# 7

# Groundwater Investigation and Remediation

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During 2004, groundwater investigations and remediations under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) continued at both the Livermore site and Site 300. LLNL samples and analyzes groundwater from areas of known or suspected contamination. Portions of the two sites where soil or groundwater contains or may contain chemicals of concern are actively investigated to define the hydrogeology and nature and extent of the contamination and its source. Where necessary, remediation strategies are developed and evaluated in preparation for a CERCLA removal action or through the feasibility study process. An approved remedy for each area is developed in consultation with the regulatory agencies and the community.

This chapter reviews the distribution of contaminants in groundwater and the progress LLNL has made in removing contaminants from groundwater and from the unsaturated zone (soil vapor) at the Livermore site and Site 300. The sites are similar in that the contamination is, for the most part, confined to the site. The sites differ in that Site 300, with an area of 30.3 $km^2$ (11.8 $mi^2$), is much larger than the Livermore site and has been divided into eight operable units based on the nature and extent of contamination, and topographic and hydrologic considerations. The Livermore site at 3.3 $km^2$ (1.3 $mi^2$) is effectively one operable unit.

## Livermore Site Ground Water Project

Initial releases of hazardous materials 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, leaking tanks and impoundments, and landfills contributed volatile organic compounds (VOCs), fuel hydrocarbons, metals, and tritium to the groundwater and unsaturated sediment (unconsolidated subsurface material) in the post-Navy era. The Livermore site was placed on the U.S. Environmental Protection Agency National Priorities List in 1987.

An analysis of all environmental media showed that groundwater, and saturated and unsaturated sediments are the only media that require remediation (Thorpe et al. 1990). The identified compounds that currently exist in groundwater at various locations beneath the site at concentrations above drinking water standards, or maximum contaminant levels (MCLs), are trichloroethylene (TCE), perchloroethylene (PCE), 1,1-dichloroethylene, chloroform, 1, 2-dichloroethylene, 1,1-dichloroethane, 1,2-dichloroethane, trichlorotrifluoroethane (Freon 113), trichlorofluoromethane (Freon 11), and carbon tetrachloride.

## Physiographic Setting

The general topography of the Livermore site is described in Chapter 1. The Livermore Valley groundwater system is a sequence of semiconfined aquifers in which groundwater moves downslope from the valley uplands toward the east-west axis of the valley. It then flows generally westward toward the southwest portion of the basin. From there, groundwater has historically flowed south into the Sunol Valley Groundwater Basin.

The largest quantities of groundwater are pumped from the central and western portions of the Livermore Valley, where the valley fill sediment is thickest. These sediments make up two aquifers: the Livermore Formation and its overlying alluvium. The Livermore Formation averages about 1000 m in thickness and occupies an area of approximately 250 $km^2$. The alluvium, which is about 100 m thick, is the principal water-producing formation within the valley.

## Hydrogeology of the Livermore Site

Sediment types at the Livermore site are grouped into four categories—clay, silt, sand, and gravel—based on the dominant particle type. Groundwater flow beneath the site is primarily in alluvial sand bodies, gravel lenses, and channels, bounded by the less permeable clay and silt. The alluvial sediments have been mapped into nine hydrostratigraphic units (HSUs) beneath the Livermore site (see **Figure 7-1**). HSUs can be defined as sedimentary sequences whose permeable layers show evidence of hydraulic connection. Six of the nine HSUs contain contaminants at concentrations above their MCLs: HSUs 1B, 2, 3A, 3B, 4, and 5 (Blake et al. 1995; Hoffman et al. 2003). HSUs 1A, 6, and 7 do not contain contaminants of concern above action levels and are therefore not discussed further.

## Remediation Activities and Monitoring Results

In 2004, the Livermore site Ground Water Project (GWP) treated about 1.2 billion liters of groundwater and removed approximately 86 kg of VOCs (**Table 7-1**). The GWP also brought new treatment facilities on line, installed wells, conducted hydraulic and pneumatic (soil vapor) tests, developed groundwater models, published required documents, and maintained close contact with regulatory agencies and the community.

LLNL removes contaminants from groundwater and from the unsaturated zone (soil vapor) at the Livermore site through a system of 30 treatment facilities whose extraction wells are completed in the 6 HSUs containing contaminants of concern. Extraction wells at each facility are used to extract groundwater, which is then treated to remove VOCs. Treatment usually consists of removing VOCs with an air-stripping system, after which any VOCs present in the stripper's effluent air are removed with granular activated carbon filters.

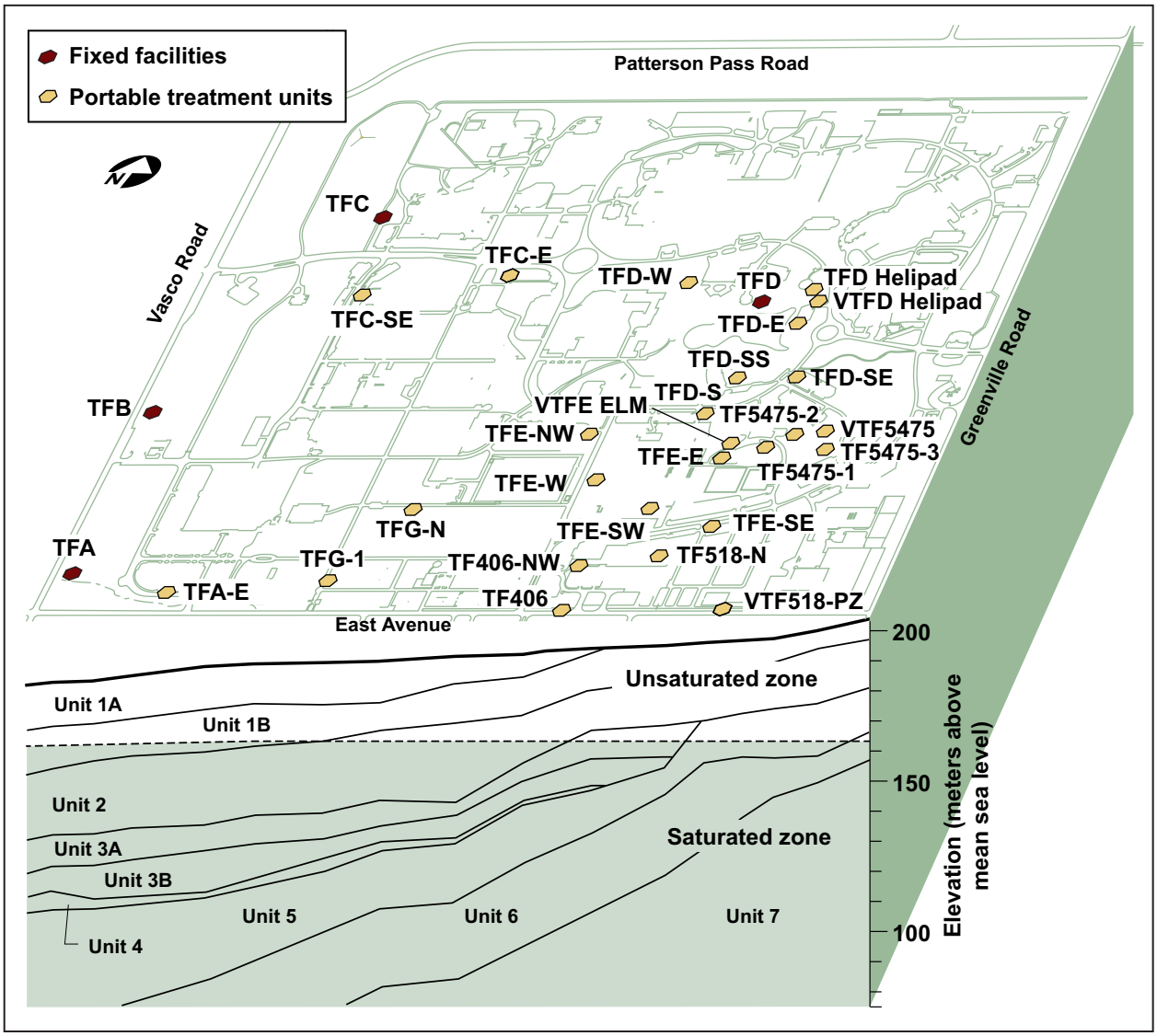


**Figure 7-1.** Map and cross section of the Livermore site showing hydrostratigraphic units and the locations of the treatment facilities

Of the 30 treatment facilities in operation in 2004, 26 are groundwater treatment facilities and 4 are a vapor treatment facilities (VTFs). A total of 80 groundwater extraction wells, 16 dual extraction wells, and 9 soil vapor extraction wells operated in 2004. Since operations began in 1989, approximately 9.7 billion liters of groundwater and approximately 2.6 million $m^3$ of vapor have been treated, and more than 1778 kg of VOCs have been removed. Table 7-1 shows both the 2004 totals and the cumulative totals of groundwater and soil vapor treated at the facilities and the estimated VOCs removed from the subsurface. A graph of VOC mass removal at the Livermore site since 1989 is

**Table 7-1.** Volatile organic compounds removed from groundwater and soil at the Livermore site

| Groundwater treatment facility[a] | Startup date | 2004 | | Cumulative total | |
|---|---|---|---|---|---|
| | | Water treated (ML)[b] | VOCs removed (kg) | Water treated (ML) | VOCs removed (kg) |
| TFA | 9/89 | 480 | 8.9 | 4510 | 171.6 |
| TFB | 10/90 | 98.8 | 3.3 | 1011 | 62.5 |
| TFC | 10/93 | 109.0 | 5.6 | 825.6 | 66.1 |
| TFD | 9/94 | 311.5 | 53.9 | 2080 | 607.1 |
| TFE | 11/96 | 106.4 | 11.2 | 748.4 | 162.5 |
| TFG | 4/96 | 23.5 | 1.1 | 115.1 | 5.9 |
| TF406 | 8/96 | 45.8 | 1.2 | 308.1 | 10.2 |
| TF518 | 1/98 | 4.9 | 0.5 | 47.7 | 5.3 |
| TF5475 | 9/98 | 0.4 | 0.2 | 3.0 | 5.5 |
| Total[c] | | 1180 | 86 | 9649 | 1097 |
| **Vapor treatment facility** | | **Soil vapor treated ($10^3 m^3$)** | **VOCs removed (kg)** | **Soil vapor treated ($10^3 m^3$)** | **VOCs removed (kg)** |
| VTF518 | 9/95 | 0 | 0 | 427.2 | 153 |
| VTF5475 | 1/99 | 319.8 | 46.2 | 1232 | 390.4 |
| VTFE ELM | 9/03 | 684.9 | 45.3 | 778.1 | 95.7 |
| VTFD HPD | 6/04 | 151.4 | 7.6 | 151.4 | 7.6 |
| VTF518 PZ | 9/04 | 28.7 | 34.1 | 28.7 | 34.1 |
| Total[c] | | 1185 | 133 | 2617 | 681 |

a Includes fixed and portable units

b ML = million liters

c Totals rounded to nearest whole number

presented in **Figure 7-2**. GWP activities, such as the types of treatment used at the different facilities and total VOC isoconcentration maps for each HSUs, are further described in the *Ground Water Project 2004 Annual Report* (Karachewski et al. 2005).

In 2004, concentrations continued to decrease in most Livermore site VOC plumes. The decline in VOC concentrations is primarily attributed to active remediation and reflects the 86 kg of VOCs removed by the groundwater extraction wells during 2004 (**Table 7-1**). Notable trends and results of VOC analyses of groundwater received from the fourth quarter 2003 to the third quarter 2004 are discussed below.

VOC concentrations on the western margin of the site either declined or remained unchanged during 2004, indicating continued effective hydraulic control of the boundary plumes in the Treatment Facility (TF) A, TFB, and TFC areas. VOC

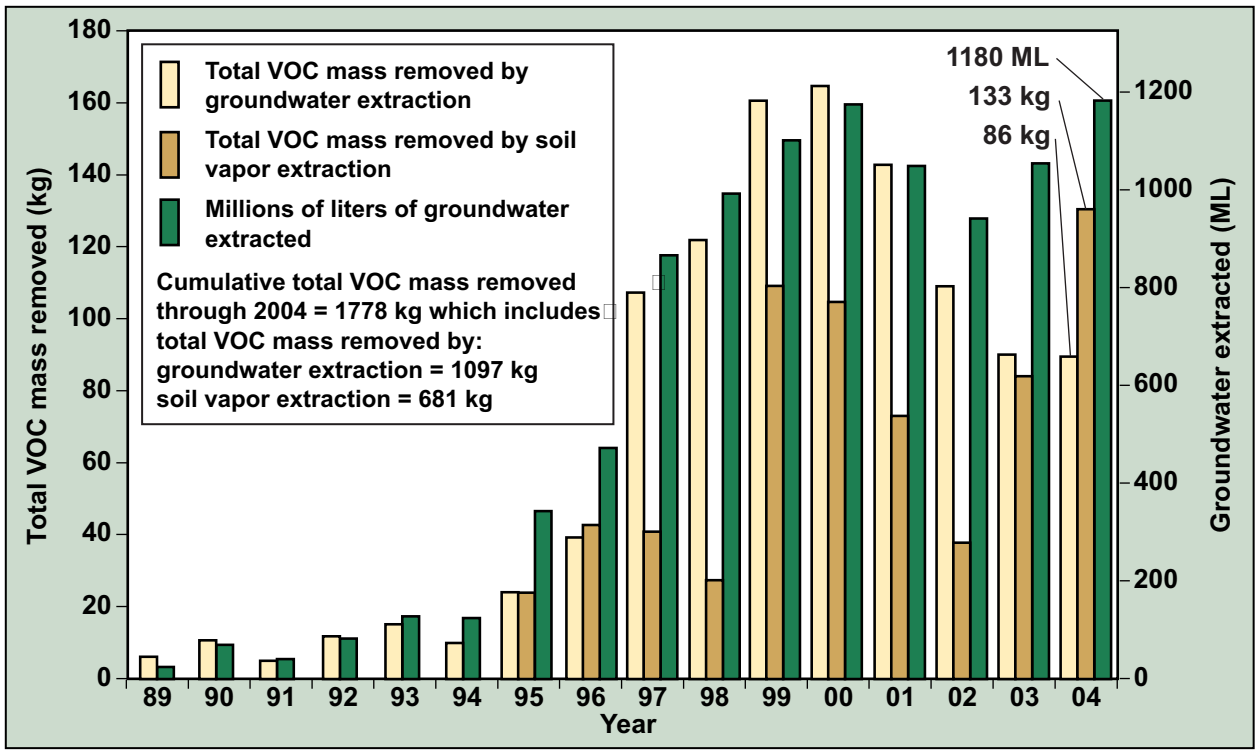


**Figure 7-2.** Total VOC mass removed and groundwater extracted from the subsurface of the Livermore site, 1989–2004

concentrations in the TFA, TFB, and TFC source areas remained unchanged as well. The offsite HSU 1B VOC plumes were below MCLs for all VOCs of concern except at two wells where PCE was slightly above the MCL (PCE was detected at 6 µg/L and 11 µg/L at wells W-506 and W-1425, respectively, in July 2004). The entire off-site and on-site TFA HSU 2 plume remained below 50 µg/L total VOCs again, for a second year. All offsite TFA HSU 3A wells remained below MCLs for all VOCs of concern.

VOC concentrations in a mobile HSU 2 plume located in the western TFE area continued to decline in 2004. Downgradient from the source area, total VOC concentrations decreased below 100µg/L, except at TFE-W extraction well W-305, and total VOCs in well SIP-331-001, located in the distal portion of the plume, declined from 80 µg/L in 2003 to 69 µg/L in 2004. Concentrations further downgradient to the west declined slightly, probably in response to continued pumping of TFG-North extraction well W-1807, located at the leading edge of the plume. Total VOC concentrations in the Old Salvage Yard in the southeastern part of the site, also known as the TFE Hotspot source area, remained elevated in 2004 (e.g., 1815 µg/L total VOCs at SIP-ETS-601, July 2004). Source area cleanup at the TFE Hotspot source area is scheduled to begin in 2005.

HSU 3A total VOC concentrations continued to decline in the TFD Helipad area in 2004, in part due to the start of vacuum-enhanced groundwater extraction. For example, the total VOC concentrations in W-1651 declined from 1125 ppb in October 2003 to 400 ppb total VOCs in July 2004. In the TFE and T5475 areas, slight declines in VOC concentrations were observed in HSU 3A wells. Elsewhere in HSU 3A, concentrations remained largely unchanged.

In HSU 3B, variations in TCE concentration observed near TFD South suggest that VOCs within HSU 3B may be migrating out of the southern TFD East Traffic Circle source area toward the TFD South area. TCE in well W-1511 decreased from 750 µg/L in 2003 to 380 µg/L in 2004. Hydraulic containment of the HSU 3B source area and associated TCE groundwater plume will be addressed as part of an upcoming 2005 milestone. Elsewhere in HSU 3B, VOC concentrations remained largely unchanged.

Concentrations in both HSU 4 and HSU 5 remained relatively unchanged in 2004. In HSU 4, slight decreases in total VOC concentrations were noted in the western TFE area at wells W-304 and W-1211 as well as in the TFD area.

During 2004, tritium activities in groundwater from all wells in the TF5475 area remained below the 740 Bq/L (20,000 pCi/L) MCL and continued to decrease by natural decay. Except for one sample from UP-292-007 (803 Bq/L [21,700 pCi/L] in May 2004), tritium activities in the Building 292 area also remained below the MCL in 2004.

## Groundwater Flow and Transport Modeling

Groundwater flow and contaminant transport models are used at the Livermore site to optimize the design and operation of remediation systems; to support ongoing subsurface characterization activities; and to improve LLNL's ability to forecast, monitor, and interpret the progress of the remediation program. An existing production model for the western portion of the site is currently used to optimize groundwater remediation. In 2004, LLNL continued development of a three-dimensional (3-D) basin-scale groundwater flow and transport model that incorporates the Livermore site HSU framework. The model is updated by incorporating remediation system improvements and hydrogeologic information from new wells. LLNL is currently improving this 3-D model to simulate the extensive extraction well field and the resultant dewatering observed at the eastern portion of the site. LLNL is also using this model to understand contaminant migration between adjacent HSUs and the role of source areas in affecting cleanup time.

In addition to groundwater flow and transport models, LLNL also developed a one-dimensional vadose zone model for the Building 514 Area to determine the potential impact from residual contamination in soil to groundwater. This model is used to support Resource Conservation and Recovery Act (RCRA) activities currently underway in the Building 514 Area.

## Environmental Impacts

At the Livermore site, LLNL strives to reduce risks arising from chemicals released to the environment and to conduct all its restoration activities to protect environmental resources and to preserve the health and safety of all site workers. LLNL's Environmental Restoration project is committed to preventing present day and future human exposure to contaminated soil and groundwater, preventing further contaminant migration of concentrations above drinking water standards, reducing concentrations in groundwater, and minimizing contaminant migration from the unsaturated zone to the underlying groundwater.

Remedial solutions are implemented that have been determined to be most appropriate for individual areas of contamination. The selected remedial solutions have been agreed upon by DOE and the regulatory agencies with public input and are designed to achieve the goals of reducing risks to human health and the environment and to satisfying remediation objectives, regulatory standards for chemicals in water and soil, and other state and federal requirements. These remedial solutions include groundwater extraction and treatment, soil vapor extraction and treatment, or a combination of both.

Groundwater and soil vapor extraction and treatment at the Livermore site continue to reduce the mass of contaminants in the subsurface. During 2004, extraction wells yielded about 1.2 billion liters of groundwater. During the year, 1.2 million $m^3$ of vapor were also extracted. In 2004, the Livermore site treatment facilities removed approximately 219 kg of VOCs. Since remediation efforts began in 1989, more than 9.6 billion liters of groundwater and approximately 2.6 million $m^3$ of vapor have been treated, yielding about 1778 kg of removed VOCs.

# Site 300 CERCLA Project

Environmental investigations and cleanup activities at Site 300 began in 1981. Site 300 became a CERCLA site in 1990, when it was placed on the National Priorities List. The CERCLA environmental restoration operable units (OUs) are shown in **Figure 7-3**. All characterized contaminant release sites have been assigned to one of eight OUs based on the nature, extent, and sources of contamination, and topographic and hydrologic considerations. The major contaminants of concern for each OU are listed in **Table 7-2**. CERCLA work at Site 300 is conducted under a Federal Facility Agreement (FFA) and other requirements. Background information for LLNL environmental characterization and restoration activities at Site 300 can be found in the *Final Site-Wide Remedial Investigation Report, Lawrence Livermore National Laboratory Site 300* (Webster-Scholten 1994). Key milestone and deliverable due dates for 2004 are listed in **Table 7-3**. All milestone and deliverable due dates were met during 2004.

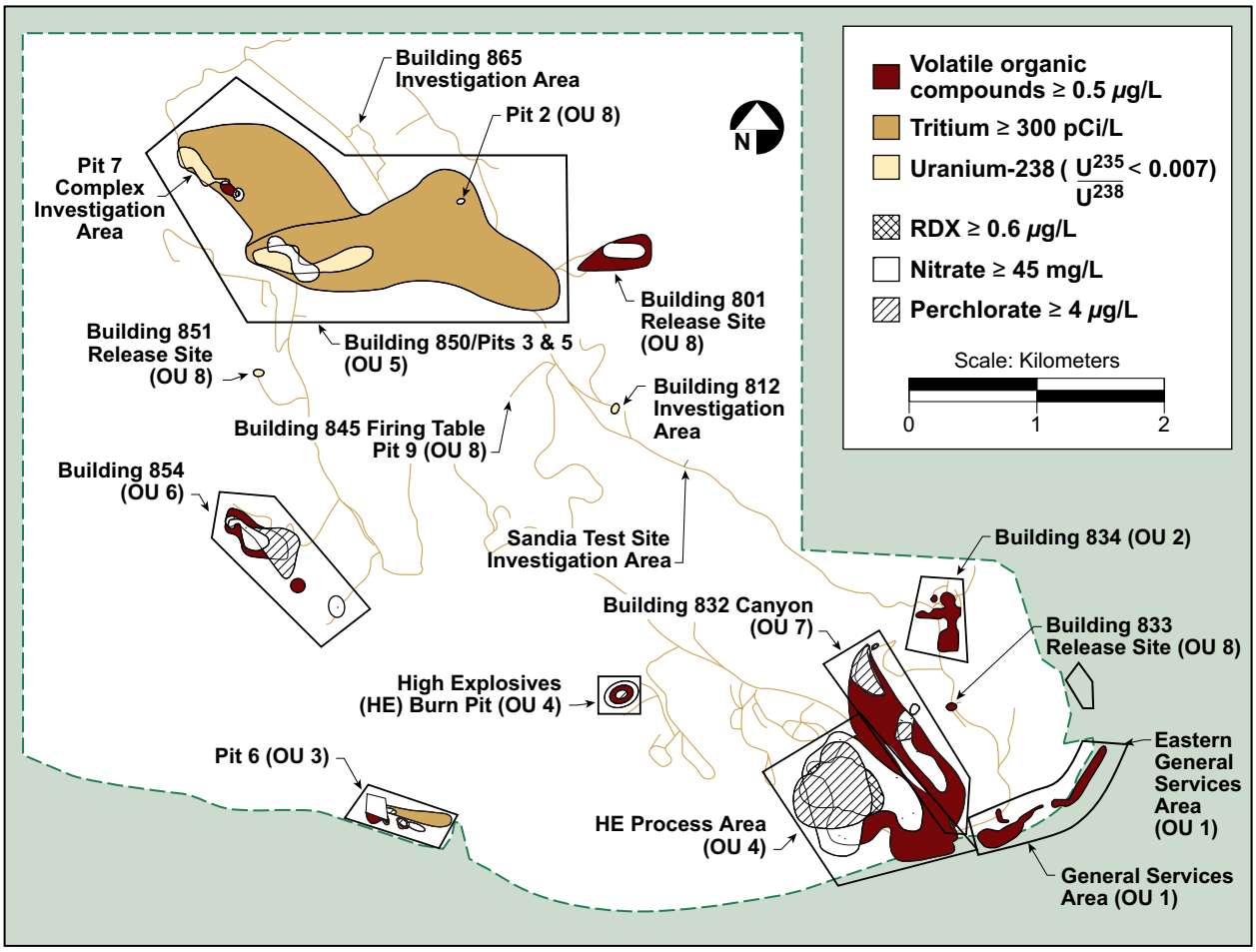


**Figure 7-3.** Environmental restoration operable units, investigation areas, and contaminants of concern

## Geology of Site 300

Site 300 is located in the sparsely populated Altamont Hills, which are part of the Coast Ranges Physiographic Province and separate the Livermore Valley to the west from the San Joaquin Valley to the east. Site 300 stratigraphy is shown in **Figure 7-4**. Rocks exposed in the region are classified into three groups:

- Late Tertiary-Quaternary (0–5 million years ago)—alluvium and semi-lithified sediments, mainly of continental origin
- Early to late Tertiary (5–65 million years ago)—shallow marine and continental sedimentary and volcaniclastic rocks
- Jurassic-Cretaceous (65–180 million years ago)—Great Valley sequence (marine sedimentary rocks and ophiolites) and Franciscan Complex (sheared and variably metamorphosed sedimentary and igneous rocks)

**Table 7-2.** Major contaminants of concern found in soil, rock, and groundwater at Site 300

| Operable Unit (OU) | Contaminant of concern[a] |
|---|---|
| General Services Area (GSA) (OU1) | VOCs (primarily TCE) |
| Building 834 Complex (OU2) | VOCs (primarily TCE), organosilicate oil, nitrate |
| Pit 6 (OU3) | VOCs (primarily TCE), tritium, nitrate, perchlorate |
| High Explosives Process Area (OU4) | VOCs (primarily TCE), HE (primarily RDX), nitrate, perchlorate |
| Building 850/Pits 3 & 5 (OU5) | Tritium, depleted uranium, VOCs (primarily TCE), nitrate, perchlorate |
| Building 854 (OU6) | VOCs (primarily TCE), nitrate, perchlorate |
| Building 832 Canyon (OU7) | VOCs (primarily TCE), nitrate, perchlorate |
| Site-Wide Operable Unit (OU8) | VOCs (primarily TCE and Freon 113), nitrate, perchlorate, depleted uranium, tritium, metals, RDX |

a See Acronyms and Abbreviations for list of acronyms.

**Table 7-3.** Calendar year 2004 deliverable and milestone dates for Site 300 environmental restoration activities outlined in the FFA and other agreements

| Deliverable/Milestone | Due Date |
|---|---|
| *Draft Remedial Investigation/Feasibility Study (RI/FS) for the Pit 7 Complex* | March 3, 2004 (met) |
| Public Workshop for the Pit 7 Complex RI/FS | April 1, 2004 (met) |
| Final Building 850 Remedial Design report | June 30, 2004 (met) |
| *Draft Final RI/FS for the Pit 7 Complex* | July 29, 2004 (met) |

Distinctive blue-gray to brown weathering volcaniclastic sandstone and sandy siltstone, interbedded with light gray weathering tuffaceous claystone and conglomerate, are exposed extensively within Site 300. These rocks are mapped as the late Miocene Neroly Formation (Huey 1948; Dibblee 1980). The Neroly Formation is also present in the subsurface beneath Site 300. It is the principal hydrologic unit within Site 300 and has been the focus of the detailed geologic and hydrogeologic studies conducted during recent years (summarized in the *Final Site-Wide Remedial Investigation Report, Lawrence Livermore National Laboratory Site 300*, [Webster-Scholten 1994]). The complete section of the Neroly Formation is about 150 m thick beneath Site 300.

The floodplain of Corral Hollow Creek lies along the southern boundary of Site 300 and borders portions of the General Services Area (GSA), the High Explosives Process Area, and the area of closed landfill Pit 6. Floodplain alluvium consists dominantly of coarse cobble-bearing terrace gravel derived from sources to the south, with lenses and local coverings of sandy silt and silty clay.

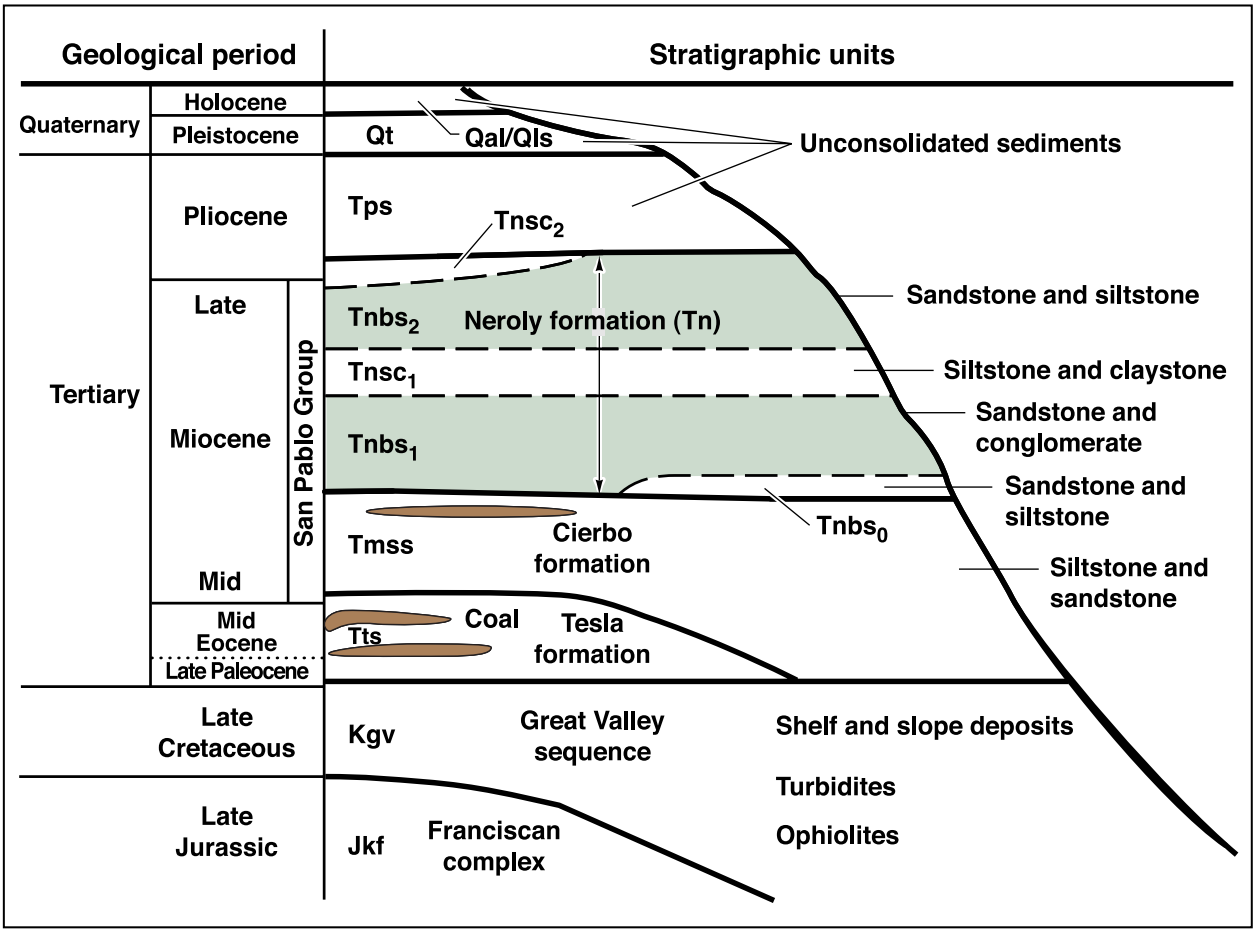


**Figure 7-4.** Site 300 stratigraphy

The bedrock sequence within Site 300 has been slightly deformed into several gentle, low-amplitude folds. The locations and characteristics of these folds, in combination with the regional fault and fracture patterns, locally influence groundwater flow within the site and have therefore been studied in great detail as part of the CERCLA investigations.

## Hydrogeology of Site 300

Site 300 is semiarid, with an average annual rainfall of 27 cm. The site is underlain by gently dipping sedimentary bedrock dissected by steep ravines. The bedrock consists of interbedded conglomerates, sandstones, siltstones, and claystones (see **Figure 7-4**). Groundwater primarily occurs in the Neroly Formation upper and lower blue sandstone units ($Tnbs_2$ and $Tnbs_1$) and in the underlying Cierbo Formation (Tmss). Saturated conditions also exist in two units that occur at the base of the Neroly Formation in the

Building 854 and Pits 3 and 5 areas, respectively ($Tnsc_0$ and $Tnbs_0$). Groundwater can also be present in permeable Quaternary alluvium valley fill (Qal) during the winter rainy season.

Some groundwater is present as perched water-bearing zones beneath hilltops. The perched water-bearing zones primarily occur in the unconsolidated sediments of the Miocene-age nonmarine unit (Tps) in the Building 833 and Building 834 areas and in the High Explosives Process Area. An extensive perched water-bearing zone also occurs in $Tnbs_0$ sandstones in the northwestern portion of the East and West Firing Area. Fine-grained siltstone and claystone interbeds in $Tnbs_1$ and Tmss act as aquitards, confining layers, or perching horizons. Portions of the bedrock section at Site 300 are abundantly fractured, and thus much of the groundwater flow occurs in fractures as well as in pores. Bedrock-hosted groundwater is typically present under confined conditions in the southern half of the site but is often unconfined elsewhere. **Figure 7-5** is a map of the potentiometric surface for the first continuous water-bearing zone at Site 300, which principally occurs in the Neroly lower blue sandstone aquifer ($Tnbs_1$) and $Tnbs_0$.

Recharge occurs where saturated alluvial valley fill is in contact with underlying permeable bedrock, and where bedrock strata crop out. Local recharge occurs on hilltops, creating the perched waterbearing zones in the Building 832, Building 834, Building 854, and Building 829/High Explosives Burn Pit areas. Low rainfall and high evapotranspiration rates, steep topography, and intervening aquitards generally preclude direct vertical recharge to the deeper bedrock aquifers.

Groundwater flow in the bedrock follows the inclination, or dip, of the rock layers. The tectonic forces that uplifted the Altamont Hills faulted, gently folded, and tilted the once-horizontal sedimentary strata. A major structure, the east-west trending Patterson anticline, occupies a central location within the site. North of the anticline, bedrock generally dips east-northeast. South of the anticline, bedrock dips south-southeast.

All groundwater contaminant plumes at Site 300 occur in Neroly Formation (Tn) rocks, unnamed Pliocene nonmarine sediments (Tps), or unconsolidated Quaternary sediments (Qal, Qls, or Qt) stratigraphic units. The extent of groundwater contamination at Site 300 is shown in **Figure 7-3**.

## Remediation Activities and Monitoring Results

This section presents a summary of monitoring and remediation results for contaminant release sites at Site 300. Detailed monitoring and remediation results for the central GSA, Building 834, High Explosives Process Area, Building 850, Building 854, Pit 6, Building 832 Canyon, and Site-Wide OUs are presented in the Compliance Monitoring Program (CMP) reports for Site 300 (Dibley et al. 2004, 2005). The *2004 Annual Compliance Report for Lawrence Livermore National Laboratory Site 300* (Dibley et al. 2005) is included on the report CD. The eastern GSA treatment system is not included in the CMP report; it operates under a separate waste discharge requirements permit and results are presented quarterly (Yow 2004a,b,c; Yow 2005). The results of ongoing and

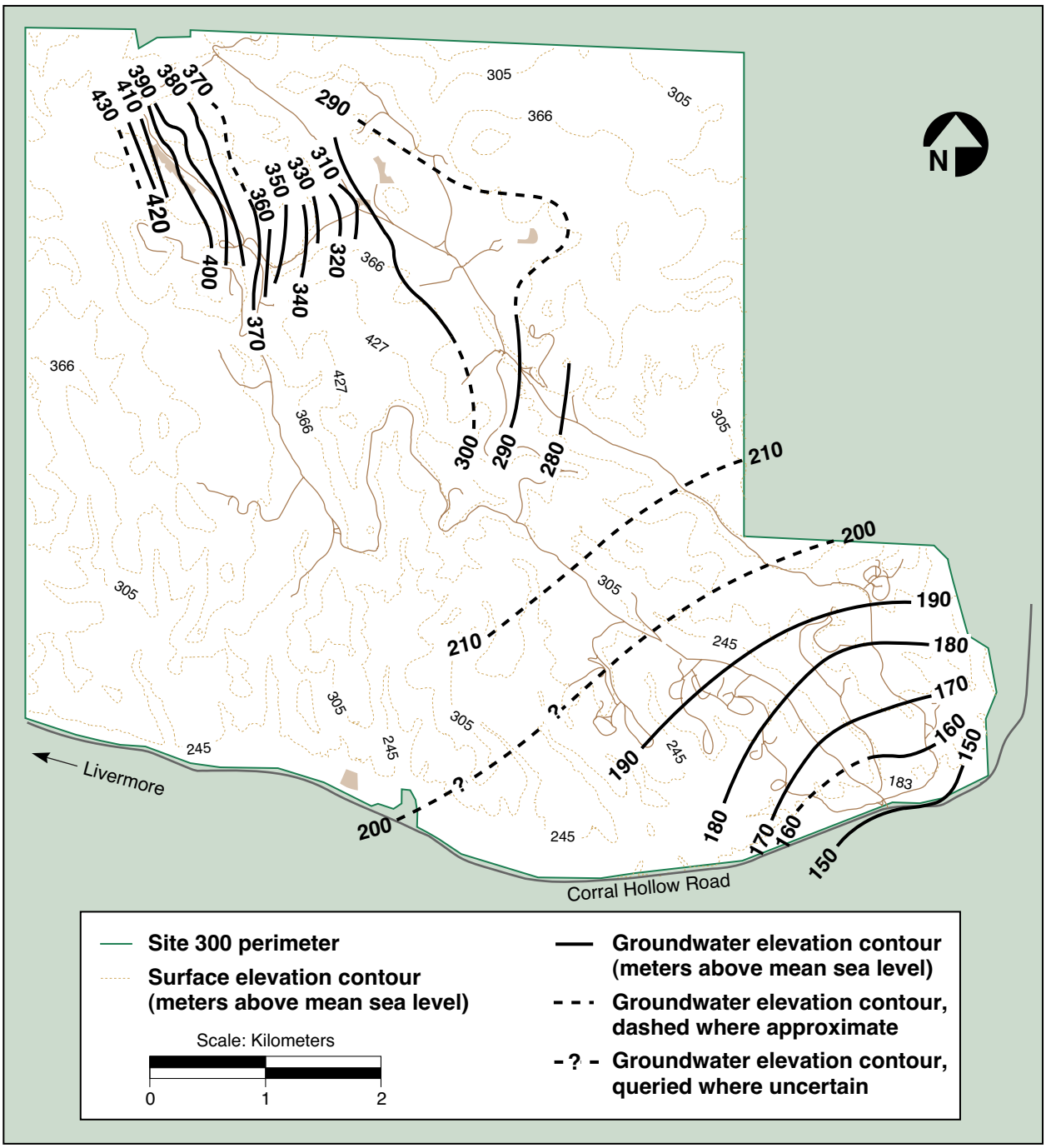


**Figure 7-5.** Approximate groundwater elevations in the principal continuous water-bearing zone at Site 300

planned investigations at the Pit 7 Complex, Building 865, Building 812, and Sandia Test Site are also not a part of the CMP report. Current information for each of these portions of Site 300 is presented at the end of this section.

At Site 300, there are three dedicated (non-portable) groundwater and soil vapor extraction and treatment facilities at the eastern GSA, central GSA, and Building 834 areas, respectively. There are also 10 portable treatment facilities at Site 300. All 10 of these facilities operated during calendar 2004. Thus, 13 treatment facilities that remove VOCs operated during 2004. Twenty-three wells that extract only groundwater, 8 wells that extract only soil vapor, and 13 wells that extract both groundwater and soil vapor were pumped and fed into treatment systems during 2004. In 2004, the 23 wells that extract only groundwater and the 13 wells that extract both groundwater and soil vapor yielded about 101 million L of groundwater. During the year, the 13 wells that extract both vapor and groundwater and the 8 wells that extract only vapor removed 2.07 million $m^3$ of vapor. In 2004, the Site 300 treatment facilities removed approximately 57.6 kg of VOCs. Since remediation efforts began in 1990, more than 1078 million L of groundwater and approximately 6.3 million $m^3$ of vapor have been treated, yielding about 291 kg of removed VOCs. **Table 7-4** summarizes 2004 and cumulative totals of volumes and masses of VOC contaminants removed from groundwater and soil vapor at each Site 300 OU. In addition to VOCs, in 2004, Site 300 treatment facilities removed from groundwater 0.3 g of perchlorate, 2.7 kg of nitrate, 0.45 g of the high explosive RDX, and 0.58 g of organo-silicate oil. Since remediation efforts began, 71.8 g of perchlorate, 705 kg of nitrate, 100 g of RDX, and 9.6 g of organosilicate oil have been removed.

The central GSA, eastern GSA, and B830-Distal, South (B830-DISS) treatment facilities discharge to surface drainage courses. The B854-Proximal (B854-PRX) solar treatment unit/containerized wetland, B815-Distal (B815-DIS) aqueous phase granular activated carbon, and B830-Proximal, North (B830-PRXN) granular activated carbon treatment systems discharge to an infiltration trench. The other seven treatment systems discharge to air by misting.

The eastern and central GSA contain maintenance and shop facilities and introduced contaminants to groundwater due to dry well and liquid storage activities. Groundwater influent TCE concentrations to the eastern GSA OU were reduced from 64 µg/L in January 1992 to 1.8 µg/L in December 2004. No longer do any off-site wells in the eastern GSA yield groundwater containing TCE concentrations in excess of the cleanup standard (maximum contaminant level; MCL) of 5 µg/L. LLNL estimates that 5 to 10 more years of groundwater extraction and treatment will be required before all groundwater VOC concentrations are below MCLs without continued remediation at the eastern GSA. TCE concentrations in shallow groundwater beneath the eastern GSA are shown on **Figure 7-6**.

Contaminated groundwater is extracted from six wells and vapor is extracted from seven wells screened in the Qt-$Tnsc_1$ HSU in the central GSA. Total VOC concentrations in the central GSA OU have been reduced from 9400 µg/L in 1993 to 3100 µg/L in June 2004. From 1994 through the end of 2004, total VOC concentrations in the central GSA soil vapor extraction influent stream were reduced from 450 $ppm_{v/v}$ to

**Table 7-4.** Volatile organic compounds removed from groundwater and soil at Site 300

| Operable Unit | Startup date | 2004 | | Cumulative total | |
|---|---|---|---|---|---|
| **Groundwater Treatment** | | **Water treated (ML)[a]** | **VOCs removed (kg)** | **Water treated (ML)[a]** | **VOCs removed (kg)** |
| Eastern GSA | 1991 | 83.1 | 0.17 | 979 | 6.56 |
| Central GSA | 1993 | 4.05 | 0.42 | 38.6 | 11.4 |
| Building 834 | 1995 | 0.07 | 0.50 | 0.32 | 32.3 |
| High Explosives Process Area | 1999 | 7.37 | 0.14 | 25.5 | 0.40 |
| Building 854 | 1999 | 2.59 | 0.38 | 17.6 | 7.12 |
| Pit 6 | 1998 | —[b] | —[b] | 0.268 | 0.0014 |
| Buildings 830 and 832 | 1999 | 3.55 | 0.59 | 16.7 | 1.26 |
| Total | | 101 | 2.20 | 1078 | 59.1 |
| **Vapor Treatment** | | **Soil vapor treated ($10^3 m^3$)** | **VOCs removed (kg)** | **Soil vapor treated ($10^3 m^3$)** | **VOCs removed (kg)** |
| Central GSA | 1994 | 53.0 | 0.19 | 2318 | 67.5 |
| Building 834 | 1998 | 157. | 55 | 1814 | 163 |
| Building 832 | 1999 | 1858 | 0.25 | 2195 | 1.80 |
| Total | | 2068 | 55.4 | 6328 | 232 |

a ML = 1 million liters

b Groundwater treatment is not routine at Pit 6. A hydraulic pump test with a portable treatment unit for TCE removal was conducted there in 1998.

0.4 $ppm_{v/v}$. Total VOC concentrations in individual central GSA soil vapor extraction wells have also been significantly reduced. Total VOC concentrations in groundwater beneath the central GSA are shown on Figure 2.1-3 of the *2004 Annual CMP Report* (Dibley et al. 2005).

At Building 834, prototype weapons components were subjected to a variety of environmental stresses including heat and pressure. TCE was used as a heat-exchange fluid and was circulated in piping that leaked. The maximum 2004 total VOC concentration in groundwater at Building 834 was 180,000 µg/L. Total VOC concentrations in Tpsg-hosted groundwater beneath the Building 834 area are shown on Figure 2.2-3 of the *2004 Annual CMP Report* (Dibley et al. 2005). (Tpsg is the gravel portion of the Tps unit shown in **Figure 7-4**.) Treatment facility modifications, including installation of new control systems, well head monitoring equipment, and wellfield expansion, were made throughout 2003 and were completed during 2004. Groundwater and soil vapor treatment were reinitiated on September 20, 2004. Twelve wells that extract both groundwater and soil vapor compose the extraction network. Although some VOC mass was destroyed by in situ bioremediation, this mass was not quantified.

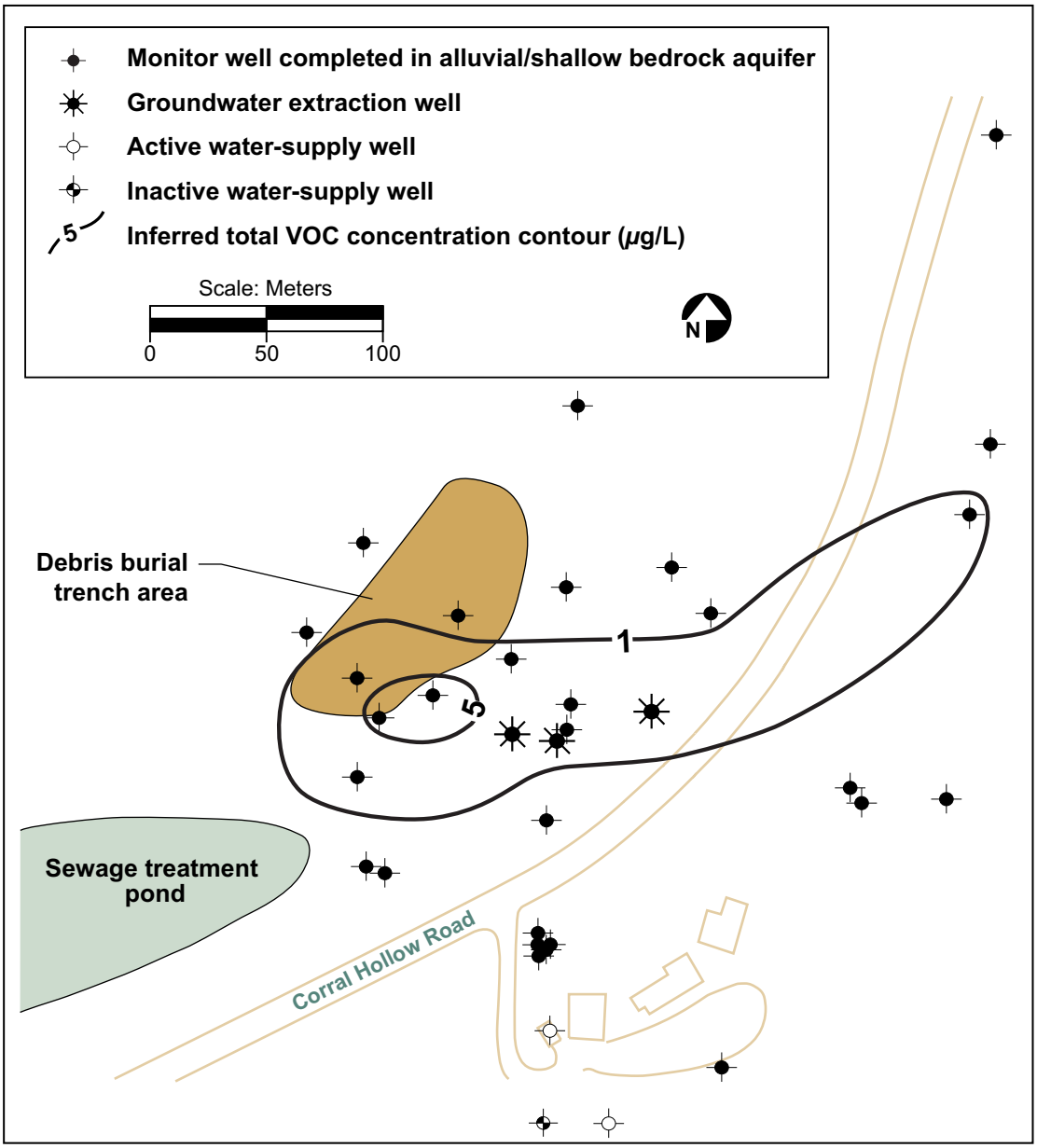


**Figure 7-6.** Total VOC concentrations in groundwater in the eastern GSA and vicinity (4th quarter 2004)

At the High Explosives Process Area OU, high explosives are pressed and formed. Surface spills from 1958 to 1986 resulted in the release of contaminants at the former Building 815 steam plant. Subsurface contamination is also attributed to HE waste water discharges to former unlined rinse-water lagoons. Six extraction wells in the OU pump groundwater that is treated at four treatment facilities (B815-SRC, B815-PRX, B815-DSB, and B817-SRC). Total VOC concentrations in groundwater beneath the

High Explosives Process Area are shown on Figure 2.4-3 of the *2004 Annual CMP Report* (Dibley et al. 2005). Maximum 2004 total VOC concentrations of 45 µg/L were detected in groundwater in the $Tnbs_2$ aquifer. ($Tnbs_2$ is the upper blue sandstone of the Neroly Formation shown in **Figure 7-4**.) The total VOC concentrations in source area wells have been reduced by about 40% since remediation began in 1999.

Building 850 is an explosives firing table. During 2004, the maximum detected tritium activity in groundwater at the Building 850 OU was 2176 Bq/L (58,800 pCi/L). Tritium activities in groundwater beneath the Building 850 OU are shown on Figure 2.5-3 of the *2004 Annual CMP Report* (Dibley et al. 2005). Monitored natural attenuation (MNA) is the selected remedy for the remediation of tritium in groundwater emanating from the Building 850 area. MNA continues to be effective for tritium in that the extent of the 740 Bq/L (20,000 pCi/L) MCL contour continues to diminish and the highest tritium activities continue to be located immediately downgradient of the firing table. The maximum 2004 total uranium activity in groundwater that contains some depleted uranium was 0.33 Bq/L (9.07 pCi/L). Total uranium activity continues to be below the 0.74 Bq/L (20 pCi/L) State MCL. The *Final Remedial Design for the Building 850 Subarea* (Taffet et al. 2004a) was submitted prior to the agreed upon regulatory due date.

The Building 854 OU is another site where weapons components were subjected to environmental stresses and where pipes containing TCE leaked. Two extraction wells pump groundwater that is treated at two treatment systems (B854-SRC and B854-PRX) that operate in the OU. The 2004 maximum total VOC concentration in groundwater was 180 µg/L, down from a historic maximum detected TCE concentration of 2900 µg/L. Total VOC concentrations in groundwater beneath the Building 854 OU are shown on Figure 2.6-3. of the *2004 Annual CMP Report* (Dibley et al. 2005).

Pit 6 is a landfill that received waste from 1964 to 1973. The landfill was capped and closed under CERCLA in 1997. MNA is the selected remedy for the remediation of VOCs in groundwater emanating from Pit 6. The maximum 2004 groundwater total VOC concentration was 5.2 µg/L. The maximum 2004 groundwater tritium activity was 68.8 Bq/L (1680 pCi/L). Total VOC and tritium concentrations in groundwater at Pit 6 are shown on Figures 2.3-3 and 2.3-4, respectively, of Dibley et al. 2005. Tritium activities in groundwater at the pit are shown on Figure 2.3-4 of the *2004 Annual CMP Report* (Dibley et al. 2005).

Building 832 Canyon OU facilities were used to test the stability of weapons components under a variety of environmental stresses. Contaminants were released from Buildings 830 and 832 through piping leaks and surface spills. Four groundwater extraction and treatment systems operate in the OU: B832-SRC, B830-SRC, B830-PRXN, and B830-DISS. B832-SRC and B830-SRC extract and treat groundwater and soil vapor. The other two facilities only treat groundwater. Nine extraction wells operate in the OU. The maximum 2004 groundwater total VOC concentration was 8800 µg/L. These maximum concentrations occur in the $Tnsc_{1b}$ hydrostratigraphic unit. ($Tnbs_{1b}$ is a subunit of $Tnbs_1$ shown in **Figure 7-4**.) Maximum 2004 total VOC concentrations of 2100 µg/L were detected in the Qal hydrostratigraphic unit. Total VOC concentrations measured during 2004 in groundwater from the$Tnsc_{1b}$ HSU at the Building 832

Canyon OU are shown on Figure 2.7-6 of the *2004 Annual CMP Report* (Dibley et al. 2005). Total 2004 VOC concentrations in the Qal HSU are shown on Figure 2.7-5. of that document.

The Site 300 Site-Wide OU is composed of release sites at which no significant ground water contamination and no unacceptable risk to human health or the environment is present. For this reason, a monitoring-only remedy was selected for these release sites, which include the Building 801 Firing Table, Building 833, Building 845 Firing Table/Pit 9, Pit 2, and Building 851 Firing Table areas. The results of routine monitoring of these sites are included in Section 2.8 and Chapter 3 of the *2004 Annual CMP Report* (Dibley et al. 2005).

The following sections describe the current status of investigations under way at four sites that are still under investigation and have not yet reached the Record of Decision for a final remedy to address environmental contamination. These areas are the Pit 7 Complex, Building 865, the Building 812 Firing Table, and the Sandia Test Site.

# Ongoing and Planned Investigations and Cleanup Activities

## Pit 7 Complex

The Pit 7 Complex is composed of four landfills—Pits 3, 4, 5, and 7—that received waste from explosives experiments conducted at Site 300 firing tables. Pits 3 and 5 have released tritium to groundwater. Pits 3, 5, and 7 have released depleted uranium to groundwater. The maximum tritium activity detected in groundwater in 2004 in the OU was 16,169 Bq/L (437,000 pCi/L) in $Tnbs_0$ bedrock. The maximum detected total uranium activity in groundwater that contained some depleted uranium was 4.16 Bq/L (112.4 pCi/L) and was detected in a sample from the Qal/weathered bedrock. Perchlorate, TCE, and nitrate also occur in Pit 7 Complex groundwater. **Figure 7-7** presents maps of tritium activities in groundwater in Qal/weathered bedrock and $Tnbs_0$ HSUs.

LLNL submitted the *Draft Final Remedial Investigation/Feasibility Study for the Pit 7 Complex* (Taffet et al. 2004b) prior to the September 30, 2004, milestone date established in the FFA (**Table 7-3**). The report presents details of the hydrogeology, nature and extent of contamination, and risk assessment and specifies remedial actions that can be applied to address the contamination.

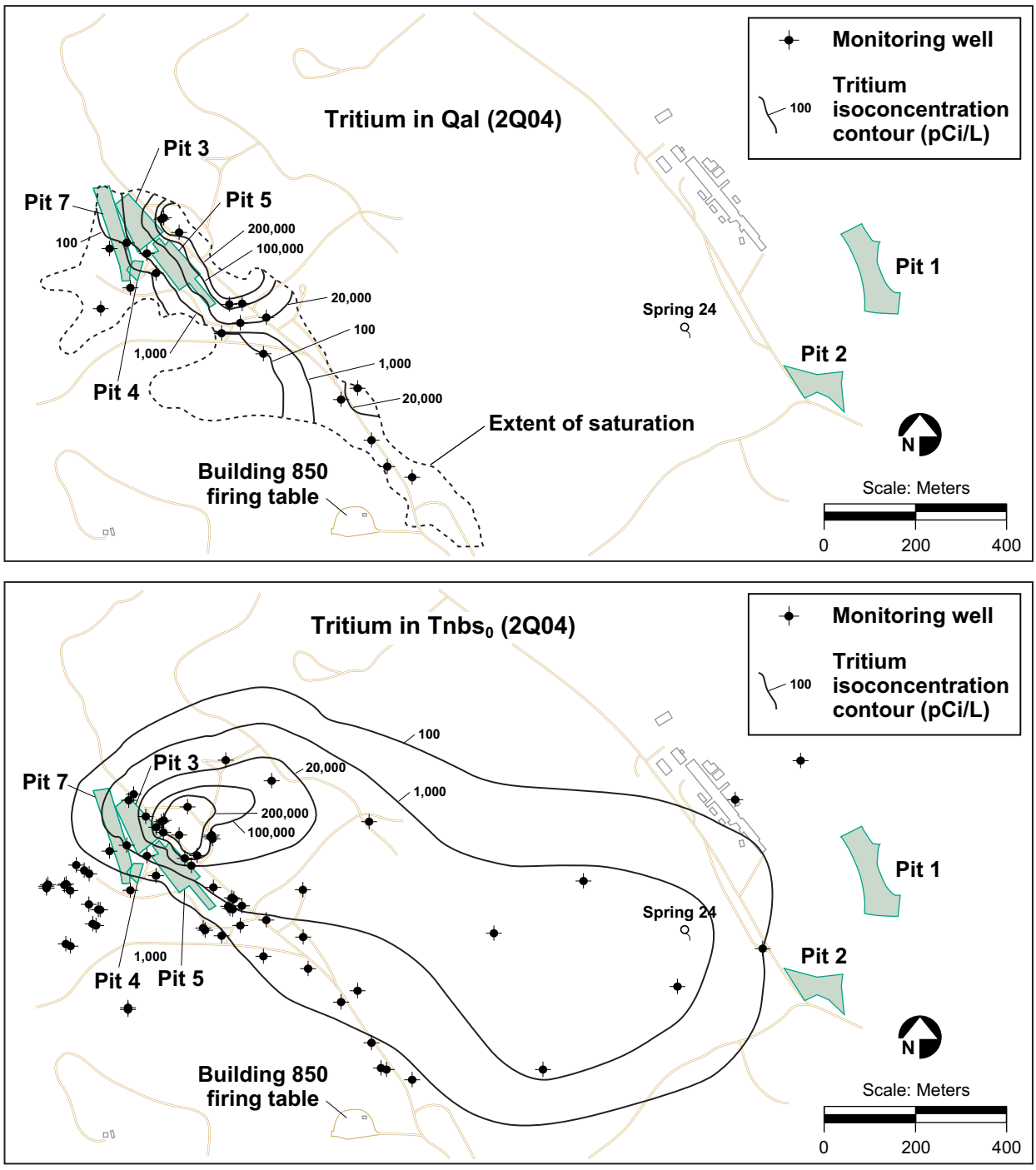


**Figure 7-7.** Tritium plume in Qal and $Tnbs_0$ (2nd quarter 2004)

### Building 865

Building 865 is a former linear accelerator, the Advanced Testing Accelerator. Freon-113 was used as a degreaser there and has been released to groundwater. The maximum Freon-113 concentration detected in groundwater during 2004 was 290 μg/L. The federal and state MCL for Freon-113 in drinking water is 1200 μg/L.

During 2004, LLNL installed two monitoring wells as a part of the remedial investigation of Building 865. LLNL will complete a Characterization Summary report detailing the hydrogeology and nature and extent of contamination emanating from Building 865. This report is currently scheduled for submission to the regulatory agencies by September 30, 2006.

### Building 812 Firing Table

Building 812 is an explosives test firing table. A remedial investigation is in process. During 2004, a maximum detected groundwater activity of total uranium, in which some of the uranium was due to addition of depleted uranium, was 0.75 Bq/L (20.3 pCi/L). LLNL will complete a Characterization Summary report detailing the hydrogeology and nature and extent of contamination emanating from Building 812. This report is currently scheduled for submission to the regulatory agencies by September 30, 2005.

### Sandia Test Site

The Sandia Test Site was used in the past for several open air explosives experiments. During 2004, ten boreholes were drilled and soil and rock samples were collected and analyzed for metals and radionuclides. Three of these boreholes were completed as piezometers. Two of the piezometers were removed and backfilled after water samples were collected. Otherwise, no anthropogenic contamination has been observed in samples of water, soil, or rock collected from the Sandia Test Site. LLNL will complete a Characterization Summary report detailing the hydrogeology and nature and extent of contamination emanating at the site. This report is currently scheduled for submission to the regulatory agencies by September 30, 2006.

## Environmental Impact

LLNL strives to reduce elevated risks arising from chemicals released to the environment at Site 300 and to conduct its activities to protect ecological resources. At each OU, LLNL proposes a range of remediation options that are applicable for each release site. The option that achieves the goals of reducing risks to human, health and the environment and satisfying remediation action objectives, regulatory standards for chemicals in water and soil, and other state and federal requirements is then negotiated by DOE and the regulatory agencies with public input. The agreed upon actions are implemented.

These actions have included groundwater and soil vapor extraction and treatment, source area (lagoon and landfill) capping, monitored natural attenuation, monitoring, and institutional controls

Groundwater and soil vapor extraction and treatment at Site 300 continue to reduce the mass of contaminants in the subsurface. As stated previously, during 2004, extraction wells yielded about 101 million L of groundwater. During the year, 2.07 million $m^3$ of vapor were also extracted. In 2004, the Site 300 treatment facilities removed approximately 57.6 kg of VOCs. Since remediation efforts began in 1990, more than 1078 million L of groundwater and approximately 6.3 million $m^3$ of vapor have been treated, yielding about 291 kg of removed VOCs. In addition to VOCs, during 2004, Site 300 treatment facilities removed from groundwater 0.3 g of perchlorate, 2.7 kg of nitrate, 0.45 g of the high explosive RDX, and 0.58 g of organosilicate oil. Since remediation efforts began, 71.8 g of perchlorate, 705 kg of nitrate, 100 g of RDX, and 9.6 g of organosilicate oil have been removed.

All ground-disturbing activities, such as well drilling, construction and operation of treatment systems, and groundwater sampling are planned and conducted to minimize disturbance of animal and plant habitat. A biologist inspects all sites and makes recommendations that are incorporated into the plan for each activity. Erosion controls and other recommendations made by the surface water hydrologist are also incorporated into the plans for ground-disturbing activities.