dose received by member(s) of the public from exposure to radiation and to radioactive material released by a DOE facility or operation, whether the exposure is within a DOE site boundary or off site. It does not include dose received from occupational exposures, doses received from naturally occurring "background" radiation, doses received as a patient from medical practices or doses received from consumer products.
quality factor	The principal modifying factor used to regulate the dose equivalent from the absorbed dose. For the purposes of DOE Order 5400.5, quality factors taken from DOE Order 5480.11 are to be used.
rad	Historical unit of measurement of the radiation energy absorption (dose) in matter. The rad is defined as the amount of radiation required for absorption of 100 ergs (1 erg = 10^{-7} joule) per gram of irradiated material.
radioactivity	Property or characteristic of radioactive material to spontaneously "disintegrate" with the emission of energy in the form of radiation. The unit of radioactivity is the Curie (or Becquerel).

Term	Definition
reference man	A hypothetical aggregation of human (male and female) physical and physiological characteristics arrived at by international consensus (International Council for Radiation Protection Publication 23). These characteristics may be used by researchers and public health workers to standardize results of experiments and to relate biological effects from ionizing radiation to a common base. The "reference man" is assumed to inhale 8,400 cubic meters of air in a year and to ingest 730 liters of water in a year.
remedial action	Those actions consistent with permanent remedy taken instead of, or in addition to, removal action in the event of a release or threatened release of a hazardous substance into the environment, to prevent or minimize the release of hazardous substances so that they do not migrate to cause substantial danger to present or future public health or welfare or the environment.
residual radioactive material	Any radioactive material which is in or on soil, air, equipment, or structures as a consequence of past operations or activities.
RESRAD	Residual Radioactivity model. Argonne National Laboratory computer model for evaluating radioactively contaminated sites. (Argonne National Laboratory)
risk-based action standard	Site-specific, soil contaminant-specific concentrations above which an unacceptable risk to human health is predicted to exist. An unacceptable risk to human health is defined as exceeding a one-in-one million excess cancer risk over a 60-year exposure period.
Roentgen	A unit of radiation exposure equal to the quantity of ionizing radiation that will produce one electrostatic unit of electricity in one cubic centimeter of dry air at zero degrees Celsius and standard atmospheric pressure.
Roentgen equivalent man (rem)	The dosage of ionizing radiation that will cause the same biological effect as one roentgen of x-ray or one gamma-ray dosage.

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