U.S. Department of Energy

Oakland Operations Office, Oakland, California 94612

Lawrence Livermore National Laboratory

University of California   Livermore, California 94551

UCRL-AR-126020-98

LLNL
Ground Water Project

1998 Annual Report

Technical Editors:

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L. Berg
F. Hoffman
G. Howard
R. Bainer
E. Folsom
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Contributing Authors:

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Environmental Protection Department

Environmental Restoration Program and Division

Work performed under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under Contract W-7405-Eng-48.

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Acknowledgments

The Lawrence Livermore National Laboratory (LLNL) Ground Water Project is supported by a number of people who contribute significantly to the project. The editors and authors are pleased to recognize their efforts.

A. Lamarre, LLNL Environmental Restoration Program/Division Leader, and J. Steenhoven, LLNL Environmental Restoration Deputy Program/Division Leader, provided overall direction and technical guidance.

D. Bishop of LLNL was the interface with Zone 7 on the ground water modeling project.

P. Anderson and S. Kawaguchi of LLNL maintained Treatment Facilities A and B, and provided technical support.

F. Bancalari, K. Barber, D. Lager, G. Laguna, and D. Martini of LLNL provided computer programming support.

K. Barber of LLNL produced CADD maps and archived geophysical logs.

J. Bear and K. Mansoor of Weiss Associates assisted with modeling activities.

California Laboratory Services, BC Laboratories, General Environmental Laboratory, and Quanterra Analytical Services provided analytical chemistry services to the project.

M. Campbell of LLNL assisted in the ground water sampling.

M. Chiarappa and K. Carroll of LLNL worked on ground water and sediment chemistry investigations.

J. Chiu of Weiss Associates oversaw and performed well development, initial well sampling, hydraulic tests and measured ground water levels.

D. Coufal of Jobs Plus maintained Treatment Facility E East and provided technical support.

R. Depue and J. Kelley of LLNL performed report composition, editing, proofreading, and compilation.

A. Elsholz of LLNL maintained Treatment Facility 5475 and provided technical support.

S. Ellis and R. Baine of LLNL coordinated computer resources.

S. Fleming, E. Cummins, J. Moore, C. Northhart, and P. Sheperd of PC Exploration operated the drill rigs.

B. Goodrich of LLNL prepared Quarterly ground water monitoring reports.

J. Greci, L. Kita, and P. Lyra of LLNL coordinated field activities.

D. Hall of LLNL provided technical guidance for the development of treatment technologies.

K. Heyward of LLNL prepared the graphics.

D. Hill of Weiss Associates provided QA/QC of geophysical log data.

B. Jakub of Weiss Associates assisted with drilling coordination and provided geologic oversight and technical support.

B. Johnson of LLNL maintained Treatment Facility 518, and provided technical support.

B. Kidd of LLNL maintained Treatment Facility G-1, Treatment Facility D East, Portable Treatment Unit 4, and provided technical support.

C. Kuks of LLNL provided administrative support.

P. Lyra served as LLNL's Site Safety Officer, maintained Treatment Facility D West, and provided technical support.

S. Martins of LLNL oversaw technical evaluations and assisted in maintaining Vapor Treatment Facilities VTF518 and VTF5475.

W. McConihe, E. Nielsen, L. Niles, and J. Valett of Weiss Associates supervised drilling, monitor well installation, well development, and borehole logging.

D. McQueen of LLNL ran the sampling algorithm.

B. Mitchell of LLNL maintained wells and provided technical support.

S. Orloff of LLNL maintained Treatment Facility D and provided technical support.

T. Ottesen, D. Burrus, S. Chamberlain, L. Graves, R. Higgins, S. Hodgson, S. Lambaren, and N. Montez of LLNL maintained the database, and provided chemical and water level data.

R. Ruiz of LLNL provided technical guidance and development of new technologies.

J. Taggert of LLNL provided electronics technical support.

J. Tulk, K. Graham, and K. Rauhut of LLNL provided legal support.

J. Ulrich of LLNL and maintained Treatment Facility D Southeast, and provided technical support.

H. Van Noy of LLNL maintained Treatment Facility C, TFC Southeast, TFE Northwest, and provided technical support.

D. White of LLNL maintained Treatment Facility 406, and provided technical support.

K. Williams of LLNL provided assistance in the development of electronics in treatment facilities.

Table of Contents

Summary Summm-1
1. Introduction........ 1
2. Regulatory Compliance........ 1
    2.1. CERCLA Documents........ 1
    2.2. Milestones and Activities........ 2
    2.3. Community Relations........ 3
3. Field Investigations........ 3
    3.1. Ground Water Sampling........ 3
    3.2. Source Investigations........ 4
        3.2.1. National Ignition Facility Construction Site Boreholes/Test Excavations........ 4
        3.2.2. Big Trees Park 1998 Soil Sampling........ 4
        3.2.3. Infiltration Study at Treatment Facility A........ 4
4. Ground Water Flow and Transport Modeling........ 5
    4.1. Treatment Facility A and B Model........ 5
    4.2. Site-Wide Model for all HSUs........ 5
    4.3. Trailer 5475 Model........ 5
    4.4. Zone 7 Project........ 6
5. Annual Summary of Remedial Action Program........ 6
    5.1. Treatment Facility A........ 6
        5.1.1. Performance Summary........ 7
        5.1.2. Field Activities........ 7
    5.2. Treatment Facility B........ 8
        5.2.1. Performance Summary........ 8
        5.2.2. Field Activities........ 8
    5.3. Treatment Facility C........ 8
        5.3.1. Performance Summary........ 9
        5.3.2. Field Activities........ 9
    5.4. Treatment Facility D........ 9
        5.4.1. Performance Summary........ 10
        5.4.2. Field Activities........ 10

5.4.3. Field-Scale Pilot Tests 10
5.5. Treatment Facility E........ 11
5.5.1. Performance Summary........ 11
5.5.2. Field Activities........ 11
5.5.3. Field-Scale Pilot Tests 12
5.6. Treatment Facility G 12
5.6.1. Performance Summary........ 12
5.6.2. Field Activities........ 12
5.6.3. Field-Scale Pilot Tests 12
5.7. Treatment Facility 406........ 13
5.7.1. Performance Summary........ 13
5.7.2. Field Activities........ 13
5.8. Vapor Treatment Facility 518........ 13
5.8.1. Performance Summary........ 14
5.8.2. Field Activities........ 14
5.9. Ground Water Treatment Facility 518 14
5.9.1. Performance Summary........ 15
5.9.2. Field Activities........ 15
5.10. Treatment Facility 5475........ 15
5.10.1. Performance Summary 15
5.10.2. Field Activities........ 15
6. Trends in Ground Water Analytical Results 16
References

List of Figures

Figure 1. Locations of Livermore Site monitor wells, extraction wells, and treatment facilities, January 1999.

Figure 2. Comparison of 1998 HSU 1B measured (top) and simulated (bottom) aqueous TCE concentrations in the TFB area.

Figure 3. Comparison of 1998 HSU 2 measured (top) and simulated (bottom) aqueous TCE concentrations in the TFB area.

Figure 4. Total VOC mass removed from the Livermore Site subsurface over time.

Figure 5. Ground water elevation contour map based on water levels collected from 128 wells completed within HSU 1B showing estimated hydraulic capture areas, LLNL and vicinity, November 1998.

Figure 6. Ground water elevation contour map based on water levels collected from 160 wells completed within HSU 2 showing estimated hydraulic capture areas, LLNL and vicinity, November 1998.

Figure 7. Ground water elevation contour map based on water levels collected from 63 wells completed within HSU 3A showing estimated hydraulic capture areas, LLNL and vicinity, November 1998.

Figure 8. Ground water elevation contour map based on water levels collected from 34 wells completed within HSU 4 showing estimated hydraulic capture areas, LLNL and vicinity, November 1998.

Figure 9. Ground water elevation contour map based on water levels collected from 46 wells completed within HSU 5 showing estimated hydraulic capture areas, LLNL and vicinity, December 1998.

Figure 10. Isoconcentration contour map of total VOCs for 125 wells completed within HSU 1B based on samples collected in the fourth quarter of 1998 (or the next most recent data), and supplemented with soil chemistry data from 43 borehole locations.

Figure 11. Isoconcentration contour map of total VOCs for 179 wells completed within HSU 2 based on samples collected in the fourth quarter of 1998 (or the next most recent data), and supplemented with soil chemistry data from 106 borehole locations.

Figure 12. Isoconcentration contour map of total VOCs for 78 wells completed within HSU 3A based on samples collected in the fourth quarter of 1998 (or the next most recent data), and supplemented with soil chemistry data from 142 borehole locations.

Figure 13. Isoconcentration contour map of total VOCs for 44 wells completed within HSU 4 based on samples collected in the fourth quarter of 1998 (or the next most recent data), and supplemented with soil chemistry data from 59 borehole locations.

Figure 14. Isoconcentration contour map of total VOCs for 50 wells completed within HSU 5 based on samples collected in the fourth quarter of 1998 (or the next most recent data), and supplemented with soil chemistry data from 94 borehole locations.

Figure 15. 1998 TFA extraction well, pipeline and discharge locations.

Figure 16. 1998 TFB extraction well, pipeline and discharge locations.

Figure 17. 1998 TFC extraction well, pipeline and discharge locations.

Figure 18. 1998 TFC Southeast extraction well, pipeline and discharge locations.

Figure 19. 1998 TFD extraction well, pipeline and discharge locations.

Figure 20. 1998 TFD Southeast extraction well, pipeline and discharge locations.
Figure 21. 1998 TFD West extraction well, pipeline and discharge locations.
Figure 22. 1998 TFD East extraction well, pipeline and discharge locations.
Figure 23. 1998 TFE East extraction well, pipeline and discharge locations.
Figure 24. 1998 TFE Northwest extraction well, pipeline and discharge locations.
Figure 25. 1998 TFG-1 extraction well, pipeline and discharge locations.
Figure 26. 1998 TF406 extraction well, pipeline and discharge locations.
Figure 27. 1998 TF518 extraction well, pipeline and discharge locations.

List of Tables

Table 1. 1998 RAIP milestones.
Table 2 Summary of 1998 VOC remediation.
Table 3. Summary of cumulative VOC remediation.

Appendices

Appendix A—Well Construction and Closure Data............ A-1
Appendix B—Hydraulic Test Results............ B-1
Appendix C—1999 Ground Water Sampling Schedule............ C-1
Appendix D—1998 Drainage Retention Basin Annual Monitoring Program Summary........ D-1

Summary

Significant 1998 Livermore Site Ground Water Project (GWP) restoration activities included the following:

1. The Lawrence Livermore National Laboratory (LLNL) Livermore Site GWP produced two major Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) documents in 1998 in compliance to the 1998 amended schedule of the Remedial Action Implementation Plan schedule (RAIP). Both Draft Final and Final Remedial Design Report No. 4 (RD4) were submitted ahead of schedule. Submission of RD4 marked the successful completion of all primary CERCLA document milestones until the second Five-Year Review in August 2002. Twelve additional documents or letter reports were submitted to the regulatory agencies in 1998, consisting of the Action Memorandum for an Emergency Removal Action at the National Ignition Facility Construction Site, seven Remedial Project Managers Meeting Summaries, the revised Livermore Site Consensus Statement, changes in the guard well sampling frequency, the Big Trees Park 1998 Soil Sampling Plan, and the GWP 1997 Annual Report. All six 1998 U.S. Department of Energy (DOE)/LLNL RAIP milestones were met on or ahead of schedule.
2. The Community Work Group met once in 1998 to discuss topics including the DOE budget, progress on Livermore Site cleanup and the Livermore Site Priority List/Consensus Statement.
3. DOE/LLNL met three times with members of Tri-Valley Citizens Against Radioactive Environment and their scientific advisor. DOE/LLNL also held a public workshop to discuss community comments on the Draft Final Big Trees Park 1998 Sampling Plan.
4. The GWP submitted 850 ground water samples for analyses that were collected during 850 individual sampling events from 417 wells and piezometers.
5. LLNL provided oversight for surface geophysical studies in the northeastern and southeastern quadrants of the Livermore Site as required by the United States District Court’s Joint Stipulation Order following the excavation of buried capacitors at the National Ignition Facility construction site in September of 1997. A total of 17 shallow boreholes were drilled and three test pits were excavated to further investigate the possible presence of buried objects.
6. LLNL/DOE prepared the Big Trees Park Soil Sampling Plan, conducted soil sampling at the park, and performed data validation on the data.
7. Additional vadose zone infiltration study boreholes were drilled in the southwest corner of Treatment Facility A (TFA) area.
8. LLNL continued to use the three-dimensional ground water flow and contaminant transport model of hydrostratigraphic units 1B and 2 (HSU 1B and HSU 2) to evaluate perchloroethylene (PCE) and trichloroethylene transport in the TFA and Treatment Facility B (TFB) areas. The modeling effort was expanded to include development of a site-wide model for all HSUs using the FEFLOW computer code. A two-dimensional model was developed for the Trailer T5475 area to evaluate placement of potential extraction and injection wells.
9. LLNL completed a project for the Alameda County Flood Control and Water Conservation District, Zone 7, using the existing Livermore Site ground water models to

assess future ground water use and potential for subsurface storage in the basin surrounding LLNL. The report was submitted in February 1998.

10. The 1998 extraction wells, extraction rates, and estimated volatile organic compound (VOC) mass removed from the ground water Treatment Facilities (TF) and Vapor Treatment Facilities (VTF) in the TFA, TFB, TFC, TFD, TFE, TFG, TF406, TF518, and TF5475 areas are summarized in Table Summ-1.

11. Construction activities in 1998 included:
    - Replacement of the ground water treatment system at TFB to a more cost-effective, large-capacity air-stripping system.
    - Construction of portable treatment unit (PTU) stations at TFD Southeast, TFE Northwest and a miniature PTU (MTU) at TF518.
    - A down-hole *in situ* catalytic reductive dehalogenation (CRD) treatment unit was installed in well W-1302 as TF5475-1. The CRD unit is successfully treating VOCs *in situ* while keeping tritium in the subsurface.
    - Extraction wells W-1309 and W-1310 were connected to TF406 via a pipeline.

12. Twenty-five wells installed in 1998 are listed in Table Summ-2.

13. Hydraulic tests conducted in 1998 are listed in Table Summ-3.

14 DOE/LLNL operated all facilities in the TFA, TFB, TFC, TFD, TFE, TFG, TF406, TF518, and TF5475 areas in 1998. A total of 60 ground water extraction wells operated at 16 separate locations at an average flow rate of 725,000 gal per day. VTF518 operated at an average flow of 70,000 standard cubic ft per day. Together, these treatment facilities removed approximately 150 kg of VOC mass in 1998. Since initial operation, approximately 831 million gal of ground water and almost 11.2 million cubic ft of vapor have been treated, removing more than 483 kg of VOCs.

15. In the TFA area along the western margin of the site, total VOC concentrations east of Vasco Road near newly activated extraction well W-1001 declined below 100 parts per billion (ppb) for the first time. Offsite HSU 1B concentrations remained below the maximum contaminant level for all contaminants of concern except for in well W-1425 where the PCE concentration was 8.3 ppb in September 1998. Total VOC concentrations in HSU 2 declined from over 100 ppb to around 50 ppb near extraction well W-415 and the 50 ppb total VOC contour in HSU 2 is now east of extraction well W-904.

16. VOC concentrations in the western part of the TFB HSU 1B plume continued to decline, while concentrations around the TFB source area remained relatively unchanged. VOC concentrations in HSU 2 in the TFB area also remained relatively unchanged in 1998.

17. In the northwestern TFC area, concentrations of VOCs declined from over 100 ppb to about 50 ppb around extraction well W-1104.

Table Summ-1. 1998 extraction wells, extraction rates, and estimated VOC mass removed.

Treatment facility area	Extraction wells	Extraction rate	Estimated total VOC mass removed (kg)
TFA	W-109, W-262, W-408, W-415, W-457, W-518, W-520, W-522, W-601, W-602, W-603, W-605, W-609, W-614, W-712, W-714, W-903, W-904, W-1001, W-1004, W-1009	179-362 gpm	15.0
TFB	W-357, W-610, W-620, W-621, W-655, W-704	39-60 gpm	5.2
TFC	W-701, W-1015, W-1102, W-1103, W-1104, W-1116, W-1213	47-55 gpm	7.9
TFD	W-361, W-906, W-907, W-1208, W-1215, W-1216, W-1218, W-1220, W-1301, W-1303, W-1306, W-1307, W-1308	111-163 gpm	73.3
TFE	W-566, W-1109	18-47 gpm	16.7
TF406	GSW-445, W-1309, W-1310	13-34 gpm	2.1
TFG	W-1111	6.5-8 gpm	0.4
TF5475	W-1302	1-2 gpm	0.1
TF518	W-112, W-211	5-23 gpm	1.0
VTF518	SVI-518-201, SVI-518-303	20-50 scfm	27.3
1998 Total		420-754 gpm 20-50 scfm	149.0

Notes:

kg = Kilograms.

gpm = Gallons per minute.

scfm = Standard cubic feet per minute.

Table Summ-2. Wells installed in 1998.

Treatment facility area	Well(s)
TFA	W-1424, W-1425
TFB	W-1420, W-1423, W-1426
TFC	W-1427, W-1428, W-1501
TFD	W-1408, W-1416, W-1417, W-1419, W-1421, W-1502, W-1503, W-1504
TFE	W-1409, W-1418, W-1422
TF406	W-1410, W-1411
TF518	W-1412, W-1413, W-1414
TF5475	W-1415

Table Summ-3. Summary of 1998 hydraulic tests.

Treatment facility area	Well(s)
TFA	W-1424, W-1425
TFB	W-1420, W-1423, W-1426
TFC	W-1501
TFD	W-1403, W-1404, W-1405, W-1406, W-1407, W-1408, W-1416, W-1417, W-1419, W-1421
TFE	W-1418, W-1422
TF406	W-1410, W-1411
TF518	W-1412, W-1413
TF5475	W-1415

1. Introduction

This report summarizes the 1998 Lawrence Livermore National Laboratory (LLNL) Livermore Site Ground Water Project (GWP) activities in five sections: Regulatory Compliance; Field Investigations; Ground Water Flow and Transport Modeling; Annual Summary of Remedial Action Program, including discussions of treatment facility activities; and Trends in Ground Water Analytical Results. The 1998 GWP quarterly self-monitoring reports (Bainer and Littlejohn, 1998a; 1998c; 1998d; 1999) were issued separately.

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 1998 are shown in larger type.

Appendices A through D present Well Construction and Closure Data, Hydraulic Test Results, the 1999 Ground Water Sampling Schedule, and the 1998 Drainage Retention Basin (DRB) Annual Monitoring Program Summary, respectively. Ground water volatile organic compound (VOC) analyses, water level elevations, and the Treatment Facility F/Treatment Facility 406 (TFF/TF406) area ground water fuel hydrocarbon (FHC) analyses are available on request.

2. Regulatory Compliance

In 1998, 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 and community activities as discussed below.

2.1. CERCLA Documents

During 1998, DOE/LLNL issued two CERCLA documents for the Livermore Site specified in the amended schedule in the Remedial Action Implementation Plan (RAIP) (Dresen et al., 1993). Both Draft Final and Final Remedial Design Report No. 4 (RD4) (Berg et al., 1998) were submitted ahead of schedule. Submission of RD4 marked the successful completion of all primary FFA document milestones until the second Five-Year Review in August 2002.

As required by the FFA, DOE/LLNL issued the 1997 Ground Water Project Annual Report (Hoffman et al., 1998) on March 31, 1998. DOE/LLNL also finalized and issued seven Remedial Project Managers' (RPMs') meeting summaries. The March RPM summary (Bainer and Littlejohn, 1998a) included quarterly self-monitoring data. Subsequent 1998 quarterly self-monitoring data were reported in letter reports (Bainer and Littlejohn, 1998c, 1998d, 1999). DOE/LLNL also updated the Quality Assurance Project Plan (Dibley, in progress) and are in the process of responding to the U.S. Environmental Protection Agency (EPA) comments.

An Action Memorandum for an emergency removal action was issued February 2, 1998 (Bainer and Berg, 1998) in response to a discovery of undocumented buried capacitors containing polychlorinated biphenyls (PCBs) during excavation for the National Ignition Facility (NIF) in the northeast corner of the Livermore Site. The GWP also prepared sections of NIF quarterly progress reports pursuant to an agreement specified in the Joint Stipulation and Order, in partial settlement of a Natural Resources Defense Council (NRDC) v. Pena (DOE) lawsuit.

DOE/LLNL prepared a sampling plan for determining the extent of elevated plutonium concentrations in soil in Livermore's Big Trees Park (DOE/LLNL, 1998). This plan and the associated sampling and analyses were DOE/LLNL's voluntary response to community concerns expressed in the Agency for Toxic Substances and Disease Registry/California Department of Health Services (CDHS) Environmental Health Investigations Branch's February 1998 draft Public Health Consultation. The sampling plan was prepared under the direction and oversight of the EPA and the CDHS Radiologic Health Branch.

2.2. Milestones and Activities

Table 1 presents the 1998 RAIP milestones (Table 5 in Dresen et al., 1993) for the Livermore Site. All six milestones were completed on or ahead of schedule.

Livermore Site Environmental Restoration activities in 1998 also included the following:

- Continuing to implement Engineered Plume Collapse (EPC) to accelerate mass removal and cleanup of the Livermore Site. EPC incorporates hydrostratigraphic unit (HSU) analysis, smart pump and treat, source isolation, and treatment of VOCs in fine-grained sediments.
- Overseeing magnetometer surveys conducted by the U.S. Navy Unexploded Ordinance Detachment in the Helipad Area, Northern Boundary Area, and the southeast corner of the Livermore Site as part of the settlement of the NRDC motion for the NIF site. Field activities also included drilling along a proposed 4,500-ft-long NIF utility trench, drilling shallow boreholes in the NIF area, digging a test pit in the area of an unconfirmed magnetic anomaly near the Helipad Area, and installing two monitor wells in the NIF area.
- Overseeing excavation of mammoth bones from the NIF construction site and transfer of the bones to U.C. Berkeley.
- Conducting soil sampling at Big Trees Park during August and September, and performing quality assurance on the data.
- Preparing a Fiscal Year 1999 Accelerated Site Technology Deployment Initiative proposal to perform phased source area remediation.
- Activating the first miniature portable treatment unit (MTU-1) in the Building 518 area.
- Providing technical assistance to Zone 7 of the Alameda Country Flood Control and Water Conservation District to help plan for long-range ground water demand (Hoffman and Bishop, 1998).
- Drilling three new wells that were funded by the Advanced Strategic Computing Initiative project in the Treatment Facility D (TFD) area.
- Activating a new air stripper with increased treatment capacity at Treatment Facility B (TFB) on October 22, 1998. This replaces the ultraviolet oxidation treatment system to significantly lower electrical power costs.
- Agreeing to a revised Livermore Site Consensus Statement/Priority List and the RAIP milestone schedule on June 23, 1998 (Bainer and Littlejohn, 1998b).
- Reducing the sampling frequency of the guard wells listed in the Compliance Monitoring Plan (Chou, 1998).
- Providing support for an infiltration study funded through DOE's Environmental Management Science Program.
- Starting construction of Vapor Treatment Facility 5475 (VTF5475).

- Starting a treatability test at Treatment Facility G-1 (TFG-1) to remediate ground water containing VOCs using granular activated carbon.
- Supporting geophysical studies by students from the University of California, Berkeley and Stanford University, in the TFD area.
- Preparing to dispose PCB contaminated soil excavated during a construction project in the East Traffic Circle.

2.3. Community Relations

The Community Work Group (CWG) met once in 1998 to discuss the DOE budget, progress on the Livermore Site cleanup, and the Livermore Site Priority List/Consensus Statement. Correspondence and communication with CWG members continued throughout the year. DOE/LLNL met three times with members of Tri-Valley Citizens Against a Radioactive Environment and their scientific advisor as part of the activities funded by an EPA Technical Assistance Grant. DOE/LLNL also held a public workshop in August 1998 to discuss community comments on the Draft Final Big Trees Park 1998 Sampling Plan.

Other Livermore Site community relations activities in 1998 included communications and meetings with neighbors; local, regional and national interest groups; other community organizations; public presentations including those to local Realtors, and to national and northern California peace leaders; producing and 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 1998, the GWP collected water samples during 876 sampling events. The samples were analyzed for VOCs, FHCs, PCBs, metals, radionuclides, or combinations of these analytes depending on the compounds of concern.

Livermore Site ground water sampling frequency recommendations are updated quarterly using a cost-effective sampling algorithm that evaluates trends in contaminant levels in each well over an 18-month period. The sampling frequency is determined by the treatment facility Task Leaders based on algorithm results and other data. 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 or biennially (every two years).
- Wells exhibiting moderate change (≥10 ppb but <30 ppb per year) are sampled semiannually (twice a year).
- Wells showing large change (≥30 ppb) are sampled quarterly.
- Wells with less than 18 months of analytical history are sampled quarterly for the first 18 months, then algorithm logic and input from the Task Leaders for each treatment facility area determine the sampling frequency.

Sampling methods for the 415 sampling locations vary, depending on the yield of each well. Substantial cost reduction is achieved through the use of Low-Volume and Specific-Depth Grab Sampling methods and devices. Sampling methods used in 1998 were:

- Three volume pre-sample purge (three casing volumes removed by electric submersible pump prior to sampling): 220 locations.
- Low-volume pre-sample purge (less than one casing volume removed by electric submersible pump prior to sampling): 42 locations.
- Specific-Depth Grab Sampling (sample collected from a specific point within the screened interval with an EasyPump): 153 locations.

Wells located at the leading edge of VOC plumes are sampled quarterly, using a three casing volume pre-sample purge method. The sampling schedule for 1999 is presented in Appendix C.

3.2. Source Investigations

Source investigations conducted in 1998 are discussed below by area.

3.2.1. National Ignition Facility Construction Site Boreholes/Test Excavations

Following the NIF emergency removal action in September 1997, geophysical studies in the northeastern and southeastern quadrants of the Livermore Site were conducted in 1998 as required by the Joint Stipulation and Order. Geophysical anomalies discovered during these studies were further assessed in comparison to known buried utilities. Anomalies that did not coincide with known buried utilities, or required additional study after interpreting the geophysical data were investigated by drilling or excavating. A total of 17 shallow boreholes were drilled and three test pits were excavated at the NIF construction site and the Helipad area to further investigate the possible presence of additional buried objects. Soil samples were collected from each borehole and analyzed for VOCs, PCBs and, in some cases dioxins (DOE, 1998a; 1998b; 1998c; 1998d).

In addition, as required by the RPM's in response to the Joint Stipulation and Order, two ground water monitor wells were installed in the TFD area in the northeast quadrant of the Livermore Site, downgradient of the NIF construction site. Well W-1402, located inside the East Traffic Circle, was completed as an HSU 3A monitor well. Well W-1416, located adjacent to the Helipad, was completed as an HSU 2 monitor well.

3.2.2. Big Trees Park 1998 Soil Sampling

As outlined in the Big Trees Park Sampling Plan (DOE/LLNL, 1998) soil samples were collected at various depths from more than 60 sampling locations throughout the park and surrounding areas using a combination of direct drive, coring, split-spoon and hollow-stem auger sampling. All of the samples collected during this sampling event contained plutonium concentrations below the U.S. EPA's level of concern for residential soil. Analytical results of the study are on the world wide web at http://www-erd.llnl.gov/bigtrees/.

3.2.3. Infiltration Study at Treatment Facility A

Three boreholes were drilled for infiltration studies in the Treatment Facility A (TFA) area during the first quarter of 1998. Ground water monitor wells SIP-INF-201 and SIP-INF-202 were installed in two of the boreholes, each completed in HSU 1B. The third borehole was completed as a vadose zone monitor well, IMS-INF-203, constructed using a impermeable everted membrane system (formerly called FLUTe or SEAMIST) equipped with vapor ports, temperature sensors and soil moisture sensors positioned at different depths within the vadose zone (Keller and Lowry, 1991). Well construction details are provided in Table A-1 of Appendix A.

4. Ground Water Flow and Transport Modeling

Ground water flow and transport models are used at the Livermore Site to support remediation system design and performance evaluation; to support ongoing subsurface characterization activities; and improve our ability to forecast, monitor, and interpret the progress of the ground water remediation program. In 1998, we continued to develop our three-dimensional (3-D) ground water model for the Livermore Site. The 3-D model builds vertical resolution into the two-dimensional (2-D) model previously developed for the Livermore Site (Tompson et al., 1995).

4.1. Treatment Facility A and B Model

In 1998, LLNL continued to use the 3-D ground water flow and contaminant transport model of HSUs 1B and 2 to evaluate perchloroethylene (PCE) and trichloroethylene (TCE) transport in the TFA and TFB areas. The development of this model is described in by Demir et al. (1997) and Vogele et al. (1996). This model was developed using the CFEST (Coupled Flow, Energy and Solute Transport) computer code (Gupta, 1987). The 3-D flow model was calibrated to measured ground water elevation data collected from Livermore Site monitor wells.

In 1998, the model was used to compare simulated contaminant transport to ground water concentrations observed from 1996 through 1998. These simulations were comprised of a series of remedial pumping time steps that were constructed to reflect changes in extraction well flow rates. Results from the preliminary simulations were within plausible uncertainty limits of the model (Figs. 2 and 3).

4.2. Site-Wide Model for all HSUs

In 1998, work continued to develop a 3-D ground water flow and transport model for all Livermore Site HSUs using the FEFLOW (Finite Element subsurface FLOW system) computer code (Diersch, 1998). To improve the accuracy of simulations and to better simulate contaminant migration in the source areas, all available subsurface hydraulic property data are being analyzed.

In 1998, work on the site-wide model consisted of improving the hydrogeological input data sets and beginning the flow calibration. The improvements of the hydrogeological data sets focused primarily on three major areas. First, the migration history of individual plumes was evaluated. As a result of this work, plume maps for 11 individual VOC constituents and total VOCs were generated for each quarter from 1987 to 1998 and displayed through a web-based graphical interface for analysis. Second, a revised set of HSU correlations across the entire eastern Livermore Basin was developed and input into the model. Third, heterogeneity within HSUs was evaluated by reviewing lithologic, geophysical, and hydraulic test data to better define the distribution of hydraulic conductivity within HSUs across the site. The 3-D model hydrogeological input data sets will continue to be developed 1999.

4.3. Trailer 5475 Model

In 1998, LLNL developed a 2-D FEFLOW model of the Trailer 5475 (T5475) area to evaluate the use of recirculation cells with the deployment of the catalytic reductive dehalogenation (CRD) treatment units. The objective of the model is to evaluate different potential extraction and injection well configurations to improve overall remediation performance. This effort is part of an ongoing evaluation of the T5475 area for use with engineering design and long-term planning.

4.4. Zone 7 Project

In 1997, the Alameda County Flood Control and Water Conservation District, Zone 7 (Zone 7) approached LLNL about using the existing LLNL ground water models to assist Zone 7 with an evaluation of future ground water use in the basin surrounding LLNL. LLNL submitted a report to Zone 7 (Hoffman and Bishop, 1998) on February 28, 1998 and presented the results to the Zone 7 Board on March 5, 1998. The report summarized the results of an investigation to estimate the subsurface volume of ground water and the volume of potential subsurface storage in the basin to address short- and long-term water resources management issues. A volumetric calculation was performed to determine the volume of potential ground water storage in the basin, and a potential drawdown or buildup of ground water in the area of interest. The existing 2-D CFEST flow model (Tompson et al., 1995) was used to estimate the volume of ground water flow in the basin, and to evaluate the influence of different rates of extraction and reinjection within the basin. The results of this analysis indicated about 1,000 acre/ft of ground water flow through the basin with about 2,000 to 5,000 acre/ft of additional ground water storage.

5. Annual Summary of Remedial Action Program

This section summarizes activities performed during 1998 to support the Remedial Action Program at the Livermore Site. It includes treatment system design, new construction, modifications to existing systems, treatment facility performance, treatability tests, well installation, well abandonment, and hydraulic tests performed during 1998. The volume of ground water and soil vapor treated at the facilities and the estimated VOC mass removed from the subsurface during 1998 and historically is presented in Tables 2 and 3, respectively. A graph of VOC mass removal at the Livermore Site since 1989 is presented in Figure 4. Figures 5 through 8, respectively, show the HSU 1B, 2, 3A and 4 hydraulic capture areas, based on November 1998 ground water elevation data and hydraulic capture areas. Figure 9 shows the ground water elevation and hydraulic capture areas for HSU 5, based on December 1998 data. Figures 10 through 14 show fourth quarter total VOC isoconcentrations in the same five HSUs. Figures 15 through 27 show treatment facility extraction wells, pipelines, discharge locations, and self-monitoring program sampling stations.

In 1998, DOE/LLNL operated ground water treatment facilities and vapor treatment facilities in the TFA, TFB, TFC, TFD, TFE, TFG, TF406, TF518, and TF5475 areas. A total of 60 ground water extraction wells operated at 16 separate locations at an average flow rate of 725,000 gal per day in 1998. VTF518 operated at an average flow of 70,000 standard cubic ft per day. Together, these treatment facilities removed approximately 150 kg of VOC mass in 1998. Since initial operation, approximately 831 million gal of ground water and almost 11.2 million cubic ft of vapor were treated, removing more than 483 kg of VOCs.

5.1. Treatment Facility A

TFA is located in the southwestern quadrant of the Livermore Site near Vasco Road and East Avenue (Fig. 1). In 1998, TFA treated ground water from 21 extraction wells, including seven HSU 1B wells (W-262, W-408, W-520, W-601, W-602, W-1001, W-1004), thirteen HSU 2 wells (W-109, W-415, W-457, W-518, W-520, W-603, W-605, W-609, W-614, W-714, W-903, W-904 and W-1009), and one HSU 3A well (W-712). In 1998, TFA operated at flow rates ranging from about 180 to 360 gallons per minute (gpm).

During 1998, TFA continued to treat ground water using the large-capacity air-stripping system installed in June 1997. The effluent air from the stripper is passed through granular activated carbon (GAC) filters to remove VOCs. The treated effluent air is then vented to the atmosphere. This new system is permitted by the California Regional Water Quality Control Board (RWQCB) to treat up to 500 gpm of ground water.

Treated ground water from TFA is discharged to the Recharge Basin, located about 2,000 ft southeast of TFA on DOE property administered by Sandia National Laboratories (Figs. 1 and 15). Since startup of the new system, TFA has not exceeded the 5 ppb total VOC discharge requirements limit.

From 1989 through September 1994, TFA treated ground water extracted from well W-415. The TFA North and TFA Arroyo Pipelines connected nine additional extraction wells to TFA in September 1994. The TFA South Pipeline connected eight additional extraction wells to TFA in July 1995. The TFA North Pipeline connected one additional extraction well to TFA in June 1998, and two additional extraction wells in July 1998. Extraction wells and pipelines are shown in Figure 15.

In 1998, additional vadose zone infiltration experiments were conducted in the TFA area. These experiments began in November 1998 and are planned to continue into 1999. The first experiment involved infiltration of 400 gal of water containing 1-micron-diameter polystyrene spheres, which are non-reactive but fluoresce, and trace quantities of deuterated water, lithium bromide and potassium iodide. The infiltration events were monitored using absorbent pads, hybrid lysimeter/tensiometers, thermisters, and gypsum blocks deployed in boreholes using an instrumented membrane technology. The objective of these studies is to better understand the relationship between saturation changes near the water table and the arrival of chemical tracers.

5.1.1. Performance Summary

During 1998, TFA treated more than 124 million gal of ground water containing an estimated 15.0 kg of VOCs (Table 2). Since system startup in 1989, TFA has treated about 515 million gal of ground water and removed about 109 kg of VOC mass from the subsurface (Table 3).

The TFA VOC plumes in HSUs 1B, 2, and 3A continue to be hydraulically controlled based on trends in ground water chemistry and capture zone analysis shown on the ground water elevation contour maps (Figs. 5, 6, and 7) and the total VOC isoconcentration maps (Figs. 10, 11, and 12) for each HSU. Offsite HSU 1B extraction well W-408 was temporarily shut down to increase pumping in HSU 2 Arroyo pipeline extraction wells during the Fourth Quarter of 1998. W-408 will be re-started in 1999 to ensure capture of the HSU 1B VOC plume at well W-1425 where the PCE concentration was 8.3 ppb in September 1998.

5.1.2. Field Activities

Two wells and three boreholes were installed in the TFA area in 1998. Monitor wells W-1424 and W-1425 were completed in HSUs 2 and 1B, respectively, west of LLNL and north of Arroyo Seco. Three boreholes were also drilled for the infiltration studies. Ground water monitor wells SIP-INF-201 and SIP-INF-202 were installed in two of the boreholes, each completed in HSU 1B. In the third borehole, a vadose zone monitor well IMS-INF-203 was constructed using the impermeable everted membrane system that carries soil vapor sampling instrumentation down an unlined borehole (Keller and Lowry, 1991). Well construction details are provided in Table A-1 of Appendix A.

In 1998, two one-hour drawdown tests were conducted in the TFA area on wells W-1424 and W-1425. Results are presented in Appendix B. No other hydraulic tests were conducted in the TFA area during 1998.

5.2. Treatment Facility B

TFB is located north of Mesquite Way in the west-central portion of the Livermore Site (Fig. 1). In 1998, TFB treated ground water from six extraction wells, including three HSU 1B wells (W-610, W-620, and W-704), and three HSU 2 wells (W-357, W-621, and W-655). TFB was operated at flow rates ranging from 39 to 60 gpm in 1998.

In October 1998, a new ground water treatment system was installed at TFB. From 1990 to August 1998, TFB processed VOCs in ground water using an ultra-violet/hydrogen peroxide (UV/H_2O_2) system that breaks down VOCs into carbon dioxide and chloride ions. The water was further processed with an air stripper to remove any remaining VOCs. Ground water was also treated for hexavalent chromium by adding hydrogen peroxide and carbon dioxide. In October 1998, the UV/H_2O_2 system was replaced with a more cost-effective large-capacity air-stripping system. The effluent air from the air stripper is passed through GAC to remove VOCs. The treated effluent air is vented to the atmosphere. Ground water is treated for hexavalent chromium using an ion-exchange unit. TFB requires treatment for hexavalent chromium only during the winter months based on the current RWQCB discharge substantive requirements. This new system is designed to treat up to 75 gpm of ground water.

Treated ground water from TFB is discharged into the north-flowing drainage ditch parallel to Vasco Road that empties into Arroyo Las Positas to the north (Fig. 16). TFB was in compliance throughout 1998.

From 1990 through September 1995, TFB treated ground water extracted from wells W-357 and W-704. The TFB North Pipeline and TFB West Pipeline connected four additional extraction wells to TFB in September 1995. The six extraction wells are shown in Figures 1 and 16.

5.2.1. Performance Summary

During 1998, TFB treated over 18 million gal of ground water containing an estimated 5.2 kg of VOCs (Table 2). Since system startup in 1990, TFB has treated about 83 million gal of ground water and removed about 31 kg of VOC mass from the subsurface (Table 3).

The TFB VOC plumes in HSUs 1B and 2 continue to be hydraulically controlled based on trends in ground water chemistry and capture zone analysis shown on the ground water elevation contour maps (Figs. 5 and 6) and the total VOC isoconcentration maps (Figs. 10 and 11) for each HSU.

5.2.2. Field Activities

Three wells were installed in the TFB area during 1998. Extraction well W-1423 was installed in HSU 2 and is scheduled to be connected to TFB in 1999. Monitor wells W-1420 and W-1426 were completed in HSUs 2 and 1B, respectively, in the western TFB area (Fig. 1). Well construction details are provided in Table A-1 of Appendix A.

In 1998, one-hour drawdown tests were conducted in the TFB area on wells W-1420, W-1423, and W-1426. Results are presented in Appendix B. No other hydraulic tests were conducted in the TFB area during 1998.

5.3. Treatment Facility C

TFC is located north of Westgate Drive and west of Avenue A in the northwest quadrant of the Livermore Site (Fig. 1). In 1998, TFC treated ground water from six HSU 1B extraction wells (W-701, W-1015, W-1102, W-1103, W-1104, and W-1116). Portable Treatment Unit (PTU) location TFC Southeast (TFC-SE) is located near the intersection of Avenue A and Sixth Street in the northwest quadrant of the Livermore Site (Fig. 1). TFC-SE treats ground water from one HSU 1B well (W-1213). The combined TFC facilities operated at flow rates ranging from 47 to 55 gpm in 1998.

TFC and TFC-SE process VOCs in ground water using air stripping. The effluent air from the stripper is treated with GAC prior to discharge to the atmosphere. Ground water is treated for hexavalent chromium using ion-exchange. The water from TFC and TFC-SE requires treatment for hexavalent chromium only during the winter months based on the current RWQCB discharge substantive requirements.

Treated ground water from TFC is discharged into a north-flowing drainage ditch that empties into Arroyo Las Positas (Fig. 17). Treated ground water from TFC-SE is discharged into a storm sewer that empties into Arroyo Las Positas to the north (Fig. 18). TFC was in compliance with all permits throughout 1998.

From 1993 through September 1996, TFC treated ground water extracted from well W-701. The TFC North Pipeline connected five additional extraction wells to TFC in September 1996. TFC-SE began operation in January 1997. TFC and TFC-SE extraction wells and discharge locations are shown on Figures 17 and 18, respectively.

5.3.1. Performance Summary

During 1998, the combined TFC facilities treated more than 23 million gal of ground water containing an estimated 7.9 kg of VOCs (Table 2). Since system start up in 1993, the combined TFC facilities have treated nearly 59 million gal of ground water and removed about 23 kg of VOC mass from the subsurface (Table 3).

In the TFC area, VOCs are confined to HSU 1B. The VOC plumes in the TFC area continue to be hydraulically controlled based on trends in ground water chemistry and capture zone analysis shown on the ground water elevation contour map (Fig. 5) and the total VOC isoconcentration map for HSU 1B (Fig. 10).

5.3.2. Field Activities

Three wells were installed in the TFC area during 1998. Monitor wells W-1427, W-1428, and W-1501 were completed in HSU 1B in the northwestern portion of the TFC area. Well construction details are provided in Table A-1 of Appendix A.

A one-hour drawdown test was conducted in the TFC area on well W-1501. Results are presented in Appendix B.

5.4. Treatment Facility D

TFD is located north of the Drainage Retention Basin (DRB) in the east-central portion of the Livermore Site (Fig. 1). In 1998, TFD was expanded to include permanent connections for extraction wells W-1206 and W-1208. Dual screened well, W-907, has a packer set to enable extraction from the lower screened interval (HSU 5) only. In 1998, TFD treated ground water from five extraction wells, including one HSU 2 well (W-906) one HSU 3A well (W-1208), two HSU 4 wells (W-351 and W-1206), and one HSU 5 well (W-907).

One new extraction location, TFD Southeast (TFD-SE), was activated in March 1998 using PTU11. TFD-SE is located south of the East Traffic Circle and east of Inner Loop Road (Figs. 1 and 20). TFD-SE treats ground water from two extraction wells, including one HSU 2 well (W-1308) and one HSU 4 well (W-314).

Two other extraction locations, TFD West (TFD-W) and TFD East (TFD-E), continued to treat ground water in 1998 using PTUs. TFD-W is located south of North Inner Loop Road in the central portion of the Livermore Site (Figs. 1 and 21). TFD-W treats ground water from two HSU 2 extraction wells (W-1215 and W-1216). TFD-E is located east of the DRB in the east-central portion of the Livermore Site (Figs. 1 and 22). TFD-E treats ground water from four extraction wells, including two HSU 2 wells (W-1303 and W-1306), one HSU 3A well (W-1301), and one HSU 4 well (W-1307). The combined TFD facilities were operated at flow rates ranging from 111 to 163 gpm in 1998.

TFD, TFD-W, TFD-E, and TFD-SE process ground water for treatment of VOCs using air stripping. The effluent air from the stripper is treated using GAC prior to venting to the atmosphere. Treated ground water from TFD and TFD-E is discharged either into the DRB or into an underground pipeline downstream of the DRB weir, and flows northward to Arroyo Las Positas (Figs. 19 and 22). Treated ground water from TFD-W is discharged into a nearby storm sewer that also empties into Arroyo Las Positas (Fig. 21). Treated ground water from TFD-SE is discharged into a lined drainage ditch which flows northwest into the DRB (Fig. 20). All TFD facilities were in compliance throughout 1998.

TFD began operation in September 1994 treating ground water from wells W-351, W-906, and W-907. In January 1997, well W-1208 was connected to TFD. Wells W-1206 and W-1208 were permanently connected to TFD in April 1998. PTU location TFD-W was activated in April 1997. PTU location TFD-E began operation in September 1997. PTU location TFD-SE was activated on March 27, 1998, to meet the RAIP milestone date.

5.4.1. Performance Summary

During 1998, the combined TFD facilities treated more than 63 million gal of ground water containing an estimated 73.3 kg of VOCs (Table 2). Since system start up in 1994, the combined TFD facilities have treated over 124 million gal of ground water and removed about 147 kg of VOC mass from the subsurface (Table 3).

The TFD area extraction wells hydraulically control VOCs in HSUs 2, 3A, 4, and 5 based on the capture zone analysis shown on the ground water elevation contour maps (Figs. 6, 7, 8, and 9) and the total VOC isoconcentration maps (Figs. 11, 12, 13, and 14) for each HSU. Distal VOC plumes in the western TFD area should be hydraulically controlled once planned TFC-East and TFC-Northeast treatment facilities are operating.

5.4.2. Field Activities

Eight wells were installed in the TFD area during 1998, including extraction wells W-1419 (HSU 2), W-1417 (HSU 3A), and W-1504 (HSU 3A/3B), and W-1421 (HSU 4), and W-1503 (HSU 4). These five wells are scheduled for connection to the TFD-S PTU in 1999. Monitor well W-1416 was completed in HSU 2 in the TFD-E area, and monitor wells W-1408 (HSU 3A) and W-1502 (HSU 2) were completed in the TFD-SE area. Well construction details are provided in Table A-1 of Appendix A.

In 1998, one-hour drawdown tests were conducted on TFD area wells W-1408, W-1416, W-1417, and W-1421. Eight-hour step-drawdown tests were performed on proposed extraction wells W-1417, W-1419, and W-1421 to evaluate their effectiveness. Results are presented in Appendix B.

5.4.3. Field-Scale Pilot Tests

Following the successful treatability test conducted at TFD in 1997, the Solar-Powered Water Activated-Carbon Treatment (SWAT) unit was again connected to well W-361, located south of the DRB (Fig. 1) in September 1998. The SWAT uses a solar-powered pump to extract ground water, which is then passed through a series of three 55 gal GAC canisters for treatment. The treated ground water is discharged into the DRB. During 1998, the SWAT unit treated about 80,000 gal of ground water containing an estimated 0.6 kg of VOCs.

An additional PTU was operated at wells W-1220 and W-1218 from March 1998 to November 1998 in the southern part of the TFD area to expedite VOC mass removal and site cleanup. Wells W-1220 and W-1218 pumped at a combined flow rate of about 25 gpm, and treated about 7 million gal of ground water containing an estimated 2.4 kg of VOCs. These data are included in the TFD volume and VOC mass numbers presented in Tables 2 and 3.

5.5. Treatment Facility E

The TFE area is located in the southeastern quadrant of the Livermore Site. In 1998, TFE East (TFE-E) continued treating ground water using a PTU. TFE-E is located in the east-central portion of the Livermore Site (Figs. 1 and 23). TFE-E treats ground water from two extraction wells, W-1109 (HSU 2) and W-566 (HSU 5). TFE-E operated at flow rates ranging from 18 to 47 gpm in 1998.

One additional extraction location, TFE Northwest (TFE-NW), began operation in 1998 using a PTU. TFE-NW is located south of the Inner Loop Road, immediately west of Southgate Drive (Figs. 1 and 24). TFE-NW treats ground water from two extraction wells, W-1409 (HSU 2) and W-1211 (HSU 4).

TFE-E and TFE-NW process ground water for treatment of VOCs using an air stripper, and the effluent air is treated using GAC to remove VOCs prior to venting to the atmosphere. Treated ground water from TFE-E is discharged into a drainage ditch that flows north into the DRB (Fig. 23). Treated ground water from TFE-NW is discharged into a storm drain that flows north into Arroyo Las Positas (Fig. 24). TFE-E and TFE-NW were in compliance throughout 1998.

PTU location TFE-E began operation in November 1996, and TFE-NW was activated on June 23, 1998, 3 days ahead of its RAIP milestone date.

5.5.1. Performance Summary

During 1998, the combined TFE facilities treated more than 14 million gal of ground water containing an estimated 16.7 kg of VOCs (Table 2). Since system start up in 1996, the combined TFD facilities have treated over 24 million gal of ground water and removed about 34 kg of VOC mass from the subsurface (Table 3).

The TFE-E extraction wells provide hydraulic containment of some portions of VOC plumes in HSUs 2, 4, and 5 in the TFE area based on the capture zone analysis shown on the ground water elevation contour maps (Figs. 6, 8, and 9) and the total VOC isoconcentration maps (Figs. 11, 13, and 14) for each HSU. The VOC plumes in HSUs 3A, 4, and 5, located in the western and southern TFE areas, should be hydraulically controlled once the TFE-Southwest, TFE-Southeast, and TFE-West treatment facilities are operating. The planned start-up dates for these treatment facilities are March and June of 2000, and January 2001, respectively.

5.5.2. Field Activities

Three wells were installed in the TFE area during 1998. Extraction well W-1409 was installed in HSU 2 in the TFE-NW area. Monitor wells W-1418 and W-1422 were completed in HSUs 4 and 3B, respectively. Well construction details are provided in Table A-1 of Appendix A.

In 1998, one-hour drawdown tests were conducted in the TFE area on wells W-1418 and W-1422. In addition, eight-hour step-drawdown tests were conducted on these two wells to estimate extraction rates. Results are presented in Appendix B.

5.5.3. Field-Scale Pilot Tests

An additional PTU was operated at wells W-1418 and W-1422 in December 1998 in the northern part of the TFE area to expedite VOC mass removal and site cleanup. Pumping at these wells is planned to continue into 1999. During 1998, wells W-1418 and W-1422 pumped at a combined flow rate of about 10 gpm, and treated about 137,000 gal of ground water containing an estimated 0.9 kg of VOCs. These data are included in the TFE volume and mass numbers presented in Tables 2 and 3.

5.6. Treatment Facility G

Treatment Facility G is located in the south-central portion of the Livermore Site. Treatment Facility G-1 (TFG-1) is located near Avenue B, about 300 ft north of East Avenue in the south-central part of the Livermore Site (Figs. 1 and 25). TFG-1, activated in April 1996, treats ground water from extraction well W-1111 (HSU 2) and operated at flow rates ranging from 6.5 to 8 gpm in 1998.

TFG-1 processes ground water for VOC treatment using an air stripper, and the effluent air is treated using GAC to remove VOCs prior to venting to the atmosphere. Ground water is treated for hexavalent chromium using an ion-exchange unit. Under the current RWQCB discharge substantive requirements, water from TFG-1 requires treatment for hexavalent chromium only during the winter months.

Treated ground water from TFG-1 is discharged to a storm drain located about 50 ft north of TFG-1 (Fig. 25), which empties into Arroyo Seco. TFG-1 was in compliance throughout 1998.

5.6.1. Performance Summary

During 1998, TFG-1 treated about 3 million gal of ground water containing an estimated 0.4 kg of VOCs (Table 2). Since system startup in 1996, TFG-1 has treated over 7 million gal of ground water and removed about 1.2 kg of VOC mass from the subsurface (Table 3).

TFG-1 extraction well W-1111 provides hydraulic control of HSU 2 in the TFG area based on the capture zone analysis shown on the ground water elevation contour map (Fig. 6) and the total VOC isoconcentration map for HSU 2 (Fig. 11).

5.6.2. Field Activities

No boreholes or wells were drilled and no hydraulic tests were conducted in the TFG area during 1998.

5.6.3. Field-Scale Pilot Tests

Since January 1998, a treatability study using GAC to treat ground water from extraction well W-1111 has been underway. Three 400-lb GAC canisters in series are used to process water from well W-1111. The existing PTU was used for backup treatment during the test to ensure that no VOCs were discharged. Breakthrough of the first carbon canister occurred after three months of operation. At the time of breakthrough, 690,000 gal of ground water had already been treated. The GAC treatment unit has proved to be effective and efficient. Based on the results of the test, a GAC treatment unit (GTU) will replace the PTU at TFG-1 in 1999.

5.7. Treatment Facility 406

TF406 is located east of Southgate Drive near East Avenue in the south-central part of the Livermore Site (Figs. 1 and 26). In 1998, TF406 treated ground water from three extraction wells, GSW-445 and W-1309 (HSU 4) and W-1310 (HSU 5). TF406 was operated at flow rates ranging from 13 to 34 gpm in 1998.

TF406 processes ground water for VOC treatment using an air stripper, and the effluent air is treated using GAC to remove VOCs prior to discharge to the atmosphere. All treated ground water is discharged to a storm drain that flows to Arroyo Las Positas (Fig. 26). TF406 was in compliance throughout 1998.

When activated in August 1996, TF406 processed ground water from extraction wells GSW-445 and W-1114. In 1997, well W-1114 was destroyed and two new extraction wells, W-1309 and W-1310 were installed. TF406 began processing ground water from wells W-1309 and W-1310 in February 1998. Cumulative flow from the three extraction wells is about 26 gpm.

Passive bioremediation continued in the TF406 area during 1998 to remediate fuel hydrocarbons (FHCs) in HSUs 3A and 3B. Active ground water extraction and treatment for residual dissolved FHCs at Treatment Facility F was discontinued in 1996 with regulatory agency concurrence (RWQCB, 1996).

5.7.1. Performance Summary

During 1998, TF406 treated about 12 million gal of ground water from wells W-1309, W-1310, and GSW-445 containing an estimated 2.1 kg of VOCs (Table 2). Since system startup in 1996, TF406 has treated over 14 million gal of ground water and removed about 3.2 kg of VOC mass from the subsurface (Table 3).

The TF406 extraction wells provide significant hydraulic control of VOC plumes in HSUs 4 and 5 in the TF406 area based on trends in ground water chemistry and capture zone analysis shown on the ground water elevation contour maps (Figs. 8 and 9) and the total VOC isoconcentration maps (Figs. 13 and 14) for each HSU. The VOC plumes in HSUs 3A, 4, and 5 should be hydraulically controlled once treatment facilities at TF406-Northwest and TF518-North are installed.

5.7.2. Field Activities

Two wells were installed in the TF406 area during 1998. Monitor well W-1410 was installed in HSU 3B, and monitor well W-1411 was installed in HSU 4. Well W-1411 was installed as a replacement well for GSW-10, damaged during the Dynamic Underground Stripping Demonstration Project. Well GSW-10 was drilled out, and well W-1411 was installed in the same borehole. Both new wells are located north of the TF406 PTU location. Well construction details are provided in Table A-1 of Appendix A. Well closure data are presented in Table A-2 of Appendix A.

One-hour drawdown tests were performed on monitor wells W-1410 and W-1411. Results are presented in Appendix B.

5.8. Vapor Treatment Facility 518

VTF518 is located in the southeastern quadrant of the Livermore Site, north of East Avenue and near Avenue H (Fig. 1). Soil vapor is extracted from the vadose zone using a vapor extraction system. VOCs are removed from the vapor using GAC canisters. Following treatment, the effluent air is discharged to the atmosphere. VTF518 was in compliance with the Bay Area Air Quality Management District permit throughout 1998.

VTF518 began operation in September 1995 by treating soil vapor from extraction well SVI-518-201. In 1991, extraction well SVI-518-303 was added to the system. VTF518 operated at flow rates ranging from 35 to 50 standard cubic feet per minute (scfm) in 1998.

5.8.1. Performance Summary

During 1998, VTF518 processed about 4,977,000 cubic feet (ft^3) of soil vapor, removing an estimated 27.3 kg of VOCs (Table 2). Since VTF518 began operating in September 1995, about 134 kg of VOC mass has been removed from approximately 11,173,000 ft^3 of soil vapor (Table 3).

5.8.2. Field Activities

Two Instrumented Membrane System (IMS) sampling/monitoring wells, SEA-518-301 and SEA-518-304, continue to monitor vadose zone remediation in the VTF518 area. The IMS system is used to collect vapor, pressure, soil temperature, soil moisture, and soil vapor concentration data from various discrete depths. VOC vapor concentrations at SEA-518-301, the IMS borehole nearest VTF518 vapor extraction well SVI-518-201, have declined from an average of 111 parts per million by volume (ppmv) in September 1995 to an average of 6.7 ppmv in the upper zones (6 ft, 15 ft, 26 ft and 37 ft) in September 1998. However, an increase has recently been observed in the lowest zone at 85 ft, from 143 ppmv in September 1995 to 220 ppmv in September 1998. Monitoring of the vadose zone will continue to evaluate the progress of remediation of the vadose zone in the VTF518 area.

5.9. Ground Water Treatment Facility 518

TF518 is located in the southeastern quadrant of the Livermore Site, north of East Avenue and near Avenue H, adjacent to VTF518 (Fig. 1). TF518 was constructed in 1997 and began operating on January 27, 1998, three days prior to its RAIP milestone date. In 1998, TF518 treated ground water from two extraction wells, W-112 (HSU 5) and W-211 (HSU 6). TF518 operated at flow rates ranging from 5 to 23 gpm in 1998.

Pumping from well W-211 was discontinued in May 1998 after six consecutive sampling events between September 1997 and April 1998 showed TCE concentrations remained below the 5 ppb Maximum Contaminant Level (MCL). An additional sample taken four months after pumping ceased indicates that concentrations in the well remain below the MCL. Quarterly sampling of well W-211 will continue in 1999.

Sustainable flow rates from well W-112 have decreased steadily during 1998 from about 20 gpm to about 5 gpm. Hydraulic data indicate that the cumulative pumping from HSU 5 wells at TF406, TFE-E and TF518 is significantly lowering water levels in the southeastern corner of the Livermore Site, thereby reducing the yield in well W-112.

In July 1998, the first miniature portable treatment unit (MTU-1) was activated in the TF518 area, replacing the full-size PTU that had processed ground water there since January 1998. Both the PTU and MTU process ground water for VOC treatment using an air stripper, and the effluent air is treated using GAC to remove VOCs prior to venting to the atmosphere. All treated ground water is discharged to a storm drain located about 250 ft north of TF518 that ultimately empties into Arroyo Las Positas (Fig. 27). TF518 was in compliance throughout 1998.

5.9.1. Performance Summary

Since facility startup in January 1998, TF518 has processed about 2.8 million gal of ground water containing an estimated 1.0 kg of VOCs (Tables 2 and 3).

The TF518 extraction wells provide hydraulic control of VOC plumes in HSU 5 in the TF518 source area based on the capture zone analysis shown on the ground water elevation contour map (Fig. 9) and the total VOC isoconcentration map (Fig. 14).

5.9.2. Field Activities

During 1998, three wells were installed in the TF518 area. Extraction well W-1414 was installed in the TF518 North (TF518-N) area in HSU 3A. This well was installed in the borehole created during the overdrilling of piezometer SIP-419-201, which was destroyed because it was screened over both HSUs 3A and 3B. VOC concentrations are an order of magnitude greater in HSU 3A than to HSU 3B in this area. Monitor wells W-1412 and W-1413 were also installed in the TF518-N area in HSUs 3A and 5, respectively. Well construction details are provided in Table A-1 of Appendix A. Well closure data for SIP-419-201 are presented in Table A-2 of Appendix A.

During 1998, a one-hour drawdown test was conducted on monitor well W-1413 and a slug test was conducted on monitor well W-1412. Results are presented in Appendix B.

5.10. Treatment Facility 5475

The TF5475 area is located in the southeastern quadrant of the Livermore Site (Fig. 1). Tritium in concentrations above its MCL is present in HSU 3A ground water in the T5475 area. TF5475-1 was activated on September 9, 1998, 21 days before its RAIP milestone date. TF5475-1 treats ground water from extraction well W-1302 (HSU 3A) and operated at flow rates ranging from 0.5 to 1.0 gpm in 1998.

TF5475-1 uses down-hole, *in situ* catalytic reductive dehalogenation (CRD) to treat VOCs in ground water. This technology is based upon the reaction of dissolved hydrogen, introduced to the ground water through a hydrophobic membrane, with VOCs on a palladium-alumina catalyst to form ethane and chloride. Because of the high reaction rates of CRD, treatment takes place during one pass through the unit, allowing the treatment unit to be placed in the well casing. This technology treats VOCs in ground water while keeping the tritium in the subsurface.

The CRD unit operates in extraction well W-1302, a dual-screened well in which the unit extracts from the lower screened interval and injects treated ground water containing tritium into the upper screened interval. TF5475-1 was in compliance throughout 1998.

5.10.1. Performance Summary

During 1998, TF5475-1 processed about 31,000 gal of ground water from well W-1302 and removed an estimated 0.4 kg of VOCs (Table 2). Since 1997, TF5475-1 has treated nearly 36,000 gal of ground water and removed about 0.5 kg of VOC mass from the subsurface (Table 3).

5.10.2. Field Activities

During 1998, one extraction well, W-1415, was installed in HSU 2 in the TF5475 area. Well construction details are provided in Table A-1 of Appendix A.

A one-hour drawdown test was conducted on W-1415. Results of the test are presented in Appendix B.

6. Trends in Ground Water Analytical Results

Notable results of VOC analyses of ground water received from January 1998 through December 1998 are discussed below. Figures 10 through 14 show isoconcentration maps for total VOCs underlying the Livermore Site and vicinity within HSU 1B, HSU 2, HSU 3A, HSU 4, and HSU 5, respectively. All chemical trends discussed below were based on a comparison of 1998 and 1997 annual isoconcentration maps (Hoffman, 1998).

1. In the TFA area, along the western margin of the site, total VOC concentrations east of Vasco Road near newly activated extraction well W-1001 (HSU 1B) declined below 100 ppb for the first time (Fig. 10). Offsite HSU 1B concentrations remained below the MCL for all contaminants of concern except for well W-1425 where PCE concentrations were 8.3 ppb in September 1998. Total VOC concentrations in HSU 2 declined from over 100 ppb to around 50 ppb near extraction well W-415 and the 50 ppb total VOC contour in HSU 2 is now east of extraction well W-904 (Fig. 11).
2. VOC concentrations in the western part of the TFB HSU 1B plume continued to decline, while concentrations around the TFB source area remained relatively unchanged. VOC concentrations in HSU 2 in the TFB area also remained relatively unchanged in 1998.
3. In the northwestern TFC area, concentrations of VOCs declined from over 100 ppb to about 50 ppb around extraction well W-1104. Concentrations in the TFC-SE area remain relatively unchanged from 1997.
4. In the TF406 area, along the southern margin of the Livermore Site, VOC concentrations are relatively unchanged in HSU 4 since 1997. Total VOC concentrations in HSU 5 south of the Livermore Site boundary declined from over 150 ppb to below 75 ppb in 1998 (well W-509, August 21, 1998 data). In the TFG area south of the Livermore Site boundary, total VOC concentrations in HSU 2 declined from a high of about 39 ppb to about 9 ppb total VOCs in 1998 (piezometer SIP-212-101, July 13, 1998 data).
5. In the eastern and southeastern TFD areas, total VOC concentrations in HSU 2 are beginning to decline as shown by the smaller area encompassed by the 500 total VOC ppb contour (Fig. 11). Total VOC concentrations in HSU 3A in the eastern and southeastern part of the Livermore Site remain relatively unchanged.
6. Total VOC concentrations in both HSU 4 and HSU 5 in the eastern part of the Livermore Site remained relatively unchanged in 1998. However, data from 1998 drilling indicate an additional area of high concentration (over 1,500 ppb total VOCs) in HSU 4 in the TFD/TFE-NW area (Fig. 13). A PTU will treat ground water in this high concentration area from HSU 4 monitor well W-1418 in 1999.

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Figures

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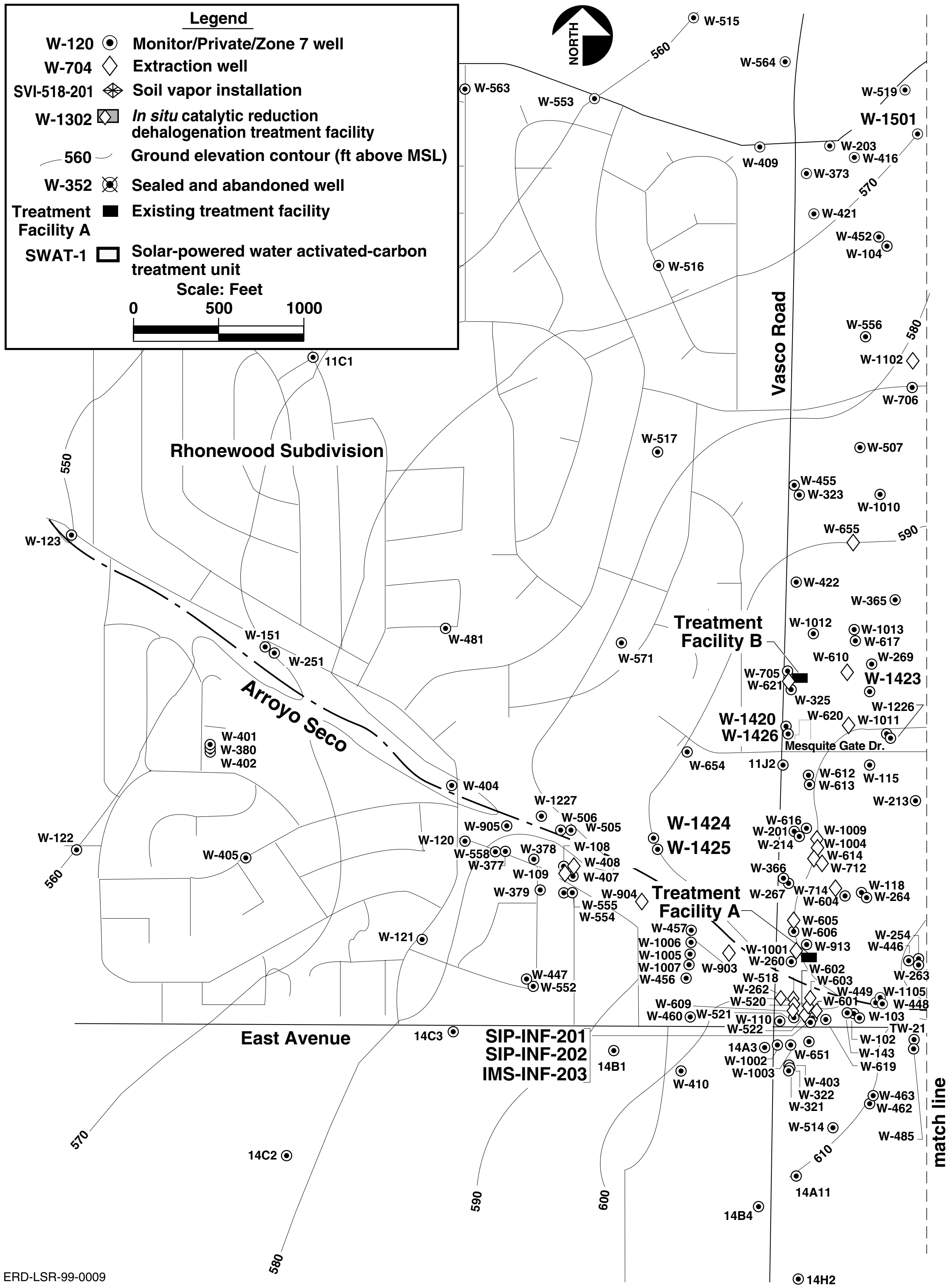

Figure 1. Locations of Livermore Site monitor wells, extraction wells, and treatment facilities, January 1999.

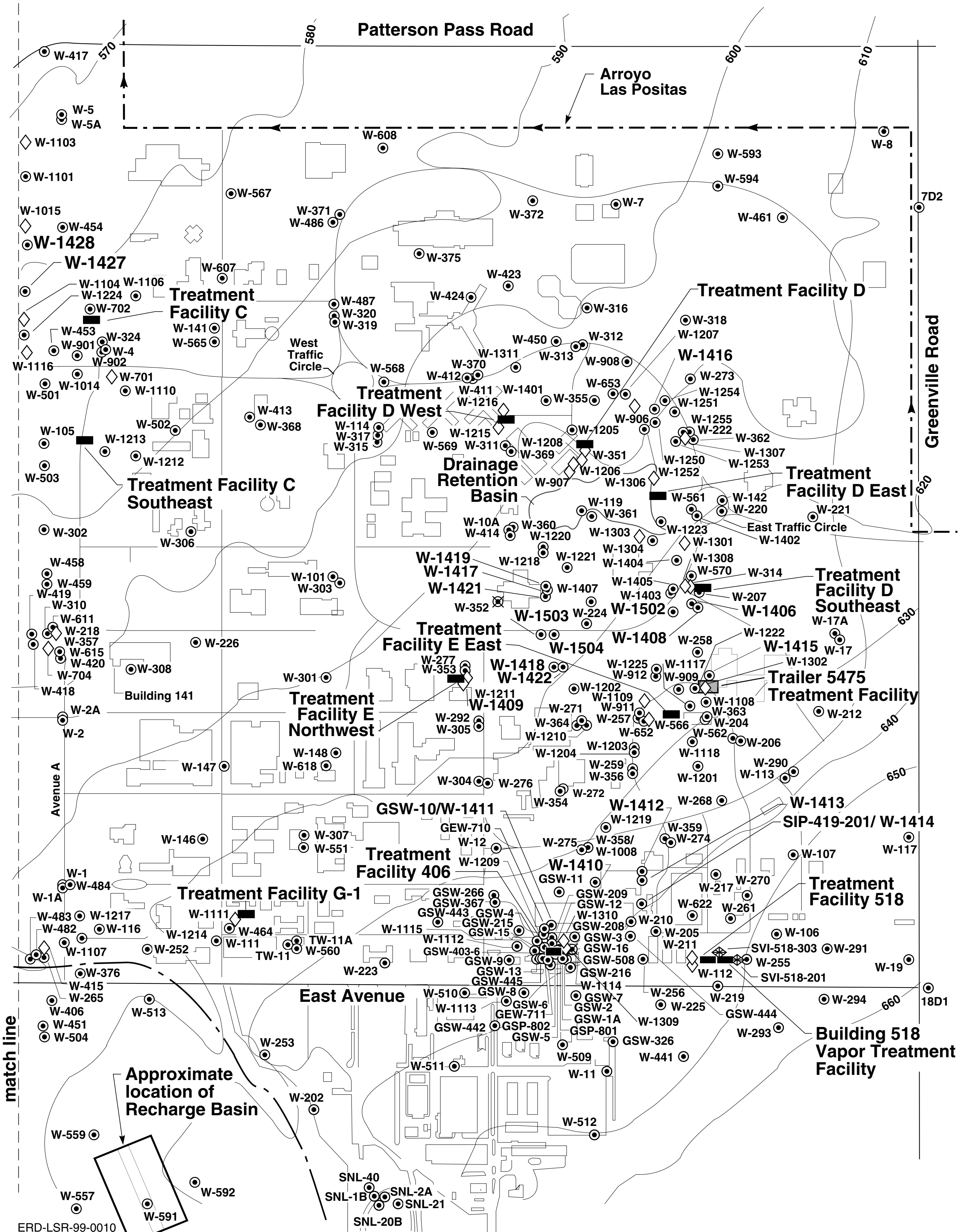

Figure 1 (continued).

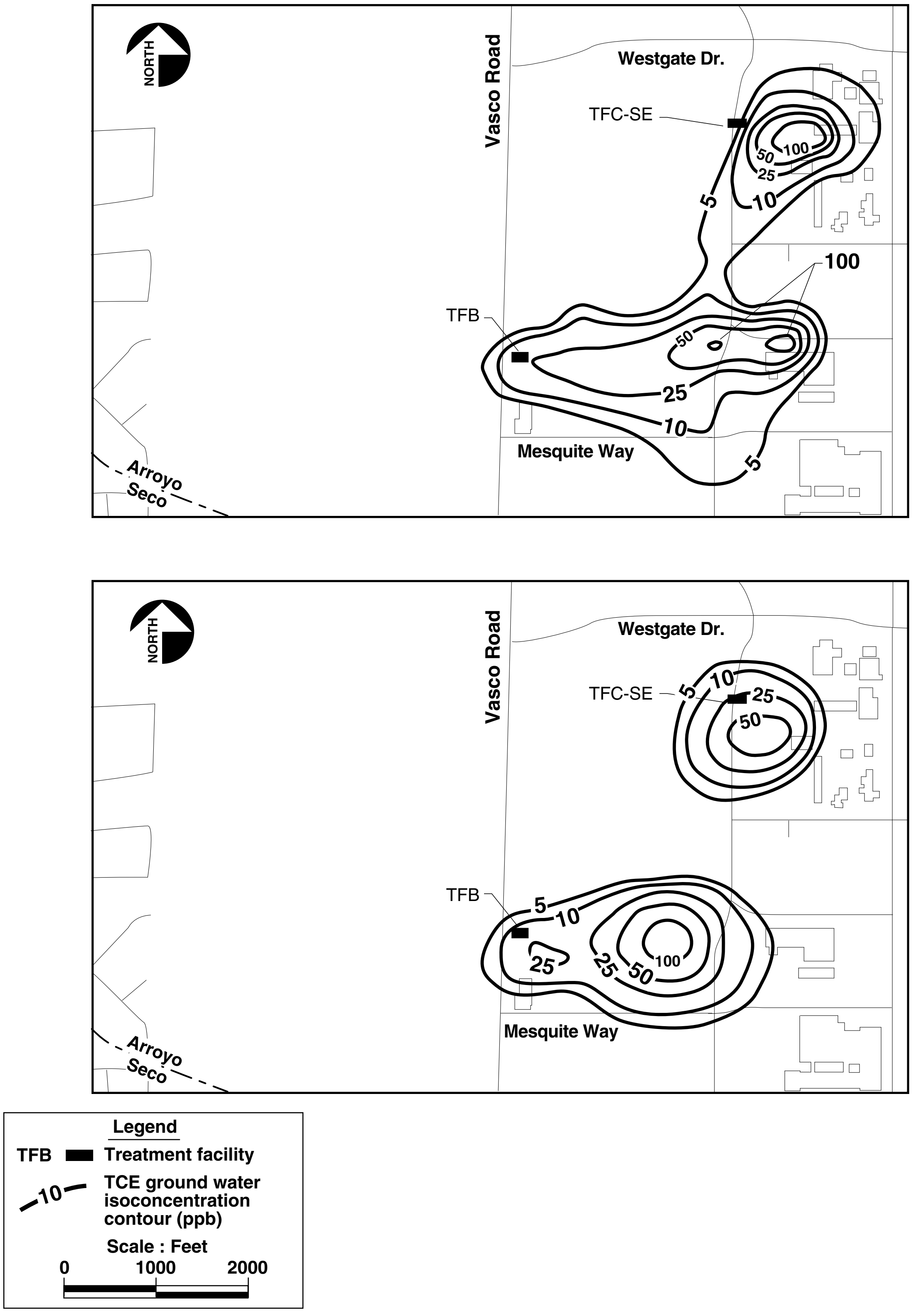

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Figure 2. Comparison of 1998 HSU 1B measured (top) and simulated (bottom) aqueous TCE concentrations in the TFB area.

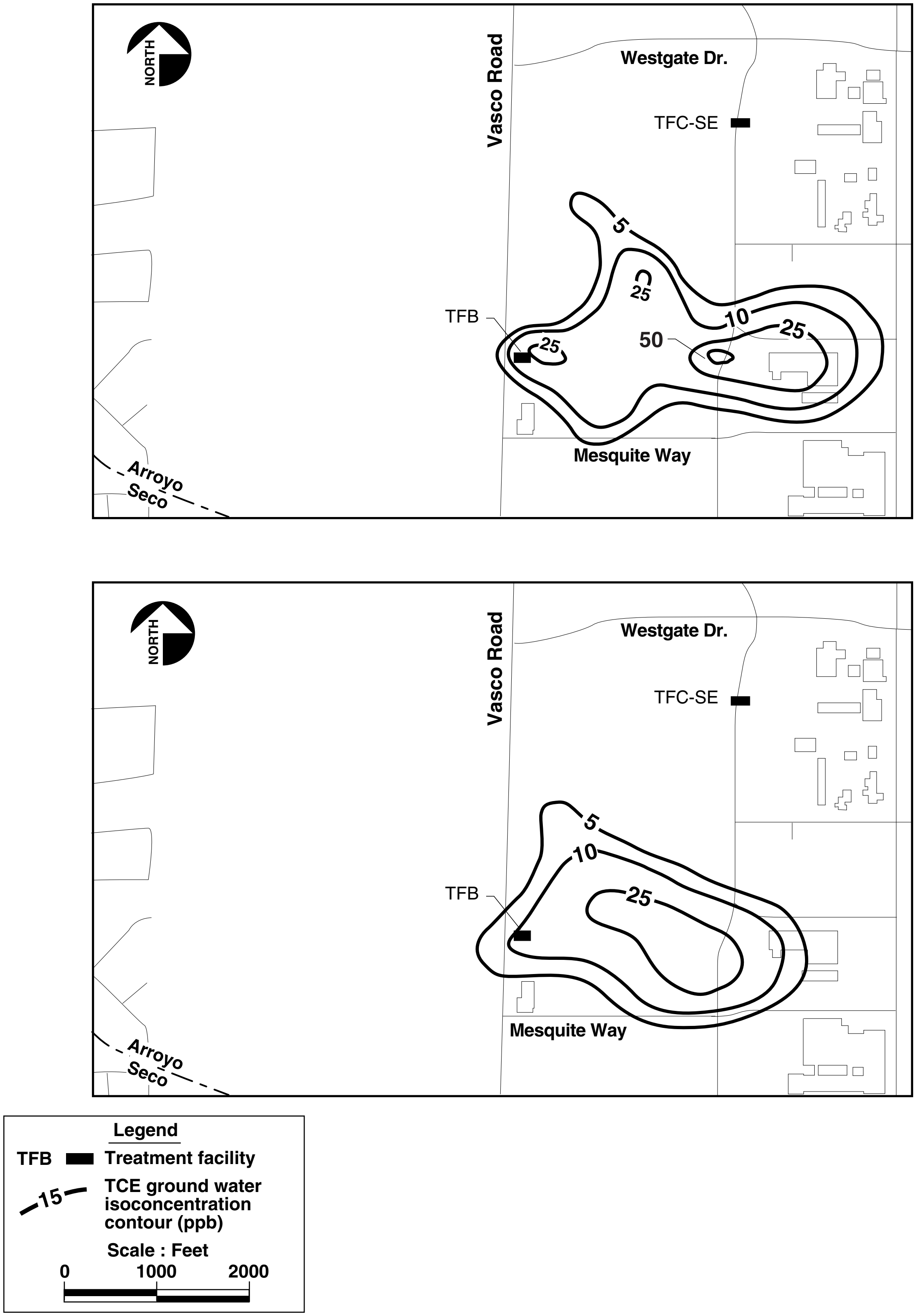

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Figure 3. Comparison of 1998 HSU 2 measured (top) and simulated (bottom) aqueous TCE concentrations in the TFB area.

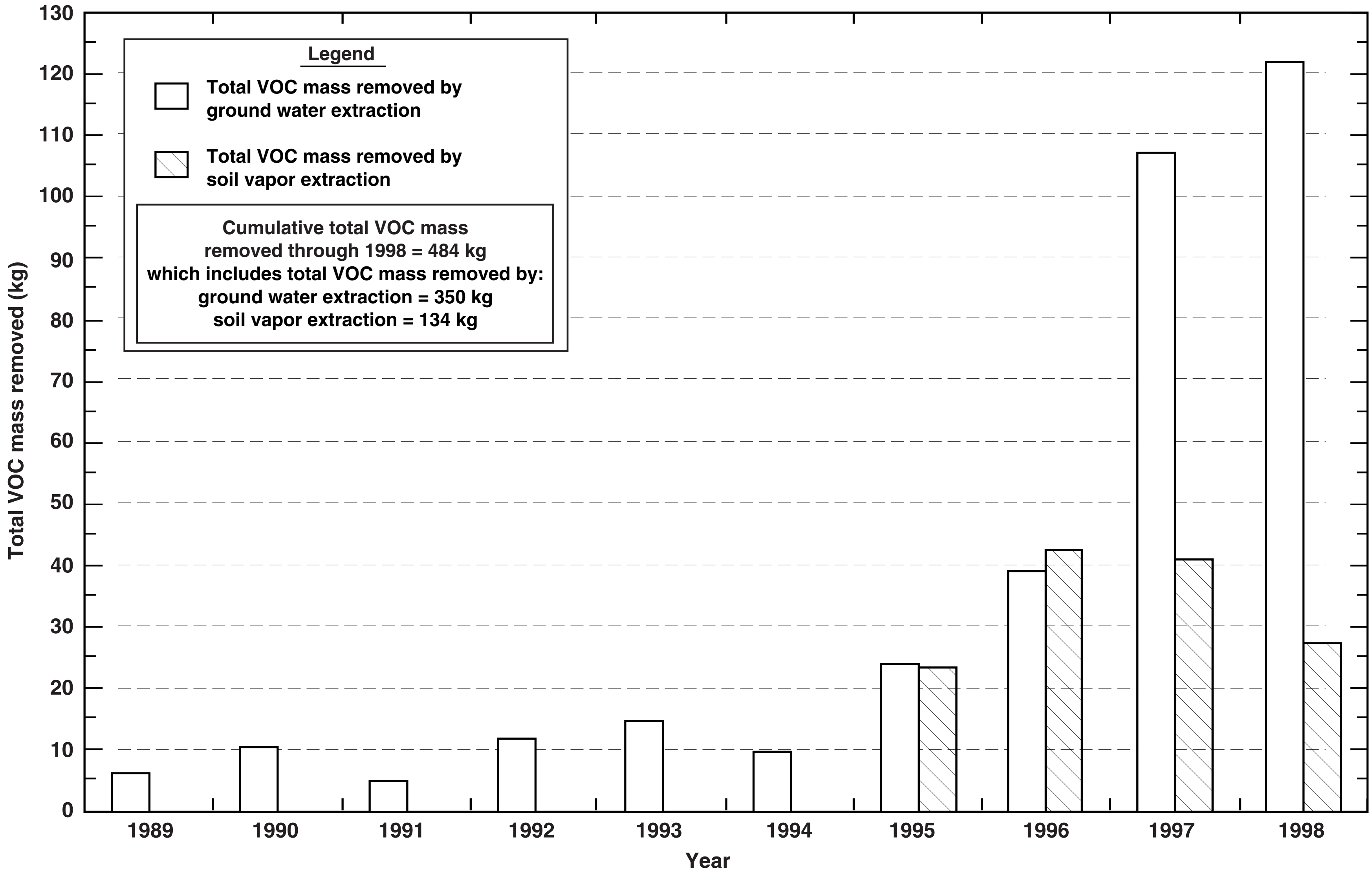

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Figure 4. Total VOC mass removed from the Livermore Site subsurface over time.

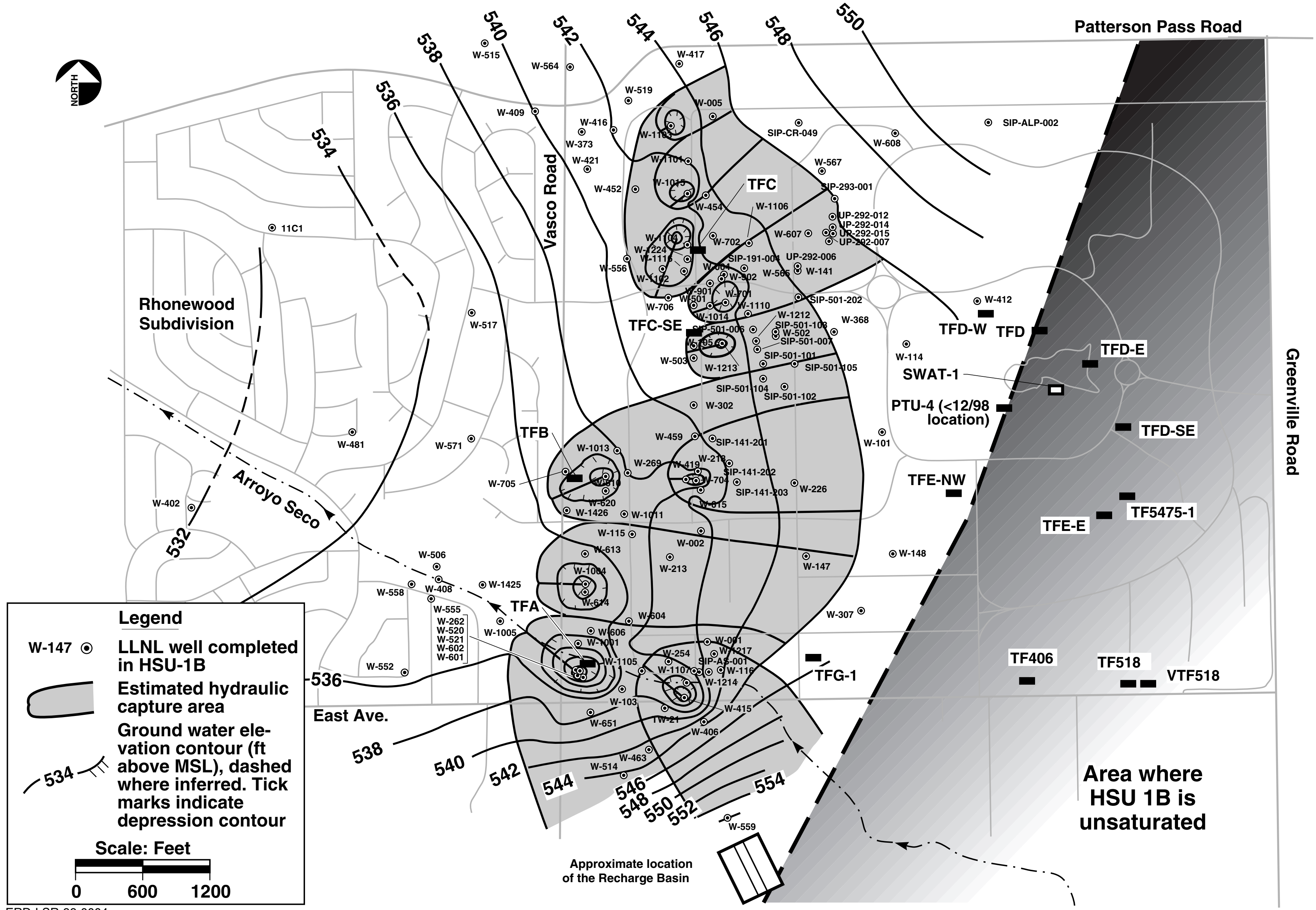

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Figure 5. Ground water elevation contour map based on water levels collected from 128 wells completed within HSU 1B showing estimated hydraulic capture areas, LLNL and vicinity, November 1998.

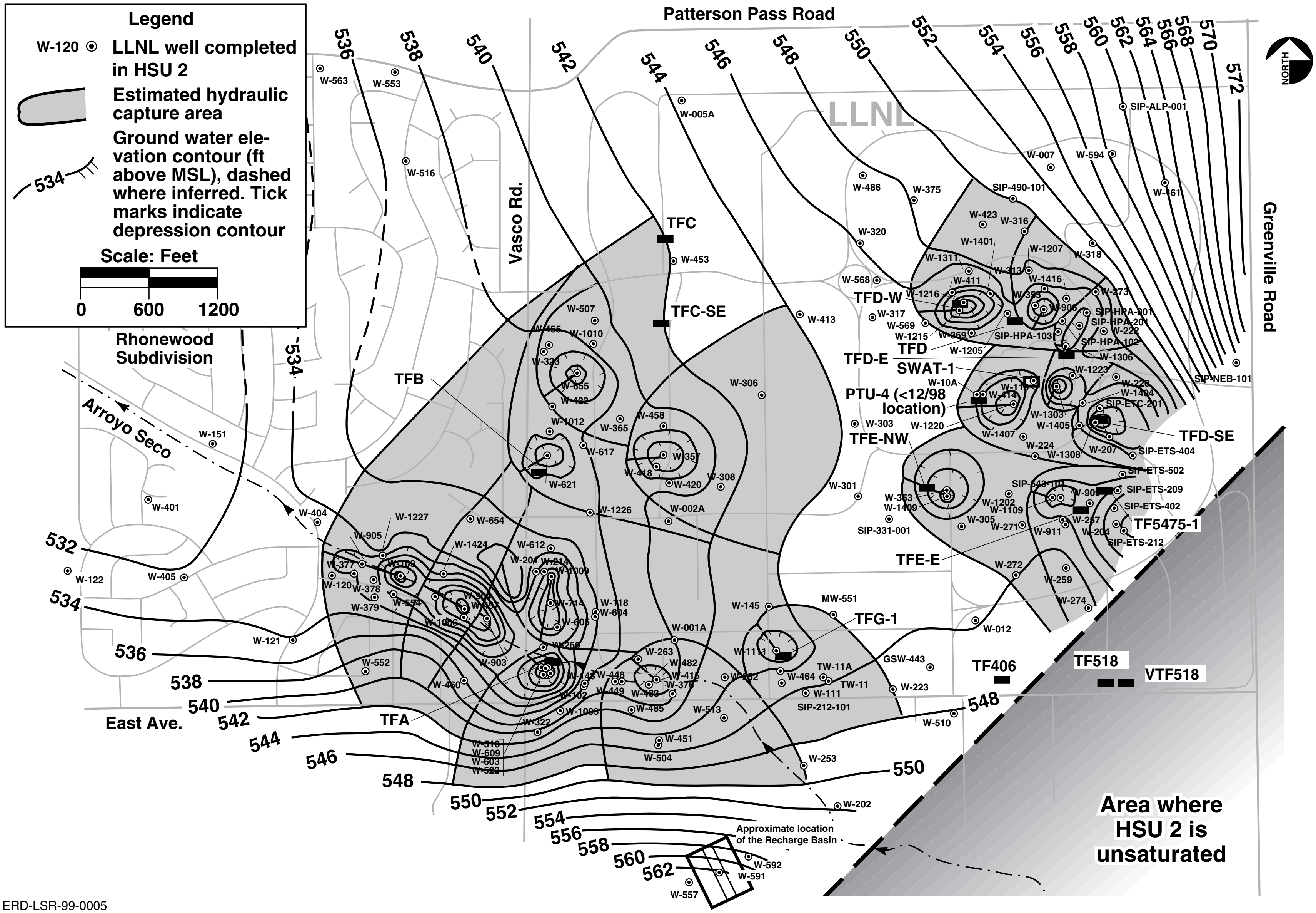

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Figure 6. Ground water elevation contour map based on water levels collected from 160 wells completed within HSU 2 showing estimated hydraulic capture areas, LLNL and vicinity, November 1998.

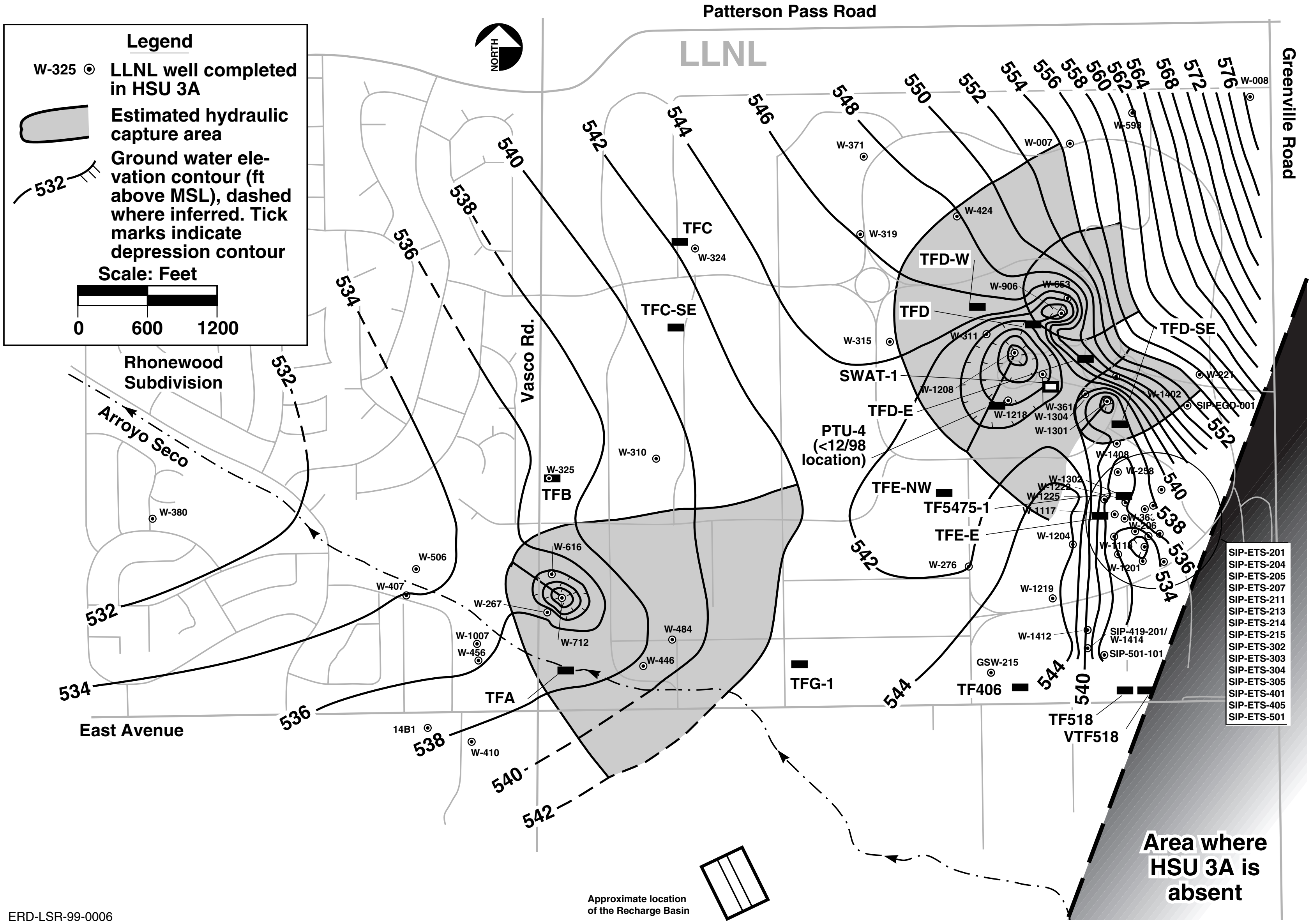

Figure 7. Ground water elevation contour map based on water levels collected from 63 wells completed within HSU 3A showing estimated hydraulic capture areas, LLNL and vicinity, November 1998.

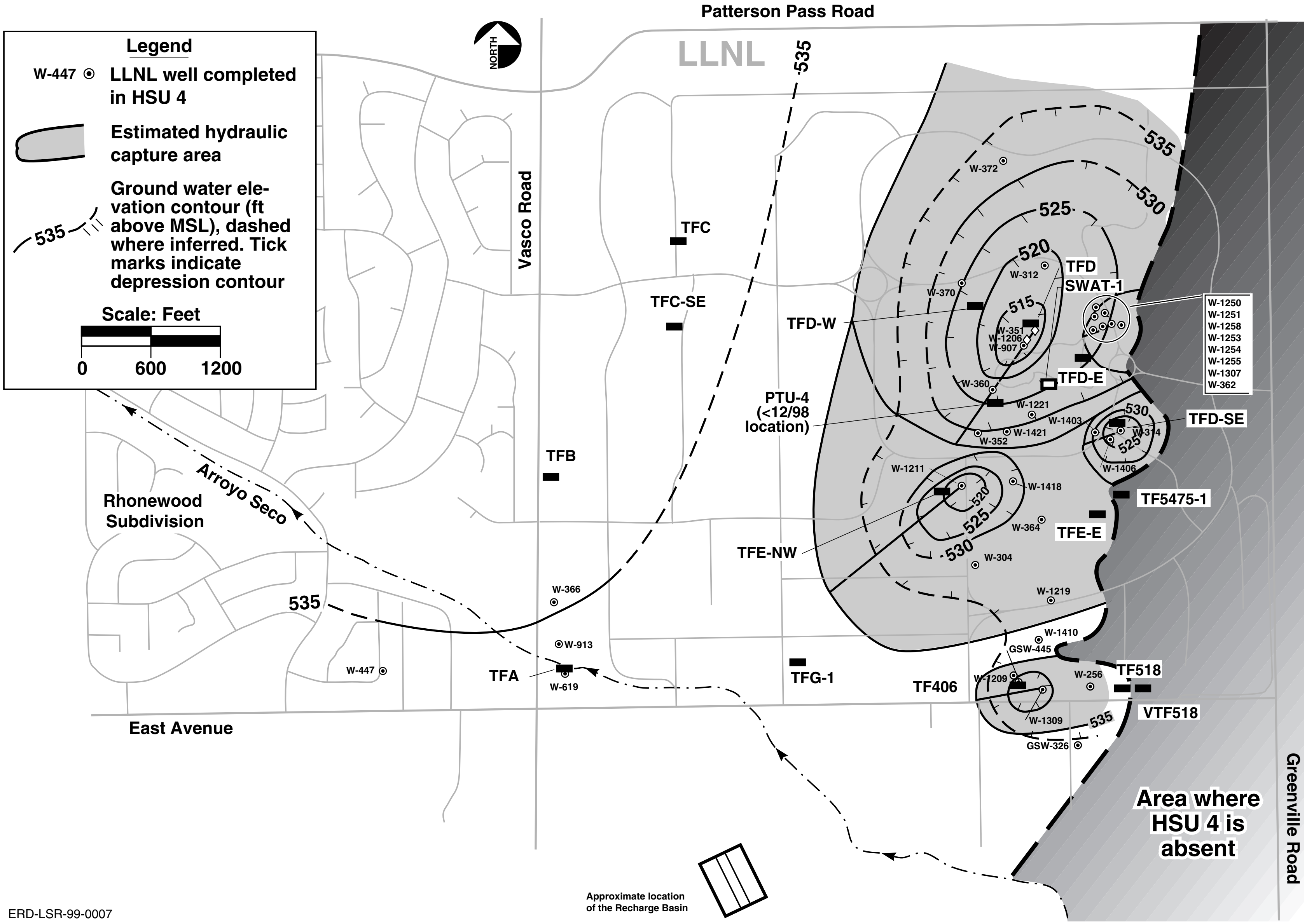

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Figure 8. Ground water elevation contour map based on water levels collected from 34 wells completed within HSU 4 showing estimated hydraulic capture areas, LLNL and vicinity, November 1998.

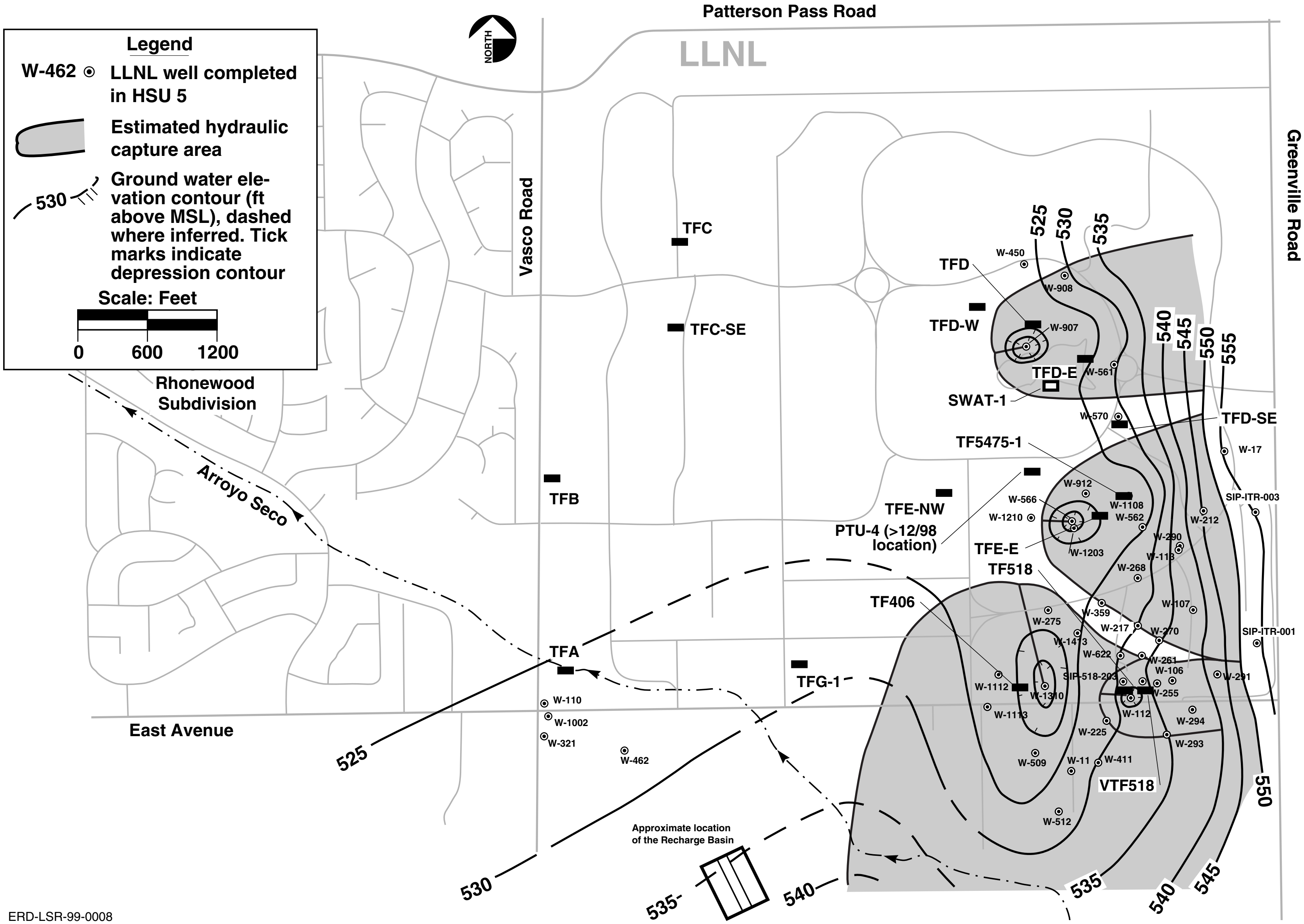

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Figure 9. Ground water elevation contour map based on water levels collected from 46 wells completed within HSU 5 showing estimated hydraulic capture areas, LLNL and vicinity, December 1998.

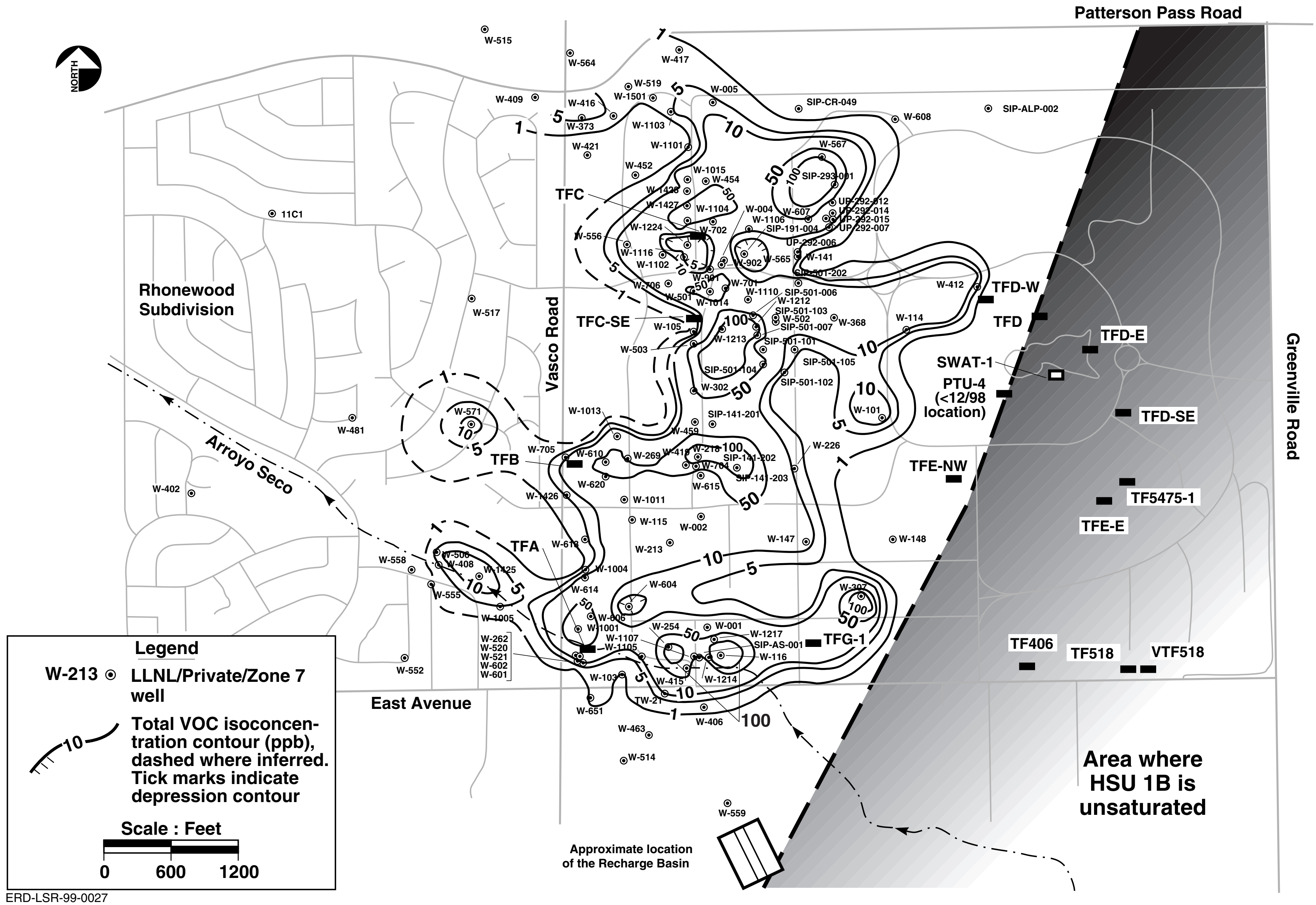

Figure 10. Isoconcentration contour map of total VOCs for 125 wells completed within HSU 1B based on samples collected in the fourth quarter of 1998 (or the next most recent data), and supplemented with soil chemistry data from 43 borehole locations.

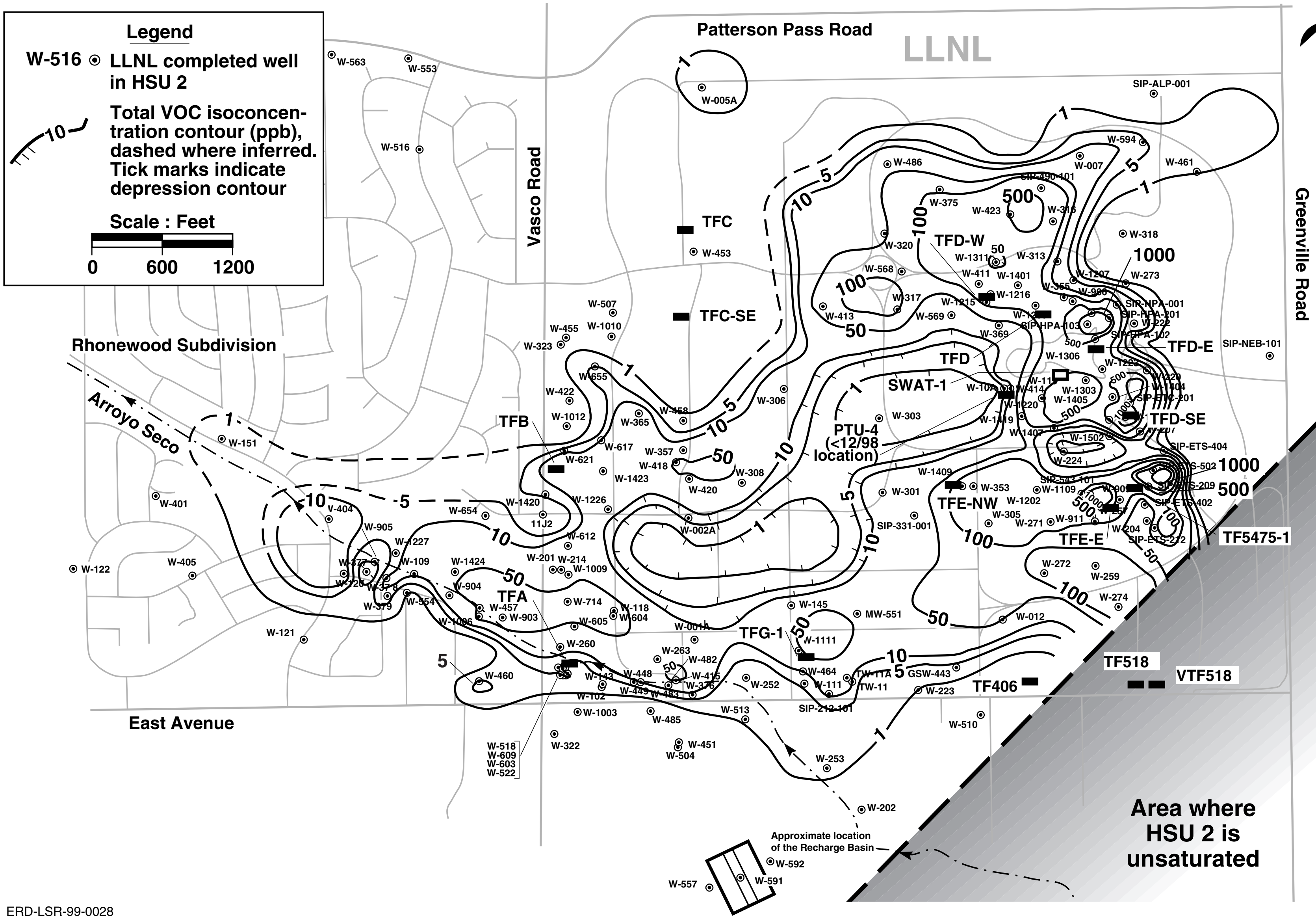

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Figure 11. Isoconcentration contour map of total VOCs for 179 wells completed within HSU 2 based on samples collected in the fourth quarter of 1998 (or the next most recent data), and supplemented with soil chemistry data from 106 borehole locations.

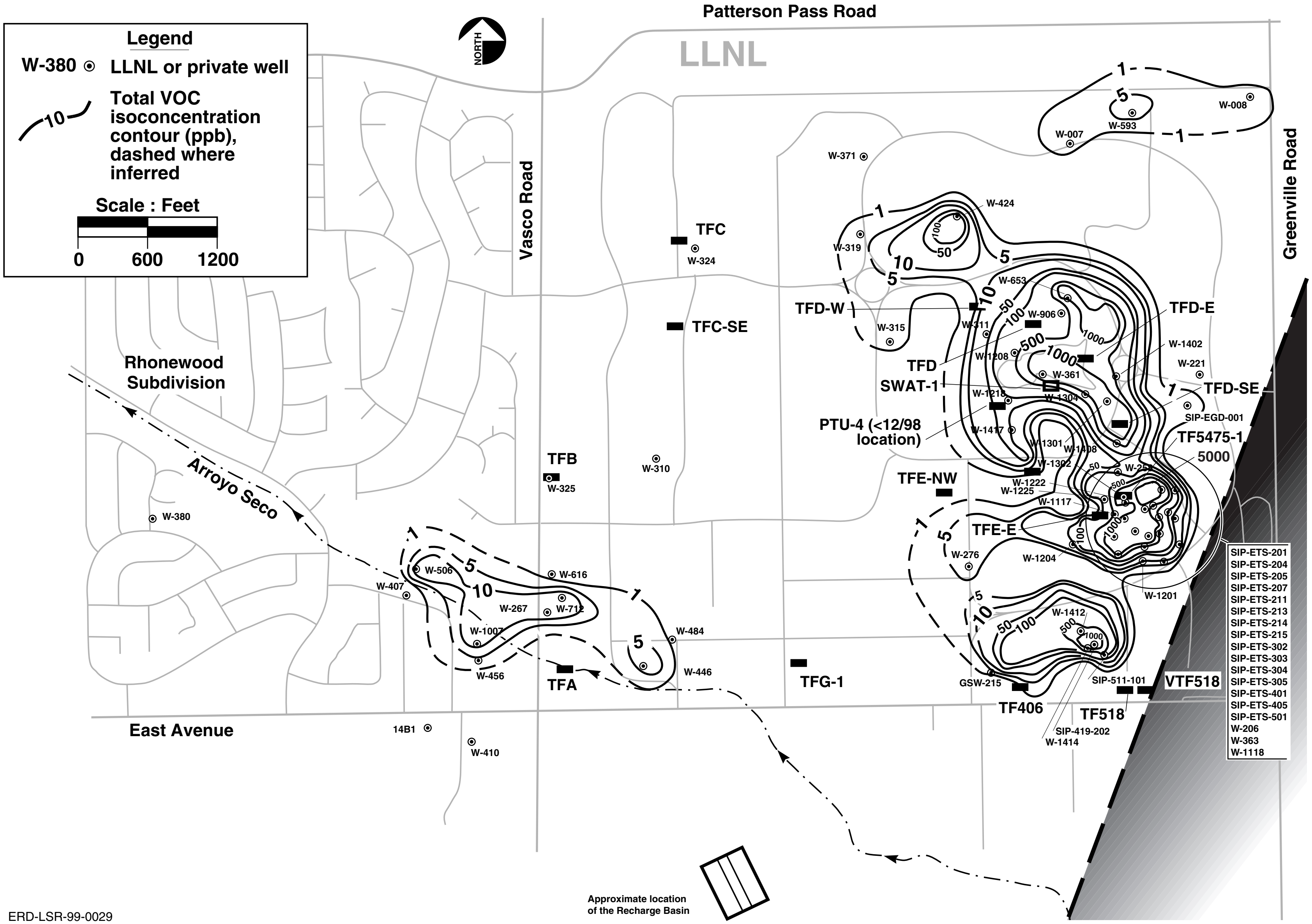

Figure 12. Isoconcentration contour map of total VOCs for 78 wells completed within HSU 3A based on samples collected in the fourth quarter of 1998 (or the next most recent data), and supplemented with soil chemistry data from 142 borehole locations.

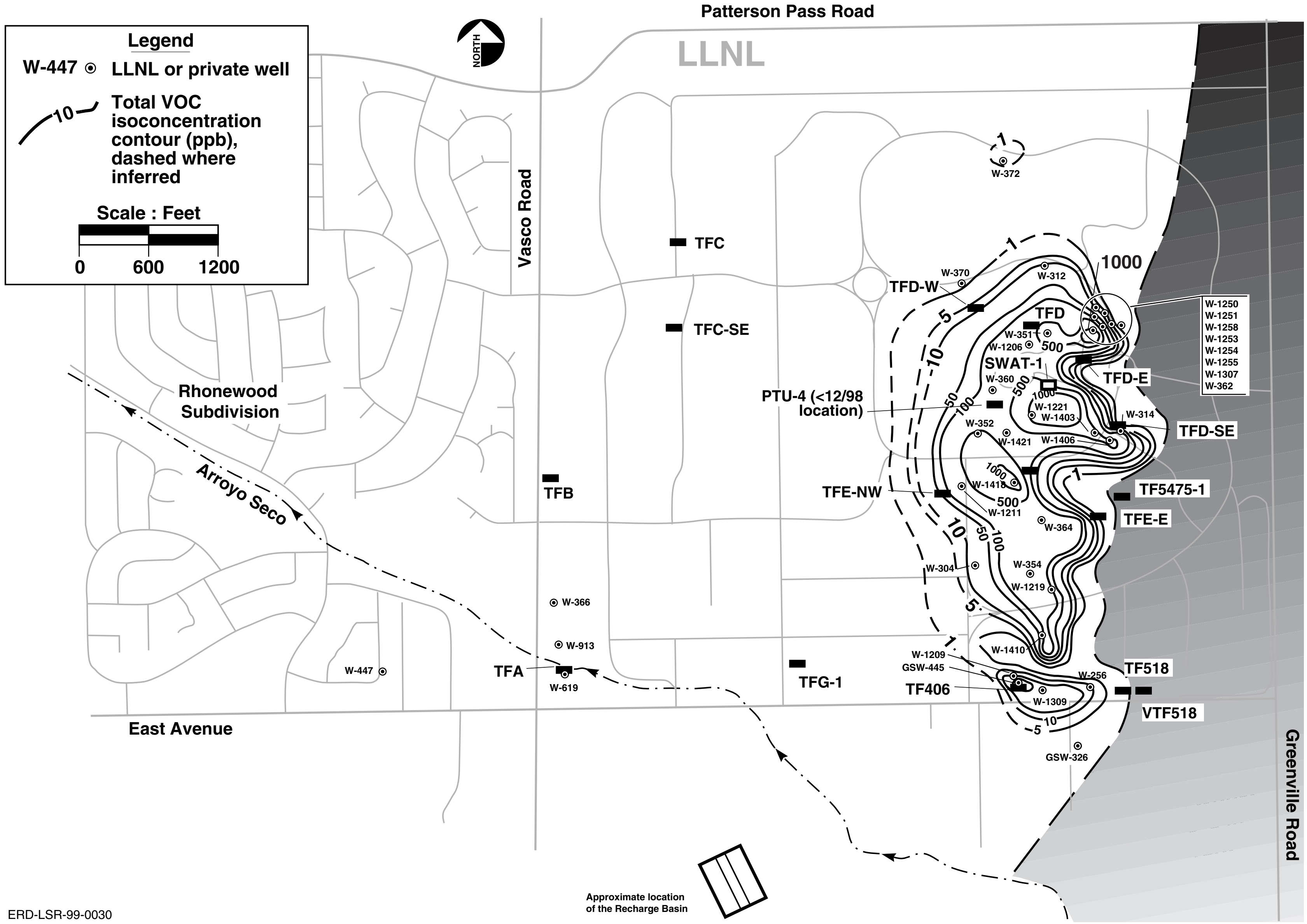

Figure 13. Isoconcentration contour map of total VOCs for 44 wells completed within HSU 4 based on samples collected in the fourth quarter of 1998 (or the next most recent data), and supplemented with soil chemistry data from 59 borehole locations.

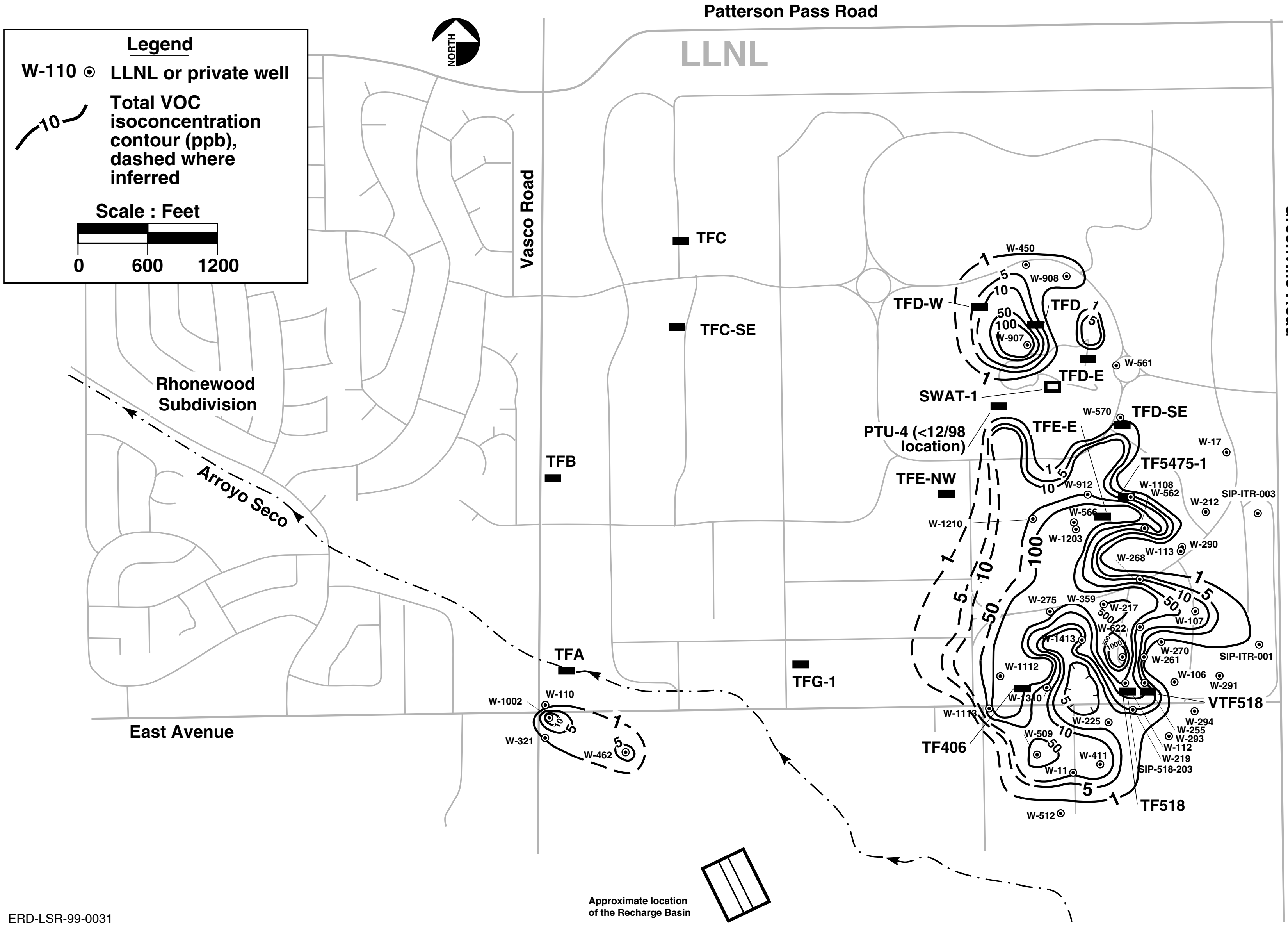

Figure 14. Isoconcentration contour map of total VOCs for 50 wells completed within HSU 5 based on samples collected in the fourth quarter of 1998 (or the next most recent data), and supplemented with soil chemistry data from 94 borehole locations.

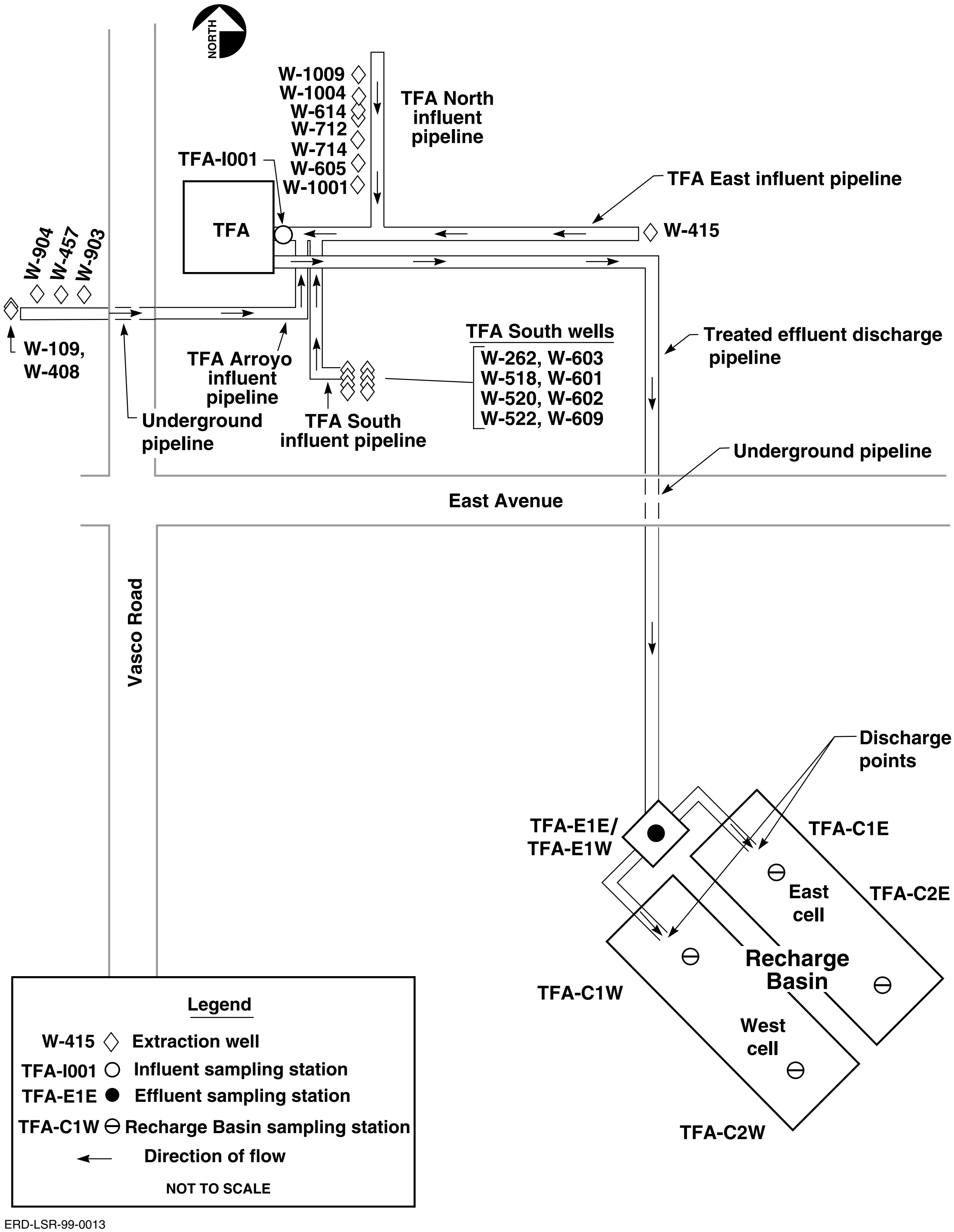

Figure 15. 1998 TFA extraction well, pipeline and discharge locations.

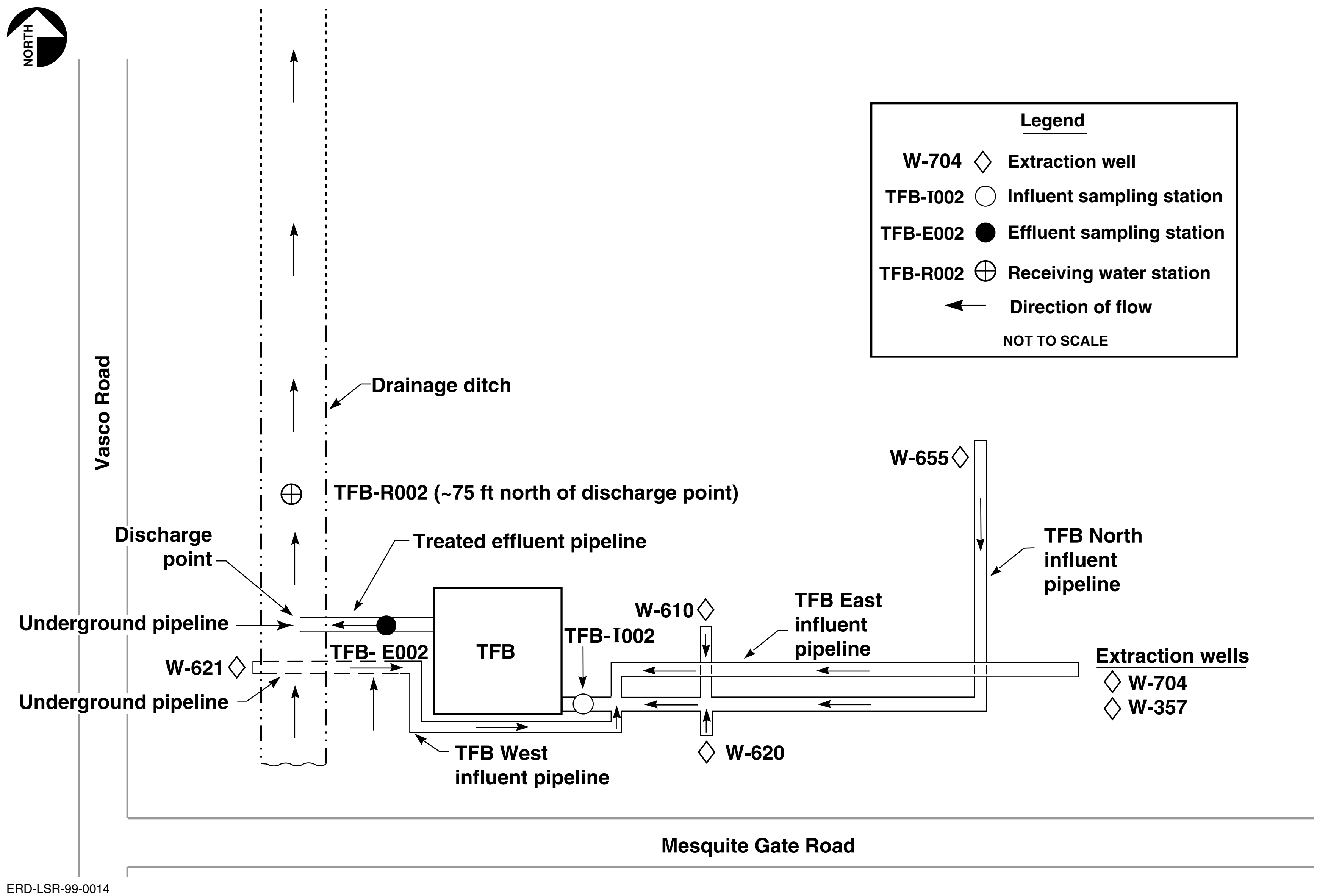

Figure 16. 1998 TFB extraction well, pipeline and discharge locations.

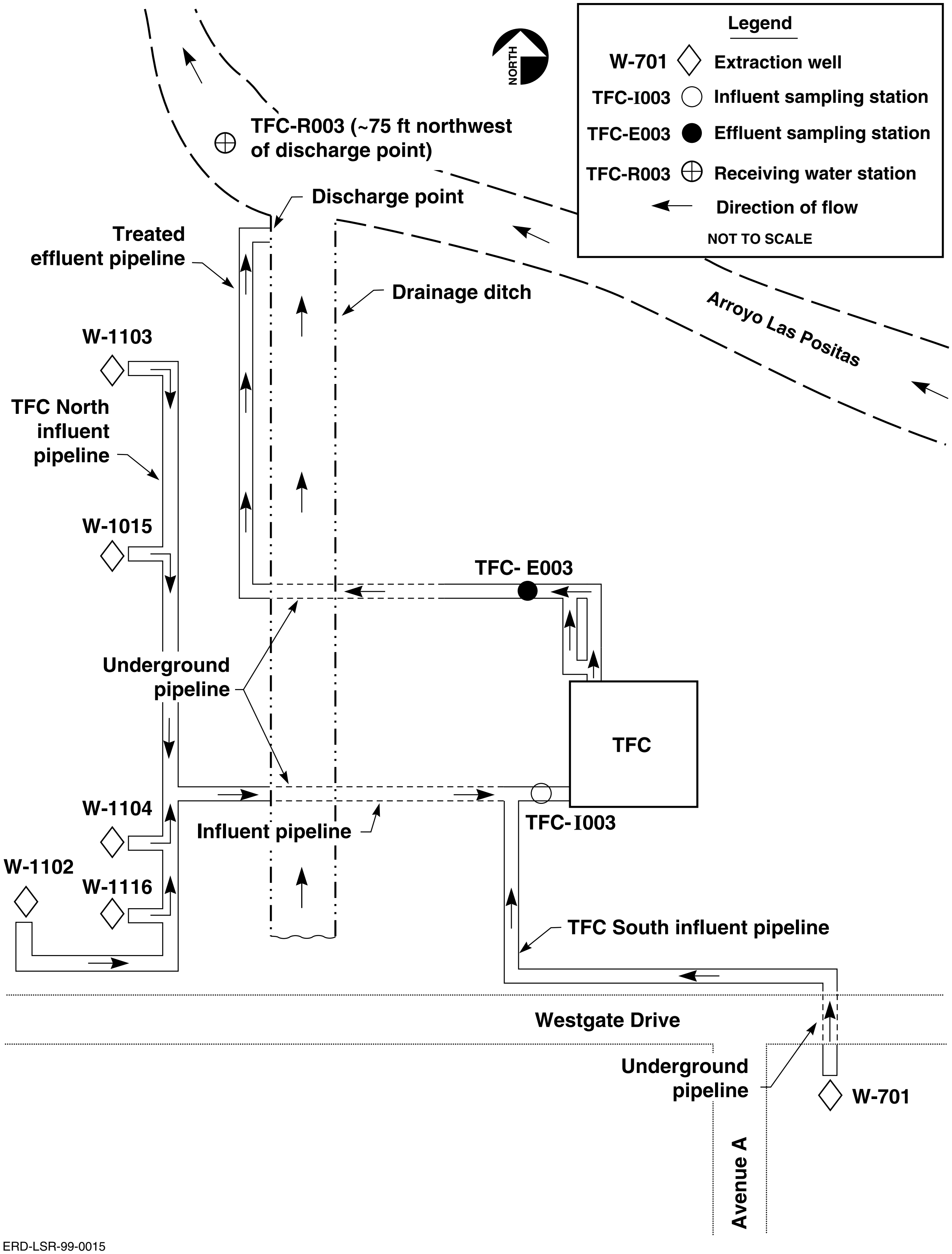

Figure 17. 1998 TFC extraction well, pipeline and discharge locations.

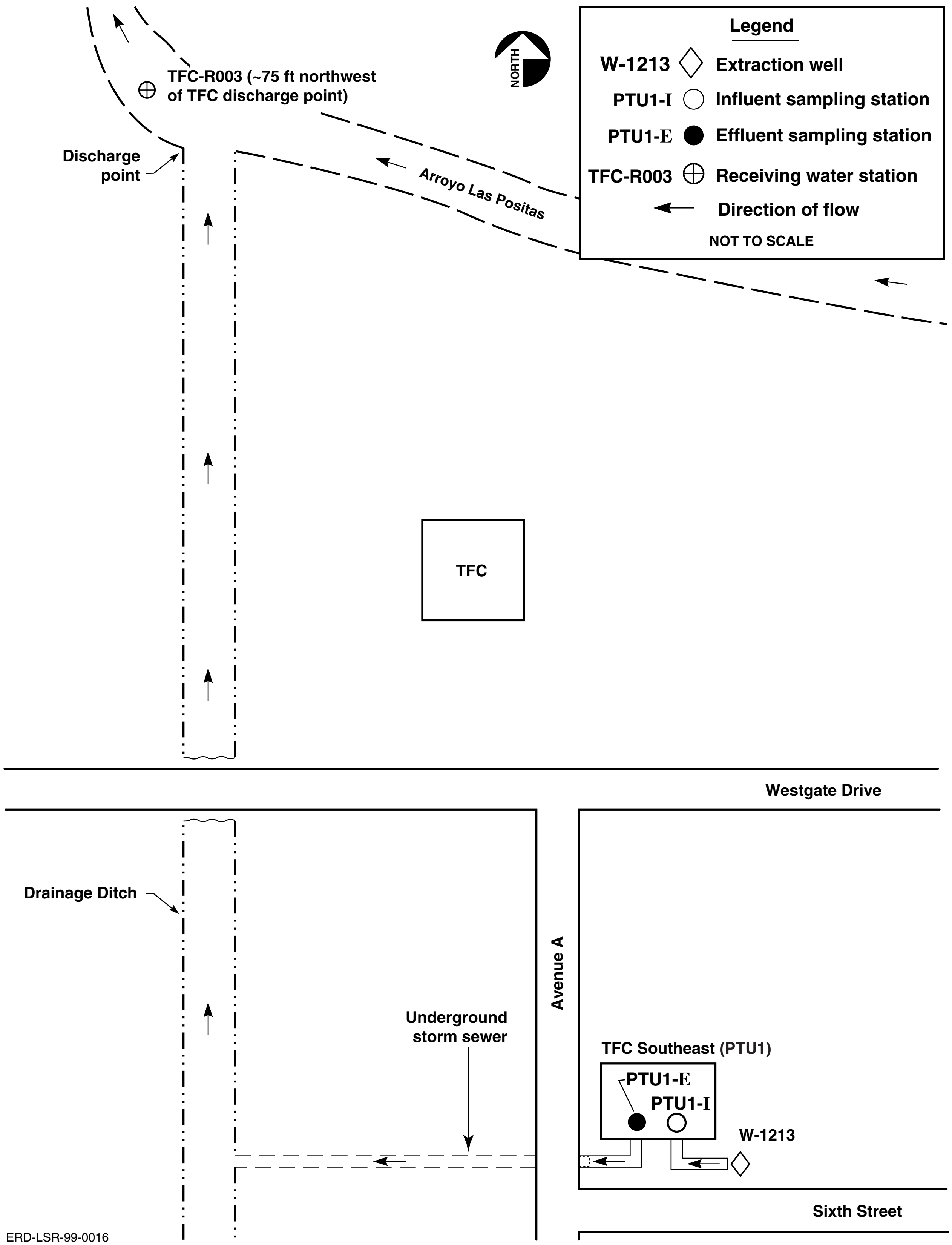

Figure 18. 1998 TFC Southeast extraction well, pipeline and discharge locations.

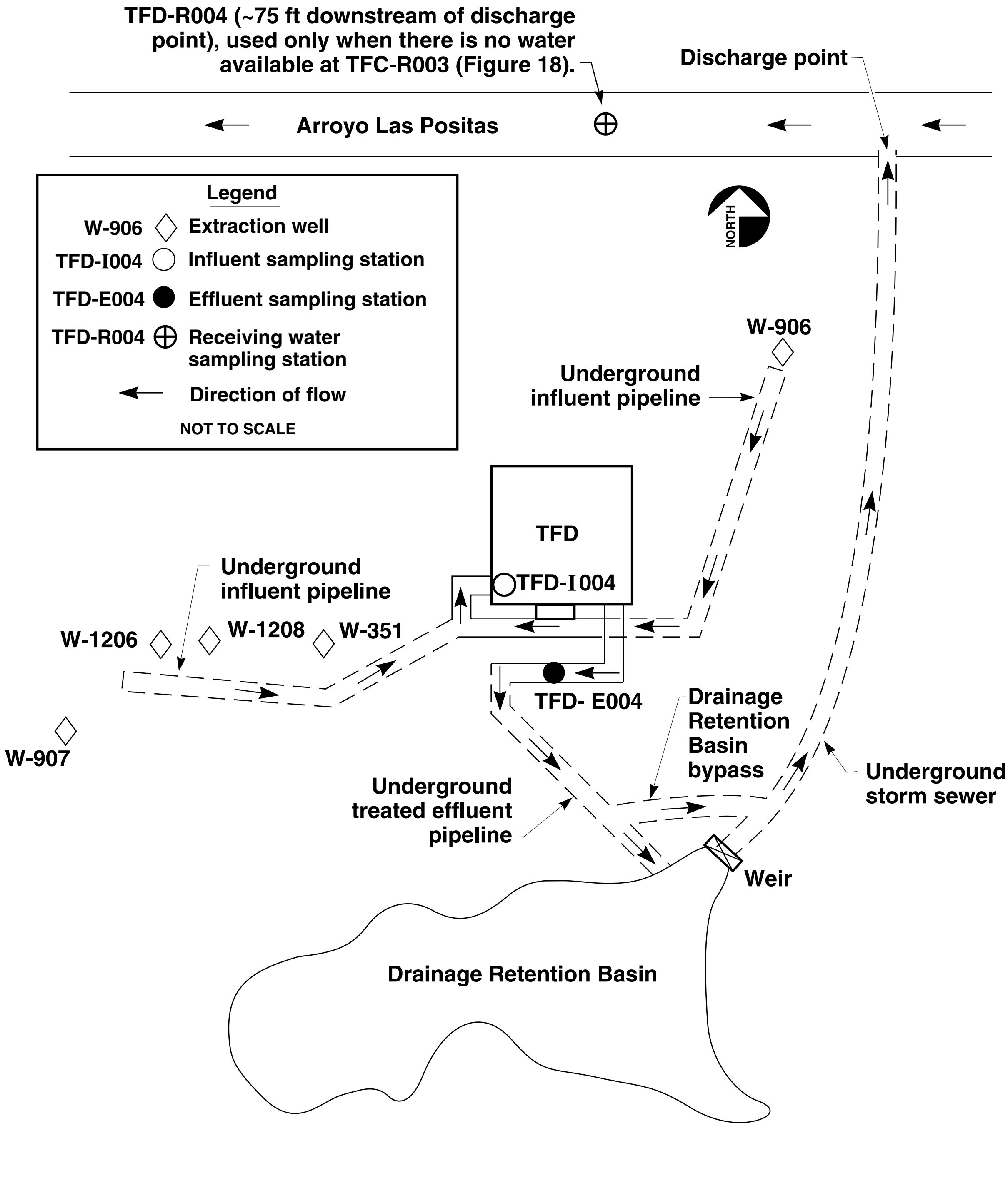

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Figure 19. 1998 TFD extraction well, pipeline and discharge locations.

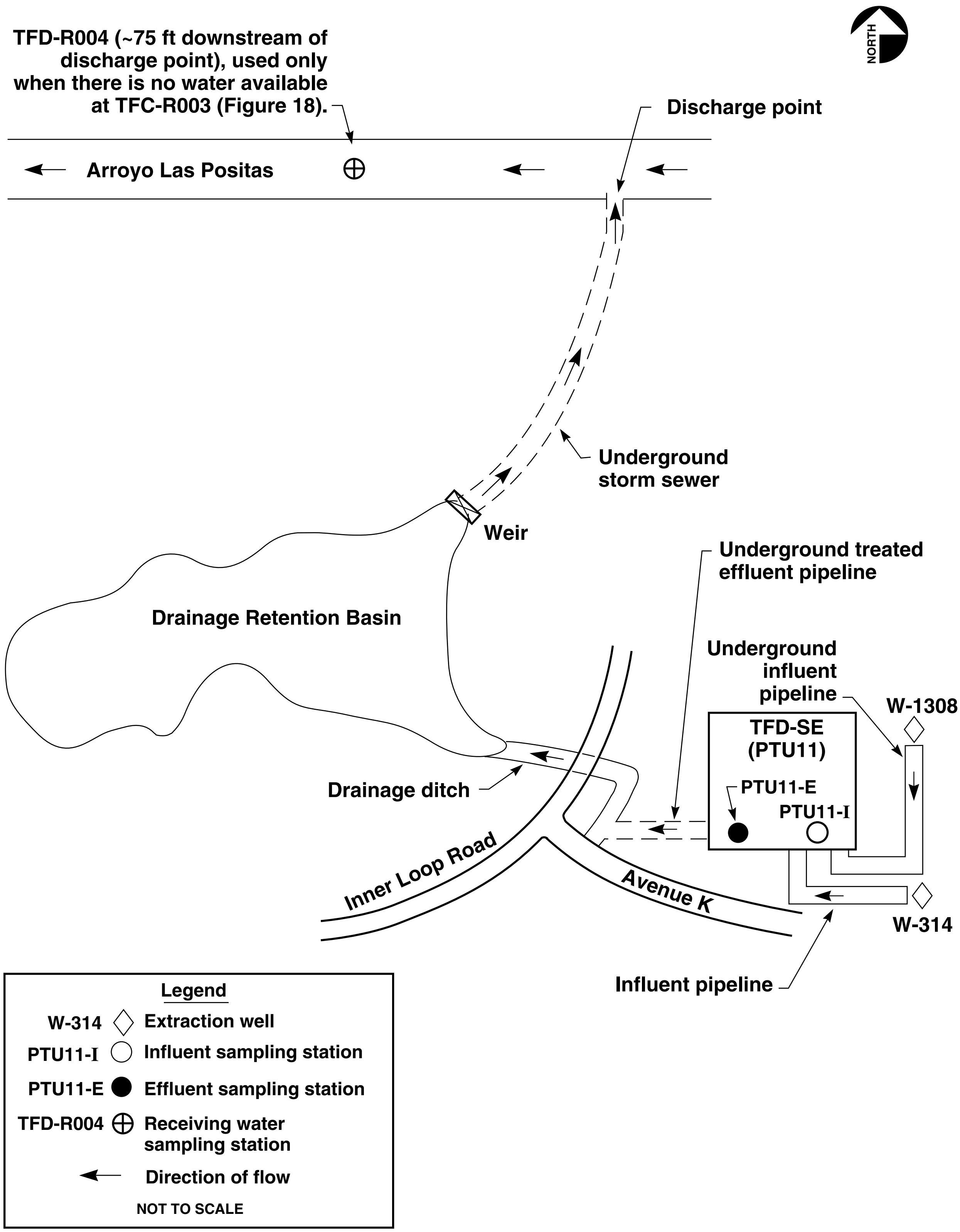

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Figure 20. 1998 TFD Southeast extraction well, pipeline and discharge locations.

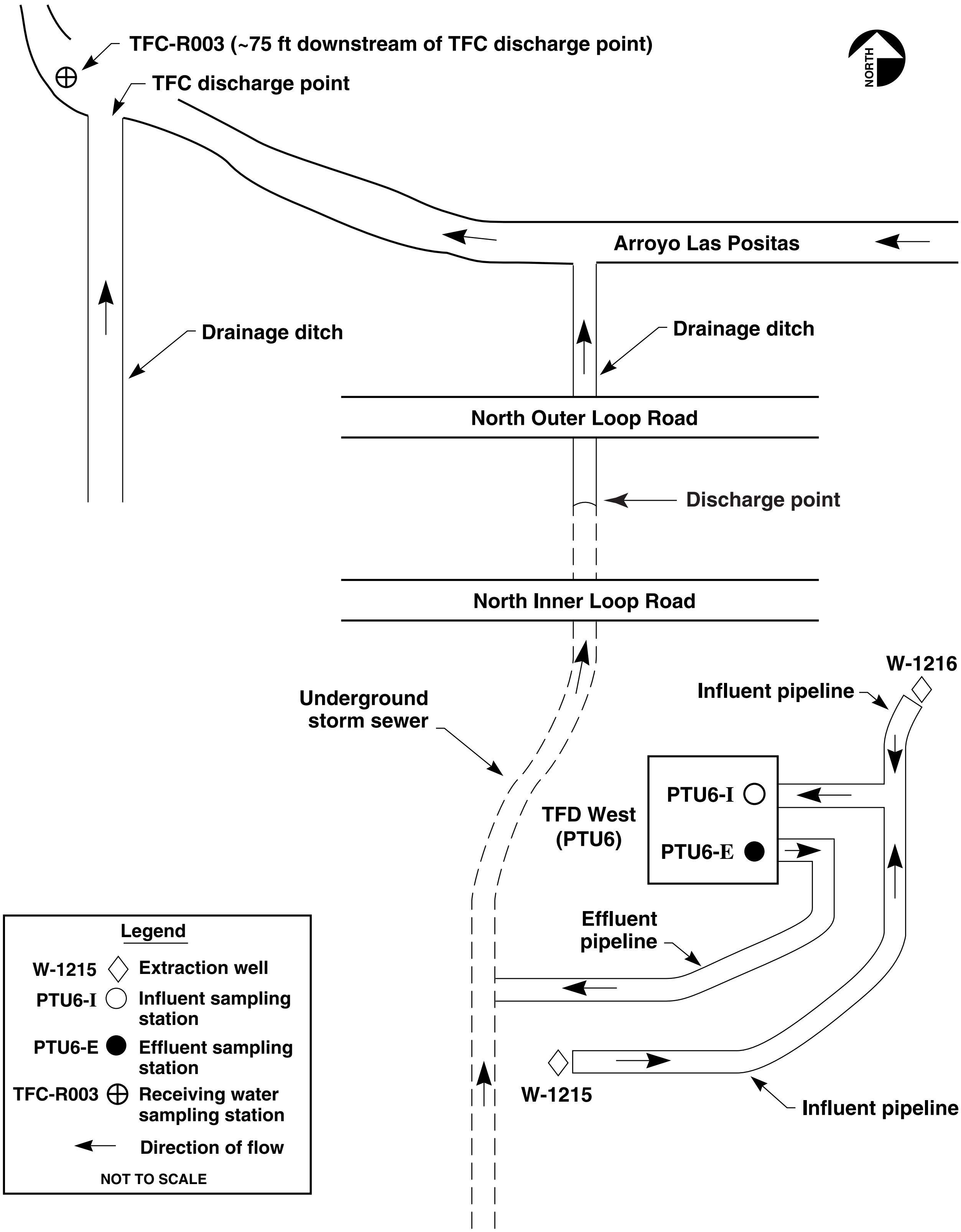

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Figure 21. 1998 TFD West extraction well, pipeline and discharge locations.

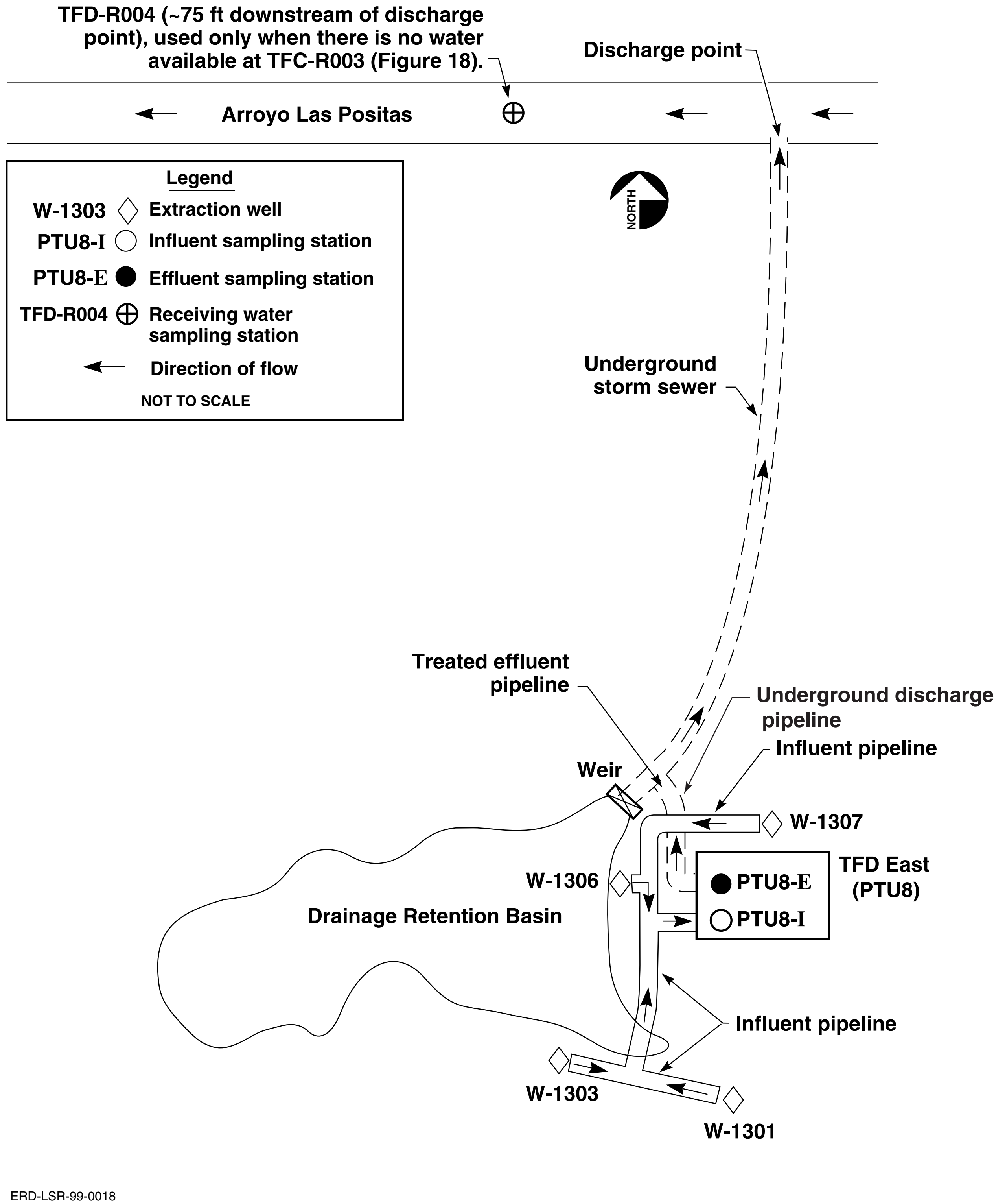

Figure 22. 1998 TFD East extraction well, pipeline and discharge locations.

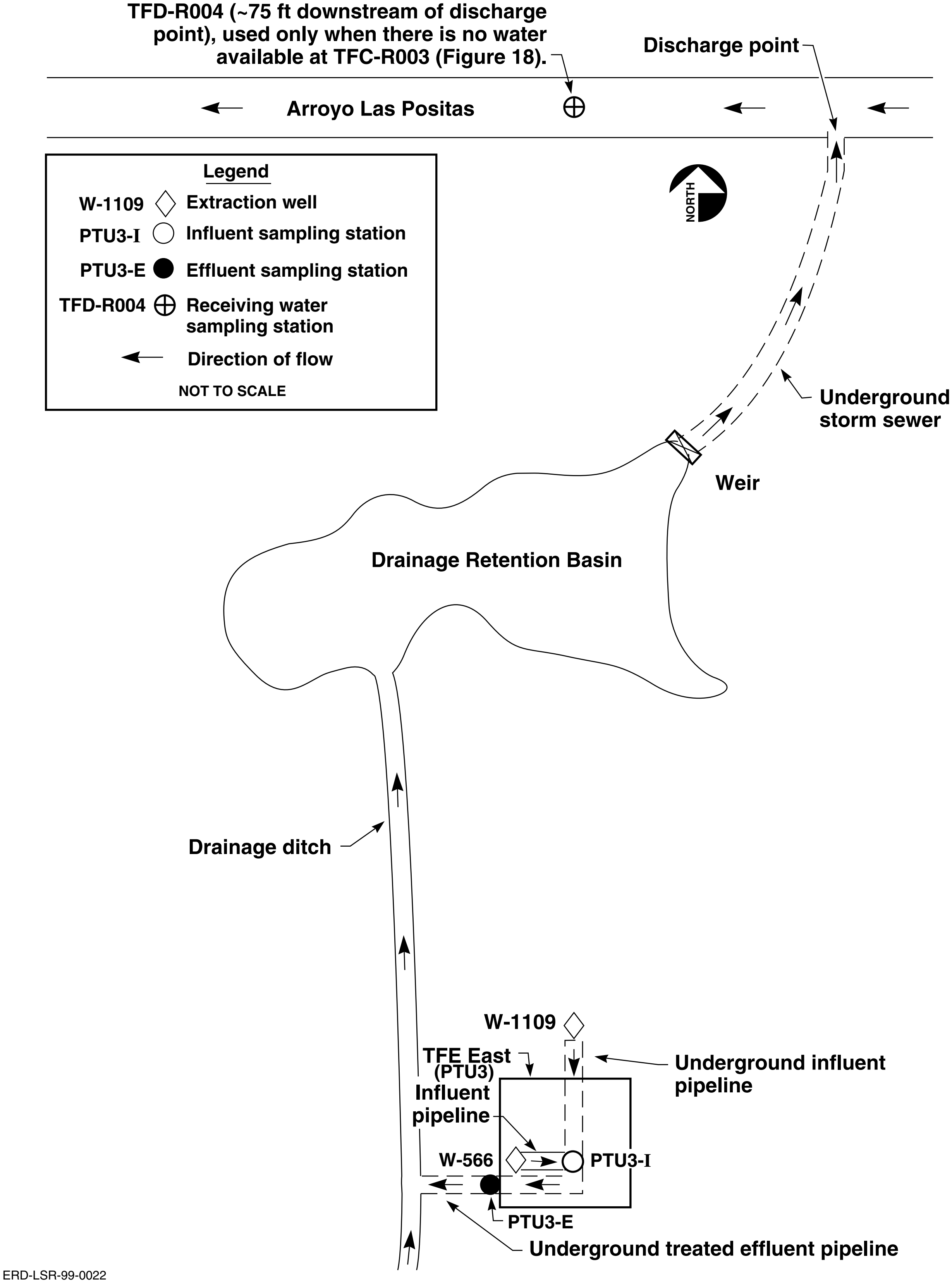

Figure 23. 1998 TFE East extraction well, pipeline and discharge locations.

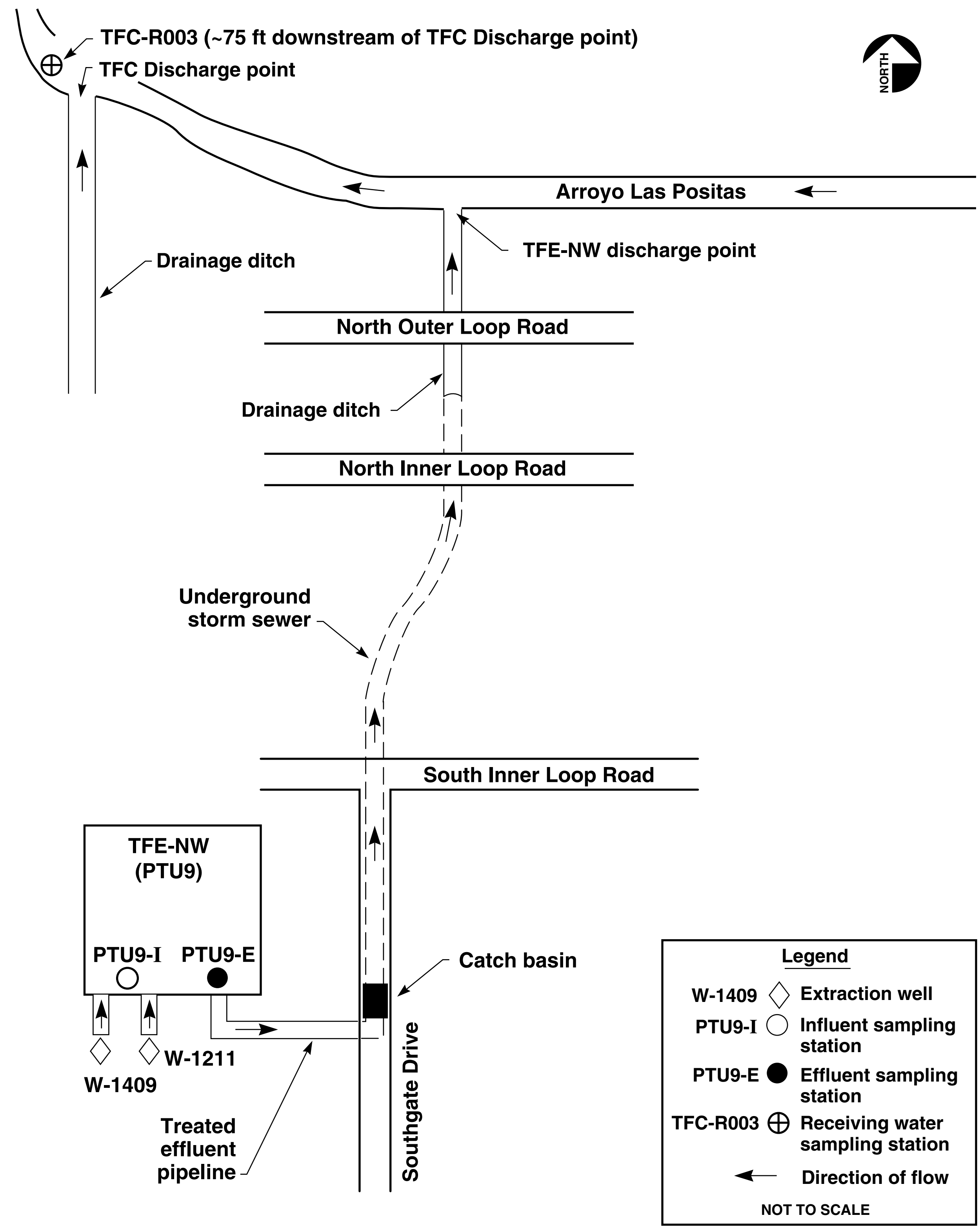

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Figure 24. 1998 TFE Northwest extraction well, pipeline and discharge locations.

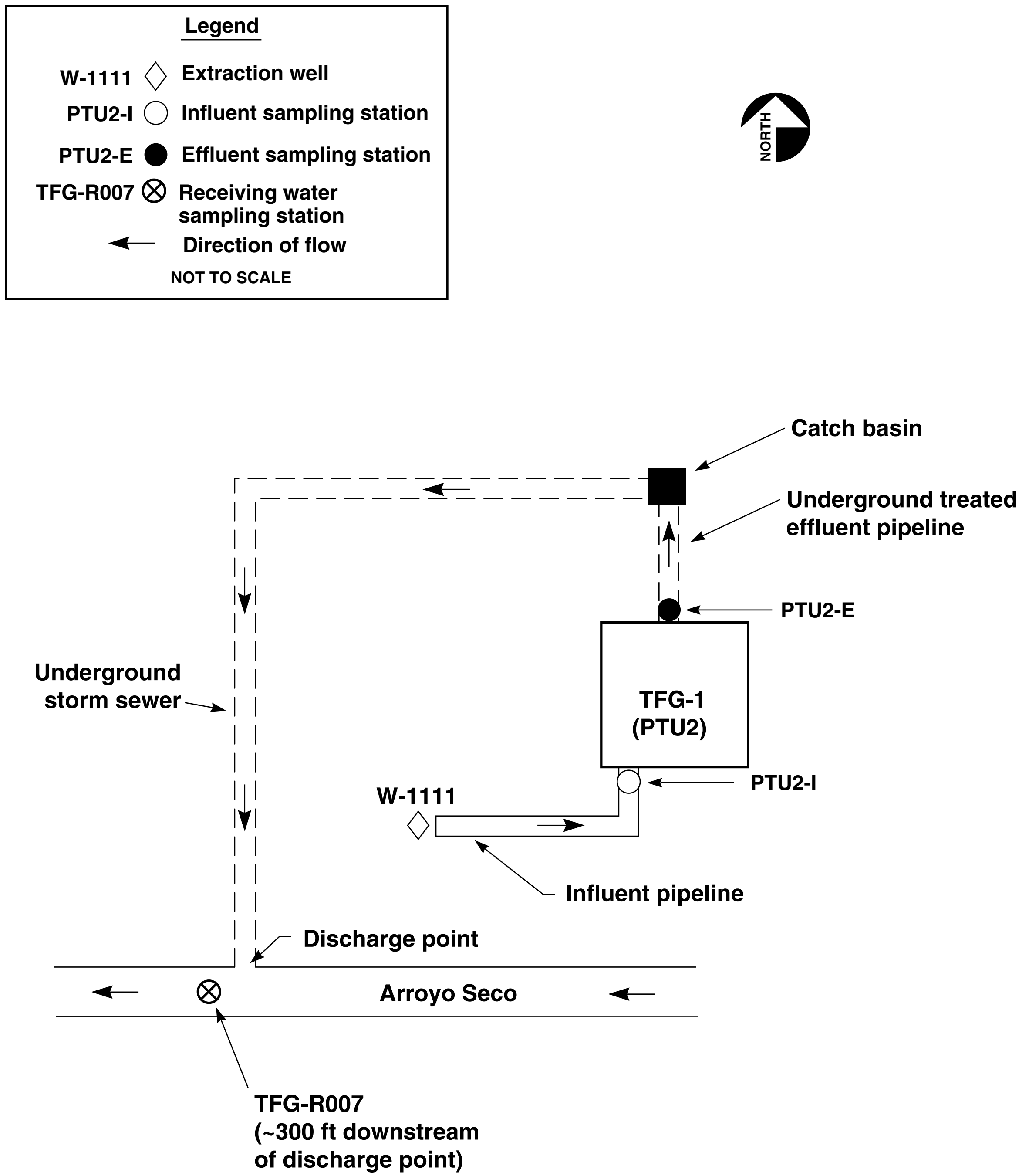

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Figure 25. 1998 TFG-1 extraction well, pipeline and discharge locations.

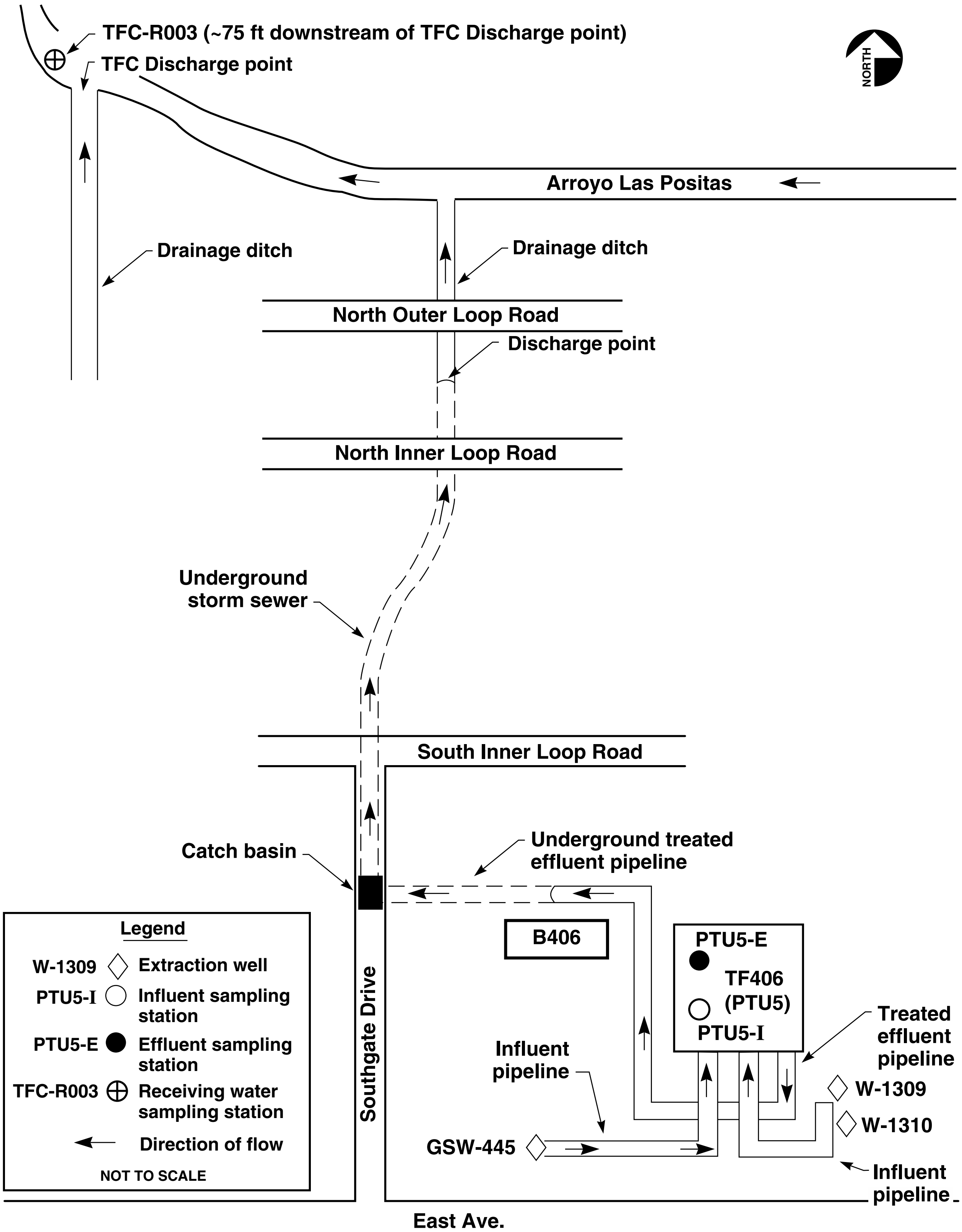

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Figure 26. 1998 TF406 extraction well, pipeline and discharge locations.

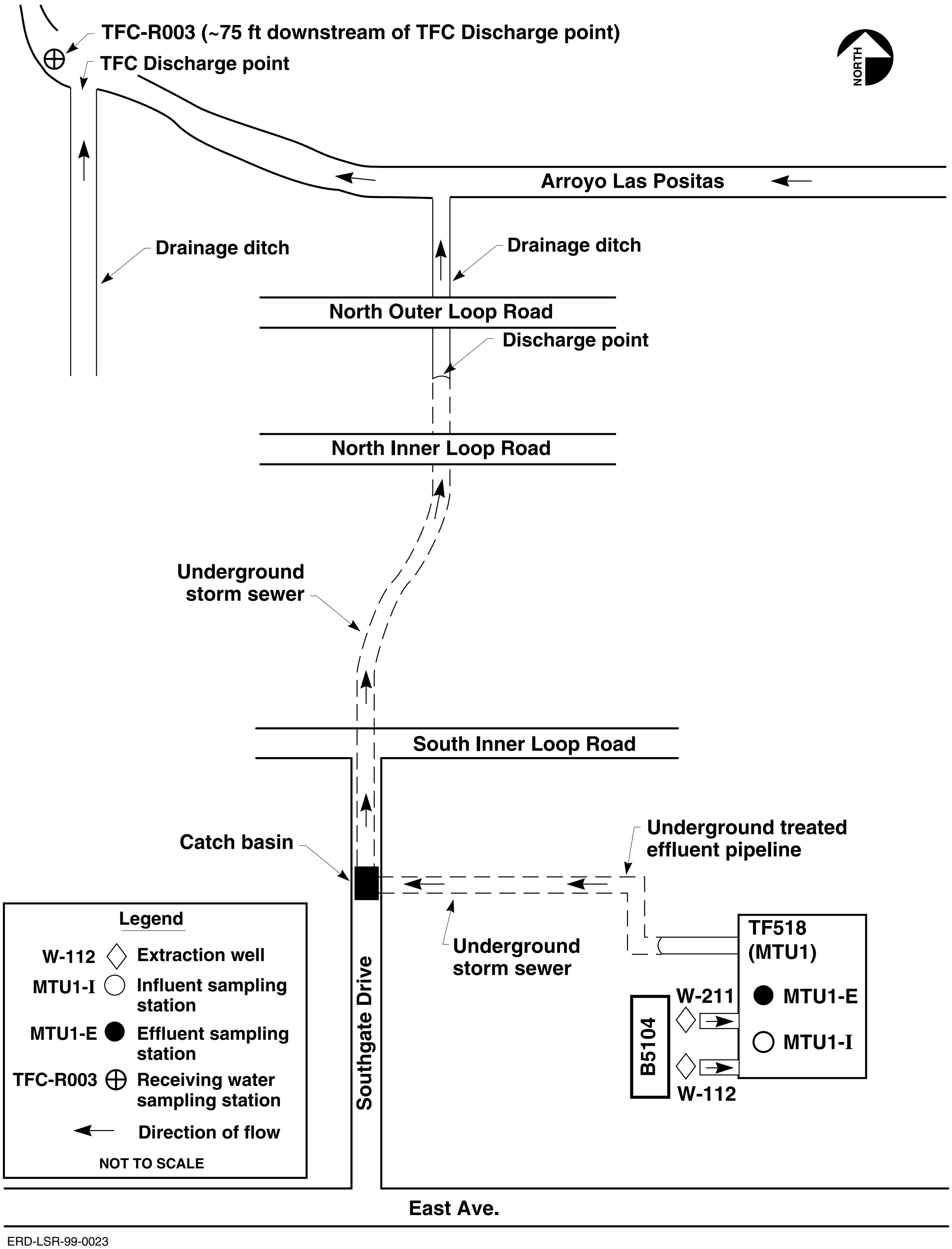

Figure 27. 1998 TF518 extraction well, pipeline and discharge locations.

Tables

Table 1. 1998 RAIP milestones.

Milestone	Milestone date	Completion date
Submit Draft Final RD4	1/15/98	1/14/98
Issue RD4	2/16/98	2/12/98
Begin operation of Treatment Facility 518 Portable Treatment Unit (PTU)	1/30/98	1/27/98
Begin operation of Treatment Facility D Southeast PTU	3/27/98	3/27/98
Begin operation of Treatment Facility E Northwest PTU	6/26/98	6/23/98
Begin operation of Treatment Facility 5475 catalytic reductive dehalogenation (phase 1)	9/30/98	9/09/98

Table 2. Summary of 1998 VOC remediation.

Treatment facility area	Volume of ground water treated (Mgal)	Volume of soil vapor treated (Kft^3)	Estimated total VOC mass removed (kg)
TFA	124.1	–	15.0
TFB	18.3	–	5.2
TFC	23.4	–	7.9
TFD	63.7	–	73.3
TFE	14.6	–	16.7
TFG	3.0	–	0.4
TF406	12.0	–	2.1
TF5475	0.03	–	0.4
TF518	2.8	–	1.0
VTF518	–	4,977	27.3
Total	261.93	4,977	149.3

Notes:

kg = Kilograms.

Kft^3 = Thousands of cubic feet.

Mgal = Millions of gallons.

Table 3. Summary of cumulative VOC remediation.

Treatment facility area	Volume of ground water treated (Mgal)	Volume of soil vapor treated (Kft^3)	Estimated total VOC mass removed (kg)
TFA	515.1	–	109.3
TFB	83.6	–	30.7
TFC	59.0	–	23.3
TFD	124.3	–	146.7
TFE	24.5	–	33.8
TFG	7.3	–	1.2
TF406	14.7	–	3.2
TF5475	0.03	–	0.5
TF518	2.8	–	1.0
VTF518	–	11,173	134.1
Total	831.33	11,173	483.8

Notes:

kg = Kilograms.

Kft^3 = Thousands of cubic feet.

Mgal = Millions of gallons.

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	1B/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 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 88-98	2/3A	NA
W-8	14-May-81	110.0	105.0	72-77 92-102	3A/3B	NA
W-10A	08-Sep-80	110.7	110.0	85-95 100-105	2	NA
W-11	03-Jun-81	252.0	191.0	136-141 177-187	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	127-132 147-157	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	1B	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
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

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-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-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	3B	<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	3B	<0.5
W-211	19-Mar-86	215.5	193.0	183-193	7	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
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

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-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-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	3A	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	3A/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
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

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-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-353	12-Nov-86	205.0	101.0	95.5-101	2	1
W-354	24-Nov-86	185.0	179.0	163-179	4/5	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
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

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-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
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

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-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-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
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

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-511	31-Mar-89	316.0	176.0	167-176	3B	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-521	13-Sep-89	166.0	95.0	86-95	1B	1
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	1B	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	1B	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-567	27-Apr-89	194.0	61.5	51-61	1B	10
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	5	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

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-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	3B/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	7	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	126.0	90.0	77-90	1B	2
W-706	16-Jan-91	178.0	84.0	71-84	1B	2
W-714	02-Jul-91	135.0	128.0	107-128	2	7.5
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
W-905	07-Apr-93	221.0	144.5	134-144	2	4
W-908	18-Aug-93	239.0	197.0	180-197	5/6	<0.5
W-909	04-Nov-93	252.0	113.5	80.5-108.5	2	2
W-911	20-Dec-93	180.0	113.5	73.5-108.5	2	3
W-912	07-Oct-93	239.0	174.0	168-174	5	3
W-913	08-Dec-93	454.0	255.0	235-255	4	25
W-1001	20-Dec-93	105.0	92.0	85-92	1B	1.4
W-1002	31-Jan-94	292.5	260.0	246-260	5	16
W-1003	08-Feb-94	184.0	147.0	140-147	2	1.5
W-1005	14-Mar-94	192.0	110.0	98-110	1B	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]
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-Apr-94	246.0	238.0	229.5-238	7	10
W-1010	24-May-94	463.0	142.0	128-142	2	20
W-1011	06-Jun-94	106.0	89.0	75-89	1B	3
W-1012	20-Jun-94	161.0	117.0	96-112	2	5
W-1013	29-Jun-94	147.0	73.0	65-73	1B	1.4
W-1014	12-Jul-94	99.0	89.0	65-89	1B	30
W-1101	10-Nov-94	200.0	79.0	76.0-79.0	1B	0.5
W-1105	17-Jan-95	110.0	93.0	78-93	1B	3.5-4
W-1106	08-Feb-95	245.0	86.0	76-85	1B	15
W-1107	06-Mar-95	199.5	93.0	74-88	1B	<0.5
W-1108	27-Mar-95	250.0	156.0	142-156	5	12
W-1110	04-May-95	252.0	92.2	68-92	1B	7
W-1112	28-Jun-95	263.0	210.0	201-210	5	3
W-1113	18-Jul-95	260.0	214.0	204-214	5	2.5
W-1115	12-Oct-95	126.5	118.2	108-118	3A	1
W-1117	11-Sep-95	154.0	132.3	122-132	3A	1
W-1118	27-Sep-95	225.0	125.0	115-125	3A	3.5
W-1201	18-Oct-95	225.0	133.0	125-133	3A	1
W-1202	26-Oct-95	99.3	99.0	83-99	2	5^+
W-1203	07-Nov-95	224.0	206.2	196-206	5	18^+
W-1204	20 Nov-95	225.0	126.2	118-126	3A	2.5
W-1205	27-Nov-95	91.0	82.0	72-82	2	<0.5
W-1206	06-Dec-95	220.0	191.0	174-186	4	40^+
W-1207	13-Dec-95	92.0	90.0	70-90	2	<0.5
W-1208	09-Jan-96	166.0	163.0	135-163	3A/3B	40
W-1209	26-Jan-96	210.0	164.0	148-164	4	3
W-1210	12-Feb-96	250.0	223.0	213-223	5	3
W-1211	05-Mar-96	273.0	205.0	185-200	4	25^+
W-1212	19-Mar-96	150.0	75.0	52-75	1B	3
W-1213	02-Apr-96	129.0	76.0	64-76	1B	5^+
W-1214	22-Apr--96	180.0	100.0	80-100	1B	2
W-1215	17-Apr-96	175.0	120.0	103-120.5	2	8.5

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-1216	07-May-96	200.0	124.0	94-124	2	14
W-1217	15-May-96	182.0	98.5	78-98	1B	<0.5
W-1218	29-May-96	240.0	145.5	127-145	3A	6.7
W-1219	04-Jun-96	201.0	142.0	138-142	4	<0.5
W-1220	12-Jun-96	120.0	117.0	90-112	2	18
W-1221	01-Jul-96	220.0	172.0	162-172	4	4
W-1222	26-Jun-96	175.0	125.5	115-125	3A	6
W-1223	23-Jul-96	175.0	102.0	87-97	2	4
W-1224	05-Sep-96	125.0	104.5	99-104	1B	4.3
W-1225	14-Aug-96	150.0	121.2	113-121	3A	2
W-1226	06-Aug-96	155.0	126.5	116-126	2	1
W-1227	09-Oct-96	200.0	134.0	126-134	2	11
W-1250	07-Jun-96	210.0	200.0	130-135	4	0.85
W-1251	03-Jul-96	210.0	200.0	134-139	4	1.3
W-1252	25-Jul-96	208.0	202.3	135-140	4	<0.5
W-1253	15-Aug-96	206.0	200.1	127-132	4	<0.5
W-1254	15-Aug-96	125.0	200.0	131-141	4	26
W-1255	27-Aug-96	208.0	200.7	124-129	4	<0.5
W-1301	04-Dec-96	180.0	120.3	112-120	3A	15
W-1302	21-Jan-97	145.0	138.9	116.5-122.2	3A	7.5
				125.8-133.8		
W-1304	20-Feb-97	149.5	125.0	120-125	3A	0.75
W-1308	22-Jul-97	150.0	116.0	81-111	2	7
W-1309	11-Aug-97	220.0	157.0	142-152	4	6.0
W-1310	08-Sep-97	220.0	198.0	173-193	5	28
W-1311	25-Sep-97	153.0	120.5	100-120	2	14
W-1401	15-Oct-97	250.0	120.0	105-120	2	7
W-1402	04-Nov-97	135.0	112.0	102-112	3A	4
W-1403	12-Nov-97	175.0	142.5	132-142	4	3.5
W-1404	20-Nov-97	162.0	97.7	87-97	2	3.1
W-1405	24-Nov-97	100.0	97.8	87-97	2	4.5
W-1406	15-Dec-97	201.0	150.0	139.2-149.2	4	9.2
W-1407	12-Dec-97	224.0	118.7	105-118	2	1.5
W-1408	12-Jan-98	134.0	128.0	118-128	3A	3.8

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]
W-1410	20-Feb-98	205.0	133.0	126-131	3B/4	8
W-1411	04-Feb-98	133.0	128.0	114-128	3B	10
W-1412	11-Feb-98	201.0	107.0	92-107	2	0.75
W-1413	26-Mar-98	163.5	157.7	147-157	5	1
W-1414	31-Mar-98	128.0	107.5	97-107	3A	0.1
W-1415	15-Apr-98	182.0	104.8	74.5-104.5	2	2
W-1416	02-Jun-98	194.5	105.0	85-100	2	10
W-1417	23-Apr-98	225.0	155.0	130-150	3A/3B	20
W-1418	05-May-98	252.5	190.0	176-190	4	9
W-1419	11-May-98	175.0	115.5	90-110	2	4.5
W-1420	17-June-98	177.5	112.0	102-112	2	10
W-1421	28-May-98	230.0	172.0	156-167	4	3
W-1422	14-May-98	173.5	169.0	162-169	3A/3B	10
W-1423	08-Jul-98	175.0	134.5	99.5-109.5 119.5-129.5	2	22.4
W-1424	20-Aug-98	225.0	146.0	126-146	2	6.2
W-1425	31-Aug-98	115.0	100.5	88.5-100.5	1B	1
W-1426	09-Sep-98	89.0	85.0	70-85	1B	8
W-1427	22-Sep-98	104.0	80.2	70-80	1B	17
W-1428	29-Sep-98	104.0	78.4	63-78	1B	25
W-1501	13-Oct-98	126.0	86.0	72-86	1B	7.5
W-1502	28-Oct-98	204.0	98.7	88-98	2	1.7
W-1503	18-Nov-98	234.0	181.5	171-181	4	25
W-1504	14-Dec-98	168.0	162.5	140-160.4	3A/3B	21.7
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

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-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-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	1B	3.5
				38-44	1B	
				50-56	2	
				60-64	2	
				68-73	2	
				77-83	2	
				95-105	3A	
				120-130	3B	
GSW-16	19-Oct-87	146.0	145.0	23-28	1B	20.5-30
				38-43	1B	
				50-55	2	
				61-66	2	
				78-83	2	
				95-105	3A	
				120-130	3B	
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	4	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

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-444	20-Nov-87	278.0	120.0	110-120	3B	0.3
GSW-445	09-Dec-87	319.0	161.0	155-161	4	3
Dynamic Stripping Project Wells[c]						
GSP-SNL-001	07-Jan-92	147.0	104.0	99-104	3A	NA
			131.0	118-131	3B	NA
GEW-808	05-Jun-92	164.0	150.0	50-140	2/3A/3B	25
GIW-813	25-Jun-92	140.7	87.0	67-87	2	NA
			104.0	89-99	3A	
			127.0	107-127	3A/3B	NA
GIW-814	19-Jun-92	149.6	106.5	86.5-106.5	2/3A	NA
			117.0	110-120	3A	
			132.0	121-141	3B	NA
GIW-815	15-Jun-92	143.0	97.0	77-97	2/3A	NA
			117.0	102-112	3A	
			132.0	112.8-132	3B	NA
GEW-816	03-Jun-92	161.7	150.0	50-140	3A/3B	40
GIW-817	29-Jun-92	150.1	102.0	82-102	2/3A	NA
			122.0	107-117	3A	
			141.0	121-141	3B	NA
GIW-818	06-Jul-92	150.0	102	82-102	2/3A	NA
			125	110-120	3A	
			140	120-140	3B	NA
GIW-819	10-Jul-92	150.0	98.6	78.6-98.6	2/3A	NA
			123	108-118	3A/3B	
			141	121-141		NA
GIW-820	16-Jul-92	143.3	105	85-105	2/3A	NA
			132	112-132	3A3B	NA
HW-GP-001	17-Apr-92	120.0	77.0	67-77	2	NA
			113.0	103-113	3A	NA
HW-GP-002	13-May-92	120.0	78.0	68-78	2	NA
			117.0	107-117	3A	NA
HW-GP-003	20-May-92	119.0	76.5	66.5-76.5	2	NA
			119.0	109-119	3A	NA
HW-GP-102	13-Aug-93	140.0	137.5	72.5-133.5	2/3A/3B	NA
HW-GP-103	23-Aug-93	138.0	137.5	71.5-132.5	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-104	02-Sep-93	138.0	137.2	72.2-132.2	2/3A/3B	NA
HW-GP-105	28-Sep-93	138.0	137.5	72.5-132.5	2/3A/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-262	20-Mar-86	256.0	100.0	91-100	1B	7
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/2	>50
W-457	22-Jun-88	289.0	149.5	130-149.5	2	20
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-522	05-Oct-89	145.5	141.5	134-141.5	2	25
W-566	19-Apr-89	317.0	207.0	197-207	5	12
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	2	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 88-97	1B	20
W-712	29-Aug-91	200.0	185.5	170-185.5	3A	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]
W-903	28-Apr-93	223.0	145	132-140	2	20
W-904	06-May-93	212.0	154.0	121-133 140-149	2	20
W-906	27-Jul-93	200.0	132.0	58-132	2/3A	10
W-907	02-Sep-93	239.0	220.0	172.7-188.8 204.5-215.0	4 5	25 NA
W-1004	23-Feb-94	99.0	97.0	71-91	1B	7
W-1009	02-May-94	191	140	134-140	2	20
W-1015	10-Aug-94	437	94	84-94	1B	20
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 92-98	1B	35+
W-1109	11-Apr-95	121	113	94-108	2	3
W-1111	01-Jun-95	152	129	88-108 120-124	1B/2 2	10.5 NA
W-1116	17-Aug-95	214	101	72-98	1B	9
W-1303	06-Feb-97	199.5	107	78-102	2	10
W-1306	06-May-97	200	106	81-101	2	3.3
W-1307	07-Feb-97	150	142	126-136	4	20
W-1409	23-Jan-98	143	140	76-140	2	20
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	90-92 102-108	1B 2	NA
11Q4	NA	NA	NA	NA	NA	NA
11Q5	NA	NA	NA	NA	NA	NA
14A3	07-Dec-77	NA	110	100-105	1B	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]
14A11[d]	NA	NA	NA	NA	NA	NA
14B1	13-Aug-59	300	234	146-149	2	NA
				192-195	3A	
				198	3A	
				200	3A	
				203	3A	
				205	3A	
				207	3A	
				209-213	3A	
				226	3A	
				230	3B	
				234	3B	
14B4	Aug-60	NA	260	143-148	2	NA
				155-159	2	
				186-189	3A	
				205-215	3A	
				245-250	4	
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
Source Investigation Piezometers						
SIP-141-201	02-Feb-96	77	74.2	57-74	1B	NA
SIP-141-202	12-Feb-96	80	74	64-74	1B	NA
SIP-141-203	20-Feb-96	87	83	72-83	1B	NA
SIP-191-001	15-Apr-94	50	45	40-45	1A	NA
SIP-191-002	21-Apr-94	50	61	45-61	1B	NA
SIP-191-003	26-Apr-94	50.5	45	35-45	1B	NA
SIP-191-004	29-Apr-94	57.5	53.5	47.5-53.5	1B	NA
SIP-191-005	04-May-94	54	48	42-48	1A	NA
SIP-191-101	18-Nov-94	68.5	64	58-64	1B	NA
SIP-212-101	14-Mar-96	94	90.5	87-90.5	2	NA
SIP-293-001	05-Dec-90	56.5	50	45-50	1B	NA
SIP-331-001	21-Sep-91	122	116.5	106.5-116.5	2	NA
SIP-419-101	08-Sep-98	127	123	112-123	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]
SIP-419-202	06-Mar-96	110	106.5	97-106.5	3A	NA
SIP-490-102	08-Nov-95	75	73.5	53.5-73.5	2	NA
SIP-501-004	20-0ct-94	60	56.9	48-56.9	1B	NA
SIP-501-006	11-Nov-92	59.5	56	50-56	1B	NA
SIP-501-007	16-Nov-92	64	59	53-59	1B	NA
SIP-501-101	10-May-94	77.5	73	69-73	1B	NA
SIP-501-102	16-May-94	77	73	67-73	1B	NA
SIP-501-103	20-Mar-94	63	57.5	51-57.5	1B	NA
SIP-501-104	15-Jul-94	67	62	50-62	1B	NA
SIP-501-105	01-Sep-94	73	68	63-68	1B	NA
SIP-501-201	29-Nov-94	65	58.5	54-58.5	1B	NA
SIP-501-202	01-Jul-95	70	64.5	58-64.5	1B	NA
SIP-511-101	25-Jan-96	110	106.7	100-106.7	3A	NA
SIP-511-102	02-Apr-96	114	110.3	108-110	3B	NA
SIP-514-107	03-Jan-90	21.5	17	9-17	1B	NA
SIP-514-109	05-Jan-90	21.5	20	7-22	1B	NA
SIP-514-112	08-Jan-90	21.5	18	7-18	1B	NA
SIP-514-114	09-Jan-90	21.5	17	4-17	1B	NA
SIP-514-116	10-Jan-90	21.5	17	7-17	1B	NA
SIP-514-117	11-Jan-90	21.5	17.5	7-17.5	1B	NA
SIP-514-119	12-Jan-90	21.5	16	6-16	1B	NA
SIP-514-123	17-Jan-90	26.5	23	11.5-23	1B	NA
SIP-514-124	18-Jan-90	21.5	17	6-17	1B	NA
SIP-514-125	19-Jan-90	21.5	15	6-15	1B	NA
SIP-514-126	18-Jan-90	26.5	21.5	4-21.5	1B	NA
SIP-518-203	19-Sep-95	127	127	121-127	5	NA
SIP-543-101	31-Jan-95	111	104	43-103	2	NA
SIP-ALP-001	03-May-90	66	60	45-60	2	NA
SIP-ALP-002	07-May-90	62	57.5	47.5-57.5	1B/2	NA
SIP-AS-001	30-Apr-90	100	100.5	81-90.5	1B	NA
SIP-CR-049	26-Feb-90	42	40	36-40	1B	NA
SIP-EGD-001	16-Oct-90	101.5	85	75-85	3A	NA
SIP-ETC-201	26-Mar-96	106	101	81-101	2	NA
SIP-ETS-201	05-Feb-91	95	90	85-90	3A	NA
SIP-ETS-204	07-May-91	93	97	87-97	3A	NA
SIP-ETS-205	20-Jun-91	103	95	89.5-95	3A	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]
SIP-ETS-207	11-Jul-91	103.5	98.5	89.75-98.5	3A	5
SIP-ETS-209	25-Jul-91	96.6	90	79.75-90	2	NA
SIP-ETS-211	06-Aug-91	103	98.5	95-98.5	3A	NA
SIP-ETS-212	14-Aug-91	106.5	1023	97.5-1023	2	NA
SIP-ETS-213	15-Nov-91	118.5	116.5	108.5-116.5	3A	NA
SIP-ETS-214	22-Nov-91	101	101	86-101	3A	NA
SIP-ETS-215	03-Dec-91	94.5	94.5	84.5-94.5	3A	NA
SIP-ETS-302	30-Mar-92	117.4	113	97-113	3A	NA
SIP-ETS-303	02-Apr-92	110.7	102	95-102	3A	NA
SIP-ETS-304	27-Aug-92	100	97	90-97	3A	NA
SIP-ETS-306	11-Sep-92	101	93	80-5-93	3A	NA
SIP-ETS-401	02-Aug-95	122	121	116-121	3A	NA
SIP-ETS-402	08-Aug-95	110	107	97-107	2	NA
SIP-ETS-404	22-Aug-95	99	95.5	83.5-95.5	2	NA
SIP-ETS-405	29-Aug-95	126	123	114.5-123	3A	NA
SIP-ETS-501	16-Nov-95	110	106.5	100-1006.5	3A	NA
SIP-ETS-502	05-Dec-95	95	88	80-88	2	NA
SIP-HPA-001	20-Apr-90	92.75	75	65-75	2	NA
SIP- HPA-003	19-Apr-90	91.5	66	61-66	2	NA
SIP- HPA-102	08-Dec-94	76	72	67-72	2	NA
SIP-HPA-103	01-Mar-95	77	72.5	67-72.7	2	NA
SIP- HPA-201	14-May-96	97.5	76	71-76	2	NA
SIP-IES-001	16-Sep-92	50.2	46.5	44-46.5	1B	NA
SIP-IES-002	05-Oct-92	41.5	39.2	33-39.2	1A	NA
SIP-INF-201	30-Jun-98	85.9	85.0	64.9-84.6	1B	NA
SIP-INF-202	02-Jul-98	86.3	85.2	64.9-84.8	1B	NA
SIP-ITR-001	19-Apr-91	121.6	115	105-115	5	NA
SIP-ITR-002	02-Apr-91	100	84	79-84	2	NA
SIP-ITR-003	25-Apr-91	121.5	106	98.5-106	5	NA
SIP-NEB-101	23-Sep-92	68.7	66	57-66	2	NA
UP-292-006	07-Nov-90	74	57.5	47.5-57.5	1B	NA
UP-292-007	26-Nov-90	71	56	46-56	1B	NA
UP-292-012	31-Oct-91	67.7	60	45-60	1B	NA
UP-292-014	07-Nov-91	66	66	50-66	1B	NA
UP-292-015	11-Nov-91	61.5	60.5	49.5-60.5	1B	NA
UP-292-020	30-Oct-92	68.5	64	56.5-64	1B	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]
SIP-PA-002	29-Jan-90	16.5	16.5	4-16.5	1B	NA
SIP-PA-003	26-Jan-90	18	14	4-14	1B	NA
SIP-PA-005	04-Jan-90	11.5	8	3-8	1B	NA
SIP-PA-006	04-Jan-90	13.5	12	5-12	1B	NA
SIP-PA-007	04-Jan-90	11.5	5	1-5	1B	NA
SIP-PA-010	25-Jan-90	11.5	9	3-9	1B	NA
SIP-PA-012	29-Jan-90	11.5	9	2-9	1B	NA
SIP-PA-013	24-Jan-90	16.5	13	8-13	1B	NA
SIP-PA-015	25 -Jan-90	21.5	17.5	2-17.5	1B	NA
SIP-PA-016	24 -Jan-90	11.5	11.5	7-11.5	1B	NA
SIP-PA-017	24 -Jan-90	16.5	14	7-14	1B	NA
SIP-PA-018	25 -Jan-90	11.5	8	6-8	1B	NA
SIP-PA-019	26 -Jan-90	16.5	12	2-12	1B	NA
SIP-PA-021	23 -Jan-90	11.5	10	2-10	1B	NA
SIP-PA-024	23 -Jan-90	16.5	15	5-15	1B	NA
SIP-PA-025	23 -Jan-90	11.5	7	4-7	1B	NA
SIP-PA-026	29 -Jan-90	11.5	10	2-10	1B	NA
SIP-PA-027	29 -Jan-90	8.5	7	2-7	1B	NA
SIP-PA-028	23 -Jan-90	11	8	5-8	1B	NA
SIP-PA-030	24 -Jan-90	11.5	8	4-8	1B	NA
SIP-PA-034	04-Jan-90	6.5	5	3-5	1B	NA
SIP-PA-035	04 -Jan-90	11.5	11.5	6.5-11.5	1B	NA
Soil Vapor Installations						
IMS-INF-203	08-Jul-98	63	63	NA[e]	1A	NA
SVI-518-101	21-Sep-90	125	61	55-61	2	NA
SVI-518-201	03-Mar-93	59.8	50	34-50	1B/2	NA
SVI-518-202	03-Nov-93	120.6	73.8	19-73.8	1B/2	NA
SVI-518-204	05-Nov-93	121.5	46	24-46	1B/2	NA
SEA-518-301	11-Sep-95	102.6	100	NA[e]	1B/2/5	NA
SVI-518-302	22-Jun-95	104.5	39.3	11-39	1B	NA
SVI-518-303	29-Jun-95	104.5	42	6-40	1B	NA
SEA-518-304	11-Sep-95	100	50	NA[e]	1B/2/5	NA
SEA-ETS-305	03-9-92	85	85	NA[e]	1B/2	NA
SVI-ETS-504	09-Jul-96	76.5	67	42-67	2	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]
SVI-ETS-505	18-Jul-96	80.5	77.5	45-75	2	NA
SEA-ETS-506	24-Jul-96	75	66	NA[e]	1B/2	NA
SEA-ETS-507	30-Jul-96	75	66	NA[e]	1B/2	NA

Notes: 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."

NA = Not applicable or not available.

[a] Hydrostratigraphic Units (HSUs) are numbered consecutively downward from ground surface. An HSU is defined as 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 hours 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. inside diameter (ID) piezometers surrounding a blank fiberglass 2-in. ID casing instrumented with geophysical sensors. Therefore, the screened intervals listed refer 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

[e] Instrumented membrane systems (IMS)(formerlyFLUTe/SEAMIST membranes) with vapor ports set at varying depths.

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	
W-149	23-Aug-85	201.0	169.0	161-169	2	29-Aug-96
W-150	13-Sep-85	212.0	162.0	157-162	2	11-Apr-90
W-352	29-Oct-86	235.0	201.0	181-201	4	18-Dec-97
W-358	04-Feb-87	248.0	239.0	230-239	7	15-Apr-94
W-1114	07-Aug-95	223	205	177-200	5	22-Apr-97
GSW-1	05-Feb-85	112.0	109.0	85-106	3A	06-Jun-86
GSW-10	29-Apr-86	205.5	127.5	114-127.5	3B	27-Jan-98
GSW-20	18-May-84	134.0	101.3	95-101.3	3A	03-Sep-87
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
2R9 (11A5)[a]	NA	NA	NA	NA	NA	19-Jul-88
11BA[b]	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	

Table A-2. (Continued)

Well number	Date installed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU monitored	Closure date
				254-256	NA	
				306-314	NA	
				319-327	NA	
				339-342	NA	
				414-419	NA	
				424-431	NA	
				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[c]	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[c]	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[c]	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	

Table A-2. (Continued)

Well number	Date installed	Borehole depth (ft)	Casing depth (ft)	Perforated interval (ft)	HSU monitored	Closure date
				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[c]	29-Oct-56	NA	400	200-400	NA	23-Aug-88
14A1[c]	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[c]	15-Nov-56	NA	229	122-130	NA	12-Sep-88
				140-150	NA	
				160-180	NA	
14A4[c]	15-Jun-59	NA	252	167-170	NA	29-Aug-88
				175-179	NA	
				192-202	NA	
				235-246	NA	
14A8	NA	NA	86	NA	NA	22-Jul-88
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	97.0 117.0 160.5	87-97 107-117	3A 3B	09-Feb-93
TEP-GP-003	28-Jan-92	161.0	129.5 161.0	124.5-129.5	3B	13-Feb-93
TEP-GP-004	05-Feb-92	161.0	106.0 134.0 161.0	96-106 124-134	3A 3B	13-Feb-93
TEP-GP-005	18-Feb-92	161.0	124.5 161.0	114.5-124.5	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-006	26-Feb-92	161.0	127.0 161.0	107-127	3B	13-Feb-93
TEP-GP-007	13-Mar-92	161.0	161.0			NA
TEP-GP-008	03-Mar-92	161.0	110.0 161.0	100-110	3A	13-Feb-93
TEP-GP-009	06-May-92	161.7	107.0 130.5 161.0	98-107 120.5-130.5	3A 3B	13-Feb-93
TEP-GP-010	24-Mar-92	161.0	124.5	114.5-124.5	3B	12-Feb-93
TEP-GP-011	07-Apr-92	161.0	108.0 161.0	98-108	3A	13-Feb-93
TEP-GP-002	24-Jun-92	161.4	133.0 161.0	102-112.5 122-133	3A 3B	NA
Source Investigation Piezometers						
SIP-ETS-105	11-Feb-90	110	103	87-103	3A	18-Nov-93
SIP-PA-029	22 -Jan-90	11.5	7	5-7	1B	18-Nov-93
SIP-419-201	29-Feb-96	126	107	97-107	3A/3B	25-Mar-98
SIP-490-101	01-Nov-95	59	56	53-56	2	21-Dec-95
SIP-514-101	28-Dec-89	26	22	7-22	1B	03-Sep-96
UP-292-001	03-Dec-90	54.6	49.5	44.5-49.5	1B	25-Sep-95

Note:

NA = Not applicable or not available.

[a] **Well 11A5 was renamed 2R9 by the Alameda County Flood Control and Water Conservation District, Zone 7 in November 1997. Well 11A5 now corresponds to monitor well W-409.**

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

[c] **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

Appendix B

Hydraulic Test Results

Table B-1. 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]
W-001	1-Dec-83	Drawdown	5.7	2,000	110	Fair
W-001	23-Jan-85	Drawdown	7.1	3,100	170	Good
W-001A	22-Jan-85	Drawdown	1.4	190	19	Good
W-002	1-Dec-83	Slug	0.0	110	34	Poor
W-002A	24-Jan-85	Drawdown	10.3	2,700	200	Good
W-004	1-Dec-83	Drawdown	3.3	63	13	Good
W-005	1-Dec-83	Drawdown	4.3	110	20	Good
W-005	24-Jan-85	Drawdown	7.9	1,100	210	Fair
W-005A	23-Jan-85	Drawdown	13.0	1,300	130	Poor
W-007	1-Dec-83	Slug	0.0	43	14	Fair
W-008	1-Dec-83	Drawdown	2.9	29	4.9	Fair
W-011	1-Dec-83	Drawdown	4.1	130	15	Good
W-017	1-Dec-83	Slug	0.0	38	2.5	Good
W-017	21-Feb-86	Slug	0.0	85	5.7	Good
W-018	1-Dec-83	Drawdown	2.6	20	2.7	Poor
W-102	25-Mar-86	Drawdown	6.4	1,100	76	Good
W-102	5-Sep-86	Drawdown	24.0	770	53	Good
W-102	15-Sep-86	Longterm	27.5	4,200	290	Good
W-103	25-Apr-86	Drawdown	6.7	15,000	1,500	Good
W-104	3-Mar-88	Drawdown	5.4	1,200	170	Fair
W-104	25-Mar-88	Drawdown	3.3	450	45	Fair
W-105	6-Apr-87	Drawdown	0.8	73	7.3	Fair
W-106	19-Feb-86	Slug	0.0	7.4	1.3	Excel
W-107	17-Jun-85	Drawdown	1.0	94	9.4	Poor
W-108	29-Oct-85	Drawdown	7.9	750	63	Poor
W-109	5-Mar-86	Drawdown	8.1	3,200	530	Good
W-109	4-Sep-87	Drawdown	20.0	1,600	270	Good
W-109	29-Sep-87	Longterm	11.6	130	22	Fair
W-109	16-Oct-87	Drawdown	8.0	2,300	380	Fair
W-110	18-Jun-85	Drawdown	5.0	1,300	130	Good
W-111	13-Jun-85	Drawdown	1.0	370	37	Good
W-111	21-Nov-85	Drawdown	1.0	370	37	Good
W-112	18-Nov-86	Drawdown	13.4	2,100	170	Fair
W-112	15-Dec-86	Longterm	13.2	3,100	260	Fair
W-112	5-Nov-96	Longterm	13.7	3,300	260	Fair

Table B-1. (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]
W-113	17-Apr-86	Slug	0.0	7.4	1.2	Excel
W-115	5-Mar-86	Drawdown	1.1	180	30	Good
W-116	24-Dec-85	Slug	0.0	37	7.5	Good
W-117	20-Feb-86	Slug	0.0	2	0.4	Good
W-118	5-Mar-86	Drawdown	10.0	2,100	230	Good
W-119	8-Aug-85	Drawdown	2.0	1,600	110	Good
W-120	22-Apr-86	Drawdown	1.1	23	5.6	Poor
W-121	10-Sep-85	Drawdown	2.0	120	7.5	Good
W-121	23-Sep-85	Drawdown	4.0	23	1.5	Excel
W-121	14-Oct-85	Drawdown	3.0	34	2.2	Excel
W-121	15-Oct-85	Drawdown	4.5	45	3.0	Excel
W-122	28-Oct-85	Drawdown	10.8	490	49	Good
W-123	28-Oct-85	Drawdown	5.8	40	4.4	Poor
W-142	3-Mar-88	Slug	0.0	2,600	330	Excel
W-143	3-Mar-88	Slug	0.0	1,200	240	Excel
W-149	9-Sep-85	Drawdown	4.0	120	19	Good
W-149	11-Sep-85	Drawdown	8.0	95	16	Excel
W-149	11-Oct-85	Drawdown	4.8	58	9.7	Excel
W-149	11-Oct-85	Drawdown	7.0	70	12	Good
W-150	2-Oct-85	Drawdown	3.1	640	210	Fair
W-150	3-Oct-85	Drawdown	6.0	720	240	Fair
W-150	10-Oct-85	Drawdown	8.8	630	210	Fair
W-150	10-Oct-85	Drawdown	12.0	620	210.	Fair
W-151	28-Oct-85	Drawdown	5.8	550	61	Poor
W-201	5-Mar-86	Drawdown	10.0	740	86	Excel
W-203	2-Mar-88	Drawdown	6.6	1,100	110	Good
W-204	23-Jan-86	Drawdown	1.9	100	15	Fair
W-205	14-Feb-86	Slug	0.0	5.9	1.9	Good
W-205	18-Feb-86	Slug	0.0	5.9	1.9	Good
W-206	14-Apr-86	Slug	0.0	120	11	Good
W-207	2-Mar-88	Slug	0.0	380	32	Excel
W-210	9-Jun-86	Slug	0.0	0.6	0.1	Good
W-211	22-Oct-86	Drawdown	2.9	37	12	Fair
W-211	8-Dec-86	Longterm	1.0	44	15	Fair
W-211	16-Sep-97	Longterm	1.1	14	1.4	Good
W-212	12-May-86	Drawdown	0.8	18	3.1	Poor

Table B-1. (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]
W-213	22-Apr-86	Drawdown	3.8	190	38	Good
W-214	7-Oct-86	Longterm	27.6	2,300	350	Good
W-217	15-Jul-86	Slug	0.0	750	120	Good
W-218	17-Jun-86	Drawdown	11.7	6,400	1,100	Good
W-218	12-Nov-86	Longterm	7.7	4,000	670	Good
W-219	15-Jul-86	Drawdown	4.3	620	76	Good
W-219	23-Feb-87	Longterm	5.2	66	8.0	Fair
W-220	21-Aug-86	Slug	0.0	28	5.5	Excel
W-221	5-Aug-86	Drawdown	2.1	120	16	Fair
W-222	12-Aug-86	Drawdown	16.0	1,700	160	Excel
W-222	8-Mar-85	Longterm	7.7	1,100	180	Good
W-223	27-Aug-86	Drawdown	4.0	510	110	Good
W-224	28-Oct-86	Drawdown	7.6	3,600	400	Excel
W-225	23-Oct-86	Drawdown	4.0	85	11	Good
W-225	12-Jan-87	Longterm	2.0	62	8.5	Fair
W-226	31-Mar-87	Slug	0.0	1,700	160	Fair
W-252	4-Nov-85	Drawdown	4.0	920	50	Fair
W-252	19-Nov-85	Drawdown	5.6	800	43	Fair
W-254	27-Jan-86	Drawdown	4.2	340	38	Fair
W-254	27-Feb-86	Drawdown	3.2	370	41	Good
W-255	21-Jan-86	Drawdown	5.0	2,800	250	Fair
W-255	21-Jan-86	Drawdown	6.0	2,000	180	Fair
W-255	6-Jan-87	Longterm	2.0	400	36	Fair
W-256	11-Apr-86	Slug	0.0	11	5.5	Good
W-257	15-Apr-86	Slug	0.0	120	24	Good
W-258	5-Jun-86	Slug	0.0	35	9.0	Excel
W-258	29-Oct-86	Slug	0.0	32	8.0	Good
W-259	26-Mar-88	Slug	0.0	15	5.0	Good
W-260	25-Mar-86	Drawdown	3.0	140	22	Good
W-260	1-Oct-86	Longterm	1.4	120	18	Good
W-261	27-May-86	Slug	0.0	7	2.3	Excel
W-262	11-Apr-86	Drawdown	12.5	2,000	250	Excel
W-262	23-Sep-86	Longterm	22.0	2,750	340	Good
W-262	27-Apr-87	Longterm	23.1	6,800	810	Good
W-263	22-Apr-86	Drawdown	1.2	37	7.4	Poor
W-263	4-Nov-86	Longterm	1.8	76	15	Excel

Table B-1. (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]
W-264	7-May-86	Drawdown	8.1	930	100	Good
W-264	29-Oct-86	Longterm	23.0	480	50	Good
W-265	19-May-86	Drawdown	0.7	180	34	Fair
W-267	2-Jun-86	Drawdown	0.5	420	85	Poor
W-268	14-Nov-86	Drawdown	5.0	230	18	Good
W-269	14-Jul-86	Drawdown	5.0	570	95	Good
W-270	30-Dec-86	Slug	0.0	14	2.0	Good
W-271	4-Aug-86	Drawdown	5.5	340	76	Fair
W-272	19-Aug-86	Drawdown	0.8	150	30	Fair
W-273	27-Aug-86	Drawdown	3.2	600	90	Good
W-274	25-Mar-85	Slug	0.0	38	7.6	Fair
W-275	30-Oct-86	Drawdown	7.0	730	150	Fair
W-275	2-Mar-87	Longterm	5.5	830	170	Fair
W-276	21-Nov-86	Drawdown	13.0	960	110	Good
W-276	4-May-87	Longterm	24.0	2,700	300	Fair
W-277	3-Nov-86	Drawdown	0.9	74	25	Fair
W-290	5-Jan-87	Slug	0.0	14	4.0	Excel
W-291	27-Jan-87	Slug	0.0	25	7.1	Fair
W-292	28-Aug-86	Drawdown	6.0	400	56	Excel
W-294	29-Dec-86	Drawdown	5.3	5,300	29	Fair
W-294	29-Dec-86	Drawdown	5.9	5,400	300	Good
W-301	30-Oct-86	Drawdown	6.0	460	100	Good
W-302	18-Nov-86	Drawdown	1.0	100	27	Good
W-302	18-Nov-86	Drawdown	2.0	76	21	Fair
W-303	12-Nov-86	Drawdown	11.1	210	70	Good
W-304	13-Mar-87	Drawdown	0.9	74	25	Fair
W-305	26-Nov-86	Drawdown	19.0	720	72	Excel
W-305	18-May-87	Longterm	20.1	640	64	Excel
W-306	31-Mar-87	Drawdown	9.5	270	68	Good
W-307	26-Mar-87	Drawdown	0.9	66	33	Fair
W-308	4-Dec-87	Drawdown	2.6	27	5.4	Good
W-310	17-Feb-87	Drawdown	6.7	58	850	Good
W-311	19-Mar-87	Drawdown	9.8	130	12	Good
W-311	17-Nov-87	Longterm	9.9	370	26	Good
W-312	27-Mar-87	Drawdown	20.5	1,800	300	Poor
W-312	3-Nov-87	Longterm	18.8	1,700	280	Good

Table B-1. (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]
W-313	25-Mar-87	Drawdown	7.9	3,000	600	Good
W-313	5-Oct-87	Longterm	9.6	3,400	680	Good
W-314	10-Apr-87	Drawdown	26.4	2,900	390	Good
W-314	13-Jul-87	Longterm	13.6	2,500	330	Fair
W-314	14-Oct-97	Longterm	12	1,400	100	Fair
W-315	9-Apr-87	Drawdown	15.4	150	11	Good
W-315	5-Jan-85	Longterm	24.5	571	41	Excel
W-316	4-May-87	Drawdown	7.8	1,400	280	Good
W-317	12-May-87	Drawdown	12.1	300	43	Fair
W-317	15-Dec-87	Longterm	8.2	120	17.1	Good
W-318	7-Aug-87	Slug	0.0	120	16	Good
W-319	29-Jul-87	Drawdown	48.0	7,200	1,500	Good
W-320	15-May-87	Drawdown	1.8	58	17	Fair
W-320	15-May-87	Drawdown	3.0	22	3.7	Fair
W-320	26-Jun-87	Drawdown	2.1	49	14	Fair
W-321	28-Jul-87	Drawdown	40.0	6,600	450	Good
W-322	3-Aug-87	Drawdown	3.1	85	15	Good
W-323	11-Aug-87	Drawdown	3.4	205	59	Good
W-324	10-Sep-87	Drawdown	6.6	200	50	Good
W-325	10-Sep-87	Drawdown	6.0	160	13	Excel
W-351	12-Nov-86	Drawdown	5.7	27	14	Poor
W-352	30-Dec-86	Drawdown	20.0	280	14	Good
W-352	7-Jul-87	Longterm	19.5	120	6.0	Excel
W-353	20-Nov-86	Drawdown	2.1	60	17	Good
W-354	30-Dec-86	Drawdown	17.6	2,000	220	Fair
W-354	30-Dec-86	Drawdown	18.0	2,400	260	Good
W-354	20-Apr-87	Longterm	17.8	310	34	Good
W-355	29-Dec-86	Drawdown	2.1	19	5.0	Fair
W-356	17-Mar-87	Drawdown	5.7	180	59	Good
W-356	16-Jul-96	Longterm	4.9	230	57	Poor
W-357	18-Feb-87	Drawdown	15.0	1,300	110	Good
W-357	21-Jul-87	Longterm	9.2	210	18	Good
W-358	18-Mar-87	Drawdown	9.2	210	32	Excel
W-359	9-Mar-87	Longterm	19.0	2,800	290	Fair
W-359	20-Mar-87	Drawdown	18.6	1,100	110	Good
W-360	22-May-87	Drawdown	30.0	4,800	210	Excel

Table B-1. (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]
W-361	16-Mar-87	Drawdown	4.3	67	11	Good
W-361	12-Jan-85	Longterm	5.3	178	30	Good
W-362	23-Mar-87	Drawdown	16.4	470	49	Good
W-362	21-Sep-87	Longterm	13.6	370	39	Good
W-363	24-Jul-87	Slug	0.0	20	3.0	Excel
W-364	8-Apr-87	Drawdown	8.6	51	10	Fair
W-364	1-Jun-87	Longterm	4.8	110	22	Good
W-365	14-May-87	Drawdown	10.0	36	15	Fair
W-366	11-May-87	Drawdown	19.0	780	92	Fair
W-368	11-May-87	Drawdown	2.9	81	8.5	Fair
W-369	25-Jun-87	Drawdown	7.0	580	96	Good
W-369	10-Nov-87	Longterm	5.5	89	18	Good
W-370	23-Jun-87	Drawdown	4.4	84	10	Fair
W-371	24-Jun-87	Drawdown	3.3	15	3.0	Good
W-372	23-Nov-87	Slug	0.0	310	62	Excel
W-373	28-Jul-87	Drawdown	4.0	660	77	Fair
W-373	28-Jul-87	Drawdown	6.5	50	6.0	Poor
W-376	26-Jan-88	Drawdown	2.9	65	8.5	Fair
W-380	23-Oct-87	Drawdown	4.0	33	4.7	Excel
W-401	23-Oct-87	Drawdown	42.0	950	24	Excel
W-402	22-Oct-87	Drawdown	41.0	13,500	1,400	Good
W-403	3-Dec-87	Drawdown	9.7	370	26	Good
W-404	4-Feb-85	Drawdown	45.0	3,200	530	Good
W-405	16-Feb-85	Drawdown	47.2	546	14	Good
W-406	28-Jan-85	Drawdown	7.4	7,500	940	Fair
W-407	23-Feb-85	Drawdown	14.4	75	7.5	Fair
W-408	5-Apr-85	Drawdown	45.0	43,000	3,100	Good
W-409	22-Mar-85	Drawdown	20.0	230	38	Good
W-410	28-Apr-85	Drawdown	35.0	6,800	570	Fair
W-411	5-May-85	Drawdown	14.0	50	83	Good
W-412	6-May-88	Drawdown	4.1	700	64	Fair
W-414	27-Jul-85	Slug	0.0	150	38	Good
W-415	31-Aug-85	Drawdown	10.0	3,100	78	Fair
W-416	11-Jul-85	Drawdown	50.0	2,600	330	Good
W-417	27Jun-88	Drawdown	5.3	340	57	Fair
W-420	16-Aug-85	Drawdown	3.5	710	100	Excel

Table B-1. (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]
W-421	12-Sep-85	Drawdown	4.8	320	27	Excel
W-422	19-Sep-85	Drawdown	8.6	230	42	Good
W-423	12-Oct-85	Drawdown	22.0	1,500	130	Good
W-424	17-Oct-85	Drawdown	4.5	130	19	Good
W-441	30-Oct-87	Drawdown	6.0	500	56	Good
W-441	13-Apr-88	Drawdown	13.0	2,200	240	Poor
W-441	19-Apr-88	Longterm	14.0	470	52	Good
W-447	26-Feb-88	Drawdown	7.1	124	850	Poor
W-448	24-Mar-85	Drawdown	24.5	4,200	600	Good
W-449	21-Mar-85	Drawdown	6.2	170	11	Good
W-450	14-Apr-88	Drawdown	3.3	38	650	Fair
W-451	27-Apr-88	Drawdown	2.1	80	16	Good
W-452	2-May-88	Drawdown	5.2	310	21	Excel
W-453	3-May-88	Drawdown	5.8	67	7.4	Fair
W-455	22-Jun-88	Drawdown	5.8	160	13	Good
W-456	14-Jul-85	Drawdown	4.5	260	33	Fair
W-457	29-Jul-85	Drawdown	20.5	450	24	Excel
W-458	2-Aug-85	Drawdown	0.8	24	150	Fair
W-460	1-Sep-85	Drawdown	17.0	1,900	380	Fair
W-461	7-Sep-85	Slug	0.0	690	140	Good
W-462	27-Sep-85	Drawdown	19.0	360	60	Good
W-463	11-Oct-85	Drawdown	24.0	1,600	200	Good
W-464	8-Nov-88	Drawdown	9.0	370	53	Good
W-481	2-Dec-87	Drawdown	1.1	8	1.7	Good
W-486	23-Mar-85	Drawdown	6.0	230	30	Good
W-487	14-Apr-88	Drawdown	2.2	45	15	Good
W-501	21-Oct-85	Drawdown	9.7	170	21	Good
W-502	14-Nov-85	Slug	0.0	12	30	Good
W-503	11-Nov-88	Drawdown	1.3	15	3.0	Fair
W-504	8-Dec-85	Drawdown	10.0	590	84	Good
W-505	21-Mar-89	Drawdown	34.2	653	76	Good
W-506	10-Feb-89	Drawdown	31.0	7,423	460	Good
W-507	6-Feb-89	Drawdown	39.0	2,900	290	Good
W-508	29-Mar-89	Drawdown	30.0	47,000	2,600	Good
W-509	11-May-89	Drawdown	0.9	10	2.0	Fair
W-510	11-May-89	Slug	0.0	220	110	Good

Table B-1. (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]
W-511	11-May-89	Drawdown	1.7	63	11	Fair
W-512	27-Apr-89	Drawdown	2.9	85	9.4	Good
W-513	9-May-89	Drawdown	0.6	33	3.0	Fair
W-514	26-May-89	Drawdown	1.4	84	530	Fair
W-515	6-Jun-89	Drawdown	2.8	37	4.2	Fair
W-516	19-Jun-89	Drawdown	19.5	1,428	286	Good
W-517	27-Jun-89	Drawdown	7.3	370	53	Good
W-518	10-Aug-89	Drawdown	6.2	1,421	178	Good
W-519	31-Aug-89	Drawdown	31.5	5,700	475	Excel
W-520	24-Jan-90	Drawdown	22.8	3,300	560	Excel
W-521	1-Feb-90	Drawdown	0.6	44	4.9	Fair
W-522	5-Feb-90	Drawdown	20.0	3,700	620	Fair
W-551	8-Nov-85	Drawdown	37.0	350	88	Good
W-552	12-Dec-88	Drawdown	38.0	4,700	390	Good
W-553	17-Nov-85	Drawdown	2.2	55	7.9	Fair
W-554	10-Jan-89	Drawdown	21.5	1,800	150	Good
W-555	28-Dec-88	Drawdown	14.0	460	23	Fair
W-556	25-Jan-89	Drawdown	17.0	850	170	Fair
W-557	23-Jan-89	Drawdown	1.2	570	36	Poor
W-558	23-Mar-89	Drawdown	24.7	5,200	650	Good
W-560	8-Mar-89	Drawdown	1.7	30	7.6	Fair
W-561	13-Mar-89	Drawdown	1.1	12	2.1	Fair
W-562	28-Mar-89	Drawdown	1.0	16	2.3	Fair
W-563	31-Mar-89	Drawdown	1.1	14	2.3	Fair
W-564	26-Apr-89	Drawdown	1.6	44	5.0	Poor
W-565	18-Apr-89	Drawdown	15.6	1,600	260	Good
W-566	2-May-89	Drawdown	17.0	780	86	Good
W-566	31-Aug-93	Longterm	22.5	2580	520	Fair
W-567	4-May-89	Drawdown	10.4	2,600	320	Excel
W-568	20-Jun-89	Drawdown	18.3	620	160	Fair
W-569	24-May-89	Drawdown	2.8	100	15	Fair
W-570	8-Jun-89	Drawdown	1.1	7	1.1	Fair
W-571	17-Jul-89	Drawdown	17.7	1,000	200	Excel
W-592	23-Jan-89	Drawdown	2.2	2,200	280	Poor
W-593	22-Feb-89	Drawdown	2.2	57	11.4	Good
W-594	16-Mar-89	Slug	0.0	380	54	Excel

Table B-1. (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]
W-601	8-Feb-90	Drawdown	22.5	6,900	770	Excel
W-602	29-Jan-90	Drawdown	24.0	5,300	620	Good
W-603	7-Feb-90	Drawdown	6.1	100	20	Fair
W-604	20-Feb-90	Slug	0.0	380	63	Good
W-605	28-Feb-90	Drawdown	4.8	50	12	Good
W-606	21-Feb-90	Slug	0.0	120	20	Fair
W-607	22-Feb-90	Drawdown	1.4	800	100	Good
W-608	28-Feb-90	Drawdown	1.2	230	30	Fair
W-609	9-Mar-90	Drawdown	6.7	470	70	Good
W-610	28-Mar-90	Drawdown	5.8	5,500	380	Good
W-611	16-Apr-90	Drawdown	3.5	1,000	110	Fair
W-612	24-May-90	Drawdown	13.5	550	55	Good
W-612	05-Apr-94	Longterm	14	230	40	Good
W-613	23-May-90	Drawdown	4.8	2,550	360	Good
W-614	7-Jun-90	Drawdown	6.7	1,650	130	Good
W-615	21-Jun-90	Drawdown	1.3	130	19	Fair
W-616	27-Jun-90	Drawdown	2.0	390	40	Fair
W-617	12-Jul-90	Drawdown	2.8	53	6.8	Good
W-618	1-Aug-90	Drawdown	1.9	24	4.8	Fair
W-619	30-Aug-90	Drawdown	11.8	190	11	Good
W-620	1-Oct-90	Drawdown	5.8	6,500	650	Good
W-621	4-Oct-90	Drawdown	3.8	310	39	Good
W-622	12-Oct-90	Slug	0.0	130	16	Fair
W-651	16-Mar-90	Slug	0.0	530	180	Fair
W-652	22-Mar-90	Drawdown	1.0	11	3.8	Good
W-653	11-Apr-90	Drawdown	0.3	2	1.9	Fair
W-654	25-Apr-90	Drawdown	21.7	390	25	Fair
W-655	12-May-90	Drawdown	12.2	1,000	220	Good
W-701	23-Oct-90	Drawdown	14.5	6,800	650	Good
W-701	3-Oct-92	Step	16.5	5,200	430	Good
W-701	1-Apr-93	Drawdown	24	3,700	370	Good
W-702	29-Nov-90	Drawdown	2.5	150	30	Good
W-702	25-Feb-93	Step	4.6	36	7	Poor
W-703	19-Dec-90	Drawdown	7.0	230	9.1	Good
W-704	4-Mar-91	Drawdown	19.0	1,800	140	Fair
W-705	20-Feb-91	Drawdown	0.8	40	6.1	Fair

Table B-1. (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]
W-706	29-Jan-91	Drawdown	0.2	8	1	Fair
W-712	25-Feb-92	Drawdown	7.8	750	48	Good
W-712	18-Mar-93	Longterm	15.1	1440	93	Good
W-714	6-Dec-91	Drawdown	2.9	140	6.7	Good
W-902	25-Mar-93	Drawdown	0.6	6	2	Fair
W-909	18-Oct-95	Drawdown	2.7	150	5.1	Good
W-911	2-Feb-96	Drawdown	1.4	53	2.1	Good
W-912	10-Nov-95	Drawdown	4.1	65	11	Poor
W-913	16-Aug-95	Drawdown	23.5	730	36	Good
W-1001	13-Aug-95	Drawdown	1.3	170	25	Fair
W-1002	19-Jun-97	Drawdown	16.8	680	49	Good
W-1003	26-Jun-97	Drawdown	1.2	5.1	0.7	Poor
W-1006	17-Jun-97	Drawdown	17.4	180	23	Fair
W-1007	23-Sep-95	Drawdown	1.6	13	1.3	Fair
W-1008	17-Jan-97	Drawdown	7.3	110	13	Good
W-1010	10-Jul-95	Drawdown	20.3	1,650	140	Fair
W-1011	11-Jul-95	Drawdown	3.8	240	17	Good
W-1012	13-Jul-95	Drawdown	3.3	35	2.2	Fair
W-1013	13-Jul-95	Drawdown	2.7	2,000	250	Poor
W-1014	28-Aug-96	Drawdown	31.1	7,700	320	Good
W-1101	22-Nov-95	Drawdown	0.8	9.9	3.3	Good
W-1102	29-Jan-96	Drawdown	14.7	81	4.5	Fair
W-1103	29-Nov-95	Drawdown	3	19	1.6	Fair
W-1105	17-Jul-95	Drawdown	2.4	320	26	Fair
W-1106	24-Jul-96	Drawdown	7.1	5,200	580	Good
W-1107	9-Apr-97	Drawdown	6.7	3,500	250	Poor
W-1108	3-Nov-95	Drawdown	12.3	950	68	Good
W-1108	25-Jun-96	Longterm	11.6	1,000	70	Poor
W-1109	26-Jun-95	Drawdown	8.7	460	33	Fair
W-1109	4-Jun-96	Longterm	6.8	760	40	Poor
W-1110	22-Jan-96	Drawdown	6.3	690	29	Fair
W-1111	20-Oct-95	Drawdown	15.8	2,100	95	Good
W-1111	9-Dec-96	Longterm	11.2	160	7.9	Poor
W-1112	24-May-96	Drawdown	6.4	94	10	Fair
W-1113	26-Aug-96	Drawdown	1	5.5	0.6	Good
W-1114	27-Oct-95	Longterm	15.1	270	12	Fair

Table B-1. (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]
W-1116	23-Feb-96	Drawdown	6.6	290	11	Fair
W-1117	23-Aug-96	Drawdown	0.7	3.4	0.34	Fair
W-1118	18-Jan-96	Drawdown	5.6	350	35	Good
W-1201	1-Nov-96	Drawdown	1	8.3	0.92	Poor
W-1203	2-May-96	Drawdown	18.8	900	90	Good
W-1204	22-Feb-96	Drawdown	1.3	17	2.2	Poor
W-1205	27-Nov-96	Slug	0	330	33	Fair
W-1207	27-Nov-96	Slug	0	900	45	Poor
W-1209	17-May-96	Drawdown	0.98	11	0.69	Good
W-1210	30-May-96	Drawdown	3.8	7.3	0.73	Fair
W-1211	26-Jul-96	Drawdown	28.6	5,000	330	Good
W-1212	14-May-96	Drawdown	1.9	35	2.5	Good
W-1212	10-Sep-96	Longterm	1.3	85	3.6	Poor
W-1213	22-Jul-96	Drawdown	11.6	500	42	Fair
W-1213	30-Jul-96	Longterm	9.6	440	37	Poor
W-1214	28-Apr-97	Drawdown	2.2	110	5.4	Fair
W-1215	15-Aug-96	Drawdown	11.6	610	61	Fair
W-1215	8-Oct-96	Longterm	9.8	3,000	300	Poor
W-1216	14-Aug-96	Drawdown	11.4	210	6.9	Good
W-1216	15-Oct-96	Longterm	11.1	160	5.4	Poor
W-1218	11-Nov-96	Drawdown	5.8	83	4.6	Fair
W-1218	8-Jul-97	Longterm	4.8	210	12	Fair
W-1219	27-May-97	Drawdown	0.4	2.5	0.63	Poor
W-1220	13-Nov-96	Drawdown	20.3	2,600	120	Good
W-1220	15-Jul-97	Longterm	20	4,700	210	Fair
W-1221	27-Dec-96	Drawdown	3.1	29	2.9	Fair
W-1222	31-Oct-96	Drawdown	6.1	430	43	Good
W-1224	22-May-97	Drawdown	5	55	11	Good
W-1225	31-Mar-97	Drawdown	4.1	83	10	Good
W-1226	27-Feb-97	Drawdown	2.2	14	1.4	Excel
W-1227	11-Apr-97	Drawdown	15.1	380	48	Fair
W-1254	19-Nov-96	Longterm	18.9	1,130	110	Fair
W-1301	10-Mar-97	Longterm	4.7	120	15	Fair
W-1303	18-Mar-97	Longterm	7.8	490	21	Fair
W-1304	2-Jul-97	Drawdown	0.7	2.6	0.52	Poor
W-1306	30-Apr-97	Drawdown	2.8	24	1.2	Good

Table B-1. (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]
W-1306	18-Jun-97	Longterm	1.6	54	2.7	Poor
W-1307	31-Jul-97	Drawdown	11.6	1,100	110	Good
W-1308	14-Aug-97	Drawdown	6.5	150	5.1	Good
W-1308	7-Oct-977	Longterm	4	530	18	Fair
W-1309	15-Oct-97	Drawdown	9.1	90	8.9	Fair
W-1310	10-Mar-97	Drawdown	27.9	1,060	53	Good
W-1311	29-Oct-97	Drawdown	12.2	290	15	Good
W-1401	11-Nov-97	Drawdown	7	100	6.8	Excel
W-1402	12-Dec-97	Drawdown	2.6	100	10.2	Fair
W-1403	21-Jul-98	Drawdown	5.4	95	13	Good
W-1404	21-Apr-98	Drawdown	6.5	210	84	Good
W-1405	23-Apr-98	Drawdown	6.4	1,300	360	Fair
W-1406	17-Apr-98	Drawdown	11.1	3,600	360	Good
W-1407	3-Apr-98	Drawdown	1.1	8.7	1.0	Excellent
W-1408	15-Apr-98	Drawdown	2.7	85	28	Fair
W-1410	29-Jun-98	Drawdown	11.5	3,000	500	Poor
W-1411	15-May-98	Drawdown	12.3	14,700	1300	Poor
W-1412	29-May-98	Slug	0.0	2	0.67	Fair
W-1413	8-Jun-98	Drawdown	0.63	8.7	3.5	Fair
W-1415	11-Jun-98	Drawdown	0.87	18	1.2	Fair
W-1416	28-Jul-98	Drawdown	12.3	1,300	180	Good
W-1417	1-Jul-98	Drawdown	15.1	130	11	Good
W-1417	16-Jul-98	Step	5.9	150	13	Fair
W-1418	25-Sep-98	Drawdown	10.7	78	6.5	Excellent
W-1418	16-Dec-98	Step	10.5	490	41	Fair
W-1419	15-Jul-98	Step	6.1	47	3	Poor
W-1420	12-Aug-98	Drawdown	13.1	3,000	220	Poor
W-1421	14-Jul-98	Step	1.82	14	1.8	Poor
W-1421	17-Jul-98	Step	3.8	22	2.8	Poor
W-1422	18-Sep-98	Drawdown	12.0	170	33	Excellent
W-1422	18-Dec-98	Step	11.7	160	32	Good
W-1423	12-Nov-98	Drawdown	24.6	540	39	Fair
W-1424	1-Oct-98	Drawdown	6	48	6.9	Excellent
W-1425	1-Oct-98	Drawdown	1.4	15	2.4	Fair
W-1426	13-Nov-98	Drawdown	6.5	840	56	Good
W-1501	20-Nov-98	Drawdown	7.2	68	11	Good

Table B-1. (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]
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
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
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
11H4	15-Jan-85	Drawdown	24.6	2,000	77	Good
11H4	19-Jan-85	Longterm	29.5	1,780	18	Good

Table B-1. (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]
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

1999 Ground Water Sampling Schedule

Table C-1. 1999 LLNL Livermore Site ground water sampling schedule.

Well number	1999 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-99)	VOCs
W-001	A	1-99		E601
W-001A	A	1-99		E601
W-002	A	3-99		E601
W-002A	O	4-99		E601
W-004	A	2-99		E601
W-005	A	1-99		E601
W-005A	A	4-99		E601
W-007	E	4-00		E601
W-008	A	4-99	WGMG	E601
W-010A	A	3-99		E601
W-011	A	1-99		E601
W-012	Q	1-99		E601
W-017	E	4-00		E601
W-017A	E	3-00		E601
W-019	E	4-00		E601
W-101	A	1-99		E601
W-102	A	2-99		E601
W-103	A	3-99		E601
W-104	Q	1-99		E601
W-105	S	1-99		E601
W-106	E	3-00		E601
W-107	Q	1-99		E601
W-108	O	2-99		E601
W-110	Q	1-99		E601
W-111	A	2-99		E601
W-113	E	4-00		E601
W-114	S	1-99		E601
W-115	A	3-99		E601
W-116	Q	1-99		E601
W-117	E	4-00		E601
W-118	S	1-99		E601
W-119	Q	1-99	WGMG	E601
W-120	Q	1-99		E601
W-121	Q	1-99	WGMG	E601
W-122	E	1-00		E601
W-123	E	1-00		E601

Table C-1. (Continued)

Well number	1999 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-99)	VOCs
W-141	E	2-00		E601
W-142	Q	1-99		E601
W-143	A	4-99		E601
W-146	A	1-99		E601
W-147	A	1-99		E601
W-148	A	4-99		E601
W-151	Q	1-99		E601
W-201	A	4-99		E601
W-202	E	4-00		E601
W-203	E	2-00		E601
W-204	A	1-99	WGMG	E601
W-205	Q	1-99		E601
W-206	Q	1-99		E601
W-207	Q	1-99		E601
W-210	E	1-99	E906	E601
W-212	E	4-00		E601
W-213	A	1-99		E601
W-214	A	2-99		E601
W-217	Q	1-99		E601
W-219	Q	1-99		E601
W-220	A	1-99		E601
W-221	E	1-99	WGMG	E601
W-222	S	1-99		E601
W-223	A	1-99		E601
W-224	A	1-99		E601
W-225	A	4-99		E601
W-226	Q	1-99	NPDES	E601
W-251	Q	1-99		E601
W-252	A	2-99		E601
W-253	A	4-99		E601
W-254	Q	1-99		E601
W-255	A	2-99		E601
W-256	O	1-99		E601
W-257	Q	1-99		E601
W-258	Q	1-99		E601
W-259	Q	1-99		E601

Table C-1. (Continued)

Well number	1999 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-99)	VOCs
W-260	A	4-99		E601
W-261	E	3-00		E601
W-263	Q	1-99		E601
W-264	S	2-99		E601
W-265	E	3-00		E601
W-267	S	1-99		E601
W-268	Q	1-99		E601
W-269	S	1-99		E601
W-270	Q	1-99		E601
W-271	Q	1-99		E601
W-272	Q	1-99		E601
W-273	A	4-99		E601
W-274	Q	1-99		E601
W-275	S	2-99		E601
W-276	S	1-99		E601
W-277	A	1-99		E601
W-290	E	4-00		E601
W-291	E	4-00		E601
W-292	A	1-99		E601
W-293	E	2-00		E601
W-294	O	2-99		E601
W-301	A	4-99		E601
W-302	A	3-99		E601
W-303	A	1-99		E601
W-304	A	3-99		E601
W-305	Q	1-99		E601
W-306	Q	1-99	NPDES	E601
W-307	Q	1-99	NPDES	E601
W-308	A	4-99		E601
W-310	E	3-00		E601
W-311	S	1-99		E601
W-312	A	2-99		E601
W-313	A	1-99		E601
W-315	Q	1-99		E601
W-316	Q	1-99		E601
W-317	S	2-99		E601

Table C-1. (Continued)

Well number	1999 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-99)	VOCs
W-318	O	2-99		E601
W-319	E	4-00		E601
W-320	S	2-99	E906	E601
W-321	O	1-99		E601
W-322	Q	1-99		E601
W-323	Q	1-99		E601
W-324	E	2-00		E601
W-325	E	4-00		E601
W-353	S	1-99		E601
W-354	Q	1-99		E601
W-355	Q	1-99		E601
W-356	S	2-99		E601
W-359	Q	1-99		E601
W-360	Q	1-99		E601
W-362	E	2-00		E601
W-363	Q	1-99	WGMG/E906	E601
W-364	Q	1-99		E601
W-365	A	3-99		E601
W-366	O	2-99		E601
W-368	A	1-99		E601
W-369	A	3-99		E601
W-370	A	4-99		E601
W-371	E	3-00		E601
W-372	E	3-00		E601
W-373	A	1-99	WGMG	E601
W-375	Q	1-99		E601
W-376	A	2-99		E601
W-377	A	2-99		E601
W-378	A	4-99		E601
W-379	A	4-99		E601
W-380	E	4-00		E601
W-401	E	2-00		E601
W-402	E	4-00		E601
W-403	E	3-00		E601
W-404	Q	1-99		E601
W-405	Q	1-99		E601

Table C-1. (Continued)

Well number	1999 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-99)	VOCs
W-406	A	1-99		E601
W-407	Q	1-99		E601
W-409	A	2-99		E601
W-410	Q	1-99		E601
W-411	S	1-99		E601
W-412	S	2-99		E601
W-413	A	1-99	E906	E601
W-414	A	3-99		E601
W-416	A	2-99		E601
W-417	E	2-00		E601
W-418	A	2-99		E601
W-419	Q	1-99		E601
W-420	A	2-99		E601
W-421	Q	1-99		E601
W-422	E	3-00		E601
W-423	Q	1-99		E601
W-424	S	2-99		E601
W-446	O	4-99		E601
W-447	A	3-99		E601
W-448	A	2-99		E601
W-449	A	4-99		E601
W-450	A	1-99		E601
W-451	E	1-00		E601
W-452	E	4-00		E601
W-453	E	3-00		E601
W-454	S	1-99		E601
W-455	E	1-00		E601
W-456	A	3-99		E601
W-458	E	4-00		E601
W-459	A	2-99		E601
W-460	A	4-99		E601
W-461	A	1-99		E601
W-462	A	3-99		E601
W-463	A	1-99		E601
W-464	A	3-99		E601
W-481	Q	1-99		E601

Table C-1. (Continued)

Well number	1999 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-99)	VOCs
W-482	A	2-99		E601
W-483	A	4-99		E601
W-484	O	3-00		E601
W-485	A	2-99		E601
W-486	A	1-99	E906	E601
W-487	A	1-99		E601
W-501	S	2-99		E601
W-502	A	2-99		E601
W-503	A	2-99		E601
W-504	O	3-99		E601
W-505	A	2-99		E601
W-506	Q	1-99		E601
W-507	E	3-00		E601
W-509	Q	1-99		E601
W-510	E	3-00		E601
W-511	O	3-99		E601
W-512	A	4-99		E601
W-513	A	3-99		E601
W-514	O	2-99		E601
W-515	Q	1-99		E601
W-516	E	4-00		E601
W-517	Q	1-99		E601
W-519	E	4-00		E601
W-521	A	4-99		E601
W-551	A	2-99		E601
W-552	A	2-99		E601
W-553	E	4-00		E601
W-554	A	2-99		E601
W-555	E	2-00		E601
W-556	A	4-99	WGMG	E601
W-557	E	3-00		E601
W-558	Q	1-99		E601
W-559	E	3-00		E601
W-560	O	4-99		E601
W-561	E	2-00		E601
W-562	Q	1-99		E601

Table C-1. (Continued)

Well number	1999 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-99)	VOCs
W-563	E	2-00		E601
W-564	Q	1-99		E601
W-565	E	4-00		E601
W-567	A	1-99		E601
W-568	S	2-99		E601
W-569	S	1-99		E601
W-570	E	2-00		E601
W-571	E	2-00	WGMG	E601
W-591	E	3-00		E601
W-592	O	3-99		E601
W-593	O	1-99	WGMG	E601
W-594	O	1-99		E601
W-604	Q	1-99		E601
W-606	S	2-99		E601
W-607	S	2-99		E601
W-608	E	3-00		E601
W-611	S	1-99		E601
W-612	A	2-99		E601
W-613	A	1-99		E601
W-615	A	2-99		E601
W-616	A	4-99		E601
W-617	A	2-99		E601
W-618	Q	1-99		E601
W-619	E	3-00		E601
W-622	Q	1-99		E601
W-651	Q	1-99		E601
W-652	E	2-00		E601
W-653	Q	1-99		E601
W-654	S	2-99		E601
W-702	A	2-99		E601
W-705	S	1-99		E601
W-706	A	3-99		E601
W-750	Q	1-99		E601
W-901	Q	1-99		E601
W-902	A	3-99		E601
W-905	A	4-99		E601

Table C-1. (Continued)

Well number	1999 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-99)	VOCs
W-908	A	1-99		E601
W-909	Q	1-99		E601
W-911	Q	1-99		E601
W-912	Q	1-99		E601
W-913	Q	1-99		E601
W-1002	A	2-99		E601
W-1003	E	4-00		E601
W-1005	A	1-99		E601
W-1006	Q	1-99		E601
W-1007	A	1-99		E601
W-1008	E	4-00		E601
W-1010	O	4-99		E601
W-1011	A	2-99		E601
W-1012	A	1-99	WGMG	E601
W-1013	A	3-99		E601
W-1014	S	1-99		E601
W-1101	A	2-99		E601
W-1105	A	2-99		E601
W-1106	A	4-99		E601
W-1107	Q	1-99		E601
W-1108	Q	1-99		E601
W-1110	S	1-99		E601
W-1112	Q	1-99		E601
W-1113	Q	1-99		E601
W-1115	Q	1-99	E602	E601
W-1117	Q	1-99		E601
W-1118	Q	1-99		E601
W-1201	Q	1-99		E601
W-1202	Q	1-99		E601
W-1203	Q	1-99		E601
W-1204	Q	1-99		E601
W-1205	Q	1-99		E601
W-1207	Q	1-99		E601
W-1209	Q	1-99		E601
W-1210	A	4-99		E601
W-1212	Q	1-99		E624

Table C-1. (Continued)

Well number	1999 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-99)	VOCs
W-1214	Q	1-99		E601
W-1217	Q	1-99		E601
W-1218	Q	1-99		E601
W-1219	Q	1-99		E601
W-1220	Q	1-99		E601
W-1221	Q	1-99		E601
W-1222	Q	1-99		E601
W-1223	Q	1-99		E601
W-1224	A	2-99		E601
W-1225	Q	1-99		E601
W-1226	A	2-99		E601
W-1227	A	4-99		E601
W-1250	Q	1-99		E601
W-1251	A	4-99		E601
W-1252	Q	1-99		E601
W-1253	Q	1-99		E601
W-1254	A	4-99		E601
W-1255	Q	1-99		E601
W-1304	Q	1-99		E601
W-1311	Q	1-99		E601
W-1401	Q	1-99		E601
W-1402	Q	1-99		E601
W-1403	Q	1-99		E601
W-1404	Q	1-99		E601
W-1405	Q	1-99		E601
W-1406	Q	1-99		E601
W-1407	Q	1-99		E601
W-1408	Q	1-99		E601
W-1410	Q	1-99		E601
W-1411	Q	1-99	E602	E601
W-1412	Q	1-99	E906	E601
W-1413	Q	1-99		E601
W-1414	Q	1-99	E906	E601
W-1415	Q	1-99		E601
W-1416	Q	1-99		E601
W-1417	Q	1-99		E601

Table C-1. (Continued)

Well number	1999 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-99)	VOCs
W-1419	Q	1-99		E601
W-1420	Q	1-99		E601
W-1421	Q	1-99		E601
W-1423	Q	1-99		E601
W-1424	Q	1-99		E601
W-1425	Q	1-99		E601
W-1426	Q	1-99		E601
W-1427	Q	1-99		E601
W-1428	Q	1-99		E601
W-1501	Q	1-99		E601
TW-11	A	2-99		E601
TW-11A	E	3-00		E601
TW-21	A	4-99		E601
11C1	E	1-00		E601
14A11	E	2-00		E601
14A3	A	4-99		E601
14B1	E	4-00	WGMG	E601
14B4	O	2-99		E601
14C1	O	3-99		E601
14C2	O	3-99		E601
14C3	A	4-99		E601
14H1	E	2-00		E601
18D1	E	2-00		E601
GEW-710	A	4-99		E601
GSW-006	A	4-99	E602	E601
GSW-007	O	4-99		E601
GSW-008	O	4-00	E602	E601
GSW-009	A	4-99	E602	E601
GSW-011	A	1-99		E601
GSW-013	E	4-99	E602	E624
GSW-215	S	2-99	E602	E601
GSW-266	Q	1-99	E602	E601
GSW-326	Q	1-99		E601

Table C-1. (Continued)

Well number	1999 VOC sampling frequency	Next quarter sample date	Metals, RAD, etc. (1-99)	VOCs
GSW-367	A	2-99		E601
GSW-442	E	4-00		E601
GSW-443	A	2-99		E601
GSW-444	A	2-99		E601

Notes:

O = Odd years.

A = Annual.

S = Semiannual.

Q = Quarterly.

E = Even years.

E601 = EPA Method 601 for purgeable halocarbons.

E602 = EPA Method 602 for aromatic volatile compounds.

E624 = EPA Method 624 for volatile organic compounds (VOCs).

E906 = EPA Method 906 for tritium.

WGMG = Water Guidance and Monitoring Group. - This work is related to the environmental surveillance monitoring programs carried out at DOE sites to compliment restoration activities.

Appendix D

1998 Drainage Retention Basin Annual Monitoring Program Summary

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This Appendix summarizes the 1998 LLNL Operations and Regulatory Affairs Division routine maintenance activities, maintenance monitoring, 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 43 acre-ft (approximately 1.4×10^7 gal) capacity. It was designed to receive storm water runoff and treated ground water discharges.

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, as requested by the California Regional Water Quality Control Board-San Francisco Bay Region (CRWQCB-SF). In addition samples are collected during each dry season release. Release water samples are collected at location CDBX and are compared with the LLNL Arroyo Las Positas outfall samples collected at sample location WPDC (Fig. D-1). Release samples are used to determine compliance with current discharge limits. Discharge limits are established in the CERCLA *Record of Decision for the Lawrence Livermore National Laboratory, Livermore Site* (Department of Energy, 1992) and the *Explanation of Significant Differences for Metals Discharge Limits at the Lawrence Livermore National Laboratory, Livermore Site* (Berg et al., 1997).

Weekly maintenance field monitoring measurements are conducted at sample locations CDBA, CDBC, CDBD, CDBE, CDBF, CDBJ, CDBK, and 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 DRB management decisions. Management action levels (MALs) are specified in the *Drainage Retention Basin Management Plan, Lawrence Livermore National Laboratory* (Limnion Corp., 1991). The MAL is the concentration at which corrective management responses should be implemented. In most cases, short-term variances outside the normal range are not significant, and management response is required only if the MAL is substantially exceeded.

Complete analytical results of release and basin samples are reported in the LLNL Livermore Site Project Quarterly Self-Monitoring Reports for 1998.

D.1. Drainage Retention Basin Maintenance Monitoring

Samples collected during 1998 within the DRB at location CDBE did not meet the MALs for ammonia, chemical oxygen demand, dissolved oxygen, fecal coliform, nitrate (as nitrogen), pH, temperature, total dissolved solids, total phosphorus (as phosphorus) and turbidity (Table D-1).

Table D-1. Constituents monitored at CDBE exceeding Management Action Levels (MALs).

Analysis	MAL	Maximum value	Minimum value	Samples not meeting MAL/ samples collected
Ammonia as Nitrogen (mg/L)	>0.1	0.26	<0.02	03/12
Chemical Oxygen Demand (mg/L)	>20	32	22	04/04
Dissolved Oxygen (% saturation)	<80%	128%	39%	33/48
Dissolved Oxygen (mg/L)	<5	13.6	3.4	11/48
Fecal Coliform (MPN)	>400	1600	<2	02/05
Nitrate (as N) (mg/L)	>0.2	1.9	<0.1	09/12
pH (units)	<6.0 and >9.0	9.35	7.48	02/11
Temperature (degrees F)	<15 and > 26	26.9	6.8	22/49
Total Dissolved Solids (mg/L)	>400	440	196	03/11
Total Phosphorous (mg/L)	>0.02	1.3	0.25	11/11
Turbidity (meters)	<0.914	.94	0.15	39/40

MPN = most probable number.

Ammonia, as nitrogen, occasionally exceeded its MAL in 1998. Ammonia is an indication of anaerobic conditions in the DRB, as also indicated by several low dissolved oxygen readings recorded during the year. Dissolved oxygen is believed to be low for two reasons. First, the pumps that circulate water in the DRB were left off 6 weeks longer than usual in an effort to increase water clarity. Water clarity improved as indicated by turbidity levels near or below the MAL. Water clarity, which is assessed by measuring turbidity, is typically low in the winter months when runoff transports suspended sediment to the DRB. However, once the recirculation pumps were turned on to manage dissolved oxygen levels, water clarity began to decrease.

The other reason for low dissolved oxygen is that the pumps apparently cannot keep up with the oxygen demand occurring in the DRB, as indicated by the high chemical oxygen demand throughout the year. Chemical oxygen demand first exceeded the MALs in 1997 and continued to be high during 1998. The high chemical oxygen demand is primarily due to decaying organic materials that are washed into the DRB during winter storms and from decaying algae biomass.

Fecal coliform was high in the DRB for the second year in a row. Fecal coliform exceeded the MAL for the first time in 1997 since the DRB began to operate in 1991. Total coliform counts were also high, but below the MAL, in the two samples collected in January and February 1998. The source of the coliform is mostly likely the ranch lands located in the watershed upstream of the DRB.

Total phosphorous continued to be above the MAL throughout 1998. Phosphorous concentration reached a maximum of 1.9 mg/L in December 1998. The anticipated decrease in phosphorous was not observed when the treatment facilities discharging into the DRB stopped using a phosphate based anti corrosion agent. Nitrate as nitrogen concentrations also continued to exceed the MAL during 1997. The source of nitrate has not been identified.

Although nutrient levels have been high since 1994, chlorophyll "a", which indicates the level of algae growth, remains well below the 10 mg/L MAL, ranging from <0.0038 mg/L to 0.043 mg/L in 1998. Though the chlorophyll "a" levels did not increase significantly from last year, algae growth was visually evident this year and the DRB experienced a mild algae bloom in late October through early February. The algae bloom, high nutrient levels, low oxygen saturation, high temperature, and high chemical oxygen demand are believed to be the cause of the bacteria-related catfish kill that occurred in October. Approximately 70 juvenile catfish died between October 14 and October 16. The Department of Fish and Game identified the probable cause of death as an opportunistic bacteria that causes disease when the fish experience environmental stress. Annual toxicity tests collected in October indicated low levels of toxicity for Selanastrum capricornutum and Ceriodaphnia dubia (2 toxicity units for each). At the Department of Fish and Game biologist's recommendation, approximately seven million gallons of water were released from the DRB, which reduced the nutrient loading. No further fish deaths were observed though nutrient levels continued to be elevated.

Semiannual and annual maintenance sampling was conducted during April and October of 1998. Quarterly sampling was conducted in January, April, July, and October. Oil and grease, volatile organic compounds, total organic carbon, gross alpha, gross beta, and tritium all met their MALs.

In 1997, LLNL began quarterly microbiological monitoring as a tool to evaluate the nature and health of the DRB aquatic community as an expression of water quality. LLNL also began semi-annual biological monitoring to evaluate the impact that the DRB has on surrounding and downstream ecosystems. These data continued to be collected in 1998.

D-2. Drainage Retention Basin Discharge Monitoring

Approximately 81 million gallons of water were discharged from the DRB during 1998. Due to flow meter problems, the discharge volume can only be estimated. Approximately 72 million gallons of water were released from the DRB during the wet season releases (October 1 through May 31). Dry season releases (June 1 through September 30) totaled approximately 9 million gallons. For the first time, discharges from the DRB occurred in every month; much of the discharge was continuous. The largest single day discharge occurred on December 17, 1998 (3.4 million gallons) which was associated with a manual discharge from the DRB to reduce the volume of water stored in preparation for upcoming winter storms.

The dry season release was continuous. A single sample was collected in August to characterize the dry season release. Three samples were collected during the wet season. A sample was collected November 4, 1998 to characterize the first manual release of the season. The purpose of this release was to reduce the volume of water stored in the DRB, as well as to allow flushing to improve water quality within the DRB. Two additional wet season samples were collected in 1998 on February 12 and November 30.

All discharge samples complied with discharge limits identified in the *Record of Decision for the Lawrence Livermore National Laboratory, Livermore Site* and the *Explanation of Significant Differences for Metals Discharge Limits at the Lawrence Livermore National Laboratory Livermore Site,* Dry season (April 1–November 30) limits were used to evaluate the compliance of the August and November samples. Wet weather limits (December 1–March 31) were used to evaluate the compliance of the February sample. Though not regulated, residual levels of bromacil (2.5 µg/L) and diruon (3.5 µg/L) were detected in the November 30 sample. These concentrations were well below levels identified in previous years as inhibiting algae growth.

D-3. References

Berg, L., E. Folsom, M. Dresen, R. Bainer, A. Lamarre (Eds.) (1997), *Explanation of Significant Differences for Metals Discharge Limits at the Lawrence Livermore National Laboratory Livermore Site*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-125927).

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

U.S. Department of Energy (DOE) (1992), *Record of Decision for the Lawrence Livermore National Laboratory, Livermore Site*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-AR-109105).

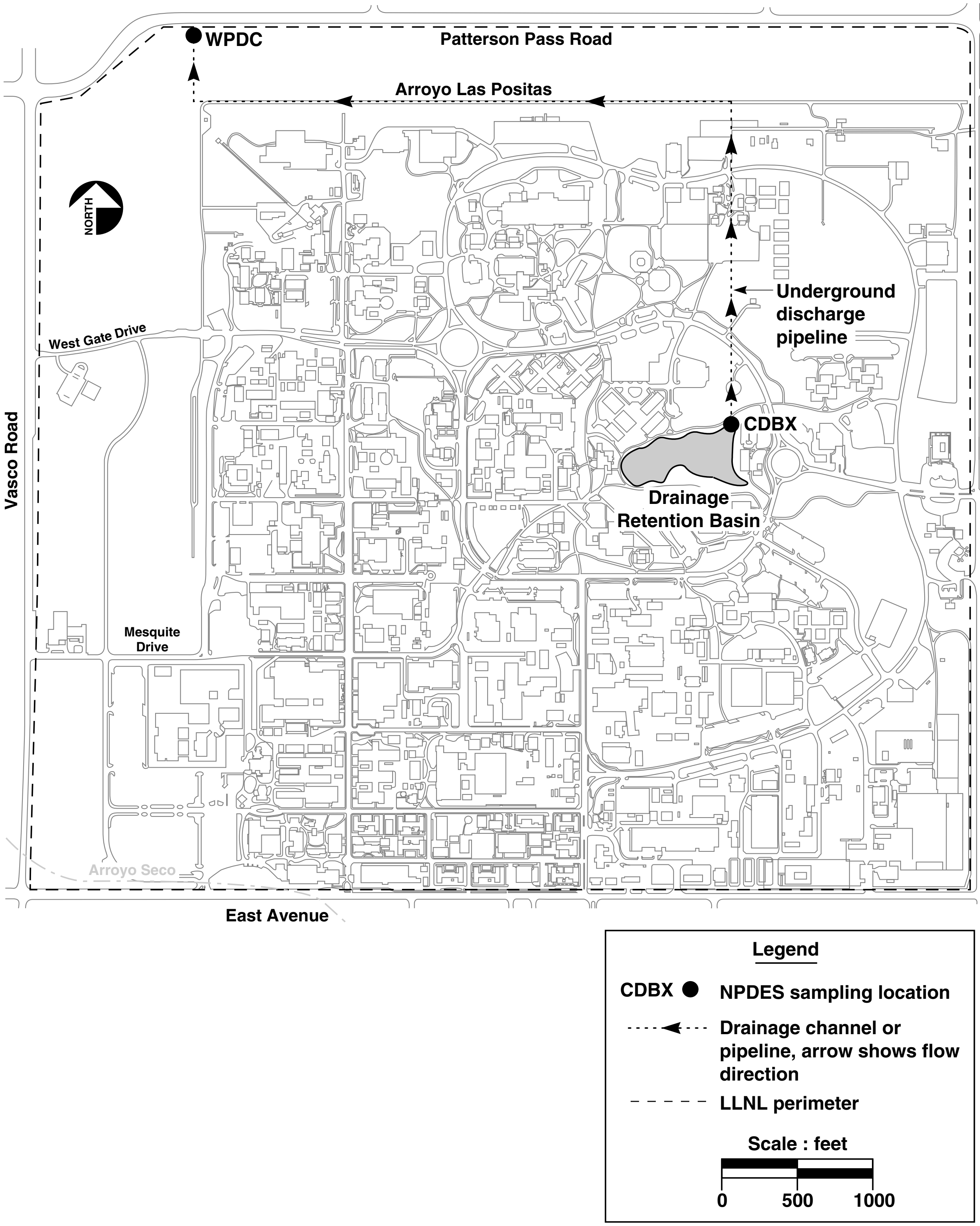

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Figure D-1. Location of the Drainage Retention Basin showing discharge sampling locations.

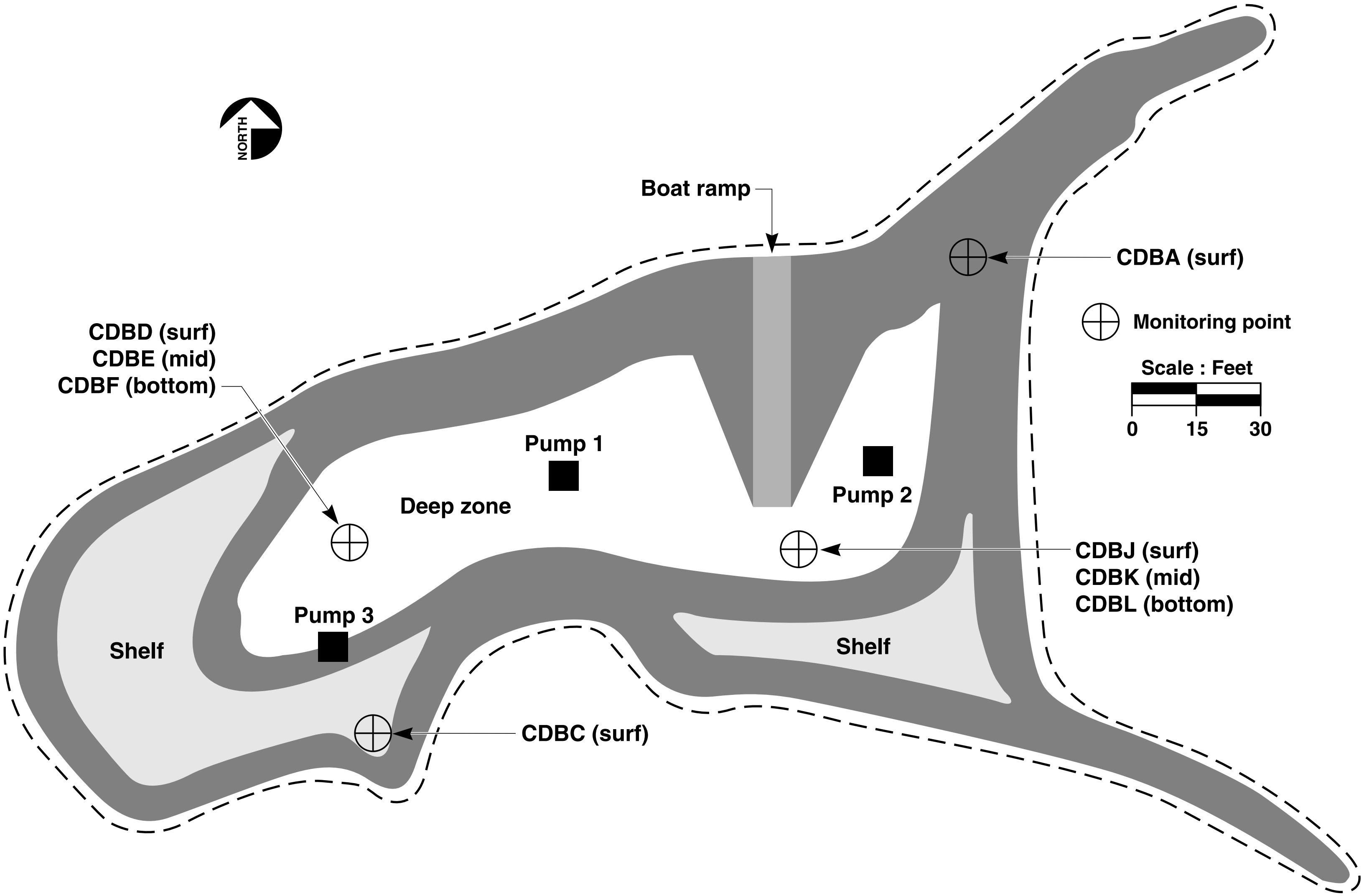

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Figure D-2. Monitoring locations in the Drainage Retention Basin.