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**Oakland Operations Office, Oakland, California 94612**

**Lawrence Livermore National Laboratory**
**University of California  Livermore, California 94551**

UCRL-AR-122596

# LLNL
# Ground Water Project

## 1995 Annual Report

**Technical Editors:**

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**Operations and Regulatory Affairs Division

**Environmental Protection Department**
**Environmental Restoration Division**

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# Summary

The major Livermore Site Ground Water Project (GWP) restoration activities conducted in 1995 are:

1. The Lawrence Livermore National Laboratory (LLNL) Livermore Site GWP produced two major Comprehensive Environmental Response, Compensation, and Liability Act documents in 1995: Remedial Design Report No. 5 (RD5), issued April 25; and the draft final version of the Compliance Monitoring Plan (CMP), issued December 21. Twelve additional documents or letter reports were submitted to the regulatory agencies in 1995, including Monthly GWP Progress Reports; Remedial Program Managers Meeting Summaries and the GWP 1994 Annual Report. All five Department of Energy (DOE)/LLNL milestones were submitted to the regulatory agencies ahead of schedule.

2. The Community Work Group met three times in 1995 to discuss topics, including: RD5; tritium monitoring findings; soil sampling for plutonium at Big Trees Park; the Baseline Environmental Management Report; off-site plume capture; DOE budget status; LLNL's Environmental Restoration Division (ERD) organization; and the CMP.

3. Twenty six source investigation boreholes were drilled during 1995 in the following areas: Treatment Facility E (TFE); Treatment Facility C (TFC); Building 518 Vapor Extraction Treatment Facility (TF518); Treatment Facility G (TFG); Treatment Facility D (TFD)/Building 490; Treatment Facility F (TFF); the Salvage Yard; Building 419; Building 331; and Trailer 5475 (T5475). Eleven were completed as piezometers, one was completed as an extraction well, two were completed as air inlet wells, and two were completed as SEAMIST instrumented boreholes.

4. The NUFT (Nonisothermal Unsaturated Flow and Transport) computer model was used to evaluate the potential impact of tritium in the unsaturated zone in the Building 292 Area. Results indicate a downward tritium migration rate of less than 1 ft/yr. The Building 292 tank and the piezometer closest to the tank leak point were closed in place by grouting. Monitoring will continue on a quarterly basis.

5. A technical report presenting results of the TF518 vadose zone modeling is in preparation. The NUFT computer model was used to evaluate the potential impact of volatile organic compounds (VOCs) in the unsaturated zone on the ground water in the Building 518 Area, and to support the appropriate soil vapor extraction remedial design.

6. A report summarizing the two dimensional ground water flow and contaminant transport simulations conducted at the Livermore Site was issued in 1995. This model was used as the numerical basis for continuing work on a three-dimensional (3-D) flow and transport model. This 3-D model is based on hydraulic parameters determined for each hydrostratigraphic unit (HSU). The model is being calibrated by using pre-pumping ground water perchloroethylene (PCE) concentrations for the Treatment Facility A (TFA) Area, and comparing simulation results with actual pumping and chemical trend data.

7. The extraction wells, extraction rates, and estimated VOC mass removed in 1995 at TFA, Treatment Facility B (TFB), TFC, and TFD are summarized on the following table.

| Treatment Facility | Extraction wells | Extraction rate (gpm) | Estimated total VOC mass removed (kg) |
|---|---|---|---|
| **TFA** | **W-109, W-408, W-415, W-518, W-520, W-521, W-522, W-601, W-602, W-603, W-609, W-614, W-712, W-1004, W-1009** | **175-200** | **12** |
| **TFB** | **W-357, W-610, W-620, W-621, W-655, W-704,** | **25-50** | **3.4** |
| **TFC** | **W-701** | **15** | **2.7** |
| **TFD** | **W-351, W-906** | **8.5** | **5.8** |
| **1995 Total** | | | **23.9** |

**Notes:** **kg = kilograms.**
**gpm = gallons per minute.**

8. The TFA North and TFB North pipelines were completed this year. Three additional extraction wells were connected to the TFA Arroyo Pipeline. The TFC North Pipeline design was completed in 1995. A diversion conveying treated ground water from TFD through an underground pipeline to Arroyo Las Positas was completed in May. Portable Treatment Unit #1 (PTU-1) was constructed.

9. Well installations in 1995 included:
    - Two ground water wells in the TFA Area,
    - Four ground water wells in the TFC Area,
    - Three ground water wells in the TFD Area,
    - Eight ground water wells in the TFE/T5475 Area,
    - Four ground water wells in the TFF Area,
    - One ground water well in the TFG Area, and
    - Four vadose zone wells in the TF518 Area.

10. In 1995, hydraulic tests were conducted on the following wells:

| Treatment Facility Area | Well(s) |
|---|---|
| **TFA** | **W-903, W-904, W-913, W-1004, W-1009, W-1105** |
| **TFB** | **W-357, W-704, W-1010, W-1011,W-1012, W-1013** |
| **TFC** | **W-1101, W-1103** |
| **TFE** | **W-1109** |
| **TFF** | **W-1114** |
| **T5475** | **W-1108** |

11. During 1995, TFA, TFB, TFC, and TFD were operational. To date, over 214 million gal of ground water has been processed, removing more than 80 kg of VOCs.

12. TFF continued to treat ground water and vapor from extraction wells GEW-808 and GEW-816, and vapor only from well GSW-16. During 1995, 3.6 gal of liquid-equivalent gasoline were removed from the subsurface and treated. Closure of vadose zone treatment was granted by the regulatory agencies in August. In December, interim closure of ground water treatment was granted for the gasoline contaminated zone.
13. Construction of TF518 was completed, and began operation in September. The treatment facility removed approximately 20 kg of VOC mass from September through December.
14. During 1995, ERD used HSUs to aid remediation optimization. An HSU is defined as a sequence of sediments that are grouped together based on their hydrogeologic and contaminant transport properties.

# 1. Introduction

This report summarizes the 1995 Lawrence Livermore National Laboratory (LLNL) Livermore Site Ground Water Project (GWP) activities in five sections: Regulatory Compliance; Field Investigations; Data Analysis and Interpretation; Annual Summary of Remedial Action Program, including discussions of treatment facility activities; and Trends in Ground Water Analytical Results. The 1995 GWP quarterly self-monitoring reports (McConachie and Brown, 1995a, 1995c, 1995d, and 1996) were issued as separate documents.

Figure 1 shows the locations of monitor wells, piezometers, extraction wells, and treatment facilities at the Livermore Site and vicinity as well as other areas referenced in this report. Wells and boreholes drilled in 1995 are shown in bold typeface.

Appendices A through D present Well Construction and Closure Data, Results of Hydraulic Tests, the 1996 Ground Water Sampling Schedule, and the Drainage Retention Basin Annual Monitoring Program Summary . Ground water volatile organic compound (VOC) analyses, water level elevations, and the Treatment Facility F (TFF) Area ground water VOC and fuel hydrocarbon (FHC) analyses are available on request.

# 2. Regulatory Compliance

In 1995, the U.S. Department of Energy (DOE)/LLNL submitted documents required by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and the Livermore Site Federal Facility Agreement (FFA). In addition, DOE/LLNL continued environmental restoration activities and community activities as discussed below.

## 2.1. CERCLA Documents

During 1995, DOE/LLNL submitted two CERCLA documents for the Livermore Site according to the amended Remedial Action Implementation Plan (RAIP) (Dresen *et al.*, 1993) schedule. All five of the 1995 CERCLA/FFA documents/milestones for which DOE/LLNL were responsible, were submitted ahead of schedule (Table 1). The final version of Remedial Design Report No. 5 (RD5) for Treatment Facilities G-1 and G-2 (Berg *et al.*, 1995) was issued on April 25, 1995. The draft and draft final versions of the Compliance Monitoring Plan (CMP) (Nichols *et al.*, 1995) were distributed to the regulatory agencies on August 29 and December 21, 1995, respectively.

As required by the FFA, DOE/LLNL issued the 1994 Ground Water Project Annual Report (Hoffman *et al.*, 1995) and the January and February 1995 Ground Water Project Monthly Progress Reports on schedule. In March 1995, the following changes to reporting requirements were implemented by the Livermore Site Remedial Program Managers (RPMs) to reduce the scope and associated costs of document preparation:

- Discontinue monthly progress reports and schedule RPM meetings monthly. The RPM Meeting Summary now constitutes the monthly report and records all decisions, agreements, noncompliances, if any, and policy changes discussed at RPM meetings.

- Provide self-monitoring data quarterly as an attachment to RPM Meeting Summaries.

In 1995, DOE/LLNL submitted nine RPM Meeting Summaries; the March, June, September, and December summaries included quarterly self-monitoring data (McConachie and Brown, 1995a, 1995c, 1995d, and 1996).

## 2.2. Milestones and Activities

Table 1 presents the amended 1995 RAIP milestones (Dresen *et al.*, 1993) for the Livermore Site.

**Table 1. 1995 RAIP milestones.**

| Milestone | RAIP due date | Date issued |
|---|---|---|
| Receive regulatory comments on Draft RD5 | 01/30/95 | 01/30/95 |
| Submit Draft Final RD5 to the regulatory agencies[a] | 03/31/95 | 03/30/95 |
| Issue RD5[a] | 05/1/95 | 04/25/95 |
| Submit Draft CMP to the regulatory agencies and the community[a] | 08/30/95 | 08/29/95 |
| Begin operation of Building 518 Vapor Extraction Treatment Facility[a] | 09/29/95 | 09/25/95 |
| Receive regulatory comments on Draft Final CMP | 10/30/95 | 10/30/95 |
| Submit Draft Final CMP to regulatory agencies[a] | 12/29/95 | 12/21/95 |

[a] Milestone completed ahead of schedule.

In addition to RAIP milestones, DOE/LLNL accomplished the following tasks on the LLNL Livermore Site priority list (Liddle, 1994):

- Conducted source investigations in the Treatment Facilities C, D, E, F and G (TFC, TFD, TFE, TFF, and TFG) Areas. In addition, we conducted source investigations southeast of the Building 518 Vapor Extraction Treatment Facility (TF518), and at Buildings 331 and 419.
- Completed the Treatment Facility A (TFA) North Pipeline on July 27, 1995; completed the Arroyo Pipeline upgrade on November 20, 1995; completed the Treatment Facility B (TFB) North Pipeline on September 5, 1995; and began procurement for the TFC North Pipeline.

Environmental restoration activities in 1995 also included the following:

- Achieved hydraulic control of the offsite VOC plume along Arroyo Seco (McConachie and Brown, 1995b).
- The RPMs agreed to use Portable Treatment Units (PTUs) in the TFG Area instead of fixed treatment facilities to reduce capital costs. PTUs will utilize the same treatment technologies as specified in the Record of Decision (ROD) (DOE, 1992), and thereby do not constitute a change to the ROD.
- The RPMs agreed to closure of vadose zone treatment at TFF (Gill, 1995).

- The RPMs agreed to temporarily cease the ground water extraction and treatment of the gasoline contaminated zone at TFF until new extraction wells are installed to treat VOCs in ground water from a deeper hydrostratigraphic unit (HSU) (McConachie and Brown, 1995c). A PTU will be installed in the future to treat ground water from the deeper HSU.
- Closed and cemented in place an underground storage tank and a piezometer at Building 292 (McConachie and Brown, 1995d). The RPMs agreed to reduce the sampling frequency for wells in the Building 292 Area (McConachie and Brown, 1995e).
- California Regional Water Quality Control Board (RWQCB), San Francisco Bay Region and the other RPMs agreed to increase treatment capacity at TFA to 350 gallons per minute (gpm) (Ritchie, 1995).
- The RPMs agreed for LLNL to collect a single receiving water sample downstream from TFC and TFD (McConachie and Brown, 1995a).
- The RPMs agreed to place TFA, TFB, TFC, and TFD on similar sampling schedules to streamline reporting processes and increase sampling efficiency (McConachie and Brown, 1995a).

## 2.3. Community Relations

The Community Work Group (CWG) met three times in 1995 to discuss topics including: RD5; tritium monitoring; results of soil sampling for plutonium at Big Trees Park; the Baseline Environmental Management Report; offsite plume capture; DOE budget status; LLNL's Environmental Restoration Division (ERD) organization; and the CMP.

Other community relations activities in 1995 included communications and meetings with a local interest group and other community organizations; public presentations; distributing the *Environmental Community Letter;* maintaining the Information Repositories and the Administrative Record; conducting tours of the site environmental activities; and responding to public and news media inquiries.

# 3. Field Investigations

## 3.1. Ground Water Sampling

In 1995, the GWP submitted 1,442 samples from 351 wells, consisting of 306 monitor wells, 35 source investigation piezometers, and 10 Alameda County Flood Control and Conservation District (Zone 7) or domestic wells. The samples were analyzed for VOCs, FHCs, metals, tritium and gamma-emitting radionuclides, or a combination of analyses depending on the compounds of concern.

Livermore Site ground water sampling frequency recommendations are updated quarterly by an algorithm that evaluates trends in contaminant levels in each well over an 18-month period. The algorithm is a guide to aid in the evaluation of chemical trends. The final decision of the sampling frequency is made by the treatment facility Task Leaders based on algorithm results and other data requirements. The main features of the algorithm that help to determine the sampling frequencies are based on the following criteria:

- Wells exhibiting little change [< 10 parts per billion (ppb) per year] are sampled annually.
- Wells exhibiting moderate change (≥ 10 ppb but < 30 ppb per year) are sampled semiannually.
- Wells showing large change (≥ 30 ppb) are sampled quarterly.
- Wells with less than 18 months of analytical history will be sampled quarterly for the first 18 months, then the algorithm logic, and input from the Task Leaders for each treatment facility area, will determine the sampling frequency.

Wells located at the leading edge of VOC plumes remain on a quarterly sampling frequency. The sampling schedule for 1996 is presented in Appendix C.

## 3.2. Source Investigations

Source investigations conducted in 1995 are presented below and shown in Figure 1.

**Table 2. 1995 source investigation drilling.**

| Area | Boreholes | Completions | Well completion type |
|---|---|---|---|
| TFE | 3 | 1 | Piezometer |
| TFC | 1 | 1 | Piezometer |
| TF518 | 4 | 4 | Two SEAMIST<br>Two air inlet |
| TFG | 1 | 1 | Extraction |
| Salvage Yard | 6 | 0 | — |
| Building 419 | 1 | 1 | Piezometer |
| Building 331 | 1 | 1 | Piezometer |
| Trailer 5475/East Taxi Strip | 7 | 6 | Piezometer |
| TFD/Building 490 | 2 | 1 | Piezometer |

Details of the 1995 source investigation activities are briefly summarized below.

- During the first quarter of 1995, three boreholes were drilled in the TFE Area to follow up source investigation drilling initiated in 1989 and 1990 (Fig. 1). One of these boreholes, SIP-543-101 was completed as a piezometer screened in the first water-bearing zone (HSU 2) from 93 to 103 ft. Flowing sands in this area prevented completing the other two boreholes as piezometers. SIB-543-102 and SIB-543-103 were grouted to the surface.
- Also in the first quarter of 1995, we drilled and installed piezometer SIP-501-202 (Fig. 1) in the TFC Area to better define the extent of perchloroethylene (PCE) in the shallow ground water near TFC (Fig. 1). This piezometer is screened in the first water-bearing zone (HSU 1B), 58 to 64 ft below ground surface.
- In the second quarter of 1995, we drilled four boreholes in the TF518 Area (Fig. 1) to further characterize the extent of VOCs in the unsaturated zone (Fig. 1). Two of these boreholes were completed as SEAMIST vadose zone instrumented boreholes (SEA-518-301 and SEA-518-304) to monitor the effects of soil vapor extraction in the area, and two

of the boreholes were completed as vadose zone air inlet wells (SVB-518-302 and SVB-518-303). The SEAMIST boreholes are installed with instrumented membranes to an approximate depth of 100 ft. Further discussion of these SEAMIST instrumented boreholes is provided in the Building 518 Vapor Extraction Treatment Facility section of this report. The vadose zone air inlet wells were screened between about 4 and 40 ft below the ground surface.

- We also drilled a borehole in the TFG Area (Fig. 1) in the second quarter of 1995, completed as an extraction well, which further characterized the unsaturated zone in this area. This well, W-1111, was completed in the first water bearing (HSU 2) from 88 to 108 ft below the ground surface.
- In the third quarter of 1995, we drilled six shallow boreholes ($\leq$ 15 ft) SIB-PA-101, SIB-PA-102, SIB-PA-103, SIB-PA-104, SIB-PA-105, and SIB-PA-106 in the Salvage Yard Area, located in the southeast corner of the Livermore Site (Fig. 1). These boreholes were drilled to investigate the cause of buckling of the asphalt cover in the area, and to collect sediment samples for chemical analysis to determine the need for further characterization of the area.
- In the third quarter of 1995, we also drilled one borehole each in the Buildings 419 and 331 areas completed as piezometers (Fig. 1). Piezometer SIP-419-101 was completed in the first water-bearing zone (HSU 5) from 112 to 123 ft below ground surface. This piezometer was also drilled to investigate the upgradient source of the VOC plume in the TFF Area. Borehole SIP-331-001 was completed in the second water-bearing zone (HSU 2) from 106 to 116 ft. Sampling plans for these two boreholes were more extensive than for other source investigation boreholes drilled this year due to a larger suite of contaminants of concern. The sediment samples were analyzed for VOCs (EPA Method 8010), aromatics (EPA Method 8020), tritium, gross alpha, gross beta, and Soluble Threshold Limit Concentration (STLC) and Total Threshold Limit Concentration (TTLC) metals. Analyses of water samples collected from the open boreholes at these locations included EPA Method 601, EPA Method 602, tritium, gross alpha, gross beta, and dissolved National Pollution Discharge Elimination System (NPDES) metals.
- In the third and fourth quarters of 1995, we drilled seven boreholes in the Trailer 5475/East Taxi Strip (T5475/ETS) Area to further delineate the VOC/tritium plumes in this source area. Six of these boreholes, SIP-ETS-401, SIP-ETS-402, SIP-ETS-404, SIP-ETS-405, SIP-ETS-501, and SIP-ETS-502 were completed as piezometers screened in HSUs 2 and 3A, about 78 to 123 ft below ground surface. SIB-ETS-403 was grouted to the surface due to planned construction work.
- In the fourth quarter of 1995, we drilled two boreholes in the Building 490 Area (Fig. 1) to investigate the source of a westward migrating Freon 11 plume in the northern portion of the TFD Area. Both of these boreholes were completed as piezometers, but SIP-490-101 (SIB-490-101 in Fig. 1) was abandoned and grouted to the surface after the bottom cap of the casing was dislodged while developing, allowing sand to fill the screened interval. SIP-490-102 was completed in the first water-bearing zone (HSU 2) from 53 to 73 ft below the ground surface.

- Samples collected from approximately 5- and 10-ft depths, and each consecutive 10 ft interval to the water table in all source investigation boreholes, were analyzed for VOCs and tritium. Additional samples were collected for STLC metals analyses at depths of 5 ft, and in some cases 10 ft and a half-way depth to the water table in selected boreholes. Ground water samples bailed from the open boreholes drilled to the water table were analyzed for VOCs, tritium, and most piezometers for dissolved NPDES metals.
- All source investigation piezometers installed in 1995 were initially developed using a combination of air-lift and/or surge block, and bailing. Most 1995 source investigation piezometers were geophysically logged through the casing using gamma and induction tools. All previously installed T5475/ETS Area piezometers were geophysically logged in July 1995 to obtain data for Remedial Design Report No. 4 (RD4).

Significant highlights of 1995 source investigation studies include the following:

- Total VOCs of 13.4 parts per million (ppm) were detected in a bailed ground water sample collected from borehole SIB-543-103 in the TFE Area. Subsequently, well W-1109, planned for future ground water extraction was installed adjacent to this borehole. Total VOC concentrations in ground water collected from well W-1109 are not as high (2.8 ppm), but are still greater than other HSU 2 wells in the area.
- No PCE was detected in the unsaturated zone of SIP-501-202, but 2.9 ppb PCE was detected in the bailed open borehole ground water sample.
- Analytical results from the four TF518 Area boreholes indicate that the 0.1 and 0.01 ppm contours at the 30 ft depth as presented in Figure 3 of Remedial Design Report No. 6 (RD6) (Berg *et al.*, 1994) extends approximately 10 ft further north.
- Freon 113 $< 7.5$ ppb in two sediment samples collected from one borehole was the only VOC detected from the six boreholes drilled in the Salvage Yard Area.
- At Building 419, total VOCs $\leq 42$ ppb were detected below 30 ft in the unsaturated zone in borehole SIB-419-101. Total VOCs in a bailed ground water sample collected from the open borehole were 36 ppb. Tritium activity increased from 38,800 picocuries per liter in the soil moisture of the sediments ($pCi/L_{sm}$) at 3 ft, to 4,270,000 $pCi/L_{sm}$ at 30 ft. Tritium activity rapidly decreased with depth, and below about 40 ft, tritium activity was either below detection limits or was within background levels. No tritium activity was detected in the bailed ground water sample.
- At Building 331, tritium activities decreased with depth in unsaturated sediment samples collected from borehole SIB-331-001 from 148,600 $pCi/L_{sm}$ at 5 ft to 16,890 $pCi/L_{sm}$ at 50 ft. Tritium activities were not detected in deeper unsaturated sediment samples. Tritium activity in ground water collected from the open borehole was 1,110 pCi/L.
- Analytical results from sediment samples collected from the seven T5475 Area boreholes indicate that the unsaturated zone source does not extend further than previously delineated.
- In the Building 490 Area, Freon 11 $\leq 30$ ppb was detected in most unsaturated sediment samples collected from borehole SIB-490-101.

# 4. Data Analysis and Interpretation

## 4.1. Flow and Transport Modeling

Both unsaturated and saturated zone modeling were conducted during 1995 in support of remedial design and to assist in further understanding the Livermore Site subsurface.

### *4.1.1. Unsaturated Zone Modeling*

A draft technical report presenting results of the TF518 Area vadose zone modeling was initiated in 1995. The report contains a detailed discussion of the technical aspects of the analysis, which was presented in RD6. The TF518 Area modeling report will also include a description of both the conceptual model and the modeling approach, which analyzed the impact of VOCs in the unsaturated zone on the ground water, and also supported the appropriate soil vapor extraction remedial design.

During 1995, the LLNL computer code NUFT (Nonisothermal Unsaturated Flow and Transport) (Lee *et al.*, 1993) was used to evaluate the potential impact of tritium in the unsaturated zone beneath the Building 292 Area on underlying ground water. Results from the two-dimensional model suggest that the tritium plume center-of-mass is migrating downward at less than 1 ft/yr.

Two-dimensional (2-D) numerical modeling results also indicate that the tritium plume beneath the Building 292 Area should not pose a long-term threat to ground water. To more accurately assess the impact of this tritium plume, we are currently conducting similar three-dimensional (3-D) calculations.

During 1995, we also revised the estimated total tritium activity in sediments underlying the Building 292 Area. Using sediment data and geostatistical techniques such as kriging, we now estimate that the total tritium activity is approximately 5 curies. The center of the tritium mass is about 14 ft below the ground surface, and the depth of the suspected release point of the tank is about 9 ft below the ground surface. Depth to ground water in this area is approximately 48 ft.

The Building 292 tank was abandoned in place by filling the tank with concrete on September 6, 1995. This tank closure should eliminate infiltration of rain water through the tank into the vadose zone, thereby reducing the migration of tritium in this area. Also, piezometer UP-292-001 was abandoned and sealed by pressure grouting on September 25, 1995. This piezometer was abandoned because it was suspected to have a leaky annular seal. Monitoring for tritium in other nearby wells and piezometers will continue on a quarterly basis.

### *4.1.2. Saturated Zone Modeling*

In June 1995, a report summarizing the 2-D ground water flow and contaminant transport simulations conducted at the LLNL Livermore Site was released (Tompson *et al.*, 1995). This 2-D model was used as the numerical basis for a 3-D flow and transport model.

Details of the 3-D model are based on a conceptual model that describes the subsurface as a distinct suite of HSUs. For each HSU, physical properties were compiled and correlated, including lithology, geophysical measurements, ground water and soil chemistry, and hydraulic tests. The top and bottom surfaces of the HSUs were defined on the basis of hydraulic connectivity and mapped to 3-D code descriptions using interpolation software. Professional judgment was used to supplement the data set with estimated values in areas of limited field data.

HSU-specific averages of the measured field and analytical data were used for model input-parameters (i.e., hydraulic conductivity, porosity). Properties designated as calibration parameters, such as horizontal and vertical hydraulic conductivity, were later adjusted within the measured ranges to achieve calibration. The calibration process is conducted to minimize the difference between simulated and measured subsurface behavior. Calibrations enable the most reliable simulations to be achieved from the existing base of sparse field data.

Boundary conditions of the model were compiled from both historical project data and Zone 7 data. The hydraulic heads used as calibration targets were derived from these same data.

The initial simulations focused on the migration of PCE in ground water beneath the TFA Area. The flow model was first calibrated to pre-remedial pumping ground water levels. Subsequently, the flow model was calibrated to several pumping schedules, which represented time periods when extraction wells in the TFA Area were actively pumping. This approach assures the validity of model predictions under both stressed and non-stressed conditions.

Initial PCE concentrations in ground water were derived from data measured in 1988. The final calibration goal is a time history match of the PCE plume from 1988 through 1995.

The 3-D model was constructed with the aid of MapIt, a GUI (Graphical User Interface) pre-processor for CFEST (Coupled Flow, Energy and Solute Transport) and other numerical models. MapIt was developed at LLNL in 1995 and is an invaluable tool for efficiently developing 3-D numerical models.

In December 1995, the flow portion of the model described above was nearly calibrated. Preliminary results of the TFA modeling analysis are expected to be completed in early 1996.

In addition, we succeeded in producing a conceptual model and 3-D visualization of subsurface braided stream channels in HSU 1B underlying the TFA Area (DOE, 1995). This model was produced using an LLNL generated program (SLICE).

# 5. Annual Summary of Remedial Action Program

The progress of remediation at the Livermore Site is discussed below by treatment facility area, and is graphically depicted in Figure 2.

## 5.1. Treatment Facility A

TFA is located in the southwestern quadrant of LLNL near Vasco Road (Fig. 1). TFA processes ground water using a combination of ultraviolet light/hydrogen peroxide ($UV/H_2O_2$) treatment and air stripping.

Hydraulic capture of the western off-site plumes at TFA was accomplished in 1995 (Figures 3 and 4). Ground water was pumped from W-415 from January through July at an average rate of 50 gpm. Eight wells south of TFA (W-518, W-520, W-521, W-522, W-601, W-602, W-603, and W-609) provided an additional average flow rate of 100 gpm via the TFA South Pipeline. Construction of the TFA North Pipeline was completed in July and pumping began from extraction wells W-614, W-712, W-1004, and W-1009 (Fig. 1) at an average combined flow rate of 50 gpm. Arroyo Pipeline extraction wells W-109 and W-408 were pumped at an average flow of about 45 gpm in 1995. Three new Arroyo Pipeline extraction wells (W-457, W-903, and W-904), located west of Vasco Road, were activated in October and will be fully operational in early 1996. With completion of the four TFA pipelines, the TFA wellfield has the ability to extract about 300 gpm, which exceeds the TFA design capacity of 200 gpm. In December, TFA was shut down for facility modifications designed to increase the maximum flow rate. Under a new air permit issued by the Bay Area Air Quality Management District (BAAQMD), TFA can treat up to 1000 gpm. As previously discussed in the Regulatory Compliance section of this report, the RWQCB and the other RPMs agreed to treating up to 350 gpm.

During 1995, more than 72 million gal of ground water containing VOCs were processed at TFA (Table 3). All treated ground water was discharged to the Recharge Basin, located about 2,000 ft southeast of TFA (Fig. 1). Based on monthly influent concentrations and flow data, we estimate that about 1.7 kilograms (kg) of VOC mass was removed from ground water at TFA during the fourth quarter of 1995. The total mass removed during 1995 was about 12 kg (Table 3). Since system startup in 1989, TFA has processed nearly 170 million gal of ground water and removed about 58 kg of VOC mass from the subsurface (Table 4).

**Table 3. Summary of 1995 ground water VOC remediation.**

| Treatment facility | Volume of ground water treated (Mgal)[a] | Estimated total VOC mass removed (kg) |
|---|---|---|
| TFA | 72 | 12 |
| TFB | 10.4 | 3.4 |
| TFC | 5.7 | 2.7 |
| TFD | 2.1 | 5.8 |
| Total | 90.2 | 23.9 |

[a] Millions of gallons.

**Table 4. Summary of cumulative ground water VOC remediation.**

| Treatment facility | Total volume of ground water treated (Mgal)[a] | Estimated total VOC mass removed (kg) |
|---|---|---|
| TFA | 170 | 58 |
| TFB | 33 | 12 |
| TFC | 8.5 | 3.9 |
| TFD | 2.2 | 6.1 |
| Total | 214 | 80 |

[a] Millions of gallons.

#### 5.1.1. Field Activities

During 1995, two HSU 1B wells (W-1105 and W-1107) were installed in the southeastern portion of the TFA Area (Fig. 1) to monitor VOC concentrations and water levels proximal to the suspected source area. Construction details for these wells are presented in Appendix A

#### 5.1.2. Hydraulic Tests

No long-term multi-day hydraulic tests were conducted in the TFA Area in 1995. One-h drawdown tests were conducted on extraction wells W-903, W-904, W-1004, and W-1009, and also on piezometers W-913 and W-1105. The results of these tests are pending.

### 5.2. Treatment Facility B

TFB is located along Vasco Road just North of Mesquite Way (Fig. 1). Similar to TFA, TFB processes ground water using a combination of UV/$H_2O_2$ treatment and air-stripping technologies. TFB remediation performance is summarized below.

During 1995, construction of the TFB North Pipeline was completed and activated on September 5, 1995. This pipeline connects wells W-610, W-620, W-621 and W-655 to TFB. These wells add an additional 25 gpm, increasing the total flow to TFB to about 50 gpm. Combined with ground water extracted from wells W-357 and W-704, about 10.4 million gal of ground water was extracted and treated at TFB during 1995. The facility discharges the treated water into a north flowing drainage ditch along Vasco Road. Maintenance of the drainage ditch was completed in August before increasing the flow in September. TFB is operating in compliance with NPDES discharge limits for VOCs.

Tests are being performed to determine the effectiveness of reducing hexavalent chromium to trivalent chromium by using hydrogen peroxide, followed by lowering the pH with carbon dioxide, and then increasing the residence time prior to air stripping to provide the necessary conditions and time required to reduce chromium to permissible levels. Subsequent air stripping removes the excess carbon dioxide, thereby raising the pH to meet discharge requirements. The initial test reduced hexavalent chromium from 24 to 17 ppb in the TFB effluent. Additional tests reduced the hexavalent chromium from 25 ppb to 10 ppb. The hydrogen peroxide will be kept at low concentrations ($\leq$ 20 ppm) to ensure compliance with fish toxicity requirements.

No wells were installed in the TFB Area in 1995.

We estimate that about 1.0 kg of VOC mass was removed from ground water at TFB during the fourth quarter of 1995. The total VOC mass removed during 1995 was about 3.4 kg (Table 3). Since system startup in 1991, TFB has processed more than 33 million gal of ground water and removed about 12 kg of VOC mass from the subsurface (Table 4).

#### 5.2.1. Hydraulic Tests

In January 1995, a four-week long hydraulic test was completed for TFB extraction wells W-357 and W-704 (Fig. 1). Twelve nearby wells were monitored to determine the hydraulic influence of each well. The results of the tests were used to better understand the hydrostratigraphy of the area, improve our understanding of the plume movement, and to better manage remediation.

One-h drawdown tests were performed on wells W-1010, W-1011, W-1012, and W-1013 to obtain well performance data and aquifer characteristics. Results of these tests are pending.

## 5.3. Treatment Facility C

TFC is located in the northwest quadrant of LLNL (Fig. 1) and utilizes air-stripping and ion-exchange to process ground water. The ion exchange resin was regenerated seven times, and replaced once in 1995. A polyphosphate additive (JP7) is now being used to control calcium carbonate scale in the TFC piping. No major repairs or upgrades were performed on the system during 1995.

In 1995, we completed the design of the TFC North Pipeline. This pipeline will convey water from extraction wells W-1015, W-1102, W-1103, W-1104, and W-1116 to TFC. Construction of the pipeline is expected to be completed by mid-1996.

During 1995, TFC processed about 5.7 million gal of ground water extracted from well W-701 (Table 3) at an average flow rate of about 15 gpm. We estimate about 0.6 kg of VOC mass was removed by TFC during the fourth quarter of 1995. The total VOC mass removed during 1995 was about 2.7 kg. Since system startup in October 1993, TFC has processed about 8.5 million gal of ground water removing about 3.9 kg of VOC mass (Table 4).

### *5.3.1. Field Activities*

During 1995 (Appendix A), wells W-1104, W-1106, W-1110, and W-1116 were installed in the TFC Area (Fig. 1). Wells W-1104 and W-1116 are tentatively scheduled to pump ground water to TFC in 1996 via the TFC North Pipeline. Because these wells would replace wells discussed in Remedial Design Report No. 2 (Berg, et al., 1993), they are being evaluated to ensure that they will hydraulically capture the VOC plume in the northwest portion of LLNL. In 1996, one additional extraction well is also planned in the southeast portion of the TFC Area.

### *5.3.2. Hydraulic Tests*

Drawdown tests (one-h) were performed on wells W-1101 and W-1103 to obtain data on well performance and aquifer characteristics. Results of these tests are pending.

## 5.4. Treatment Facility D

TFD is located in the northeast quadrant of LLNL (Fig. 1) and uses air-stripping and ion-exchange to process ground water. TFD operated using only extraction wells W-351 and W-906 (Fig. 1) during most of 1995. Nickel concentrations exceeding the 7.1 ppb NPDES discharge limit constrained us from using extraction well W-907.

In January 1995, TFD discharged 175,820 gal of treated ground water into the Drainage Retention Basin. On January 30, treated water was temporarily diverted past the drainage retention basin into an underground pipe which discharges into the Arroyo Las Positas. In February 1995, we began injecting polyphosphate at 10 ppm or less to control calcium carbonate scale. To avoid loading additional phosphates into the Drainage Retention Basin, on May 18, the diversion of TFD water to the underground pipe was made permanent, although the capability of discharging to the basin still exists.

During 1995, TFD processed about 2.1 million gal of ground water containing VOCs (Table 3). The combined flow rate from wells W-351 and W-906 averaged about 8.5 gpm. We estimate about 0.54 kg of VOC mass was removed at TFD during the fourth quarter of 1995. The total VOC mass removed during 1995 was about 5.8 kg. Since system startup in September 1994, about 2.2 million gal of ground water have been treated, removing about 6.1 kg of VOC mass (Table 4).

### *5.4.1. Field Activities*

Wells W-1205, W-1206, and W-1207 (Appendix A) were installed in the TFD Area during the fourth quarter of 1995 (Fig. 1). Well W-1206 is an HSU 4 extraction well that replaces well W-907. As discussed above, well W-907 contains concentrations of nickel above NPDES discharge limits. A geochemical evaluation determined that the elevated nickel concentration was probably due to corrosion of the stainless steel screen in the well. Replacement well W-1206 was completed with PVC screen and casing. Well W-907 will continue to serve as a monitor well. In 1996, an additional TFD extraction well, screened in HSU 3A, is planned to be drilled adjacent to well W-1206.

As discussed in the Source Investigation section of this report, two boreholes were drilled in the Building 490 Area, north of TFD to further characterize the Freon 11 plume in that area.

## 5.5. Treatment Facility E

In 1995, TFE Area activities were limited to well installations and hydraulic testing. As agreed with the regulatory agencies, TFE is scheduled to begin operation by September 30, 1999.

### *5.5.1. Field Activities*

Seven wells were installed in the TFE Area in 1995. Well W-1109 is an extraction well that was installed after source investigation borehole SIB-543-103 detected concentrations between 2 and 5 ppm of trichloroethylene (TCE), PCE, 1,1-dichloroethylene and Freon 113 in a bailed ground water sample collected from the open borehole. Wells W-1202 and W-1203 were installed to monitor future TFE remediation performance. Four wells, W-1117, W-1118, W-1201, and W-1204 were installed within the TFE Area as part of the investigation of the T5475 Area for RD4, which is due in July 1997. These wells will be used to determine the downgradient extent and nature of communication between plumes originating in the TFE and T5475 areas. Construction details for these new wells can be found in Appendix A, and locations are shown in Figure 1.

### *5.5.2. Hydraulic Tests*

A one-h drawdown test was performed on well W-1109 to obtain well performance data and aquifer characteristics. Results of this test are pending.

## 5.6. Treatment Facility F

TFF is located in the southeastern portion of LLNL (Fig. 1). Prior to remediation, significant FHC concentrations existed in the vadose zone, the ground water and saturated sediments in HSUs 3A and 3B . Only low levels of VOCs are present within the FHC plume. VOCs exist in the greater TFF Area in deeper HSUs 4 and 5, extending from TF518 southwest onto DOE property administered by Sandia National Laboratory (SNL).

During 1995, ground water was extracted and treated at TFF over five months during business hours only. Ground water extraction ceased at TFF on April 18 for a six month biodegradation study, and re-started on October 17. The treatment facility was again shut down on December 8 because of storm damage. With regulatory concurrence extraction and treatment of the residual dissolved FHCs in HSU 3A and 3B has been temporarily discontinued in favor of a passive bioremediation approach. We will be submitting a Containment Zone (CZ) report for HSU 3 in the TFF Area to the regulatory agencies in early 1996.

During 1995, an extraction well and two monitor wells were installed in HSU 5. TFF will be replaced in FY96 with a PTU to remediate ground water extracted from HSUs 4 and 5.

The TFF vapor system continued to extract and treat FHCs during business hours for the first three months of the year. Since January 1994, FHC concentrations in extracted vapors have exhibited an exponential decline with time, indicating that the majority of the vapor phase FHCs have been successfully recovered and that concentrations had reached asymptotic low levels (Table 5). The vapor system was shut down on March 30 with approval from the regulatory agencies. From March 30 to July 6, 1995, sampling continued with biweekly monitoring of the FHCs vapor concentrations using one-h extraction tests. An eight-h vapor extraction test was conducted on June 8. No rebound of vapor FHC concentrations was observed. In addition, vadose sediment samples were collected in July from the pilot boreholes of two new TFF wells. One borehole (W-1114) was located near the center of the spill and the other borehole (W-1115) was located just east of the spill area (Fig. 1). Chemical analyses of these sediments clearly indicated the absence of residual FHCs in the vadose zone. Based on these results, closure of the vadose zone at TFF was granted by the regulatory agencies in August 1995.

As shown in Table 6, TFF treated approximately 1.4 million gal of ground water in 1995 from extraction wells GEW-808 and GEW-816 containing a volume-weighted average FHC concentration of about 1,323 ppb. This is equivalent to about 2.8 gal liquid-equivalent of gasoline removed. In addition, TFF extracted about 1.4 million cubic feet ($ft^3$) of vapor from extraction wells GEW-808, GEW-816, and GSW-16, containing a volume-weighted FHC concentration of about 20 parts per million by volume (ppmv), for about 0.73 gal liquid-equivalent of gasoline removed. The total liquid-equivalent of gasoline removed from the TFF subsurface during 1995 was about 3.6 gal (Table 6). As shown in Table 5, the 1994 TFF FHC removal rate continued to decline steadily throughout the year as recoverable FHCs remaining in the area is dramatically reduced.

**Table 5. 1994 TFF fuel hydrocarbon removal.**

| Month | FHC Concentration[a] | | Volumes pumped | | Gasoline removal (gal)[b] | | |
|---|---|---|---|---|---|---|---|
| | Water (ppb) | Vapor (ppmv) | Water (1,000 gal) | Vapor (1,000 ft$^3$) | Water | Vapor | Totals |
| January | 6,400 | 1,172 | 193 | 430 | 1.6 | 18.8 | 20 |
| February | 5,200 | 724 | 265 | 400 | 1.8 | 10.8 | 13 |
| March | 4,200 | 592 | 401 | 530 | 2.2 | 11.7 | 14 |
| April | 3,200 | 320 | 380 | 645 | 1.6 | 7.7 | 9 |
| May | 3,500 | 168 | 87 | 176 | 0.4 | 1.1 | 2 |
| June | 2,200 | 113 | 383 | 785 | 1.1 | 3.3 | 4 |
| July | 2,100 | 99 | 400 | 840 | 1.1 | 3.1 | 4 |
| August | 2,300 | 66 | 462 | 1,020 | 1.4 | 2.5 | 4 |
| September | 2,300 | 34 | 433 | 1,020 | 1.3 | 1.3 | 3 |
| October | 2,200 | 36 | 280 | 665 | 0.8 | 0.9 | 2 |
| November | 2,200 | 29 | 276 | 730 | 0.8 | 0.8 | 2 |
| December | 1,600 | 49 | 387 | 924 | 0.8 | 1.7 | 3 |
| Totals | 2,900 | 209 | 3,950 | 8,170 | 15 | 64 | 79 |

[a] Flow-weighted concentration averages.

[b] Liquid-equivalent gal of gasoline.

**Table 6. 1995 TFF fuel hydrocarbon removal.**

| Month | FHC Concentration[a] | | Volumes pumped | | Gasoline removal (gal)[b] | | |
|---|---|---|---|---|---|---|---|
| | Water (ppb) | Vapor (ppmv) | Water (1,000 gal) | Vapor (1,000 ft$^3$) | Water | Vapor | Totals |
| January | 1,880 | 33 | 30 | 15, | 0.07 | 0.02 | 0.09 |
| February | 2,140 | 17 | 391 | 649 | 1.08 | 0.41 | 1.49 |
| March | 1,350 | 11 | 447 | 724 | 0.78 | 0.30 | 1.08 |
| April | 1,350[c] | - | 234 | 0 | 0.41 | - | 0.41 |
| October | 1,000 | - | 198 | 0 | 0.26 | - | 0.26 |
| November | 770 | - | 123 | 0 | 0.12 | - | 0.12 |
| December | 770[c] | - | 17 | 0 | 0.12 | - | 0.12 |
| Totals | 1,323 | 20 | 1,410 | 1,388 | 2.84 | 0.73 | 3.57 |

[a] Flow-weighted concentration averages.

[b] Liquid-equivalent gal of gasoline.

[c] Estimated concentration due to sampling problems.

### *5.6.1. Field Activities*

During 1995, extraction well W-1114 was installed to capture and treat VOCs in HSU 5. Wells W-1112 and W-1113 were installed to monitor the hydraulic effects of pumping well W-1114 (Fig. 1). Well W-1115 was installed in a permeable layer between the upper and lower steam zones to monitor the hydraulic effects of pumping from GEW-808 and GEW-816. GEW-808 and GEW-816 are screened in both steam zones. Well W-1115 also collected vadose zone sediment samples for the intrinsic bioremediation study (see below) and to evaluate current FHC concentrations. Construction details for these new wells can be found in Appendix A.

A field study assessing the *in situ* effect of indigenous microorganisms on FHC biodegradation was planned, implemented, and completed in 1995. The goal of this study was to determine if the residual FHCs in HSUs 3A and 3B are being degraded by microbial activity. Although microbial degradation of hydrocarbons is well documented and is currently being recommended as a viable treatment option at sites where the hydrocarbon source has been removed (Rice *et al.*, 1995), the TFF subsurface is still a high temperature environment (40-60°C) following the Dynamic Underground Stripping. The effectiveness of biodegradation under these conditions was uncertain. Four types of data were evaluated during a six month study of intrinsic bioremediation: 1) ground water geochemistry; 2) laboratory soil microcosm data; 3) analysis of ground water for microbial metabolite products; and 4) measurement of benzene, toluene, ethyl benzene, and xylenes concentrations in ground water from wells completed in HSUs 3A and 3B in the TFF Area. These data indicate that active intrinsic biodegradation of the residual FHCs is occurring in HSUs 3A and 3B. The intrinsic biodegradation will continue to degrade the residual FHCs. Based on this study, and the greatly diminished gasoline removal rates, the regulatory agencies have agreed to temporarily stop pumping from GEW-808 and GEW-816 while LLNL pursues CZ status for the FHC impacted ground water in the TFF Area.

### *5.6.2. Hydraulic Tests*

A thirty-h hydraulic test was conducted on W-1114 to determine its maximum sustainable flow rate. Thirty-two surrounding wells in the TFF Area were monitored to evaluate the extent of hydraulic influence. W-1114 sustained 15 gpm during the test, with 30 ft of available drawdown remaining. A broad hydraulic capture zone extending at least 500 ft north and south of the pumping well formed during the test. These initial results suggest that W-1114 alone should effectively capture the leading edge of the HSU 5 VOC plume in the TFF Area. Additional results from this test are pending.

## 5.7. Treatment Facility G

Treatment Facility G-1 (TFG-1), which consists of a PTU for treating ground water, will commence operation in April, 1996. TFG-1 will be located in the south-central portion of LLNL, about 300 ft north of East Avenue (Fig. 1). TFG-2 is scheduled for startup August 2, 1999 according to a revised schedule presented in the RAIP (Dresen *et al.*, 1993). TFG-2 will be located about 750 ft northeast of TFG-1 (Fig. 1).

### 5.7.1. Field Activities

During 1995, extraction well W-1111 was installed, which will extract ground water containing VOCs in HSU 2 (Appendix A). A drawdown test conducted in October indicates that the well will sustain about 20 gpm. In 1996, we plan to conduct a long-term hydraulic test at well W-1111 to evaluate the need for additional extraction wells in the TFG-1 Area.

## 5.8. Building 518 Vapor Extraction Treatment Facility

TF518 is located in the southeast quadrant of LLNL near East Avenue (Fig. 1). TF518 treats soil vapor collected from the vadose zone using a vapor extraction system with granulated activated carbon (GAC) canisters to remove the VOCs. A summary of the 1995 activities for TF518 are listed below:

- TF518 began operating on September 25, 1995.
- A soil vapor (VOC) extraction absorption efficiency test (source test) was conducted on October 4, 1995, which complied with the BAAQMD. The results of the source test are summarized in a report prepared by Best Environmental, Inc. (Cartner, 1995). An abatement efficiency of 98.5% was required to pass this test. The source test performed well, with an abatement efficiency of 99.85%.
- TF518 has removed about 20 kg of VOC mass from system startup through December 29, 1995.
- Four new vadose zone wells were installed during 1995 as described below.

### 5.8.1. Field Activities

Two vadose zone air inlet wells and two SEAMIST vadose zone instrumentation boreholes were installed in the TF518 Area (Fig. 1), as described in the Source Investigation section of this report.

The cleanup of the vadose zone in this area is being monitored by the SEAMIST instrumented/sampling wells. The SEAMIST system is an air-pressure driven, impermeable, everted membrane that can carry soil vapor sampling instrumentation down an unlined borehole (Keller and Lowry, 1991). The membrane effectively lines the borehole similar to a continuous packer, thereby preventing fluid flow into the borehole. Once the membrane is emplaced, the SEAMIST system is completed by filling the interior of the membrane with air and keeping the system pressurized to prevent the borehole from collapsing. The SEAMIST system is used to collect vapor pressure, soil temperature, soil moisture, and soil vapor VOC concentration data from various discrete depths. These data, which are collected periodically during operation of the treatment facility, are used to: 1) monitor cleanup of the VOCs in both the shallow and deeper zones; 2) help optimize flow rates at the extraction well(s); and 3) help determine when confirmatory sediment and/or soil vapor samples should be collected.

## 5.9. Trailer 5475 Treatment Facility

The T5475 Area is located in the southeast quadrant of the Livermore Site (Fig. 1). In concurrence with the regulatory agencies, design and construction activities for the T5475

Treatment Facility have been postponed from March 1995 to September 1998 to be consistent with expected funding and project priorities. However, field activities in support of the HSU analysis continue in preparation for the submittal of RD4 in July 1997.

### 5.9.1. Field Activities

Six wells were installed either in or downgradient of the T5475 Area in 1995; W-1108, W-1117, W-1118, W-1201, W-1203 and W-1204 (Fig. 1). These wells were installed as part of the characterization of the T5475 Area for RD4. These wells are also being used to determine the distribution and downgradient extent of the VOCs and tritium in ground water in the T5475 Area. Construction details for these wells can be found in Appendix A.

As discussed in the Source Investigation section of this report, seven source investigation boreholes were drilled in the T5475 Area to further characterize the VOCs and tritium in the subsurface. Six of these boreholes were completed as piezometers screened in either HSU 2 or 3A.

### 5.9.2. Hydraulic Tests

A one-h drawdown test was performed on well W-1108 to obtain well performance data and aquifer characteristics. Results of this test are pending.

# 6. Trends in Ground Water Analytical Results

Discussed below are notable results of VOC analyses of ground water received from January 1995 through December 1995. Figures 5 and 6 show isoconcentration contours for total VOCs underlying the Livermore Site and vicinity within HSU 1 and HSU 2. VOC analytical data can be made available upon request.

1. The TCE concentration in well W-4 has gradually decreased. W-4 is located directly south of TFC (Fig. 1), and is screened from 75 to 90 ft in HSU 1. In May 1983, <1 ppb TCE was reported in the initial analysis. Since then, the TCE increased to a high of 120 ppb in February 1989, but has decreased to 16 ppb as of August 1995.
2. The PCE concentration in well W-109 has gradually decreased. W-109 is located about 1,700 ft northwest of TFA, south of Arroyo Seco (Fig. 1), and is screened from 137 to 147 ft in HSU 2. In May 1985, 200 ppb PCE was reported in the initial analysis. Since then, the PCE increased to a high of 270 ppb in July 1989, but has decreased to 32 ppb as of November 1995.
3. The PCE concentration in well W-214 has gradually decreased. W-214 is located about 700 ft north of TFA (Fig. 1), and is screened from 134 to 141 ft in HSU 2. In May 1986, 83 ppb PCE was reported in the initial analysis. Since then, the PCE concentration increased to a high of 100 ppb in August 1986, but has decreased to 11 ppb as of October 1995.
4. The TCE concentration in well W-219 has gradually decreased. W-219 is located directly south of TF518 on the SNL Site, (Fig. 1) and is screened from 141 to 148 ft in HSU 5. In July 1986, 900 ppb TCE was reported in the initial analysis. TCE subsequently increased

to a high of 1600 ppb in September 1986, but has decreased to 73 ppb as of October 1995.

5. The TCE concentration in well W-224 has gradually decreased. W-224 is located about 1,200 ft directly south of TFD (Fig. 1), and is screened from 78 to 88 ft in HSU 2. In September 1986, 3.6 ppb TCE was reported in the initial analysis. Since then, the TCE increased to a high of 170 ppb in October 1992, but has decreased to 5.4 ppb as of November 1995.
6. The TCE concentration in well W-225 has decreased. W-225 is located in the northeast potion of the SNL Site near East Avenue (Fig. 1), and is screened from 152 to 166 ft in HSU 5. In September 1986, 430 ppb TCE was reported in the initial analysis. TCE subsequently increased to a high of 2,100 ppb in December 1987, but has decreased to 56 ppb as of July 1995.
7. The PCE and TCE concentrations in well W-356 have gradually increased. W-356 is located about 450 ft southwest of TFE (Fig. 1), and is screened from 133 to 137 ft in HSU 4. In January 1987, <2.5 ppb PCE and 49 ppb TCE were reported in the initial analysis. Since then, the concentrations have increased to 41 ppb PCE and 480 ppb TCE in October 1995.
8. The TCE concentration in well W-564 has gradually decreased. W-564 is located northwest of the Livermore Site near the corner of Vasco and Patterson Pass Road (Fig. 1), and is screened from 79 to 85 ft in HSU 1. In April 1989, 2,100 ppb TCE was reported in the initial analysis. The TCE concentration has decreased to 110 ppb in July 1995.

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# Figures

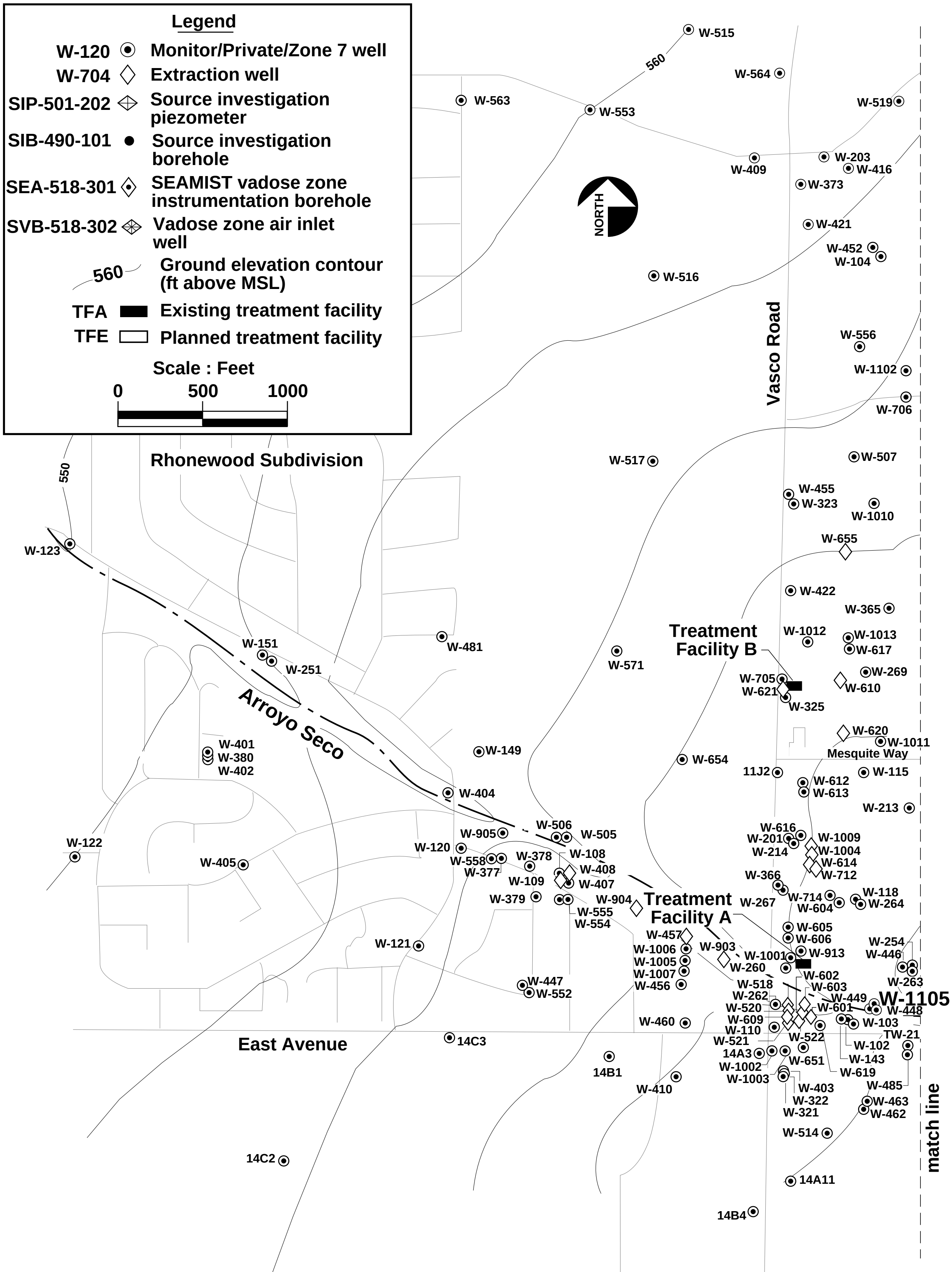


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**Figure 1. Locations of Livermore Site monitor wells, piezometers, extraction wells, and treatment facilities, December 1995.**

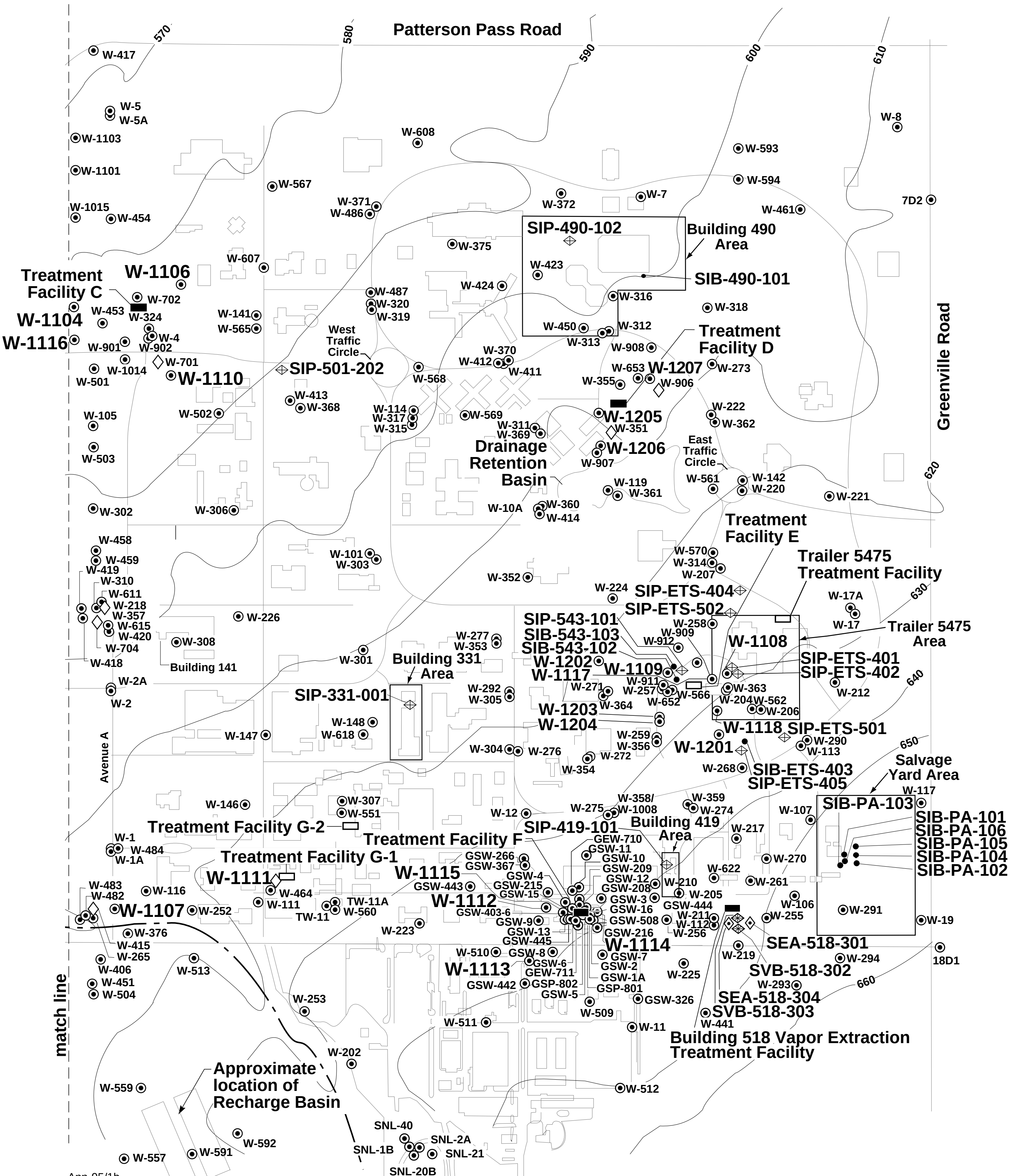


Figure 1 (continued).

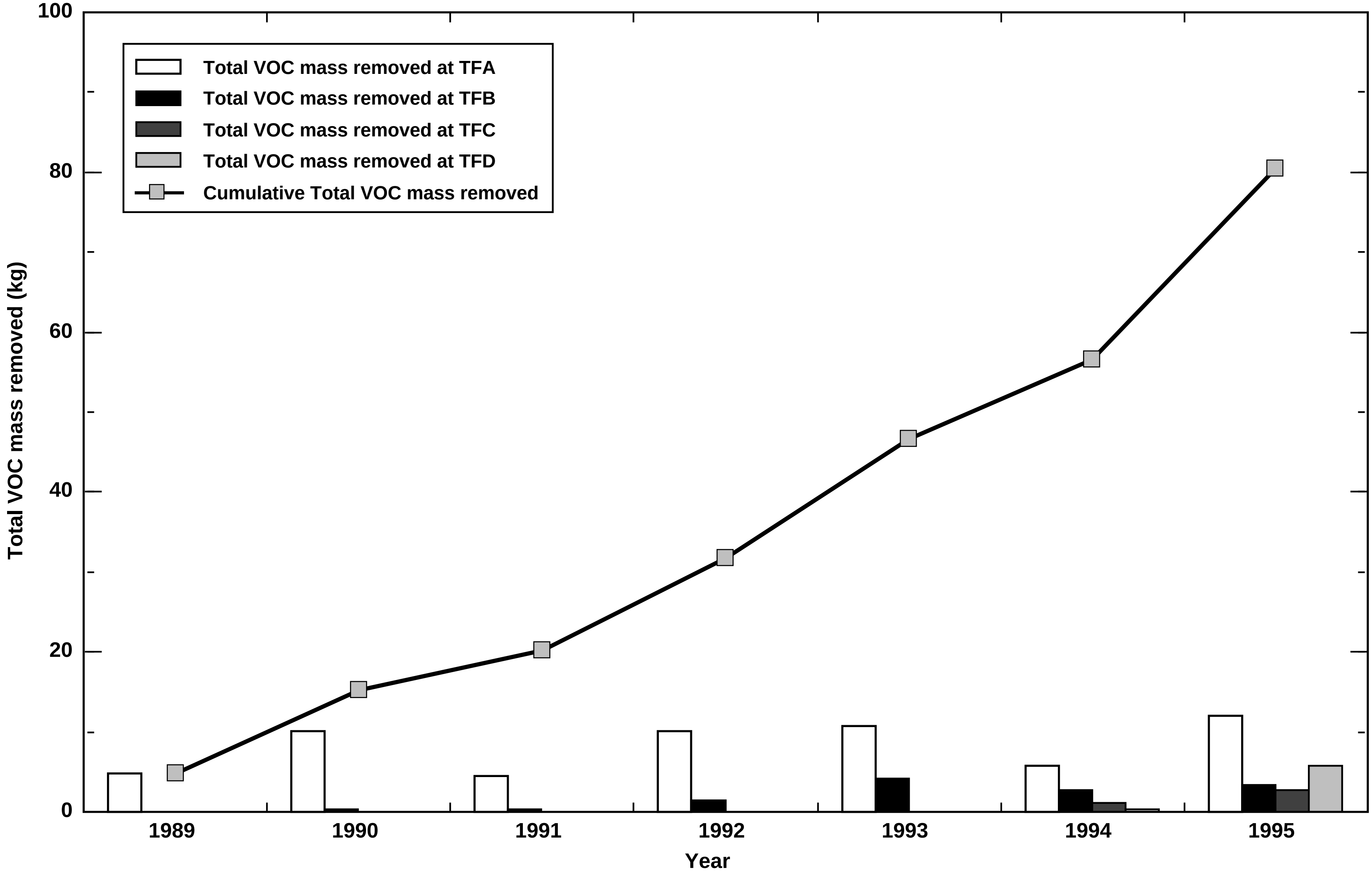


**Figure 2. LLNL Treatment Facilities Performance Summary.**

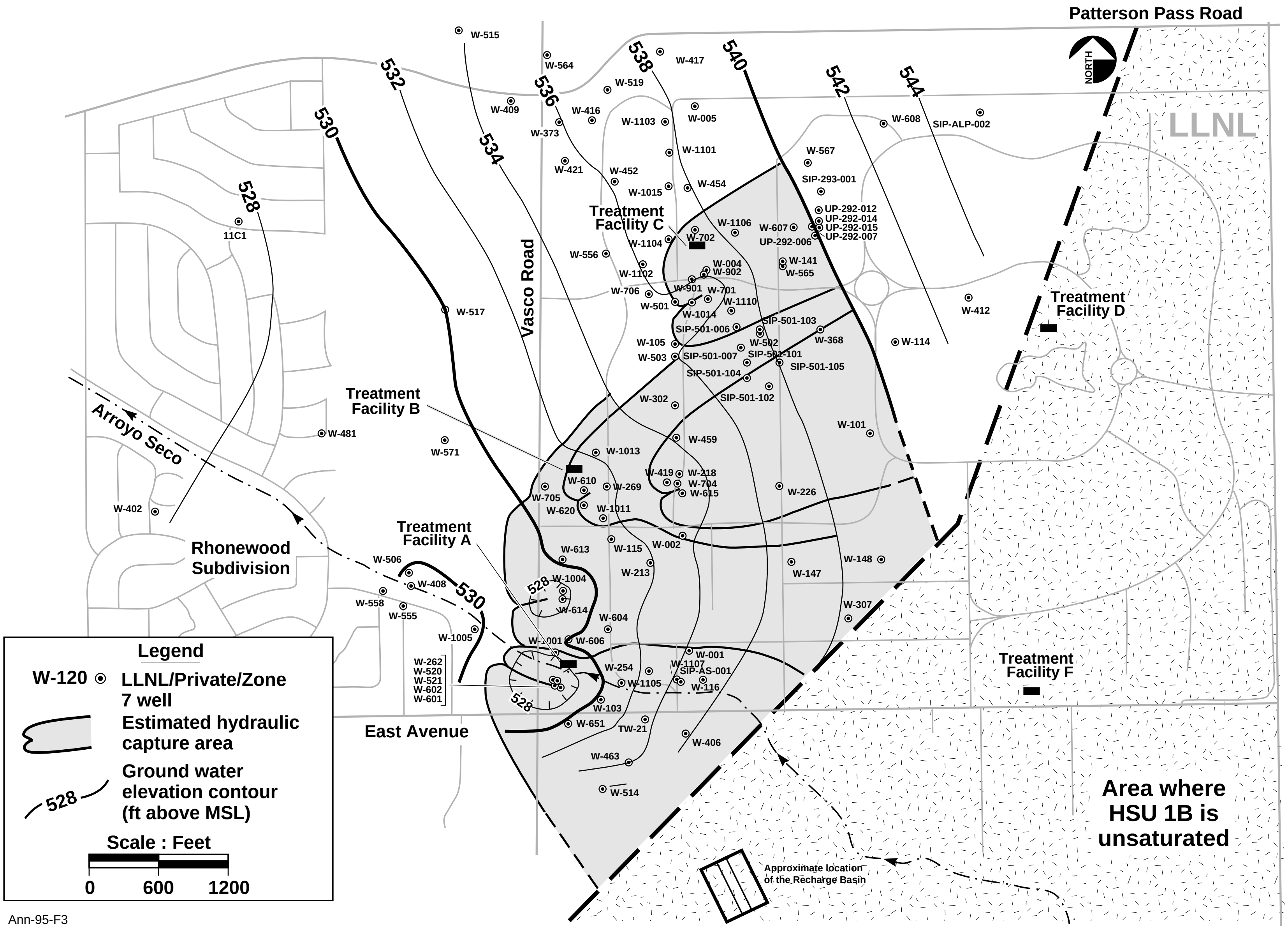


**Figure 3. Ground water elevation contour map based on 107 wells completed within HSU 1B and estimated HSU 1B hydraulic capture areas, LLNL and vicinity, November 1995.**

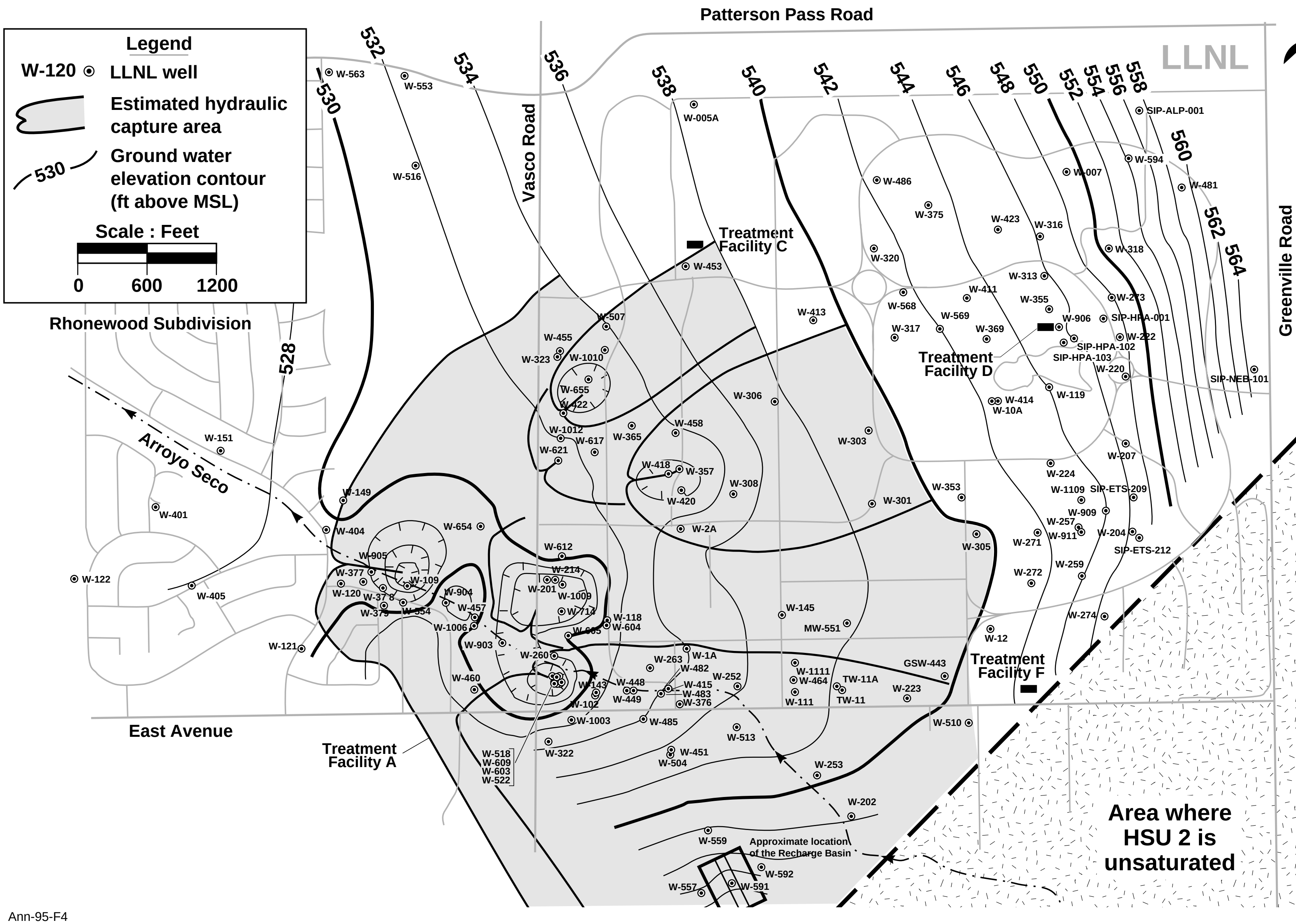


**Figure 4. Ground water elevation contour map based on 127 wells completed within HSU 2 and estimated HSU 2 hydraulic capture areas, LLNL and vicinity, November 1995.**

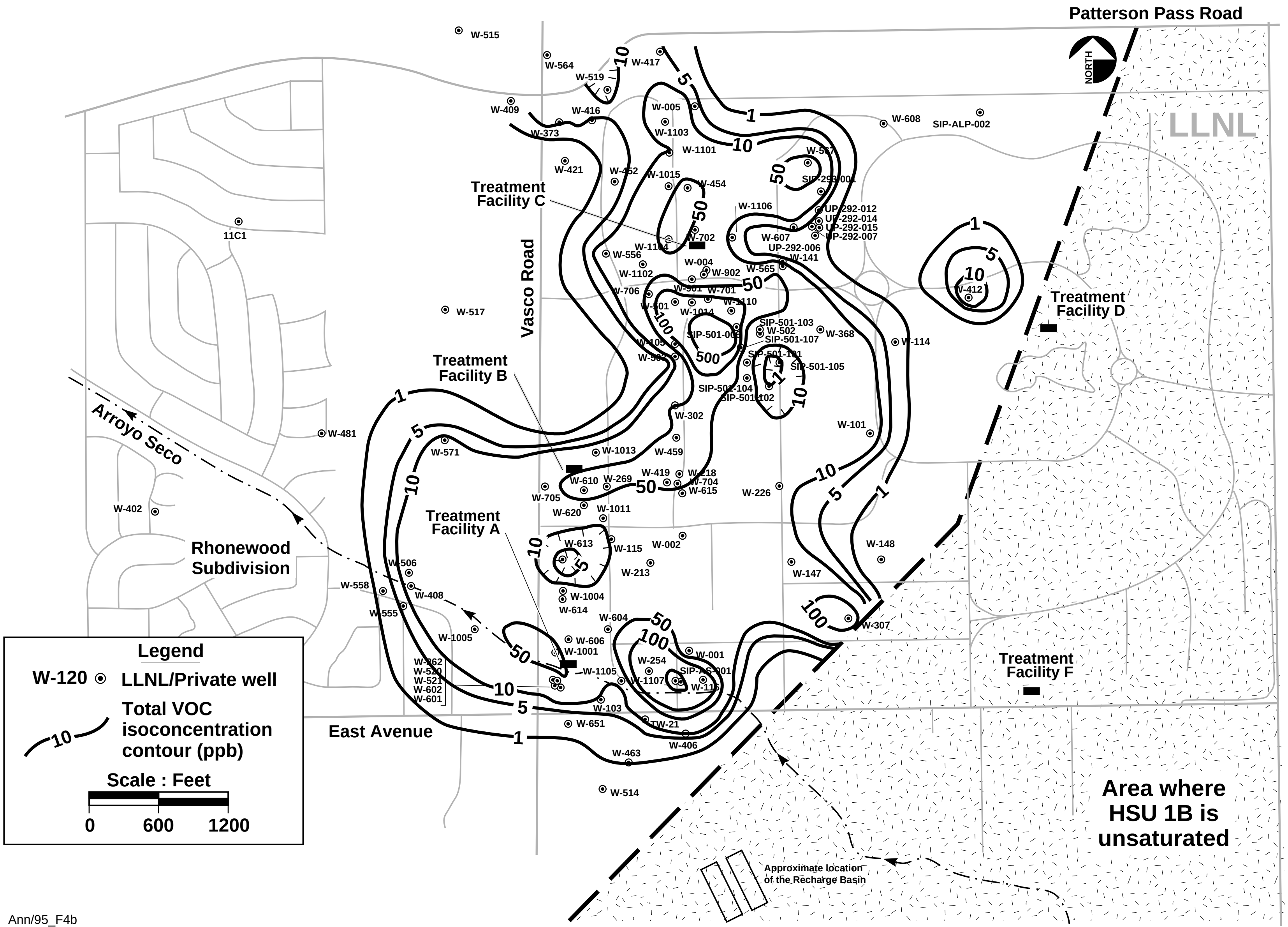


**Figure 5. Isoconcentration contour map of total VOCs for 94 wells completed within HSU 1 based on samples collected in the fourth quarter of 1995 (or the next most recent data.)**

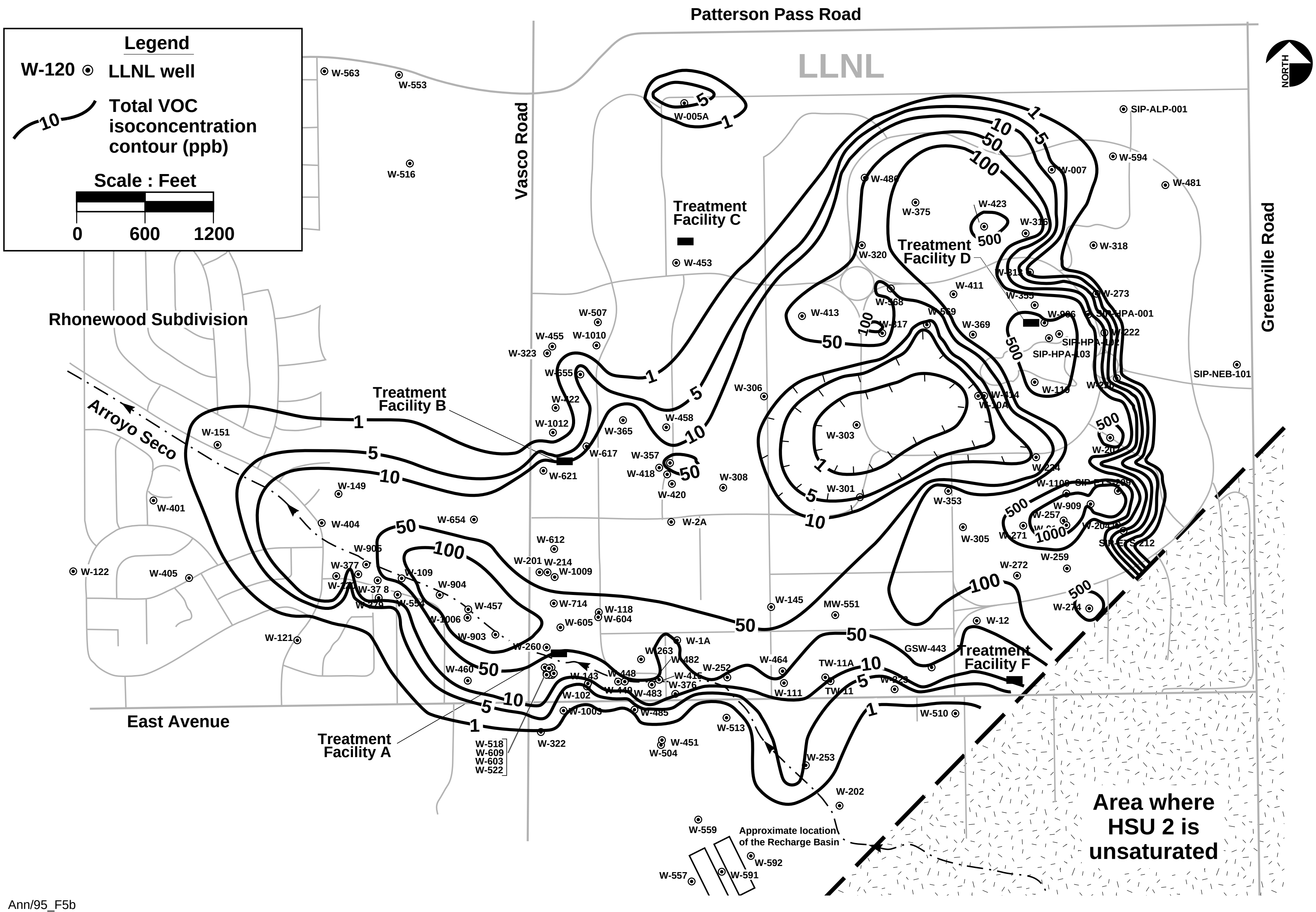


**Figure 6. Isoconcentration contour map of total VOCs for 135 wells completed within HSU 2 based on samples collected in the fourth quarter of 1995 (or the next most recent data.)**

# Appendix A

# Well Construction and Closure Data

**Table A-1. Well construction data, Lawrence Livermore National Laboratory and vicinity, Livermore, California.**

| Well number | Date completed | Borehole depth (ft) | Casing depth (ft) | Perforated interval (ft) | HSU[a] monitored | Well development flow rate (gpm)[b] |
|---|---|---|---|---|---|---|
| ***Monitor Wells*** | | | | | | |
| W-1 | 21-Oct-80 | 122.5 | 116.0 | 95-100 | 2 | NA |
| W-1A | 12-Apr-84 | 180.0 | 156.0 | 145-156 | 2 | NA |
| W-2 | 29-Aug-80 | 102.5 | 101.0 | 86-101 | 1B | NA |
| W-2A | 02-Apr-84 | 185.0 | 164.0 | 150-164 | 2 | NA |
| W-4 | 28-Jul-80 | 92.0 | 90.0 | 75-90 | 1B | NA |
| W-5 | 24-Oct-80 | 93.5 | 90.0 | 56-71<br>81-86 | 1B | NA |
| W-5A | 09-Apr-84 | 115.0 | 105.0 | 95-105 | 2 | NA |
| W-7 | 03-Oct-80 | 110.5 | 100.5 | 76-81<br>88-98 | 2 | NA |
| W-8 | 14-May-81 | 110.0 | 105.0 | 72-77<br>92-102 | 3A | NA |
| W-10A | 08-Sep-80 | 110.7 | 110.0 | 85-95<br>100-105 | 2 | NA |
| W-11 | 03-Jun-81 | 252.0 | 191.0 | 136-141<br>177-187 | 5 | NA |
| W-12 | 14-Aug-80 | 115.75 | 115.0 | 99-114 | 2 | NA |
| W-17 | 08-Oct-80 | 114.0 | 114.0 | 94-109 | 5 | NA |
| W-17A | 20-May-81 | 181.4 | 160.0 | 127-132<br>147-157 | 7 | NA |
| W-19 | 19-Sep-80 | 164.75 | 161.0 | 147-157 | 7 | NA |
| W-101 | 25-Jan-85 | 77.0 | 72.0 | 62-72 | 1B | 1 |
| W-102 | 12-Feb-85 | 396.5 | 171.5 | 151.5-171.5 | 2 | 40 |
| W-103 | 14-Feb-85 | 96.0 | 89.5 | 79.5-89.5 | 1B | 5 |
| W-104 | 21-Feb-85 | 61.5 | 56.5 | 38.75-56.5 | 1A | 2.5 |
| W-105 | 26-Feb-85 | 69.0 | 62.0 | 42-62 | 1B | 0.7 |
| W-106 | 06-Mar-85 | 144.0 | 134.5 | 127.5-134.5 | 5 | 0.1-0.2 |
| W-107 | 13-Mar-85 | 128.0 | 122.0 | 115-122 | 5 | 1-3 |
| W-108 | 21-Mar-85 | 113.5 | 69.0 | 57-69 | 1A | 10 |
| W-110 | 26-Apr-85 | 371.0 | 365.0 | 340-365 | 5 | 6 |
| W-111 | 02-May-85 | 122.0 | 117.0 | 97-117 | 2 | 1.5 |

**Table A-1. (Continued)**

| Well number | Date completed | Borehole depth (ft) | Casing depth (ft) | Perforated interval (ft) | HSU[a] monitored | Well development flow rate (gpm)[b] |
|---|---|---|---|---|---|---|
| W-112 | 10-May-85 | 129.0 | 123.5 | 111-123.5 | 5 | 4 |
| W-113 | 16-May-85 | 124.0 | 115.0 | 100-115 | 5 | 0.9 |
| W-114 | 23-May-85 | 70.5 | 63.0 | 51-63 | 1B | 0.5 |
| W-115 | 03-Jun-85 | 106.0 | 95.0 | 88-95 | 1B | 1.1 |
| W-116 | 14-Jun-85 | 181.0 | 91.0 | 86-91 | 1B | 0.3 |
| W-117 | 27-Jun-85 | 202.0 | 148.0 | 138-148 | 7 | 0.2 |
| W-118 | 19-Jul-85 | 206.5 | 110.0 | 99-110 | 2 | 8 |
| W-119 | 02-Aug-85 | 139.0 | 102.5 | 87.5-102.5 | 2 | 3.3 |
| W-120 | 19-Aug-85 | 195.0 | 153.0 | 147-153 | 2 | 1 |
| W-121 | 23-Aug-85 | 194.0 | 171.0 | 159-171 | 2 | 3.75 |
| W-122 | 17-Aug-85 | 189.0 | 132.0 | 125-132 | 2 | 15 |
| W-123 | 01-Oct-85 | 174.0 | 47.7 | 37.3-47.7 | 1A | 5 |
| W-141 | 23-Mar-85 | 61.5 | 60.0 | 45-60 | 1B | 0.8 |
| W-142 | 29-Mar-85 | 74.2 | 72.0 | 62-72 | 2 | 0.8 |
| W-143 | 12-Apr-85 | 130.0 | 126.0 | 121-126 | 2 | 0.8 |
| W-146 | 16-Jul-85 | 225.0 | 125.0 | 115-125 | 2 | 5 |
| W-147 | 26-Jul-85 | 137.0 | 87.0 | 77-87 | 1B | 0.5 |
| W-148 | 08-Aug-85 | 152.0 | 98.0 | 83-98 | 1B | 0.5 |
| W-149 | 23-Aug-85 | 201.0 | 169.0 | 161-169 | 2 | 6 |
| W-151 | 30-Sep-85 | 237.0 | 157.5 | 148.5-157.5 | 2 | 1.5 |
| | | | | | | |
| W-201 | 17-Oct-85 | 211.0 | 161.0 | 151-161 | 2 | 14 |
| W-202 | 07-Nov-85 | 191.0 | 109.0 | 99-109 | 2 | 0.5 |
| W-203 | 15-Nov-85 | 87.0 | 41.0 | 31-41 | 1A | 3 |
| W-204 | 22-Nov-85 | 110.0 | 110.0 | 100-110 | 2 | 5+ |
| W-205 | 09-Dec-85 | 180.0 | 117.0 | 107-117 | 3A | <0.1 |
| W-206 | 19-Dec-85 | 188.0 | 118.0 | 106-118 | 3A | <0.5 |
| W-207 | 24-Jan-86 | 150.0 | 85.0 | 69-85 | 2 | <0.5 |
| W-210 | 11-Mar-86 | 176.0 | 113.0 | 108-113 | 3A | <0.5 |
| W-211 | 19-Mar-86 | 215.5 | 193.0 | 183-193 | 6 | 1 |
| W-212 | 28-Mar-86 | 183.0 | 136.0 | 124-136 | 5 | 1 |
| W-213 | 04-Apr-86 | 174.0 | 100.0 | 94-100 | 1B | 2 |
| W-214 | 11-Apr-86 | 146.0 | 141.5 | 134-141.5 | 2 | 20+ |
| W-217 | 20-May-86 | 200.0 | 112.5 | 98.5-112.5 | 5 | <0.5 |
| W-218 | 30-May-86 | 201.0 | 71.0 | 64.5-71 | 1B | 6 |

**Table A-1. (Continued)**

| Well number | Date completed | Borehole depth (ft) | Casing depth (ft) | Perforated interval (ft) | HSU[a] monitored | Well development flow rate (gpm)[b] |
|---|---|---|---|---|---|---|
| W-219 | 13-Jun-86 | 214.0 | 148.0 | 141-148 | 5 | 2 |
| W-220 | 25-Jun-86 | 196.0 | 92.5 | 82.5-92.5 | 2 | <0.5 |
| W-221 | 07-Jul-86 | 178.0 | 95.0 | 82-95 | 3A | 2 |
| W-222 | 17-Jul-86 | 197.0 | 83.0 | 63-83 | 2 | 5 |
| W-223 | 15-Aug-86 | 202.0 | 153.0 | 146-153 | 2 | 5.2 |
| W-224 | 26-Aug-86 | 199.0 | 88.0 | 78-88 | 2 | 3 |
| W-225 | 09-Sep-86 | 238.0 | 166.0 | 152-166 | 5 | 2.5 |
| W-226 | 25-Sep-86 | 173.0 | 86.0 | 71-86 | 1B | <0.25 |
| W-251 | 03-Oct-85 | 50.0 | 47.5 | 35.5-47.5 | 1A | 2 |
| W-252 | 18-Oct-85 | 197.0 | 126.0 | 108-126 | 2 | 3 |
| W-253 | 30-Oct-85 | 180.0 | 128.0 | 112.5-128 | 2 | 1 |
| W-254 | 21-Nov-85 | 277.0 | 91.5 | 84.5-91.5 | 1B | 5 |
| W-255 | 05-Dec-85 | 187.0 | 124.0 | 115-124 | 5 | 1 |
| W-256 | 19-Dec-85 | 187.0 | 137.0 | 132-137 | 4 | <0.5 |
| W-257 | 15-Jan-86 | 197.0 | 96.5 | 82.5-96.5 | 2 | <0.5 |
| W-258 | 31-Jan-86 | 157.0 | 121.5 | 116.5-121.5 | 3A | 0.5 |
| W-259 | 07-Feb-86 | 200.0 | 99.0 | 93.5-99 | 2 | <0.5 |
| W-260 | 27-Feb-86 | 215.0 | 151.0 | 141-151 | 2 | 3.5 |
| W-261 | 12-Mar-86 | 225.0 | 118.5 | 109-118.5 | 5 | <0.5 |
| W-262 | 20-Mar-86 | 256.0 | 100.0 | 91-100 | 1B | 7 |
| W-263 | 07-Apr-86 | 146.0 | 130.0 | 123-130 | 2 | 2 |
| W-264 | 14-Apr-86 | 170.0 | 151.0 | 141-151 | 2 | 20+ |
| W-265 | 25-Apr-86 | 216.0 | 211.0 | 205-211 | 3B | 3 |
| W-267 | 27-May-86 | 196.0 | 179.0 | 172.5-179 | 3A | 1 |
| W-268 | 04-Jun-86 | 213.0 | 150.5 | 138-150.5 | 5 | 1 |
| W-269 | 16-Jun-86 | 185.0 | 92.0 | 79-92 | 1B | 2 |
| W-270 | 26-Jun-86 | 185.0 | 127.0 | 113-127 | 5 | <0.5 |
| W-271 | 07-Jul-86 | 201.0 | 112.0 | 105-112 | 2 | 2.1 |
| W-272 | 18-Jul-86 | 226.0 | 110.0 | 95-110 | 2 | 1 |
| W-273 | 11-Aug-86 | 203.0 | 84.0 | 64-84 | 2 | 3 |
| W-274 | 21-Aug-86 | 217.0 | 95.0 | 90-95 | 2 | <0.5 |
| W-275 | 05-Sep-86 | 262.0 | 184.0 | 179-184 | 5 | 4 |
| W-276 | 17-Sep-86 | 267.0 | 170.0 | 153.5-169.5 | 3B | 12 |
| W-277 | 03-Oct-86 | 254.0 | 169.0 | 163-169 | 3B | 1.1 |
| W-290 | 08-Jul-86 | 181.0 | 126.0 | 119.5-126 | 5 | <0.5 |

**Table A-1. (Continued)**

| Well number | Date completed | Borehole depth (ft) | Casing depth (ft) | Perforated interval (ft) | HSU[a] monitored | Well development flow rate (gpm)[b] |
|---|---|---|---|---|---|---|
| W-291 | 24-Jul-86 | 194.0 | 137.0 | 127-137 | 5 | <0.5 |
| W-292 | 14-Aug-86 | 250.0 | 184.5 | 176-184.5 | 3B | 9 |
| W-293 | 27-Aug-86 | 229.0 | 155.0 | 145-155 | 5 | <1 |
| W-294 | 15-Sep-86 | 251.0 | 139.0 | 122-139 | 5 | 1 |
| W-301 | 07-Oct-86 | 203.0 | 141.0 | 136-141 | 2 | 5.5 |
| W-302 | 22-Oct-86 | 191.0 | 83.5 | 78-83.5 | 1B | 2 |
| W-303 | 28-Oct-86 | 197.0 | 128.0 | 124-128 | 2 | 15 |
| W-304 | 12-Nov-86 | 207.0 | 200.0 | 195-200 | 4 | 1 |
| W-305 | 18-Nov-86 | 146.0 | 138.0 | 128-138 | 2 | 20 |
| W-306 | 04-Dec-86 | 207.0 | 110.0 | 98-110 | 2 | 8.5 |
| W-307 | 15-Dec-86 | 214.0 | 102.0 | 93-102 | 1B | 1 |
| W-308 | 13-Jan-87 | 194.0 | 113.0 | 107-113 | 2 | 2 |
| W-309 | 20-Jan-87 | 73.0 | NA | NA | NA | NA |
| W-310 | 04-Feb-87 | 202.0 | 184.5 | 176.5-184.5 | 3A | 10 |
| W-311 | 20-Feb-87 | 226.5 | 147.5 | 134.5-147.5 | 3A | 5 |
| W-312 | 05-Mar-87 | 224.5 | 168.0 | 160-168 | 4 | 25 |
| W-313 | 12-Mar-87 | 99.0 | 85.0 | 80-85 | 2 | 5.5 |
| W-314 | 20-Mar-87 | 228.0 | 142.0 | 129-142 | 4 | 9.5 |
| W-315 | 03-Apr-87 | 215.0 | 156.0 | 141-156 | 3A | 15 |
| W-316 | 15-Apr-87 | 196.0 | 71.0 | 66-72 | 2 | 3 |
| W-317 | 20-Apr-87 | 100.0 | 95.0 | 88-95 | 2 | 7 |
| W-318 | 28-Apr-87 | 200.0 | 81.0 | 74-81 | 2 | 0.5 |
| W-319 | 05-May-87 | 198.0 | 125.0 | 119-125 | 3A | 25 |
| W-320 | 11-May-87 | 106.0 | 99.0 | 94-99 | 2 | 3 |
| W-321 | 29-May-87 | 356.0 | 321.5 | 305-321.5 | 5 | 60 |
| W-322 | 01-Jul-87 | 565.5 | 152.0 | 142-152 | 2 | 4 |
| W-323 | 04-Aug-87 | 200.0 | 127.0 | 122-127 | 2 | 7 |
| W-324 | 17-Aug-87 | 219.0 | 189.0 | 184-189 | 3A | 15 |
| W-325 | 28-Aug-87 | 312.0 | 170.0 | 158-170 | 3A | 4 |
| W-352 | 29-Oct-86 | 235.0 | 201.0 | 181-201 | 4 | 12.5 |
| W-353 | 12-Nov-86 | 205.0 | 101.0 | 95.5-101 | 2 | 1 |
| W-354 | 24-Nov-86 | 185.0 | 179.0 | 163-179 | 4 | 8 |
| W-355 | 05-Dec-86 | 202.0 | 107.0 | 102-107 | 2 | 2 |
| W-356 | 18-Dec-86 | 237.0 | 137.0 | 133-137 | 3B | 6 |

**Table A-1. (Continued)**

| Well number | Date completed | Borehole depth (ft) | Casing depth (ft) | Perforated interval (ft) | HSU[a] monitored | Well development flow rate (gpm)[b] |
|---|---|---|---|---|---|---|
| W-359 | 10-Feb-87 | 195.0 | 150.5 | 138-150.5 | 5 | 10 |
| W-360 | 24-Feb-87 | 260.0 | 204.5 | 181.5-204.5 | 4 | 30 |
| W-361 | 05-Mar-87 | 257.0 | 135.0 | 125-135 | 3A | 4 |
| W-362 | 13-Mar-87 | 151.0 | 145.0 | 131-145 | 4 | 12 |
| W-363 | 24-Mar-87 | 195.0 | 129.0 | 117-129 | 3A | <0.5 |
| W-364 | 31-Mar-87 | 195.0 | 165.0 | 155-165 | 3B,4 | 5 |
| W-365 | 09-Apr-87 | 187.0 | 125.0 | 120-125 | 2 | 8.5 |
| W-366 | 20-Apr-87 | 273.0 | 251.0 | 240-251 | 4 | 13 |
| W-368 | 06-May-87 | 206.0 | 78.0 | 70-78 | 1B | 3 |
| W-369 | 14-May-87 | 204.0 | 113.0 | 107-113 | 2 | 2 |
| W-370 | 29-May-87 | 286.0 | 208.0 | 196.5-208 | 4 | 5 |
| W-371 | 12-Jun-87 | 233.0 | 162.0 | 155-162 | 3A | 1.5 |
| W-372 | 25-Jun-87 | 218.0 | 152.5 | 147.5-152.5 | 4 | 1 |
| W-373 | 06-Jul-87 | 178.0 | 99.0 | 89-99 | 1B | 7 |
| W-375 | 29-Jul-87 | 223.0 | 71.0 | 65-71 | 2 | 0.75 |
| W-376 | 27-Aug-87 | 249.0 | 172.0 | 162-172 | 2 | 2 |
| W-377 | 04-Sep-87 | 159.0 | 144.0 | 141.5-144 | 2 | 2.5 |
| W-378 | 09-Sep-87 | 155.0 | 150.0 | 146-150 | 2 | 5 |
| W-379 | 14-Sep-87 | 155.0 | 150.0 | 146-150 | 2 | 5 |
| W-380 | 01-Oct-87 | 195.0 | 182.0 | 170-182 | 3A | 10 |
| W-401 | 05-Nov-87 | 159.0 | 153.0 | 109-153 | 2 | 25 |
| W-402 | 13-Oct-87 | 104.0 | 102.0 | 92-102 | 1B | 40 |
| W-403 | 16-Nov-87 | 585.0 | 495.0 | 485-495 | 7 | 3 |
| W-404 | 04-Dec-87 | 245.0 | 158.0 | 150-158 | 2 | 33 |
| W-405 | 04-Jan-88 | 244.0 | 162.0 | 132-162 | 2 | 50 |
| W-406 | 20-Jan-88 | 213.0 | 94.0 | 79-84 | 1B | 2 |
| W-407 | 04-Feb-88 | 215.0 | 205.0 | 192-205 | 3A | 4 |
| W-409 | 07-Mar-88 | 272.0 | 78.0 | 71-78 | 1B | 30 |
| W-410 | 30-Mar-88 | 369.0 | 205.0 | 193-205 | 3A | 35 |
| W-411 | 12-Apr-88 | 192.0 | 138.0 | 131-138 | 2 | 8 |
| W-412 | 18-Apr-88 | 104.0 | 74.0 | 67-74 | 1B | 2.5 |
| W-413 | 28-Apr-88 | 163.0 | 115.0 | 100-115 | 2 | 25 |
| W-414 | 20-May-88 | 179.0 | 74.0 | 69.5-74 | 2 | 0.5 |
| W-416 | 10-Jun-88 | 152.0 | 80.5 | 72-80.5 | 1B | 30 |

**Table A-1. (Continued)**

| Well number | Date completed | Borehole depth (ft) | Casing depth (ft) | Perforated interval (ft) | HSU[a] monitored | Well development flow rate (gpm)[b] |
|---|---|---|---|---|---|---|
| W-417 | 20-Jun-88 | 152.0 | 60.0 | 51-60 | 1B | 5 |
| W-418 | 24-Jun-88 | 124.0 | 118.0 | 108-118 | 2 | 2.5 |
| W-419 | 29-Jun-88 | 82.0 | 75.5 | 62.5-75.5 | 1B | 3 |
| W-420 | 26-Jul-88 | 127.0 | 111.0 | 105-111 | 2 | 5 |
| W-421 | 23-Aug-88 | 181.0 | 90.0 | 75-90 | 1B | 4.5 |
| W-422 | 02-Sep-88 | 203.0 | 139.5 | 133-139.5 | 2 | 5 |
| W-423 | 09-Sep-88 | 308.0 | 118.0 | 106-118 | 2 | 14 |
| W-424 | 04-Oct-88 | 208.0 | 144.0 | 137-144 | 3A | 3 |
| W-441 | 14-Oct-87 | 250.0 | 144.0 | 135-144 | 5 | 2.5 |
| W-446 | 18-Dec-87 | 202.0 | 196.0 | 186-196 | 3A | 3 |
| W-447 | 05-Feb-88 | 353.0 | 274.0 | 256-274 | 4 | 5 |
| W-448 | 17-Feb-88 | 235.0 | 127.5 | 120.5-127.5 | 2 | 15 |
| W-449 | 07-Mar-88 | 172.0 | 165.0 | 152-165 | 2 | 3 |
| W-450 | 21-Mar-88 | 300.0 | 200.0 | 193-200 | 5 | 2 |
| W-451 | 06-Apr-88 | 202.0 | 112.0 | 106-112 | 2 | 1.5 |
| W-452 | 15-Apr-88 | 210.0 | 79.5 | 64-79.5 | 1B | 5 |
| W-453 | 27-Apr-88 | 185.0 | 130.3 | 121-130 | 2 | 4 |
| W-454 | 09-May-88 | 196.0 | 83.5 | 73-83.5 | 1B | 3 |
| W-455 | 19-May-88 | 184.0 | 162.5 | 148-162.5 | 2 | 5 |
| W-456 | 09-Jun-88 | 343.0 | 180.5 | 172-180.5 | 3A | 2 |
| W-457 | 22-Jun-88 | 289.0 | 149.5 | 130-149.5 | 2 | 20 |
| W-458 | 30-Jun-88 | 212.5 | 116.0 | 108-116 | 2 | 2 |
| W-459 | 20-Jul-88 | 76.0 | 73.0 | 59.5-73 | 1B | 1.5 |
| W-460 | 22-Jul-88 | 361.0 | 140.5 | 135-140.5 | 2 | 30 |
| W-461 | 16-Aug-88 | 133.0 | 51.5 | 41.5-51.5 | 2 | <0.5 |
| W-462 | 12-Sep-88 | 385.0 | 336.5 | 331-336.5 | 5 | 5 |
| W-463 | 16-Sep-88 | 93.0 | 92.5 | 87-92.5 | 1B | 5 |
| W-464 | 30-Sep-88 | 253.0 | 104.5 | 96-104.5 | 2 | 3.5 |
| W-481 | 04-Nov-88 | 224.5 | 105.0 | 100-105 | 1B | 2 |
| W-482 | 15-Jan-88 | 218.0 | 170.0 | 165-170 | 2 | <0.5 |
| W-483 | 26-Jan-88 | 140.0 | 130.0 | 115-130 | 2 | 2.5 |
| W-484 | 11-Feb-88 | 255.0 | 188.0 | 185-188 | 3A | 0.5 |
| W-485 | 25-Feb-88 | 249.0 | 157.0 | 151-157 | 2 | 2 |
| W-486 | 11-Mar-88 | 167.0 | 108.0 | 100-108 | 2 | 2 |
| W-487 | 17-Mar-88 | 180.0 | 151.0 | 148-151 | 3B | 1 |

**Table A-1. (Continued)**

| Well number | Date completed | Borehole depth (ft) | Casing depth (ft) | Perforated interval (ft) | HSU[a] monitored | Well development flow rate (gpm)[b] |
|---|---|---|---|---|---|---|
| W-501 | 13-Oct-88 | 174.0 | 92.0 | 84-92 | 1B | 6.5 |
| W-502 | 25-Oct-88 | 158.0 | 59.0 | 55-59 | 1B | <0.5 |
| W-503 | 02-Nov-88 | 187.0 | 80.0 | 74-80 | 1B | 1 |
| W-504 | 21-Nov-88 | 358.0 | 167.0 | 157-167 | 2 | 3 |
| W-505 | 15-Dec-88 | 278.0 | 180.0 | 167-180 | 3A | 60 |
| W-506 | 22-Dec-88 | 120.0 | 115.0 | 101-115 | 1B | 30 |
| W-507 | 18-Jan-89 | 158.0 | 139.0 | 129-139 | 2 | 50 |
| W-508 | 17-Feb-89 | 316.0 | 305.0 | 287-305 | 7 | 60 |
| W-509 | 03-Mar-89 | 305.0 | 184.0 | 179-184 | 5 | 1 |
| W-510 | 15-Mar-89 | 300.0 | 119.0 | 111-119 | 2 | <0.5 |
| W-511 | 31-Mar-89 | 316.0 | 176.0 | 167-176 | 4 | 1 |
| W-512 | 13-Apr-89 | 261.0 | 176.0 | 166-176 | 5 | 2.5 |
| W-513 | 26-Apr-89 | 259.0 | 115.0 | 102-115 | 2 | 1 |
| W-514 | 17-May-89 | 386.0 | 115.5 | 92-115.5 | 1B | 2 |
| W-515 | 30-May-89 | 211.0 | 78.0 | 68-78 | 1B | 3.5 |
| W-516 | 09-Jun-89 | 203.0 | 119.0 | 114-119 | 2 | 15 |
| W-517 | 20-Jun-89 | 215.0 | 88.0 | 80-88 | 1B | 6.7 |
| W-519 | 14-Aug-89 | 186.5 | 80.5 | 60-80.5 | 1B | 25 |
| W-551 | 18-Oct-88 | 308.0 | 155.5 | 151-155.5 | 2 | 20 |
| W-552 | 25-Oct-88 | 70.5 | 64.0 | 48.5-64 | 1A | 3 |
| W-553 | 03-Nov-88 | 186.0 | 106.5 | 99-106.5 | 2 | 1 |
| W-554 | 22-Nov-88 | 239.0 | 141.5 | 126.5-141.4 | 2 | 60 |
| W-555 | 05-Dec-88 | 122.0 | 116.5 | 102.5-116.5 | 1B | 20 |
| W-556 | 15-Dec-88 | 192.0 | 81.5 | 76-81.5 | 1B | 6 |
| W-557 | 22-Dec-88 | 122.5 | 118.0 | 102-118 | 2 | 2 |
| W-558 | 17-Jan-89 | 117.0 | 110.5 | 101-110.5 | 1B | 20 |
| W-559 | 24-Jan-89 | 105.0 | 100.0 | 93-100 | 2 | 0.75 |
| W-560 | 07-Feb-89 | 263.0 | 206.5 | 201-206.5 | 3B | 10 |
| W-561 | 23-Feb-89 | 180.0 | 152.0 | 143-152 | 5 | 4 |
| W-562 | 08-Mar-89 | 263.0 | 158.0 | 145-158 | 5 | 2 |
| W-563 | 17-Mar-89 | 192.0 | 105.0 | 95-105 | 2 | 2 |
| W-564 | 30-Mar-89 | 184.0 | 85.0 | 79.5-85 | 1B | 3 |
| W-565 | 06-Apr-89 | 177.0 | 82.5 | 75-82.5 | 1B | 15 |
| W-566 | 19-Apr-89 | 317.0 | 207.0 | 197-207 | 5 | 12 |
| W-567 | 27-Apr-89 | 194.0 | 61.5 | 51-61 | 1B | 10 |

**Table A-1. (Continued)**

| Well number | Date completed | Borehole depth (ft) | Casing depth (ft) | Perforated interval (ft) | HSU[a] monitored | Well development flow rate (gpm)[b] |
|---|---|---|---|---|---|---|
| W-568 | 05-Jun-89 | 156.0 | 101.0 | 97-101 | 2 | 30 |
| W-569 | 16-May-89 | 215.0 | 109.5 | 101-109.5 | 2 | 4 |
| W-570 | 09-Jun-89 | 180.0 | 175.0 | 161-175 | 7 | 1 |
| W-571 | 15-Jun-89 | 223.5 | 207.5 | 102-107 | 1B | 22 |
| W-591 | 29-Nov-88 | 112.0 | 107.5 | 97-107.5 | 2 | <0.5 |
| W-592 | 12-Dec-88 | 136.5 | 113.0 | 101-113 | 2 | 1.5 |
| W-593 | 06-Feb-89 | 159.0 | 92.5 | 82-92.5 | 3A | 1.5 |
| W-594 | 27-Feb-89 | 156.0 | 61.0 | 55-61 | 2 | 0.5 |
| W-604 | 27-Nov-89 | 111.0 | 83.0 | 76-82 | 1B | 0.5 |
| W-605 | 08-Dec-89 | 246.0 | 136.0 | 130-136 | 2 | 10 |
| W-606 | 21-Dec-89 | 145.0 | 89.0 | 73-89 | 1B | 2 |
| W-607 | 24-Jan-90 | 186.0 | 55.0 | 49-55 | 1B | 3 |
| W-608 | 07-Feb-90 | 162.0 | 66.0 | 55-66 | 1B | 3 |
| W-611 | 04-Apr-90 | 161.0 | 98.0 | 87.5-98 | 1B | 2 |
| W-612 | 19-Apr-90 | 222.0 | 136.0 | 126-136 | 2 | 10 |
| W-613 | 02-May-90 | 93.0 | 88.0 | 81.5-88 | 1B | 7 |
| W-615 | 01-Jun-90 | 121.0 | 99.0 | 91-99 | 1B | 3 |
| W-616 | 14-Jun-90 | 255.0 | 188.0 | 178-188 | 3A | 8 |
| W-617 | 26-Jun-90 | 200.0 | 110.0 | 103-110 | 2 | 6 |
| W-618 | 17-Jul-90 | 357.0 | 205.0 | 201-205 | 3B | 10 |
| W-619 | 07-Aug-90 | 330.0 | 252.0 | 232-252 | 4 | 30 |
| W-622 | 28-Sep-90 | 206.0 | 112.0 | 104-112 | 5 | <0.5 |
| W-651 | 22-Feb-90 | 155.0 | 89.0 | 82-89 | 1B | 0.5 |
| W-652 | 15-Mar-90 | 318.0 | 256.0 | 245-256 | 6 | 2 |
| W-653 | 29-Mar-90 | 225.0 | 128.0 | 122-128 | 3A | 0.5 |
| W-654 | 11-Apr-90 | 240.0 | 158.0 | 140-158 | 2 | 20 |
| W-702 | 24-Oct-90 | 180.5 | 95.0 | 77-95 | 1B | 10 |
| W-703 | 03-Dec-90 | 586.0 | 325.0 | 298-325 | 5 | 10 |
| W-705 | 26-Dec-90 | 126.00 | 90.0 | 77-90 | 1B | 2 |
| W-706 | 16-Jan-91 | 178.0 | 84.0 | 71-84 | 1B | 2 |
| W-901 | 24-Feb-93 | 97.8 | 88.0 | 79-83 | 1B | 1 |
| W-902 | 22-Jan-93 | 95.5 | 88.0 | 80-83 | 1B | 1 |

**Table A-1. (Continued)**

| Well number | Date completed | Borehole depth (ft) | Casing depth (ft) | Perforated interval (ft) | HSU[a] monitored | Well development flow rate (gpm)[b] |
|---|---|---|---|---|---|---|
| W-903 | 28-Apr-93 | 223.0 | 145 | 132-140 | 2 | 20 |
| W-904 | 06-May-93 | 212.0 | 154.0 | 121-133<br>140-149 | 2 | 20 |
| W-905 | 07-Apr-93 | 221.0 | 144.5 | 134-144 | 2 | 4 |
| W-907 | 2-Sep-93 | 239.0 | 220.0 | 172.7-188.8<br>204.5-215.0 | 4<br>5 | 25<br>NA |
| W-908 | 18-Aug-93 | 239.0 | 197.0 | 180-197 | 6 | <0.5 |
| W-909 | 4-Nov-93 | 252.0 | 113.5 | 80.5-108.5 | 2 | 2 |
| W-911 | 20-Dec-93 | 180 | 113.5 | 73.5-108.5 | 2 | 3 |
| W-912 | 07-Oct-93 | 239 | 174 | 168-174 | 5 | 3 |
| W-913 | 08-Dec-93 | 454 | 255 | 235-255 | 4 | 25 |
| W-1001 | 20-Dec-93 | 105 | 92 | 85-92 | 1B | 1.4 |
| W-1002 | 31-Jan-94 | 292.5 | 260 | 246-260 | 5 | 16 |
| W-1003 | 08-Feb-94 | 184.0 | 147 | 140-147 | 2 | 1.5 |
| W-1005 | 14-Mar-94 | 192.0 | 110.0 | 98-110 | 1B | 20 |
| W-1006 | 10-Mar-94 | 154.0 | 149.0 | 141-149 | 2 | 15 |
| W-1007 | 31-Mar-94 | 199.5 | 182.0 | 172-182 | 3A | 2 |
| W-1008 | 13-April-94 | 246 | 238 | 229.5-238 | 7 | 10 |
| W-1010 | 24-May-94 | 463 | 142 | 128-142 | 2 | 20 |
| W-1011 | 06-June-94 | 106 | 89 | 75-89 | 1B | 3 |
| W-1012 | 20-June-94 | 161 | 117 | 96-112 | 2 | 5 |
| W-1013 | 29-June-94 | 147 | 73 | 65-73 | 1B | 1.4 |
| W-1014 | 12-July-94 | 99 | 89 | 65-89 | 1B | 30 |
| W-1015 | 10-Aug-94 | 437 | 94 | 84-94 | 1B | 20 |
| W-1101 | 10-Nov-94 | 200.0 | 79.0 | 76.0-79.0 | 1B | 0.5 |
| W-1102 | 29-Nov-94 | 163.0 | 95.5 | 76.0-94.0 | 1B | 8 |
| W-1103 | 15-Dec-94 | 200.0 | 82.0 | 70.0-82.0 | 1B | 3.5 |
| W-1104 | 18-Jan-95 | 165.0 | 99.0 | 77-87<br>92-98 | 1B | $35^+$ |
| W-1105 | 17-Jan-95 | 110 | 93 | 78-93 | 1B | 3.5-4 |
| W-1106 | 8-Feb-95 | 245 | 86 | 76-85 | 1B | 15 |
| W-1107 | 6-Mar-95 | 199.5 | 93 | 74-88 | 1B | <0.5 |
| W-1108 | 27-Mar-95 | 250 | 156 | 142-156 | 5 | 12 |

**Table A-1. (Continued)**

| Well number | Date completed | Borehole depth (ft) | Casing depth (ft) | Perforated interval (ft) | HSU[a] monitored | Well development flow rate (gpm)[b] |
|---|---|---|---|---|---|---|
| W-1109 | 11-Apr-95 | 121 | 113 | 94-108 | 2 | 3 |
| W-1110 | 4-May-95 | 252 | 92.2 | 68-92 | 1B | 7 |
| W-1111 | 1-Jun-95 | 152 | 129 | 88-108 | 2 | 10.5 |
| | | | | 120-124 | 2 | NA |
| W-1112 | 28-Jun-95 | 263 | 210 | 201-210 | 5 | 3 |
| W-1113 | 18-July-95 | 260 | 214 | 204-214 | 5 | 2.5 |
| W-1114 | 7-Aug-95 | 223 | 205 | 177-200 | 5 | 8.5 |
| W-1115 | 12-Oct-95 | 126.5 | 118.2 | 108-118 | 3A | 1 |
| W-1116 | 17-Aug-95 | 214 | 101 | 72-98 | 1B | 9 |
| W-1117 | 11-Sep-95 | 154 | 132.3 | 122-132 | 3A | 1 |
| W-1118 | 27-Sep-95 | 225 | 125 | 115-125 | 3A | 3.5 |
| W-1201 | 18-Oct-95 | 225 | 133 | 125-133 | 3A | 1 |
| W-1202 | 26-Oct-95 | 99.3 | 99 | 83-99 | 2 | $5^{+}$ |
| W-1203 | 7-Nov-95 | 224 | 206.2 | 196-206 | 5 | 18+ |
| W-1204 | 20 Nov-95 | 225 | 126.2 | 118-126 | 3A | 2.5 |
| W-1205 | 27-Nov-95 | 91 | 82 | 72-82 | 2 | <0.5 |
| W-1206 | 6-Dec-95 | 220 | 191 | 174-186 | 4 | 40+ |
| TW-11 | 09-Jun-81 | 112.5 | 107.0 | 97-107 | 2 | NA |
| TW-11A | 16-Mar-84 | 163.0 | 160.0 | 133-160 | 2 | NA |
| TW-21 | 12-Jun-81 | 111.5 | 95.0 | 85-95 | 1B | NA |
| GEW-710 | 02-Aug-91 | 159.0 | 158.0 | 94-137 | 3A,3B | 25 |
| GSW-1A | 12-Jun-86 | 208.0 | 133.0 | 115-133 | 3B | 12 |
| GSW-2 | 14-Feb-85 | 113.0 | 107.0 | 87-107 | 3A | NA |
| GSW-3 | 07-Feb-85 | 115.0 | 105.0 | 85-105 | 3A | NA |
| GSW-4 | 22-Feb-85 | 112.0 | 106.0 | 86-106 | 3A | NA |
| GSW-5 | 19-Mar-85 | 110.0 | 104.0 | 94-104 | 3A | NA |
| GSW-6 | 28-Feb-86 | 212.0 | 137.0 | 121-137 | 3B | 6 |
| GSW-7 | 14-Mar-86 | 176.5 | 123.4 | 110.8-123.4 | 3B | 2 |
| GSW-8 | 01-Apr-86 | 176.0 | 133.0 | 127.5-133 | 3B | 2 |
| GSW-9 | 14-Apr-86 | 197.5 | 152.5 | 147-152.5 | 3B | 1 |
| GSW-10 | 29-Apr-86 | 205.5 | 127.5 | 114-127.5 | 3B | 8 |

**Table A-1. (Continued)**

| Well number | Date completed | Borehole depth (ft) | Casing depth (ft) | Perforated interval (ft) | HSU[a] monitored | Well development flow rate (gpm)[b] |
|---|---|---|---|---|---|---|
| GSW-11 | 07-May-86 | 182.5 | 126.0 | 116-126 | 3B | 2 |
| GSW-12 | 27-May-86 | 205.0 | 191.0 | 186.5-191 | 5 | 1 |
| GSW-13 | 27-Jun-86 | 198.0 | 134.5 | 125-134.5 | 3B | 1 |
| GSW-15 | 14-Aug-87 | 148.0 | 145.0 | 20.5-28 | 3A,3B | 3.5 |
| | | | | 38-44 | | |
| | | | | 50-56 | | |
| | | | | 60-64 | | |
| | | | | 68-73 | | |
| | | | | 77-83 | | |
| | | | | 95-105 | | |
| | | | | 120-130 | | |
| GSW-16 | 19-Oct-87 | 146.0 | 145.0 | 23-28 | 3A,3B | 20.5-30 |
| | | | | 38-43 | | |
| | | | | 50-55 | | |
| | | | | 61-66 | | |
| | | | | 78-83 | | |
| | | | | 95-105 | | |
| | | | | 120-130 | | |
| GSW-208 | 06-Feb-86 | 211.0 | 123.0 | 108-118 | 3B | <2 |
| GSW-209 | 27-Feb-86 | 204.0 | 135.2 | 112.8-132.8 | 3B | 2 |
| GSW-215 | 22-Apr-86 | 213.5 | 133.5 | 127-133.5 | 3A | 2 |
| GSW-216 | 09-May-86 | 193.0 | 120.5 | 110.5-120.5 | 3B | 3 |
| GSW-266 | 08-May-86 | 220.0 | 166.0 | 159-166 | 3B | 1 |
| GSW-326 | 02-Oct-87 | 230.0 | 134.0 | 129-134 | 3B | 0.5 |
| GSW-367 | 29-Apr-87 | 159.0 | 124.0 | 114-124 | 2 | 2 |
| GSW-403-6 | 11-May-84 | 138.0 | 113.6 | 90-110 | 3A | NA |
| GSW-442 | 27-Oct-87 | 270.0 | 145.0 | 138-145 | 3B | 0.5 |
| GSW-443 | 09-Nov-87 | 291.0 | 141.0 | 123-141 | 2 | 5 |
| GSW-444 | 20-Nov-87 | 278.0 | 120.0 | 110-120 | 3A | 0.3 |
| GSW-445 | 09-Dec-87 | 319.0 | 161.0 | 155-161 | 4 | 3 |

**Table A-1. (Continued)**

| Well number | Date completed | Borehole depth (ft) | Casing depth (ft) | Perforated interval (ft) | HSU[a] monitored | Well development flow rate (gpm)[b] |
|---|---|---|---|---|---|---|
| *Dynamic Stripping Project Wells*[c] | | | | | | |
| GSP-SNL-001 | 7-Jan-92 | 147.0 | 104.0 | 99-104 | 3A | NA |
| | | | 131.0 | 118-131 | 3B | NA |
| GEW-808 | 5-Jun-92 | 164.0 | 150.0 | 50-140 | 3A,3B | 25 |
| GEW-816 | 3-Jun-92 | 161.7 | 150.0 | 50-140 | 3A,3B | 40 |
| GIW-813 | 25-Jun-92 | 140.7 | 87.0 | 67-87 | 3A | NA |
| | | | 104.0 | 89-99 | | |
| | | | 127.0 | 107-127 | 3B | NA |
| GIW-814 | 19-Jun-92 | 149.6 | 106.5 | 86.5-106.5 | 3A | NA |
| | | | 117.0 | 110-120 | | |
| | | | 132.0 | 121-141 | 3B | NA |
| GIW-815 | 15-Jun-92 | 143.0 | 97.0 | 77-97 | 3A | NA |
| | | | 117.0 | 102-112 | | |
| | | | 132.0 | 112.8-132 | 3B | NA |
| GIW-817 | 29-Jun-92 | 150.1 | 102.0 | 82-102 | 3A | NA |
| | | | 122.0 | 107-117 | | |
| | | | 141.0 | 121-141 | 3B | NA |
| GIW-818 | 6-Jul-92 | 150.0 | 102 | 82-102 | 3A | NA |
| | | | 125 | 110-120 | | |
| | | | 140 | 120-140 | 3B | NA |
| GIW-819 | 10-Jul-92 | 150.0 | 98.6 | 78.6-98.6 | 3A | NA |
| | | | 123 | 108-118 | | |
| | | | 141 | 121-141 | 3B | NA |
| GIW-820 | 16-Jul-92 | 143.3 | 105 | 85-105 | 3A | NA |
| | | | 132 | 112-132 | 3B | NA |
| HW-GP-001 | 17-April-92 | 120.0 | 77.0 | 67-77 | 3A | NA |
| | | | 113.0 | 103-113 | 3B | NA |
| HW-GP-002 | 13-May-92 | 120.0 | 78.0 | 68-78 | 3A | NA |
| | | | 117.0 | 107-117 | 3B | NA |
| HW-GP-003 | 20-May-92 | 119.0 | 76.5 | 66.5-76.5 | 3A | NA |
| | | | 119.0 | 109-119 | 3B | NA |
| HW-GP-102 | 13-Aug-93 | 140.0 | 137.5 | 72.5-133.5 | 3A,3B | NA |
| HW-GP-103 | 23-Aug-93 | 138.0 | 137.5 | 71.5-132.5 | 3A,3B | NA |
| HW-GP-104 | 2-Sep-93 | 138.0 | 137.2 | 72.2-132.2 | 3A,3B | NA |

**Table A-1. (Continued)**

| Well number | Date completed | Borehole depth (ft) | Casing depth (ft) | Perforated interval (ft) | HSU[a] monitored | Well development flow rate (gpm)[b] |
|---|---|---|---|---|---|---|
| HW-GP-105 | 28-Sep-93 | 138.0 | 137.5 | 72.5-132.5 | 3A,3B | NA |
| TEP-GP-106 | 21-Sep-93 | 137.5 | 135.5 | | | |
| *Extraction Wells* | | | | | | |
| W-109 | 02-Apr-85 | 289.0 | 147.0 | 137-147 | 2 | 12 |
| W-351 | 17-Oct-86 | 191.0 | 151.0 | 146-152 | 4 | 2.9 |
| W-357 | 12-Jan-87 | 197.0 | 123.0 | 107-123 | 2 | 8 |
| W-408 | 16-Feb-88 | 131.0 | 122.5 | 101-122.5 | 1B | 35 |
| W-415 | 12-Aug-88 | 205.0 | 183.7 | 79-179 | 1B | >50 |
| W-518 | 08-Aug-89 | 251.0 | 139.0 | 131-139 | 2 | 2.5 |
| W-520 | 30-Aug-89 | 160.0 | 101.5 | 94-101.5 | 1B | 12 |
| W-521 | 13-Sep-89 | 166.0 | 95.0 | 86-95 | 1B | 1 |
| W-522 | 05-Oct-89 | 145.5 | 141.5 | 134-141.5 | 2 | 25 |
| W-601 | 13-Oct-89 | 146.0 | 96.0 | 88-96 | 1B | 15 |
| W-602 | 06-Nov-89 | 168.0 | 100.0 | 90-100 | 1B | 10 |
| W-603 | 15-Nov-89 | 150.0 | 147.0 | 141-147 | 2 | 5 |
| W-609 | 21-Feb-90 | 120.0 | 112.0 | 104-112 | 2 | 4 |
| W-610 | 16-Mar-90 | 453.0 | 84.5 | 69-84.5 | 1B | 4 |
| W-614 | 18-May-90 | 262.0 | 123.0 | 100-123 | 1B | 12 |
| W-620 | 30-Aug-90 | 206.0 | 88.5 | 75-88.5 | 1B | 5 |
| W-621 | 09-Sep-90 | 149.0 | 120.0 | 113-120 | 2 | 4 |
| W-655 | 25-Apr-90 | 193.0 | 130.0 | 121-129.5 | 2 | 2 |
| W-701 | 10-Oct-90 | 159.0 | 86.0 | 74-86 | 1B | 10 |
| W-704 | 01-Feb-91 | 135.0 | 107.0 | 67-76<br>88-97 | 1B | 20 |
| W-712 | 29-Aug-91 | 200.0 | 185.5 | 170-185.5 | 3A | 8 |
| W-714 | 02-Jul-91 | 135.0 | 128.0 | 107-128 | 2 | 7.5 |
| W-906 | 27-Jul-93 | 200.0 | 132.0 | 58-132 | 2,3A | 10 |
| W-1004 | 23-Feb-94 | 99.0 | 97.0 | 71-91 | 1B | 7 |
| W-1009 | 02-May-94 | 191 | 140 | 134-140 | 2 | 20 |

**Table A-1. (Continued)**

| Well number | Date completed | Borehole depth (ft) | Casing depth (ft) | Perforated interval (ft) | HSU[a] monitored | Well development flow rate (gpm)[b] |
|---|---|---|---|---|---|---|
| *Other Wells* | | | | | | |
| 7D2 | 07-Jun-76 | 74 | 72.3 | 63.2-67.3 | 3A | NA |
| 11C1 | 08-Jun-76 | 68 | 66.2 | 56.2-61.2 | 1B | NA |
| 11H5 | 08-Nov-85 | NA | 255 | NA | NA | NA |
| 11J2 | 26-Apr-79 | 112 | 110 | 90-92 | 2 | NA |
| | | | | 102-108 | | |
| 11Q4 | NA | NA | NA | NA | NA | NA |
| 11Q5 | NA | NA | NA | NA | NA | NA |
| 14A3 | 07-Dec-77 | NA | 110 | 100-105 | NA | NA |
| 14A11[d] | NA | NA | NA | NA | NA | NA |
| 14B1 | 13-Aug-59 | 300 | 234 | 146-149 | NA | NA |
| | | | | 192-195 | | |
| | | | | 198 | | |
| | | | | 200 | | |
| | | | | 203 | | |
| | | | | 205 | | |
| | | | | 207 | | |
| | | | | 209-213 | | |
| | | | | 226 | | |
| | | | | 230 | | |
| | | | | 234 | | |
| 14B4 | Aug-60 | NA | 260 | 143-148 | NA | NA |
| | | | | 155-159 | | |
| | | | | 186-189 | | |
| | | | | 205-215 | | |
| | | | | 245-250 | | |
| 14B7 | NA | NA | NA | NA | NA | NA |
| 14H1 | NA | NA | 288 | NA | NA | NA |
| 14H2[d] | NA | NA | NA | NA | NA | |
| 18D1[d] | NA | NA | NA | NA | 7 | NA |

**Note: Footnotes to appear on the following page.**

## Table A-1. (Continued)

**Note: Boreholes B-707, B-708, B-709, B-713, B-715, and B-750 were drilled for the Dynamic Underground Stripping Demonstration Project "Clean Site."**

**[a] Hydrostratigraphic Units (HSUs) are numbered consecutively downward from ground surface. An HSU is defined as a sequence of sediments that are grouped together based on the hydrogeologic and contaminant transport properties. The permeable layers within an HSU are considered to be in good hydraulic communication, whereas permeable layers in different HSUs are considered to be in poor hydraulic communication. HSU contacts are interpreted and are subject to change.**

**[b] Flow rate after 4 h of air-lift pumping/surging.**

**[c] Wells installed for the Dynamic Underground Stripping Demonstration Project include extraction wells (GEW series), injection wells (GIW series), temperature monitoring wells (TEP series), and heating wells (HW series). TEP wells consist of two nested 1-in ID piezometers surrounding a blank fiberglass 2-in ID casing instrumented with geophysical sensors. The screened intervals listed therefore pertain to the two individual piezometers.**

**[d] Well number was changed in December 1988 to be consistent with Alameda County Flood Control and Water Conservation District, Zone 7 well identification. Well number changes made on this table are:**

**4A6 ------> 14H2**

**18D81 ------> 18D1**

**14A84 ------> 14A11**

**NA = Not applicable.**

**Table A-2. Well closure data, Lawrence Livermore National Laboratory and vicinity, Livermore, California.**

| Well number | Date installed | Borehole depth (ft) | Casing depth (ft) | Perforated interval (ft) | HSU monitored | Closure date |
|---|---|---|---|---|---|---|
| *Monitor Wells* | | | | | | |
| W-14A | 26-Aug-80 | 111.0 | 109.0 | 80,95,105 | 2 | 11-Dec-87 |
| W-15 | 17-Nov-80 | 285.0 | 267.0 | 239-265 | 7 | 13-May-88 |
| W-18 | 22-Aug-80 | 161.0 | 152.5 | 80-90 | 2 | 11-Nov-85 |
| | | | | 100-105 | 2 | |
| | | | | 112-117 | 3A | |
| | | | | 128-133 | 5 | |
| | | | | 143-153 | 5 | |
| GSW-1 | 5-Feb-85 | 112.0 | 109.0 | 85-106 | 3A | 06-Jun-86 |
| GSW-20 | 18-May-84 | 134.0 | 101.3 | 95-101.3 | 3A | 03-Sep-87 |
| W-150 | 13-Sep-85 | 212.0 | 162.0 | 157-162 | 2 | 11-Apr-90 |
| W-358 | 04-Feb-87 | 248.0 | 239.0 | 230-239 | 7 | 15-Apr-94 |
| *Extraction Wells* | | | | | | |
| GEW-711 | 24-May-91 | 167.5 | 157.0 | 94-137 | 3A,3B | 16-Jun-92 |
| *Other Wells* | | | | | | |
| 1N1 | 15-Jan-48 | 600 | 600 | 427-442 | 7 | 21-Oct-88 |
| | | | | 450-453 | 1B | |
| | | | | 465-469 | NA | |
| | | | | 500-515 | NA | |
| | | | | 575-588 | NA | |
| 11A1 | 08-Jun-76 | 66 | 64.7 | 54.7-59.7 | NA | 18-Aug-88 |
| 11A5 | NA | NA | NA | NA | NA | 19-Jul-88 |
| 11BA[a] | NA | NA | NA | NA | NA | 10-Jun-87 |
| 11H1 | 04-Nov-41 | NA | 519 | 157-161 | NA | 31-Oct-88 |
| | | | | 169-177 | NA | |
| | | | | 224-228 | NA | |
| | | | | 243-245 | NA | |
| | | | | 254-256 | NA | |
| | | | | 306-314 | NA | |
| | | | | 319-327 | NA | |
| | | | | 339-342 | NA | |
| | | | | 414-419 | NA | |
| | | | | 424-431 | NA | |

**Table A-2. (Continued)**

| Well number | Date installed | Borehole depth (ft) | Casing depth (ft) | Perforated interval (ft) | HSU monitored | Closure date |
|---|---|---|---|---|---|---|
| | | | | 477-479 | NA | |
| 11H4 | 05-Apr-60 | 272 | 272 | 166-170 | NA | 07-Oct-88 |
| | | | | 174-176 | NA | |
| | | | | 183-185 | NA | |
| | | | | 200-202 | NA | |
| | | | | 211-214 | NA | |
| | | | | 224-230 | NA | |
| | | | | 250-252 | NA | |
| | | | | 260-265 | NA | |
| 11J1 | 1941 | 160 | NA | NA | NA | 03-Aug-88 |
| 11J4[b] | 1965 | NA | NA | NA | NA | 11-Oct-88 |
| 11K1 | 06-Jan-42 | NA | 621 | 247-255 | NA | 26-Sep-88 |
| | | | | 272-276 | NA | |
| | | | | 297-304 | NA | |
| | | | | 322-339 | NA | |
| | | | | 554-557 | NA | |
| | | | | 580-602 | NA | |
| 11K2 | NA | NA | 232 | NA | NA | 03-Oct-88 |
| 11Q2 | NA | NA | 264 | NA | NA | 16-Aug-88 |
| 11Q3 | NA | NA | 120 | NA | NA | 10-Aug-88 |
| 11Q6[b] | NA | NA | 280 | NA | NA | 11-Jan-89 |
| 11R3 | 08-May-61 | 140 | 117 | NA | NA | 03-Sep-85 |
| 11R4 | NA | NA | NA | NA | NA | 03-Sep-85 |
| 11R5[b] | NA | NA | NA | NA | NA | 26-Jul-85 |
| 12M1 | 09-Dec-42 | 702 | 702 | 375-378 | NA | 15-Apr-84 |
| | | | | 420-426 | NA | |
| | | | | 452-473 | NA | |
| | | | | 560-564 | NA | |
| | | | | 609-621 | NA | |
| | | | | 626-657 | NA | |
| 12N1 | 14-Apr-42 | 702 | 681 | 392-399 | NA | 24-Jan-89 |
| | | | | 514-518 | NA | |
| | | | | 527-536 | NA | |
| | | | | 666-670 | NA | |
| | | | | 678-681 | NA | |
| 13D1[b] | 29-Oct-56 | NA | 400 | 200-400 | NA | 23-Aug-88 |

**Table A-2. (Continued)**

| Well number | Date installed | Borehole depth (ft) | Casing depth (ft) | Perforated interval (ft) | HSU monitored | Closure date |
|---|---|---|---|---|---|---|
| 14A8 | NA | NA | 86 | NA | NA | 22-Jul-88 |
| 14A1[b] | 12-Jul-43 | 246 | 227 | 102-107 | NA | 13-Sep-88 |
| | | | | 113-119 | NA | |
| | | | | 144-148 | NA | |
| | | | | 176-179 | NA | |
| | | | | 188-190 | NA | |
| | | | | 192-194 | NA | |
| | | | | 219-222 | NA | |
| | | | | 223-227 | NA | |
| 14A2[b] | 15-Nov-56 | NA | 229 | 122-130 | NA | 12-Sep-88 |
| | | | | 140-150 | NA | |
| | | | | 160-180 | NA | |
| 14A4[b] | 15-Jun-59 | NA | 252 | 167-170 | NA | 29-Aug-88 |
| | | | | 175-179 | NA | |
| | | | | 192-202 | NA | |
| | | | | 235-246 | NA | |
| 14B2 | 22-Aug-56 | NA | 312 | 185-312 | NA | 11-Nov-88 |
| 14B8 | NA | NA | 385 | NA | NA | 23-Oct-89 |
| TEP-GP-001 | 21-Jan-92 | 165.0 | 97.0<br>117.0<br>160.5 | 87-97<br>107-117 | 3A<br>3B | 09-Feb-93 |
| TEP-GP-003 | 28-Jan-92 | 161.0 | 129.5<br>161.0 | 124.5-129.5 | 3B | 13-Feb-93 |
| TEP-GP-004 | 5-Feb-92 | 161.0 | 106.0<br>134.0<br>161.0 | 96-106<br>124-134 | 3A<br>3B | 13-Feb-93 |
| TEP-GP-005 | 18-Feb-92 | 161.0 | 124.5<br>161.0 | 114.5-124.5 | 3B | 13-Feb-93 |
| TEP-GP-006 | 26-Feb-92 | 161.0 | 127.0<br>161.0 | 107-127 | 3B | 13-Feb-93 |
| TEP-GP-007 | 13-Mar-92 | 161.0 | 161.0 | | | NA |
| TEP-GP-008 | 3-Mar-92 | 161.0 | 110.0<br>161.0 | 100-110 | 3A | 13-Feb-93 |
| TEP-GP-009 | 6-May-92 | 161.7 | 107.0<br>130.5<br>161.0 | 98-107<br>120.5-130.5 | 3A<br>3B | 13-Feb-93 |

**Table A-2. (Continued)**

| Well number | Date installed | Borehole depth (ft) | Casing depth (ft) | Perforated interval (ft) | HSU monitored | Closure date |
|---|---|---|---|---|---|---|
| TEP-GP-010 | 24-Mar-92 | 161.0 | 124.5 | 114.5-124.5 | 3B | 12-Feb-93 |
| TEP-GP-011 | 7-Apr-92 | 161.0 | 108.0<br>161.0 | 98-108 | 3A | 13-Feb-93 |
| TEP-GP-002 | 24-Jun-92 | 161.4 | 133.0<br>161.0 | 102-112.5<br>122-133 | 3A<br>3B | NA |

[a] Well not recognized by Alameda County Flood Control and Water Conservation District, Zone 7.

[b] Well number was changed in December 1988 to be consistent with Alameda County Flood Control and Water Conservation District, Zone 7 well identification. Well identification changes made on this table are:

11J81 ------> 1J4

11R81 ------> 11R5

11Q81 ------> 11Q6

13D81 ------> 13D1

14A81 ------> 14A1

14A82 ------> 14A2

14A83 ------> 14A4

NA = Not applicable.

# Appendix B

# Results of Hydraulic Tests

**Appendix B. Results of hydraulic tests[a].**

| Well | Date | Type of test[b] | Flow rate (Q) (gpm) | Transmis-sivity (T) (gpd/ft) | Hydraulic conductivity (K)[c] (gpd/sq ft) | Data quality[d] |
|---|---|---|---|---|---|---|
| MW-001 | 1-Dec-83 | Drawdown | 5.7 | 2,000 | 110 | Fair |
| MW-001 | 23-Jan-85 | Drawdown | 7.1 | 3,100 | 170 | Good |
| MW-001A | 22-Jan-85 | Drawdown | 1.4 | 190 | 19 | Good |
| MW-002 | 1-Dec-83 | Slug | 0.0 | 110 | 34 | Poor |
| MW-002A | 24-Jan-85 | Drawdown | 10.3 | 2,700 | 200 | Good |
| MW-004 | 1-Dec-83 | Drawdown | 3.3 | 63 | 13 | Good |
| MW-005 | 1-Dec-83 | Drawdown | 4.3 | 110 | 20 | Good |
| MW-005 | 24-Jan-85 | Drawdown | 7.9 | 1,100 | 210 | Fair |
| MW-005A | 23-Jan-85 | Drawdown | 13.0 | 1,300 | 130 | Poor |
| MW-007 | 1-Dec-83 | Slug | 0.0 | 43 | 14 | Fair |
| MW-008 | 1-Dec-83 | Drawdown | 2.9 | 29 | 4.9 | Fair |
| MW-011 | 1-Dec-83 | Drawdown | 4.1 | 130 | 15 | Good |
| MW-017 | 1-Dec-83 | Slug | 0.0 | 38 | 2.5 | Good |
| MW-017 | 21-Feb-86 | Slug | 0.0 | 85 | 5.7 | Good |
| MW-018 | 1-Dec-83 | Drawdown | 2.6 | 20 | 2.7 | Poor |
| MW-102 | 25-Mar-86 | Drawdown | 6.4 | 1,100 | 72 | Good |
| MW-102 | 5-Sep-86 | Drawdown | 24.0 | 770 | 53 | Good |
| MW-102 | 15-Sep-86 | Longterm | 27.5 | 4,200 | 290 | Good |
| MW-103 | 25-Apr-86 | Drawdown | 6.7 | 15,000 | 1,500 | Good |
| MW-104 | 3-Mar-88 | Drawdown | 5.4 | 1,200 | 170 | Fair |
| MW-104 | 25-Mar-88 | Drawdown | 3.3 | 450 | 45 | Fair |
| MW-105 | 6-Apr-87 | Drawdown | 0.8 | 73 | 7.3 | Fair |
| MW-106 | 19-Feb-86 | Slug | 0.0 | 7.40 | 1.3 | Excel |
| MW-107 | 17-Jun-85 | Drawdown | 1.0 | 94 | 9.4 | Poor |
| MW-108 | 29-Oct-85 | Drawdown | 7.9 | 750 | 63 | Poor |
| MW-109 | 5-Mar-86 | Drawdown | 8.1 | 3,200 | 540 | Good |
| MW-109 | 4-Sep-87 | Drawdown | 20.0 | 1,600 | 270 | Good |
| MW-109 | 29-Sep-87 | Longterm | 11.6 | 130 | 22 | Fair |
| MW-109 | 16-Oct-87 | Drawdown | 8.0 | 2,300 | 380 | Fair |
| MW-110 | 18-Jun-85 | Drawdown | 5.0 | 1,300 | 130 | Good |
| MW-111 | 13-Jun-85 | Drawdown | 1.0 | 370 | 37 | Good |
| MW-111 | 21-Nov-85 | Drawdown | 1.0 | 37 | 2.3 | Good |
| MW-112 | 18-Nov-86 | Drawdown | 13.4 | 2,100 | 170 | Fair |
| MW-112 | 15-Dec-86 | Longterm | 13.2 | 3,100 | 260 | Fair |

**Appendix B. (Continued)**

| Well | Date | Type of test[b] | Flow rate (Q) (gpm) | Transmis-sivity (T) (gpd/ft) | Hydraulic conductivity (K)[c] (gpd/sq ft) | Data quality[d] |
|---|---|---|---|---|---|---|
| MW-113 | 17-Apr-86 | Slug | 0.0 | 7.40 | 1.2 | Excel |
| MW-115 | 5-Mar-86 | Drawdown | 1.1 | 180 | 30 | Good |
| MW-116 | 24-Dec-85 | Slug | 0.0 | 37 | 7.5 | Good |
| MW-117 | 20-Feb-86 | Slug | 0.0 | 2 | 0.4 | Good |
| MW-118 | 5-Mar-86 | Drawdown | 10.0 | 2,100 | 240 | Good |
| MW-119 | 8-Aug-85 | Drawdown | 2.0 | 1,600 | 100 | Good |
| MW-120 | 22-Apr-86 | Drawdown | 1.1 | 23 | 5.6 | Poor |
| MW-121 | 10-Sep-85 | Drawdown | 2.0 | 120 | 7.5 | Good |
| MW-121 | 23-Sep-85 | Drawdown | 4.0 | 23 | 1.5 | Excel |
| MW-121 | 14-Oct-85 | Drawdown | 3.0 | 34 | 2.2 | Excel |
| MW-121 | 15-Oct-85 | Drawdown | 4.5 | 45 | 3.0 | Excel |
| MW-122 | 28-Oct-85 | Drawdown | 10.8 | 490 | 49 | Good |
| MW-123 | 28-Oct-85 | Drawdown | 5.8 | 40 | 4.4 | Poor |
| MW-142 | 3-Mar-88 | Slug | 0.0 | 2,600 | 330 | Excel |
| MW-143 | 3-Mar-88 | Slug | 0.0 | 1,200 | 240 | Excel |
| MW-149 | 9-Sep-85 | Drawdown | 4.0 | 120 | 19 | Good |
| MW-149 | 11-Sep-85 | Drawdown | 8.0 | 95 | 16 | Excel |
| MW-149 | 11-Oct-85 | Drawdown | 4.8 | 58 | 9.7 | Excel |
| MW-149 | 11-Oct-85 | Drawdown | 7.0 | 70 | 12 | Good |
| MW-150 | 2-Oct-85 | Drawdown | 3.1 | 640 | 210 | Fair |
| MW-150 | 3-Oct-85 | Drawdown | 6.0 | 720 | 240 | Fair |
| MW-150 | 10-Oct-85 | Drawdown | 8.8 | 630 | 210 | Fair |
| MW-150 | 10-Oct-85 | Drawdown | 12.0 | 620 | 210. | Fair |
| MW-151 | 28-Oct-85 | Drawdown | 5.8 | 550 | 61 | Poor |
| MW-201 | 5-Mar-86 | Drawdown | 10.0 | 740 | 86 | Excel |
| MW-203 | 2-Mar-88 | Drawdown | 6.6 | 1,100 | 110 | Good |
| MW-204 | 23-Jan-86 | Drawdown | 1.9 | 100 | 15 | Fair |
| MW-205 | 14-Feb-86 | Slug | 0.0 | 5.90 | 1.9 | Good |
| MW-205 | 18-Feb-86 | Slug | 0.0 | 5 | 1.9 | Good |
| MW-206 | 14-Apr-86 | Slug | 0.0 | 120 | 11 | Good |
| MW-207 | 2-Mar-88 | Slug | 0.0 | 380 | 32 | Excel |
| MW-210 | 9-Jun-86 | Slug | 0.0 | 0.60 | 0.1 | Good |
| MW-211 | 22-Oct-86 | Drawdown | 2.9 | 37 | 12 | Fair |
| MW-211 | 8-Dec-86 | Longterrn | 1.0 | 44 | 15 | Fair |
| MW-212 | 12-May-86 | Drawdown | 0.8 | 18 | 3.1 | Poor |

**Appendix B. (Continued)**

| Well | Date | Type of test[b] | Flow rate (Q) (gpm) | Transmis-sivity (T) (gpd/ft) | Hydraulic conductivity (K)[c] (gpd/sq ft) | Data quality[d] |
|---|---|---|---|---|---|---|
| MW-213 | 22-Apr-86 | Drawdown | 3.8 | 190 | 38 | Good |
| MW-214 | 7-Oct-86 | Longterm | 27.6 | 2,300 | 350 | Good |
| MW-217 | 15-Jul-86 | Slug | 0.0 | 750 | 120 | Good |
| MW-218 | 17-Jun-86 | Drawdown | 11.7 | 6,400 | 1,100 | Good |
| MW-218 | 12-Nov-86 | Longterm | 7.7 | 4,000 | 670 | Good |
| MW-219 | 15-Jul-86 | Drawdown | 4.3 | 620 | 76 | Good |
| MW-219 | 23-Feb-87 | Longterrn | 5.2 | 66 | 8.0 | Fair |
| MW-220 | 21-Aug-86 | Slug | 0.0 | 28 | 5.5 | Excel |
| MW-221 | 5-Aug-86 | Drawdown | 2.1 | 120 | 16 | Fair |
| MW-222 | 12-Aug-86 | Drawdown | 16.0 | 1,700 | 160 | Excel |
| MW-222 | 8-Mar-85 | Longterm | 7.7 | 1,100 | 180 | Good |
| MW-223 | 27-Aug-86 | Drawdown | 4.0 | 510 | 110 | Good |
| MW-224 | 28-Oct-86 | Drawdown | 7.6 | 3,600 | 400 | Excel |
| MW-225 | 23-Oct-86 | Drawdown | 4.0 | 85 | 11 | Good |
| MW-225 | 12-Jan-87 | Longterm | 2.0 | 62 | 8.5 | Fair |
| MW-226 | 31-Mar-87 | Slug | 0.0 | 1,700 | 160 | Fair |
| MW-252 | 4-Nov-85 | Drawdown | 4.0 | 920 | 50 | Fair |
| MW-252 | 19-Nov-85 | Drawdown | 5.6 | 800 | 43 | Fair |
| MW-254 | 27-Jan-86 | Drawdown | 4.2 | 340 | 38 | Fair |
| MW-254 | 27-Feb-86 | Drawdown | 3.2 | 370 | 41 | Good |
| MW-255 | 21-Jan-86 | Drawdown | 5.0 | 2,800 | 250 | Fair |
| MW-255 | 21-Jan-86 | Drawdown | 6.0 | 2,000 | 180 | Fair |
| MW-255 | 6-Jan-87 | Longterm | 2.0 | 400 | 36 | Fair |
| MW-256 | 11-Apr-86 | Slug | 0.0 | 11 | 5.5 | Good |
| MW-257 | 15-Apr-86 | Slug | 0.0 | 120 | 24 | Good |
| MW-258 | 5-Jun-86 | Slug | 0.0 | 35 | 9.0 | Excel |
| MW-258 | 29-Oct-86 | Slug | 0.0 | 32 | 8.0 | Good |
| MW-259 | 26-Mar-88 | Slug | 0.0 | 15 | 5.0 | Good |
| MW-260 | 25-Mar-86 | Drawdown | 3.0 | 140 | 22 | Good |
| MW-260 | 1-Oct-86 | Longterrn | 1.4 | 120 | 18 | Good |
| MW-261 | 27-May-86 | Slug | 0.0 | 7 | 2.3 | Excel |
| MW-262 | 11-Apr-86 | Drawdown | 12.5 | 2,000 | 250 | Excel |
| MW-262 | 23-Sep-86 | Longterm | 22.0 | 2,750 | 340 | Good |
| MW-262 | 27-Apr-87 | Longterm | 23.1 | 6,800 | 810 | Good |
| MW-263 | 22-Apr-86 | Drawdown | 1.2 | 37 | 7.4 | Poor |

**Appendix B. (Continued)**

| Well | Date | Type of test[b] | Flow rate (Q) (gpm) | Transmis-sivity (T) (gpd/ft) | Hydraulic conductivity (K)[c] (gpd/sq ft) | Data quality[d] |
|---|---|---|---|---|---|---|
| MW-263 | 4-Nov-86 | Longterrn | 1.8 | 76 | 15 | Excel |
| MW-264 | 7-May-86 | Drawdown | 8.1 | 930 | 100 | Good |
| MW-264 | 29-Oct-86 | Longterrn | 23.0 | 480 | 50 | Good |
| MW-265 | 19-May-86 | Drawdown | 0.7 | 180 | 34 | Fair |
| MW-267 | 2-Jun-86 | Drawdown | 0.5 | 420 | 85 | Poor |
| MW-268 | 14-Nov-86 | Drawdown | 5.0 | 230 | 18 | Good |
| MW-269 | 14-Jul-86 | Drawdown | 5.0 | 570 | 95 | Good |
| MW-270 | 30-Dec-86 | Slug | 0.0 | 14 | 2.0 | Good |
| MW-271 | 4-Aug-86 | Drawdown | 5.5 | 340 | 76 | Fair |
| MW-272 | 19-Aug-86 | Drawdown | 0.8 | 150 | 30 | Fair |
| MW-273 | 27-Aug-86 | Drawdown | 3.2 | 600 | 90 | Good |
| MW-274 | 25-Mar-85 | Slug | 0.0 | 38 | 7.6 | Fair |
| MW-275 | 30-Oct-86 | Drawdown | 7.0 | 730 | 150 | Fair |
| MW-275 | 2-Mar-87 | Longterrn | 5.5 | 830 | 170 | Fair |
| MW-276 | 21-Nov-86 | Drawdown | 13.0 | 960 | 110 | Good |
| MW-276 | 4-May-87 | Longterm | 24.0 | 2,700 | 300 | Fair |
| MW-277 | 3-Nov-86 | Drawdown | 0.9 | 74 | 25 | Fair |
| MW-290 | 5-Jan-87 | Slug | 0.0 | 14 | 4.0 | Excel |
| MW-291 | 27-Jan-87 | Slug | 0.0 | 25 | 7.1 | Fair |
| MW-292 | 28-Aug-86 | Drawdown | 6.0 | 400 | 56 | Excel |
| MW-294 | 29-Dec-86 | Drawdown | 5.3 | 5,300 | 29 | Fair |
| MW-294 | 29-Dec-86 | Drawdown | 5.9 | 5,400 | 300 | Good |
| MW-301 | 30-Oct-86 | Drawdown | 6.0 | 460 | 100 | Good |
| MW-302 | 18-Nov-86 | Drawdown | 1.0 | 100 | 27 | Good |
| MW-302 | 18-Nov-86 | Drawdown | 2.0 | 76 | 21 | Fair |
| MW-303 | 12-Nov-86 | Drawdown | 11.1 | 210 | 70 | Good |
| MW-304 | 13-Mar-87 | Drawdown | 0.9 | 74 | 25 | Fair |
| MW-305 | 26-Nov-86 | Drawdown | 19.0 | 720 | 72 | Excel |
| MW-305 | 18-May-87 | Longterm | 20.1 | 640 | 64 | Excel |
| MW-306 | 31-Mar-87 | Drawdown | 9.5 | 270 | 68 | Good |
| MW-307 | 26-Mar-87 | Drawdown | 0.9 | 66 | 33 | Fair |
| MW-308 | 4-Dec-87 | Drawdown | 2.6 | 27 | 5.4 | Good |
| MW-310 | 17-Feb-87 | Drawdown | 6.7 | 58 | 850 | Good |
| MW-311 | 19-Mar-87 | Drawdown | 9.8 | 130 | 12 | Good |
| MW-311 | 17-Nov-87 | Longterm | 9.9 | 370 | 26 | Good |

**Appendix B. (Continued)**

| Well | Date | Type of test[b] | Flow rate (Q) (gpm) | Transmis-sivity (T) (gpd/ft) | Hydraulic conductivity (K)[c] (gpd/sq ft) | Data quality[d] |
|---|---|---|---|---|---|---|
| MW-312 | 27-Mar-87 | Drawdown | 20.5 | 1,800 | 300 | Poor |
| MW-312 | 3-Nov-87 | Longterm | 18.8 | 1,700 | 280 | Good |
| MW-313 | 25-Mar-87 | Drawdown | 7.9 | 3,000 | 600 | Good |
| MW-313 | 5-Oct-87 | Longterm | 9.6 | 3,400 | 680 | Good |
| MW-314 | 10-Apr-87 | Drawdown | 26.4 | 2,900 | 390 | Good |
| MW-314 | 13-Jul-87 | Longterm | 13.6 | 2,500 | 330 | Fair |
| MW-315 | 9-Apr-87 | Drawdown | 15.4 | 150 | 11 | Good |
| MW-315 | 5-Jan-85 | Longterm | 24.5 | 571 | 41 | Excel |
| MW-316 | 4-May-87 | Drawdown | 7.8 | 1,400 | 280 | Good |
| MW-317 | 12-May-87 | Drawdown | 12.1 | 300 | 43 | Fair |
| MW-317 | 15-Dec-87 | Longterm | 8.2 | 120 | 17.1 | Good |
| MW-318 | 7-Aug-87 | Slug | 0.0 | 120 | 16 | Good |
| MW-319 | 29-Jul-87 | Drawdown | 48.0 | 7,200 | 1,500 | Good |
| MW-320 | 15-May-87 | Drawdown | 1.8 | 58 | 17 | Fair |
| MW-320 | 15-May-87 | Drawdown | 3.0 | 22 | 3.7 | Fair |
| MW-320 | 26-Jun-87 | Drawdown | 2.1 | 49 | 14 | Fair |
| MW-321 | 28-Jul-87 | Drawdown | 40.0 | 6,600 | 450 | Good |
| MW-322 | 3-Aug-87 | Drawdown | 3.1 | 85 | 15 | Good |
| MW-323 | 11-Aug-87 | Drawdown | 3.4 | 205 | 59 | Good |
| MW-324 | 10-Sep-87 | Drawdown | 6.6 | 200 | 50 | Good |
| MW-325 | 10-Sep-87 | Drawdown | 6.0 | 160 | 13 | Excel |
| MW-351 | 12-Nov-86 | Drawdown | 5.7 | 27 | 14 | Poor |
| MW-352 | 30-Dec-86 | Drawdown | 20.0 | 280 | 14 | Good |
| MW-352 | 7-Jul-87 | Longterm | 19.5 | 120 | 6.0 | Excel |
| MW-353 | 20-Nov-86 | Drawdown | 2.1 | 60 | 17 | Good |
| MW-354 | 30-Dec-86 | Drawdown | 17.6 | 2,000 | 220 | Fair |
| MW-354 | 30-Dec-86 | Drawdown | 18.0 | 2,400 | 260 | Good |
| MW-354 | 20-Apr-87 | Longterm | 17.8 | 310 | 34 | Good |
| MW-355 | 29-Dec-86 | Drawdown | 2.1 | 19 | 5.0 | Fair |
| MW-356 | 17-Mar-87 | Drawdown | 5.7 | 180 | 59 | Good |
| MW-357 | 18-Feb-87 | Drawdown | 15.0 | 1,300 | 110 | Good |
| MW-357 | 21-Jul-87 | Longterm | 9.2 | 210 | 18 | Good |
| MW-358 | 18-Mar-87 | Drawdown | 9.2 | 210 | 32 | Excel |
| MW-359 | 9-Mar-87 | Longterm | 19.0 | 2,800 | 290 | Fair |
| MW-359 | 20-Mar-87 | Drawdown | 18.6 | 1,100 | 110 | Good |

**Appendix B. (Continued)**

| Well | Date | Type of test[b] | Flow rate (Q) (gpm) | Transmis-sivity (T) (gpd/ft) | Hydraulic conductivity (K)[c] (gpd/sq ft) | Data quality[d] |
|---|---|---|---|---|---|---|
| MW-360 | 22-May-87 | Drawdown | 30.0 | 4,800 | 210 | Excel |
| MW-361 | 16-Mar-87 | Drawdown | 4.3 | 67 | 11 | Good |
| MW-361 | 12-Jan-85 | Longterm | 5.3 | 178 | 30 | Good |
| MW-362 | 23-Mar-87 | Drawdown | 16.4 | 470 | 49 | Good |
| MW-362 | 21-Sep-87 | Longterm | 13.6 | 370 | 39 | Good |
| MW-363 | 24-Jul-87 | Slug | 0.0 | 20 | 3.0 | Excel |
| MW-364 | 8-Apr-87 | Drawdown | 8.6 | 51 | 10 | Fair |
| MW-364 | 1-Jun-87 | Longterm | 4.8 | 110 | 22 | Good |
| MW-365 | 14-May-87 | Drawdown | 10.0 | 36 | 15 | Fair |
| MW-366 | 11-May-87 | Drawdown | 19.0 | 780 | 92 | Fair |
| MW-368 | 11-May-87 | Drawdown | 2.9 | 81 | 8.5 | Fair |
| MW-369 | 25-Jun-87 | Drawdown | 7.0 | 580 | 96 | Good |
| MW-369 | 10-Nov-87 | Longterm | 5.5 | 89 | 18 | Good |
| MW-370 | 23-Jun-87 | Drawdown | 4.4 | 84 | 10 | Fair |
| MW-371 | 24-Jun-87 | Drawdown | 3.3 | 15 | 3.0 | Good |
| MW-372 | 23-Nov-87 | Slug | 0.0 | 310 | 62 | Excel |
| MW-373 | 28-Jul-87 | Drawdown | 4.0 | 660 | 77 | Fair |
| MW-373 | 28-Jul-87 | Drawdown | 6.5 | 50 | 6.0 | Poor |
| MW-376 | 26-Jan-88 | Drawdown | 2.9 | 65 | 8.5 | Fair |
| MW-380 | 23-Oct-87 | Drawdown | 4.0 | 33 | 4.7 | Excel |
| MW-401 | 23-Oct-87 | Drawdown | 42.0 | 950 | 24 | Excel |
| MW-402 | 22-Oct-87 | Drawdown | 41.0 | 13,500 | 1,400 | Good |
| MW-403 | 3-Dec-87 | Drawdown | 9.7 | 370 | 26 | Good |
| MW-404 | 4-Feb-85 | Drawdown | 45.0 | 3,200 | 530 | Good |
| MW-405 | 16-Feb-85 | Drawdown | 47.2 | 546 | 14 | Good |
| MW-406 | 28-Jan-85 | Drawdown | 7.4 | 7,500 | 940 | Fair |
| MW-407 | 23-Feb-85 | Drawdown | 14.4 | 75 | 7.5 | Fair |
| MW-408 | 5-Apr-85 | Drawdown | 45.0 | 43,000 | 3,100 | Good |
| MW-409 | 22-Mar-85 | Drawdown | 20.0 | 230 | 38 | Good |
| MW-410 | 28-Apr-85 | Drawdown | 35.0 | 6,800 | 570 | Fair |
| MW-411 | 5-May-85 | Drawdown | 14.0 | 50 | 83 | Good |
| MW-412 | 6-May-88 | Drawdown | 4.1 | 700 | 64 | Fair |
| MW-414 | 27-Jul-85 | Slug | 0.0 | 150 | 38 | Good |
| MW-416 | 11-Jul-85 | Drawdown | 50.0 | 2,600 | 330 | Good |
| MW-417 | 27Jun-88 | Drawdown | 5.3 | 340 | 57 | Fair |

**Appendix B. (Continued)**

| Well | Date | Type of test[b] | Flow rate (Q) (gpm) | Transmis-sivity (T) (gpd/ft) | Hydraulic conductivity (K)[c] (gpd/sq ft) | Data quality[d] |
|---|---|---|---|---|---|---|
| P-420 | 16-Aug-85 | Drawdown | 3.5 | 710 | 100 | Excel |
| MW-421 | 12-Sep-85 | Drawdown | 4.8 | 320 | 27 | Excel |
| MW-422 | 19-Sep-85 | Drawdown | 8.6 | 230 | 42 | Good |
| MW-423 | 12-Oct-85 | Drawdown | 22.0 | 1,500 | 130 | Good |
| MW-424 | 17-Oct-85 | Drawdown | 4.5 | 130 | 19 | Good |
| MW-441 | 30-Oct-87 | Drawdown | 6.0 | 500 | 56 | Good |
| MW-441 | 13-Apr-88 | Drawdown | 13.0 | 2,200 | 240 | Poor |
| MW-441 | 19-Apr-88 | Longterm | 14.0 | 470 | 52 | Good |
| MW-447 | 26-Feb-88 | Drawdown | 7.1 | 124 | 850 | Poor |
| MW-448 | 24-Mar-85 | Drawdown | 24.5 | 4,200 | 600 | Good |
| MW-449 | 21-Mar-85 | Drawdown | 6.2 | 170 | 11 | Good |
| MW-450 | 14-Apr-88 | Drawdown | 3.3 | 38 | 650 | Fair |
| MW-451 | 27-Apr-88 | Drawdown | 2.1 | 80 | 16 | Good |
| MW-452 | 2-May-88 | Drawdown | 5.2 | 310 | 21 | Excel |
| MW-453 | 3-May-88 | Drawdown | 5.8 | 67 | 7.4 | Fair |
| MW-455 | 22-Jun-88 | Drawdown | 5.8 | 160 | 13 | Good |
| MW-456 | 14-Jul-85 | Drawdown | 4.5 | 260 | 33 | Fair |
| MW-457 | 29-Jul-85 | Drawdown | 20.5 | 450 | 24 | Excel |
| MW-458 | 2-Aug-85 | Drawdown | 0.8 | 24 | 150 | Fair |
| MW-460 | 1-Sep-85 | Drawdown | 17.0 | 1,900 | 380 | Fair |
| MW-461 | 7-Sep-85 | Slug | 0.0 | 690 | 140 | Good |
| MW-462 | 27-Sep-85 | Drawdown | 19.0 | 360 | 60 | Good |
| MW-463 | 11-Oct-85 | Drawdown | 24.0 | 1,600 | 200 | Good |
| MW-464 | 8-Nov-88 | Drawdown | 9.0 | 370 | 53 | Good |
| MW-481 | 2-Dec-87 | Drawdown | 1.1 | 8 | 1.7 | Good |
| MW-486 | 23-Mar-85 | Drawdown | 6.0 | 230 | 30 | Good |
| MW-487 | 14-Apr-88 | Drawdown | 2.2 | 45 | 15 | Good |
| MW-501 | 21-Oct-85 | Drawdown | 9.7 | 170 | 21 | Good |
| MW-502 | 14-Nov-85 | Slug | 0.0 | 12 | 30 | Good |
| MW-503 | 11-Nov-88 | Drawdown | 1.3 | 15 | 3.0 | Fair |
| P-504 | 8-Dec-85 | Drawdown | 10.0 | 590 | 84 | Good |
| P-505 | 21-Mar-89 | Drawdown | 34.2 | 653 | 76 | Good |
| P-506 | 10-Feb-89 | Drawdown | 31.0 | 7,423 | 460 | Good |
| MW-507 | 6-Feb-89 | Drawdown | 39.0 | 2,900 | 290 | Good |
| MW-508 | 29-Mar-89 | Drawdown | 30.0 | 47,000 | 2,600 | Good |

**Appendix B. (Continued)**

| Well | Date | Type of test[b] | Flow rate (Q) (gpm) | Transmis-sivity (T) (gpd/ft) | Hydraulic conductivity (K)[c] (gpd/sq ft) | Data quality[d] |
|---|---|---|---|---|---|---|
| MW-509 | 11-May-89 | Drawdown | 0.9 | 10 | 2.0 | Fair |
| MW-510 | 11-May-89 | Slug | 0.0 | 220 | 110 | Good |
| MW-511 | 11-May-89 | Drawdown | 1.7 | 63 | 11 | Fair |
| MW-512 | 27-Apr-89 | Drawdown | 2.9 | 85 | 9.4 | Good |
| MW-513 | 9-May-89 | Drawdown | 0.6 | 33 | 3.0 | Fair |
| MW-514 | 26-May-89 | Drawdown | 1.4 | 84 | 530 | Fair |
| MW-515 | 6-Jun-89 | Drawdown | 2.8 | 37 | 4.2 | Fair |
| MW-516 | 19-Jun-89 | Drawdown | 19.5 | 1,428 | 286 | Good |
| MW-517 | 27-Jun-89 | Drawdown | 7.3 | 370 | 53 | Good |
| MW-518 | 10-Aug-89 | Drawdown | 6.2 | 1,421 | 178 | Good |
| MW-519 | 31-Aug-89 | Drawdown | 31.5 | 5,700 | 475 | Excel |
| MW-520 | 24-Jan-90 | Drawdown | 22.8 | 3,300 | 560 | Excel |
| MW-521 | 1-Feb-90 | Drawdown | 0.6 | 44 | 4.9 | Fair |
| P-522 | 5-Feb-90 | Drawdown | 20.0 | 3,700 | 620 | Fair |
| MW-551 | 8-Nov-85 | Drawdown | 37.0 | 350 | 88 | Good |
| MW-552 | 12-Dec-88 | Drawdown | 38.0 | 4,700 | 390 | Good |
| MW-553 | 17-Nov-85 | Drawdown | 2.2 | 55 | 7.9 | Fair |
| P-554 | 10-Jan-89 | Drawdown | 21.5 | 1,800 | 150 | Good |
| P-555 | 28-Dec-88 | Drawdown | 14.0 | 460 | 23 | Fair |
| MW-556 | 25-Jan-89 | Drawdown | 17.0 | 850 | 170 | Fair |
| P-557 | 23-Jan-89 | Drawdown | 1.2 | 570 | 36 | Poor |
| P-558 | 23-Mar-89 | Drawdown | 24.7 | 5,200 | 650 | Good |
| MW-560 | 8-Mar-89 | Drawdown | 1.7 | 30 | 7.6 | Fair |
| MW-561 | 13-Mar-89 | Drawdown | 1.1 | 12 | 2.1 | Fair |
| MW-562 | 28-Mar-89 | Drawdown | 1.0 | 16 | 2.3 | Fair |
| MW-563 | 31-Mar-89 | Drawdown | 1.1 | 14 | 2.3 | Fair |
| MW-564 | 26-Apr-89 | Drawdown | 1.6 | 44 | 5.0 | Poor |
| MW-565 | 18-Apr-89 | Drawdown | 15.6 | 1,600 | 260 | Good |
| MW-566 | 2-May-89 | Drawdown | 17.0 | 780 | 86 | Good |
| MW-566 | 31-Aug-93 | Longterm | 22.5 | 2580 | 520 | Fair |
| MW-567 | 4-May-89 | Drawdown | 10.4 | 2,600 | 320 | Excel |
| MW-568 | 20-Jun-89 | Drawdown | 18.3 | 620 | 160 | Fair |
| MW-569 | 24-May-89 | Drawdown | 2.8 | 100 | 15 | Fair |
| MW-570 | 8-Jun-89 | Drawdown | 1.1 | 7 | 1.1 | Fair |
| MW-571 | 17-Jul-89 | Drawdown | 17.7 | 1,000 | 200 | Excel |

**Appendix B. (Continued)**

| Well | Date | Type of test[b] | Flow rate (Q) (gpm) | Transmis-sivity (T) (gpd/ft) | Hydraulic conductivity (K)[c] (gpd/sq ft) | Data quality[d] |
|---|---|---|---|---|---|---|
| P-592 | 23-Jan-89 | Drawdown | 2.2 | 2,200 | 280 | Poor |
| MW-593 | 22-Feb-89 | Drawdown | 2.2 | 57 | 11.4 | Good |
| MW-594 | 16-Mar-89 | Slug | 0.0 | 380 | 54 | Excel |
| P-601 | 8-Feb-90 | Drawdown | 22.5 | 6,900 | 770 | Excel |
| MW-602 | 29-Jan-90 | Drawdown | 24.0 | 5,300 | 620 | Good |
| P-603 | 7-Feb-90 | Drawdown | 6.1 | 100 | 20 | Fair |
| P-604 | 20-Feb-90 | Slug | 0.0 | 380 | 63 | Good |
| P-605 | 28-Feb-90 | Drawdown | 4.8 | 50 | 12 | Good |
| P-606 | 21-Feb-90 | Slug | 0.0 | 120 | 20 | Fair |
| P-607 | 22-Feb-90 | Drawdown | 1.4 | 800 | 100 | Good |
| MW-608 | 28-Feb-90 | Drawdown | 1.2 | 230 | 30 | Fair |
| MW-609 | 9-Mar-90 | Drawdown | 6.7 | 470 | 70 | Good |
| MW-610 | 28-Mar-90 | Drawdown | 5.8 | 5,500 | 380 | Good |
| MW-611 | 16-Apr-90 | Drawdown | 3.5 | 1,000 | 110 | Fair |
| MW-612 | 24-May-90 | Drawdown | 13.5 | 550 | 55 | Good |
| MW-612 | 05-Apr-94 | Longterm | 14.0 | 230 | 40.0 | Good |
| MW-613 | 23-May-90 | Drawdown | 4.8 | 2,550 | 360 | Good |
| MW-614 | 7-Jun-90 | Drawdown | 6.7 | 1,650 | 130 | Good |
| MW-615 | 21-Jun-90 | Drawdown | 1.3 | 130 | 19 | Fair |
| MW-616 | 27-Jun-90 | Drawdown | 2.0 | 390 | 40 | Fair |
| MW-617 | 12-Jul-90 | Drawdown | 2.8 | 53 | 6.8 | Good |
| MW-618 | 1-Aug-90 | Drawdown | 1.9 | 24 | 4.8 | Fair |
| P-619 | 30-Aug-90 | Drawdown | 11.8 | 190 | 11 | Good |
| P-620 | 1-Oct-90 | Drawdown | 5.8 | 6,500 | 650 | Good |
| P-621 | 4-Oct-90 | Drawdown | 3.8 | 310 | 39 | Good |
| MW-622 | 12-Oct-90 | Slug | 0.0 | 130 | 16 | Fair |
| P-651 | 16-Mar-90 | Slug | 0.0 | 530 | 180 | Fair |
| MW-652 | 22-Mar-90 | Drawdown | 1.0 | 11 | 3.8 | Good |
| MW-653 | 11-Apr-90 | Drawdown | 0.3 | 2 | 1.9 | Fair |
| MW-654 | 25-Apr-90 | Drawdown | 21.7 | 390 | 25 | Fair |
| MW-655 | 12-May-90 | Drawdown | 12.2 | 1,000 | 220 | Good |
| P-701 | 23-Oct-90 | Drawdown | 14.5 | 6,800 | 650 | Good |
| P-701 | 3-Oct-92 | Step | 16.5 | 5,200 | 430 | Good |
| P-701 | 1-Apr-93 | Drawdown | 24 | 3,700 | 370 | Good |
| P-702 | 29-Nov-90 | Drawdown | 2.5 | 150 | 30 | Good |

**Appendix B. (Continued)**

| Well | Date | Type of test[b] | Flow rate (Q) (gpm) | Transmis-sivity (T) (gpd/ft) | Hydraulic conductivity (K)[c] (gpd/sq ft) | Data quality[d] |
|---|---|---|---|---|---|---|
| P-702 | 25-Feb-93 | Step | 4.6 | 36 | 7 | Poor |
| P-703 | 19-Dec-90 | Drawdown | 7.0 | 230 | 9.1 | Good |
| EW-704 | 4-Mar-91 | Drawdown | 19.0 | 1,800 | 140 | Fair |
| P-705 | 20-Feb-91 | Drawdown | 0.8 | 40 | 6.1 | Fair |
| P-706 | 29-Jan-91 | Drawdown | 0.2 | 8 | 1 | Fair |
| EW-712 | 25-Feb-92 | Drawdown | 7.8 | 750 | 48 | Good |
| EW-712 | 18-Mar-93 | Longterm | 15.1 | 1440 | 93 | Good |
| P-714 | 6-Dec-91 | Drawdown | 2.9 | 140 | 6.7 | Good |
| P-902 | 25-Mar-93 | Drawdown | 0.6 | 6 | 2 | Fair |
| TW-11 | 24-Jan-85 | Drawdown | 0.3 | 200 | 20 | Good |
| TW-11A | 24-Jan-85 | Drawdown | 10.0 | 3,100 | 110 | Fair |
| GSW-01 | 11-Dec-85 | Slug | 0.0 | 72 | 0.2 | Fair |
| GSW-01A | 14-Jul-86 | Drawdown | 13.4 | 12,000 | 790 | Good |
| GSW-02 | 17-Dec-85 | Slug | 0.0 | 240 | 10 | Good |
| GSW-03 | 23-Dec-85 | Slug | 0.0 | 510 | 41 | Good |
| GSW-04 | 19-Dec-85 | Slug | 0.0 | 17 | 0.9 | Good |
| GSW-05 | 12-Feb-86 | Slug | 0.0 | 99 | 9 | Excel |
| GSW-06 | 23-Iun-86 | Drawdown | 25.0 | 4,800 | 310 | Good |
| GSW-06 | 16-Jun-87 | Longterm | 20.0 | 5,500 | 350 | Good |
| GSW-07 | 3-Apr-86 | Drawdown | 4.3 | 230 | 23 | Excel |
| GSW-08 | 19-Nov-86 | Drawdown | 2.0 | 230 | 38 | Good |
| GSW-09 | 28-May-86 | Drawdown | 1.9 | 500 | 63 | Poor |
| GSW-10 | 22-May-86 | Drawdown | 14.3 | 21,000 | 2,000 | Good |
| GSW-11 | 2-Jun-86 | Drawdown | 4.7 | 390 | 45 | Excel |
| GSW-12 | 7-Jun-86 | Drawdown | 0.8 | 51 | 11 | Fair |
| GSW-13 | 4-Aug-86 | Slug | 0.0 | 110 | 13 | Excel |
| GSW-13 | 8-Aug-86 | Slug | 0.0 | 62 | 7 | Good |
| GSW-15 | 23-Feb-88 | Drawdown | 25.8 | 1,500 | 190 | Good |
| GSW-208 | 8-May-86 | Drawdown | 1.9 | 440 | 80 | Good |
| GSW-209 | 8-May-86 | Drawdown | 6.1 | 1,200 | 120 | Good |
| GSW-215 | 4-Jun-86 | Drawdown | 1.9 | 220 | 40 | Poor |
| GSW-216 | 16-Jan-92 | Drawdown | 10.5 | 3,500 | 440 | Fair |
| GSW-266 | 20-Jun-86 | Drawdown | 2.1 | 470 | 72 | Good |
| GSW-266 | 18-Nov-86 | Drawdown | 3.0 | 450 | 64 | Good |
| GSW-266 | 18-Nov-86 | Drawdown | 4.7 | 410 | 59 | Good |

**Appendix B. (Continued)**

| Well | Date | Type of test[b] | Flow rate (Q) (gpm) | Transmis-sivity (T) (gpd/ft) | Hydraulic conductivity (K)[c] (gpd/sq ft) | Data quality[d] |
|---|---|---|---|---|---|---|
| GSW-367 | 11-May-87 | Drawdown | 6.9 | 200 | 29 | Fair |
| GSW-403-6 | 8-Dec-85 | Slug | 0.0 | 4 | 0.2 | Good |
| GSW-442 | 23-Nov-87 | Drawdown | 1.2 | 32 | 4.6 | Good |
| P-702 | 25-Feb-93 | Step | 1-4.6 | 36 | 7 | Poor |
| GSW-443 | 30-Nov-87 | Drawdown | 10.3 | 260 | 8.7 | Good |
| GSW-444 | 28-Jan-88 | Slug | 0.0 | 9 | 0.86 | Good |
| GSW-445 | 26-Jan-85 | Drawdown | 4.7 | 43 | 4.30 | Fair |
| GEW-710 | 23-Sept-91 | Step | 36.0 | 4,800 | 220 | Excel |
| GEW-816 | 15-Aug-92 | Drawdown | 39.0 | 12,000 | 1,100 | Good |
| EW-415 | 31-Aug-85 | Drawdown | 10.0 | 3,100 | 78 | Fair |
| EW-704 | 3-May-91 | Drawdown | 19.0 | 1,800 | 140 | Fair |
| EW-712 | 25-Feb-92 | Drawdown | 7.8 | 790 | 50 | Good |
| 11H4 | 15-Jan-85 | Drawdown | 24.6 | 2,000 | 77 | Good |
| 11H4 | 19-Jan-85 | Longterm | 29.5 | 1,780 | 18 | Good |
| 11J4 | 10-Jun-88 | Drawdown | 17.0 | 1,000 | 15 | Excel |
| 11J4 | 14-Jun-85 | Longterm | 16.0 | 1,100 | 16 | Good |
| 13D1 | 9-Feb-85 | Longterm | 50.0 | 4,800 | 48 | Excel |

[a] The pumping test results were obtained by using the analytic techniques of Theis (1935), Cooper and Jacob (1946), Papadopulos and Cooper (1967), Hantush and Jacob (1955), Hantush (1960), or Boulton (1963). The particular method used is dependent on the character of the data obtained. The slug test results were obtained using the method of Cooper *et al.* (1967). (See references below.)

[b] "DRAWDOWN" denotes 1-h pumping tests; "LONGTERM" denotes 24- to 48-h pumping tests; "STEP" denotes a step drawdown test, flow rate given is the maximum or final step.

[c] K is calculated by dividing T by the thickness of permeable sediments intercepted by the sand pack of the well. This thickness is the sum of all sediments with moderate to high estimated conductivities determined from the geologic and geophysical logs of the well.

[d] Hydraulic test quality criteria:

Excel: High confidence that type curve match is unique. Data are smooth and flow rate well controlled.

Good: Some confidence that curve match is unique. Data are not too "noisy." Well bore storage effects, if present, do not significantly interfere with the curve match. Boundary effects can be separated from properties of the pumped zone.

Fair: Low confidence that curve match is unique. Data are "noisy." Multiple leakiness and other boundary effects tend to obscure the curve match.

Poor: Unique curve match cannot be obtained due to multiple boundaries, well bore storage, uneven flow rate, or equipment problems. Usually, the test is repeated.

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# Appendix C

# 1996 Ground Water Sampling Schedule

**Appendix C. 1996 ground water sampling schedule.**

| Well number | Final sampling frequency (1-96) | Next quarter sample date | Regulatory compliance requested analyses | VOCs | RAD |
|---|---|---|---|---|---|
| W-001 | A | 4-96 | Cr6-96A | 601 | |
| W-001A | S | 2-96 | | 601 | |
| W-002 | A | 3-96 | Cr6-96A | 601 | |
| W-002A | A | 1-96 | Cr6-95A | 601 | |
| W-004 | S | 1-96 | Cr6-96A | 601 | |
| W-005 | S | 1-96 | | 601 | |
| W-005A | A | 1-96 | | 601 | |
| W-007 | A | 3-96 | Cr6-96A | 601 | |
| W-008 | Q[a] | 1-96 | WGMG | | |
| W-010A | A | 3-96 | | 601 | |
| W-011 | S | 1-96 | | 601 | |
| W-012 | S | 2-96 | | 624 | |
| W-017 | A | 4-96 | | 601 | |
| W-017A | A | 3-96 | | 601 | |
| W-019 | A | 4-96 | | 601 | |
| W-101 | A | 2-96 | Cr6-96A | 601 | |
| W-102 | Q | 1-96 | | 601 | |
| W-103 | A | 3-96 | | 601 | |
| W-104 | Q[b] | 1-96 | | 601 | |
| W-105 | S | 2-96 | Cr6-96A | 601 | |
| W-106 | A | 3-96 | | 601 | |
| W-107 | A | 4-96 | | 601 | |
| W-108 | A | 2-96 | | 601 | |
| W-110 | Q[b] | 1-96 | Cr6-96A | 601 | |
| W-111 | Q | 1-96 | | 601 | |
| W-112 | Q | 1-96 | NPDESMET Q | 601 | |
| W-113 | A | 4-96 | | 601 | |
| W-114 | A | 1-96 | Cr6-96A | 601 | |
| W-115 | A | 3-96 | Cr6-96A | 601 | |
| W-116 | Q | 1-96 | | 601 | |
| W-117 | A | 4-96 | | 601 | |
| W-118 | Q | 1-96 | | 601 | |
| W-119 | Q | 1-96 | | 601 | |
| W-120 | Q | 1-96 | Cr6-96A | 601 | |
| W-121 | Q[a] | 1-96 | WGMG | 601 | |
| W-122 | A | 1-96 | | 601 | |
| W-123 | A | 1-96 | | 601 | |
| W-141 | A | 2-96 | Cr6-96A | 601 | |

**Appendix C. (Continued)**

| Well number | Final sampling frequency (1-96) | Next quarter sample date | Regulatory compliance requested analyses | VOCs | RAD |
|---|---|---|---|---|---|
| W-142 | Q | 1-96 | | 601 | Trit-96 |
| W-143 | Q | 1-96 | Cr6-96A | 601 | |
| W-146 | S | 2-96 | | 601 | |
| W-147 | A | 4-96 | | 601 | Trit-96 |
| W-148 | A | 4-96 | | 601 | Trit-96 |
| W-149 | Q | 1-96 | Cr6-96A | 601 | |
| W-151 | S[a] | 1-96 | WGMG | 601 | |
| W-201 | Q | 1-96 | | 601 | |
| W-202 | A | 4-96 | | 601 | |
| W-203 | A | 2-96 | | 601 | |
| W-204 | Q | 1-96 | | 601 | Trit |
| W-205 | Q | 1-96 | Cr6-96A | 601 | |
| W-206 | Q[c] | 1-96 | | 601 | Trit |
| W-207 | Q | 1-96 | | 601 | |
| W-210 | Q | 1-96 | | 601 | Trit-96 |
| W-211 | Q | 1-96 | | 601 | |
| W-212 | A | 4-96 | | 601 | |
| W-213 | A | 3-96 | | 601 | |
| W-214 | Q | 1-96 | | 601 | |
| W-217 | A | 4-96 | | 601 | |
| W-219 | S | 2-96 | | 601 | |
| W-220 | S | 1-96 | Cr6-96A | 601 | |
| W-221 | S[a] | 1-96 | WGMG | 601 | |
| W-222 | Q | 1-96 | | 601 | |
| W-223 | A | 1-96 | NPDESMET & Cr6 (x1) | 601 | |
| W-224 | Q | 1-96 | | 601 | |
| W-225 | Q | 1-96 | | 601 | |
| W-226 | A | 4-96 | Cr6-96A | 601 | |
| W-218 | Q | 1-96 | Cr6-92A (dry) | 601 | |
| W-251 | Q[b] | 1-96 | Cr6-96A | 601 | |
| W-252 | S | 1-96 | | 601 | |
| W-253 | A | 4-96 | | 601 | |
| W-254 | Q | 1-96 | | 601 | |
| W-255 | Q | 1-96 | | 601 | |
| W-256 | A | 1-96 | Cr6-96A | 601 | |
| W-257 | Q | 1-96 | Cr6-96A | 601 | Trit-96 |
| W-258 | Q[c] | 1-96 | | 601 | Trit |
| W-259 | Q | 1-96 | | 601 | Trit-96 |
| W-260 | Q | 1-96 | | 601 | |

**Appendix C. (Continued)**

| Well number | Final sampling frequency (1-96) | Next quarter sample date | Regulatory compliance requested analyses | VOCs | RAD |
|---|---|---|---|---|---|
| W-261 | A | 3-96 | | 601 | Trit-96 |
| W-263 | Q[b] | 1-96 | | 601 | |
| W-264 | S | 2-96 | Cr6-96A | 601 | |
| W-265 | A | 2-96 | | 601 | |
| W-267 | S | 1-96 | Cr6-96A | 601 | |
| W-268 | A | 4-96 | | 601 | |
| W-269 | Q | 1-96 | | 601 | |
| W-270 | A | 4-96 | | 601 | |
| W-271 | Q | 1-96 | | 601 | |
| W-272 | A | 3-96 | | 624 | |
| W-273 | A | 3-96 | | 601 | |
| W-274 | Q | 1-96 | | 601 | |
| W-275 | Q | 1-96 | Cr6-96A | 601 | |
| W-276 | A | 4-96 | | 624 | |
| W-277 | A | 1-96 | Cr6-96A | 601 | |
| W-290 | A | 4-96 | | 601 | |
| W-291 | A | 4-96 | | 601 | |
| W-292 | S | 2-96 | | 601 | |
| W-293 | A | 1-96 | | 601 | |
| W-294 | A | 1-96 | | 601 | |
| W-301 | A | 2-96 | | 601 | |
| W-302 | A | 3-96 | Cr6-96A | 601 | |
| W-303 | A | 1-96 | | 601 | |
| W-304 | S | 2-96 | | 601 | |
| W-305 | A | 4-96 | | 601 | |
| W-306 | A | 4-96 | | 601 | |
| W-307 | Q | 1-96 | | 601 | |
| W-308 | S | 2-96 | Cr6-96A | 601 | |
| W-310 | A | 3-96 | | 601 | |
| W-311 | S | 1-96 | | 601 | |
| W-312 | A | 4-96 | | 601 | |
| W-313 | Q | 1-96 | | 601 | |
| W-314 | Q | 1-96 | | 601 | |
| W-315 | Q[b] | 1-96 | Cr6-96A | 601 | |
| W-316 | Q | 1-96 | | 601 | |
| W-317 | Q | 1-96 | | 601 | |
| W-318 | A | 2-96 | Cr6-96A | 601 | |
| W-319 | A | 4-96 | Cr6-96A | 601 | |
| W-320 | Q | 1-96 | Cr6-96A | 601 | |

**Appendix C. (Continued)**

| Well number | Final sampling frequency (1-96) | Next quarter sample date | Regulatory compliance requested analyses | VOCs | RAD |
|---|---|---|---|---|---|
| W-321 | A | 3-96 | | 601 | |
| W-322 | Q[b] | 1-96 | | 601 | |
| W-323 | Q[b] | 1-96 | Cr6-96A | 601 | |
| W-324 | A | 2-96 | | 601 | |
| W-325 | A | 4-96 | | 601 | |
| W-352 | Q | 1-96 | | 601 | |
| W-353 | S | 1-96 | Cr6-96A | 601 | |
| W-354 | S | 1-96 | | 601 | |
| W-355 | Q | 1-96 | | 601 | |
| W-356 | Q | 1-96 | | 601 | Trit-96 |
| W-359 | Q | 1-96 | | 601 | |
| W-360 | S | 1-96 | NPDESMET × 1 | 601 | |
| W-361 | Q | 1-96 | | 601 | |
| W-362 | A | 2-96 | | 601 | |
| W-363 | Q[c] | 1-96 | | 601 | Trit |
| W-364 | Q | 1-96 | | 601 | |
| W-365 | Q | 1-96 | | 601 | |
| W-366 | A | 1-96 | | 601 | |
| W-368 | A | 1-96 | | 601 | |
| W-369 | Q | 1-96 | | 601 | |
| W-370 | A | 2-96 | | 601 | |
| W-371 | A | 3-96 | Cr6-96A | 601 | |
| W-372 | A | 2-96 | Cr6-96A | 601 | |
| W-373 | S[a] | 1-96 | WGMG | 601 | |
| W-375 | Q | 1-96 | Cr6-96A | 601 | |
| W-376 | A | 2-96 | Cr6-96A | 601 | |
| W-377 | S | 2-96 | | 601 | |
| W-378 | Q | 1-96 | Cr6-96A | 601 | |
| W-379 | S | 2-96 | | 601 | |
| W-380 | A | 4-96 | | 601 | |
| W-401 | A | 4-96 | | 601 | |
| W-402 | A | 4-96 | | 601 | |
| W-403 | A | 3-96 | | 601 | |
| W-404 | Q | 1-96 | Cr6-96A | 601 | |
| W-405 | Q[b] | 1-96 | | 601 | |
| W-406 | A | 1-96 | | 601 | |
| W-407 | Q[b] | 1-96 | | 601 | |
| W-409 | A | 1-96 | Cr6-96A | 601 | |
| W-410 | Q[b] | 1-96 | | 601 | |

**Appendix C. (Continued)**

| Well number | Final sampling frequency (1-96) | Next quarter sample date | Regulatory compliance requested analyses | VOCs | RAD |
|---|---|---|---|---|---|
| W-411 | S | 1-96 | | 601 | |
| W-412 | A | 2-96 | | 601 | |
| W-413 | A | 1-96 | Cr6-96A | 601 | |
| W-414 | A | 3-96 | | 601 | Trit-96 |
| W-416 | A | 2-96 | Cr6-96A | 601 | |
| W-417 | A | 2-96 | Cr6-96A | 601 | |
| W-418 | S | 2-96 | Cr6-96A | 601 | |
| W-419 | Q | 1-96 | Cr6-96A | 601 | |
| W-420 | S | 2-96 | | 601 | |
| W-421 | Q[b] | 1-96 | Cr6-96A | 601 | |
| W-422 | A | 1-96 | Cr6-96A | 601 | |
| W-423 | Q | 1-96 | | 601 | |
| W-424 | S | 1-96 | | 601 | |
| W-441 | A | Collapsed | None | | |
| W-446 | A | 1-96 | | 601 | |
| W-447 | A | Transduc. | | 601 | |
| W-448 | Q | 1-96 | Cr6-96A | 601 | |
| W-449 | Q | 1-96 | Cr6-96A | 601 | |
| W-450 | A | 1-96 | | 601 | |
| W-451 | A | 1-96 | | 601 | |
| W-452 | A | 4-96 | | 601 | |
| W-453 | A | 2-96 | Cr6-96A | 601 | |
| W-454 | Q | 1-96 | Cr6-96A | 601 | |
| W-455 | A | 1-96 | Cr6-96A | 601 | |
| W-456 | S | 2-96 | Cr6-96A | 601 | |
| W-458 | S | 2-96 | Cr6-96A | 601 | |
| W-459 | S | 2-96 | Cr6-96A | 601 | |
| W-460 | Q | 1-96 | Cr6-96A | 601 | |
| W-461 | A | Dry | | 601 | |
| W-462 | A | 3-96 | | 601 | |
| W-463 | A | 3-96 | | 601 | |
| W-464 | Q | 1-96 | | 601 | |
| W-481 | Q[b] | 1-96 | Cr6-96A | 601 | |
| W-482 | Q | 1-96 | Cr6-96A | 601 | |
| W-483 | Q | 1-96 | Cr6-96A | 601 | |
| W-484 | A | 3-96 | | 601 | |
| W-485 | A | 2-96 | | 601 | |
| W-486 | S | 1-96 | Cr6-96A | 601 | |
| W-487 | A | 1-96 | Cr6-96A | 601 | |

**Appendix C. (Continued)**

| Well number | Final sampling frequency (1-96) | Next quarter sample date | Regulatory compliance requested analyses | VOCs | RAD |
|---|---|---|---|---|---|
| W-501 | S | 1-96 | Cr6-96A | 601 | |
| W-502 | A | 4-96 | Cr6-96A | 601 | |
| W-503 | A | 2-96 | Cr6-96A | 601 | |
| W-504 | A | 3-96 | | 601 | |
| W-505 | S | 2-96 | Cr6-96A | 601 | |
| W-506 | Q | 1-96 | | 601 | |
| W-507 | A | 3-96 | Cr6-96A | 601 | |
| W-508 | A | Sanded | None | | |
| W-509 | S | 2-96 | | 601 | |
| W-510 | A | 3-96 | Cr6-96A | 624 | |
| W-511 | S | 1-96 | | 601 | |
| W-512 | S | 2-96 | | 601 | |
| W-513 | A | 2-96 | | 601 | |
| W-514 | A | 2-96 | | 601 | |
| W-515 | S | 2-96 | Cr6-96A | 601 | |
| W-516 | A | 4-96 | Cr6-96A | 601 | |
| W-517 | Q[b] | 1-96 | Cr6-96A | 601 | |
| W-519 | A | 3-96 | | 601 | |
| W-521 | Q | 1-96 | | 601 | |
| W-551 | Q | 1-96 | | 601 | |
| W-552 | A | 4-96 | | 601 | |
| W-553 | A | 4-96 | Cr6-96A | 601 | |
| W-554 | S | 2-96 | Cr6-96A | 601 | |
| W-555 | S | 2-96 | | 601 | |
| W-556 | S[a] | 1-96 | WGMG | 601 | |
| W-557 | A | 3-96 | | 601 | |
| W-558 | Q[b] | 1-96 | | 601 | |
| W-559 | A | 3-96 | | 601 | |
| W-560 | Q | 1-96 | | 601 | |
| W-561 | A | 2-96 | | 601 | |
| W-562 | Q[c] | 1-96 | | 601 | Trit |
| W-563 | A | 2-96 | Cr6-96A | 601 | |
| W-564 | Q | 1-96 | Cr6-96A | 601 | |
| W-565 | A | 2-96 | Cr6-96A | 601 | |
| W-566 | Q | 1-96 | | 601 | Trit |
| W-567 | S | 1-96 | | 601 | |
| W-568 | S | 1-96 | Cr6-96A | 601 | |
| W-569 | S | 1-96 | | 601 | |
| W-570 | A | 3-96 | | 601 | |

**Appendix C. (Continued)**

| Well number | Final sampling frequency (1-96) | Next quarter sample date | Regulatory compliance requested analyses | VOCs | RAD |
|---|---|---|---|---|---|
| W-571 | S[a] | 1-96 | WGMG | 601 | |
| W-591 | A | 3-96 | | 601 | |
| W-592 | A | 3-96 | | 601 | |
| W-593 | A | 1-96 | | 601 | |
| W-594 | A | 1-96 | | 601 | |
| W-604 | Q | 1-96 | | 601 | |
| W-605 | Q | 1-96 | Cr6-96A | 601 | |
| W-606 | Q | 1-96 | Cr6-96A | 601 | |
| W-607 | Q | 1-96 | Cr6-96A | 601-96A | Trit-Q |
| W-608 | A | 1-96 | Cr6-96A | 601 | |
| W-611 | Q | 1-96 | Cr6-96A | 601 | |
| W-612 | Q | 1-96 | | 601 | |
| W-613 | S | 1-96 | | 601 | |
| W-615 | S | 2-96 | Cr6-96A | 601 | |
| W-616 | A | 1-96 | | 601 | |
| W-617 | Q | 1-96 | | 601 | |
| W-618 | Q[b] | 1-96 | | 601 | Trit-96 |
| W-619 | A | 2-96 | | 601 | |
| W-622 | Q | 1-96 | | 601 | |
| W-651 | Q[b] | 1-96 | | 601 | |
| W-652 | A | 1-96 | | 601 | Trit-96 |
| W-653 | Q | 1-96 | | 601 | |
| W-654 | S | 1-96 | Cr6-96A | 601 | |
| W-702 | S | 1-96 | Cr6-96A | 601 | |
| W-703 | | GAP | None | 601 | |
| W-705 | Q | 1-96 | | 601 | |
| W-706 | A | 3-96 | Cr6-96A | 601 | |
| W-714 | Q | 1-96 | | 601 | |
| W-750 | Q | 1-96 | | 601 | |
| W-905 | Q | 2-96 | Baseline taken | | |
| W-908 | | N/A | None | 601 | |
| W-909 | Q[c] | 1-96 | | 601 | Trit |
| W-912 | Q[c] | 1-96 | | 601 | Trit |
| W-913 | Q[b] | 1-96 | | 601 | |
| W-1001 | Q | 1-96 | | 601 | |
| W-1002 | Q | 1-96 | BL Suite:Cr6/GM/NPDESMET | 624 | Trit/*a/b* |
| W-1003 | Q | 1-96 | BL Suite:Cr6/GM/NPDESMET | 624 | Trit/*a/b* |
| W-1004 | Q | 1-96 | BL Suite:Cr6/GM/NPDESMET | 624 | Trit/*a/b* |
| W-1005 | Q | 2-96 | Baseline taken | | |

**Appendix C. (Continued)**

| Well number | Final sampling frequency (1-96) | Next quarter sample date | Regulatory compliance requested analyses | VOCs | RAD |
|---|---|---|---|---|---|
| W-1006 | Q | 2-96 | Baseline taken | | |
| W-1007 | Q | 1-96 | | 601 | |
| W-1008 | Q | 1-96 | | 601 | |
| W-1010 | Q | 1-96 | | 601 | |
| W-1011 | Q | 1-96 | | 601 | |
| W-1012 | S[a] | 1-96 | WGMG | 601 | |
| W-1013 | Q | 1-96 | | 601 | |
| W-1014 | Q | 1-96 | | 601 | |
| W-1101 | Q | 1-96 | | 601 | |
| W-1103 | Q | 1-96 | | 601 | |
| W-1105 | Q | 1-96 | | 601 | |
| W-1107 | Q | 1-96 | BL Suite:Cr6/GM/NPDESMET | 624 | Trit/*a/b* |
| W-1108 | Q[c] | 1-96 | | 601 | Trit |
| W-1109 | Q | 1-96 | | 601 | |
| W-1110 | Q | 2-96 | Baseline taken | | |
| W-1111 | Q | 1-96 | | 601 | |
| W-1114 | Q | 1-96 | Cr+6 (Q), NPDESMET (Q) | 601 | |
| W-1117 | Q[c] | 1-96 | | 601 | Trit |
| W-1118 | Q[c] | 2-96 | Baseline taken | | |
| W-1201 | Q[c] | 1-96 | | 601 | Trit |
| W-1203 | Q[c] | 1-96 | | 601 | Trit |
| W-1204 | Q[c] | 1-96 | | 601 | Trit |
| TW11 | S | 1-96 | | 601 | |
| TW11A | S | 1-96 | | 601 | |
| TW21 | S | 2-96 | | 601 | |
| 11C1 | Q | 1-96 | | 601 | |
| 14A11 | Q | 1-96 | | 601 | |
| 14A3 | Q | 1-96 | | 601 | |
| 14B1 | Q[a] | 1-96 | WGMG semi only | 601 | |
| 14B4 | Q | 1-96 | | 601 | |
| 14C1 | Q | 1-96 | | 601 | |
| 14C2 | Q | 1-96 | | 601 | |
| 14C3 | Q | 1-96 | | 601 | |
| 14H1 | A | 2-96 | | 601 | |
| 18D1 | A | 2-96 | | 601 | |
| 7D2 | A | 3-96 | | 601 | |
| GSW009 | Q[b] | 1-96 | | 601 | |
| GSW011 | S | 1-96 | 602/TPH | 601 | |

**Appendix C. (Continued)**

| Well number | Final sampling frequency (1-96) | Next quarter sample date | Regulatory compliance requested analyses | VOCs | RAD |
|---|---|---|---|---|---|
| GSW215 | Q | 1-96 | | 601 | |
| GSW266 | Q | 1-96 | | 601 | |
| GSW326 | A | 4-96 | | 601 | |
| GSW367 | S | 2-96 | | 601 | |
| GSW442 | A | 4-96 | | 601 | |
| GSW443 | Q | 1-96 | | 601 | |
| GSW445 | Q | 1-96 | NPDESMET Q | 601 | |
| SIP-ETS-201 | Q[c] | 1-96 | | 601 | Trit |
| SIP-ETS-204 | Q[c] | 1-96 | | 601 | Trit |
| SIP-ETS-205 | Q[c] | 1-96 | | 601 | Trit |
| SIP-ETS-207 | Q[c] | 1-96 | | 601 | Trit |
| SIP-ETS-209 | Q[c] | 1-96 | | 601 | Trit |
| SIP-ETS-211 | Q[c] | 1-96 | | 601 | Trit |
| SIP-ETS-212 | Q[c] | 1-96 | | 601 | Trit |
| SIP-ETS-213 | Q[c] | 1-96 | | 601 | Trit |
| SIP-ETS-214 | Q[c] | 1-96 | | 601 | Trit |
| SIP-ETS-215 | Q[c] | 1-96 | | 601 | Trit |
| SIP-ETS-302 | Q[c] | 1-96 | | 601 | Trit |
| SIP-ETS-303 | Q[c] | 1-96 | | 601 | Trit |
| SIP-ETS-304 | Q[c] | 1-96 | | 601 | Trit/*a/b* |
| SIP-ETS-306 | Q[c] | 1-96 | | 601 | Trit/*a/b* |
| SIP-ETS-401 | Q[c] | 1-96 | | 601 | Trit |
| SIP-ETS-402 | Q[c] | 1-96 | | 601 | Trit |
| SIP-ETS-404 | Q[c] | 1-96 | | 601 | Trit |
| SIP-ETS-405 | Q[c] | 1-96 | | 601 | Trit |
| SIP-543-101 | Q[c] | 1-96 | | 601 | Trit |
| SIP-AS-001 | Q | 1-96 | | 601 | |
| SIP-HPA-001 | Q | 1-96 | | 601 | |
| SIP-HPA-003 | Q | 1-96 | | 601 | |
| SIP-HPA-102 | Q | 1-96 | | 601 | |
| SIP-191-003 | Q | 1-96 | | 601 | |
| SIP-501-004 | Q | 1-96 | | 601 | |
| SIP-501-006 | Q | 1-96 | | 601 | |
| SIP-501-007 | Q | 1-96 | | 601 | |
| SIP-501-101 | Q | 1-96 | | 601 | |
| SIP-501-102 | Q | 1-96 | | 601 | |
| SIP-501-104 | Q | 1-96 | | 601 | |

**Appendix C. (Continued)**

| Well number | Final sampling frequency (1-96) | Next quarter sample date | Regulatory compliance requested analyses | VOCs | RAD |
|---|---|---|---|---|---|
| SIP-501-105 | Q | 1-96 | | 601 | |
| SIP-501-201 | Q | 1-96 | | 601 | |
| SIP-501-202 | Q | 1-96 | | 601 | |
| SIP-518-203 | Q | 1-96 | | 601 | |

[a] Water Guidance and Monitoring Group (WGMG).

[b] Guard well.

[c] T-5475 area.

A = Annual

S = Semiannual

Q = Quarterly

Cr6 = Hexavalent chromium

601 = EPA Method 601

624 = EPA Method 624

NPDESMET = National Pollution Discharge Elimination System Metals

BL = Baseline

GM = General minerals

Trit = Tritium

*a* = Gross alpha

*b* = Gross beta

# Appendix D

# Drainage Retention Basin Annual Monitoring Program Summary, 1995

# Appendix D

# Drainage Retention Basin Annual Monitoring Program Summary, 1995

This Appendix summarizes the 1995 LLNL Operations and Regulatory Affairs Division routine maintenance activities, maintenance monitoring data, and discharge data for the Drainage Retention Basin (DRB). The DRB, located in the central portion of the Livermore Site (Fig. D-1), is an artificial water body with about 52.9 megaliters (1.4 x $10^7$ gal or approximately 43 acre-ft) capacity, which was designed to receive storm water runoff and treated ground water. Discharge samples are collected at the first planned release of the rainy season and, at a minimum, in conjunction with one additional storm water monitoring event. Release samples are collected at sample location CDBX and are compared with the LLNL Arroyo Las Positas outfall samples collected at sample location WPDC (Fig. D-1). Weekly maintenance field monitoring measurements are conducted at sample locations CDBA, CDBC, CDBD, CDBE, CDBF, CDBJ, CDBK, CDBL (Fig. D-2). Monthly, quarterly, semi-annual and annual maintenance samples are collected at sampling location CDBE (Fig. D-2). Maintenance samples are used as the basis for decisions regarding management of the DRB.

One manual release was sampled during 1995. This was the first release in the 1995/1996 rainy season. No other releases were sampled in 1995 though additional releases over the DRB weir gate occurred concurrent with storm events during January through March and later in December 1995. Samples of releases for the 1994/1995 rainy season were all collected in 1994 and reported in Appendix D of the *LLNL Ground Water Project 1994 Annual Report* (Hoffman, *et al.*, 1995). Complete analytical results of samples collected within the basin and from releases are available upon request.

## D.1. Drainage Retention Basin Maintenance Monitoring

Analytical detection limits for nitrate and nitrite exceeded the recommended management action levels (MALs) specified in the *Drainage Retention Basin Management Plan: Lawrence Livermore National Laboratory* (Limnion Corp., 1991). Samples collected during 1995 within the DRB at sample location CDBE did not meet the MALs for alkalinity, four nutrients, turbidity, temperature, dissolved oxygen, and four metals.

Total phosphate as phosphorous was above the 0.02 milligrams per liter (mg/L) MAL each month in 1995 with concentrations ranging from 0.076 to 0.22 mg/L. Nitrate concentrations ranging from <0.5 mg/L to 3.4 mg/L also exceeded the 0.2 mg/L MAL every month during 1995. Nitrate was above the 0.5 mg/L detection limit in February through May, July, and December with detectable concentrations ranging from 0.75 to 3.4 mg/L. Nitrite concentrations remained below the 0.5 mg/L detection limit. However, this detection limit is above the 0.2 mg/L MAL. Ammonia nitrogen concentrations were above the 0.1 mg/L MAL in May through September and December. Detectable concentrations of ammonia nitrogen ranged from 0.12 mg/L to 0.32 mg/L. Despite attempts in 1993 and 1994, LLNL has been unable to successfully establish a plant community within the DRB to control nutrient levels. Until a successful plant community has been established, high nutrient levels resulting from storm water runoff into the DRB are expected to continue. During 1996, LLNL plans to try and establish a viable plant community in the DRB to uptake nutrients using a combination of free floating and rooted plants. Once the plant community is established, nutrient levels should be easier to maintain within the identified MALs by controlling the plant biomass.

Nutrient levels appear to be increasing, although chlorophyll “a”, which indicates the level of algae growth, remains well below the 10 mg/L MAL, ranging from 0.0015 mg/L to 0.0052 mg/L. This may indicate that the persistent high turbidity of 0.1 meters (m) to 0.71 m measured by a secchi disk is limiting algae growth. Turbidity first dropped below the 0.914 m MAL during August 1994 and remained below the MAL throughout 1995. Turbidity is expected to continue to remain low until the suspended sediment is removed by flushing with anticipated clearer storm water runoff during the 1996 winter storms, or by chemical clarification to settle out the solids.

In January 1995, total alkalinity dropped below the MAL of not less than 50 mg/L for the first time since June 1993 and continued below the MAL in every month except October and November 1995. The *Drainage Retention Basin Management Plan: Lawrence Livermore National Laboratory* did not anticipate alkalinity dropping below 50 mg/L but recommends if this occurs that the alkalinity be adjusted to 75 to 100 mg/L using either hydrated lime or sodium sesquicarbonate. The low alkalinity could contribute to the high turbidity observed in the DRB by affecting the ability of solids to settle out of solution. In 1996, LLNL will treat the DRB with hydrated lime to maintain alkalinity above the management objective level of 75 mg/L. In addition, weekly alkalinity field measurements will be conducted until the alkalinity level in the DRB stabilizes above the MAL.

During September 1995, LLNL conducted chronic toxicity tests on algae and fish to determine if the lack of algae growth was due to something other than turbidity. The results of the test using algae, <u>Selanastrum</u> <u>capricornutum,</u> indicated algae growth inhibition occurred at a 12.5% concentration of DRB water. The test using fathead minnow, <u>Pimephales</u> <u>promelas</u> showed no chronic toxicity in up to 100% DRB water. LLNL is continuing to look into the cause of the low algae growth within the DRB, as well as investigating a means to remove the turbidity and establish a viable plant community within the DRB.

Dissolved oxygen remained above the MAL of 5 mg/L except for short periods when the recirculation pumps were not operating. The pumps were started immediately after a low dissolved oxygen reading was observed in the DRB. Dissolved oxygen and water temperature conditions in the DRB continue to result in dissolved oxygen saturation levels below the 80% recommended MAL. Dissolved oxygen levels below 5 mg/L allow anaerobic bacteria to thrive, potentially releasing metals and nutrients from the sediments into the water column.

Semiannual and annual sampling was conducted during April and September 1995. Quarterly sampling was conducted in January, April, July, and November. In July, LLNL began monitoring for metals on a monthly basis to track three metals (iron, nickel, and lead) which were detected above the MALs in previous semiannual monitoring. As reported in the *Annual Storm Water Runoff Monitoring Report for the Livermore Site* (Brandstetter, 1995), influent data indicates that these metals are introduced into the DRB from storm water runoff. Samples were analyzed for total metals during 6 months of 1995. Nickel levels were above the 7.1 micrograms per liter (µg/L) MAL in April, August, September, November, and December. Detectable levels of nickel ranged from 5.2 to 17 µg/L. Lead was above the recommended 2 µg/L MAL (though the discharge limit is 5.6 µg/L) in April, July, August, and September. In December, a new analytical laboratory was used to analyze samples collected for metals. No lead was detected in the December sample, however, the laboratory's reporting limit (5 µg/L) was above the MAL. Detectable levels of lead ranged from 3.5 µg/L to 6 µg/L. Iron was above the 3,000 µg/L MAL April, July, August, September, and December. Detectable levels of iron ranged from 110 to 6800 µg/L. Zinc is normally at or just below the 58 µg/L MAL. However, zinc exceeded the MAL during the months of November (410 µg/L) and December (70 µg/L). Detectable levels of zinc ranged from 28 to 410 µg/L.

No semi-volatile or volatile organic compounds, total petroleum hydrocarbons, polyaromatic hydrocarbons, or ethylene dibromide were detected in DRB samples collected during 1995. Gross alpha, beta and tritium were consistent with background levels. Acute fish toxicity testing (100% survival) met the 90% survival MAL.

## D-2. Drainage Retention Basin Discharge Monitoring

Only one manual release was sampled in 1995. No other releases were sampled in 1995, though additional releases over the weir occurred concurrent with storm events during January through March and later in December 1995. Samples of releases for the 1994/1995 rainy season were all collected in 1994 and reported in Appendix D of the *LLNL Ground Water Project 1994 Annual Report* (Hoffman, *et al.*, 1995). The 1995 release represented the first release of the 1995/1996 rainy season and occurred on December 12, 1995. The release was necessary to prevent flooding of areas around the DRB and the upstream channels. Samples were collected during this release from locations CDBX and WPDC. Only discharges from CDBX are subject to the discharge limits established in RWQCB Waste Discharge Requirements (WDR) Order No. 91-091. Discharges from WPDC are monitored at the request of the RWQCB to evaluate the impact of the release as it runs through the main LLNL storm water drainage channel. Samples collected at WPDC on December 12, 1995, were a combination of the Site runoff, runon, and the release from the DRB.

Samples collected from CDBX contained iron, lead, and zinc above discharge limits established in WDR 91-091. All other constituents were below discharge limits. Iron (4,700 µg/L) exceeded the 3,000 µg/L discharge limit, lead (8 µg/L) exceeded the 5.6 µg/L discharge limit , and zinc (70 µg/L) exceeded the 58 µg/L discharge limit.

Samples collected from WPDC also exceeded the discharge limits in WDR 91-091 for iron (17,000 µ/L), lead (11 µg/L), and zinc (200 µg/L). These constituents are commonly associated with automobile operation and are believed to be generated primarily from this source.

In December 1995, LLNL purchased and installed a flow meter at CDBX to measure the flow and volume of releases from the DRB. The flow meter is installed to measure both manual releases and overflow of the DRB weir gate during rain storms.

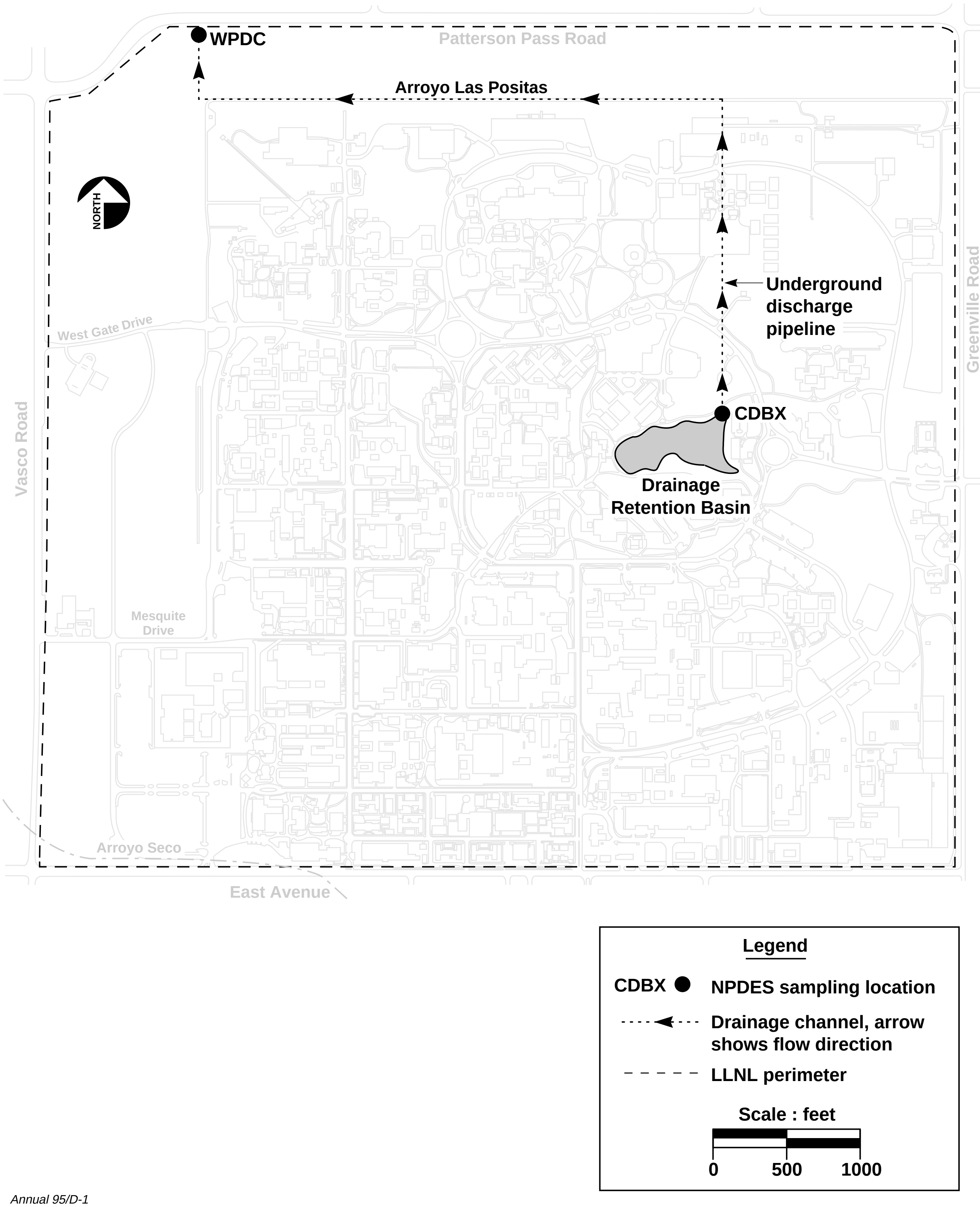


**Figure D-1. Location of the Drainage Retention Basin showing National Pollutant Discharge Elimination System (NPDES) discharge locations.**

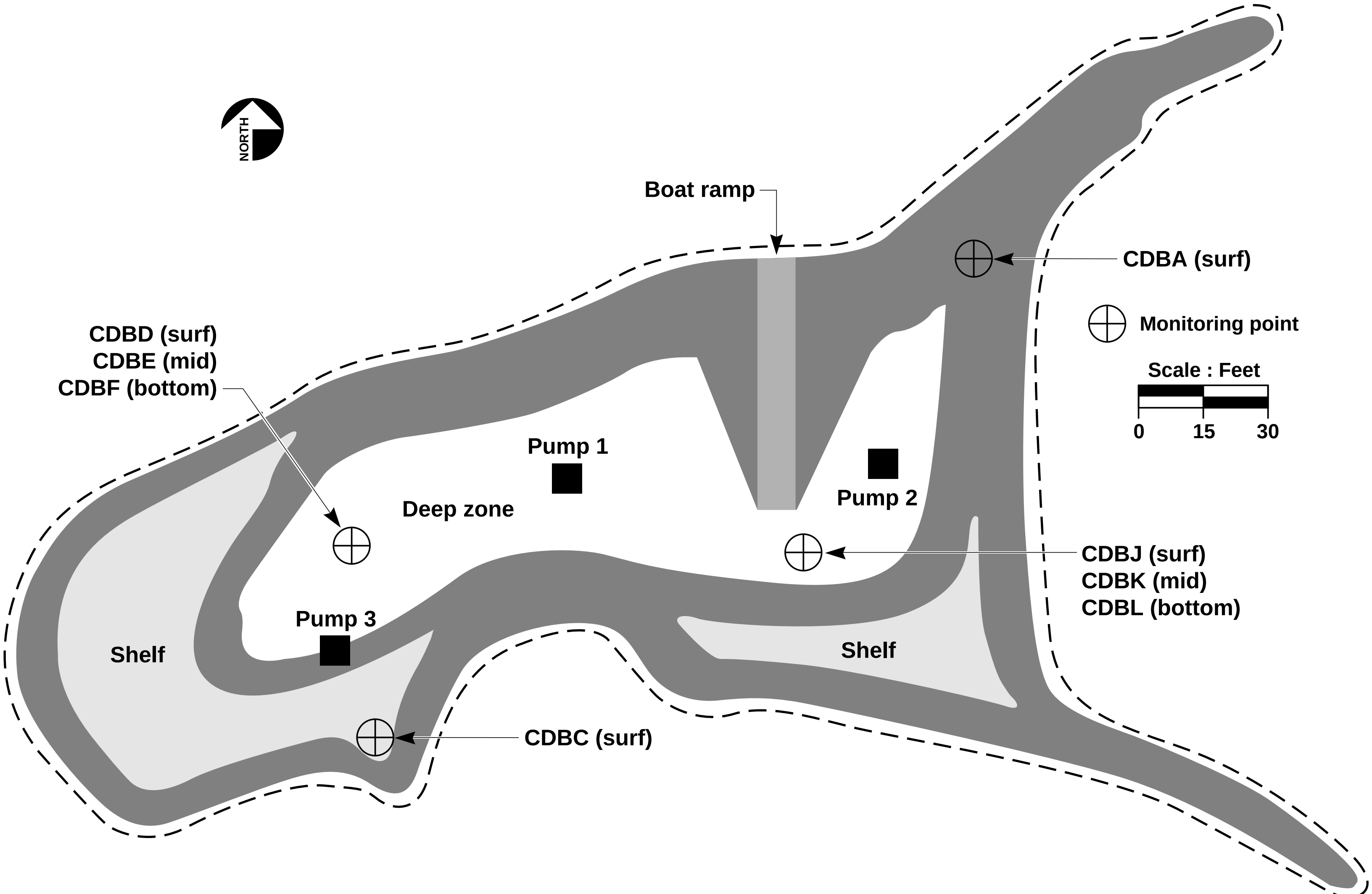


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**Figure D-2. Monitoring locations in the Drainage Retention Basin.**

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The Limnion Corporation (1991), *Drainage Retention Basin Management Plan: Lawrence Livermore National Laboratory*, Concord, Calif.