Section 2

Investigation Methodology

2.1 DATA QUALITY OBJECTIVES

During the soil and groundwater investigations, two questions were asked:

- Has an analyte been detected at concentrations above preliminary remediation goals (PRGs)? PRGs are contaminant specific health–based levels developed by EPA Region IX to determine if additional investigation is necessary to evaluate potential health impacts.
- Have additional sources (hot spots) of contamination been detected?

To answer these questions with confidence, data quality objectives were established, as discussed below.

2.1.1 Overview

Tables 2-1 through 2-8 list: (1) the analytes measured during the soil and groundwater investigations and quarterly groundwater monitoring, (2) the Chemical Abstract Service (CAS) numbers and the lowest available contract required quantitation limits (CRQLs) associated with the analytes for the analytical method selected, (3) the preliminary remediation goals (PRGs), as published by the U.S. EPA Region 9 for the second half of 1995, (4) for groundwater, the maximum contaminant levels (MCLs), and (5) for all analytes except petroleum hydrocarbons, the carcinogenic properties of the analyte (i.e., carcinogenic or noncarcinogenic).

Table 2-1 concerns volatile organic compounds (VOCs) in soil samples; Tables 2-2 and 2-3 concern organochlorine pesticides and polychlorinated biphenyls in soil. Tables 2-4 and 2-5 deal, respectively, with measurements of organophosphorus pesticides and carbamate/urea pesticides in soil; Table 2-6 with total recoverable petroleum hydrocarbons in soil. Tables 2-7 and 2-8 deal with measurements of VOCs in groundwater by two different methods.

The target analyte list was developed based on hazardous substances found at the Frontier Fertilizer site during previous investigations, specifically the EPA preliminary site assessment conducted in the spring of 1993. The results of the site assessment indicated the presence of VOCs, carbamate/urea pesticides, organophosphorus pesticides, and organochlorine pesticides in site soils. The EPA site assessment also indicated that groundwater beneath and north of the site is contaminated with VOCs.

Based on these results, soil samples were analyzed to determine the levels of VOCs, carbamate/urea pesticides, organophosphorus pesticides, and organochlorine pesticides. Groundwater samples were analyzed to determine the levels of VOCs. These target classes of analytes were augmented by analyses for total petroleum hydrocarbons (TPH) as gasoline and diesel. TPH analyses were performed to detect agricultural spray adjuvants (crop oil) and

emulsifying agents (soaps) that are commonly used in large volumes in conjunction with pesticides, fuels, and lubricating oils.

Table 2-1 Determination of Volatile Organic Compounds in Soil Samples by FASP SOP F93001

Volatile Organic Compound	Carcinogen (c) or Noncarcinogen* (nc)	CAS Number	Lowest Available CRQL (µg/kg)	PRG (µg/kg)*
Chloromethane	c	74-87-3	10	4,300
Bromomethane	nc	74-83-9	10	57,000
Vinyl chloride	c	75-01-4	10	11
Chloroethane	c	75-00-3	10	—
Methylene chloride	c	75-09-2	2	25,000
1,1-Dichloroethene	c	75-35-4	2	82
1,1-Dichloroethane	nc	75-34-3	2	3,000,000
Chloroform	c	67-66-3	2	1,100
1,2-Dichloroethane	c	107-06-2	2	980
1,1,1-Trichloroethane	nc	71-55-6	2	3,000,000
Carbon tetrachloride	c	56-23-5	2	1,100
Bromodichloromethane	c	75-27-4	2	3,400
1,2-Dichloropropane	c	78-87-5	2	1,500
cis-1,3-Dichloropropene	c	10061-01-5	2	1,200
Trichloroethene	c	79-01-6	2	17,000
Dibromochloromethane	c	124-48-1	2	23,000
1,1,2-Trichloroethane	c	79-00-5	2	3,300
Benzene	c	71-43-2	2	3,200
trans-1,3-Dichloropropene	c	10061-02-6	2	1,200
Bromoform	c	75-25-2	2	240,000
Tetrachloroethene	c	127-18-4	2	25,000
Toluene	nc	108-88-3	2	2,800,000
1,1,2,2-Tetrachloroethane	c	79-34-5	2	2,400
Chlorobenzene	nc	108-90-7	2	570,000
Ethylbenzene	nc	100-41-4	2	690,000
Styrene	nc	100-42-5	2	2,200,000
Xylenes (total)	nc	1330-20-7	2	980,000
1,2-Dibromoethane (EDB)	c	106-93-4	2	21
1,2-Dibromo-3-chloropropane (DBCP)	c	96-12-8	2	1,400

* Region 9 Industrial Soil PRGs, September 1995, Stanford Smucker, September 1, 1995. A dash indicates a PRG has not been developed.

Table 2-2 Determination of Organochlorine Pesticides and Polychlorinated Biphenyls in Soil by FASP SOP F93006

Organochlorine Pesticides and Polychlorinated Biphenyls	Carcinogen (c) or Noncarcinogen (nc)*	CAS Number	Lowest Available CRQL (µg/kg)	PRG (µg/kg)*
Alpha-BHC	c	319-84-6	50	300
Beta-BHC	c	319-85-7	50	1,100
Delta-BHC	c	319-86-8	50	—
Gamma-BHC (Lindane)	c	58-89-9	50	1,500
Heptachlor	c	76-44-8	50	420
Aldrin	c	309-00-2	50	110
Heptachlor epoxide	c	1024-57-3	50	210
Endosulfan I	c	959-98-8	50	34,000
Dieldrin	c	60-57-1	100	120
4,4'-DDE	c	72-55-9	100	5,600
Endrin	nc	72-20-8	100	200,000
Endosulfan II	nc	33213-65-9	100	34,000
4,4'-DDD	c	72-54-8	100	7,900
Endosulfan sulfate	c	1031-07-8	100	—
4,4'-DDT	c	50-29-3	100	5,600
Methoxychlor	nc	72-43-5	500	3,400,000
Endrin ketone	c	53494-70-5	100	—
Endrin aldehyde	c	7421-93-4	100	—
Alpha-chlordane	c	5103-71-9	50	—
Gamma-chlordane	c	5103-74-2	50	—
Toxaphene	c	8001-35-2	5,000	1,700
Aroclor-1016	nc	12674-11-2	1,000	65,000
Aroclor-1221	c	11104-28-2	2,000	340
Aroclor-1232	c	11141-16-5	1,000	340
Aroclor-1242	c	53469-21-9	1,000	340
Aroclor-1248	c	12672-29-6	1,000	340
Aroclor-1254	c	11097-69-1	1,000	340
Aroclor-1260	c	11096-82-5	1,000	340

* Region 9 Industrial Soil PRGs, September 1995, Stanford Smucker, September 1, 1995. A dash indicates a PRG has not been developed.

Table 2-3 Determination of Organochlorine Pesticides and Polychlorinated Biphenyls in Soil by EPA Method 8080

Organochlorine Pesticides and Polychlorinated Biphenyls	Carcinogen (c) or Noncarcinogen (nc)*	CAS Number	Lowest Available CRQL (µg/kg)	PRG (µg/kg)*
Alpha-BHC	c	319-84-6	2	300
Beta-BHC	c	319-85-7	2	1,100
Delta-BHC	c	319-86-8	2	—
Gamma-BHC (Lindane)	c	58-89-9	2	1,500
Heptachlor	c	76-44-8	2	420
Aldrin	c	309-00-2	2	110
Heptachlor epoxide	c	1024-57-3	2	210
Endosulfan I	c	959-98-8	2	34,000
Dieldrin	c	60-57-1	3	120
4,4'-DDE	c	72-55-9	3	5,600
Endrin	nc	72-20-8	3	200,000
Endosulfan II	nc	33213-65-9	3	34,000
4,4'-DDD	c	72-54-8	3	7,900
Endosulfan sulfate	c	1031-07-8	3	—
4,4'-DDT	c	50-29-3	3	5,600
Methoxychlor	nc	72-43-5	17	3,400,000
Endrin ketone	c	53494-70-5	3	—
Endrin aldehyde	c	7421-93-4	3	—
Alpha-chlordane	c	5103-71-9	2	—
Gamma-chlordane	c	5103-74-2	2	—
Toxaphene	c	8001-35-2	170	1,700
Aroclor-1016	nc	12674-11-2	33	65,000
Aroclor-1221	c	11104-28-2	67	340
Aroclor-1232	c	11141-16-5	33	340
Aroclor-1242	c	53469-21-9	33	340
Aroclor-1248	c	12672-29-6	33	340
Aroclor-1254	c	11097-69-1	33	340
Aroclor-1260	c	11096-82-5	33	340

* Region 9 Industrial Soil PRGs, September 1995, Stanford Smucker, September 1, 1995. A dash indicates a PRG has not been developed.

Table 2-4 Determination of Organophosphorus Pesticides in Soil by EPA Method 8141

Organophosphorus Pesticides	Carcinogen (c) or Noncarcinogen (nc)	CAS Number	Lowest Available CRQL (µg/kg)	PRG (µg/kg)*
Azinphos methyl	nc	86-50-0	50	—
Bolstar (Sulprofos)	nc	35400-43-2	35	—
Chlorpyrifos	nc	2921-88-2	50	2,000,000
Coumaphos	nc	56-72-4	100	—
Demeton, O,S	nc	8065-48-3	60	27,000
Diazinon	nc	333-41-5	100	610,000
Dichlorvos	c	62-73-7	400	6,600
Dimethoate	nc	60-51-5	130	140,000
Disulfoton	c	298-04-4	35	27,000
EPN	nc	2104-64-5	20	—
Ethoprop	nc	13194-48-4	100	—
Fensulfothion	nc	115-90-2	40	—
Fenthion	nc	55-38-9	50	—
Malathion	nc	121-75-5	55	14,000,000
Merphos	nc	150-50-5	100	20,000
Mevinphos	nc	7786-34-7	250	—
Naled	nc	300-76-5	250	1,400,000
Parathion-ethyl	nc	56-38-2	30	4,100,000
Parathion-methyl	nc	298-00-0	60	170,000
Phorate	nc	298-02-2	20	140,000
Ronnel	nc	299-84-3	35	34,000,000
Sulfotep	nc	3689-24-5	35	—
TEPP	nc	21646-99-1	400	—
Stirophos (Tetrachlorovinphos)	nc	22248-79-9	400	—
Tokuthion (Protothiofos)	nc	34643-46-4	55	—
Trichloronate	nc	327-98-0	400	—

* Region 9 Industrial Soil PRGs, September 1995, Stanford Smucker, September 1, 1995. A dash indicates a PRG has not been developed.

Table 2-5 Determination of Carbamate/Urea Pesticides in Soil by EPA Method 632

Carbamate and Urea Pesticides	Carcinogen (c) or Noncarcinogen* (nc)	CAS Number	Lowest Available CRQL (µg/kg)	PRG (µg/kg)*
Aminocarb	nc	2032-59-9	70	—
Barban	nc	101-27-9	330	—
Carbaryl	nc	63-27-2	13	68,000,000
Carbofuran	nc	1563-66-2	33	3,400,000
Chlorpropham	nc	101-21-3	70	100,000,000
Diuron	nc	330-54-1	20	1,400,000
Fenuron/Fenuron-TCA*	nc	101-42-8/4482-55-7	33	—
Fluometuron	nc	2164-17-2	170	8,900,000
Linuron	c	330-55-2	330	1,400,000
Methiocarb	nc	2032-65-7	330	—
Methomyl	nc	16752-77-5	130	17,000,000
Mexacarbate	nc	315-18-4	70	—
Monuron/Monuron-TCA*	nc	150-68-5/140-41-0	20	—
Neburon	nc	555-37-3	33	—
Oxamyl	nc	23135-22-0	130	17,000,000
Propham	nc	122-42-9	330	14,000,000
Propoxur	nc	114-26-1	330	—
Siduron	nc	1982-49-6	130	—
Swep	nc	1918-18-9	130	—

* Region 9 Industrial Soil PRGs, September 1995, Stanford Smucker, September 1, 1995. A dash indicates a PRG has not been developed.

Table 2-6 Determination of Total Petroleum Hydrocarbons in Soil

Compound	CAS Number	Lowest Available CRQL (mg/kg)	PRG (mg/l)*
Total petroleum hydrocarbon	14280-30-9	1	—

Table 2-7 Determination of Volatile Organic Compounds in Groundwater Investigation Samples by FASP Modified Method 504

Volatile Organic Compound	Carcinogen (c) or Noncarcinogen* (nc)	CAS Number	Lowest Available CRQL (µg/l)	Federal MCL† (µg/l)	PRG (µg/l)*
1,2-Dibromoethane	c	106-93-4	0.05	0.05	0.00076
1,2-Dibromo-3-chloropropane	c	96-12-8	0.05	0.2	0.048

* Region 9 PRGs, September 1995, Stanford Smucker, September 1, 1995. A dash indicates a PRG has not been developed.

† 40 Code of Federal Regulations Part 141.61.

Table 2-8 Determination of Volatile Organic Compounds in Quarterly Groundwater Monitoring Samples by CLPAS TCL VOCs, Including EDB and DBCP

Volatile Organic Compound	Carcinogen (c) or Noncarcinogen* (nc)	CAS Number	Lowest Available CRQL (µg/l)	Federal MCL† (µg/l)	PRG (µg/l)*
Dichloromethane	c	75-09-2	2	5.0	4.3
1,1-Dichloroethene	c	75-35-4	2	7.0	0.046
1,1-Dichloroethane	nc	75-34-3	2	5.0††	810
Chloroform	c	67-66-3	2	100	0.16
1,2-Dichloroethane	c	107-06-2	2	5.0	0.12
1,1,1-Trichloroethane	nc	71-55-6	2	200	1,300
Carbon tetrachloride	c	56-23-5	2	5.0	0.17
Bromodichloromethane	c	75-27-4	2	100	0.18
1,2-Dichloropropane	c	78-87-5	2	5.0	0.16
1,3-Dichloropropane	c	na	2	—	—
cis-1,3-Dichloropropene	c	10061-01-5	2	—	0.081
Trichloroethene	c	79-01-6	2	5.0	1.6
Dibromochloromethane	c	124-48-1	2	—	1
1,1,2-Trichloroethane	c	79-00-5	2	5.0	0.2
Benzene	c	71-43-2	2	5.0	0.39
trans-1,3-Dichloropropene	c	10061-02-6	2	—	0.081
Bromoform	c	75-25-2	2	100	8.5
Tetrachloroethene	c	127-18-4	2	5.0	1.1
Toluene	nc	108-88-3	2	1,000	720
1,1,2,2-Tetrachloroethane	c	79-34-5	2	1.0††	0.055
Chlorobenzene	nc	108-90-7	2	100	39
Ethylbenzene	nc	100-41-4	2	700	1,300
Styrene	nc	100-42-5	2	100	1,600
Xylenes (total)	nc	1330-20-7	2	10,000	1,400
1,2-Dibromoethane	c	106-93-4	2	0.05	0.0007
1,2-Dibromo-3-chloropropane	c	96-12-8	2	0.2	0.048

* Region 9 Tap Water PRGs, September 1995, Stanford Smucker, September 1, 1995. A dash indicates a PRG has not been developed.

† 40 Code of Federal Regulations Part 141.61. A dash indicates an MCL has not been developed.

†† Title 22 California Code of Regulations Part 6444.5

The analytical methods and required quantitation limits selected for this investigation provided data comparable to data collected by EPA during the Frontier Fertilizer preliminary assessment. The analytical methods and required quantitation limits enable one to evaluate whether the contamination levels at the site are below or above the published PRG or MCL, as applicable.

2.1.2 Precision, Accuracy, Representativeness, Completeness, Comparability (PARCC) Parameters

Table 2-9 presents the quantitative analytical precision, accuracy, and completeness goals for each measurement parameter determined during the soil investigation, groundwater investigation and quarterly groundwater monitoring. The goals for each analytical group of measurements were based on the requirements of analytical methods; as such, they did not represent allowable total measurement uncertainty (analytical plus sampling). Total analytical precision, accuracy, and completeness goals (analytical plus sampling) were established and evaluated on the basis of field QC results (duplicates and spikes). While goals were established for total measurement precision, accuracy, and completeness, professional judgment was used to determine if data should be qualified based solely on field QC results.

2.1.2.1 Precision

Sampling precision (total precision) was evaluated by analysis of field duplicate samples. Analytical precision was evaluated by analysis of matrix spike duplicates. The precision of pH, temperature, conductivity, and water depth measurements was not independently assessed. The precision of these measurements was ensured by following manufacturer's instruction on the use of each instrument, including all calibration requirements, and a review of field data for consistency.

2.1.2.2 Accuracy

Sampling accuracy (total accuracy) was not evaluated for groundwater. Total accuracy was evaluated for soil analyzed by the EPA Field Analytical Support Program (FASP) laboratory through the use of soil samples spiked with site-specific contaminants of concern at or near the CRQL. These samples were independently prepared performance evaluation samples. Analytical accuracy was evaluated by analysis of matrix spike samples. The accuracy of pH, temperature, conductivity, and water depth measurement was not independently assessed. The accuracy of these measurements was ensured by following the manufacturer's instructions on the use of each instrument, including all calibration requirements, and a review of the field data for consistency.

Table 2-9 Precision, Accuracy, and Completeness Goals

Measurement	Precision (Total*/ Analytical**)	Accuracy (Total*/ Analytical**)	Completeness
VOCs including EDB and DBCP, in water	±40/±30%†	na/60-140%††	90% (Quarterly GW) 95% (GW Investigation)
VOCs plus EDB and DBCP in soil	±60%/±50%†	60-135%/65-130%††	95%
Organochlorine pesticides in soil	±50%/±30%†	45-140%/50-135%††	95%
Organophosphorus pesticides in soil	±50%/±30%†	na/65-135%††	95%
Carbamate/urea pesticides in soil	±50%/±30%†	na/50-135%††	95%
TRPH in soil	±50%/±30%†	na/65-135%††	95%
pH in water	±0.2 S.U.	na	100%
Temperature in water	±1°C	na	100%
Conductivity in water	±10 µohms	na	100%
Depth to water	±0.1 foot	na	100%

* Measured using field QC samples

** Measured using laboratory QC samples

† Measured as relative percent difference between duplicate samples

†† Measured as percent recovery of the compound from a spiked solution

na not applicable

S.U. Standard Units

2.1.2.3 *Representativeness*

For quarterly groundwater monitoring, the 59 monitoring wells were located and screened at depths to provide access to groundwater that represents each saturated zone beneath the site. For the groundwater investigation, samples were taken from each saturated zone. Soil sample locations were specifically designed to be representative of site conditions. To ensure the representativeness of all samples collected, the procedures described in the field sampling plans (FSPs) were strictly followed.

2.1.2.4 *Completeness*

The required level of completeness for all sampling activities was 95 percent assuming a duplicate sample rate of 1 per 10 routine samples.

2.1.2.5 *Comparability*

The comparability of data was ensured by reporting data in consistent units. In addition, the sampling and analytical methods were consistent with those used in previous investigations.

2.2 SAMPLING AND ANALYSIS PROGRAM AND RATIONALE

The objectives and scope of field activities associated with the RI of the Frontier Fertilizer site are described below.

2.2.1 Soil Investigation

Upon review of the EPA site assessment results discussed in Section 1, it was determined that additional RI soil sampling was required to:

- Verify that all possible sources of contamination had been identified and characterized
- Determine the volume of contaminated soil associated with other sources, if such sources are present
- Evaluate if site surface soils are generally contaminated
- Construct a conceptual model of site hydrogeology

Data was collected during the soil investigation to:

- Determine if all sources of contamination have been identified
- Determine if site surface soil has been contaminated by wind and/or rain dispersion

- Determine the presence and measure the concentrations of VOCs in subsurface soil; gather data to characterize subsurface hydrogeologic conditions, and develop a vadose zone leaching model using VLEACH in the former disposal basin area. The VLEACH model will be used to evaluate potential soil clean up levels based on an evaluation of the impact of contaminated soil on groundwater
- Characterize disposal basin soil for removal and disposal
- Determine if contaminated soil has been transported off site by wind and/or water runoff
- Evaluate background soil concentrations of contaminants of concern
- Construct a conceptual model of site stratigraphy and hydrogeology

The procedures described in detail in the FSP Soil Investigation (Bechtel, 1995) were followed when collecting soil data. The statistically based experimental design ensured that all sources of contamination were identified and characterized.

To evaluate if all sources of contamination had been located, the site was divided into three zones, as shown in Figure 2-1. These zones were (1) an area of suspected contamination, primarily the northwestern portion of the site; (2) an area of potential surface soil contamination, primarily the southwestern portion of the site; and (3) an area where use or disposal of hazardous substances was indicated, primarily the eastern portion of the site.

Surface soil was also sampled to determined if it had been contaminated. A statistical approach was used to select sample locations from the hot spot search grid described above. Initially, approximately 25 percent of the grid locations were systematically sampled. If average concentrations within each of the three hot spot search zones were determined to be below PRGs at the 90 percent confidence level, then sampling was considered complete. Figures 2-2a, 2-2b, and 2-2c show the locations at which surface confirmation samples were collected.

A sampling grid was established in each zone to search for undiscovered areas of soil contamination (hot spots) and to determine the vertical and lateral extent of contamination, should hot spots be encountered. The grid size varied from 30 x 30 feet in the area of suspected contamination to 50 x 50 feet in the areas of the site where there was no indication of the use or disposal of hazardous substances. Decisions were made in the field, based on FASP analytical data, about whether additional sampling was required to determine the vertical and lateral extent of contamination or to reduce the frequency of sampling.

Biased samples were collected at designated locations based upon visual evidence (e.g., staining). Biased sampling locations, shown in Figure 2-3, were not considered part of the three zones identified above. Biased sampling locations included:

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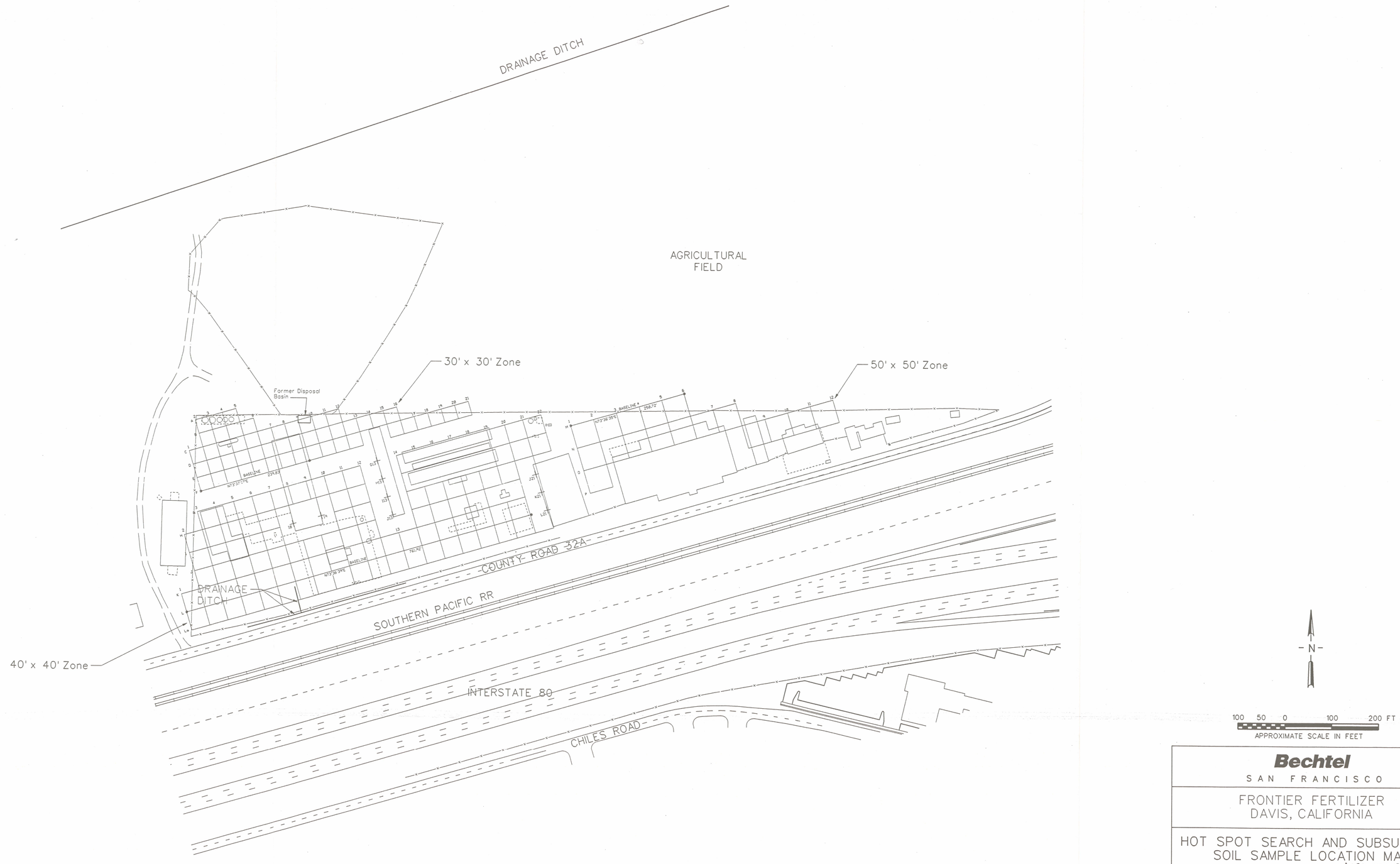

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FRONTIER FERTILIZER
DAVIS, CALIFORNIA

HOT SPOT SEARCH AND SUBSURFACE SOIL SAMPLE LOCATION MAP

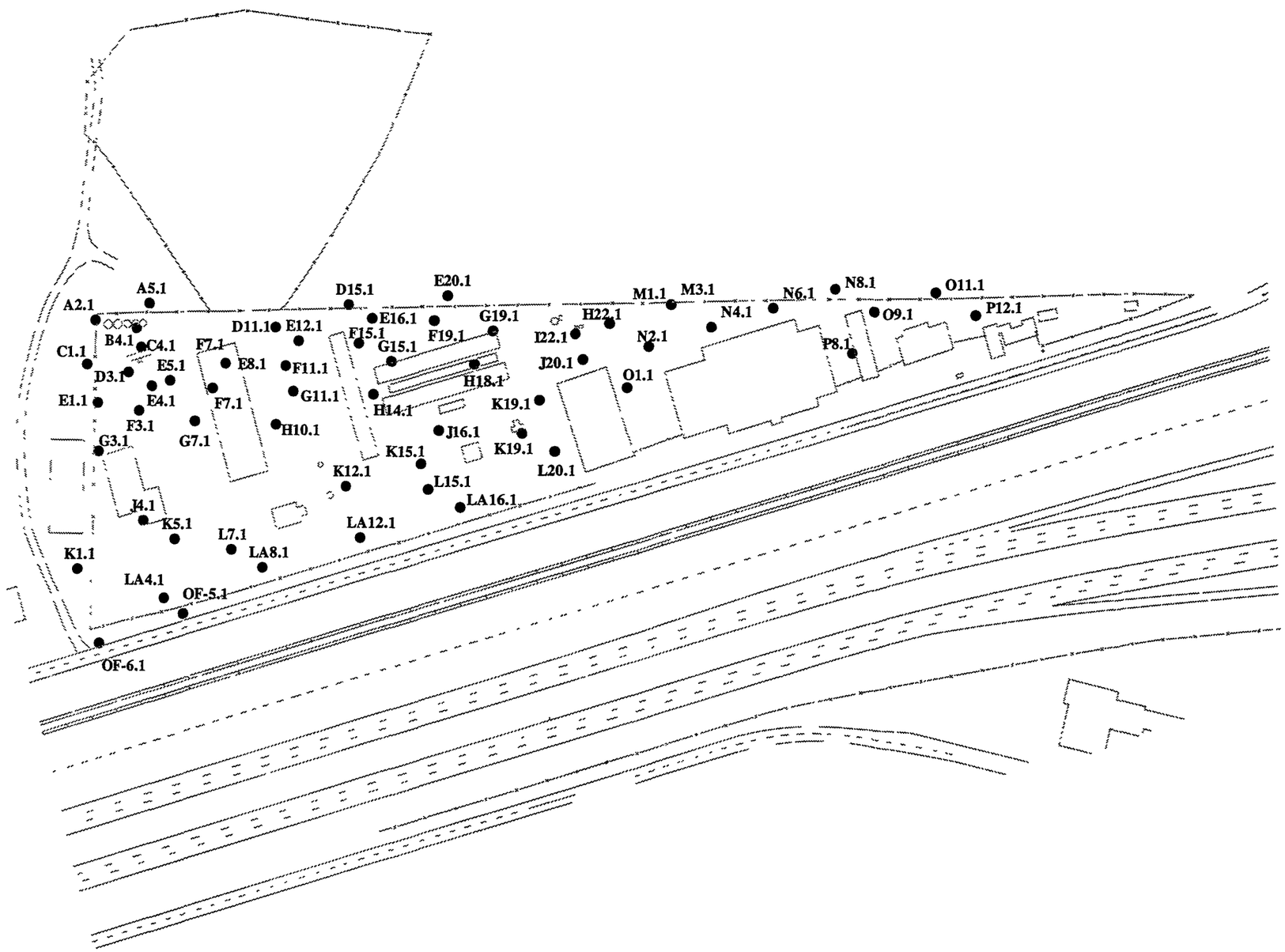
1399-0309 3 of 4

Job Number	Drawing No.	Rev.
20376	FIGURE 2-1	A

34x22 'D' SIZE

SFCRN-\63100_CHES\FRONTIER\surfconf.dgn
6/5/1996

SURFCONF.DGN /Wed Jun 5 1996 10:58:46 /GHES_MGR



EXPLANATION

● Sample Location

"D3.1" Sample Location ID

N

0 200 400

Approx. scale in feet

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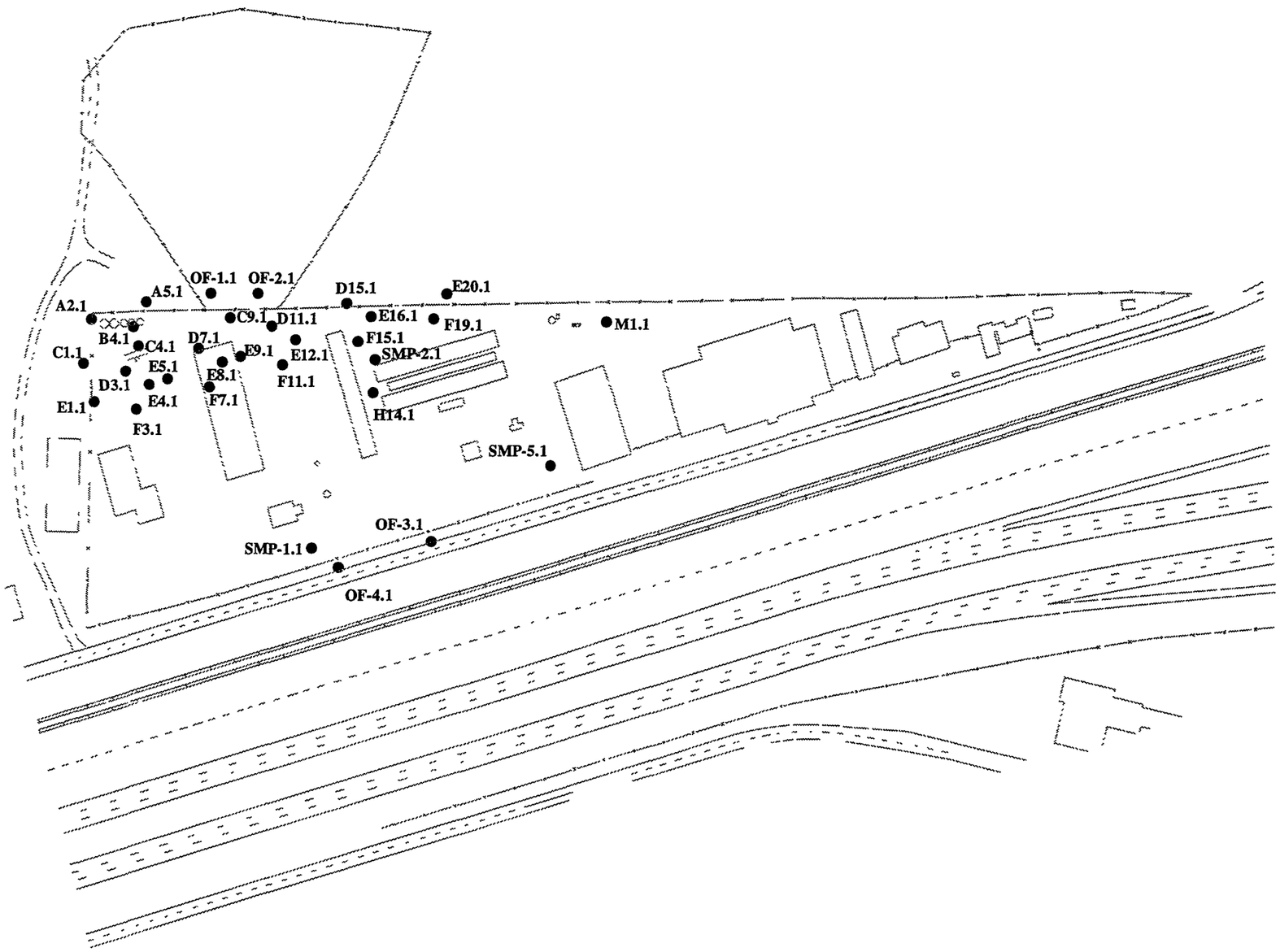
FRONTIER FERTILIZER PROJECT

Organochlorine Pesticide Sample Locations in Surface Soil

Job Number	Drawing No	Rev.
20376	FIGURE 2-2A	A



EXPLANATION

● Sample Location

"D3.1" Sample Location ID

N

0 200 400

Approx. scale in feet

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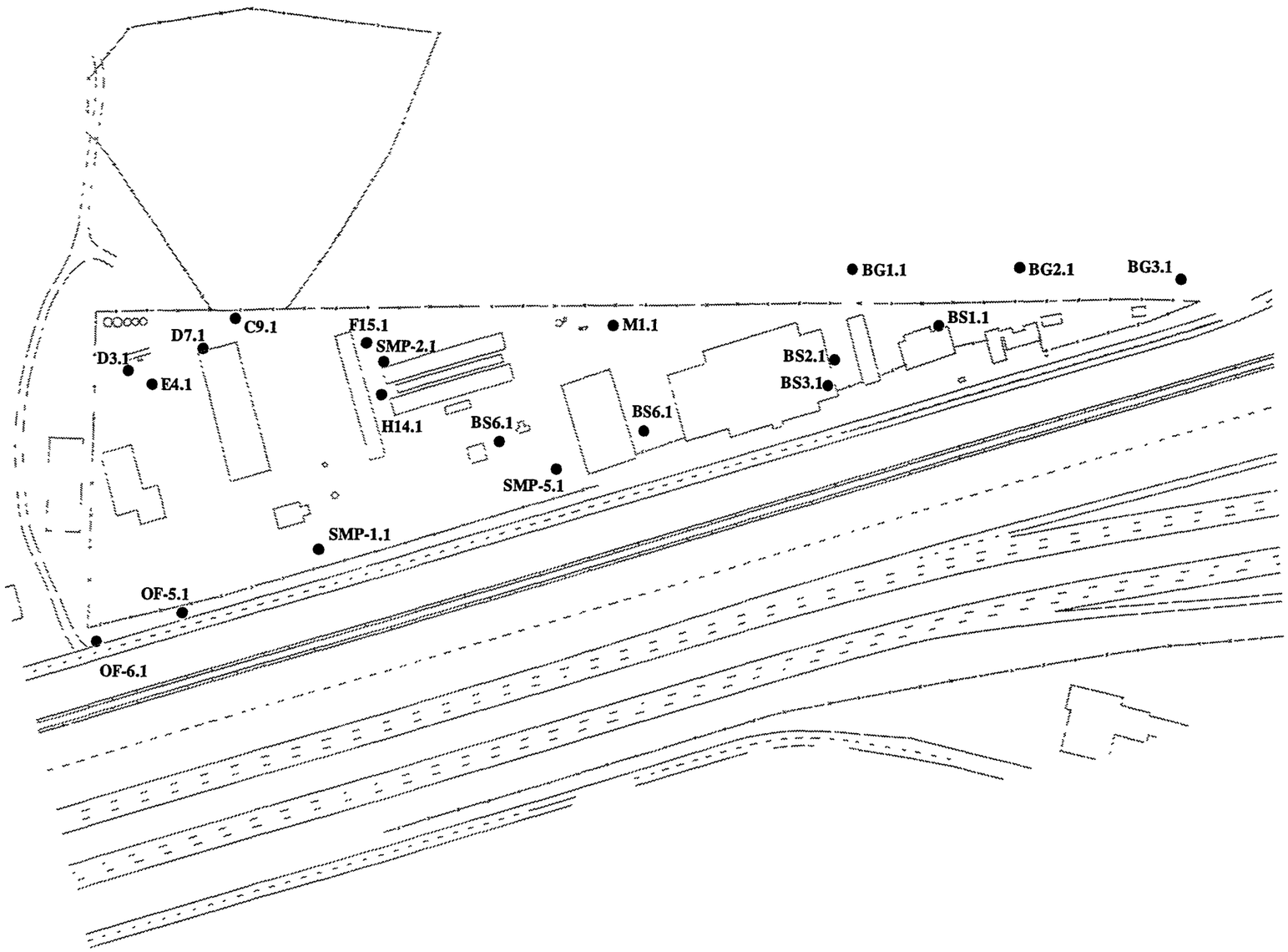
FRONTIER FERTILIZER PROJECT

Organophosphorus Pesticide Sample Locations in Surface Soil

Job Number	Drawing No	Rev.
20376	FIGURE 2-2B	A



EXPLANATION

● Sample Location

"D3.1" Sample Location ID

N

0 200 400

Approx. scale in feet

BECHTEL

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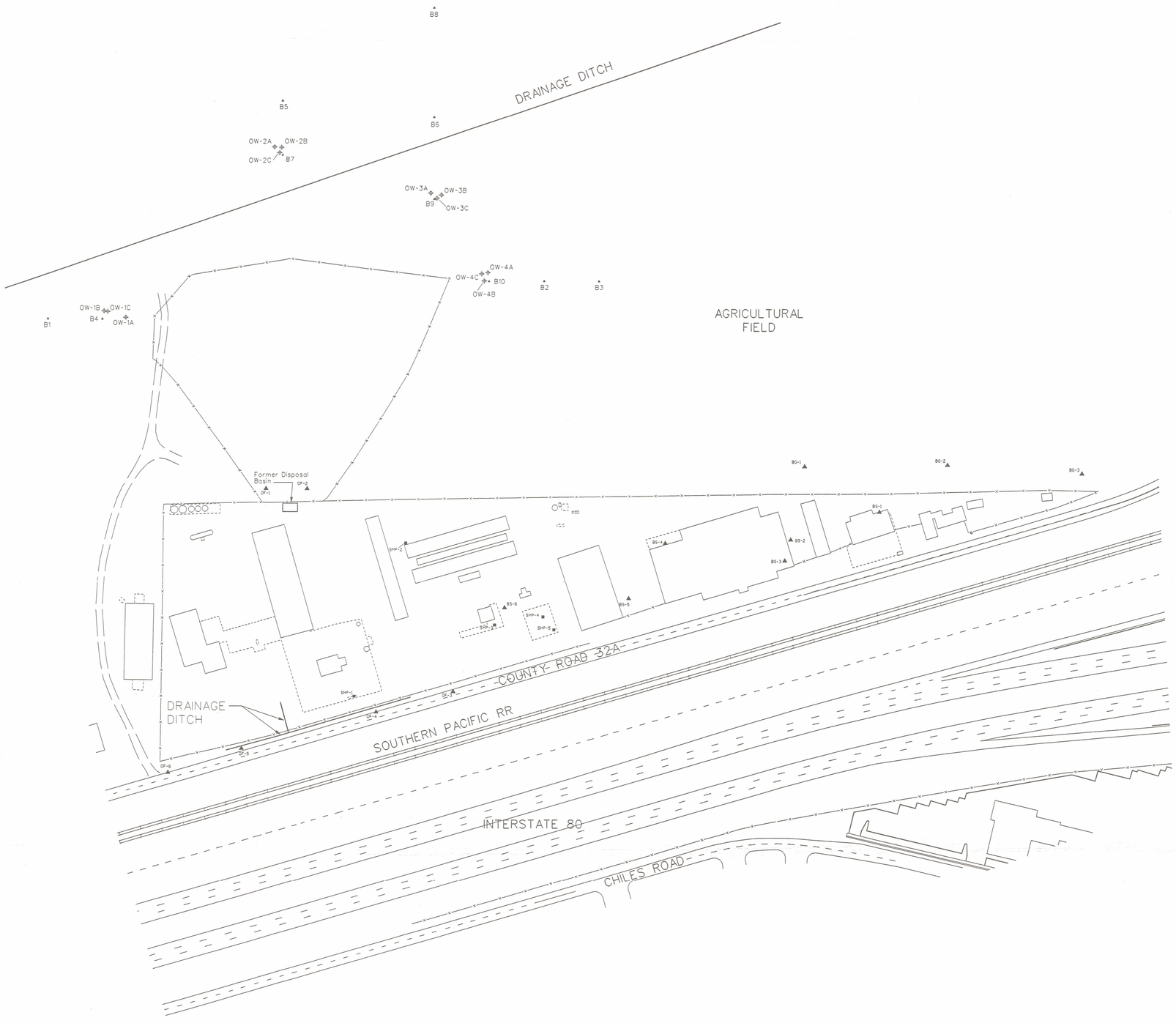
FRONTIER FERTILIZER PROJECT

Carbamate/Urea Pesticide Sample Locations in Surface Soil

Job Number	Drawing No.	Rev
20376	FIGURE 2-2C	A



EXPLANATION

B6 — HydroPunch Boring

OW-2A, OW-2B, OW-2C — Observation Well Cluster

BG-2, BS-2, DF-1 — Soil Sample with Designations

SMP-1 — Approximate Sump Location

N

100 50 0 100 200 FT

APPROXIMATE SCALE IN FEET

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SOIL SAMPLE, SUMP, HYDROPUNCH AND NEW WELL LOCATIONS

1399-0309 4 of 4

Job Number	Drawing No.	Rev
20376	FIGURE 2-3	A

34x22 'D' SIZE

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- *Areas Showing Visual Signs of Contamination (e.g., Oil Stains, Distressed Vegetation).*
- *Five Sumps Located on Site.* Soil and/or sediment samples were collected from within the five sumps.
- *The Disposal Basin, to Support Development of a Vadose Zone Leaching Model Using VLEACH.* Undisturbed soil samples were taken in thin-wall (Shelby) tubes for geologic and chemical testing at depths designated by the geologist in the field.
- *Offsite Surface Soil Samples, to Determine If Contaminated Soil Had Been Carried Off Site by Wind or Rain.* Six offsite surface soil samples were collected from areas likely to receive windblown site soil and/or site soil deposited by surface water runoff. The prevailing wind direction in the Davis area is to the south and, during stormy weather, to the north. Therefore, two surface soil samples were collected to the north and south of the site. In addition, two surface soil samples were collected from the surface water drainage ditch adjacent to the southern boundary of the site.

Background samples were collected from three areas in the site vicinity that are unlikely to have received contaminants. Background samples were taken in geological strata similar to the strata in the other sample locations, and at similar depths. Three borings were completed, and samples were collected at the soil surface and at 5-foot-deep intervals until groundwater was encountered.

2.2.2 Groundwater Investigation

Upon review of previous groundwater investigations results discussed in Section 1, it was determined that the groundwater data collected prior to the RI is sufficient to identify the nature of the groundwater contamination; however, a complete understanding of the extent of contamination was not established to the degree required to locate additional monitoring wells and to measure the performance of the groundwater treatment system. Additional groundwater data was collected during the RI to define the leading edge of the contaminated groundwater north, northeast, and northwest of the site.

Data collected during the groundwater investigation has been used to:

- Define the leading edge of pesticide contaminated groundwater in the S-1 and S-2 groundwater zones
- Determine the location for, and install, four monitoring well clusters: one cluster at the northwestern leading edge of the groundwater pesticide contamination; one cluster at the western leading edge of groundwater pesticide contamination; one cluster at the northeastern leading edge of the groundwater pesticide contamination; and one cluster at the eastern leading edge of the pesticide contamination.
- Define the lithology between the ground surface and the A-1 aquifer

The procedures described in detail in the FSP, Groundwater Investigation (Bechtel, 1995b), were followed when collecting groundwater data. As described in Section 2.4, HydroPunch™ exploratory borings were made to locate the leading edge of the groundwater contamination. The locations of the first four HydroPunch exploratory borings, shown in Figure 2-3, were as follows: B-1, approximately 300 feet west of well MW-1; B-2, approximately 300 feet north of well MW-11A; B-3, approximately 300 feet north of well MW-12A; and B-4, approximately 300 feet east of well MW-12A. These locations were chosen on the basis of previous sampling results and the results of contaminant transport modeling conducted in 1990 (URS Consultants, 1993).

The contaminant transport modeling estimated that the EDB-contaminated groundwater migrates within the S-1 groundwater zone at a rate of less than 80 ft/yr and within the S-2 groundwater zone at a rate of less than 35 ft/yr. Previous sampling confirmed the reasonableness of these estimates. EDB was detected in samples collected from well MW-7A in 1987, but was not detected in well MW-11A until 1992. These analytical results indicated that the EDB-contaminated groundwater migrates at a rate of approximately 375 feet in 5 years, or approximately 75 ft/yr. Because it appears as though the EDB-contaminated groundwater migrates at a faster rate in the S-1 groundwater zone, this zone has been used to predict the boundary of the contamination for the locations of the first four borings.

Each HydroPunch boring was drilled to the S-1 and S-2 groundwater zones and groundwater samples were extracted from each groundwater zone using a HydroPunch sampling tool for chemical analysis. The stratigraphic and chemical data from each preceding boring was used to adjust the depth and location of the next boring.

If contaminants were detected in samples collected from the S-1 and S-2 groundwater zones, that boring was not advanced to the A-1 aquifer. If contaminants were not detected, the borings that define the leading edges of the pesticide contaminated groundwater in the S-1 and S-2 zones were advanced to the A-1 aquifer and groundwater extracted for chemical analysis. If concentrations in the A-1 aquifer were less than the federal maximum contaminant levels (MCLs) for EDB and DBCP, the boring was considered as representing the leading edge of the contaminated groundwater. If concentrations in the A-1 aquifer were greater than the MCLs, additional borings were drilled to define the leading edge of all three water-bearing zones.

The information collected during the HydroPunch survey was used to select four specific areas for groundwater monitoring. Monitoring well clusters were constructed at the northern and western leading edges of groundwater pesticide contamination and at the northern and eastern leading edges of the groundwater pesticide contamination. Each well cluster is composed of three wells, screened in the S-1, S-2, and A-1 units, respectively. After the new wells had been installed, each well was developed.

In addition, three of the monitoring well borings to the A-1 aquifer were continuously sampled and logged during drilling to define the lithology between the ground surface and the A-1 aquifer.

The exact sample depths were designated by the geologist in the field based on changes in soil appearance. The lithologic characteristics of the soil samples and drill cuttings were described and logged by a geologist in accordance with the Unified Soil Classification System (USCS) (ASTM D-2488, 1993).

2.2.3 Quarterly Groundwater Monitoring Program

Installation and sampling of groundwater monitoring wells (Figure 1-2) at Frontier Fertilizer have been performed by several parties, including EPA; California EPA, Department of Toxic Substance Control (DTSC); RAMCO Enterprises, Inc.; and Frontier Fertilizer. The most recent round of groundwater sampling occurred in May 1996 and was performed by EPA. The results of this sampling and analysis are not available. The most recent round of sampling for which data are available was conducted in December 1995.

For quarterly groundwater monitoring activities conducted at the Frontier Fertilizer site, environmental measurements have included:

- Measurement of volatile organic compounds in groundwater from 59 of the 65 existing wells (6 wells are reinjection wells)
- Measurement of the pH, conductivity, and temperature of groundwater from the same monitoring wells
- Measurement of water levels in the same monitoring wells

Data collected during quarterly groundwater monitoring activities has been used to:

- Document the presence and concentrations of pesticides and VOCs, including EDB and DBCP, in groundwater in the wells that are on site or downgradient of the Frontier Fertilizer site
- Monitor trends in the areal distribution of pesticides and VOCs in groundwater in each of three water-bearing zones beneath the Frontier Fertilizer site
- Monitor trends in the vertical distribution of pesticides and VOCs in groundwater between the shallow water-bearing zones and the deeper aquifer
- Monitor water level changes in the monitoring wells
- Provide the chemical concentration data needed to prepare charts that show seasonal changes in pesticide and VOC concentrations in groundwater, and compare these changes with variations in seasonal water levels
- Further define and document seasonal variation in the groundwater flow direction
- Provide groundwater elevation data needed to prepare groundwater contour maps for inclusion in the RI report

- Describe the nature and extent of pesticide and VOC contamination in groundwater within the site's boundaries
- Describe the nature and extent of pesticide and VOC contamination in the groundwater downgradient of the site
- Evaluate potential groundwater exposure pathways and remedial technologies for further groundwater treatment

The procedures described in detail in the FSP, Quarterly Monitoring Program (Bechtel, 1994), were followed when collecting quarterly groundwater monitoring data. As described in Section 2.5, groundwater sampling has been conducted on seven occasions since 1993.

2.3 SOIL INVESTIGATION SAMPLING AND ANALYSIS

The sampling and analysis program discussed below represents an extension of the approach initiated by EPA during the Frontier Fertilizer site assessment (Ecology and Environment, 1994). The EPA site assessment established a 20-foot soil sampling grid in the pesticide disposal basin area and in the area north of the labor camp.

2.3.1 Subsurface Soil Hot Spot Search

The sampling and analysis program undertaken to complete the subsurface soil hot spot search is described below.

2.3.1.1 Sampling

The objective of the subsurface soil hot spot search was to verify that all sources of contamination at the site had been identified and characterized. To meet this objective, a subsurface soil investigation was conducted in accordance with a statistical sampling plan. In areas of suspected contamination, the statistical sampling plan provided assurance, at the 80 percent confidence level, that all potential circular hot spots with a radius greater than 15 feet had been detected. In areas of the site presumed clean, the plan provided assurance, at the 80 percent confidence level, that all potential circular hot spots with radii greater than 25 feet had been detected.

A grid was established for conducting subsurface soil sampling to search for undiscovered areas of soil contamination (hot spots) and to determine the vertical and lateral extent of contamination. The grid density varied from 30 feet in the area of suspected contamination to 50 feet in the areas of the site where there was no historical indication of the use or disposal of hazardous substances. Decisions were made in the field based on the EPA FASP analytical data to determine if additional sampling was required to determine the vertical and lateral extent of contamination or to reduce the frequency of sampling. Figure 2-1 shows the onsite soil sampling grid.

In the areas of suspected contamination, the northwestern portion of the site, subsurface soil samples were taken on a 30-foot grid at a depth of 3 feet. If contamination was detected at 3 feet, samples were collected at 5-foot intervals until concentrations in two consecutive 5-foot intervals were below PRGs or groundwater was encountered. Groundwater was first encountered at a depth of about 20 feet bgs.

In the areas where there was no historical indication of the use or disposal of hazardous substances, primarily the southern and eastern portions of the site, subsurface samples were gathered on 40-foot grids (southern portion) and 50-foot grids (eastern portion), respectively. If contamination was detected in the subsurface samples, additional samples were collected at 5-foot depth intervals until concentrations in a single interval were below PRGs or HBLs, or groundwater was encountered. However, since contamination was not detected in samples from four consecutive locations within the 50-foot grid area, sampling was conducted at every other grid point. This provided assurance, at an 80 percent confidence level, that all circular hot spots with a radius greater than 50 feet were detected.

Soil samples collected from the grid areas indicated in Figure 2-1 were numbered as follows: each grid axis running east-west was designated with a letter from "A" to "S"; the 30-foot grid had east-west axes "A" through "F"; the 40-foot grid had east-west axes "G" through "La"; and the 50-foot grid had east-west axes "M" through "P". Each north-south axis was assigned a number beginning with "1"; the 30-foot grid had north-south axes "1" through "21"; the 40-foot grid had north-south axes "1" through "22"; and the 50-foot grid had north-south axes "1" through "12." A sample location with a ".1" appended represents a surface soil sample; a sample location with a ".2" appended represents a subsurface soil sample collected at a depth of 3 feet; a sample location with a ".3" appended represents a subsurface soil sample collected at a depth of 8 feet, and so on for every 5-foot interval. For example, sample number N1.1 designates a surface soil sample collected at the intersection of the N axis and the 1 axis. Sample number G12.2 designates a subsurface soil sample collected at a depth of 3 feet at the intersection of the G axis and the 12 axis; sample number B6.5 designates a subsurface soil sample collected at a depth of 18 feet at the intersection of the B axis and the 6 axis.

Shallow subsurface soil samples were collected using a 2.5-inch-diameter core sampler equipped with three 6-inch-long brass liners. Subsurface soil samples collected from 3 feet bgs were obtained by boring to the desired depth using a 3-inch-diameter power auger. Prior to sample collection, the borehole was cleaned of all soil cuttings. A clean core sampler was inserted into the borehole and driven into the soil using a manually operated slide hammer. The 2-inch-diameter, 6-inch-long brass liners containing the sample were removed and capped, labeled, and processed for laboratory analysis.

Deep subsurface soil samples (greater than 3 feet bgs) were collected using a 2.5-inch-diameter core sampler equipped with three 6-inch-long brass liners. Deep subsurface samples were collected from depth intervals below 10 feet by drilling to the desired depth using a 4-inch-

diameter, hollow-stem auger drill rig. Prior to sample collection, the borehole was cleaned of all soil cuttings. A clean core sampler was inserted in the borehole and driven into the soil using the drill rig. The 2-inch-diameter, 6-inch-long brass liners containing the sample were removed and capped, labeled, and processed for laboratory analysis.

After collection of deep subsurface soil samples, the borings were backfilled with a cement/bentonite grout. All drilled and caved-in materials were removed from the soil borings prior to grouting. The grout was tremied into place by inserting rods, pipes, or hoses to the bottom of the borings. The rods, pipes, or hoses were withdrawn as the grout was placed, but were kept below the surface of the grout at all times. If loss or shrinkage of grout occurred, the borings were refilled until they remained full.

2.3.1.2 Analysis

Seven laboratories were used during this RI: the EPA FASP onsite laboratory, EPA Region 9 laboratory, and five EPA Contract Laboratory Program (CLP) laboratories. For each of the three grids used in the hot spot search, a unique laboratory and analysis program was conducted, as described below.

All shallow subsurface (3 feet) soil samples were analyzed for VOCs. Where VOCs were detected shallow subsurface soil samples were also analyzed for organochlorine pesticides, organophosphorus pesticides, and carbamate/urea pesticides. The EPA FASP onsite laboratory analyzed soil samples for VOCs by FASP SOP F93001 and organochlorine pesticides by FASP SOP F93006. Approximately 10 percent of the samples analyzed by the FASP laboratory for organochlorine pesticides were split, and a portion analyzed for the same parameters by a CLP laboratory for confirmation of FASP results by EPA Method 8080A. A CLP laboratory analyzed soil samples for organophosphorus pesticides by EPA Method 8141 and for carbamate/urea pesticides by EPA Method 632.

Subsurface soil samples collected from the 40-foot grid area were analyzed by the EPA FASP onsite laboratory for VOCs by FASP SOP F93001. In addition, a minimum of 10 percent of the samples were analyzed by the EPA FASP onsite laboratory for organochlorine pesticides by FASP SOP F93006 and by a CLP laboratory for organophosphorus pesticides by EPA Method 8141 and carbamate/urea pesticides by EPA Method 632, if VOCs were detected.

Subsurface soil samples collected from the 50-foot grid area were analyzed by the EPA FASP onsite laboratory for VOCs by FASP SOP F93001. In addition, a minimum of 10 percent of the samples were analyzed by a CLP laboratory for organophosphorus pesticides by EPA Method 8141, carbamate/urea pesticides by EPA Method 632, and organochlorine pesticides by EPA Method 8080A.

2.3.2 Surface Soil Confirmation Sampling

The sampling and analysis program undertaken to complete the surface soil confirmation is described below.

2.3.2.1 Sampling

Surface soil was sampled to determine if it had been contaminated. A statistical approach was used to select sampling locations from the hot spot search grid described above. Initially, 25 percent of the grid locations were sampled systematically. Grid locations were selected, as necessary, for sampling to achieve a 90 percent confidence level that average surface concentrations were less than PRGs.

2.3.2.2 Analysis

Several laboratories were used to analyze surface soil confirmation samples: the EPA FASP onsite laboratory, the EPA Region 9 laboratory, and a number of CLP laboratories. For each of the three grids, a unique laboratory and analysis program was used, as described below.

All surface soil samples collected in the area of suspected contamination (30-foot grid and 40-foot grid) were analyzed for organochlorine pesticides and organophosphorus pesticides. One-fourth of the samples collected in this area were analyzed for carbamate/urea pesticides.

All surface soil samples collected in the area of suspected contamination (50-foot grid) were analyzed for organochlorine pesticides, organophosphorus pesticides (where organochlorines were detected) and carbamate/urea pesticides (where organochlorines were detected).

2.3.2.3 Surface Soil Sampling Procedure

Surface soil samples were collected as grab samples (independent, discrete samples) at a depth of approximately 0 to 6 inches. Soil/sediment samples were collected from within the onsite sumps. In both cases, a clean stainless steel trowel was employed. Samples to be analyzed for organochlorine pesticides, organophosphorus pesticides, and carbamate/urea pesticides were placed in a sample-dedicated 1-gallon disposable pail and homogenized with a trowel. Material in the pail was transferred with a trowel from the pail to sample containers; the material was then chilled and processed for laboratory analysis. Samples to be analyzed for TPH were placed directly in sample containers without homogenization.

2.3.3 Sumps

The sump sampling and analysis program is described below.

2.3.3.1 *Sampling*

The objective of the sump soil sampling was to determine the presence and measure the concentrations of pesticides and petroleum hydrocarbons in soil/sediment and water samples collected from within the onsite sumps.

Five sumps are located on site (see Figure 2-3). Three of these lie within the concrete wash pad adjacent to the weigh station; another is adjacent to the north side of the migrant farm workers' housing; and the remaining sump is located in the concrete pad surrounding the tomato-grading station. Soil/sediment and water samples were collected from within the five onsite sumps. The five sumps were numbered "SMP-1" through "SMP-5," as shown in Figure 2-3.

2.3.3.2 *Analysis*

All soil/sediment samples collected from within the onsite sumps were analyzed for VOCs, organochlorine pesticides, organophosphorus pesticides, carbamate/urea pesticides (if VOCs were detected), and TPH. The EPA FASP onsite laboratory analyzed all soil samples for VOCs by FASP SOP F93001 and organochlorine pesticides by FASP SP F93006. An EPA Region 9-designated laboratory determined the levels of organophosphorus pesticides by EPA Method 8141 and TPH. EPA Region 9-designated laboratories also analyzed all soil samples for carbamate/urea pesticides by EPA Method 632.

2.3.4 Disposal Basin

The disposal basin sampling and analysis program is described below.

2.3.4.1 *Sampling*

Soil samples were collected from one boring within the disposal basin in order to meet the following objectives:

- Determine the presence and measure the concentrations of pesticides in surface and subsurface soil
- Gather data to characterize the soil for possible disposal and develop a vadose zone leaching model using VLEACH

The disposal basin sampling location is shown in Figure 2-3.

Two types of soil samples were collected from one boring drilled within the former pesticide disposal basin: discrete grab samples for chemical analyses, and undisturbed soil samples for geologic characterization. The discrete grab samples were collected at the surface and at 3-foot-

depth intervals until groundwater is encountered. Undisturbed soil samples were taken in thin-wall (Shelby) tubes at depths designated by the geologist in the field for geologic characterization.

The disposal basin samples for chemical analysis were labeled "DB1." The disposal basin samples for geologic characterization were labeled "DB2." A sample location with a ".1" appended represents a soil sample collected from the ground surface; a sample location with a ".2" represents a subsurface soil sample collected at a depth of 3 feet; a sample location with a ".3" appended represents a subsurface soil sample collected at a depth of 6 feet, and so on for every 3-foot interval. For example, sample number DB1.1 designates a soil sample collected at the soil surface for chemical analysis, and sample number DB2.4 designates a subsurface soil sample collected at a depth of 9 feet for geologic characterization.

2.3.4.2 Analysis

All discrete grab samples collected were analyzed by the EPA FASP onsite laboratory for VOCs. To determine the suitability of disposing of soil from the site, discrete grab samples collected were also analyzed for CLPAS TCL metals and CLPAS TCL semivolatile organic compounds.

From this boring, undisturbed vadose zone soil samples were tested for dry bulk density by the core method (Methods of Soil Analysis, Part 1 – Physical and Mineralogical Methods – Agronomy Monograph No. 9; American Society of Agronomy-Soil Science Society of America; 2nd Edition), specific gravity by ASTM Method D854, volumetric water content by ASTM Method D2216, and organic carbon fraction by EPA Method 9060A. This testing yielded data that were employed to characterize subsurface hydrogeologic conditions and to develop a vadose zone leaching model using VLEACH.

2.3.5 Offsite and Biased Samples

The offsite and biased soil sampling program is described below.

2.3.5.1 Sampling

Offsite surface soil samples were collected to determine if contaminated soil had been carried off site by wind or rain. Six offsite surface soil samples were collected from areas likely to receive windblown site soil and/or site soil deposited by surface water runoff. The prevailing wind direction in the Davis area is from the southwest and, during the winter, from the north. Therefore, four surface soil samples were collected, two north of the site and two south of the site. In addition, two surface soil samples were collected from the surface water drainage ditch adjacent to the southern boundary of the site. The offsite soil sampling locations are shown in Figure 2-3. The results of offsite soil sampling were compared with EPA Region 9 PRGs.

The objective of the biased soil sampling was to determine the presence and measure the concentrations of pesticides and petroleum hydrocarbons in surface and subsurface soil samples collected from areas showing visible signs of contamination (e.g., oil stains, distressed vegetation). During a site walk, six locations were identified that showed visible signs of contamination in surface soil. These locations are shown in Figure 2-3.

The offsite surface soil sampling locations were designated "OF-1" through "OF-6." The biased surface and subsurface soil sampling locations were designated "BS-1" through "BS-6." A sample location with a ".1" appended represents a soil sample collected from the ground surface.

2.3.5.2 Analysis

All soil samples collected in areas of visual contamination and from offsite areas likely to have received windblown site soil and/or site soil deposited by surface water runoff were analyzed for organochlorine pesticides, organophosphorus pesticides, carbamate/urea pesticides. The EPA FASP onsite laboratory analyzed all soil samples for organochlorine pesticides by FASP SOP F93006. EPA Region 9-designated laboratory determined organophosphorus pesticides by EPA Method 8141 and TPH. EPA Region 9-designated laboratory was also used to conduct analyses of soil samples for carbamate/urea pesticides by EPA Method 632.

2.3.5.3 Surface Soil Sampling Procedure

Surface soil samples were collected as grab samples (independent, discrete samples) at a depth of approximately 0 to 6 inches. A clean stainless steel hand trowel was employed. Samples to be analyzed for organochlorine pesticides, organophosphorus pesticides, and carbamate/urea pesticides were placed in a sample-dedicated 1-gallon disposable pail and homogenized with a trowel. Material in the pail was transferred with a trowel from the pail to sample containers; the material was then chilled and processed for laboratory analysis. Samples to be analyzed for TPH were placed directly in sample containers without homogenization.

2.3.6 Background Samples

The background sampling and analysis program is described below.

2.3.6.1 Sampling

In areas such as Davis, where there has been approved, widespread application of site-related chemicals (agricultural activities) into the environment, it was necessary to determine the background levels of chemicals. Background concentrations of pesticides and other chemicals of potential concern in surface and subsurface soil were determined by chemical analysis.

Background samples were collected from three areas in the site vicinity that were not likely to have received site-originated contaminants. These samples were intended to be representative of conditions that existed in the site vicinity before onsite activities. Background samples were taken in similar geological strata to the other sample locations and at similar depths. Figure 2-3 shows the background soil sampling locations. Three borings were completed, and samples were collected at the soil surface, at 3 feet bgs, and at 5-foot depth intervals until groundwater was encountered.

The background surface and subsurface soil sampling locations were designated "BG-1" through "BG-3." A sample location with a ".1" appended represents a soil sample collected from the ground surface; a sample location with a ".2" appended represents a subsurface soil sample collected at a depth of 3 feet; a sample location with a ".3" appended represents a subsurface soil sample collected at a depth of 8 feet, and so on for every 5-foot interval.

2.3.6.2 Analysis

All background soil samples collected were analyzed for all parameters determined in investigative samples, except TPH. VOCs (subsurface only), organochlorine pesticides, organophosphorus pesticides, and carbamate/urea pesticides were determined in background soil samples. The EPA Region 9-designated laboratory was used to conduct analyses of all soil samples for CLPAS VOCs, including EDB and DBCP, CLPAS pesticides/PCBs (organochlorine pesticides), organophosphorus pesticides by EPA Method 8141, and carbamate/urea pesticides by EPA Method 632.

2.4 GROUNDWATER INVESTIGATION SAMPLING AND ANALYSIS

The groundwater investigation was conducted as a HydroPunch survey. The HydroPunch survey included 10 exploratory borings (B-1 through B-10) to gather chemical and stratigraphic information and to define the northern, western, and eastern boundaries of the pesticide plume (see Figure 2-3). Drill cuttings were used to identify permeable zones in the subsurface. Groundwater level measurements for each permeable water-bearing zone were used to determine vertical hydraulic gradients. Groundwater sampling and quick turnaround analysis by the FASP laboratory were used to determine the presence and concentration of the pesticides and carbon tetrachloride in groundwater at each boring location.

Based on the information collected during the HydroPunch survey, four specific areas for groundwater monitoring were selected. The areas correlated with the northern, western, and eastern boundaries of the pesticide plume. Monitoring wells, with the exception of the OW-2 cluster, were drilled and installed where the EDB and DBCP concentrations were below the lowest available CLP contract-required quantitation limit, 0.05 µg/l, in each of the permeable water-bearing zones. The OW-2 well cluster was installed within, but near the leading edge, of

the plume to serve as extraction wells, if required. Monitoring wells were drilled and installed in the S-1, S-2, and A-1 groundwater zones at each of these locations.

Each well cluster consists of three wells, one each screened in the S-1, S-2, and A-1 units, respectively. Three deeper borings to the A-1 aquifer were continuously sampled/logged.

2.4.1 HydroPunch Survey

2.4.1.1 HydroPunch Sampling

The locations of the first four exploratory borings were as follows: B-1 was approximately 300 feet west of well MW-1; B-2 was approximately 300 feet north of well MW-11A; B-3 was approximately 300 feet north of well MW-12A; and B-4 was approximately 300 feet east of well MW-12A. These locations were selected on the basis of previous sampling results and the results of contaminant transport modeling conducted in 1990.

The first four exploratory boreholes, drilled in the sequence indicated by the assigned numbers, were used to define the leading edge of the pesticide-contaminated groundwater in the S-1 and S-2 groundwater zones. Additional borings were drilled in the S-1 and S-2 groundwater zones until the leading edges of the pesticide-contaminated groundwater were defined. Each boring was described and logged in accordance with the USCS.

Each boring was drilled to the S-1 and S-2 groundwater zones, and groundwater samples were extracted from each groundwater zone using a HydroPunch sampling tool. The stratigraphic and chemical data from each preceding boring was used to adjust the depth and location of the next boring. The placement of additional borings was determined on the basis of analytical results. If EDB and DBCP were not detected in samples collected from both the S-1 and S-2 groundwater zones, then the next boring locations was halfway between the nearest existing well and the previous location. If EDB and DBCP were detected in either sample collected from the S-1 or S-2 groundwater zones, then the next boring location was 150 feet beyond the previous location. If contaminants were detected in samples collected from the S-1 and S-2 groundwater zones, that boring was not advanced to the A-1 aquifer. Such borings were abandoned. The borings that defined the leading edges of the EDB and DBCP contaminated groundwater in the S-1 and S-2 zones were advanced to the A-1 aquifer, and groundwater was extracted for chemical analysis. If concentrations in the A-1 aquifer were less than federal MCLs for EDB and DBCP, 0.05 µg/l and 0.2 µg/l, respectively, the borings were regarded as representing the leading edge of the contaminated groundwater. If concentrations in the A-1 aquifer were greater than the MCLs, additional borings were drilled to define the leading edge of all three water-bearing zones.

Each groundwater sample collected during the HydroPunch survey had a unique sample number. The sample number was the boring location number (B-1 through B-16) with an "A1" appended for a sample collected from the S-1 groundwater zone, a "B1" for a sample collected from the S-2 groundwater zone, and a "C1" for a sample collected from the A-1 aquifer. Therefore, groundwater sample B1-A1 represents a sample collected from the S-1 groundwater zone from

boring B-1, and groundwater sample B7-B1 represents a sample collected from the S-2 groundwater zone from boring B7. Table 2-10 presents the depths below ground surface at which HydroPunch groundwater samples were collected.

2.4.1.2 Analysis

Each groundwater sample collected during exploratory drilling using a HydroPunch sampling device was analyzed for EDB and DBCP, using EPA Method 504 and for VOCs using FASP SOP F93001. The EPA FASP onsite laboratory was used for groundwater sample analyses via Method 504 and FASP SOP F93001. The analyses were used to characterize the vertical distribution and concentration of pesticides and VOCs at each borehole location and to select locations for monitoring well installation. Specific conductance, pH, and temperature were also measured for every groundwater sample collected. Water levels were measured in each permeable water-bearing zone encountered during drilling.

2.4.1.3 Exploratory Drilling

A 4-inch, hollow-stem auger drill rig was used to drill exploratory holes. The hollow-stem auger method uses a hollow helical steel drill that is rotated to advance the boring and push cuttings to the surface. The flights for the hollow-stem auger are welded onto steel pipe, and a cutter head is attached to the leading edge of the auger. During drilling, a center bit is inserted into the hollow area of the cutter head to prevent cuttings from entering the auger. Hollow-stem augers are useful for maintaining the integrity of the borehole without installing casing.

The hollow-stem auger was advanced in 1-foot increments to ensure that the drill was not advanced beyond permeable groundwater zones. Cuttings were removed before application of the HydroPunch sampling device. After the HydroPunch groundwater samples had been collected, the borings were backfilled with a cement/bentonite grout.

2.4.1.4 HydroPunch Sampling During Exploratory Drilling

Groundwater sampling during exploratory drilling was performed by means of a HydroPunch II sampling device. The HydroPunch is a drive sampler capable of collecting a representative groundwater sample without requiring the installation of a groundwater monitoring well. The sampler was driven into the undisturbed soil to the desired depth from the bottom of a drilled borehole. The body of the sampler was then pulled back about 2 feet. Soil friction holds the

Table 2-10 Depths At Which HydroPunch Samples Were Collected

Boring Number	Sample I.D.	Interval Sampled (feet bgs)
B-1	B1-A1	42-44
	B1-B1	69.5-72.5
	B1-C1	119.5
B-2	B2-A1	42.0-44.5
	B2-B2	65.5-68.1
B-3	B3-A1	46.0-47.5
	B3-B1	69.5-72.5
	B3-C1	120.5-122.5
B-4	B4-A1	41-44
	B4-B1	69.5-72.5
	B4-C1	119.5-120.0
B-5	B5-A1	42-44
	B5-B1	69.5-72.5
	B5-C1	106.5-108.5
B-6	B6-A1	42-44
	B6-B1	70.5-72.5
B-7	B7-A1	40-44
	B7-B1	70.4-72.5
B-8	B8-A1	42-44
	B8-B1	69.5-72.5
B-9	B9-A1	42-44
	B9-B1	69.5-72.0
B-10	B10-A1	42.44
	B10-B1	69.5-72.5

drive cone in place. Once the O-ring seals on the cone have been broken, groundwater flows into the open end of HydroPunch through the intake screen, by the lower intake valve, into the sample chamber, and finally out the upper check valve. When open, the HydroPunch fills from the bottom with no aeration and a minimum of agitation of the sample. When the tool was full, the sample was collected by pulling the tool toward the surface. This increased the hydrostatic pressure within the tool, closing the check valves. At the surface, the tool was inverted and the sample was decanted through an upper discharge valve and tubing into a sample container.

2.4.2 Monitoring Well Installation

The methodology for locating, installing, and developing monitoring wells is described below.

2.4.2.1 Monitoring Well Locations

Based on the information collected during the HydroPunch survey, four specific areas for groundwater monitoring were selected. Monitoring well clusters were constructed at the northern, western, and eastern leading edges of the groundwater pesticide contamination. Each well cluster consists of three wells, one each screened in the S-1, S-2, and A-1 units, respectively. After the wells had been installed, each well was developed.

Each monitoring well in the clusters has a unique well identification number. The well identification has the letter A, B, or C added to it to designate the groundwater zone in which the well is screened (A = S-1 zone, B = S-2 zone, C = A-1 zone). The wells are numbered as follows: the three wells drilled at the western leading edge of the pesticide contamination are labeled "OW-1A," "OW-1B," and "OW-1C"; the three wells drilled at the northwestern leading edge of the pesticide contamination are labeled "OW-2A," "OW-2B," and "OW-2C"; the three wells drilled at the northeastern leading edge of the pesticide contamination are labeled "OW-3A," "OW-3B," and "OW-3C"; and the three wells drilled at the northern leading edge of the pesticide contamination are labeled "OW-4A," "OW-4B," and "OW-4C" (see Figure 2-3).

2.4.2.2 Monitoring Well Installation

Permanent monitoring wells were drilled and installed where the EDB and DBCP concentrations are at or below MCLs in each of the permeable water-bearing zones. A hollow-stem auger drill rig was used to bore to the desired depths for well installation. At the completion of each boring, a 4-inch-diameter Schedule 40 PVC monitoring well, consisting of a 0.020-inch slot screen and a solid casing, was installed. This slot screen size was used in existing monitoring wells on site. Screen lengths ranged from 5 to 45 feet in the S-1 and S-2 groundwater zones and from 10 to 20 feet in the A-1 aquifer. Conditions encountered during drilling dictated the placement of the screen interval and the length of the screen. No glues or solvents were employed during well installation.

The screen intervals were selected based on the boring logs from the HydroPunch survey and the split-spoon samples that were collected from the initial boring at each well cluster. Screen intervals were originally targeted at the depths where previous workers identified the S-1 and S-2 zones and the A-1 aquifer and adjusted based on the geology observed at each drilling site. At most well clusters, there were distinct clay beds that were identified to serve as confining layers to prevent vertical groundwater migration between permeable units. The well screens were not placed across these beds, where present.

The annulus of each well was packed with a clean, well-sorted silica filter sand. The filter sand was placed with a tremie pipe or through the drive casing from the total depth of the boring to approximately 5 feet above the top of the screen. A bentonite slurry was placed on top of the filter pack interval. Type II Portland cement grout mixed with powdered bentonite was tremied into the annular space above the seal. The grout extends from the top of the seal to the ground surface. The surface completion of each well consists of a 5-foot length of 8-inch-diameter steel casing. The steel casing was grouted into place approximately 3 feet bgs and extends above the PVC-riser casing. A cement pad was constructed around each well installation. An 8-foot high chain-link fence surrounds each well cluster.

2.4.2.3 Monitoring Well and Site Survey

A registered surveyor conducted a survey to determine the horizontal coordinates of each newly installed well and the reference point elevation at the top of the well casing.

2.4.2.4 Monitoring Well Development

The newly installed groundwater wells were developed using the surge block method. This method is preferred for well development in fine-grained or poorly sorted (well-graded) unconsolidated formations because it makes use of a two-way water flow through the filter pack sand, removing fine-grained particles which may inhibit well yield.

The surge block well development was performed as follows:

1. A weighted stainless steel surge block, or "swab," attached to a rigid pipe or a line was lowered into the upper 2 feet of the well screen. The surge block was cylindrical, with a diameter approximately 0.2 inch less than the inside diameter of the well casing and screen. Water could flow between the block plate and well screen, relieving excess pressure to prevent collapse of the well screen. The surge block was used to gently agitate the water by moving the swab in a continuous up- and-down motion.
2. After 5 to 10 minutes of swabbing, the block plate was removed from the well and groundwater pumped from the well. Because the well casing was 4-inch-diameter PVC, casing storage volumes were sufficiently high that pumping, not bailing, was

effective in removing solids suspended during development. Additional agitation caused by pumping further developed the well. Water quality parameters (pH, temperature, and conductivity) were measured during purging.

3. After swabbing and pumping, the next 2-foot section of the saturated well screen was swabbed. The surge block was lowered an additional 2 feet into the well intake, and Steps 1 and 2 were repeated. At least 10 casing volumes of water were produced from each well during development. All groundwater produced during development was transferred to the onsite holding tank prior to treatment and disposed of by the onsite treatment system.
4. All sounding and developing equipment was decontaminated immediately after use in each well to avoid cross-contaminating wells.

Well development proceeded until the wells yielded water low enough in suspended solids content for sampling purposes and water quality parameters had stabilized. Turbidity was checked visually during development. Silt buildup, if present, was removed from all wells. Surge block techniques were sufficient to suspend silt at the bottom of the well screens for removal. Total well depth measurements were made during well development to ascertain progress in removing any silt buildup which might have been present in the well intake.

During development, indirect observations of the casing were made by noting the silt and sand production, the degree of silt buildup in the well intake, the presence of scale or other encrusting material during bailing, and the ease of movement of the surge block. A properly sized and weighted surge block dropped down the well did not stick or get caught on the sides of the casing or intake. Well development logs are presented in Appendix D. These logs show that the OW series of monitoring wells were developed until they produced sediment-free water. Some wells were yielding slightly cloudy to cloudy water upon completion of the development. This was considered satisfactory for well development in the fine-grained materials which make up the S-1 and S-2 zones.

2.4.3 Background Groundwater

Monitoring wells MW-2A, MW-2B, MW-6A, MW-6B, and MW-6C were chosen as background/upgradient locations (see Figure 1-2). These wells are screened in each of the three shallow groundwater zones beneath the site. Monitoring wells MW-6A and MW-6B are designated as the background sample locations for groundwater zone S-1. Monitoring wells MW-2A and MW-6C are designated as the background sample locations for groundwater zone S-2. Monitoring well MW-2B is designated as the background sample location for the A-1 aquifer.

2.4.4 Geologic and Hydrogeologic Samples

During the installation of the monitoring wells, a 10-inch-diameter hollow-stem auger drilling rig was used to bore to the desired depths. Undisturbed soil samples were collected using a thin-wall (Shelby) tube sampler from three monitor well borings to the A-1 aquifer. These samples were collected by drilling to the desired depth using a 10-inch-diameter hollow-stem auger drill rig. Prior to sample collection, the borehole was cleaned of all soil cuttings. Sampling was accomplished in advance of the drill bit at all times. Shelby tube samples were collected according to ASTM D1587 procedures for undisturbed samples. The Shelby tube was pushed into the soil using the drill rig and removed from the hole. The Shelby tube containing the sample was extruded and logged.

2.5 QUARTERLY GROUNDWATER MONITORING PROGRAM

2.5.1 Sampling

As shown in Table 2-11, groundwater sampling has been conducted seven times since March 1994. Each round of sampling has included different wells on or adjacent to the site. However, all monitoring wells on and adjacent to the site, with the exception of damaged or dry wells, have been sampled.

2.5.2 Analysis

Groundwater samples collected from monitoring wells MW-7A, MW-7B, and MW-7C were analyzed using the CLP Special Analytical Services (SAS) for Routine Analytical Services (RAS) VOCs, including EDB and DBCP. Groundwater samples collected from all other wells were analyzed using the CLP SAS for RAS VOCs plus EDB and DBCP by multimedia, multi-concentration Statement of Work (SOW) using a 25-milliliter (ml) purge volume to achieve a CRQL of 1 microgram per liter (µg/l). In addition, if EDB or DBCP was not found in the sample at a level of 1 µg/l or higher for any groundwater sample analyzed using the above method, then that sample was analyzed for EDB and DBCP using EPA Method 504.

Groundwater samples collected from monitoring wells MW-7A, MW-7B, and MW-7C were analyzed using the CLP SAS for RAS VOCs, including EDB and DBCP, because previous groundwater sampling data indicated that EDB and DBCP were present in groundwater samples collected from these wells at concentrations above 10 µg/l. Therefore, the 25 ml purge method for volatile organic compounds, which lowers the CRQL from 10 µg/l to 1 µg/l, is not required for samples collected from these wells.

Groundwater samples collected from all monitoring wells, except MW-7A, MW-7B, and MW-7C, were analyzed using the CLP SAS for RAS VOCs, including EDB and DBCP, using the 25 ml purge method because previous groundwater sampling data indicated that several

Table 2-11 Quarterly Sampling, Summary of Wells Sampled

Well	Date Sampled						
	4/94	8/94	12/94	6/95	10/95	12/95	5/96
AW-2	X	X	X	X	O	O	O
AW-2A	O	O	O	O	O	O	X
AW-2B	O	O	O	O	O	O	X
AW-3	X	X	X	X	O	O	X
AW-4	X	O	O	O	O	O	X
AW-6	X	X	X	X	O	O	X
MW-1	X	X	X	O	O	O	O
MW-10A	X	X	X	X	X	O	X
MW-10B	X	X	X	X	X	O	X
MW-11A	X	X	X	X	X	O	X
MW-11B	X	X	X	X	X	O	X
MW-12A	X	X	X	X	X	O	X
MW-12B	X	X	X	X	X	O	X
MW-13A	X	X	X	X	X	O	X
MW-13B	X	X	X	X	X	O	X
MW-13C	X	X	X	X	X	O	X
MW-2A	X	X	X	O	O	O	O
MW-2B	X	X	X	O	O	O	O
MW-3A	X	X	X	X	O	O	X
MW-3B	X	X	X	X	O	O	X
MW-3C	X	X	X	X	O	O	X
MW-4A	X	X	X	X	O	O	X
MW-4B	X	X	X	X	O	O	X
MW-4C	X	X	X	X	O	O	X
MW-5A	X	X	X	X	O	O	X
MW-5B	X	X	X	X	O	O	X
MW-5C	X	X	X	X	O	O	X
MW-6A	X	X	X	O	O	O	X
MW-6B	X	X	X	X	O	O	X
MW-6C	X	X	X	X	O	O	X
MW-7A	X	X	O	X	X	O	X

X = Well sampled O = Well not sampled

Table 2-11 (Cont'd)

Well	Date Sampled						
	4/94	8/94	12/94	6/95	10/95	12/95	5/96
MW-7B	X	X	X	X	X	O	X
MW-7C	X	X	X	X	X	O	X
MW-7D	X	X	X	X	X	O	X
MW-8A	X	X	X	X	X	O	X
MW-8B	X	X	X	X	X	O	X
MW-9A	X	X	X	X	X	O	X
MW-9B	O	O	O	X	X	O	X
MW-9C	X	X	X	X	X	O	X
OW-1A	O	O	O	O	O	X	X
OW-1B	O	O	O	O	O	X	X
OW-1C	O	O	O	O	O	X	X
OW-2A	O	O	O	O	O	X	X
OW-2B	O	O	O	O	O	X	X
OW-2C	O	O	O	O	O	X	X
OW-3A	O	O	O	O	O	X	X
OW-3B	O	O	O	O	O	X	X
OW-3C	O	O	O	O	O	X	X
OW-4A	O	O	O	O	O	X	X
OW-4B	O	O	O	O	O	X	X
OW-4C	O	O	O	O	O	X	X
X-1A	O	O	O	X	X	O	X
X-1B	O	O	O	X	X	O	X
X-1C	O	O	O	X	X	O	X
X-2A	O	O	O	O	X	O	X
X-2B	O	O	O	O	X	O	X
X-3A	O	O	O	X	X	O	X
X-3B	O	O	O	X	X	O	X
X-4A	O	O	O	X	X	O	X
X-4B	O	O	O	X	X	O	X

X = Well sampled O = Well not sampled

VOCs were present in groundwater samples collected from these wells at concentrations below the CRQL of the RAS VOCs plus EDB and DBCP analysis. Therefore, the 25 ml purge method for volatile organic compounds, which lowers the CRQL from 10 µg/l to 1 µg/l, was required for samples collected from these wells. If EDB and DBCP were not found in the sample at a level of 1 µg/l or higher for any groundwater sample analyzed for RAS VOCs, including EDB and DBCP, using the 25 ml purge method, then that sample was analyzed for EDB and DBCP using EPA Method 504. EPA Method 504 has CRQLs for EDB and DBCP of 0.05 µg/l.

2.5.3 Water-Level Measurements

All wells were sounded for depth to water from top of casing and total well depth prior to purging. An electronic sounder, accurate to the nearest ±0.01 foot, measured depth to water in each well. When an electronic sounder is employed, the probe is lowered down the casing to the top of the water column and the graduated markings on the probe wire are used to measure the depth to water from the surveyed point on the rim of the well casing. Typically, the measuring device emits a constant tone when the probe is submerged in standing water, and most electronic water level sounders have a visual indicator consisting of small light bulb or diode that turns on when the probe encounters water. Total well depth was sounded from the surveyed top of the casing by lowering the weighted probe to the bottom of the well. Because the weighted probe sinks into silt at the bottom of well screens, total well depths were measured and recorded to the nearest 0.1 foot. Water level sounding equipment was decontaminated before and after use in each well.

2.5.4 Well Purging

All wells were purged prior to sampling. At least three casing volumes of water were purged using an electric submersible pump. When pumps were used for purging, clean flexible plastic or Teflon tubes were used for groundwater extraction. Pumps were placed 2 to 3 feet from the bottom of the well to permit reasonable drawdown while preventing cascading conditions.

Before the start of sampling and after each well casing volume was purged, water temperature, pH, and specific conductance were measured by means of field test meters, and the measurements were recorded. Samples were collected after these parameters had stabilized, indicating representative formation water was entering the well. Three consecutive measurements that displayed consistent values of all parameters were taken prior to sampling. Samples were collected after three well casing volumes had been purged, if parameters had stabilized. If these parameters had not stabilized after five casing volumes had been purged, purging ceased, a notation was recorded in the field logbook, and samples were collected. If a monitoring well dewatered during purging and three casing volumes were not purged, then that well was allowed to recharge up to 80 percent of static water column, and dewatered once more. After water levels had recharged to 80 percent of the static water column, groundwater samples were

collected. Monitoring wells connected to the onsite remediation system were purged, and samples were taken directly from the sampling tap closest to the wellhead.

2.5.5 Groundwater Monitoring Well Samples

Groundwater samples were collected from the monitoring wells, indicated in Table 2-11, located on or adjacent to the site. A physical description of monitoring wells to be sampled is given in Table 2-12. All wells were sampled within 24 hours of purging. Groundwater samples were collected using a Teflon bailer or tap. Groundwater was transferred from the Teflon bailer to the appropriate sample container using a bottom emptying device to reduce agitation of the water samples during transfer. Monitoring wells connected to the onsite remediation system were sampled directly from the wellhead sampling tap. The flow was adjusted to obtain a gentle stream.

Groundwater samples were transferred from the bailer or tap directly into the appropriate sample containers, preserved, chilled, and processed for shipment to the laboratory. When transferring samples, care was taken not to touch the discharge device (bailer) or tap to the sample container. The sample container (a 40 ml glass vial) was inverted and checked for air bubbles to ensure zero headspace. If bubbles were present, the vial was opened and topped off. If air bubbles still existed, the vial was discarded and a new sample was collected.

Table 2-12 Well Construction Summary

Well ID	Northing	Easting	Ground Elevation (ft)	Top of Casing Elevation (ft)	Depth of Screen (ft)	Depth of Filter pack (ft)	Total Depth of Well (ft)	Total Depth Explored (ft)	Monitored Zone
AW-1	2085035.00	323243.32	32.48	35.5	20 to 30	17 to 10	30	40	S-1
AW-2A/AW-2B	2085330.00	322997.00	32	32.57	73 to 93	71 to 98	96	98	S-2
AW-3	2085487.12	322869.95	31.46	32.92	13 to 53	9 to 55	53	55	S-1
AW-4	2085900.24	322782.99	31.47	32.88	15 to 32.5	12.5 to 99	32.5	39	S-1
AW-5	2085685.24	322970.79	31.26	32.18	14 to 24	9 to 33	24	33	S-1
AW-6	2085293.16	322606.79	31.96	31.7	13 to 23, 33 to 53	9 to 55	53	55	S-1
IW-1	2085142.18	322818.28	31.68	31.86	25 to 90	23 to 93	93	93	S-1
IW-2	2085059.43	322934.14	32.39	32.64	25 to 90	23 to 93	93	93	S-1
IW-3	2085148.83	322898.74	31.95	32.07	25 to 90	23 to 93	93	93	S-1
IW-4	2085215.10	322874.85	31.91	32.19	25 to 90	23 to 93	93	93	S-1
IW-5	2085314.81	322922.29	31.34	31.37	25 to 90	23 to 93	93	93	S-1
IW-6	2085358.02	322948.45	31.52	31.75	25 to 90	23 to 93	93	93	S-1
IW-7	2085397.89	322969.07	31.27	31.65	25 to 90	23 to 93	93	93	S-1
MW-1	2085040.00	323298.00	33	34.39	94 to 114	74 to 148	144	148	S-2
MW-10A	2085108.47	323363.89	32.05	35.05	25 to 45	23 to 46	50	50	S-1
MW-10B	2085079.22	323361.00	32.05	35.12	67 to 77	64 to 90	77	90	S-2
MW-11A	2085266.93	323410.05	31.53	34.23	25 to 45	23 to 46	45	45	S-1
MW-11B	2085274.82	323407.70	31.51	34.65	67 to 77	63 to 79	77	90	S-2
MW-12A	2085538.95	323379.77	30.79	34.05	25 to 45	24 to 46	45	46	S-1
MW-12B	2085553.92	323379.03	30.74	33.87	67 to 77	67 to 90	77	90	S-2
MW-13A	2085100.26	323078.01	31.98	31.55	37 to 51	35 to 53	52	53	S-1
MW-13B	2085080.60	323078.06	31.98	31.54	75 to 85	72 to 86	85.5	86	S-2
MW-13C	2085060.37	323078.94	31.98	33.92	115 to 125	113 to 127	125	126	A-1
MW-2A	2085330.85	322995.08	31.25	31.12	20 to 40, 60 to 90	10 to 85	90	150	S-2
MW-2B	2085329.90	323009.46	31.02	30.98	100 to 140	95 to 150	150	150	A-1
MW-3A	2085692.00	322705.96	27.7	27.52	34 to 44	30 to 46	44	46	S-1

TBL 2 12 DOC/

Table 2-12 (Cont'd)

Well ID	Northing	Easting	Ground Elevation (ft)	Top of Casing Elevation (ft)	Depth of Screen (ft)	Depth of Filter pack (ft)	Total Depth of Well (ft)	Total Depth Explored (ft)	Monitored Zone
MW-3B	2085694.44	322701.49	27.72	27.32	66 to 76	61 to 78	76	78	S-2
MW-3C	2085697.05	322705.84	27.7	27.32	116 to 126	112 to 135	126	140	A-1
MW-4A	2085280.57	322902.20	31.46	31.43	34 to 44	32 to 46	44	46	S-1
MW-4B	2085284.27	322898.24	31.46	31.62	72 to 82	69 to 84	82	84	S-2
MW-4C	2085281.65	322897.67	31.45	31.29	114 to 124	110 to 140	124	145	A-1
MW-5A	2085060.19	322842.18	31.91	33.05	10 to 30	7 to 32	40	42	S-1
MW-5B	2085061.50	322818.94	31.76	33.15	34 to 44	32 to 48	54	56	S-1
MW-5C	2085060.56	322830.48	31.81	33.15	70 to 80	65 to 80	90	94	S-2
MW-6A	2085335.91	322382.75	32.17	34.11	12.5 to 30	10 to 34	40	42	S-1
MW-6B	2085345.97	322385.00	32.18	34.06	40 to 50	36 to 54	60	62	S-1
MW-6C	2085354.78	322388.52	32.26	34.08	70 to 80	70 to 80	90	93.5	S-2
MW-7A	2085261.99	323047.76	31.37	33.94	12.5 to 30	9 to 33	40	42	S-1
MW-7B	2085256.80	323059.65	31.27	29.81	36 to 46	34 to 49	56	58	S-1
MW-7C	2085257.83	323071.14	31.47	29.69	76 to 86	70 to 90	96	98	S-2
MW-7D	2085269.04	323048.18	31	33.88	114 to 124	111 to 130	129	130	A-1
MW-8A	2085268.08	323259.17	31.6	34.52	25 to 45	24 to 46	50	50	S-1
MW-8B	2085285.66	323257.05	31.36	34.57	80 to 90	78 to 90	90	90	S-2
MW-9A	2085492.48	323230.82	30.79	33.92	25 to 45	23 to 46	45	46	S-1
MW-9B	2085479.24	323247.90	30.69	33.76	71 to 81	69 to 82	87	88	S-2
MW-9C	2085460.27	323232.23	30.84	33.45	115 to 125	110 to 128	125	128	A-1
OW-1A	2084941.15	323298.84	32.62	34.82	42 to 57	39 to 59	59	59	S-1
OW-1B	2084941.29	323310.53	32.41	34.62	68 to 88	66 to 89	88	90	S-2
OW-1C	2084948.07	323309.40	32.29	34.58	112 to 137	110 to 138	138	138	A-1
OW-2A	2085251.74	323610.93	31.52	33.83	39 to 59	36 to 59	61	61	S-1
OW-2B	2085264.40	323610.12	31.53	33.81	64 to 109	62 to 109	111	111	S-2

TBL 2 12 DOC/

Table 2-12 (Cont'd)

Well ID	Northing	Easting	Ground Elevation (ft)	Top of Casing Elevation (ft)	Depth of Screen (ft)	Depth of Filter pack (ft)	Total Depth of Well (ft)	Total Depth Explored (ft)	Monitored Zone
OW-2C	2085260.89	323600.41	31.5	33.89	113 to 138	112 to 142	142	142	A-1
OW-3A	2085536.45	323527.40	30.95	33.2	39 to 49	38 to 50	51	51	S-1
OW-3B	2085555.89	323523.87	31.04	33.1	64 to 84	62 to 86	86	86	S-2
OW-3C	2085547.71	323517.63	31.09	33.44	103 to 133	100 to 139	139	139	A-1
OW-4A	2085640.82	323381.97	30.71	32.99	37 to 47	35 to 49	49	49	S-1
OW-4B	2085634.32	323366.94	30.76	33.02	65 to 85	62 to 87	87	87	S-2
OW-4C	2085629.75	323379.66	30.7	32.94	113 to 145	110 to 147	147	147	A-1
X-1A	2085194.26	232052.76	31.11	31.1	31 to 51	30 to 52	53	53.5	S-1
X-1B	2085176.87	323061.14	31.13	34.2	66 to 85	64 to 86	88	90	S-2
X-1C	2085192.22	323066.87	31.4	30.8	111 to 131	109 to 134	133	134	A-1
X-2A	2085153.84	323253.40	31.41	31.23	30 to 50	29 to 54	54	54	S-1
X-2B	2085160.04	323239.28	31.46	31.61	71 to 91	70 to 94	94	94	S-2
X-3A	2085057.24	323243.00	32.17	32.02	30 to 50	28 to 53	53	53	S-1
X-3B	2085057.13	323235.94	32.36	31.79	65 to 90	62 to 93	93	93	S-2
X-4A	2085184.59	323397.19	31.65	31.37	28 to 48	26 to 48			S-1
X-4B	2085171.22	323387.25	31.38	31.28	68 to 88	67 to 91	91	91	S-2

TBL 2 12 DOC/

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