U.S. Department of Energy

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Lawrence Livermore National Laboratory

University of California, Livermore, California 94550

UCRL-AR-229041

Third Five-Year Review for the Lawrence Livermore National Laboratory Livermore Site

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August 2007

Environmental Protection Department

Environmental Restoration Division

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Approval and Concurrence for the Third Five-Year Review for the Lawrence Livermore National Laboratory Livermore Site

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Five-Year Review Summary Form

Site Identification		
Site name: Lawrence Livermore National Laboratory (LLNL) Livermore Site		
EPA ID: CA 2890012584		
Region: IX	State: California	City/County: Livermore/Alameda
Site Status		
NPL status: Final		
Remediation status: Operating		
Multiple OUs: No	Construction completion date: September 2006; approved by EPA September 2007	
Has the site been put into reuse: No		
Review Status		
Reviewing agency: U.S. Department of Energy (DOE)		
Author name: Lindee Berg		
Author title: Project Leader	Author affiliation: University of California/LLNL	
Review period: June 2002 to December 2006		
Date(s) of site inspection: Not applicable		
Type of review: Statutory		
Review number: 3		
Triggering action: Record of Decision, First and Second Five-Year Reviews		
Triggering action date: July 1992, December 1997, September 2002 (signed by EPA October 2002), respectively		
Due date: October 2007		

Five-Year Review Summary Form (continued)

Issues:

No deficiencies in the overall remedy were identified during the third Five-Year Review. The remedy is performing as intended and is demonstrating good progress in remediating the ground water. To further expedite the ground water cleanup, some follow-up actions are recommended.

Recommendations and Follow-up Actions:

The following recommendations were developed by DOE/LLNL during the third Five-Year Review process:

- Complete a source area cleanup technology evaluation on all sources.
- Investigate thermal remediation technologies.
- Evaluate bioremediation, oxidizers, and mechanical fracturing under site specific conditions as possible source area remediation technologies for saturated sediments at the Livermore Site.
- Test heated air injection and dynamic operations for the cleanup of contaminants residing in the vadose zone and capillary fringe.
- Monitor increasing TCE concentration trends at piezometer SIP-191-002 to determine if further actions are warranted.
- Conduct wellfield optimization and hydraulic testing of the TFB HSU-2 plume to determine if wellfield modifications are needed.
- Conduct modeling to evaluate the need for hydraulic capture and treatment to prevent further westward migration of HSU-3A, 3B, and 4 plumes in the western TFE area.
- Conduct modeling to evaluate the need for hydraulic capture and treatment to prevent further westward migration of the HSU-3A Freon 11 plume in western TFD area.
- Investigate the source of the HSU-4 contamination at TFD Southeast where concentrations have remained relatively unchanged.
- Monitor site-wide water level rises and associated increase in source area concentrations to determine if treatment facility modifications are needed.
- Monitor the increase in concentrations west of TF406 at well W-1519 and determine if there is the need to contain further westward migration of this dilute, low-concentration TCE plume.
- Evaluate the need to expand the TF518 wellfield to include more of the western area.
- Evaluate the need to actively remediate the area south and west of Trailer 5425.

- Compare the inhalation risk methodology used for the Baseline Public Health Assessment with current methodologies to determine if the prior evaluation is sufficient or if additional modeling is warranted.

No other follow-up actions were identified related to this Five-Year Review. All cleanup actions will be conducted in concurrence with the regulatory agencies prior to implementation. The implementation and status of these recommendations will be documented in Remedial Project Manager's meeting summaries.

Protectiveness Statement:

The remedy is functioning as intended and will be protective of human health and the environment for the site's industrial land use when cleanup levels are achieved. Exposure pathways are currently controlled, and both the Health and Safety Plan and Contingency Plan are in place, properly implemented, and are sufficient to control risks. A letter to file in the Administrative Record prohibits the transfer of the property with unmitigated contamination that could cause potential harm under residential or unrestricted land use. This prohibition may be lifted if a risk assessment shows no unacceptable risk for residential or unrestricted land use and is agreed to by the DOE, the U.S. EPA, Department of Toxic Substances Control (DTSC), and the Regional Water Quality Control Board (RWQCB). In the event that the site is transferred in the future, the DOE will execute a land use covenant at the time of transfer in compliance with Title 22, California Code of Regulations, Section 67391.1.

DOE/LLNL are actively evaluating source areas cleanup technologies to reduce long-term operational costs and shorten the time to cleanup. DOE/LLNL are committed to the Livermore Site remediation objectives of (1) preventing present day and future human exposure to contaminated ground water and soil, (2) preventing contaminant migration at concentrations above Maximum Contaminant Levels, (3) reducing contaminant concentrations in ground water to levels below the state and federal Maximum Contaminant Levels, and (4) minimizing contaminant migration in the unsaturated zone that would result in concentrations in ground water above a Maximum Contaminant Level.

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1. Introduction

This report documents the third Five-Year Review period after finalizing the Record of Decision (ROD) in 1992 for the Lawrence Livermore National Laboratory (LLNL) Livermore Site. The first and second Five-Year Reviews were completed in December 1997 and September 2002, respectively. As with the prior Five-Year Reviews, this third review evaluates whether the remedial actions defined in the ROD remain protective of public health and the environment and are functioning as designed.

This Five-Year Review was conducted pursuant to Section 300.430(f)(4)(ii) of the National Oil and Hazardous Substance Pollution Contingency Plan (NCP), Title 40 Code of Federal Regulations (CFR) Part 300, which implements Section 121(c) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). Under these statutes and regulation, the Livermore Site is subject to a Five-Year Review because hazardous substances, pollutants, or contaminants remain at the site above levels that allow for unlimited use and unrestrictive exposure. Consistent with Executive Order 12580, other Federal agencies are responsible for ensuring that Five-Year Reviews are conducted as required or appropriate. This document format follows guidelines established by the EPA (EPA, 2001a) and was prepared by the University of California on behalf of DOE.

The LLNL Livermore Site ROD (U.S. Department of Energy [DOE], 1992) was signed in August 1992 by DOE and the U.S. Environmental Protection Agency (EPA). DOE is the lead agency for environmental restoration at LLNL. The lead regulatory agency for the Livermore Site is the EPA. In addition to the EPA, two California state agencies, the Regional Water Quality Control Board — San Francisco Bay Region (RWQCB), and the Department of Toxic Substances Control (DTSC), oversee the LLNL Livermore Site remediation and are parties to the Livermore Site Federal Facility Agreement (FFA).

At the end of Fiscal Year 2006 (FY 2006), all milestones on the Remedial Action Implementation Plan schedule were completed, constituting "build-out" as defined by DOE, Office of Environmental Management (EM). The Livermore Site project remains the responsibility of DOE, but has been transferred internally from EM to the National Nuclear Security Administration (NNSA) in FY 2007. The NNSA is a semi-autonomous agency within DOE.

The next Five-Year Review will be conducted in 2012.

The remedy is performing as intended and is demonstrating good progress in remediating the ground water. To further expedite the ground water cleanup, some follow-up actions are recommended in Section 8.

2. Site Chronology

Table 1 lists the chronology of major events for the Livermore Site relative to environmental restoration. Table 2 presents project restoration highlights since the second Five-Year Review.

3. Background

Livermore Site characterization and history are briefly summarized in Sections 3.1 and 3.2. Complete site description, history, and characterization information was presented in the ROD, the Livermore Site Remedial Investigation Report (Thorpe et al., 1990), and the Feasibility Study (Isherwood et al., 1990).

3.1. Site Characteristics

The Livermore Site is a research and development facility owned by DOE and operated by the University of California, located approximately three miles east of downtown Livermore, California (Fig. 1). The Livermore Site comprises approximately 800 acres. The Diablo Range hills flank the site to the south and east, and the ground surface slopes down approximately 1% to the northwest. The site is underlain by several hundred feet of interbedded alluvial and lacustrine sediments.

Ground water beneath the site is partly within the Spring and Mocho I hydrologic subbasins (California Department of Water Resources, 1974). Depth to ground water at the site varies from about 130 feet (ft) in the southeast corner to about 25 ft in the northwest corner. Municipal wells about two miles west of the site supply water to downtown Livermore. Ground water south and west of the site is used for agricultural irrigation. Two intermittent streams, Arroyo Seco and Arroyo Las Positas, are located on the site and recharge the ground water during wet periods.

Land immediately north of the Livermore Site is zoned for industrial use. To the west, the land is zoned for residential use. Sandia National Laboratories, California (SNL) is located south of the site. The area east of LLNL is zoned for agriculture and is currently used as pasture land (DOE, 2005).

3.2. Site History

The Livermore Site was converted from agricultural use by the U.S. Navy in 1942. The Navy used the site until 1946 as a flight training base and for aircraft assembly, repair, and overhaul. Solvents, paints, and degreasers were routinely used during this period. Between 1946 and 1950, the Navy housed the Reserve Training Command at the site. In 1950, the Navy allowed occupation of the site by the Atomic Energy Commission (AEC), which formally received transfer of the property in 1951. Under the AEC, the site became a weapons design and basic physics research laboratory. In 1952, the site was established as a separate part of the University of California Radiation Laboratory. Responsibility for the site was transferred to the

Energy, Research, and Development Administration in 1975. In 1977, responsibility for LLNL was transferred to DOE for the foreseeable future.

Initial hazardous materials releases occurred at the Livermore Site in the mid- to late-1940s when the site was the Livermore Naval Air Station (Thorpe et al., 1990). There is also evidence that localized spills, unlined landfills, and leaking tanks and impoundments contributed volatile organic compounds (VOCs), fuel hydrocarbons (FHCs), metals, and tritium to the ground water and unsaturated sediments in the post-Navy era. By 1987, a plume of VOCs had migrated offsite about 2,200 feet west of the current LLNL property. These past operations resulted in the Livermore Site being placed on the EPA National Priorities List in 1987 because of ground water contamination by hazardous substances, as defined in Section 101(14) of CERCLA. In August 1987, the RWQCB adopted Site Cleanup Order No. 87-018 for various parts of the site. This order was superceded in June 1988 by Order No. 88-103 that considered the site as a whole and established a schedule for CERCLA investigations and remediation.

Compounds in ground water beneath the site at concentrations above drinking water standards are:

- VOCs—trichloroethylene (TCE), perchloroethylene (PCE), 1,1-dichloroethylene (1,1-DCE), chloroform, 1,2-dichloroethylene (1,2-DCE), 1,1-dichloroethane (1,1-DCA), 1,2-dichloroethane (1,2-DCA), trichlorofluoromethane (Freon 11), and carbon tetrachloride.
- FHCs—benzene, ethylbenzene, toluene, and ethylene dibromide.
- Metals—chromium.
- Radionuclides—tritium.

Ground water is the only viable pathway of exposure, as discussed in Section 4.1. Mass remaining in the subsurface is discussed in Section 6.3.1.

Removal actions have been conducted when technically feasible at the following locations:

- Taxi Strip — The Taxi Strip area was a former radioactive liquid and storage area near the current location of Trailer 5475 (Berg, et al., 1998; Buerer, 1983; Dreicer, 1985). In 1983, soil excavation, up to a depth of 34 feet, was conducted. About 3,000 cubic yards of soil was shipped off for disposal and was completed in May 1983.
- East Traffic Circle Landfill — A landfill containing paper, construction debris, capacitors, gardening debris, etc. was excavated in August through September 1984. About 160 capacitors were removed during this removal. Nearly 14,000 cubic yards of soil and debris removed containing VOCs and polychlorinated biphenyls (PCBs). All excavated materials were shipped and disposed by September 1985 (McConachie et al., 1986).
- National Ignition Facility (NIF) Construction Site — During the NIF construction project, a cache of buried capacitors was discovered, which triggered further investigation and soil removal. Under an Emergency Removal Action (Bainer and Berg, 1998), 112 buried capacitors and 766 tons of contaminated soil and were removed and disposed in September 1997.

- East Traffic Circle residual soil clean up — Residual soil contamination from the East Traffic Circle Landfill removal was discovered in October 1998. Investigations and removal occurred during March through July 1999 under a time-critical removal action (Joma, 2000). Over 400 cubic yards of residual soil containing PCBs were removed and disposed from May through July 1999.

4. Remedial Actions

4.1. Remedy Selection

Prior to issuing the ROD, a number of assumptions were made to aid in the selection of the remedy. The assumptions were based on information available at the time, and were fully expected to change with the addition of new data, wellfield performance, and unforeseen conditions. The initial assumptions and final determinations are documented in Berg et al., 2002.

The following are the remediation objectives for all contaminants originating at the Livermore Site:

- Prevent future human exposure to contaminated ground water and soil.
- Prevent further migration of contaminants in ground water.
- Reduce contaminant concentrations in ground water to levels below Maximum Contaminant Levels (MCLs), and reduce the contaminant concentrations in treated ground water to levels below state discharge limits.
- Prevent migration in the unsaturated zone of those contaminants that would result in concentrations in ground water above an MCL.
- Meet all existing permit discharge standards for treated water and soil vapor, and to treat vapor so that there are no measurable atmospheric releases from treatment systems.

The screening conducted for the Baseline Public Health Assessment (Layton et al., 1990) considered all potential exposure pathways and concluded that ground water is the only viable pathway of exposure, and the inhalation risk from VOCs migrating from ground water to the breathing zone is insignificant. In addition, soil vapor surveys were conducted throughout the Laboratory during the Remedial Investigation, again indicating that the risk of exposure to VOCs through the inhalation pathway is insignificant.

As discussed in the Second Five-Year Review, studies were conducted in 1991 to evaluate the VOC inhalation risk to building occupants. The results from this investigation corroborated previous studies that volatilization of VOCs from the unsaturated zone do not present a health risk at LLNL.

Current LLNL property land use is restricted with the site remaining a secured DOE facility. This restriction is anticipated for the foreseeable future. Fencing around the site perimeter controls access to the site. The Livermore Site is restricted to industrial land use and the Department of Energy is prohibited from transferring any part of the site with unmitigated contamination that could cause potential harm under residential or unrestricted land use. Further explanation is provided in Section 4.6.

The following discusses the remedy selected for VOCs and tritium.

4.1.1. Ground Water Containing VOCs

The remedy selected in the ROD for ground water called for strategically placing extraction wells near contaminant plume margins to intercept and hydraulically control all ground water from LLNL with VOC concentrations exceeding MCLs. In addition, ground water would be extracted from source areas to expedite cleanup. The ROD required 18 initial extraction locations and 7 treatment facilities (TF), specifically TFA, TFB, TFC, TFD, TFE, TFF, and TFG. The total rate of ground water removal for this extraction plan was estimated to be about 350 gallons per minute (gpm). Since the ROD, TFF has been closed with regulatory concurrence, and the area encompassing the southeast corner of the site has been designated as TFH (Fig. 2).

4.1.2. Soil Vapor Containing VOCs

The primary criterion for determining if an area required vadose zone cleanup was based on whether the contamination will impact ground water in concentrations above the MCL. The remedy selected in the ROD was to use vacuum-induced venting to extract contaminant vapors from the unsaturated sediments and to treat the vapors by catalytic oxidation. Subsequent to the ROD, an Explanation of Significant Differences changed the treatment to granular activated carbon (GAC) (Dresen et al., 1993).

4.1.3. Tritium

The remedy selected in the ROD for ground water containing tritium was to minimize tritium migration, and to prevent influent to any treatment system from containing tritium in concentrations above the MCL. The approach for tritium in any media (ground water or soil vapor) was to keep it in the subsurface as much as possible where it will decay naturally.

4.1.4. Remedy Changes

Four Explanations of Significant Differences (ESDs) have been prepared for changes to the remedies selected in the ROD. An ESD is required when significant, but not fundamental, changes are made to the final remedial action plan described in the ROD. The four ESDs were prepared for changing (1) catalytic oxidation to granular activated carbon for Vapor Treatment Facility F (Dresen et al., 1993), (2) replacing ultraviolet light/hydrogen peroxide and air stripping remediation with air stripping only at Treatment Facilities A and B (Berg et al., 1997a), (3) discharge requirements for metals based on wet season and dry season beneficial use (Berg et al., 1997b), and (4) the remedy to allow ground water containing both VOCs and tritium to be brought to the surface via a closed-loop treatment system to remediate the VOCs, and returning the tritiated water to the subsurface to decay naturally (Berg, 2000). In addition, one ESD is currently in progress for sending ground water from offsite well W-404 to the Livermore Water Reclamation Plant for final treatment.

4.2. Remedy Implementation

DOE has met or exceeded the remedy construction activities described in the ROD and remedial design reports. The ROD specified construction of seven ground water and two vapor facilities to treat VOCs. After installing four fixed treatment facilities, DOE began constructing and installing less expensive portable ground water treatment units for use at more locations than specified in the ROD. This increased cleanup flexibility and reduced capital cost. Since the start of ground water cleanup, DOE has constructed and operated 35 ground water treatment facilities and 11 treatment vapor facilities. Currently, 28 ground water facilities and 9 vapor facilities are in operation (Fig. 2). In addition, the ROD specified 18 initial extraction locations (with one or more wells at these locations). Currently the Livermore Site has 93 ground water extraction wells, 35 dual extraction wells, and 19 vapor extraction wells.

Another contaminant of concern at the site is tritium. DOE continues to meet the objective of the ROD by keeping the tritium in the subsurface as much as possible (Section 4.1.3). All tritium activities are currently below the MCL. Even though mitigation actions are in place, minor tritium activities are detected in some of the granular activated carbon from treatment facilities in tritium-contaminated areas. Moisture from the soil vapor may contain tritium that can condense onto the carbon; low tritium activities from the ground water may also reside the carbon. When tritium is detected in the granular activated carbon, it is properly handled as mixed waste.

During the first and second Five-Year Reviews, the remedial actions were found to be functioning as intended, and the current remediation network continues to function as intended. At the end of Fiscal Year 2006, all milestones on the Remedial Action Implementation Plan milestone list were completed, constituting "build-out" as defined by DOE Environmental Management.

Milestone construction activities followed the Remedial Project Managers' priorities as documented in the Livermore Site Consensus Statement. The current Consensus Statement is included as Attachment A, and identifies the remediation priorities as:

1. Western site boundary (distal plumes).
2. Southern site boundary (distal plumes).
3. Internal source areas.

Engineered Plume Collapse (EPC) (Berg et al., 2002) was used to implement these priorities. Figure 3 shows an example of EPC implementation. For EPC, the first step is to hydraulically control and isolate the source, then remediate the high concentration distal plume, contain the plume leading edge, and lastly focus on source area remediation.

DOE, LLNL, and the regulatory agencies have long recognized that the sources control the long-term duration and cost of the site cleanup. A commitment to an ongoing evaluation of source technologies was made in the Second Five-Year Review. Some potential technologies have been identified. EPA's Office of Research and Development visited the site and favored thermal remediation technologies. As part of the ongoing Phased Source Remediation (PSR) strategy, the focus is now to test new technologies that may accelerate the source area cleanup. PSR strategy phases in increasingly costly technologies, as needed, to remediate the source areas.

A Source Area Cleanup Technology Evaluation (SACTE) tool is currently being used to help choose effective source cleanup technologies. This tool provides direct comparison of approaches to allow the appropriate cleanup technology to be matched to each source area, and to evaluate the cost effectiveness of the technology. SACTE will be applied to all the Livermore Site source areas (Fig. 4).

Various source remediation technologies are proposed in a series of pilot tests during FY 2007, taking advantage of existing infrastructure as much as possible. The proposed work scope for this source remediation focus includes:

- Pilot field-scale tests of heated air injection and dynamic operation flushing to enhance vadose zone and capillary fringe drying, help mobilize and extract contaminants, and enhance air permeability.
- Meeting with vendors to evaluate mechanical fracturing to enhance contaminant mass transfer in the saturated zone.
- Bench-scale tests to evaluate bioremediation, oxidants, and reductants for *in situ* contaminant destruction in the saturated zone.

Results from the pilot tests in FY 2007 will direct new technology deployments in FY 2008 and beyond. A key component of the pilot studies will be to evaluate potential long-term efficacy of the source area remediation technologies. As shown through the SACTE approach, many technologies may have a significant short-term benefit, but post-deployment contaminant rebound can extend the cleanup for long durations, deriving minimal cost benefit to deploying the technology.

This source work is the logical "next step" in source area cleanup conducted at the Livermore Site as part of the PSR strategy. To date, the following has been implemented at the Livermore Site source areas:

- Excavation of four sources.
- Application of Electro-Osmosis to enhance mobility by applying a low voltage.
- Application of Dynamic Underground Stripping to volatilize contaminants by steam injection.
- Operation of vadose zone remediation systems at 11 sources.
- Hydraulic containment and advection-dominated ground water treatment at 15 sources.
- Vacuum-enhanced ground water extraction at five sources.
- Regulatory closure of two sources.
- One agreement for source "monitoring only".

4.3. System Operation

Table 3 presents information on each operating treatment facility. All facilities are performing as designed to remediate ground water or soil vapor. Monthly self-monitoring data show that the treatment facilities are removing contaminants from ground water and soil vapor, and treating the contaminants to concentrations below discharge levels. Adherence to

substantive requirements has been consistent over the last five years with infrequent incidents promptly reported and corrected. All noncompliance issues are documented in the Remedial Project Manager's meeting summaries. Compliance issues over the last five years are summarized in Table 4.

4.4. Operation and Maintenance

Operation and Maintenance (O&M) requirements include:

- Mechanical O&M.
- Control and instrument calibration.
- Facility documentation and data collection.
- Maintaining the particulate filters, blowers, and pumps.
- Replacing granular activated carbon, and/or ion-exchange resin.
- Routinely inspecting and maintaining interlocks, extraction well pumps, pipelines, blowers, and sensors.

O&M procedures are contained in the Remedial Design documents, the facility O&M Maintenance Manuals, and with Standard Operating Procedures. The discharges and procedures are consistent with the RWQCB and Bay Area Air Quality Management District requirements.

Because the treatment facilities changed from fixed facilities to more, smaller, portable treatment units, the O&M costs described in the Remedial Design reports are not directly comparable to the current treatment facility network. Currently the direct cost to operate 37 treatment facilities is about $9.2M per year. Unexpected increases in O&M costs have been due to:

- Mixed waste issues increasing the cost of granulated activated carbon disposal.
- Higher than expected flow rates increasing the maintenance of drainage ditches.
- Electricity utility rates increasing.
- High calcium carbonate scaling requiring addition of a sequestering compound and more frequent periodic maintenance of the air strippers and discharge pumps.

4.5. Funding

Total project funding over the last five years as authorized by DOE for cleanup at the Livermore Site is presented in Table 5.

4.6. Institutional/Land Use Controls

The screening conducted for the Baseline Public Health Assessment considered all potential exposure pathways and concluded that ground water is the only viable pathway of exposure. Current offsite access is restricted by the local water purveyor controlling water supply well installation. Current onsite access to the ground water is restricted by the site remaining a

secured DOE facility. No water-supply wells are planned onsite, and any onsite drilling and excavation is first discussed with LLNL's Environmental Restoration Division.

In March 2007, the Department of Energy entered a letter to file into the Administrative Record for the Livermore Site Record of Decision that discusses the land use controls and requirements (Attachment B). This letter documents a prohibition from transferring any part of the Livermore Site with unmitigated contamination that could cause potential harm under residential or unrestricted land use. This prohibition may be lifted if a risk assessment shows no unacceptable risk for residential or unrestricted land use and is agreed to by the DOE, the U.S. EPA, DTSC, and the RWQCB. In the event that the site is transferred in the future, the DOE will execute a land use covenant at the time of transfer in compliance with Title 22, California Code of Regulations, Section 67391.1.

5. Status of Recommendations from the Second Five-Year Review

The second Five-Year Review stated that: "The remedy is functioning as intended and is protective of human health and the environment. Both the Health and Safety Plan and Contingency Plan are in place, properly implemented, and are sufficient to control risks. DOE/LLNL are actively working toward completing the remediation system build-out as quickly as possible to reduce long-term operational costs and accelerate the time to cleanup. DOE/LLNL are committed to the Livermore Site remediation objectives of (1) preventing present day and future human exposure to contaminated ground water and soil, (2) preventing contaminant migration at concentrations above MCLs, (3) reducing contaminant concentrations in ground water to levels below the state and federal MCLs, and (4) minimizing contaminant migration in the unsaturated zone that would result in concentrations in ground water above an MCL."

The following discusses the status of recommendations from the second Five-Year Review:

- <u>Characterize the source of high VOC concentrations in the Building 518 perched water-bearing zone</u>. Additional data collection through passive soil vapor investigations and soil vapor extraction tests were conducted in the Building 518 area. In September 2004, a vapor extraction system was activated in the Building 518 perched zone.
- <u>Evaluate reinjection and/or vapor extraction for dewatered locations</u>. Vapor extraction has been implemented in some areas to take advantage of dewatering, such as the Trailer 5475 area, TF406 Hotspot, and TFE Hotspot.
- <u>Continue to monitor the potential stagnation zone downgradient of Treatment Facility A to determine if ground water extraction is needed at this location</u>. DOE/LLNL looked into options for remediating the offsite detached plume and chose to pump ground water from this location for a short duration (2 to 4 years) and discharge the water to sanitary sewer for final treatment. This operation started in January 2007 as a one-year treatability test. An Explanation of Significant Difference is also being prepared and will be completed within the one year timeframe.

- Continue to characterize the source areas and further evaluate source area remediation technologies. The subsurface scientists and engineers have been focusing on the subsurface processes that influence the behavior of contaminants in source areas. The objective has been to focus on the science of contaminant behavior, source area characterization, and engineering solutions. As discussed in Section 4.2, the SACTE approach is being used to help choose effective source cleanup technologies. LLNL and DOE are working together to evaluate these technologies and potential for use at LLNL.
- Complete the remediation system build-out as soon as possible. As of September 2006, all of the Remedial Action Implementation Plan milestones for system build-out were completed. LLNL/DOE continue to evaluate where additional systems or system modifications will optimize the cleanup.
- Evaluate treated water disposal options at Treatment Facility A. Treated water is now discharged to both Arroyo Seco and Arroyo Las Positas. Because the flow rate is no longer limited by the Recharge Basin, Treatment Facility A is now able to operate at optimal flow rates.

6. Third Five-Year Review Process

This Five-Year Review consisted of examining relevant project documents and site data. A notice informing the public that this Five-Year Review was in progress was placed in the Valley Times, Tri-Valley Herald, and The Independent newspapers. A notice will also be placed at the completion of this Five-Year Review. Project documents are available in the information repositories at the LLNL Discovery Center and the Livermore Public Library. Most project documents can also be accessed electronically at LLNL's Environmental Restoration Division electronic library web page at http://www-erd/library/ or the Environmental Community Relations web page at http://www-envirinfo.llnl.gov.

6.1. Interviews and Site Inspection

Interviews or site inspection are not required because DOE, the lead agency, with oversight from EPA, RWQCB, and DTSC have an ongoing presence, and are involved with, and are knowledgeable of site activities, issues, concerns, and status (EPA, 2001a).

6.2. Risk Information Review

There have been no changes in location-, chemical- or action-specific requirements that would affect the remedies, or in exposure pathways, toxicity, and other contaminant characteristics since the ROD. However, in August 2001, U.S. EPA's Office of Research and Development released the draft "Trichloroethylene Health Risk Assessment: Synthesis and Characterization" that has since been undergoing external peer review (EPA, 2001b). This assessment indicates that, for those who have increased susceptibility and/or higher background exposures, TCE could pose a higher risk than previously considered. Since review of the toxicity value for TCE may continue for a number of years, this issue will be updated in future Five-Year Reviews.

6.3. Data Review and Evaluation

The most complete and current data set was used for the following discussions. This includes ground water analytical results, water level measurements, borehole data, and treatment facility data. Due to the timing of this report, the most current data was third quarter 2006. Figures, mass calculations, and cleanup progress are reported using this data. Five-year trends compare progress since third quarter 2001.

6.3.1. Mass Removal

Through September 2006, over 3 billion gallons of ground water and over 240 million cubic feet of soil vapor have been treated since the onset of site cleanup in 1989, removing over 2,200 kilograms (kg) of VOCs. During this Five-Year Review period, about 440 kg of VOCs were removed from ground water and about 600 kg of VOCs from soil vapor (over 1,000 kg total).

In comparison to the prior Five-Year Review, this represents over a 30% decrease in ground water mass removed due to lower concentrations in distal plumes as they are remediating, as well as dewatering in the higher-concentration areas, which limits sustainable pumping rates. Conversely, there is a significant increase (about 70%) in mass removed from soil vapor due to activating eight soil vapor and dual extraction treatment facilities since 2002.

Based on data collected over the last five years, new estimates of the remaining mass and pore volumes of VOCs exceeding 5 parts per billion (ppb) remaining in the subsurface were calculated for each hydrostratigraphic unit (Table 6). A hydrostratigraphic unit (HSU) is a sequence of sediments grouped together on the basis of hydraulic properties, geologic data, and chemical data.

The estimated remaining VOC mass in ground water changed from 940 kilograms (kg) in 2002 (Berg et al., 2002) to about 670 kg in 2006 (Table 6), resulting in a reduction of about 270 kg. However, during the same time interval, the total VOC mass removed at the ground water treatment facilities was 440 kg. The difference is because the estimated mass only accounts for VOCs dissolved in ground water and does not include VOC mass adsorbed on to the sediments at the sources; however, extraction wells recently completed in source areas are removing significant amounts of absorbed VOC mass. Thus the difference between the estimated mass reduction versus the actual mass removed highlights the progress toward source area cleanup over the last five years.

6.3.2. Chemical Trends

Chemical trends were compared over a five-year timeframe (third quarter 2001 to third quarter 2006) to evaluate the cleanup progress for this Five-Year Review. Over this five-year interval, the size and concentration of contaminant plumes at the Livermore Site have decreased significantly in areas with active ground water extraction and treatment. The following sections summarize key points of this trend analysis for the western margin, southern margin, and site interior. Figures 5 through 13 show the plume configuration at the time of the last Five-Year Review (third quarter 2001), as well as the third quarter 2006 status for HSUs 1B, 2, 3A, 3B, 4, and 5, respectively. Treatment facilities are identified on Figure 2.

6.3.2.1. Western Margin Chemical Trends

The ongoing western margin cleanup strategy consists of hydraulically containing VOC plumes within the site boundary and collapsing the offsite contaminant plumes back on site toward their respective source areas. Concentrations continued to decline across the entire western margin. Highlights of VOC concentration trends over the last five years are discussed below by individual HSUs. Wells discussed in the text are shown on Figures 5 through 7.

Hydrostratigraphic Unit 1B

- The TFA plume containing VOCs above the cleanup level retreated about 900 ft eastward toward the source area. Only one area offsite (around well W-1425) currently contains ground water VOC concentrations above the MCL (PCE at 11 parts per billion [ppb]) (Figs. 5 and 6).
- VOC concentrations continued to decline in the TFA source area. PCE concentrations declined from maximum concentrations of 540 to 150 ppb.
- The TFB plume containing VOCs above the cleanup level retreated about 500 ft eastward toward the source area. No concentrations above MCLs remain offsite in the TFB area (Fig. 6).
- TFC VOC concentrations continue to decline, with the leading edge of the plume retreating up to 500 ft eastward. Due to increasing concentration trends in the TFC Hotspot area, source area clean up was initiated in April 2006 (Table 2).
- TCE concentrations have increased about 10-fold since 2001 at piezometer SIP-191-002 (from 5 to 47 ppb), suggesting the presence of a small, local source area (Fig. 6). Since this source area is within the hydraulic capture area of well W-1104, it poses no threat to offsite ground water quality. However, it will be further investigated under items listed in Section 8.

Hydrostratigraphic Unit 2

- PCE concentrations in all TFA offsite wells declined below 25 ppb for the first time. Offsite concentrations remained highest in the stagnation zone near at monitor well W-404 (see Section 7) (Fig. 7).
- Although TFB area TCE concentrations are declining, concentrations increased along the western margin at one location, well W-422, from 1.7 to 12 ppb (Fig. 7). This will be further investigated under items listed in Section 8.

6.3.2.2. Site Interior and Southern Margin Chemical Trends

Hydraulic containment has been achieved for most of the sources within the site interior and southern margin. Additionally, high-concentration distal plumes are being aggressively targeted for cleanup. Since 2004, most treatment facility construction has focused on source area cleanup, primarily using soil vapor and dual extraction, and vacuum-enhanced ground water extraction. Highlights of VOC concentration trends over the last five years are discussed below. Wells discussed in the text are shown on Figures 7 through 13.

Hydrostratigraphic Unit 2

- The large, mobile Freon 11 contaminant plume north of TFD in HSU-2 has largely been reduced to below MCLs (Figs. 7 and 8). The remaining plume is being captured by treatment facilities TFD West and TFC East.
- In the TFD area, VOC concentrations were reduced by about 50% due to ground water extraction at TFD, TFD East, TFD Southeast, TFD West, TFD South, and TFD Southshore. VOC concentrations greater than 500 ppb have largely disappeared. For example, total VOC concentrations declined from 740 to 250 ppb at well W-1303 (Fig. 7).
- Ground water TCE concentrations from the TFE East plume showed a significant decline due to pumping at TFE East, TFE West, and TFG North (Figs. 7 and 8). Total VOC concentrations at well W-305 declined from 220 to 44 ppb; both the 25 and 50 ppb MCL isoconcentration contours collapsed eastward about 750 ft. Concentrations in the source area decreased consistently over the same period in response to both ground water and soil vapor extraction (2,200 to 660 ppb TCE in SIP-543-101).
- VOC concentrations at other source areas, such as TFE Hotspot and TF5475 remained largely unchanged. Clean up technologies to accelerate clean up in these fine-grained, low-permeability saturated source areas are currently being evaluated (see Sections 4.2 and 8).

Hydrostratigraphic Unit 3A

- In the TF5475 and eastern TFE areas, contaminant plumes consistently declined in concentrations. Total VOC concentrations at well W-363 declined from 710 to 255 ppb, and 808 to 423 ppb at well W-1201 (Fig. 9). However, concentrations remain well above MCLs in the Trailer 5425 area, where no active source area remediation is currently underway. In western TFE, a slight increase in concentration was noted in well W-276, where total VOC concentrations increased from 111 to 148 ppb. Similar increases were also observed in HSU-3B and 4. Both these issues will be further investigated under items listed in Section 8.
- VOC concentrations remained elevated in the Building 419 source area (2,200 ppb TCE in well W-1414, November 2006). Concentrations at this location are anticipated to start declining due to the recent implementation of soil vapor and dual extraction in September 2006.
- In western TFD, concentrations of Freon 11 and TCE have been reduced by ground water extraction and treatment at TFD West, TFD, and TFD Southshore. However, concentrations of Freon 11 have risen above its MCL in well W-315 (Fig. 9). This issue will be further investigated under items listed in Section 8. To the east, concentrations remain largely unchanged in the TFD Helipad, TFD East Traffic Circle South, and TFD Hotspot source areas, where clean up was recently activated (Table 2).

Hydrostratigraphic Unit 3B

- VOC concentrations declined in the TFD Southshore area, where TCE reduced from 650 to 330 ppb in well W-1601 (Fig. 10).
- In 2004, VOC concentrations appeared in well W-618 for the first time, indicating the presence of a low concentration plume (below MCLs) located west of TFE West. Consistent decreases in concentration observed within the TFE West capture area (TCE concentrations

decreased from 55 to 30 ppb at well W-292) suggest effective hydraulic containment of the plume at this location, and that the dilute portion of the plume now appearing at well W-618 was already beyond the reach of the TFE West facility upon activation.

Hydrostratigraphic Unit 4

- Along the southern border of the site, VOC concentrations remained below MCLs in the TF406 area, where extraction wells have been shutdown since 2000 (Fig. 11). Cleanup has been demonstrated by no rebound of concentrations.
- Ground water in the TFD Helipad and East Traffic Circle North areas show a general increase in VOC concentrations. Source area clean up was recently activated at both TFD Helipad and TFD East Traffic Circle North in response to these concentration trends (Table 2).
- Ground water concentrations in the central TFD area have declined in response to extraction at TFD and TFD Southshore. Concentrations of TCE reduced from 810 to 100 ppb in well W-351 (Fig. 11).
- At TFD Southeast, concentrations have remained relatively unchanged, despite ongoing pumping at well W-314. The source of this contamination remains uncertain. This issue will be further investigated under items listed in Section 8.
- In the TFE area, VOC concentrations have declined in the southwestern area (TCE in well W-1505 decreased from 360 to 100 ppb); however, further to the west they have increased in well W-304 where TCE concentrations increased from 6 to 26 ppb over the same period. This issue will be further investigated under items listed in Section 8.

Hydrostratigraphic Unit 5

- Along the southern margin, VOCs have largely been remediated beneath Sandia National Laboratories property as a result of ground water extraction at TF406. The plume containing VOCs above the cleanup level has retreated over 800 ft, with only one small area around well W-509 remaining above the cleanup level (Figs. 12 and 13). The steady decline in concentrations eliminated the need to install a treatment facility at TF406 South.
- A dilute TCE plume west of TF406 at well W-1519 remained above the cleanup level during this period (at 16 ppb). This issue will be further investigated under items listed in Section 8.
- Elsewhere in the TFH and TFE areas, concentrations in ground water have remained largely unchanged, except for a slight increase in concentrations in the western portion of TFE and a larger increase around Building 511. In the vicinity of Building 511, the increase may be related to a site-wide rise in ground water elevations that occurred between 2004 and late 2006. Source area cleanup using soil vapor extraction began the Building 511 area in September 2006.
- To the west of the Building 518 source area, elevated concentrations of VOCs were discovered in the vadose zone during this period. This issue will be further investigated under items listed in Section 8.

7. Technical Assessment

The following conclusions support the determination that the remedy is functioning as intended and is protective of human health and the environment:

- Mass removal has exceeded that predicted in the ROD.
- The Health and Safety Plan and Contingency Plan are in place, properly implemented, and are sufficient to control risks.
- All required institutional controls are in place and any current or planned changes in land use at the site suggest that they would continue to be effective.
- Ground water and soil vapor extraction and treatment will effectively control contaminant migration and reduce the contaminant concentration and areal extent.
- The ground water remedial actions continue to be effective in reducing contaminant mass and extent.
- Treatment facilities are operating as designed and in a manner consistent with requirements.
- No early indicators of potential remedy failure were noted in this Five-Year Review.
- There have been no changes in cleanup levels, and the remedial action objectives used at the time of the remedy selection are still valid.
- There have been no changes in location-, chemical- or action-specific requirements; exposure pathways, toxicity, and other contaminant characteristics; or changes in risk assessment methodologies that would invalidate the remedy selection. As discussed in Section 6.2, the TCE toxicity value is under review and will be updated in future Five-Year Reviews.
- No other information has been identified that could call into question the protectiveness of the remedy.

8. Recommended Actions Based on the Third Five-Year Review

The following recommendations were developed by DOE/LLNL during the third Five-Year Review process:

- Complete a source area cleanup technology evaluation (SACTE) on all sources.
- Investigate thermal remediation technologies.
- Evaluate bioremediation, oxidizers, and mechanical fracturing under site specific conditions as possible source area remediation technologies for saturated sediments at the Livermore Site.

- Test heated air injection and dynamic operations for the cleanup of contaminants residing in the vadose zone and capillary fringe.
- Monitor increasing TCE concentration trends at piezometer SIP-191-002 to determine if further actions are warranted.
- Conduct wellfield optimization and hydraulic testing of the TFB HSU-2 plume to determine if wellfield modifications are needed.
- Conduct modeling to evaluate the need for hydraulic capture and treatment to prevent further westward migration of HSU-3A, 3B, and 4 plumes in the western TFE area.
- Conduct modeling to evaluate the need for hydraulic capture and treatment to prevent further westward migration of the HSU-3A Freon 11 plume in western TFD area.
- Investigate the source of the HSU-4 contamination at TFD Southeast where concentrations have remained relatively unchanged.
- Monitor site-wide water level rises and any associated increases in source area concentrations to determine if treatment facility modifications are needed.
- Monitor the increase in concentrations west of TF406 at well W-1519 and determine if there is the need to contain further westward migration of this dilute, low-concentration TCE plume.
- Evaluate the need to expand the TF518 wellfield to include more of the western area.
- Evaluate the need to actively remediate the area south and west of Trailer 5425.
- Compare the inhalation risk methodology used for the Baseline Public Health Assessment with current methodologies to determine if the prior evaluation is sufficient or if additional modeling is warranted.

9. Protectiveness Statement

The remedy is functioning as intended and will be protective of human health and the environment for the site's industrial land use when cleanup levels are achieved. Exposure pathways are currently controlled, and both the Health and Safety Plan and Contingency Plan are in place, properly implemented, and are sufficient to control risks. A letter to file in the Administrative Record prohibits the transfer of the property with unmitigated contamination that could cause potential harm under residential or unrestricted land use. This prohibition may be lifted if a risk assessment shows no unacceptable risk for residential or unrestricted land use and is agreed to by the DOE, the U.S. EPA, DTSC, and the RWQCB. In the event that the site is transferred in the future, the DOE will execute a land use covenant at the time of transfer in compliance with Title 22, California Code of Regulations, Section 67391.1.

DOE/LLNL are actively evaluating source areas cleanup technologies to reduce long-term operational costs and accelerate the time to cleanup. DOE/LLNL are committed to the Livermore Site remediation objectives of (1) preventing present day and future human exposure to contaminated ground water and soil, (2) preventing contaminant migration at concentrations above Maximum Contaminant Levels, (3) reducing contaminant concentrations in ground water

to levels below the state and federal Maximum Contaminant Levels, and (4) minimizing contaminant migration in the unsaturated zone that would result in concentrations in ground water above a Maximum Contaminant Level.

10. Next Review

The next review will be conducted in 2012, within five years of the completion of this Five-Year Review.

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12. Acronyms and Abbreviations

1,1-DCA	1,1-dichloroethane
1,2-DCA	1,2-dichloroethane
1,1-DCE	1,1-dichloroethylene
1,2-DCE	1,2-dichloroethylene
AEC	Atomic Energy Commission
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CRD	Catalytic Reductive Dehalogenation
DOE	U.S. Department of Energy
DTSC	California Department of Toxic Substances Control
ELM	Eastern Landing Mat
EM	Environmental Management
EPA	U.S. Environmental Protection Agency
ESD	Explanation of Significant Differences
ETC	East Traffic Circle
ETCN	East Traffic Circle North
ETCS	East Traffic Circle South
ETS	East Taxi Strip
FFA	Federal Facility Agreement
FHC	fuel hydrocarbon
Freon 11	trichlorofluoromethane
FY	fiscal year
GAC	Granular Activated Carbon
GTU	GAC Treatment Unit
HSU	Hydrostratigraphic Unit
kg	kilograms
LLNL	Lawrence Livermore National Laboratory
MCL	Maximum Contaminant Level
Mgal	millions of gallons
MTU	Miniature Treatment Unit
NIF	National Ignition Facility

NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NNSA	National Nuclear Security Administration
O&M	Operations and Maintenance
PCB	polychlorinated biphenyl
PCE	perchloroethylene
ppb	parts per billion
PSR	Phased Source Remediation
PTU	Portable Treatment Unit
ROD	Record of Decision
ROI	Return on Investment
RWQCB	California Regional Water Quality Control Board
SACTE	Source Area Cleanup Technology Evaluation
SARA	Superfund Amendments and Reauthorization Act
SNL	Sandia National Laboratories
STU	Solar Treatment Unit
TCE	trichloroethylene
TF	Treatment Facility
TF406	Treatment Facility 406
TF5475	Treatment Facility 5475
TF518	Treatment Facility 518
TFA	Treatment Facility A
TFB	Treatment Facility B
TFC	Treatment Facility C
TFD	Treatment Facility D
TFE	Treatment Facility E
TFF	Treatment Facility F
TFG	Treatment Facility G
TFH	Treatment Facility H
UV	ultraviolet light
VES	Vapor extraction system
VOC	volatile organic compound
VTF406	Vapor Treatment Facility 406

VTF511 Vapor Treatment Facility 511

VTF518 Vapor Treatment Facility 518

VTF5475 Vapor Treatment Facility 5475

VTFE Vapor Treatment Facility E

VTFD Vapor Treatment Facility D

Figures

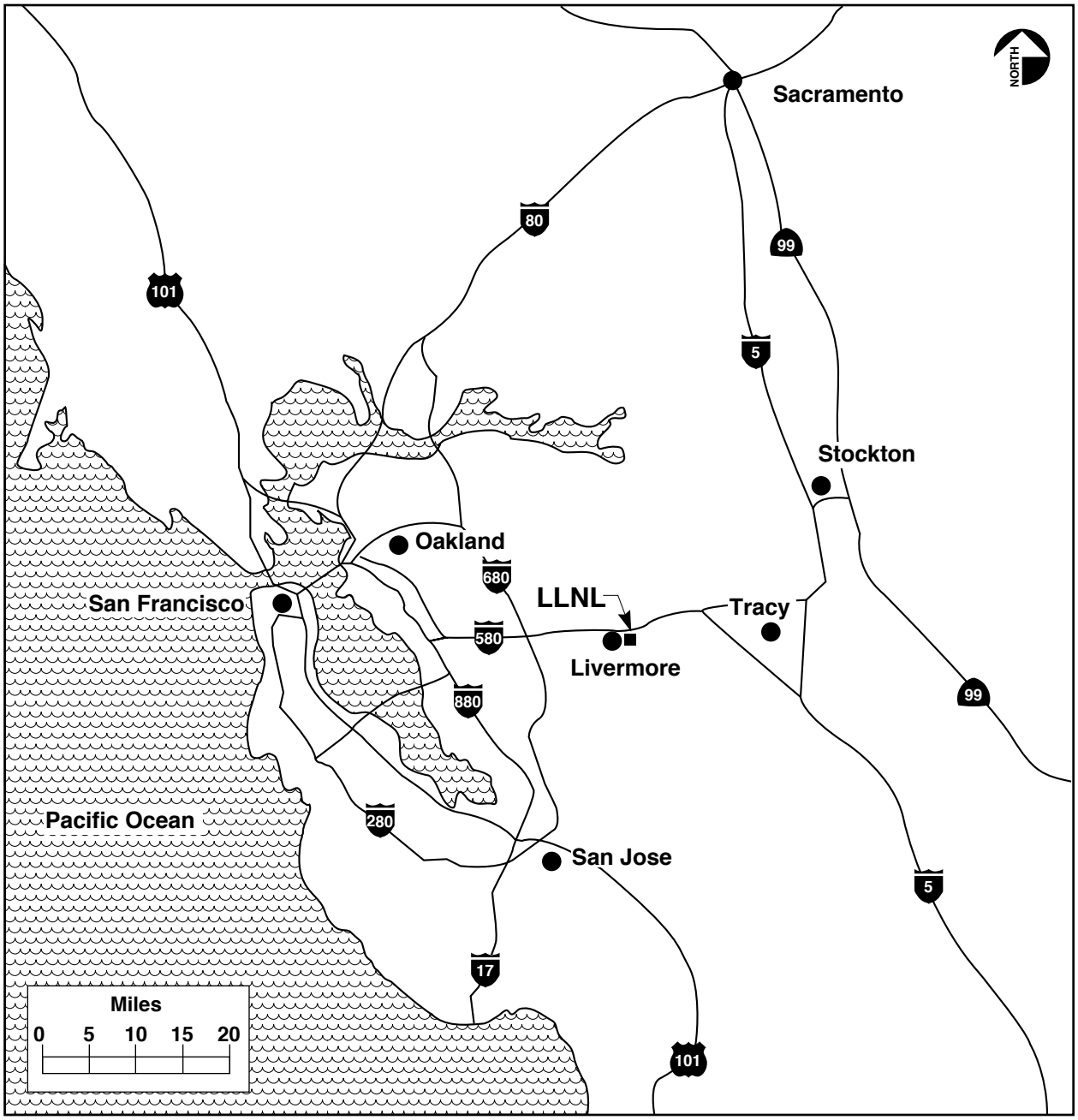

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Figure 1. Location of the LLNL Livermore Site.

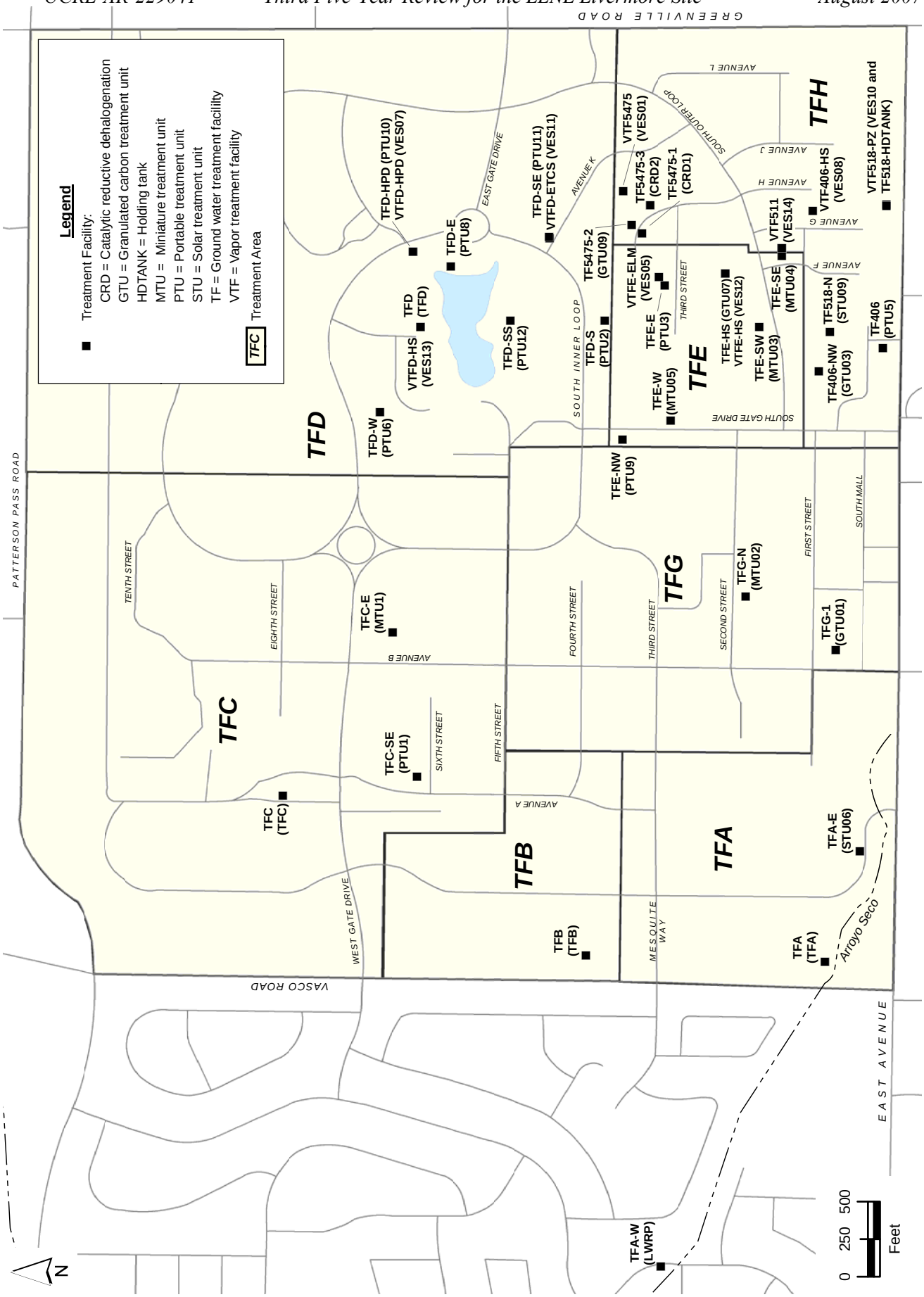

Figure 2. Livermore Site treatment areas and treatment facility locations.

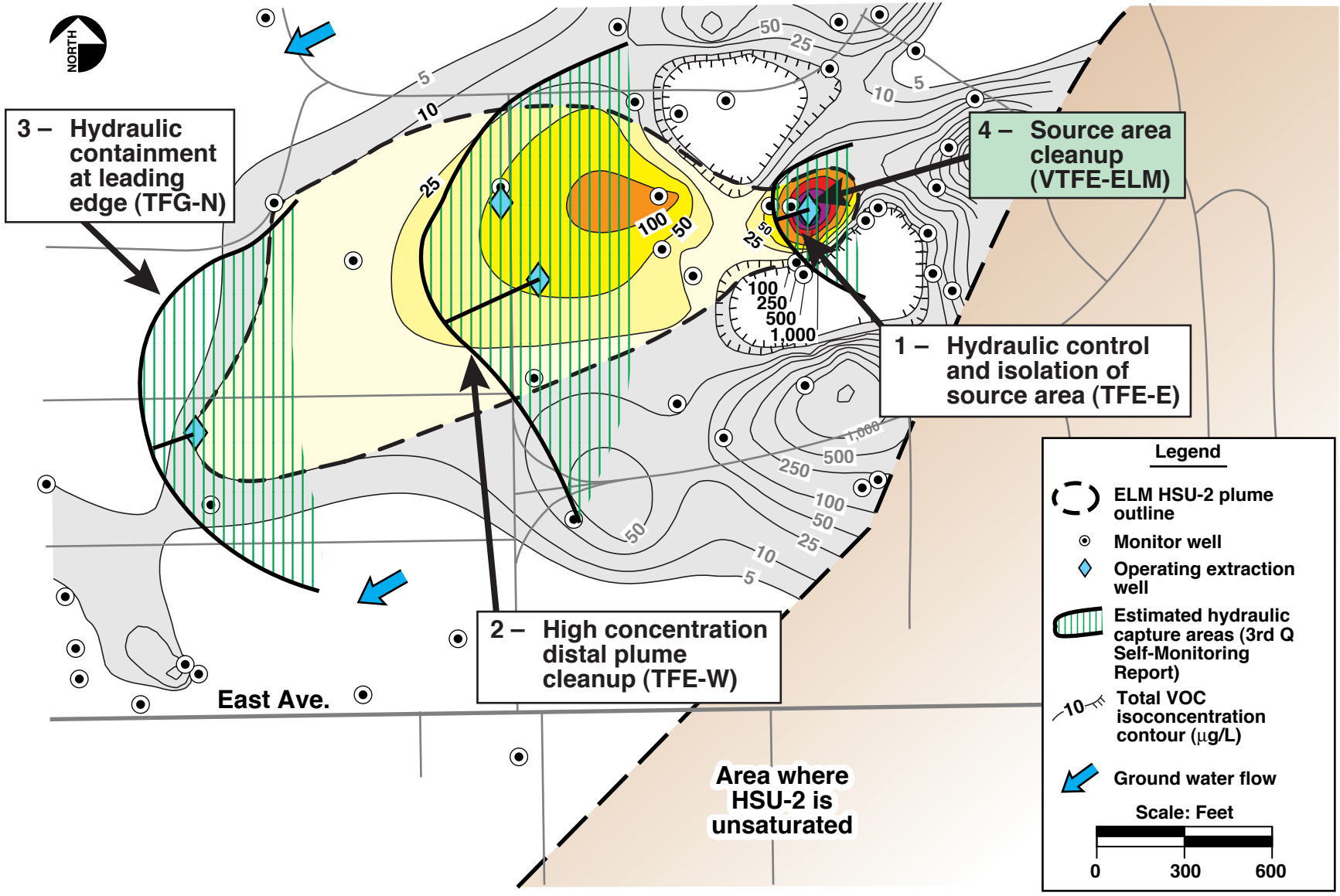

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Figure 3. Example of Engineered Plume Collapse implementation.

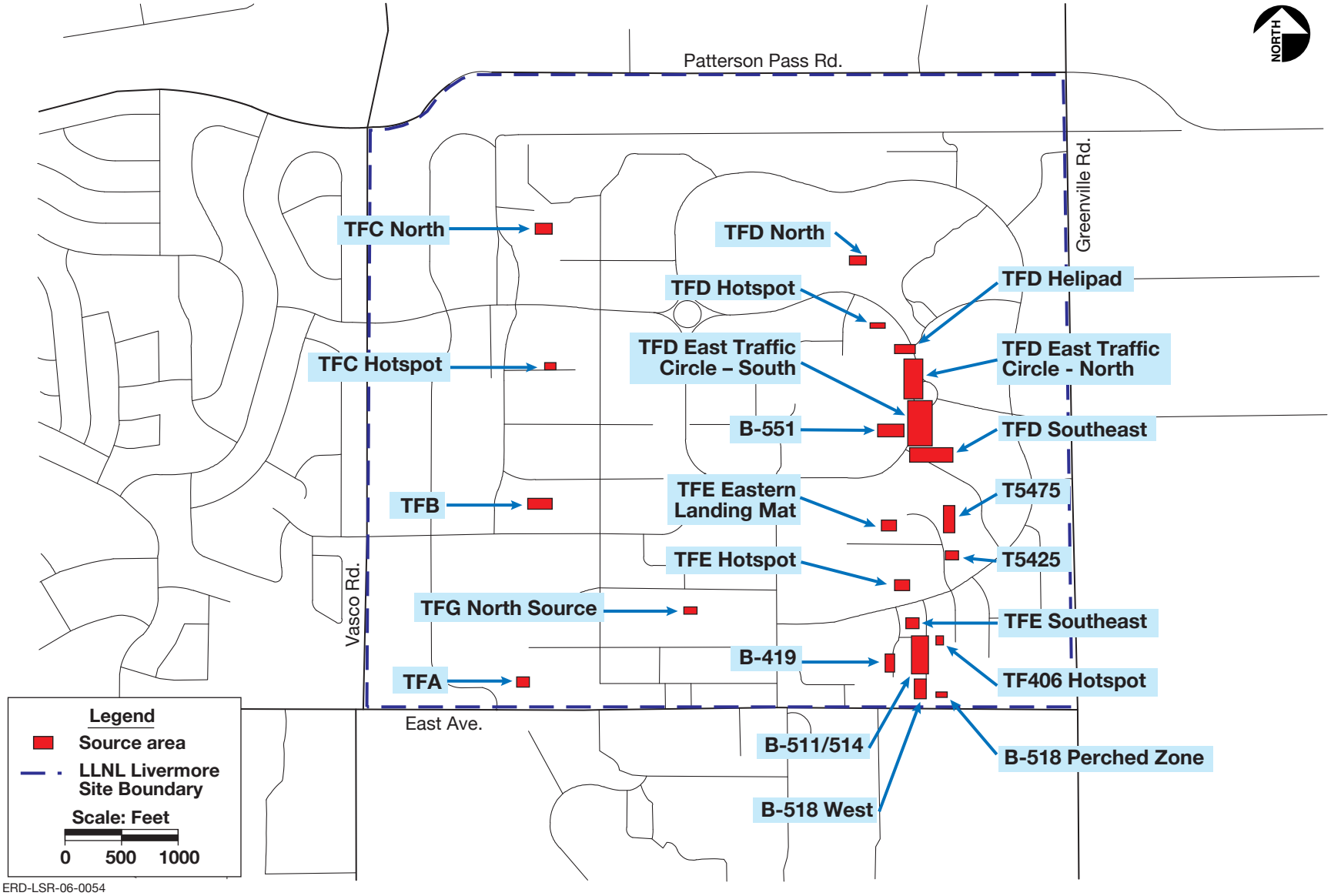
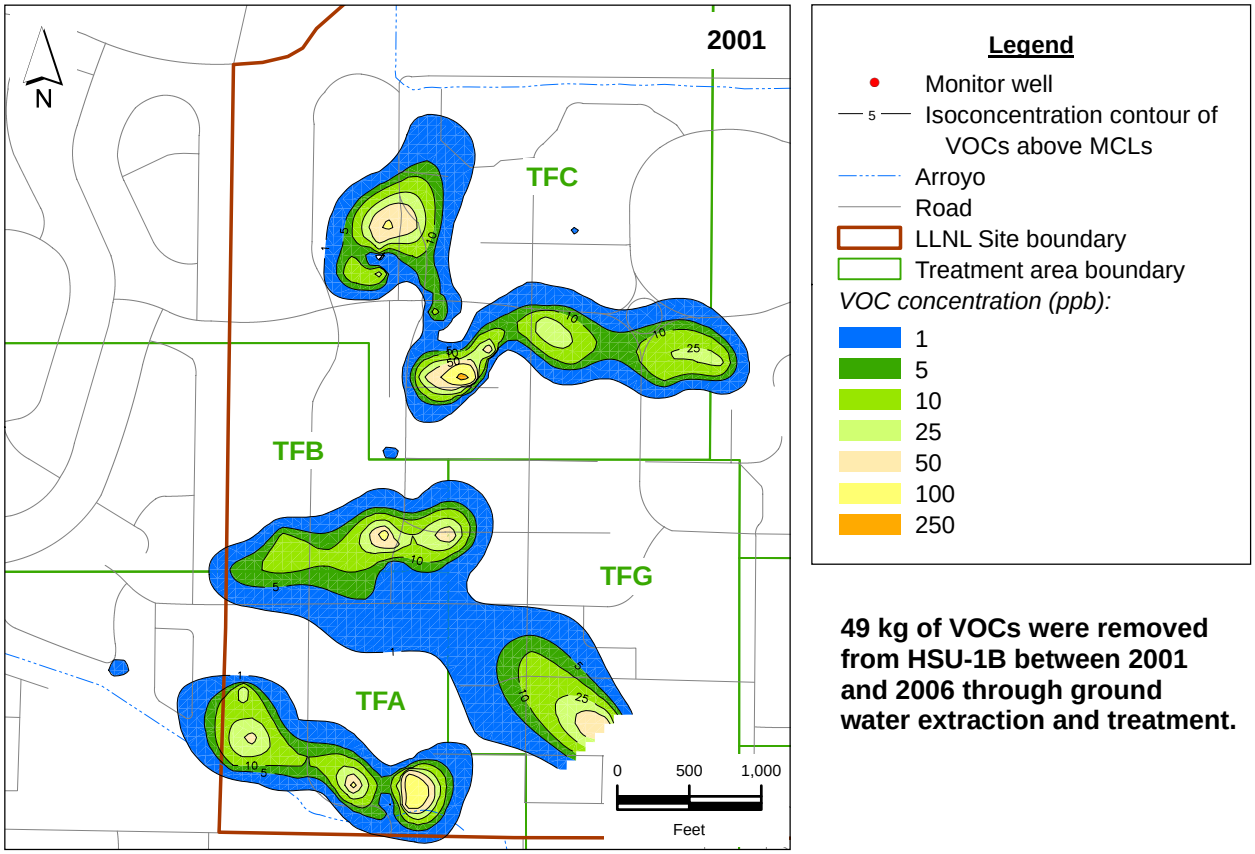


Figure 4. Livermore Site Source Areas.



49 kg of VOCs were removed from HSU-1B between 2001 and 2006 through ground water extraction and treatment.

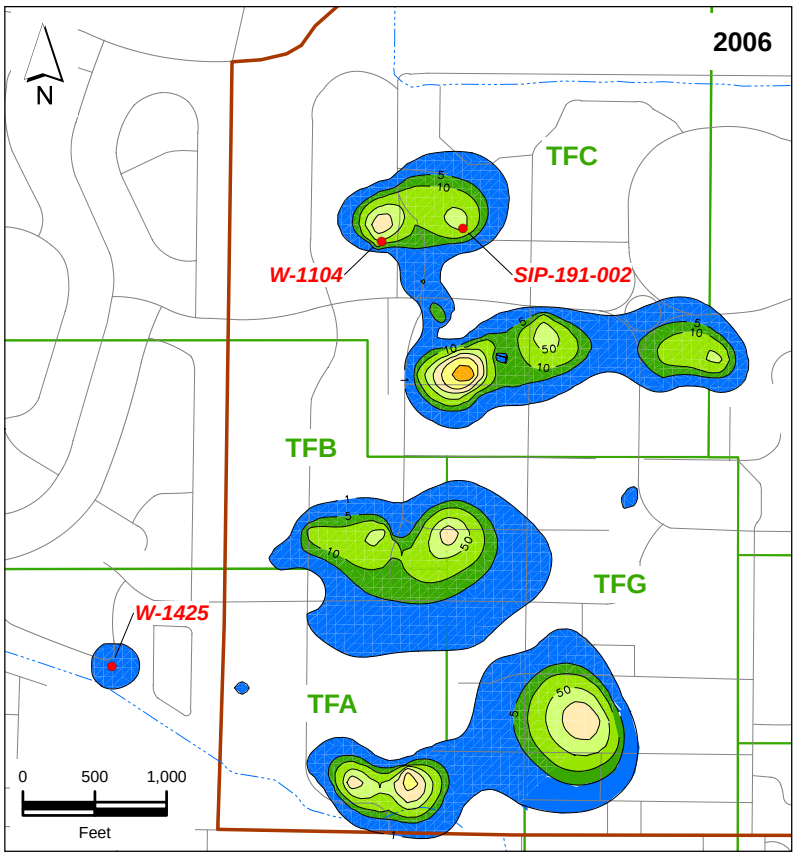


Figure 5. Time-series isoconcentration maps of VOCs above MCLs based on wells completed within Hydrostratigraphic Unit 1B (HSU-1B) for 2001 and 2006.

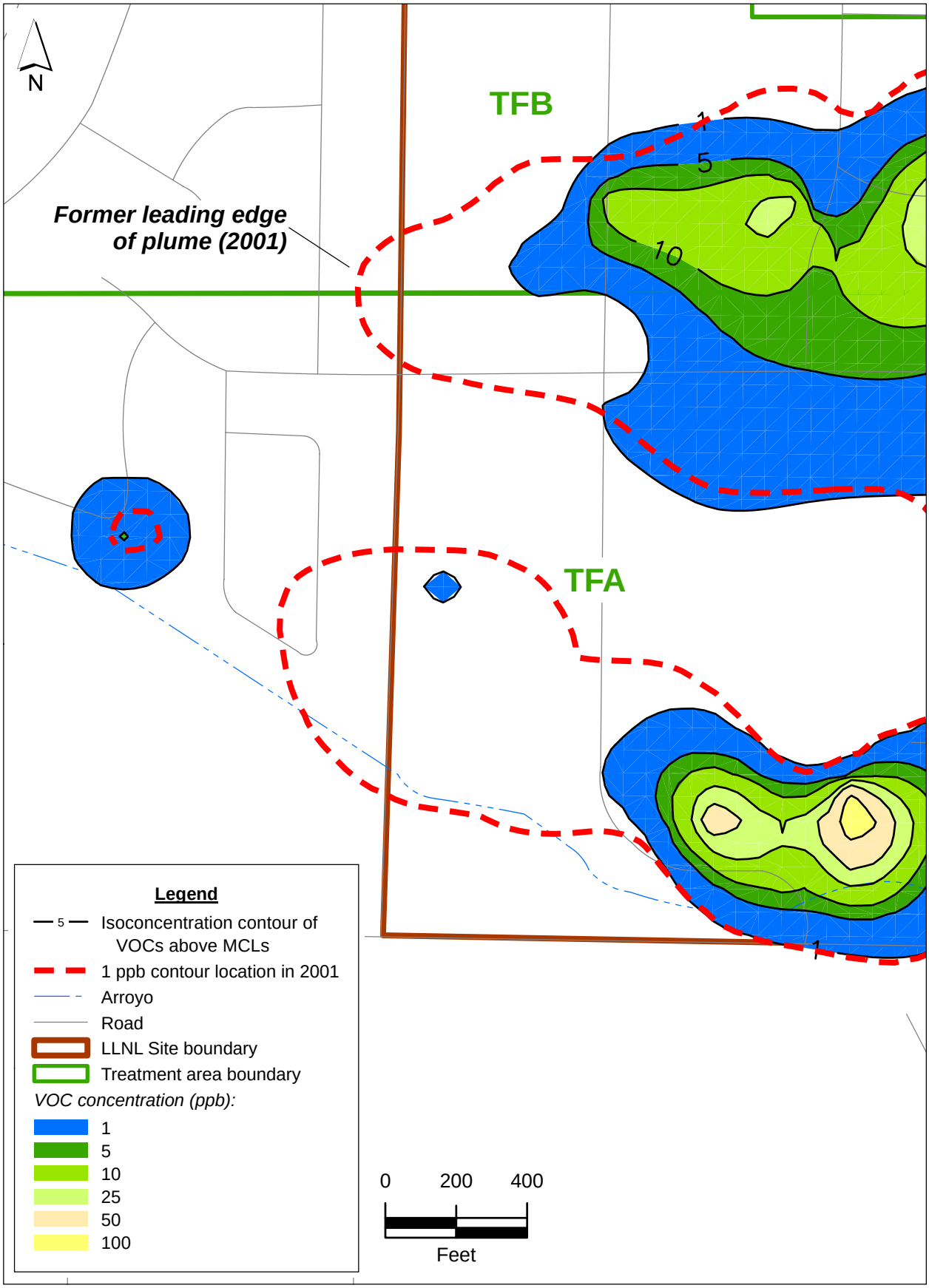
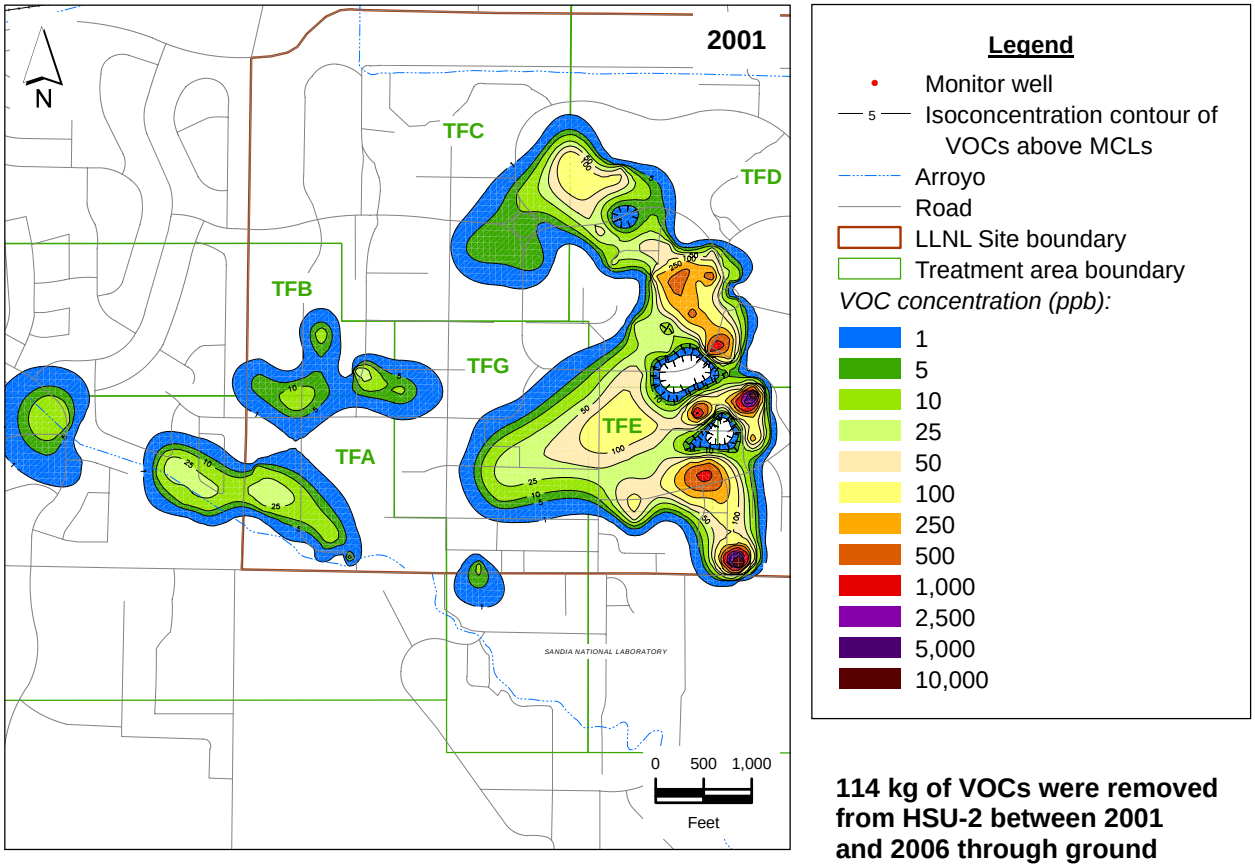


Figure 6. TFA and TFB area HSU-1B isoconcentration contour map of VOCs above MCLs showing the eastward retreat of the plume between 2001 and 2006.



114 kg of VOCs were removed from HSU-2 between 2001 and 2006 through ground water extraction and treatment.

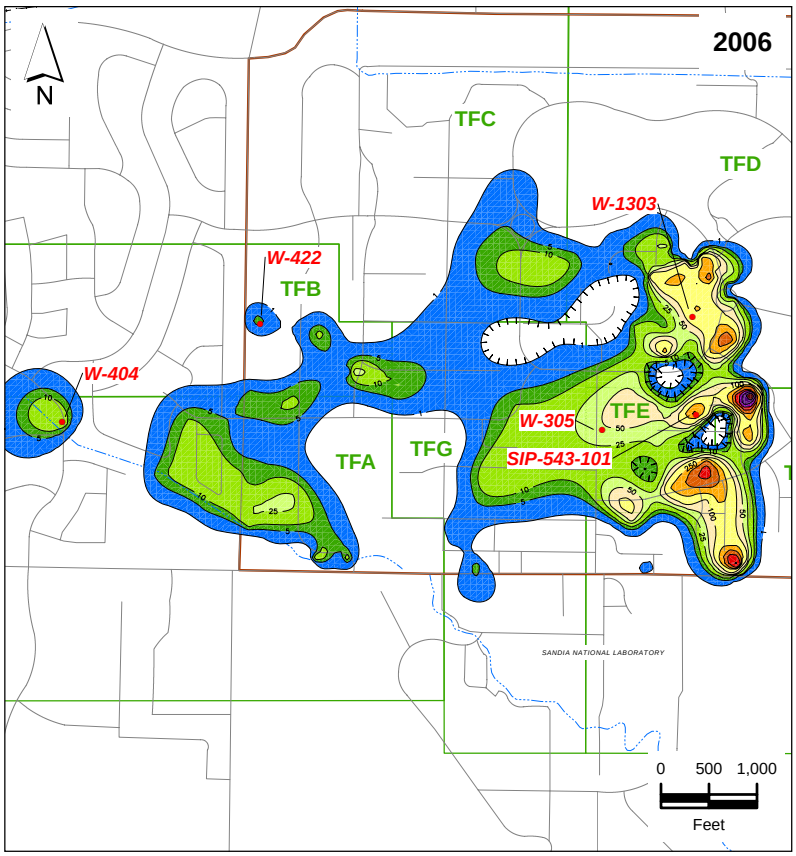


Figure 7. Time-series isoconcentration maps of VOCs above MCLs based on wells completed within Hydrostratigraphic Unit 2 (HSU-2) for 2001 and 2006.

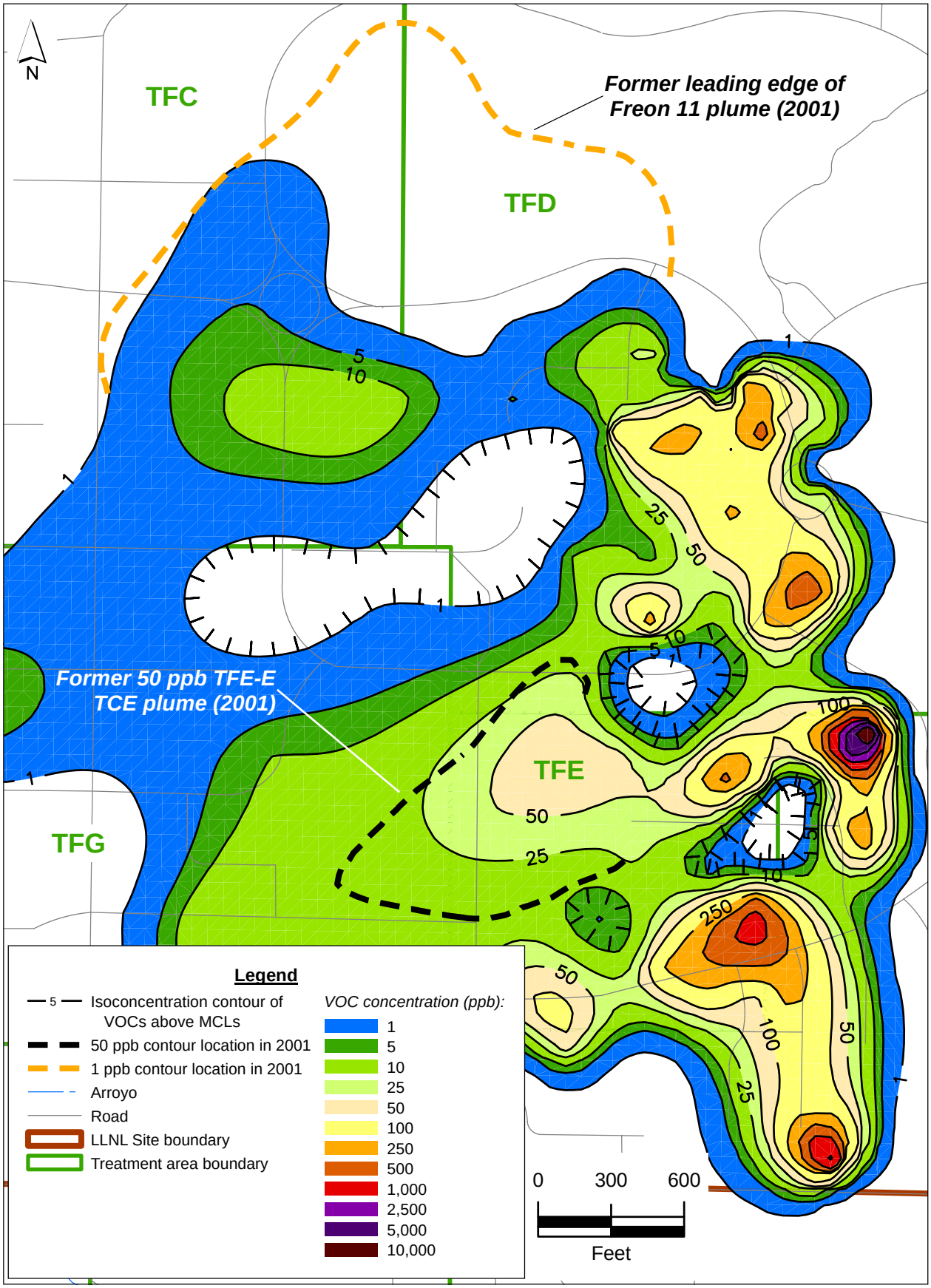
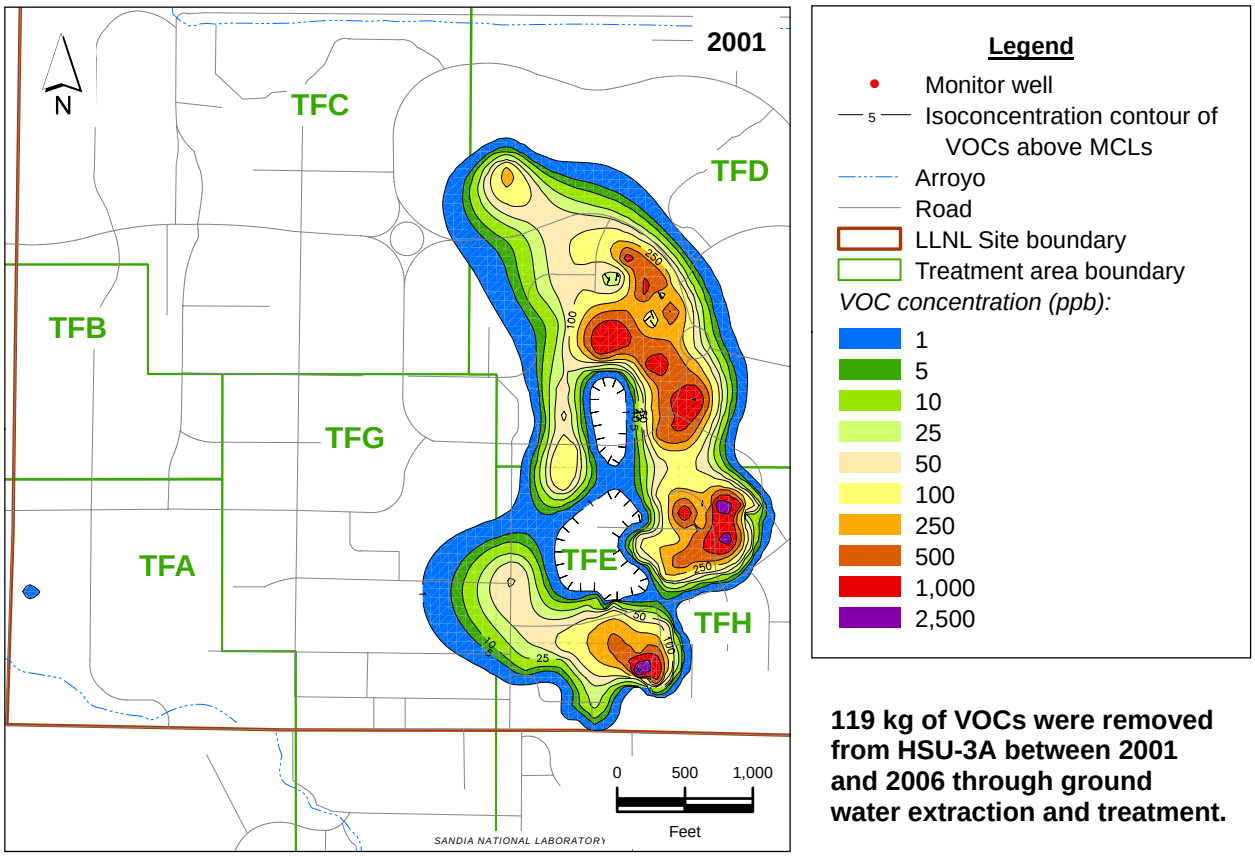


Figure 8. HSU-2 isoconcentration contour map of total VOCs above MCLs showing the retreat of the TFD area Freon 11 plume and the TFE area TCE plume between 2001 and 2006.



119 kg of VOCs were removed from HSU-3A between 2001 and 2006 through ground water extraction and treatment.

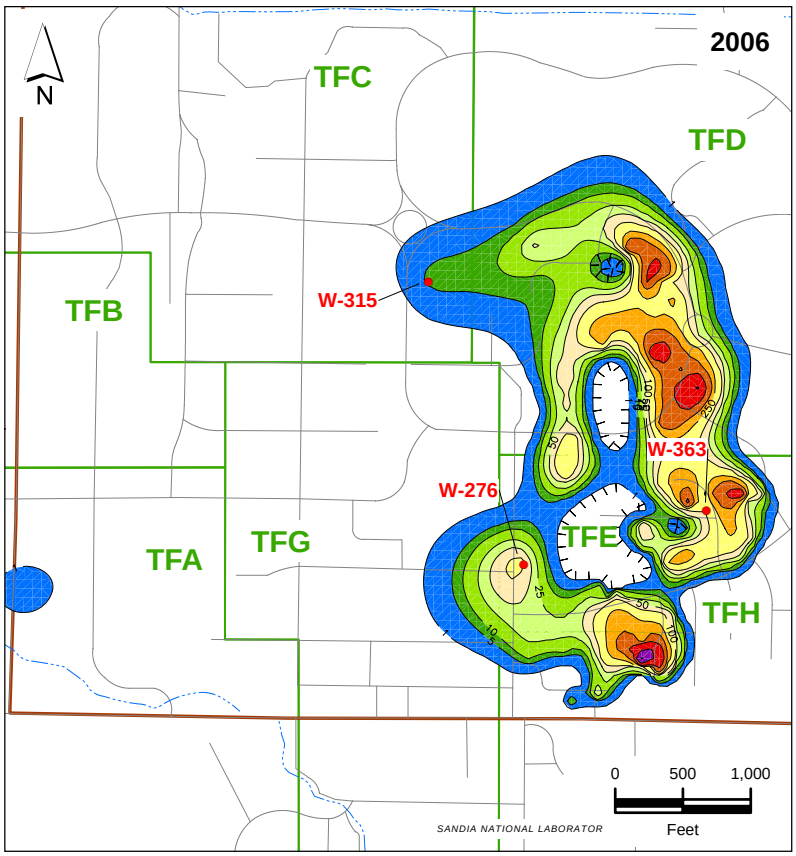
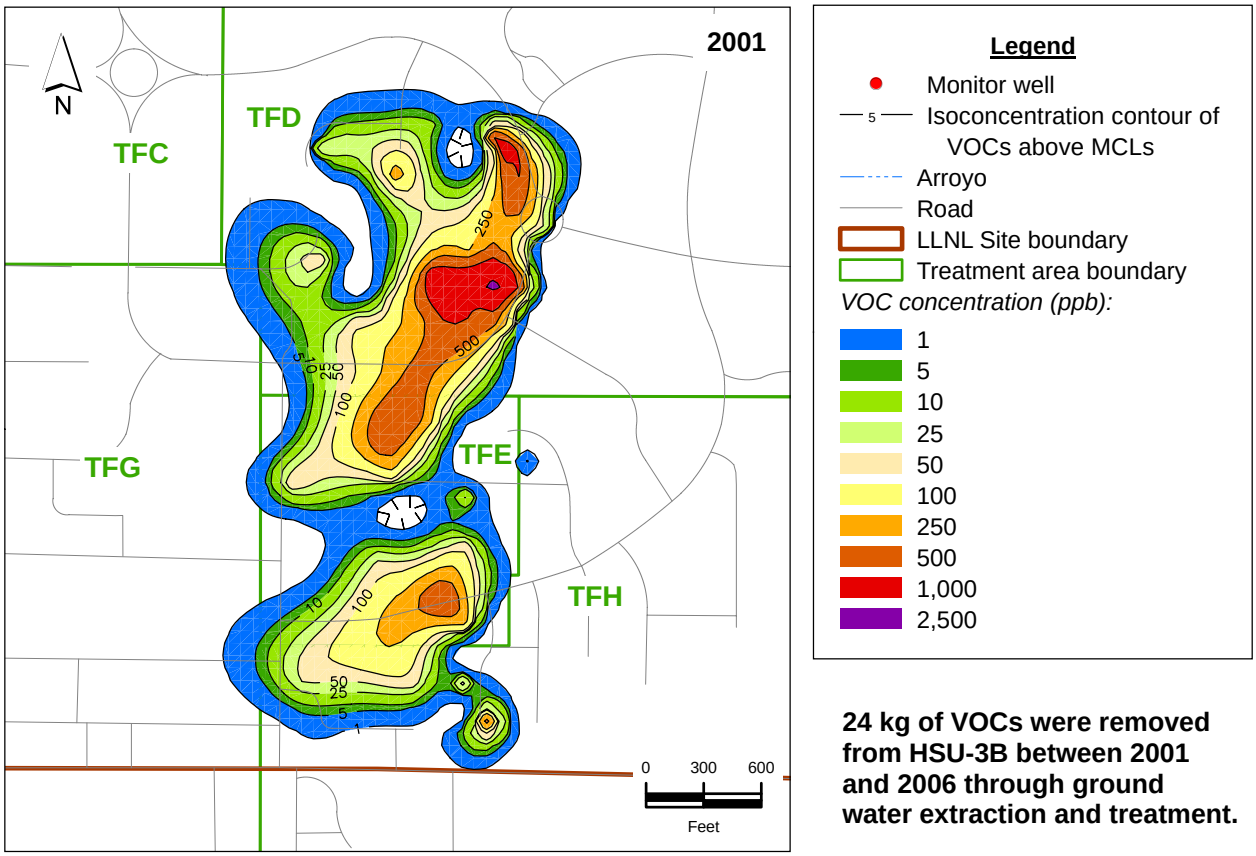


Figure 9. Time-series isoconcentration maps of VOCs above MCLs based on wells completed within Hydrostratigraphic Unit 3A (HSU-3A) for 2001 and 2006.



24 kg of VOCs were removed from HSU-3B between 2001 and 2006 through ground water extraction and treatment.

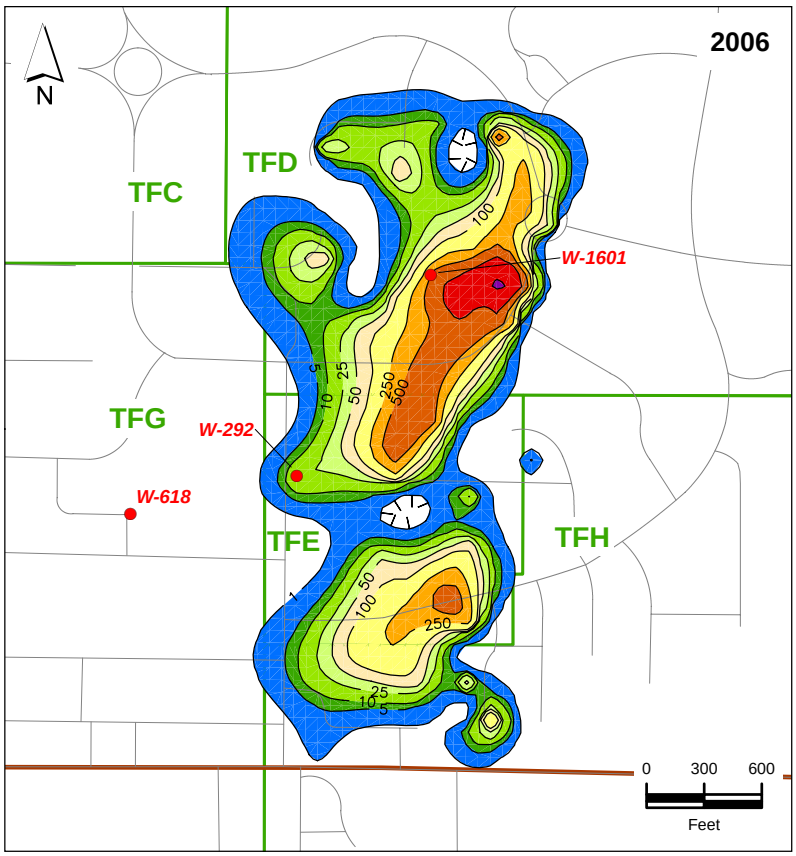
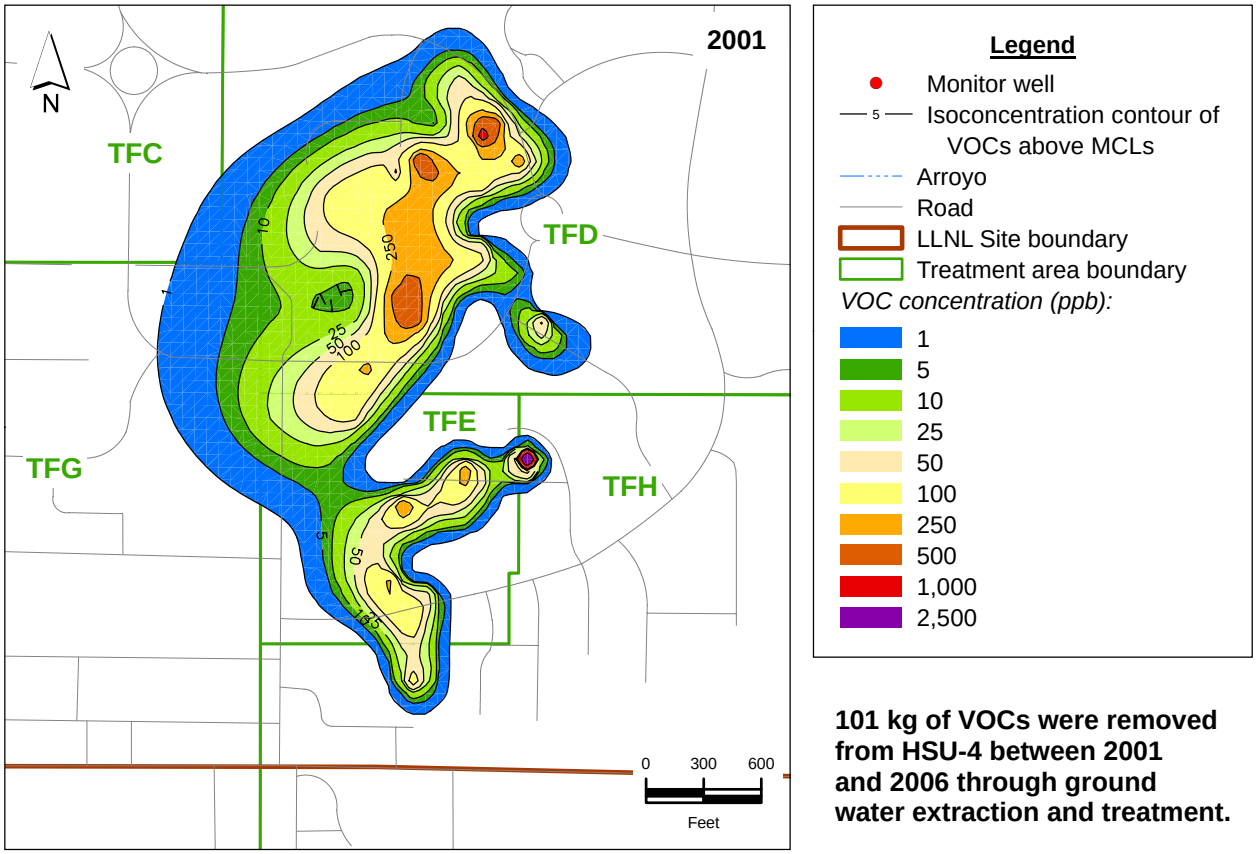


Figure 10. Time-series isoconcentration maps of VOCs above MCLs based on wells completed within Hydrostratigraphic Unit 3B (HSU-3B) for 2001 and 2006.



101 kg of VOCs were removed from HSU-4 between 2001 and 2006 through ground water extraction and treatment.

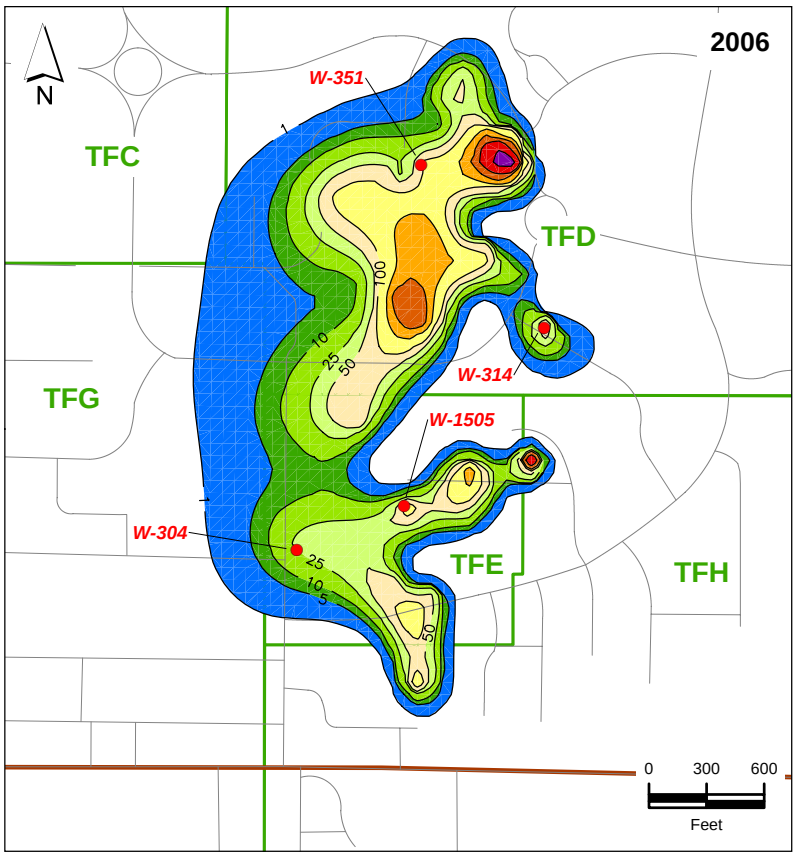
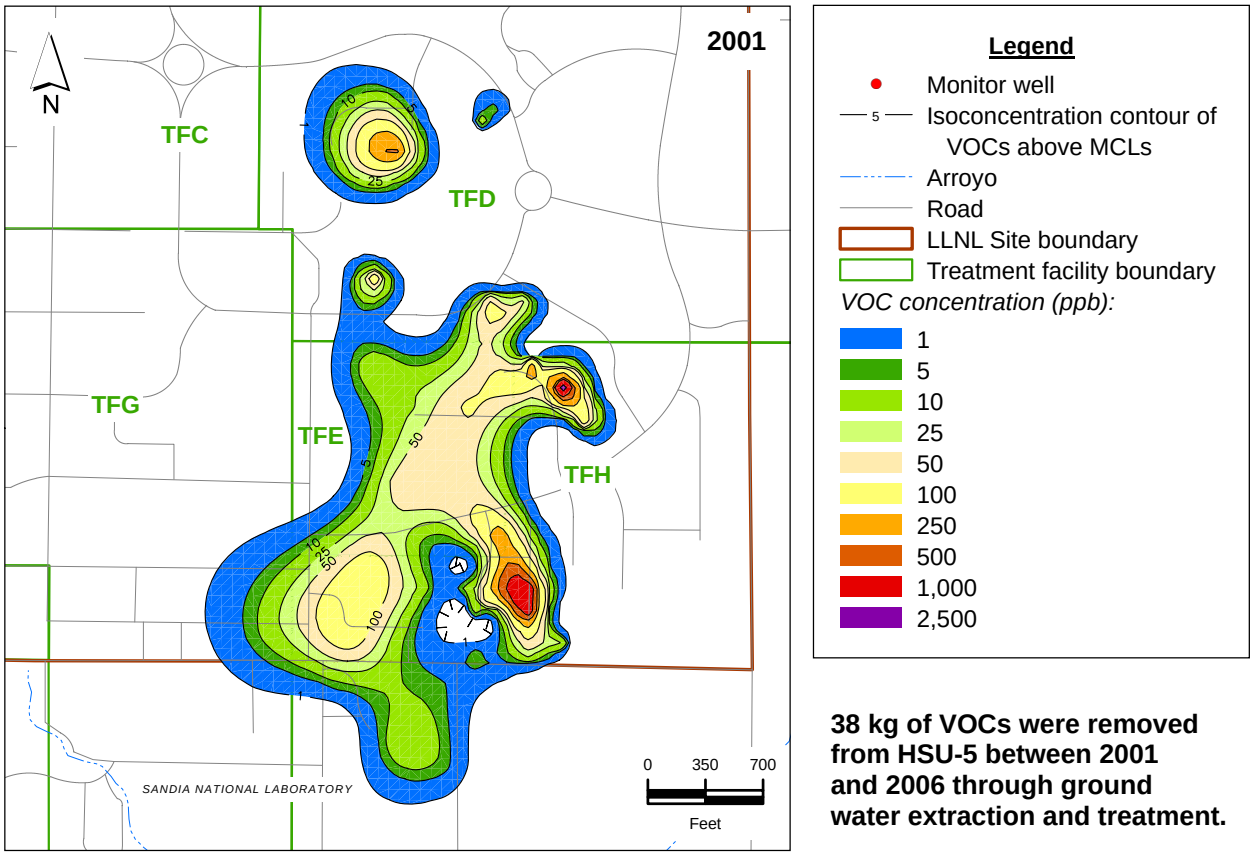


Figure 11. Time-series isoconcentration maps of VOCs above MCLs based on wells completed within Hydrostratigraphic Unit 4 (HSU-4) for 2001 and 2006.



38 kg of VOCs were removed from HSU-5 between 2001 and 2006 through ground water extraction and treatment.

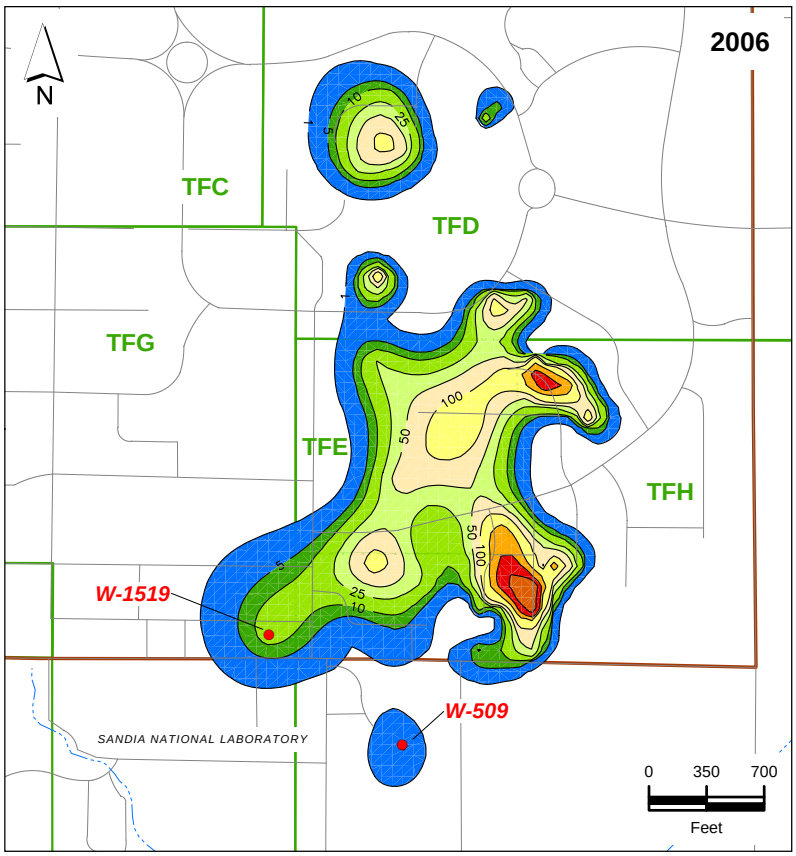


Figure 12. Time-series isoconcentration maps of VOCs above MCLs based on wells completed within Hydrostratigraphic Unit 5 (HSU-5) for 2001 and 2006.

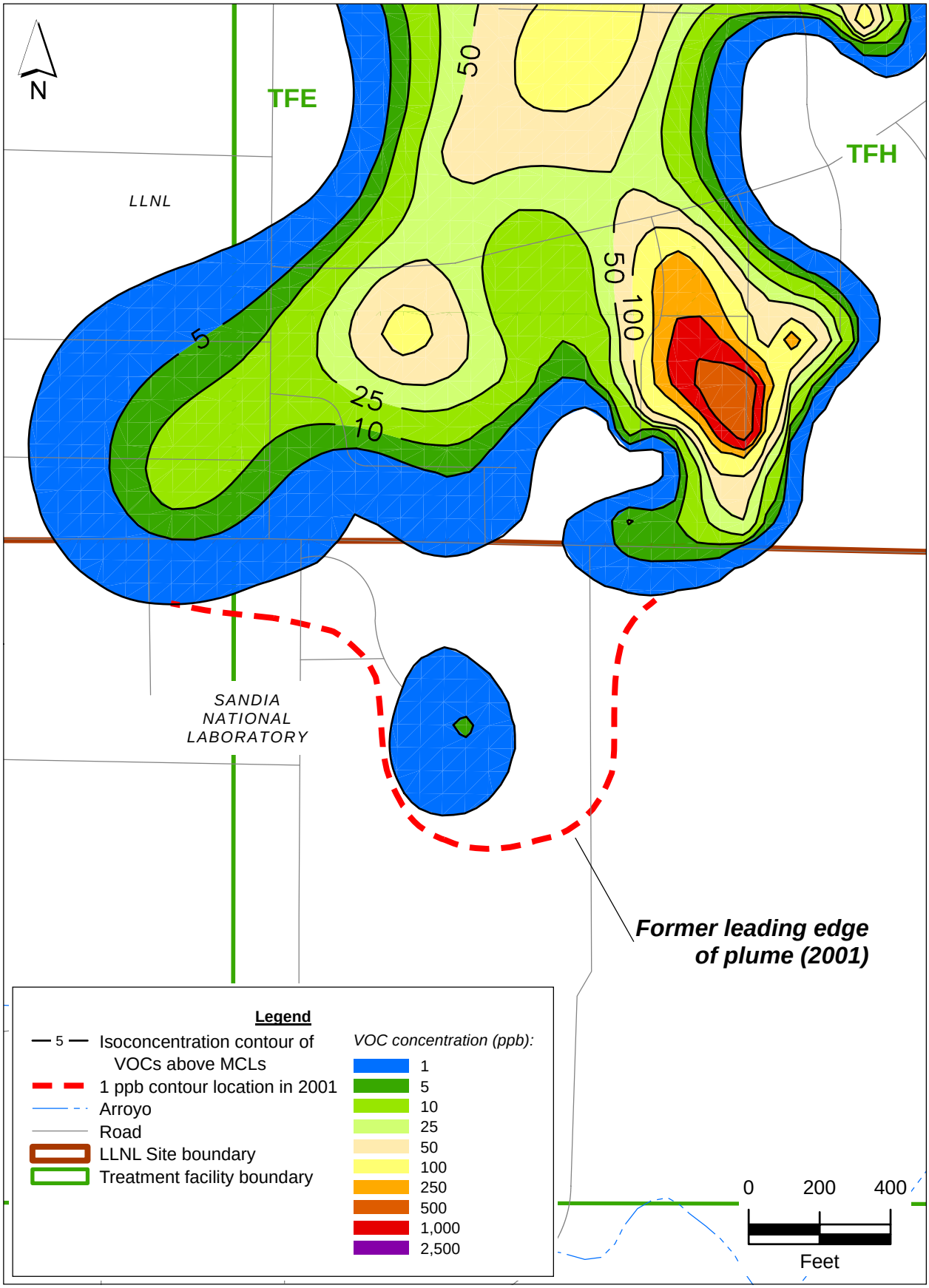


Figure 13. TFH area HSU-5 isoconcentration map of total VOCs above MCLs showing the northward retreat of the plume between 2001 and 2006.

Tables

Table 1. Livermore Site chronology of events.

Date	Event
1942–1949	Site used as U.S. Navy Air Station; first release of hazardous materials
1950s	Undocumented releases of radioactive and hazardous materials to soil
1960s	Landfills, evaporation ponds, and disposal pits constructed
1970s	DOE/LLNL began environmental investigations
1982–1983	Excavation of four disposal pits containing debris, and disposed of about 3,000 cubic yards of contaminated soil containing volatile organic compounds and radionuclides from the East Taxi Strip area (now referred to as that Trailer 5475 area)
1983	DOE/LLNL discovers ground water contamination on- and off-site and notifies regulatory agencies
1984–1985	Excavation and removal of about 14,000 cubic yards of soil and debris, and 160 buried capacitors from the East Traffic Circle Landfill
1987	Livermore Site named to the National Priorities List (Superfund)
1988	Federal Facility Agreement signed by DOE and regulatory agencies
1989	DOE/LLNL established Community Work Group
1989	DOE/LLNL initiated the Remedial Investigation
1992	Record of Decision signed determining scope and remedies of cleanup
1993	Completed Explanation of Significant Differences for a change in the vapor treatment at Treatment Facility F
1994	LLNL developed hydrostratigraphic unit analysis for more effective cleanup
1995	State closure of Treatment Facility F vadose zone cleanup
1995	DOE/LLNL achieved hydraulic control of contaminated plumes at the western site boundary
1996	State "No Further Action" for the Treatment Facility F fuel hydrocarbon contamination
1996	DOE/LLNL implemented Engineered Plume Collapse strategy using portable treatment units
1997	First five-year review concluded cleanup ahead of schedule
1997	Removed about 766 tons of contaminated soil and 112 buried capacitors containing polychlorinated biphenyls at the site of the National Ignition Facility
1997	Completed Explanation of Significant Differences for a change in the ground water treatment at Treatment Facilities A and B
1997	Completed Explanation of Significant Differences for a change in metals discharge requirements

Table 1. Livermore Site chronology of events. (Cont. Page 2 of 2)

Date	Event
1999	Removed over 400 cubic yards of residual contaminated soil containing polychlorinated biphenyls at the East Traffic Circle
1999	Cumulatively treated over 1 billion gallons of contaminated ground water
2000	Completed Explanation of Significant Differences for a design change for Treatment Facility 5475
2002	Second five-year review concluded remedy is functioning as intended and is protective of human health and the environment
2003	Cumulatively treated over 2 billion gallons of contaminated ground water
2005	Cumulatively removed over 2 tons of VOC contaminant mass from the subsurface
2006	Cumulatively treated over 3 billion gallons of contaminated ground water
2006	Completed all Remedial Action Implementation Plan (RAIP) regulatory milestones

Table 2. Project highlights since the second five-year review.

Date	Event
September 2002	Began TF5475 soil vapor extraction expansion
December 2002	Started discharging treated ground water from TFA to Arroyo Seco
First quarter 2003	Cumulatively treated over 2 billion gallons of contaminated ground water
May 2003	Began operation of TFC Northeast remediation
June 2003	Started discharging treated ground water from TFA to Arroyo Las Positas (in addition to discharge to Arroyo Seco)
July 2003	Began operation of TFG North
September 2003	Began operation of VTFE Eastern Landing Mat remediation
Calendar year 2004	Convert wells used at the prior electro-osmosis experiment to dual-extraction wells
June 2004	Began TFD Helipad Source Area remediation
August 2004	All tritium concentrations on the site dropped below the Maximum Contaminant Level
September 2004	Began TF518 perched-zone remediation
First quarter 2005	Cumulatively removed over 2 tons of VOC contaminant mass from the subsurface
June 2005	Relinquished Recharge Basin back to Sandia National Laboratories
July 2005	Began TFD East Traffic Circle South remediation
August 2005	Began TFE Hotspot remediation
August 2005	Began TF406 Hotspot remediation
September 2005	Began TFD Hotspot remediation
October 2005	Remedial Project Managers removed the TF406 South milestone from the RAIP Priority List
April 2006	Began TFC Hotspot remediation
June 2006	Began TF5475 South remediation
August 2006	Began TFD East Traffic Circle North Source Area remediation
Third quarter 2006	Cumulatively treated over 3 billion gallons of contaminated ground water
September 2006	Began Building 419 Source Area remediation
September 2006	Began Buildings 511/514 Source Area remediation

Table 2. Project highlights since the second five-year review. (Cont. Page 2 of 2)

Date	Event
February 2007	**Started extraction of the offsite plume stagnation point at well W-404 (TFA West)**
First Quarter 2007	**Transferred the project to National Nuclear Security Administration**

Table 3. Livermore Site treatment facility summary.

Facility[a]	Media treated	Contaminants	Facility type[b]	Current technologies	Operating dates
TFA	Ground water	VOCs	Fixed	Air stripping	April 1989 – present
TFA East	Ground water	VOCs	STU	Granular activated carbon (GAC)	August 1999 – present
TFB	Ground water	VOCs; hexavalent chromium	Fixed	Air stripping; ion exchange	July 1990 – present
TFC	Ground water	VOCs; hexavalent chromium	Fixed	Air stripping; ion exchange	October 1993 – present
TFC Southeast	Ground water	VOCs; hexavalent chromium	PTU	Air stripping; ion exchange	January 1997 – present
TFC East	Ground water	VOCs; hexavalent chromium	MTU	Air stripping; ion exchange	April 2002 – present
TFD	Ground water	VOCs	Fixed	Air stripping	September 1994 – present
TFD West	Ground water	VOCs	PTU	Air stripping	April 1997 – present
TFD East	Ground water	VOCs	PTU	Air stripping	September 1997 – present
TFD Southeast	Ground water	VOCs	PTU	Air stripping	March 1998 – present
TFD South	Ground water	VOCs	PTU	Air stripping	June 1999 – present
TFD Helipad	Ground water	VOCs	PTU	Air stripping	September 1999 – present
TFD Southshore	Ground water	VOCs	PTU	Air stripping	June 2000 – present
TFD area (STU-10)[c]	Ground water	VOCs	STU	GAC	March 2000 – September 2002
VTFD Helipad	Soil vapor	VOCs	VES	GAC	June 2004 – present
VTFD ETC South	Soil vapor	VOCs	VES	GAC	July 2005 – present
VTFD Hotspot	Soil vapor	VOCs	VES	GAC	September 2005 – present
TFE East	Ground water	VOCs	PTU	Air stripping	November 1996 – present
TFE Northwest	Ground water	VOCs	PTU	Air stripping	June 1998 – present
TFE North (using PTU-4) [c]	Ground water	VOCs	PTU	Air stripping	December 1998 – February 2003
TFE Southwest	Ground water	VOCs	MTU	Air stripping	June 2000 – present
TFE Southeast	Ground water	VOCs	MTU	Air stripping	March 2001 – present
TFE West	Ground water	VOCs	MTU	Air stripping	April 2001 – present
VTFE-ELM	Soil vapor	VOCs	VES	GAC	September 2003 – present

Table 3. Livermore Site treatment facility summary. (Cont. Page 2 of 3)

Facility[a]	Media treated	Contaminants	Facility type[b]	Current technologies	Operating dates
VTFE Hotspot	Soil vapor	VOCs	VES	GAC	August 2005 – present
TFE Hotspot	Ground water	VOCs	GTU	GAC	August 2005 – present
TFF [c]	Ground water	FHCs; VOCs	Fixed	UV/oxidation; air stripping	February 1993 – September 1995
VTFF [c]	Soil vapor	FHCs	VES	GAC with steam regeneration	February 1993 – September 1995
TF406	Ground water	VOCs	PTU	Air stripping	August 1996 – present
TF406 Northwest	Ground water	VOCs	GTU	GAC	July 2002 – present
VTF406 Hotspot	Soil vapor	VOCs	VES	GAC	August 2005 – present
TFG-1	Ground water	VOCs	GTU	GAC	April 1996 – present
TFG North	Ground water	VOCs	MTU	Air stripping	July 2003 – present
VTF511	Soil vapor	VOCs	VES	GAC	September 2006 – present
VTF518	Soil vapor	VOCs	VES	GAC	September 1995 – May 2001
TF518 [c]	Ground water	VOCs	MTU	Air stripping	January 1998 – June 2000
TF518 North	Ground water	VOCs	STU	GAC	January 2000 – present
VTF518 Perched Zone[d]	Soil vapor	VOCs	VES	GAC	September 2004 – present
TF5475-1	Ground water	VOCs, tritium	CRD	Catalytic Reductive Dehalogenation (CRD)	September 1998 – present
VTF5475	Soil vapor	VOCs, tritium	VES	GAC	January 1999 – present
TF5475-2	Ground water	VOCs	GTU	GAC	March 1999 – present
TF5475-3	Ground water	VOCs, tritium	CRD	CRD	September 2000 – present

Notes appear on the following page.

Table 3. Livermore Site treatment facility summary. (Cont. Page 3 of 3)

Notes:

CRD = Catalyctic reductive dehalogenation

FHCs = Fuel hydrocarbons

GTU = GAC Treatment Unit

MTU = Miniature Treatment Unit

PTU = Portable Treatment Unit

STU = Solar Treatment Unit

VES = Vapor Extraction System

[a] **Existing facility locations are shown on Figure 2.**

[b] **Facility abbreviations:**

[c] **Facility is no longer in operation.**

[d] **Water is collected from this facility into a bubble and treated in batches at TF406 Northwest.**

Table 4. Compliance issue summary 2002-2007.

Facility	Issue	Resolution and/or Lessons Learned
TFA	A 10,200-gallon leak occurred from the pipeline that connects well W-415 to TFA in December 2005. The leak was caused by an improperly connected pipe flange when a contractor modified the pipeline as part of a realignment of Arroyo Seco.	The extraction well was shutdown and the contractor fixed the pipe flange. The pipeline was tested for leaks before restarting operations. A receiving water sample downstream have no detectable volatile organic compounds (VOCs).
TFB	Treatment Facility B (TFB) was out of compliance in September 2004. An electronics technician was performing an interlock check and restarted the facility without starting the air blower, thus not treating the VOCs in about 48,000 gallons of extracted ground water.	Corrective actions included modifying the interlock so that the well pumps cannot be started until the blower is enabled. Additionally, only treatment facility technicians can initiate automatic (unmanned) operations.
TFB	A 100-gallon spill of untreated ground water from a holding tank occurred in September 2006. The water spilled onto dirt and concrete and did not reach ground water, drainage ditches or the arroyo.	The tank was removed from service and other tanks were inspected.
TFC	The TFC Southeast facility discharge pump failed July 2006 causing the release of 300-400 gallons of treated water to the pavement and to the facility discharge ditch.	The pump was repaired.
TFD Helipad	Treatment Facility D (TFD) Helipad facility spilled approximately 1,000 gallons of untreated ground water to ground in October 2003. The spill did not recharge to ground water, nor was surface water impacted.	The cause of the spill was a secondary pumping system interlock not being enabled. This interlock was reset so it cannot be bypassed.
TF5475-1 (CRD-1)	Treatment Facility 5475-1 (TF5475-1; CRD-1) was occasionally out of compliance in November 2004 – January 2005 due to an increase in the ratio of recalcitrant compounds. Recalcitrant compounds include 1, 1-DCA and 1, 2-DCA.	1, 2-DCA has increased in concentration causing this problem. Treatment efficiency of TCE for these same dates was 100, 100, 98.0 and 99.4% respectively, thus showing that the treatment process was working properly. In August 2005, DOE/LLNL added aqueous-phase carbon after CRD-1 treatment to mitigate this issue.

Table 4. Compliance issue summary 2002-2007. (Cont. Page 2 of 2)

Facility	Issue	Resolution and/or Lessons Learned
TF5475-3 (CRD-2)	Treatment Facility 5475-3 (TF5475-3; CRD-2) did not meet the VOC treatment requirement in November 2004. The reduction efficiency was only 7%, significantly below the required 90%. This was due to inadequate hydrogen flow.	Problems with hydrogen flow and hydrogen flow measurement are encountered during cold weather. Once LLNL installed heater tape along the hydrogen lines, the gas/water heat exchanger and the hydrogen meter, the facility was back in compliance.
TF5475-3 (CRD-2)	TF5475-3 (CRD-2) exceeded the 50-ppm chromium discharge limit during February - August 2005. The treated water was reinjected into the subsurface and did not impact surface water quality.	The CRD process reduces the hexavalent chromium to trivalent chromium, which adheres to the catalyst. The efficiency of this process decreases as the catalyst aged. Ion-exchange resin canisters were installed after the CRD-2 process to remove the chromium prior to discharge.
TF5475-3 (CRD-2)	Extracted ground water from well W-1108 near the Trailer 5475 area was being stored at the Treatment Facility E yard for an injection test related to the Trailer 5475 South milestone. In November 2005, a painter's vehicle collided with the spherical tank holding the water, knocking the tank over and releasing about 250 gallons of water onto asphalt.	The spill was reported and in the future, trailer outriggers are used to stabilize water tanks to prevent similar accidents.

Table 5. Total project funding authorized by DOE during 2002-2007 for cleanup of the Livermore Site.

Fiscal year	Funding ($M)
2002	10.2
2003	12.0
2004	12.9
2005	13.9
2006	14.5
2007	12.6

Table 6. Estimated volume and mass of VOCs remaining in saturated hydrostratigraphic units (HSUs) in the vicinity of the Livermore Site.[a]

HSU	Estimated pore volume containing VOCs greater than 5 ppb (Mgal)	Estimated VOC mass dissolved in ground water (kg)
HSU-1A	0.0	0.0
HSU-1B	580	66
HSU-2	1,700	320
HSU-3A	260	140
HSU-3B	88	34
HSU-4	64	20
HSU-5	290	90
Total	3,000	670

Notes:

HSU = Hydrostratigraphic unit

kg = Kilograms

Mgal = Millions of gallons

ppb = Parts per billion

VOC = Volatile organic compound

[a] Based on data through September 2006. Numbers are rounded to two significant digits as there is uncertainty in estimating mass remaining in the subsurface.

Attachment A

Livermore Site October 2005 Consensus Statement

University of California
Lawrence Livermore
National Laboratory

October 12, 2005

Ms. Naomi Feger
Regional Water Quality Control Board —
San Francisco Bay Region
1515 Clay Street, Suite 1400
Oakland, CA 94612

Mr. Ted Park, P.E.
Department of Toxic Substances Control
Northern California, Coastal Cleanup Operations Branch
700 Heinz Avenue, Suite 200
Berkeley, CA 94710-2721

Ms. Kathy Setian
U.S. Environmental Protection Agency — Region 9
SFD-8-1
75 Hawthorne Street
San Francisco, CA 94105-3901

Re: Consensus Statement and Remedial Action Implementation Plan Table 5

Dear Ms. Feger, Mr. Park, Ms. Setian:

Enclosed is the signed October 2005 Consensus Statement and a revised Table 5 for the Remedial Action Implementation Plan (RAIP). The enclosed Consensus Statement documents an agreement between the regulatory agencies and the Department of Energy on the Lawrence Livermore National Laboratory Livermore Site project priorities. The revised Table 5 for the RAIP reflects changes in deliverable and treatment facility startup dates. The revised Table 5 is being issued as a ninth addendum.

We appreciate your time in periodically reviewing Livermore Site priorities with us to implement changes that ensure cleanup is proceeding according to Stakeholders' satisfaction. If you have any questions, please contact Lindee Berg at (925) 422-0618 or Phil Wong at (925) 422-0765.

Sincerely,

Linda L. Berg
Livermore Site Project Leader
Environmental Restoration Division
UC/LLNL

Phillip W. Wong
Livermore Site Remedial Project Manager
Environmental Stewardship Division
Livermore Site Office

LLB:PW:gl

Attachment

cc: W. Bookless
M. Brown, DOE
D. Nakahara, DOE
E. Raber
J. Yow

Consensus Statement for Environmental Restoration of Lawrence Livermore National Laboratory Livermore Site October 2005

The parties to this Consensus Statement — U.S. Department of Energy (DOE), U.S. Environmental Protection Agency, the San Francisco Bay Regional Water Quality Control Board, and Department of Toxic Substances Control — are those parties that entered into the Federal Facility Agreement (FFA) of November 2, 1988, for the Lawrence Livermore National Laboratory (LLNL) Livermore Site. This Consensus Statement does not amend the existing FFA.

Consensus Statement History

In a July 1994 Consensus Statement, the parties agreed to the following Livermore Site ground water cleanup priorities:

1. Western plume capture.

2. Southern plume capture.

3. Internal source control/mass removal.

Since then, the regulatory agencies agreed that DOE/LLNL had addressed western and southern plume capture (items 1 and 2 above), and had begun to address internal source control (item 3). DOE/LLNL and the regulatory agencies also agreed to use portable ground water treatment units instead of permanent facilities and pipelines to reduce cleanup time and cost. Engineered Plume Collapse (EPC) and Phased Source Remediation (PSR) strategies were adopted that incorporated distal plume cleanup, hydraulic control of source areas, and source area remediation. EPC and PSR are intended to accelerate cleanup consistent with the remediation strategy described in the Record of Decision. Treatment facilities are actively remediating the distal plumes, and many treatment facilities are strategically located to more rapidly remove volatile organic compound (VOC) mass and eliminate downgradient movement of the plumes. Hydraulic control and cleanup of source areas are the focus of new remediation activities while western and southern plume capture, cleanup, and compliance monitoring continue.

Current Consensus

The following change is proposed to the Remedial Action Implementation Plan (RAIP) Table 5 milestone list. The construction of one treatment facility originally designed to cleanup a southern offsite plume at the TF406 South location was deferred in January 2003 until Fiscal Year (FY) 2006 because it appeared that the plume was being cleaned up with the existing treatment facilities. Data over the last few years indicates rapid collapse of the southern offsite plume as a result of Treatment Facility 406 (TF406) and Treatment Facility E Southeast (TFE-SE) developing large hydraulic capture areas that extend beyond the plume. The ongoing plume capture and cleanup occurring at the

TF406 South location indicates that construction of a new facility at this location is not warranted, and as such, is being removed from the RAIP Table 5. If the area doesn't continue to clean up, the regulators have the ability to require further remediation through the Five-Year Review process. The next Five-Year Review is in FY 2007.

The signatures of the Remedial Project Managers below demonstrate that the parties have reached consensus to the milestones on the October 2005 amendment to the Remedial Action Implementation Plan Table 5. There were no Community Work Group concerns with these changes. Priorities and milestones are reviewed annually by the parties to this Consensus Statement, and can be reviewed at any time at the request of any of the parties. Any changes must be agreed by all parties.

The following parties agree to this Consensus Statement:

10/11/05
Date

Phillip W. Wong
Remedial Project Manager
Livermore Site Office
U.S. Department of Energy

10/11/05
Date

Kathy Setian
Remedial Project Manager
U.S. Environmental Protection Agency

10/11/2005
Date

Ted Park
Remedial Project Manager
California Environmental Protection Agency
Department of Toxic Substances Control

10/11/2005
Date

Naomi Feger
Remedial Project Manager
California Environmental Protection Agency
Regional Water Quality Control Board
San Francisco Bay Region

Table 5. Schedule for LLNL Remedial Designs and Remedial Actions. (Revised October 2005)

Task	Completion date
Submit Draft RD1 to regulatory agencies and the community	10-10-92[a]
Submit Draft Final RAIP to regulatory agencies	11-6-92[a]
Receive regulatory comments on RD1	12-10-92[a]
Issue RAIP	1-6-93[a,b]
Submit Draft Revised Community Relations Plan to regulatory agencies and the community	1-31-93
Begin operation of TFF	2-93
Submit Draft Final RD1 to regulatory agencies	3-12-93[a]
Issue RD1	4-12-93[a]
Submit Draft RD2 to regulatory agencies and the community	5-10-93[a]
Submit Draft Final Revised Community Relations Plan to regulatory agencies	5-31-93
Receive regulatory comments on Draft RD2	6-25-93[a]
Issue Revised Community Relations Plan	6-30-93
Submit Draft Final RD2 to regulatory agencies	8-10-93[a]
Issue RD2	9-10-93[a,b]
Begin treatability study at Trailer 5475	9-30-93
Submit Draft RD3 to regulatory agencies and the community	9-30-93[a]
Begin operation of TFC	10-30-93
Receive regulatory comments on Draft RD3	12-1-93[a]
Submit Draft Final RD3 to regulatory agencies	2-1-94[a]
Issue RD3	3-1-94[a,b]
Complete investigation of B-518	6-1-94
Submit Draft RD6 to the regulatory agencies and the community	7-1-94[a]
Receive regulatory comments on Draft RD6	8-30-94[a]
Begin operation of TFD	9-30-94
Submit Draft Final RD6 to regulatory agencies	10-31-94[a]
Issue RD6	11-30-94[a,b]
Submit Draft RD5 to the regulatory agencies and the community	12-1-94[a]
Receive regulatory comments on Draft RD5	1-30-95[a]

Table 5. (Continued)

Task	Completion date
Submit Draft Final RD5 to the regulatory agencies	3-31-95[a]
Issue RD5	5-1-95[a,b]
Submit Draft Compliance Monitoring Plan to the regulatory agencies and the community	8-30-95
Begin operation of Building 518 vapor extraction system	9-29-95
Receive regulatory comments on Draft Compliance Monitoring Plan	10-30-95
Submit Draft Final Compliance Monitoring Plan to the regulatory agencies	12-29-95
Issue Compliance Monitoring Plan	1-29-96[b]
Begin operation of TFG-1	4-18-96
Submit Draft Contingency Plan to the regulatory agencies and the community	7-1-96
Receive regulatory comments on Draft Contingency Plan	8-30-96
Begin operation of TF406 PTU	8-30-96
Submit Draft Final Contingency Plan to the regulatory agencies	10-29-96
Begin operation of TFE East PTU	11-27-96
Issue Contingency Plan	11-28-96[b]
Begin operation of TFC Southeast PTU	1-31-97
Begin operation of TFD West PTU	4-25-97
5 Year Review	8-5-97[a]
Submit Draft RD4 to the regulatory agencies and the community	8-25-97a
Begin operation of TFD East PTU	10-3-97
Receive regulatory comments on Draft RD4	10-20-97[a]
Submit Draft Final RD4 to the regulatory agencies	12-15-97[a]
Issue RD4	1-30-98[a,b]
Begin operation of TF518 PTU	1-30-98
Begin operation of TFD Southeast PTU	3-27-98
Begin operation of TFE Northwest PTU	6-26-98
Begin operation of TF5475 CRD (Phase 1)	9-30-98
Begin operation of VTF5475 vapor extraction system	1-29-99

Table 5. (Continued)

Task	Completion date
Begin operation of TF5475 STU	3-31-99
Begin operation of TFD South PTU	6-29-99
Begin operation of STU-7	8-6-99
Begin operation of TF518 North STU	1-28-00
Begin operation of TFD Southshore MTU	3-31-00
Begin operation of TFE Southwest MTU	6-30-00
Begin operation of TF5475 CRD (Phase 2)	9-29-00
Begin operation of TFE Southeast MTU	1-31-01
Begin operation of TFE West MTU	4-30-01
Begin operation of TFD Marina Pipeline	7-31-01
Begin operation of TF5475 CRD (Phase 3)	9-28-01
Begin TFC East remediation	1-31-02 (4-3-02)[c]
Submit Draft Five-Year Review to the regulatory agencies and community	4-30-02[a]
Receive regulatory comments on Draft Five-Year Review	7-1-02[a]
Begin TF406 Northwest remediation	7-31-02
Submit Draft Final Five-Year Review to the regulatory agencies	8-30-02[a]
Issue Five-Year Review	9-30-02[a,b]
Begin TF5475 soil vapor extraction expansion	9-30-02
Begin TFC Northeast remediation	5-30-03
Begin TFG North remediation	7-31-03
Begin Eastern Landing Mat Source Area remediation	9-26-03
Begin Helipad Source Area remediation	9-30-04
Begin TF518 perched-zone remediation	9-30-04
Begin Southern East Traffic Circle Source Area remediation	9-30-05
Begin TFD Hotspot remediation	9-30-05
Begin TFE Hotspot remediation	9-30-05
Begin TF406 Hotspot remediation	9-30-05
Begin Northern East Traffic Circle Source Area remediation	9-29-06
Begin Building 419 Source Area remediation	9-29-06

Table 5. (Continued)

Task	Completion date
Begin TFC Hotspot remediation	9-29-06
Begin Buildings 511/514 Source Area remediation	9-29-06
Begin TF5475 South remediation	9-29-06

[a] These dates are enforceable under the LLNL Livermore Site Federal Facility Agreement (FFA).

[b] These dates can be met only if there are few or no comments on the Draft Final version.

[c] The milestone was delayed to the date shown in parenthesis due to a fiscal year 2002 Federal Continuing Resolution.

Notes:

All primary FFA documents will be submitted to DOE 30 days prior to submission to the regulatory agencies.

There were six phased Remedial Design (RD) submittals (RD1 through RD6).

Extraction wells will be phased-in.

Draft RD1 = TFA , TFB, and associated extraction wells and piezometers.

Draft RD2 = TFC, TFF, and associated extraction wells and piezometers.

Draft RD3 = TFD, TFE, associated extraction wells and piezometers, and Building 518 vapor extraction treatability study results.

Draft RD4 = Trailer 5475/East Taxi Strip Area.

Draft RD5 = TFG-1, TFG-2 (TFG Northeast), and associated extraction wells and piezometers.

Draft RD6 = Building 518 vapor extraction system.

PTU = Portable Treatment Unit.

CRD = Catalytic Reductive Dehalogenation.

MTU = Miniature portable Treatment Unit.

STU = Solar-powered Water Activated-carbon Treatment.

GTU = Granular activated-carbon Treatment Unit.

Attachment B

Institutional Land Use Controls at the Lawrence Livermore National Laboratory Livermore Site and Site 300

Department of Energy
National Nuclear Security Administration
Livermore Site Office
PO Box 808, L-293
7000 East Avenue
Livermore, California 94551-0808

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MEMORANDUM FOR FILE

FROM: CLAIRE HOLTZAPPLE, ACTING ER TEAM LEAD
ASSISTANT MANAGER
FOR ENVIRONMENTAL STEWARDSHIP

SUBJECT: Institutional Land Use Controls at the Lawrence Livermore National Laboratory Livermore Site and Site 300

This memorandum documents the Department of Energy's (DOE) land use control policy for the Lawrence Livermore National Laboratory Livermore Site and Site 300. Currently, both the Livermore Site and Site 300 are restricted to industrial land usage. This restriction will remain in place and the U.S. Government is prohibited from transferring any part of the Livermore Site or Site 300 with unmitigated contamination that could cause potential harm under residential or unrestricted land use.

One exception exists to this prohibition: a risk assessment may be performed by the U.S. Government in the future in accordance with then current U.S. Environmental Protection Agency (EPA) risk assessment guidance. If the risk assessment shows no unacceptable risk for residential or unrestricted land use and is agreed to by DOE, the U.S. EPA, Department of Toxic Substances Control, and the appropriate Regional Water Quality Control Board, the prohibition may be lifted.

These restrictions will be incorporated into appropriate institutional planning document(s), such as the Ten Year Comprehensive Site Plan. In addition, this letter will be placed into the administrative record files as a minor change to the Record of Decision for both the Livermore Site and Site 300.

cc:
Kathy Setian, EPA
Agnes Farres, RWQCB
Susan Timm, RWQCB
Jacinto Soto, DTSC
ERD Administrative File
L. Berg, L-544
L. Ferry, L-544

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