SEPARATOR

54-00068

HAZ WASTE

COMPLIANCE

06/21/1994

NA

9545629

Joe

EnSafe Environmental and Safety Designs, Inc.

Memphis, TN • Nashville, TN • Raleigh, NC • Pensacola, FL • North Charleston, SC

5724 Summer Trees Dr. • P.O. Box 341315 • Memphis, TN 38184-1315

CSN 54-0068
PERMIT NO #
HAZARDOUS WASTE-SORT:
PERMIT/COMPLIANCE/SUPERFUNDS

June 21, 1994

Enforcement Branch Manager
Hazardous Waste Division
Arkansas Department of Pollution Control
and Ecology
8001 National Drive
Little Rock, Arkansas 72219

Dear Sir:

Environmental and Safety Designs, Inc. (EnSafe) is pleased to submit the revised Phase II Facility Investigation Workplan on behalf of Cedar Chemical Corporation for their West Helena plant. The original Phase II Work Plan was revised based upon the comments provided to Cedar Chemical by ADPC&E in the letter dated April 8, 1994.

The following revisions have been included in the enclosed workplan to address the comments provided by ADPC&E:

1) The preliminary risk goals have been replaced with the reference concentrations found in the RFI Guidance Document. Investigation activities at each site were reviewed and adjusted as necessary to delineate the extent of contamination to these reference concentrations which includes delineating groundwater contamination to MCLs.

2) Samples being collected for risk assessment purposes will be analyzed using the Synthetic Leachate Test (Method 1312).

JUN 22 1994
#1 BH

Telephone: 901-372-7962 • Facsimile: 901-372-2454

EnSafe and Cedar Chemical Corporation are currently preparing to begin implementation of the Phase II Work Plan and are awaiting confirmation that your comments have been adequately addressed to begin field activities. If you have any questions concerning this workplan please contact me at (901) 372-7962.

Sincerely,

Environmental and Safety Designs, Inc.

Jeff Bennett
Project Manager

Enclosure

cc: M.J. Pocrass, Cedar Chemical Corporation
Ed White, Cedar Chemical Corporation
Dave Hoppel, Cedar Chemical Corporation
Allen Malone, Apperson, Crump, Duzane & Maxwell

PHASE II

FACILITY INVESTIGATION WORK PLAN
CEDAR CHEMICAL COMPANY
WEST HELENA, ARKANSAS

Prepared for:
Cedar Chemical Company
Highway 242
West Helena, Arkansas 72390

Prepared by:
Environmental and Safety Designs, Incorporated
5724 Summer Trees Drive
Memphis, Tennessee 38134
(901) 372-7962

June 21, 1994

JUN 2 2 1994

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1.0 INTRODUCTION

This Facility Investigation Work Plan (FIWP) has been written to continue the assessment of the constituents detected in soil and groundwater at the Cedar Chemical Company plant in West Helena, Arkansas (Figure 1). This work plan will be implemented as a second phase of the field work completed in the fall of 1993. The Quality Assurance Project Plan (QAPP) and Health and Safety Plan (January 22, 1993) will be the guidance documents used during Phase II of the investigation unless specified otherwise in this document.

1.1 Facility Investigation Objectives

The initial phase of the Facility Investigation (FI) was to assess the nature and existence of contamination at the West Helena plant. The contaminants identified include chlorinated solvents, organo-pesticides, and heavy metals. The Arkansas Department of Pollution Control and Ecology (ADPC&E) has tasked Cedar Chemical with the broad objectives of determining nature and extent of contamination, source characterization, hydrologic assessment, and identification of potential receptors. Based on previous reports and Phase I of the FI, some suspected sources have been identified. During Phase II, the nature and extent of suspected sources will be determined. A hydrologic assessment will be conducted to evaluate the groundwater quality beneath the facility. These data will be used to assess the fate and transport of site contaminants, determine health-based risk, and identify potential receptors.

1.2 RFI Guidance Concentrations

Guidance concentrations for site contaminants of concern (COCs) in soil and groundwater have been compiled from the *RCRA Facility Investigation Guidance Document* and the *Federal Register* (Table 1). The guidance document concentrations are compared with the concentrations of the COCs to determine which areas at the facility require additional investigation.

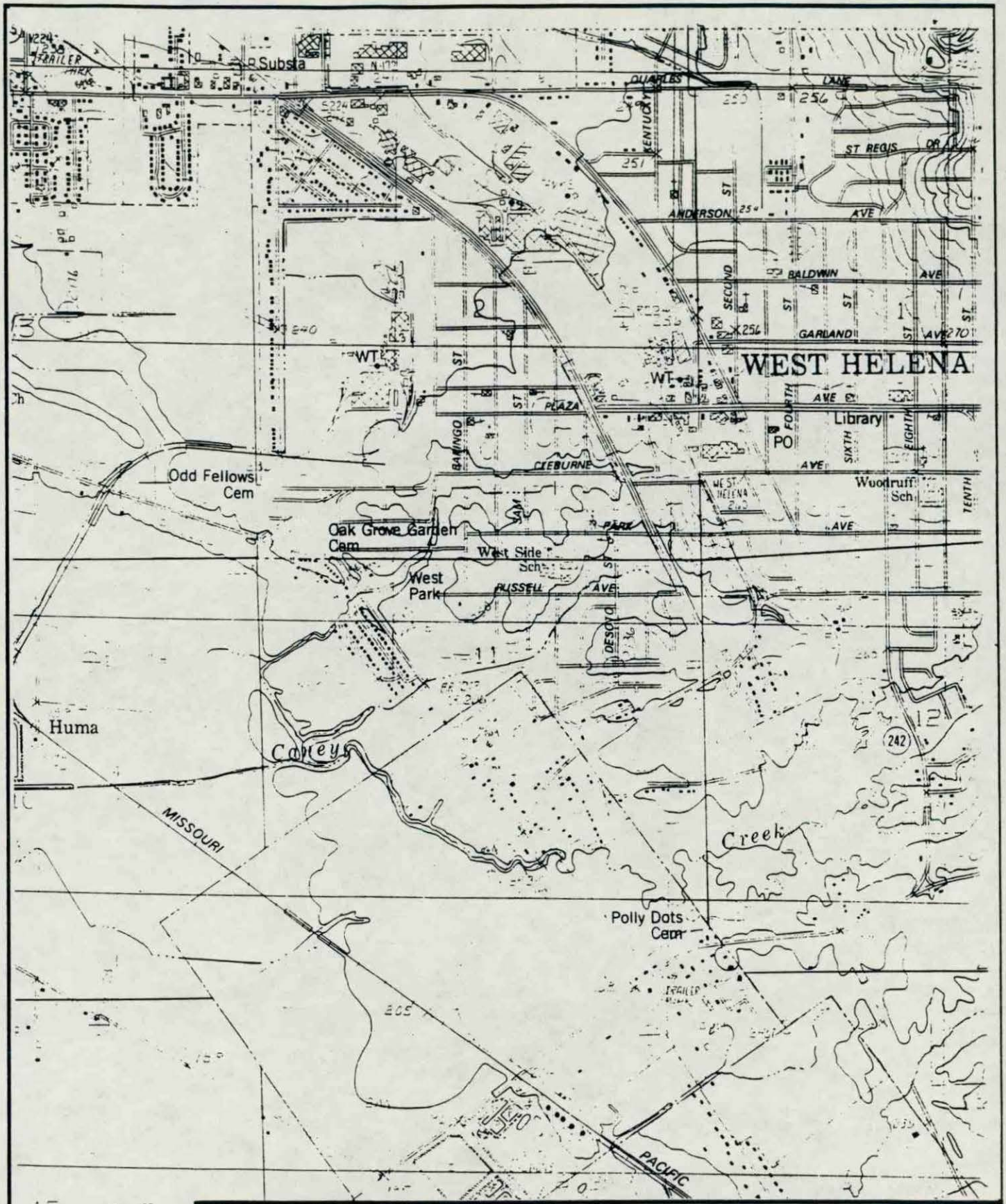

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FIGURE 1
VICINITY MAP
CEDAR CHEMICAL

DWG DATE: 02/15/94 | DWG NAME: BOARD

Table 1
RFI Guidance Concentrations/Maximum Contaminant Levels (MCLs) for COCs at the Cedar Chemical Facility

Parameter	RFI Guidance Concentrations for Soil (mg/kg)	MCLs from the Safe Drinking Water Act for Groundwater (µg/L)
Volatiles		
1,2-Dichloroethane	7.7e+00	5.0e+00
2-Butanone (MEK)	4.0e+03	2.0e+03
Acetone	8.0e+03	4.0e+03
Benzene	2.4e+01	5.0e+00
Chlorobenzene	2.0e+03	1.0e+03
Chloroform	1.1e+02	5.7e+00
Methylene Chloride	Not Available	4.7e+00
Tetrachloroethene	3.5e+01	5.0e+00
Toluene	2.0e+04	1.0e+04
Semivolatiles		
1,2-Dichlorobenzene	4.5e+03 (child)*	6.0e+02
2,4-Dinitrophenol	2.0e+02	7.0e+01
2,6-Dinitrotoluene	1.0e+00	5.0e-02
3,4-Dichloroaniline	Not Available	Not Available
4-Chloroaniline	2.0e+02 (child)*	1.4e+02 (child)*
4-Methyl-2-pentanone (MIK)	4.0e+03	2.0e+03
4-Methylphenol	Not Available	Not Available
4-Nitrophenol	Not Available	Not Available
Isophorone	2.0e+04	7.0e+03
Phenanthrene	Not Available	Not Available

Table 1
RFI Guidance Concentrations/Maximum Contaminant Levels (MCLs) for COCs at the Cedar Chemical Facility

Parameter	RFI Guidance Concentrations for Soil (mg/kg)	MCLs from the Safe Drinking Water Act for Groundwater (µg/L)
Phenol	3.0e+03	1.0e+03
Pyrene	Not Available	Not Available
Pesticides		
Aldrin	4.1e-02	2.1e-03
4,4'-DDD	2.9e+00	1.5e-01
4,4'-DDE	2.1e+00	1.0e-01
4,4'-DDT	2.1e+00	1.0e-01
Dieldrin	4.4e-02	2.2e-03
Dinoseb	8.0e+01	4.0e+01
Propanil	Not Available	Not Available
Toxaphene	6.4e-01	3.0e+00
alpha-BHC	Not Available	Not Available
beta-BHC	Not Available	Not Available
delta-BHC	Not Available	Not Available
gamma-BHC (Lindane)	5.4e+00	2.0e-01
p,p'-Methoxychlor	2.5e+02 (child) *	4.0e+01
Inorganics		
Arsenic	1.5e+01 (child) *	5.0e+01
Chromium (total)	8.0e+04	4.0e+04
Lead	Not Available	5.0e+01
Magnesium	Not Available	Not Available

* - Health Based Risk Values

1.3 Environmental Setting

The following descriptions are based on geologic and hydrologic information obtained from the Hydrogeologic Study of the Cedar Chemical Facility by Grubbs, Garner and Hoskyn, Inc. (1988), and the field work completed by EnSafe in the fall of 1993.

1.3.1 Physiography

The Cedar Chemical Company facility is located approximately two miles west of the Mississippi River in part of a physiographic setting known as the Mississippi Embayment. The topography at the site and surrounding area is relatively flat with some areas dipping gently toward the southeast. Ground surface elevations at the site tend to vary from about 188 to 197 feet mean sea level (msl). The most significant change in topographic relief is observed at Crowley's Ridge. The ridge is located approximately one mile to the east of the facility. Other relief changes are due mainly to alterations made to the original ground surface for construction purposes or for directing surface flow runoff. Generally, surface runoff flows in a southeasterly direction toward the Mississippi River. Since topography is relatively flat, overland flow velocities are low and some areas where no modifications have been made to the original ground surface are poorly drained. The facility is not located in the 100-year floodplain of the Mississippi River.

1.3.2 Regional Geology

The lowermost geologic unit of concern in the area is the Jackson-Claiborne Group. The Claiborne Clay consists mainly of silty clay with some thin, discontinuous beds of silty clay and lignite. The Jackson Clay is typically comprised of gray, brown, and green silty clay with some lignite.

A 130 to 150 foot thick alluvial deposit overlies the Jackson Clay. This unit consists of fine-grained sands, silts and clays of Quaternary age. Approximately 100 feet of this unit consists

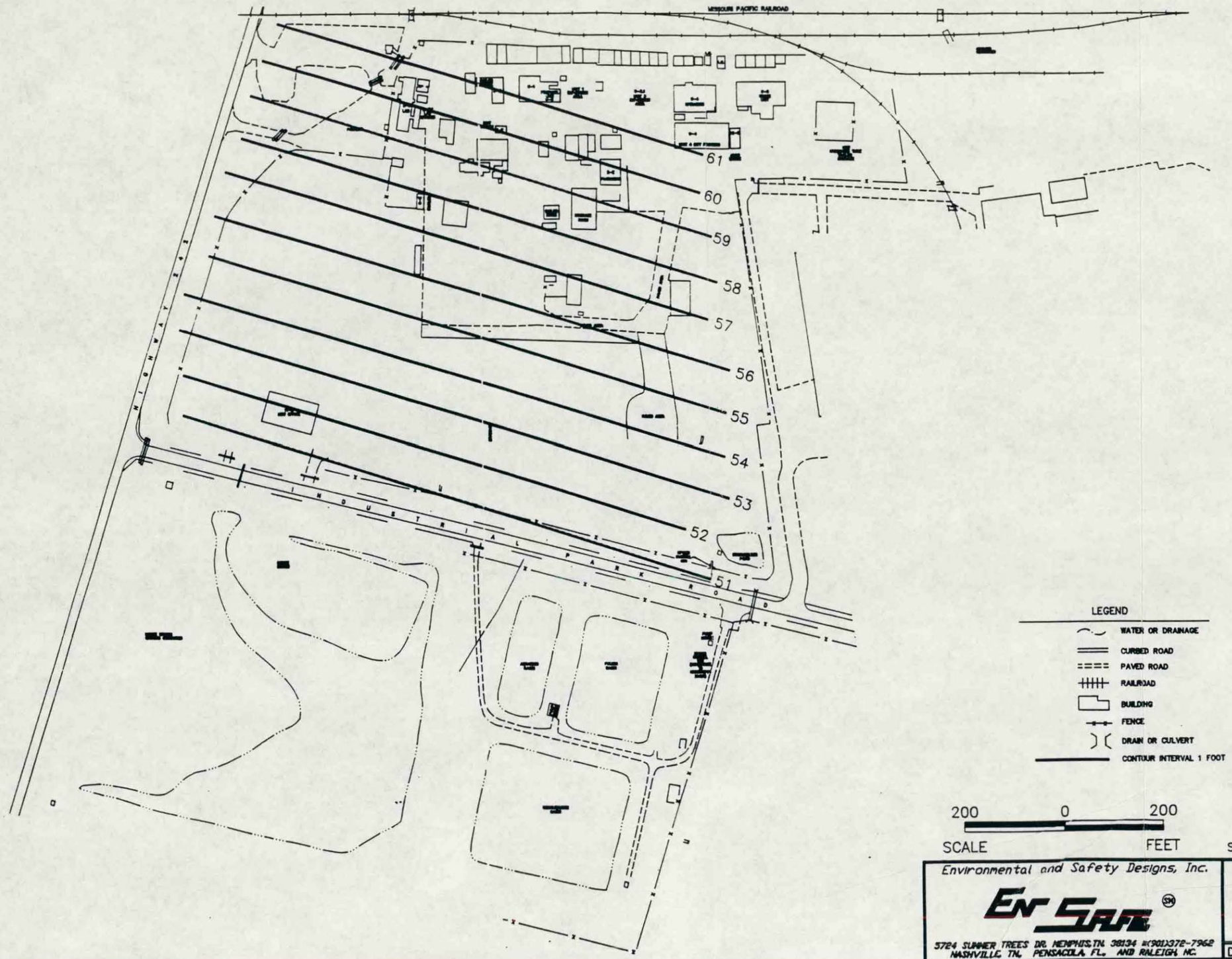
of a fining upward sequence of gravelly sands to fine sand. The upper portion of these deposits generally range from 25 to 40 feet thick and consists of silts and clays, possibly deposited through erosion from Crowley's Ridge. The Jackson-Claiborne Group behaves as an aquitard eliminating hydraulic communication between the Sparta Sands and the alluvial deposits.

1.3.3 Site Geology

Previous investigations identified three distinct stratigraphic units beneath the site. The lowermost stratigraphic unit encountered during previous field investigations consists of a very stiff, dark gray, sandy clay with lignite (Jackson Clay). This stratum was encountered at approximately 134 feet below ground surface (bgs) and exhibits an apparent dip to the southwest on a gradient of approximately 79.2 feet per mile as seen in the Structure Map of the Jackson Clay Surface (Figure 2). The gradient and direction of dip were determined during the Hydrologic Assessment conducted by Grubbs, Garner, and Hoskyn. These determinations were based on data from two soil borings installed to the surface of the Jackson-Claiborne Group and from USGS data. To confirm the dip of this unit, additional data will be obtained from deep monitoring well borings installed during Phase II.

Overlying the Jackson-Claiborne Group is a relatively clean, fine-to-coarse alluvial sand with some gravel ranging from the surface of the Jackson Clay to a depth of approximately 50 feet bgs. This sand exhibits a fining upward sequence to a medium-dense to dense silty fine sand to depths of 42 to 27 feet bgs.

Interbedded very stiff-to-firm, tan, gray and brown silty clay and clayey silts were encountered from the ground surface to the top of the alluvial sands. Coefficients of permeability of this unit were found to range from 4.0×10^{-5} cm/sec to 8.5×10^{-8} cm/sec. A dark gray clay with silt was encountered at various depths.



LEGEND

- WATER OR DRAINAGE
- CURBED ROAD
- PAVED ROAD
- RAILROAD
- BUILDING
- FENCE
- DRAIN OR CULVERT
- CONTOUR INTERVAL 1 FOOT

200 0 200

SCALE FEET

SOURCE: DELTA PROCESS MANAGEMENT, INC.

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FIGURE 2
STRUCTURAL CONTOUR MAP OF
JACKSON–CLAIBORNE GROUP

DWG DATE:02/13/94 | DWG NAME:CEDAR42

The thickness of this clay ranges from 3 to 20 feet. Geologic cross-sections of the upper 30 feet are provided in Figures 3, 4, and 5. The cross sections depict the stratigraphy beneath the site based on extrapolations between the wells indicated on the cross-section delineation map. Although the clay appears to be continuous, it was not encountered during the installation of well number CED2MW-3. During Phase II, additional lithologic data will be collected to assess the continuity of the clay. Permeabilities of the clay indicate that it may behave as an aquitard, where present.

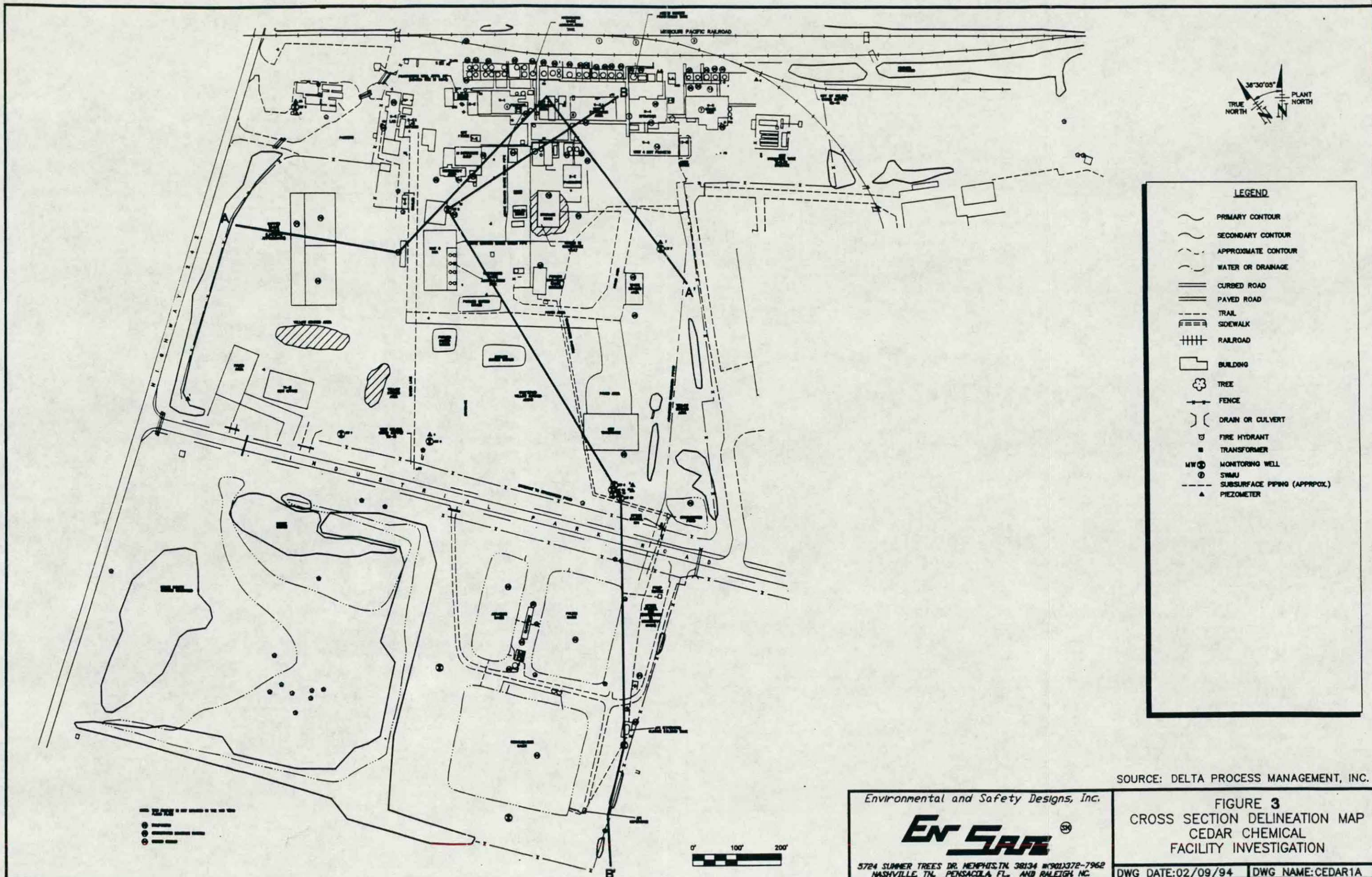
1.3.4 Site Hydrogeology

Review of available piezometric data indicates that the hydrology of the Quaternary alluvial aquifer beneath the Cedar Chemical facility varies significantly. The piezometric surface data collected by Grubbs, Garner, and Hoskyn from August 1988 and September 1988 indicate that the predominant groundwater flow is south/southwest. Grubbs, Garner, and Hoskyn data from October 1988 through February 1989 indicate bi-directional groundwater flow. Groundwater flows southeast on the eastern portion of the site and northwest in the western portion of the site. Bi-directional groundwater flow was apparent again in the piezometric surface map generated during Phase I of the FI activities.

Hydrologic data for the Quaternary-age alluvial aquifer consist of slug test data obtained in 1988 by Grubbs, Garner, and Hoskyn. Data show a variability in hydraulic conductivity with depth. Wells screened in the upper portion of the aquifer (30 to 50 feet bgs) are characterized by silty fine-grained sands and exhibited hydraulic conductivities ranging from 0.085 ft/day to 1.41 ft/day. The hydraulic conductivity of wells screened in the lower portion of the aquifer (120-150 feet) is considerably higher, on the order of 70.8 ft/day. These variabilities corresponds with the fining upward sequence of the alluvial aquifer. Phase I data indicate the alluvial aquifer may behave as a confined or semiconfined unit due to the overlying silts and clays.

Four agricultural irrigation wells are located in the Quaternary-age alluvial aquifer within one mile of the Cedar Chemical facility. All four wells are reportedly 100 to 135 feet deep and yield 700 to 1000 gallons per minute (gpm).

A discontinuous surficial saturated zone (SSZ) rests upon the clay identified in borings logs from previous investigations. Characterization of the clay surface and the piezometric surface of the SSZ is not feasible due to insufficient data. The collection of additional lithologic data for SSZ and clay surface characterization is discussed in Section 3.9.



SOURCE: DELTA PROCESS MANAGEMENT, INC.

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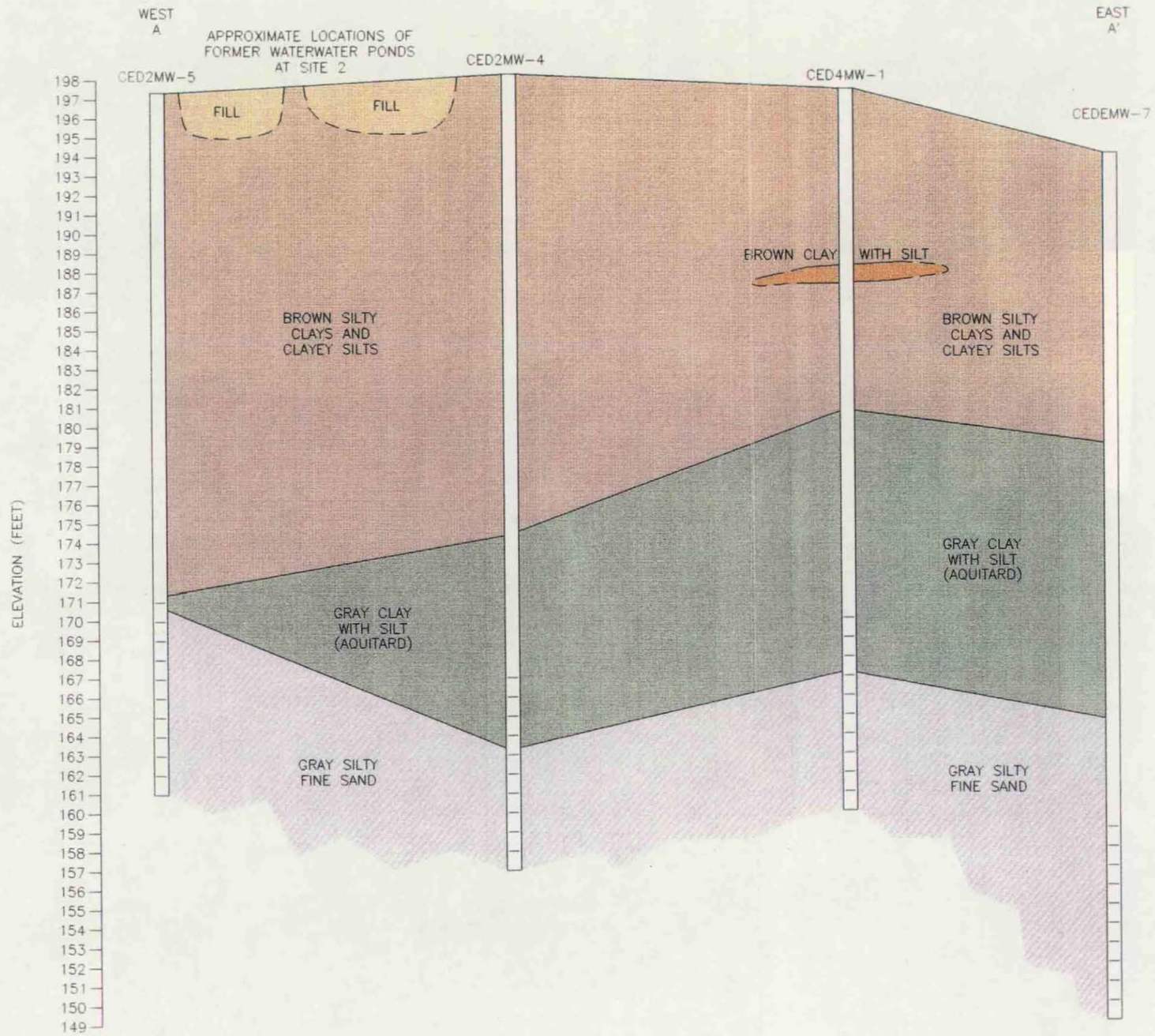
FIGURE 3
CROSS SECTION DELINEATION MAP
CEDAR CHEMICAL
FACILITY INVESTIGATION

DWG DATE:02/09/94 | DWG NAME:CEDAR1A



80 0 80

SCALE FEET

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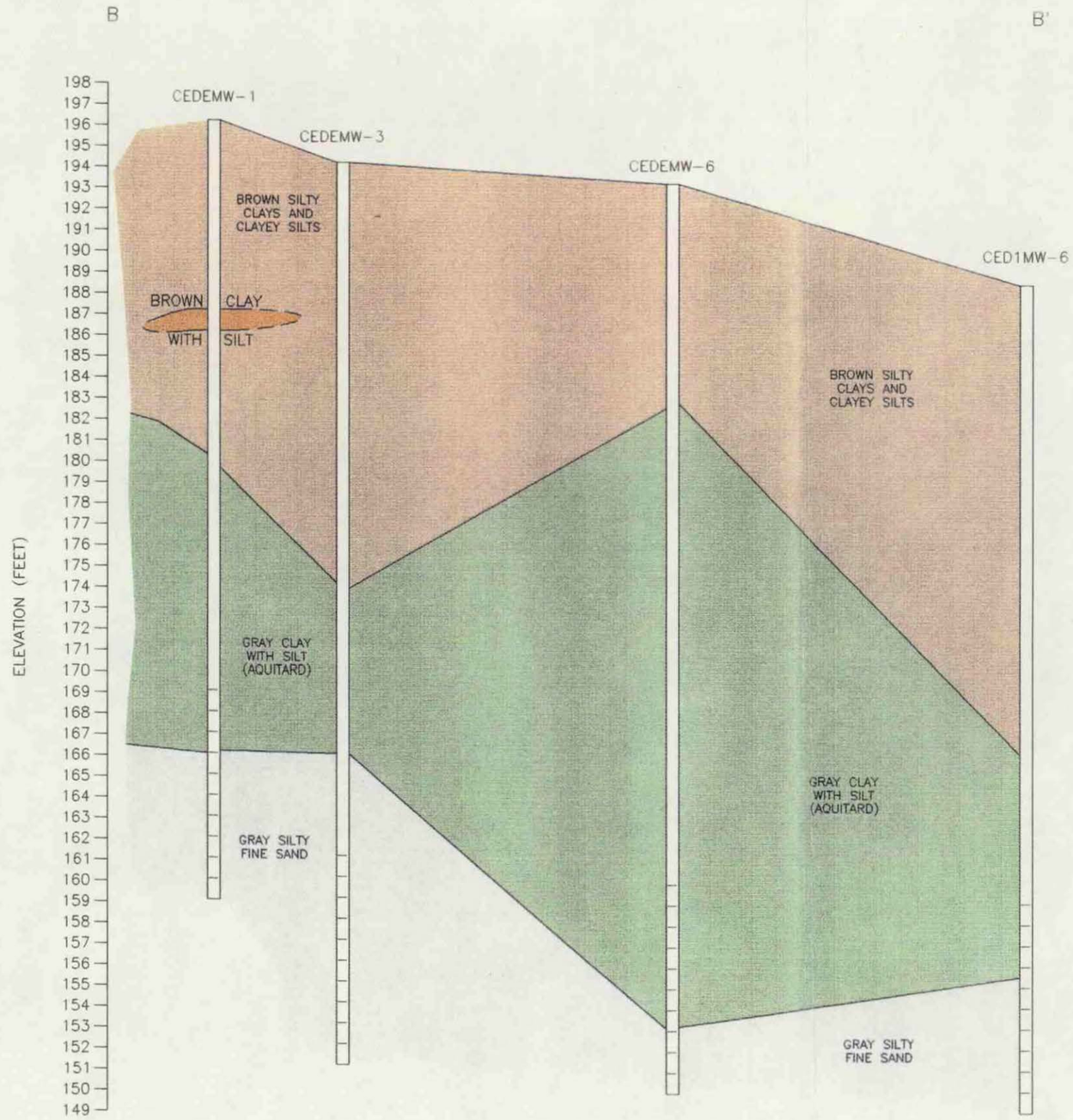
FIGURE 4
CROSS SECTION A-A'
CEDAR CHEMICAL
FACILITY INVESTIGATION

DWG DATE:02/12/94 | DWG NAME:CEDCRS1

Rescan
715



160 0 160

SCALE FEET

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FIGURE **5**
CROSS SECTION B-B'
CEDAR CHEMICAL
FACILITY INVESTIGATION

DWG DATE:02/12/94 | DWG NAME:CEDCRS3

2.0 SOIL INVESTIGATIONS

The following sections address the objectives and procedures to be implemented to assess soil contamination at each site. Unless otherwise noted, all soil samples will be analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, and metals.

2.1 Site 1 — SWMUs 63, 64, 65, 68, and the API Separator

The Phase I hand auger samples collected from the vicinity of Wastewater Tank 2 (SWMU 63) exhibited 3,4-dichloroaniline at 1,500 ppm and a dieldrin at 460 ppb in sample CED1SHA-4. These concentrations exceed the guidance concentrations for these compounds presented in Table 1. One hand auger boring is proposed to determine the vertical extent of the 3,4-dichloroaniline detected near the tank. Figure 6 presents the locations of the Phase I borings and proposed Phase II boring. The hand auger boring will be installed adjacent to boring number CED1SHA-4. One sample will be collected every three feet. The boring will be advanced to at a maximum depth of 15 feet, or until groundwater or refusal is encountered.

2.2 Site 2 — SWMUs 69, 70, and 71

The first phase of the Facility Investigation at Site 2 consisted of the installation and sampling of 12 soil borings within the boundaries of the former treatment ponds and five groundwater monitoring wells along the outer perimeter of the ponds. Some samples collected within the abandoned ponds exhibited 1,2-dichloroethane, methylene chloride, dinoseb, methoxychlor and arsenic concentrations in excess of RFI Guidance Document and health based guidance concentrations.

During Phase I, soil borings were installed on the east, south, and west sides of Site 2 and completed as groundwater monitoring wells. No COCs were detected above guidance concentrations in any soil samples collected during the installation of the borings. Vertical soil

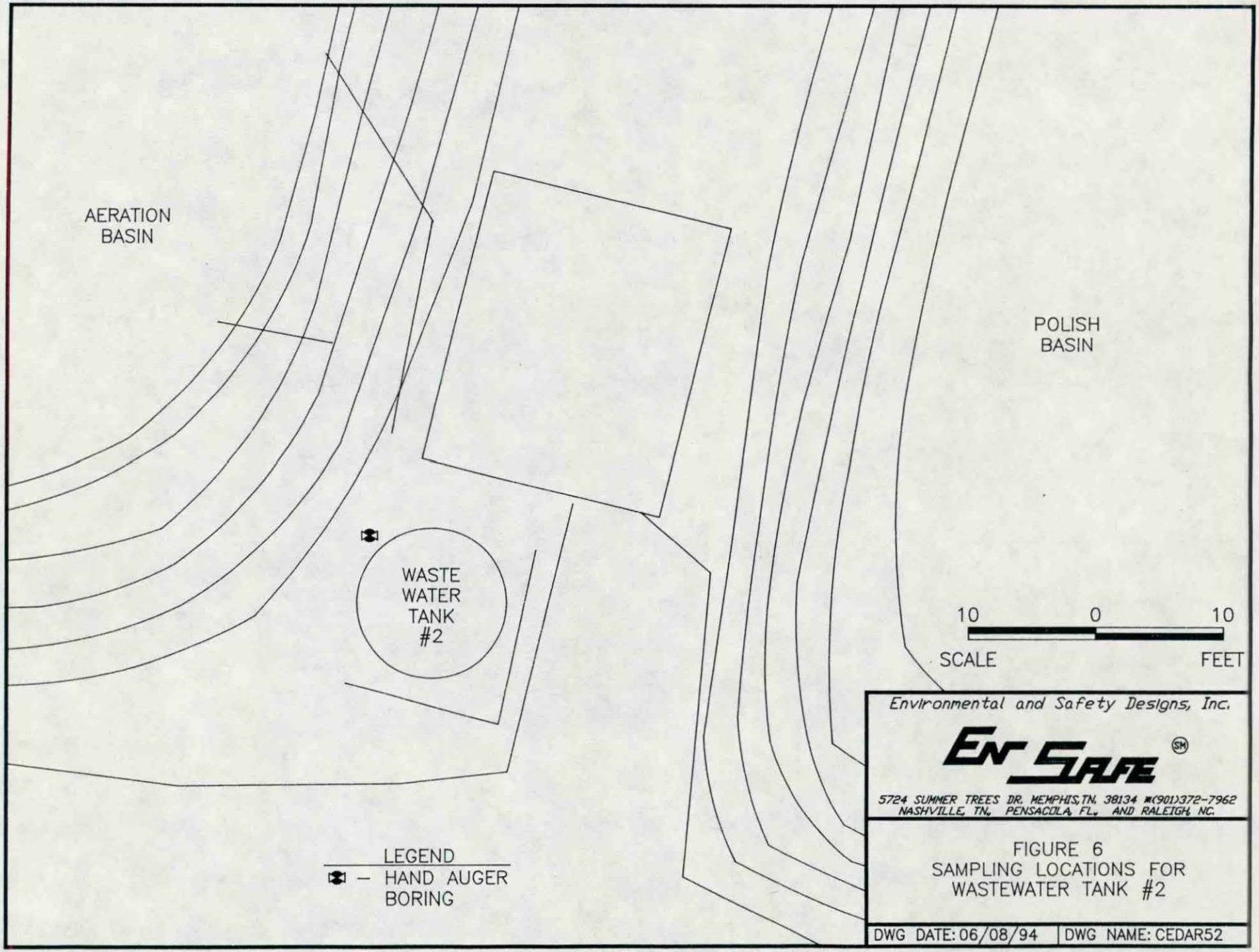
AERATION BASIN
POLISH BASIN
WASTE WATER TANK #2
10 0 10
SCALE FEET
LEGEND
– HAND AUGER BORING
Environmental and Safety Designs, Inc.
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FIGURE 6
SAMPLING LOCATIONS FOR
WASTEWATER TANK #2
DWG DATE: 06/08/94
DWG NAME: CEDAR52

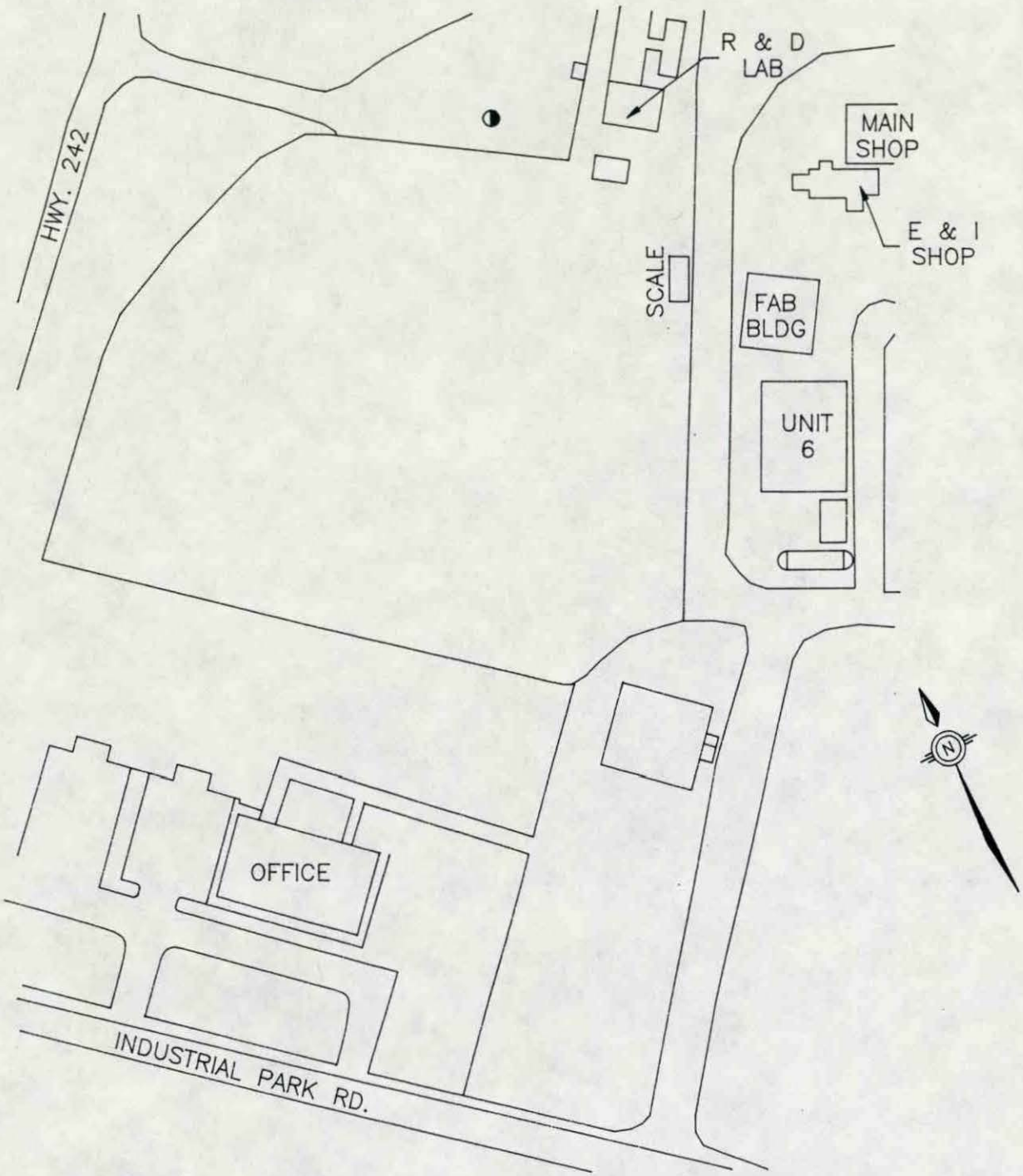
contamination extends approximately 30 feet bgs to groundwater. One additional soil boring is proposed for the north side of Site 2 (Figure 7). Site history coupled with the perimeter borings should confirm that contamination is limited to the abandoned pond area. The additional boring will be installed and sampled on 5-foot intervals until groundwater is encountered. The samples will be analyzed for VOCs, SVOCs, pesticides, and metals.

Two Synthetic Precipitation Leachate Procedure (SPLP, Method 1312) samples will be collected from Site 2. These samples will be collected to determine potential leachate characteristics of the soil. One SPLP sample will be collected from the area having the highest concentration of contamination. The second SPLP sample will be collected from an area of moderate COC concentrations as determined during Phase I activities. These areas will be selected based on data collected from the previous phase of the investigation.

2.3 Site 3 — SWMUs 59 and 60

Analytical results for samples collected at Site 3 during Phase I exhibited dieldrin and aldrin concentrations in excess of the guidance concentrations. Samples CED3SED-3, CED3SED-5, CED3SED-6, and CED3SED-7 exhibited elevated concentrations of dieldrin. An elevated concentration of aldrin was also detected in sample CED3SED-3. An arsenic concentration of 222 ppm was detected in sediment sample number CED3SED-9.

A minimum of 13 hand auger borings will be installed and sampled during Phase II of the investigation to determine the vertical and horizontal extent of the pesticides detected in the samples mentioned above (Figure 8). Samples will be collected from the 0- to 6-inch interval, a 6-inch interval immediately below the interface of settled sediment and native material at the bottom of the drainage ditches, and from a 6-inch interval one foot below the interface.



50 0 50

SCALE FEET

LEGEND

◑ – SOIL BORING PROPOSED FOR PHASE II

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FIGURE 7
SITE 2
SOIL BORING LOCATION

DWG DATE: 06/08/94 | DWG NAME: CEDAR51

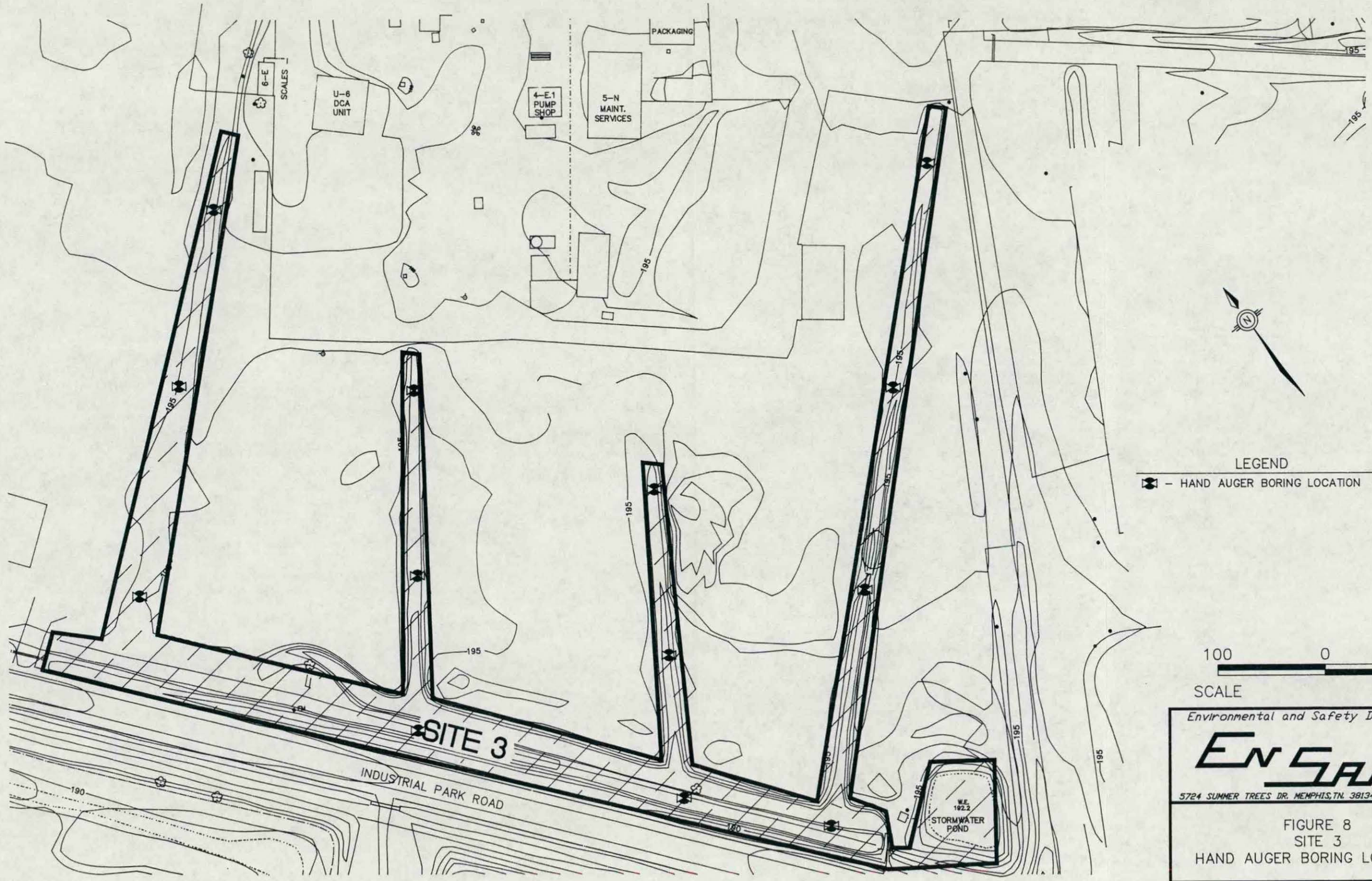

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FIGURE 8
SITE 3
HAND AUGER BORING LOCATIONS

DWG DATE:06/08/94 | DWG NAME:CEDAR50

2.4 Site 4 — SWMUs 3 and 74

As presented in the December 16, 1993, Technical Memo, concentrations of dieldrin and dinoseb were detected above regulatory and health based action levels along the rail spur at the northeastern end of the Cedar property. Although no regulatory or health based action levels were available for 3,4-dichloroaniline, further delineation of the dichloroaniline detected in soil will be conducted since concentrations detected along the rail spur were as high as 4,000 ppm. To further assess both the vertical and horizontal extent of these compounds, three soil borings will be installed and sampled at this site. Figure 9 presents the soil boring locations. Sample intervals will be 0 to 5 feet, 5 to 10 feet etc., until groundwater is encountered. Soil samples will be analyzed for VOCs, SVOCs, pesticides, and metals.

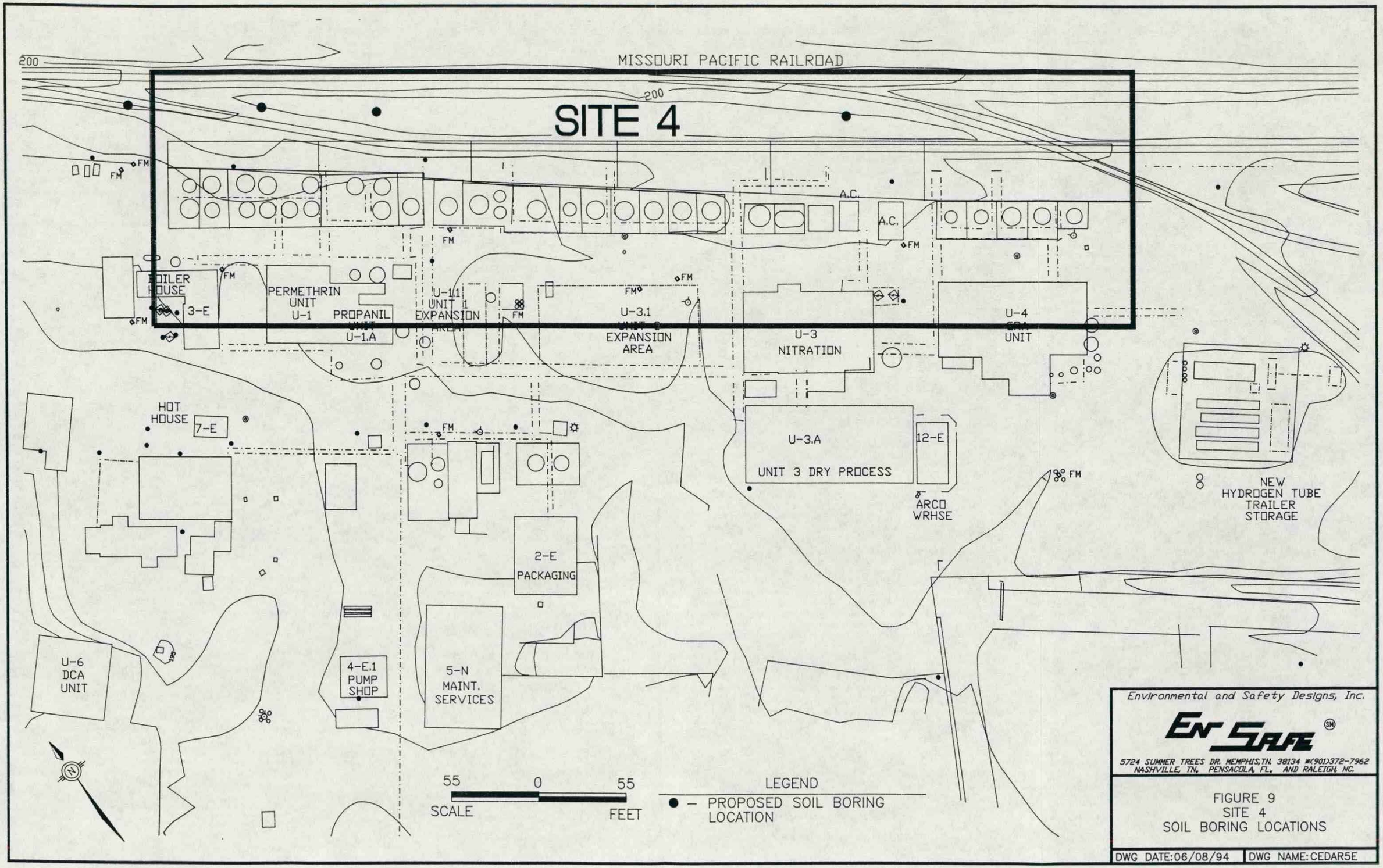
Two SPLP samples will be collected at this site for characterization of any leachate from Site 4 soil. One sample will be taken from a known area of high contamination; one sample will be taken to represent moderately contaminated soil.

2.5 Site 5 — Drum Vault

One sample collected from beneath the drum vault at Site 5 exhibited concentrations of dinoseb in excess of the regulatory limit of 80 ppm. The drum vault is within the Site 9 pond area delineated during Phase I of the investigation, therefore the detected dinoseb is likely to be associated with the Site 9 ponds. The drum vault was characterized sufficiently during Phase I.

2.6 Site 6 — Area of Concern 1

Dinoseb was detected in soil samples collected from Site 6. However, the concentrations detected do not exceed the RFI guidance concentration of 80 ppm, therefore no further sampling will be conducted at Site 6. For risk assessment purposes, a minimum of 20 hand auger samples will be taken from the 0- to 1-foot interval at locations to be determined in the field.


MISSOURI PACIFIC RAILROAD
200
SITE 4
FM
A.C.
BOILER HOUSE
3-E
PERMETHRIN UNIT U-1
PROPANIL UNIT U-1.A
U-1.1 UNIT 1 EXPANSION AREA
U-3.1 UNIT 3 EXPANSION AREA
U-3 NITRATION
U-4 SPM UNIT
HOT HOUSE
7-E
U-3.A UNIT 3 DRY PROCESS
12-E
ARCO WRHSE
NEW HYDROGEN TUBE TRAILER STORAGE
2-E PACKAGING
U-6 DCA UNIT
4-E.1 PUMP SHOP
5-N MAINT. SERVICES
N
55 0 55
SCALE FEET
LEGEND
● – PROPOSED SOIL BORING LOCATION
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EnSafe (SM)
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NASHVILLE, TN. PENSACOLA, FL. AND RALEIGH, NC.
FIGURE 9
SITE 4
SOIL BORING LOCATIONS
DWG DATE:06/08/94
DWG NAME:CEDAR5E

2.7 Site 9 — Retention Ponds

The abandoned ponds formerly used to store off specification dinoseb were identified during Phase I. As seen in Figures 10 and 11, the horizontal extent of the dinoseb contamination has been delineated. Concentrations in excess of regulatory limits are concentrated within the study area. During Phase II, three soil borings will be installed in the areas with the highest dinoseb concentrations to determine the vertical extent of soil contamination. Since the upper 10 feet were sampled during the previous phase of the investigation, sampling of the three soil borings will begin at 10 feet bgs and continue at 5-foot intervals until groundwater is encountered. Figure 12 presents the boring locations at Site 9. Two SPLP samples will also be collected to determine the leachability of the Site 9 contaminants.

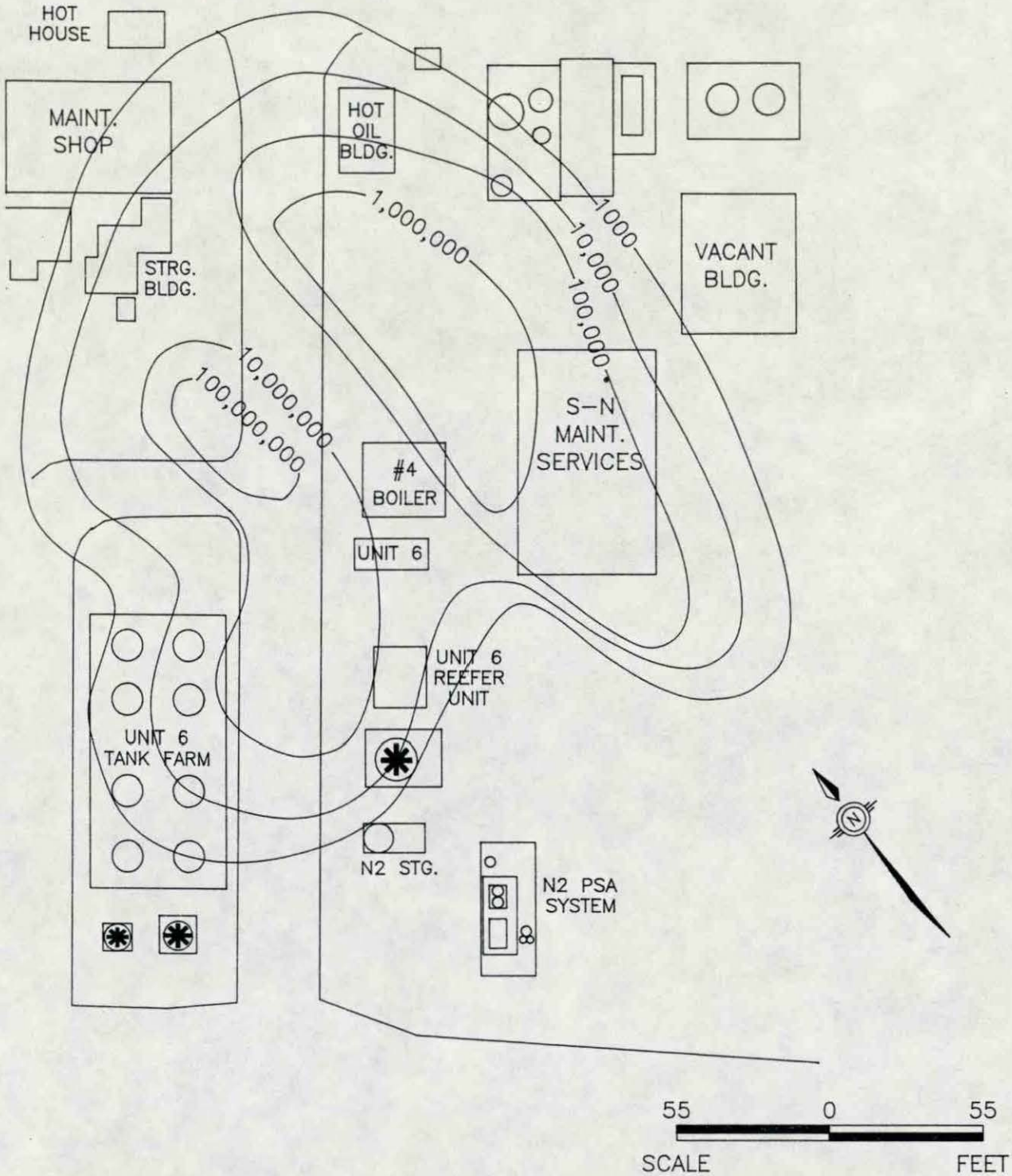

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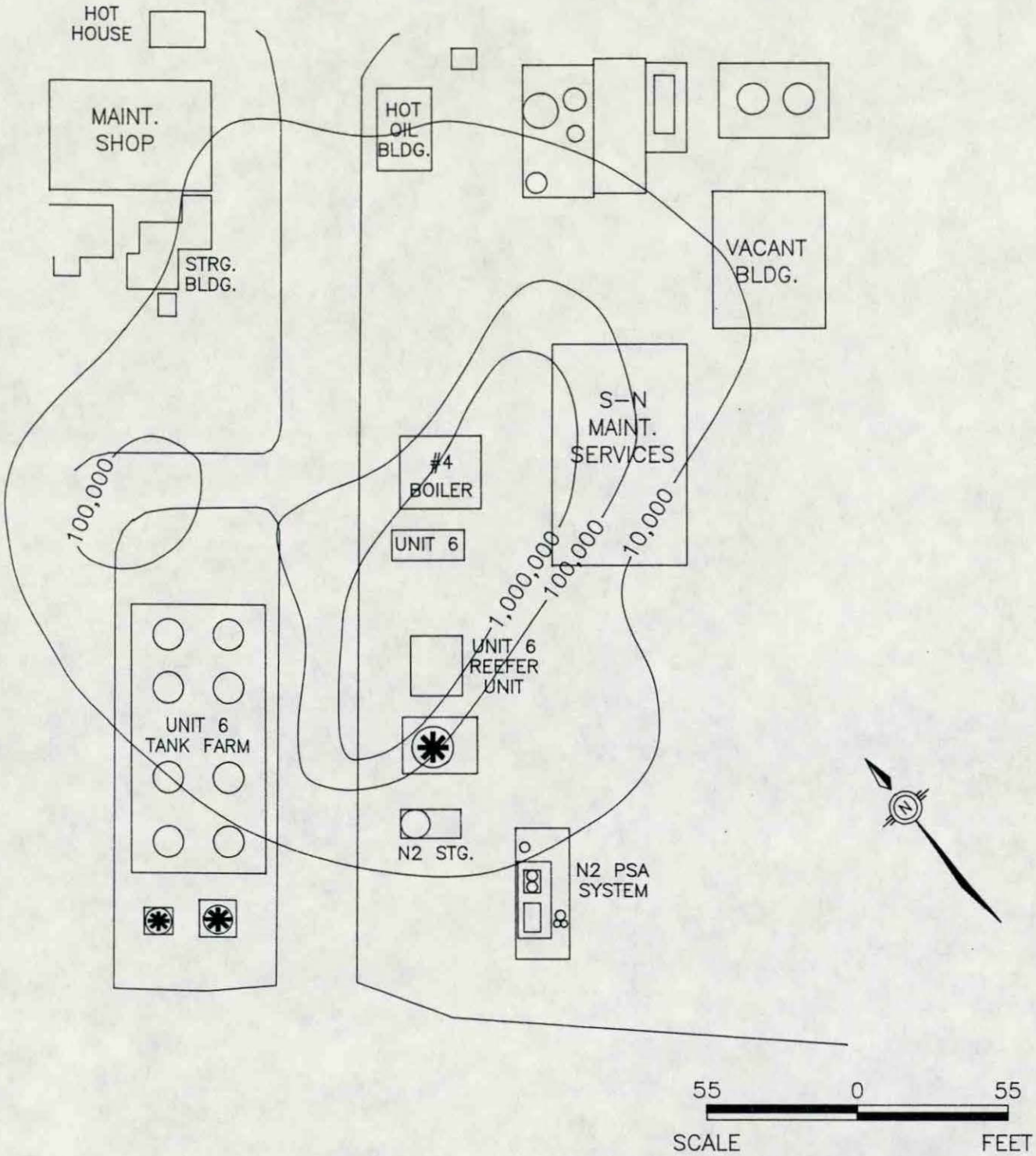
FIGURE 10
SITE 9
ISOCON MAP FOR
DINOSEB 0-5'

DWG DATE: 06/08/94 | DWG NAME: CEDAR39

LEGEND

——— - LINES OF EQUAL CONCENTRATION (ppb)



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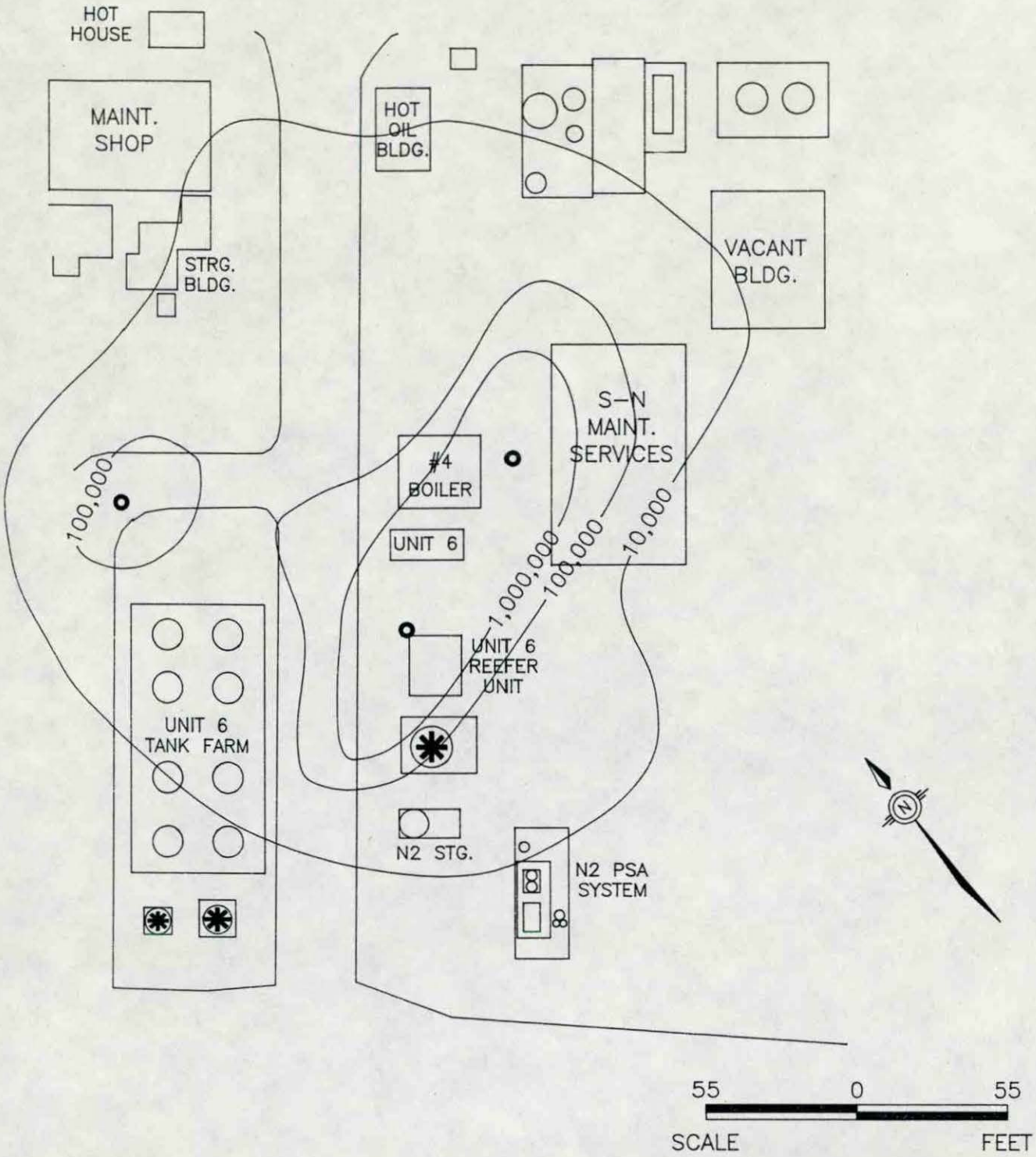
LEGEND

——— – LINES OF EQUAL CONCENTRATION (ppb)

FIGURE 11
SITE 9
ISOCON MAP FOR
DINOSEB 5-10'

DWG DATE: 06/08/94 | DWG NAME: CEDAR40



LEGEND

——— – LINES OF EQUAL CONCENTRATION (ppb)

o – PROPOSED SOIL BORING

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FIGURE 12
SITE 9
SOIL BORING
LOCATIONS

DWG DATE: 06/08/94 | DWG NAME: CEDAR41

3

3.0 GROUNDWATER INVESTIGATIONS

Elevated concentrations of one or more compounds were detected in the majority of the wells at the Cedar Chemical facility. The disposition of the groundwater offsite has yet to be determined. Due to the extreme fluctuations in groundwater flow, several wells must be strategically placed around the facility in areas were plumes, if present, will most likely be intercepted. An analytical particle tracking model, GW-Path, was used to project potential groundwater pathlines for the two potentiometric surfaces shown in Figures 13 and 14. Pathline projections were used to evaluate potential well locations. GW-Path model theory and application are discussed in Appendix A.

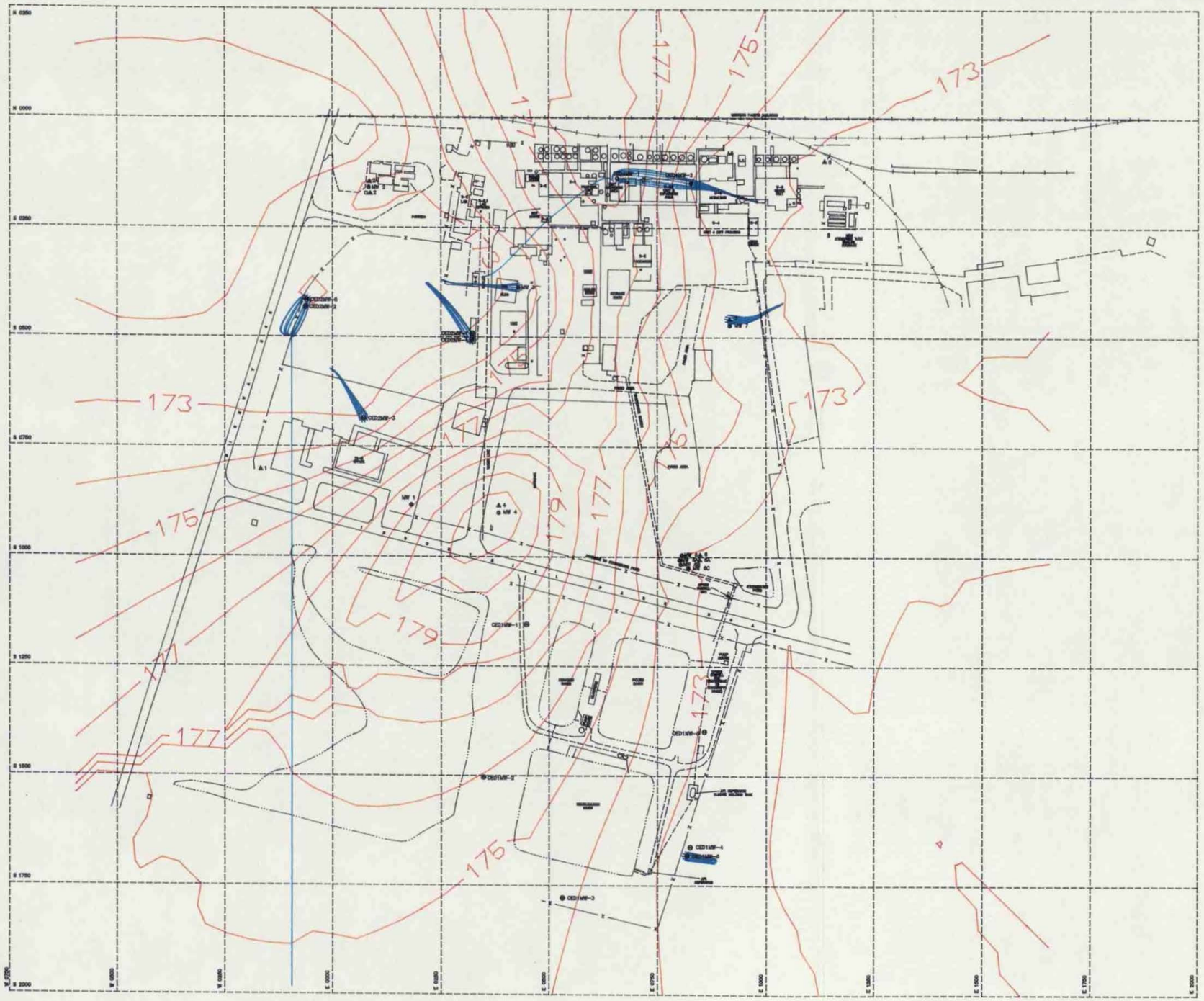
Well placement for each site is discussed in the following sections. Both particle tracking maps and both piezometric surface maps were used as guidance for determining monitoring well locations.

3.1 Monitoring Well Nomenclature

The terminology describing the wells at the Cedar Chemical facility has changed. The following paragraphs defines each type of well discussed in the well installation section.

SSZ wells are those wells installed into the surficial saturated zone above the clay. These wells will be screened at approximately 10 to 20 feet. All SSZ wells will be installed through a 6.25-inch inner diameter hollow stem augers and completed as Type II groundwater monitoring wells. Refer to the January 22, 1993 FIWP for Type II monitoring well specifications.

Shallow wells are those wells installed to the upper portion of the alluvial sand aquifer immediately below the alluvial clay. These wells will be screened at approximately 30 feet.



LEGEND

- WATER OR DRAINAGE
- ROAD
- TRAIL
- SIDEWALK
- RAILROAD
- BUILDING
- FENCE
- MW — MONITORING WELL
- SUBSURFACE PIPING (APPRPOX.)
- PIEZOMETER
- 173 — PIEZOMETRIC SURFACE CONTOURS CONTOUR INTERVAL 1 FOOT
- PARTICLE TRACKING PATHWAY

250 0 250
SCALE FEET

SOURCE: DELTA PROCESS MANAGEMENT, INC.

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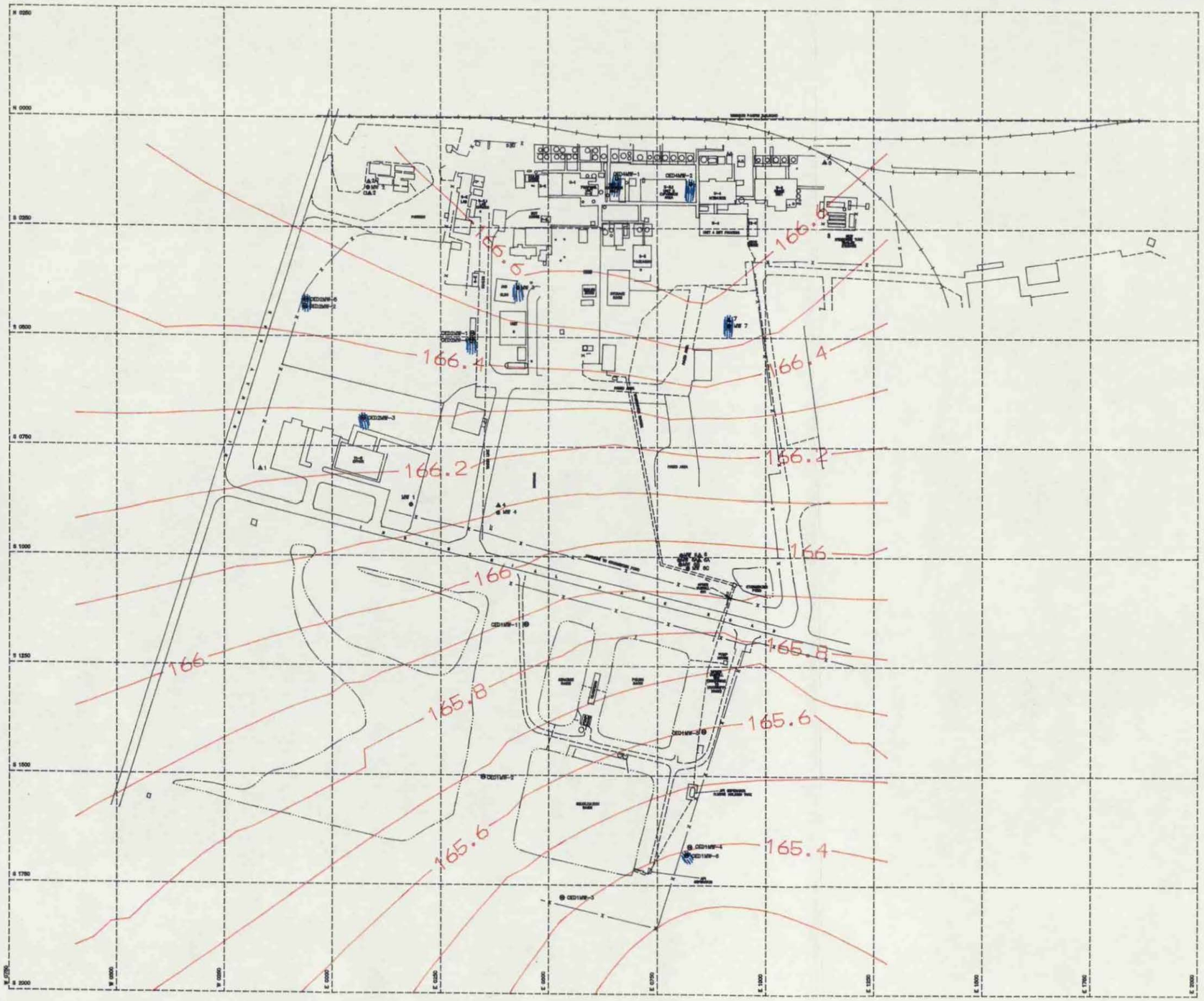
FIGURE 13
PARTICLE TRACKING USING
1993 PIEZOMETRIC SURFACE MAP

DWG DATE:06/08/94 | DWG NAME:CEDAR43A



LEGEND

- WATER OR DRAINAGE
- ROAD
- TRAIL
- SIDEWALK
- RAILROAD
- BUILDING
- FENCE
- MW — MONITORING WELL
- SUBSURFACE PIPING (APPRPOX.)
- PIEZOMETER
- 166 — PIEZOMETRIC SURFACE CONTOURS CONTOUR INTERVAL 0.1 FOOT
- PARTICLE TRACKING PATHWAY

250 0 250

SCALE FEET

SOURCE: DELTA PROCESS MANAGEMENT, INC.

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FIGURE 14
PARTICLE TRACKING USING
1988 PIEZOMETRIC SURFACE MAP

DWG DATE:06/08/94 | DWG NAME:CEDAR44A

Deep wells are those wells installed to and screened at the surface of the Jackson Clay. The anticipated depth of these wells is approximately 150 feet. In response to ADPC&E's inquiries of DNAPLs, at least four groundwater monitoring wells will be installed to the top of the Jackson Clay, to the southwest (downdip) side of any site where DNAPLs were detected in the previous phase.

While setting the deep monitoring wells, a blank section of casing will be attached to the bottom of the well screen and installed approximately 3 feet into the Jackson Clay. Installing the well in this manner will provide a sump to collect any DNAPL compounds flowing across the surface of the clay, thus facilitating detection of the target compounds.

Intermediate wells are those wells screened in any mid-point between the bottom of the surficial clay, or silty clay, and the top of the Jackson Clay. The intermediate wells may range from approximately 40 to 140 feet deep.

All monitoring wells installed into the alluvial aquifer will be of Type III construction, as described in the January 22, 1993 FIWP. Each Type III monitoring well will be installed in a borehole with a diameter between 16 inches and 24 inches in diameter. The borehole will be advanced using hollow-stem augers (HSA). If heaving sands hinder the installation of the deep wells, the drilling method will be changed to mud rotary.

3.2 Site 1 — SWMUs 63, 64, 65, 68, and the API Separator

Potential groundwater pathways generated by GW-Path indicate that two general flow directions are possible beneath Site 1: to the south and southwest. Elevated concentrations of VOCs (possibly in aqueous and non-aqueous phases) and SVOCs were detected in both the discontinuous uppermost saturated zone and the semiconfined alluvial aquifer at Site 1. CED1MW-6 is the only monitoring well at this site screened in the alluvial aquifer. The COC

1,2-Dichloroethane is present in this well at a concentration of 640 ppb; no dinoseb was detected in the alluvial aquifer at this site. Trichloroethene was detected in well number CED1MW-4 at a concentration of 28 ppb. 1,2-Dichloroethane is also present to the northeast of Site 1 in CEDEMW-6, but at a lesser concentration (190 ppb). Well number CED1MW-5 exhibited a 2,6-dinitrotoluene concentration of 320 ppb .

The installation of eight groundwater monitoring wells has been proposed to address the presence of volatile and semivolatile compounds in the discontinuous surficial aquifer and the alluvial aquifer (Figure 15). One groundwater monitoring well pair will be installed on the east side of the treatment ponds. One well will be screened in the upper portion of the semiconfined alluvial aquifer to intercept any shallow plume that may have migrated offsite from Site 1, the other will be screened at the top of the Jackson Clay to potentially intercept any aqueous and non-aqueous phase compounds (1,2-dichloroethane, and trichloroethene).

A second well pair will be installed at the southwest side of the treatment ponds. These wells will be screened in the same intervals as the other well pair to assess both the dissolved and DNAPL phases of the compounds detected in the Site 1 wells.

A third pair of wells will be installed to the northeast of well number CED1MW-5 to delineate the extent of the 2,6-dinitrotoluene detected in this well. One well will be screened in the SSZ at the same interval as CED1MW-5. The second well will be screened in the upper portion of the alluvial aquifer. As mentioned above, the 2,6-dinitrotoluene concentration detected in well CED1MW-5 was 320 ppb. The maximum contaminant level (MCL) and Practical Quantitation Limit for this compound are 0.05 ppb and 10 ppb, respectively. This indicates that current analytical methods cannot quantify this compound to the current MCL. The instrument detection limit (IDL) is lower than the PQL or the method detection limit (MDL), meaning the instruments are capable of detecting a concentration below the PQL or MDL. However, concentrations

chloride. A minimum of three additional wells will be installed to confirm that none of the contaminants has migrated offsite.

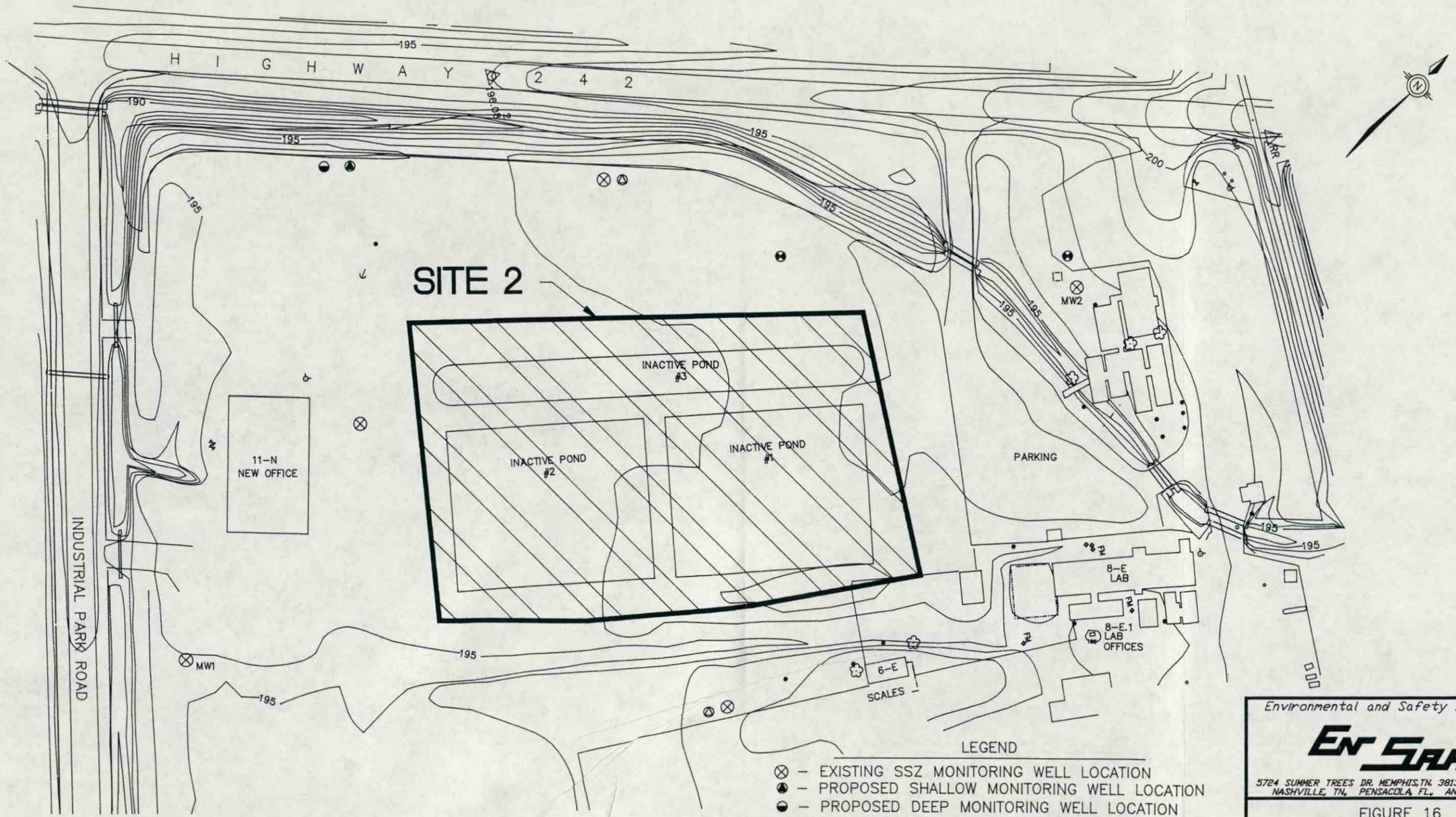
Monitoring wells CEDEMW-2 and CED2MW-5 have delineated the horizontal extent of COC migration to the north and northwest of the site in the alluvial aquifer. Monitoring well CED2MW-2 has delineated the northwest extent of contamination in the SSZ. One of the additional wells will be installed adjacent to CEDEMW-2 and screened in the SSZ, if encountered. If the analytical results of the groundwater sample collected from this well are below detection limits or below MCLs, the horizontal extent to the north and northwest will be determined in both the alluvial aquifer and the SSZ.

Review of contaminant data at this site indicates that both 1,2-dichloroethane and dinoseb are present in CEDEMW-3 (6,700 ppb and 140 ppb, respectively), located to the southeast of the site. The installation of the well adjacent to well CED1MW-1 at Site 1 will aid in determining the extent of the dinoseb and dichloroethane migration in the alluvial aquifer.

A minimum of two additional groundwater monitoring wells will be installed to address the southwestern extent of Site 2 contaminants. One shallow and one deep well pair will be installed approximately 120 feet northeast of the Industrial Park Road and Highway 242 intersection. Figure 16 presents all proposed Site 2 well locations. If the SSZ is encountered, a third well will be installed in this cluster and screened in this zone. If DNAPL phase compounds are detected in the deep well, another deep well will be installed 600 feet southwest of Industrial Park Road and adjacent to the proposed shallow well at Site 1.

3.4 Site 4 — SWMUs 3 and 74

The contaminants detected above MCLs in groundwater at Site 4 are 1,2-dichlorobenzene, 1,2-dichloroethane, toluene, and methylene chloride in well CED4MW-1, and 2,4-dinitrophenol, dinoseb, 1,2-dichloroethane, chloroform, and methylene chloride in well CED4MW-2. Pathline analysis was conducted for both the 1988 and the 1993 piezometric surfaces. Piezometric



LEGEND

- ⊗ – EXISTING SSZ MONITORING WELL LOCATION
- ◒ – PROPOSED SHALLOW MONITORING WELL LOCATION
- ◒ – PROPOSED DEEP MONITORING WELL LOCATION
- △ – EXISTING SHALLOW MONITORING WELL LOCATION
- ⊗ – PROPOSED SSZ MONITORING WELL LOCATION

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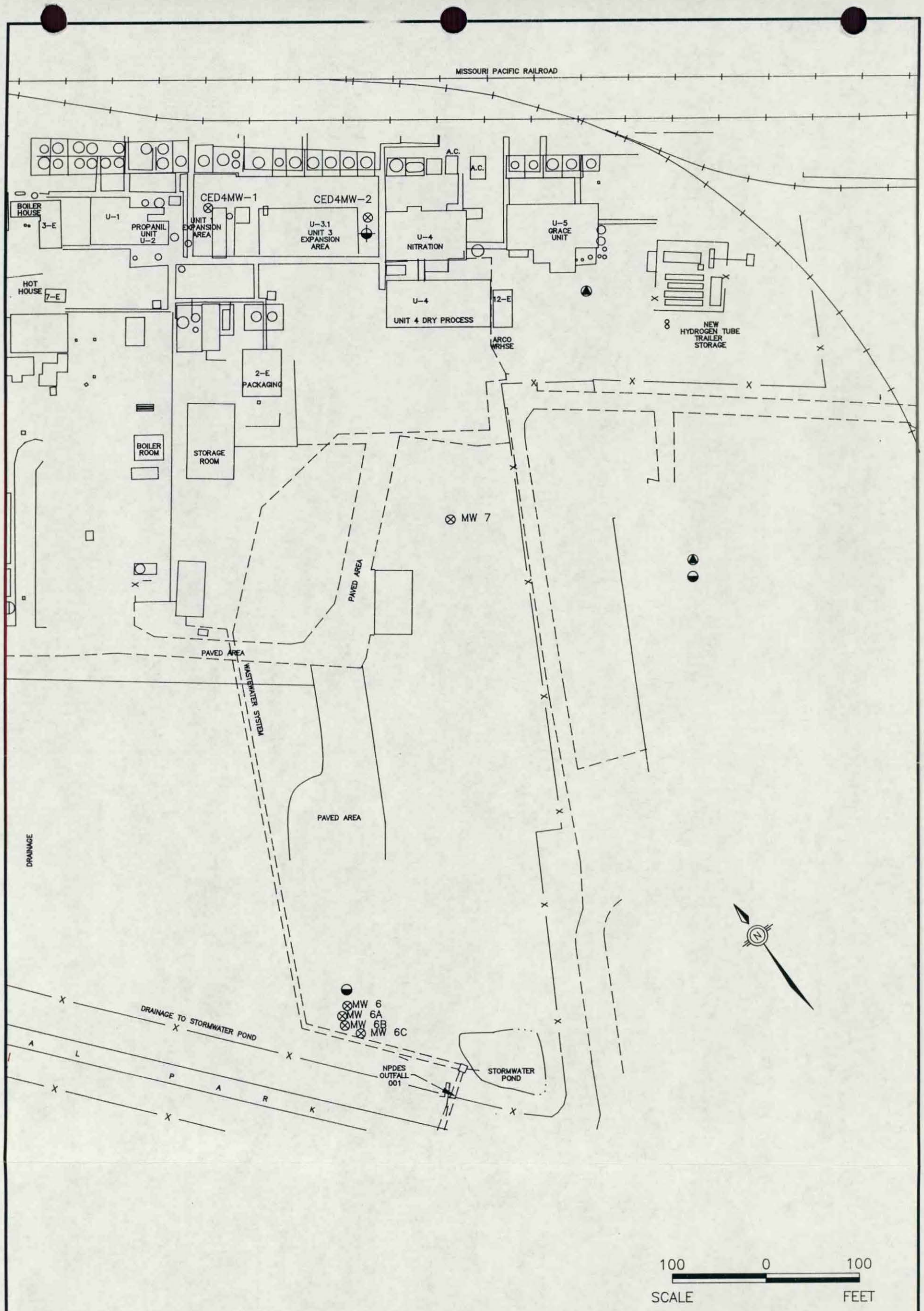
FIGURE 16
SITE 2
MONITORING
WELL LOCATIONS

DWG DATE: 06/08/94 | DWG NAME: CEDAR54

surface maps indicated potential groundwater flow to the southeast under 1988 flow conditions and to the southeast and west under 1993 flow conditions. Additional groundwater monitoring wells are necessary to determine the horizontal extent of the compounds detected in the Site 4 wells. Assuming 1993 groundwater flow conditions, the western extent of the contamination has been delineated by wells CEDEMW-2 and CED2MW-5 both of which exhibited concentrations below MCLs. Extent in the eastern directions will be delineated by the installation of three monitoring wells. One shallow well will be installed to the south of Unit 5 between Unit 4 and the Hydrogen Tube Trailer Storage area. One deep and shallow well pair will be installed approximately 250 feet southeast of well CEDEMW-7 to delineate the migration of 1,2-dichloroethane detected in this well. Figure 17 presents the proposed well locations for Site 4.

Lateral extent to the south, based on 1988 piezometric data, will be delineated by installing a deep well adjacent to wells CEDEMW-6, CEDEMW-6A and CEDEMW-6B. Concentrations of 1,2-dichloroethane were detected in these wells at 190 ppb, 18 ppb, and 1,900 ppb, respectively. This well will be screened at the surface of the Jackson Clay to detect DNAPL phase contaminants flowing across the surface of the clay.

To determine the vertical extent of the dinoseb contamination at Site 4, an intermediate well (depth to be determined in the field) will be installed near well number CED4MW-2. The delineation of the vertical extent of the dinoseb contamination will aid in the design of a production well if remediation is necessary. It will also contribute to understanding the vertical dinoseb migration. HydroPunch groundwater samples will be collected to determine the screen interval for this well. Section 5.3 describes the method for sampling with a HydroPunch groundwater sampler.



LEGEND

- ⊗ EXISTING MONITORING WELL
- ▲ PROPOSED SHALLOW MONITORING WELL
- ◒ PROPOSED DEEP MONITORING WELL
- ⌖ PROPOSED INTERMEDIATE MONITORING WELL

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FIGURE 17
SITE 4
MONITORING
WELL LOCATIONS

DWG DATE: 06/08/94 | DWG NAME: CEDAR55

When the wells at Site 4 were installed during Phase I of the investigation, a large volume of gas escaped from the borehole for well number CED4MW-1, and a lesser volume from well number CED4MW-2. There is still considerable gas pressure in each well. Therefore, in addition to continuing groundwater assessment, one Summa canister sample will be collected from each of the existing Site 4 wells and analyzed for a full VOC scan. A better determination of the source of this gas can be made once its chemical makeup is determined.

3.5 Site 9 — Retention Ponds

No wells are completed at Site 9. However, wells CEDEMW-3 and CEDEMW-7 are present to the north and southeast, respectively. CEDEMW-3 contains both 1,2-dichloroethane (6,700 ppb) and dinoseb (140 ppb), whereas CEDEMW-7 contains only dichloroethane (67,000 ppb). CEDEMW-4, southwest of Site 9, contains 1,200 ppb 1,2-dichloroethane. These wells appear to identify the nature of contaminants in groundwater under Site 9.

As discussed previously, dinoseb is the primary COCs in Site 9 soil. If soil contamination is detected in during Phase II, a minimum of one well will be installed at the location exhibiting the highest dinoseb concentration to characterize any potential dinoseb in groundwater at the site. The depth interval to be screened will be determined by collecting HydroPunch groundwater samples as described in Section 5.3.

3.6 Background Monitoring Wells

Two wells will be installed north of Site 4 on the north side of the Missouri Pacific Railroad (Figure 18). Because these wells are hydraulically upgradient from the Cedar Chemical facility, these samples will represent background groundwater conditions in the shallow and deep portions of the alluvial aquifer. Access to the background location may be difficult. Installing the wells in this area would require obtaining an access agreement from either the owner of the off-site property or from the Missouri Pacific Railroad for installation in the railroad easement.

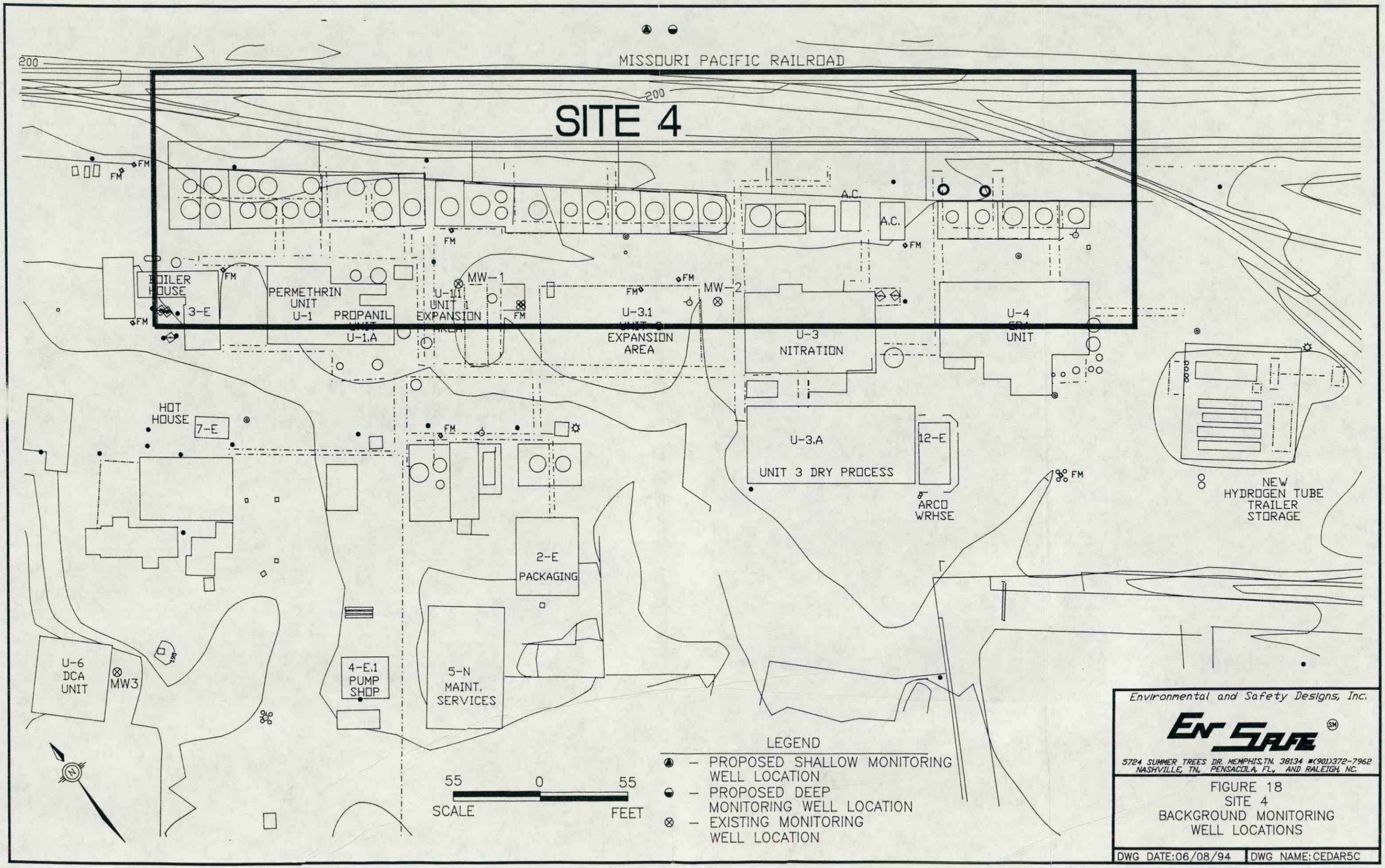
MISSOURI PACIFIC RAILROAD
200
200
SITE 4
FM
BOILER HOUSE
3-E
PERMETHRIN UNIT U-1
PROPANIL UNIT U-1.A
U-1.1 UNIT 1 EXPANSION AREA
MW-1
MW-2
U-3.1 UNIT 3 EXPANSION AREA
A.C.
U-3 NITRATION
U-4 EPA UNIT
HOT HOUSE
7-E
U-3.A UNIT 3 DRY PROCESS
12-E
ARCO WRHSE
NEW HYDROGEN TUBE TRAILER STORAGE
2-E PACKAGING
U-6 DCA UNIT
MW3
4-E.1 PUMP SHOP
5-N MAINT. SERVICES
55 0 55
SCALE FEET
LEGEND
– PROPOSED SHALLOW MONITORING WELL LOCATION
– PROPOSED DEEP MONITORING WELL LOCATION
– EXISTING MONITORING WELL LOCATION
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FIGURE 18
SITE 4
BACKGROUND MONITORING WELL LOCATIONS
DWG DATE:06/08/94
DWG NAME:CEDAR5C

3.7 Surficial Saturated Zone

The SSZ is limited vertically by a gray silty clay unit. To characterize the SSZ, two data gaps must be addressed. First, the top of the clay unit must be mapped. Second, the groundwater flow conditions must be assessed. Boring logs from both lithologic borings and monitoring wells will be used to map the surface of the clay overlying the alluvial aquifer. To further characterize the SSZ and the clay surface, seven lithologic borings will be completed across the Cedar Chemical facility. These borings are shown on Figure 19. Borings will be completed at the top of the alluvial sand.

If the SSZ is encountered during the installation of any monitoring wells targeting the alluvial aquifer, a monitoring well will be installed. All wells installed in this zone will be overdrilled 1 foot into the clay to provide a sump for DNAPLs. Wells will be monitored for VOCs, SVOCs, pesticides, and metals.

4

4.0 HYDROLOGIC ASSESSMENT

Further characterization of the alluvial aquifer system will be conducted during Phase II. Both slug test and specific capacity testing will be used to obtain first estimates of hydraulic conductivity and storativity. These aquifer parameters will be required for fate and transport assessment as well as feasibility analyses during the corrective measures study. The tasks to be accomplished during the aquifer characterization are listed below.

Aquifer Characterization Objectives:

- To evaluate groundwater flow directions in both the perched zone (if present) and the alluvial aquifer system.
- To assess historical piezometric surface and pumping data to determine potential impacts of adjacent agricultural wells and recharge sources.
- To assess variation of aquifer characteristics with depth.
- To assess future plume movement/migration patterns.

The following methods will be used to address these tasks.

4.1 Piezometric Surface Data

Historical piezometric surface data will be reviewed to assess the impacts of the apparent groundwater divide on the flow system. The potential impacts of adjacent agricultural wells will also be assessed using average transmissivity and pumping rate data. Gradients in the SSZ will be evaluated to document potential groundwater flow directions.

Water level data collected from new monitoring wells proposed for installation during Phase II field activities will also be evaluated. The data will be used to refine gradient and groundwater flow directions in both the SSZ and the alluvial aquifer.

4.2 Slug Tests

Slug tests will be performed on all wells installed during Phase I field activities. The data will be used to obtain first estimates of the hydraulic conductivity and groundwater velocity of the shallow portion of the alluvial aquifer. Due to slow recharge rates noted during Phase I activities, all new wells screened in the SSZ will be assessed using slug tests. Data from these wells will be used to estimate the hydraulic conductivity (K) and aquifer thickness (B) for fate and transport analyses. Use of slug tests for aquifer characterization offers the added benefit of reduced IDW.

Aquifer parameters are derived from slug test data using the Cooper, Bredehoeft, Papadopulos modification to the Theis solution (1967), or the Bouwer and Rice (1976) solution. The method applies curve-matching procedures to determine aquifer properties. All assumptions inherent to the Theis methodology are applicable to the Cooper (et al.) solution. An iterative computer solution (AQTESOLV 1989) will be applied to slug test data to derive the transmissivity (T) and storativity (S) from field data. Slug test analyses vary with changes in drawdown, casing radius, effective radius, the aquifer thickness, the length of the well screen, and the static height of the water column. Transmissivity and storativity estimates will be used to derive hydraulic conductivity, using:

$$K = \frac{T}{B}$$

where K is the conductivity (ft/day), T is the transmissivity (ft^2/day), and B is the thickness of the aquifer or screened interval (ft). This equation requires use of consistent units.

Groundwater velocity will be estimated for use in fate and transport modeling using Darcy's Law:

$$v = -\frac{K}{n_e}\frac{dh}{dl}$$

where K is as defined above, n_e is the effective porosity of the aquifer, and dh/dl is the hydraulic gradient. Once again, this equation assumes consistent units.

A stainless-steel or Teflon slug will be used to displace water within the well casing above static level. A pressure transducer and an automatic datalogger will be used to monitor re-equilibration in the well. A falling-head (injection) slug test is accomplished through addition of a known volume (the slug) to the well and observation of water levels returning (falling) to the static level. A rising-head (withdrawal) slug test is accomplished through removal of a known volume (slug) from the well and observation of water levels returning (rising) to the static level. Once the water level has returned to nearly static levels, the slug test is terminated and the slug is removed from the well. As a rule, both injection and withdrawal slug tests will be conducted on each well.

4.3 Specific Capacity Tests

Specific capacity testing will be performed during development or purging of all wells installed in the alluvial aquifer during Phase II to provide first estimates of transmissivity. In the specific capacity test, water is withdrawn from the well at a known discharge rate for a designated period of time. Drawdowns are measured until relative stabilization at that pumping rate occurs. This test may be continued at a higher pumping rate following stabilization.

The specific capacity of a well is the ratio of yield per foot of drawdown, usually expressed in terms of gallons per minute per foot of drawdown (gpm/ft). All water generated during the test will be containerized as IDW in 55-gallon drums. Specific capacity varies according to the variables listed below.

Specific capacity variables:

- Well efficiency.
- The transmissivity of the zone supplying water to the well, which may be less than the transmissivity of the aquifer depending on the length of the screen.
- The storage coefficient of the aquifer.
- The length of the pumping period.
- The effective radius of the well.
- The pumping rate.

The relationship between specific capacity and transmissivity is based on the Theis equation:

$$T = \frac{W(u)}{4\pi} \frac{Q}{s}$$

where T is the transmissivity, Q/s is the specific capacity, Q is the pumping rate, s is the drawdown, and $W(u)$ is the well function of u. This equation requires use of consistent units. The $W(u)$ is defined as

$$u = \frac{r^2 S}{4Tt}$$

where T is defined as above, r is the effective radius of the well, S is the storage coefficient, and t is the duration of pumping preceding the specific capacity duration. Once again, this equation requires use of consistent units. These equations may be corrected for partial penetration and well loss to better derive transmissivity estimates.

Bradbury and Rothschild have developed a computer program that facilitates the parameter estimation process using a Theis solution modified for partial penetration using a method adopted from Brons and Marting, and the Csallany-Walton correction for well loss. This method will be applied to specific capacity data to derive T and K.

4.4 Contaminant Migration

Aquifer parameters estimated using specific capacity data, slug test data, and historical data will be used to assess future dissolved plume migration. Advective particle tracking models such as GW-Path may be employed to assess groundwater movement under static, non-pumping groundwater conditions (and agricultural pumping conditions, if necessary). Flow and transport estimates will be developed using velocities developed from specific capacity or slug test data, the hydraulic gradient, and porosity. Estimates will be conservative to represent the maximum migration or exposure potential at the site.

5.0 FIELD SAMPLING PLAN

The following sections detail Phase II soil and groundwater sampling and monitoring well installation procedures.

5.1 Soil Sampling

Soil samples will be collected during the installation of soil borings and monitoring well borings from ground surface to groundwater at sites where COCs exceed regulatory limits. Sample collection procedures, unless otherwise noted in this work plan, will be as described in the Site Investigation sections of the January 22, 1993 FIWP. The sample intervals will be from 0 to 5 feet, 5 to 10 feet, 10 to 15 feet, etc. To fully assess the vertical extent of the soil contamination, a sample from each interval will be submitted to the laboratory for analysis.

Soil samples collected will be analyzed for VOCs, SVOCs, pesticides, and metals. Some samples will be analyzed only for select parameters only based on the constituents detected in Phase I of the investigation. Refer to Table 1-6 in Section 1.4 of the January 22, 1993 FIWP for analytical methods to be used. Additionally, six Toxicity Characteristic Leaching Procedure (TCLP) samples will be submitted for analysis. The data will be used both in fate and transport assessments and to facilitate disposal evaluation in the corrective measures study.

Several physical parameters will be analyzed in site soil. These samples will be collected in conjunction with TCLP and SPLP samples. The physical parameters are:

- Cation Exchange Capacity (CEC)
- Total Organic Carbon (TOC)
- Soil pH
- Total Sulfur
- Total Chlorides
- Porosity

- Bulk density
- Atterburg limits

In addition, grain size analyses will be performed on 15 samples collected at 10-foot intervals in the alluvial aquifer. Shelby tube samples collected from the Jackson Clay will also be analyzed for saturated hydraulic conductivity. These data are integral to fate and transport modeling as well as to remedial activities.

Lithologic borings will be completed to the top of the alluvial sand. Borings will be completed using a CME 5-foot continuous core sampler. Boreholes will be abandoned by installing a 2-foot bentonite plug in the bottom of each borehole. The remaining portion will be backfilled using a Portland Type I neat cement.

5.1.1 Risk Assessment Sampling

Upon completion of the FIWP, soil samples will be collected across the site for the purpose of conducting a Risk Assessment (RA). Once the data from the Phase II FIWP has been received from the laboratory and reviewed, a sampling grid will be established across the entire Cedar Chemical facility. Some sites may require a more dense sample pattern than others. Since these areas cannot be identified until the Phase II has been completed, a Risk Assessment Sampling Plan in a technical memorandum format will be submitted prior to any soil sampling activities. This plan will present the sampling grids, sampling locations and depths, describe sampling techniques and analytical parameters, and offer a description of the Risk Assessment goals.

Once the risk assessment sampling has been completed, a risk assessment will be conducted. The RA will address the entire facility as one entity, with emphasis placed on sites suspected to be of greater concern.

5.2 Groundwater Sampling

All groundwater samples will be collected as described in Section 1.2.6.5 of the Phase I FIWP and analyzed for VOCs, SVOCs, pesticides, and metals. Refer to Table 1-6 in Section 1.4 of the January 22, 1993 FIWP for the analytical methods to be used.

Physical parameters will be collected from select wells onsite for use in fate and transport modeling. These parameters include the following:

- Total bicarbonate
- Alkalinity
- Hardness
- Heterotrophic plate count

5.3 HydroPunch Groundwater Sampling

To improve the placement of the wells at Sites 4 and 9, the well screen depths for these wells will be selected by collecting groundwater screening samples with a HydroPunch. A HydroPunch is a stainless steel, in-situ groundwater sampling tool used to collect representative groundwater samples without the installation of a monitoring well.

To determine the thickness of the plume(s), a HydroPunch groundwater sample will be collected vertically every 10 feet and screened for the COCs. At Site 4, sampling will begin at the depth corresponding to the bottom of the screened interval at well number CED4MW-2. At Site 9 sampling will begin once the alluvial aquifer is encountered. Sampling will continue at 10-foot intervals until a groundwater sample with COC concentrations below the regulatory limits are recovered. A groundwater monitoring well will then be installed, and the bottom 10 feet of the plume screened.

HydroPunch Groundwater Sampling Procedures:

- A borehole will be advanced with hollow-stem augers to just above the interval to be sampled and the center bit removed.

- The decontaminated tool will be attached to the center rods of the drill rig and lowered through the annulus of the augers to the bottom of the borehole.

- The tool will be hydraulically pushed or driven (with a 140-pound hammer dropped repeatedly from a height of approximately 30 inches) to the desired sampling depth.

- The center rods will be retracted approximately 1.5 feet. This opens the tool and allows the sample to flow into the collection chamber.

- The tool will be left open for approximately 10 to 15 minutes allowing the 500-ml collection chamber to fill.

- The tool will be pulled to the surface and removed from the center rods.

- The tool will be rinsed with deionized water.

- The sample will be poured into a clean sample container.

The HydroPunch groundwater sampling tool will be decontaminated prior to the collection of each sample.

5.4 Well Installation Procedures

The Groundwater Investigations section discusses the installation of shallow, intermediate, and deep groundwater monitoring wells at each site. This section defines the types of wells to be installed during the FI, and describes the installation procedures.

5.4.1 Monitoring Well Installation

When installing Type II wells, 6.25 inch internal diameter HSA will be advanced through the upper clay-silt soil. Installation of 2-inch diameter Type III wells will use 12.25-inch internal diameter HSA. Four-inch diameter Type III wells will use 24-inch-diameter solid-stem auger.

All well installation procedures will follow the January 22, 1993 FIWP, as discussed in Section 1.2.6.3 of that document.

Pre-formed filter packs and bentonite rings will be used in the installation of the deep monitoring wells. EnSafe expects problems with sand and pellet bridging if the filter pack and bentonite seal are to be emplaced using conventional methods. Not only will the use of pre-formed filter packs and bentonite rings reduce the amount of time required to install the deep wells, it will ensure the integrity of the well and the quality of the groundwater samples collected from the well.

After the bentonite seal has hydrated for at least eight hours, the remaining annular space around the well pipe will be pressure grouted with a cement-bentonite grout mix as specified in the January 22, 1993 work plan. The grout will be emplaced through a tremie pipe. Grouting will start at the bentonite seal and proceed up to the ground surface.

5.4.2 Groundwater Sampling

Upon completion of all monitoring well installation, all monitoring wells will be sampled for VOCs, SVOCs, metals, and pesticides. In addition to the monitoring well sampling, the closest active irrigation well will be sampled for VOCs, SVOCs, metals, and pesticides.

5.5 Drinking Water/Irrigation Well Survey

A well survey will be conducted to locate any wells within a one-mile radius of the site. The survey will consist of a records search for water wells screened in the alluvial aquifer above the Jackson-Claiborne Group. When private potable water wells are located, they will be plotted on a map of the area. If available, information such as screened interval, pumping rate, type of use, etc., will be recorded.

5.6 Aquifer Test Procedures

Both slug tests and specific capacity tests will be used during field investigations to characterize the SSZ and the alluvial aquifer. Aquifer test procedures are described in the following sections.

5.6.1 Slug Tests

Slug test will be performed on all wells installed during Phase I field activities. In addition, all wells installed into the SSZ during the Phase II investigation will be assessed using slug tests. Falling head (injection) and rising head (withdrawal) slug tests will be performed using electronic data loggers in accordance with the procedures provided below.

General Procedures for Performing a Slug Test

1. Insert a decontaminated pressure transducer, calibrated to an electronic data logger, to an appropriate depth in the well to be tested.

2. Add or remove a known volume to (or from) the well or piezometer to create a rapid rise (or fall) in water level. In most cases, a stainless steel cylinder of known volume will be used.
3. Measure the rate of water-level recovery using the pressure transducer and data logger.
4. Graph data, in depth-time pairs, and determine hydraulic conductivity and aquifer transmissivity. A commercially available aquifer analysis will be used. Specific analytical techniques and assumptions made by the hydrogeologist will be provided in the final report.

Procedures for Falling-Head Slug Test

Before Slug Testing:

1. Place plastic sheeting around the wellhead. Arrange needed equipment and decontaminated materials on the sheet.
2. Put on personal protective clothing, as specified in the Health and Safety Plan.
3. Open the locking and vented caps and inspect the wellhead. Note in particular the condition of the surveyed reference mark, if any.
4. Measure and record the static water level and the depth to the bottom of the well. Record this data in the appropriate logbook.

During Slug Testing:

5. Check calibration of the pressure transducer at two different depths in the well. Check depths should be widely separated. Leave the transducer at the lower check point.
6. Rapidly insert the slug (stainless steel cylinder) into the water.
7. Using the data recorder, record fall in water level versus time.
8. Continue recording depth-time data until the well has recovered to nearly static water level. When using data recorders, it is advisable to check and record the reading every few minutes to ensure data are being properly recorded.

After Slug Testing:

9. Record the time of test completion in the logbook. If a data recorder with random access memory (RAM) or erasable programmable read only memory (EPROM) was used, record the file name used.
10. Decontaminate all equipment according to site decontamination procedures. Clean up area around the wellhead, and close and lock the well before leaving. Dispose of contaminated plastic sheeting and disposable protective clothing as per the IDW plan.

NOTE: Both rising- and falling-ead slug tests may be carried out in the same operation by first measuring the rate of water level fall immediately after slug insertion, then measuring the rate of water-level rise after slug withdrawal. Be sure the well has recovered to static water level before conducting the rising-head test.

Procedures for Rising-Head Slug Test

Before Slug Testing:

1. Lower a decontaminated slug (stainless steel cylinder) of known volume into the well until it is fully submerged. Allow the well to re-equilibrate to static water level.
2. Turn on the data recorder, if used, or verify the static water level has been re-established with a water-level meter.

During Slug Testing

3. Withdraw slug quickly, avoiding surging.
4. Using a data logger, record the rise in water level versus time.
5. Continue recording depth-time data until the well has recovered to nearly static water level. When using data recorders, it is advisable to check and record readings every few minutes to ensure data are being properly recorded.

6. Record time of test completion in the field logbook. If a data recorder with RAM or EPROM memory was used, record the file name used.

After Slug Testing:

7. Decontaminate all equipment. Clean up the site, and close and lock the well before leaving. Dispose of any contaminated plastic sheeting and disposable protective clothing as per the site IDW plan.

Restrictions/Limitations

In wells where the static water levels and water levels induced during testing are above the top of the screened or open hole interval, both rising-head and falling-head tests should be conducted to provide a check of results.

Quality Control Requirements for Slug Tests

- A pressure transducer and data logger, or strip chart recorder, must be used to perform these tests.
- Slug tests shall be performed after groundwater sampling to minimize contamination.
- All equipment must be decontaminated before each test.
- If possible, both falling- and rising-head tests shall be performed.

5.6.2 Specific Capacity Tests

Specific capacity tests will be performed on all wells installed into the alluvial aquifer during the Phase II investigation. These tests will be conducted during well development or well purging prior to sampling activities. The purpose of specific capacity testing is to obtain a first-estimate of the aquifer's hydraulic conductivity. Since this stresses a larger portion of the aquifer near the well, specific capacity testing is preferable to slug tests.

Before Specific Capacity Testing:

1. Place plastic sheeting around the well. Arrange needed equipment on plastic sheeting.
2. Don personal protective clothing, as required.
3. Open the locking cap and inspect the wellhead, noting the condition of the surveyed reference mark, if any.
4. Measure the static water level with an electronic water level indicator. Record the water level in the pumping well. If appropriate, also measure and record static water levels in adjacent wells.

During Specific Capacity Testing:

5. Install a decontaminated pump in the monitoring well. Allow the water level to re-equilibrate.
6. Begin pumping at a constant rate.
7. Use the electronic water level indicator to measure changes in water level during pumping. Record water levels and time of collection at the appropriate intervals.
8. Continue pumping and recording the pumping water levels until the level stabilizes (or until purging is complete). If appropriate, measure and record water levels in surrounding monitoring wells or temporary piezometers installed near the pumping well.
9. Record the time or test completion and the final water level. Turn the pump off.

After Specific Capacity Testing:

10. Record recovery of water level(s) in the production well and, where appropriate, observation wells, using a water level indicator and a stopwatch.
11. Plot data on a time/drawdown graph (generally done using commercial software) to calculate the hydraulic conductivity (K). Alternatively, specific capacity data can be used to estimate K using equations provided in Lohman (1972). Specific analytical techniques and assumptions used by the hydrogeologist will be provided in the final report.

12. Decontaminate all equipment as per the site decontamination procedures.
13. Close and lock the monitoring well upon completion of the aquifer test (or after well sampling).
14. Dispose of all plastic sheeting and PPE as per the site IDW plan.

NOTE: *An automatic data logger may be used in the production well in place of hand-held electronic water level indicators during specific capacity tests. This may be preferable to obtain data at very short or logarithmic intervals during the early stages of drawdown. Insertion and operation techniques for electronic data loggers are discussed in Section 5.6.1, under Slug Testing. Hand-held water level indicators should be sufficient for adjacent monitoring wells, if any. Calibrate stopwatches to the start and stop times recorded on the data logger.*

6

6.0 IDW DOCUMENTATION

This section is intended to guide EnSafe and Cedar Chemical personnel involved in the generation, handling, and disposal of IDW. While collecting soil and groundwater samples during the FI, investigators will generate many different types of potentially contaminated IDW, including soil, groundwater, used personal protective equipment (PPE), decontamination fluids, and disposable sampling equipment.

EnSafe is conducting the FI as a contractor to Cedar Chemical Company. Therefore, Cedar Chemical will be the generator and owner of the IDW. EnSafe is not responsible for the treatment, storage, or disposal of IDW generated during the FI.

6.1 Types of Wastes

IDW generated during the FI will include four types of wastes:

- Soil from drilling, well installation, and soil sampling.
- Disposable PPE, utensils, and debris.
- Aqueous liquids from well installation, well development, well purging, and pumping tests.
- Decontamination fluids generated from the cleaning of PPE, sampling equipment, and drilling equipment.

6.2 Labeling IDW Containers

Certain identifying markings and labels will be placed on each waste container associated with the FI. A separate logbook will be maintained for the sole purpose of documenting each

container of IDW generated. A uniform label will be placed on each container identifying its contents (soil, development water, PPE, etc.), date the container was filled, the boring(s) or well(s) from which the waste was generated, and the investigation area from which the waste was generated. In addition to the labels, each drum will be numbered with a grease pencil. The container number and contents of the label will then be recorded in the IDW logbook. This will allow easy identification of the contents of the container if the label is torn from the drum or fades. All empty drums will be marked to avoid any question about their contents. Once laboratory data are received, a table will be generated matching soil sample identification numbers with IDW containers.

6.3 IDW Sampling

Analytical data will be available for all IDW containers except decontamination fluids. Upon completion of the field activities, a composite sample of all containers labeled as decontamination fluids will be collected and submitted to the laboratory for VOCs, SVOCs, pesticides, and metals analysis.

6.4 Waste Storage and Handling

All IDW will initially be accumulated and stored in the area of concern at which the waste was generated. The IDW will be managed at all times as hazardous waste even though this determination may not have been made. If the waste is classified as a hazardous waste, the 90-day storage limit for RCRA hazardous waste will begin on the day the waste is moved from the area of concern. The waste can be classified as hazardous or non-hazardous once validated analytical results for the contents of the drum are received by the project manager.

A

APPENDIX A

GROUNDWATER INVESTIGATIONS

GROUNDWATER INVESTIGATIONS

An analytical particle tracking model, GW-Path, was used in conjunction with groundwater data from Phase I to identify optimal monitoring well locations. The methods used, model theory, and results are discussed below.

1.0 Methodology

Fundamental transport modeling for the alluvial aquifer at the Cedar Chemical facility was performed using the GW-Path particle tracking program. Data for the analyses included a potentiometric surface map, hydraulic properties and an estimated effective porosity of the unit.

Piezometric surface maps for the alluvial aquifer were developed on SURFER (Golden Software, Version 4.0) from hand-drawn water level data. Two maps were generated to show the variation in groundwater flow direction observed at the site; these maps may be found in Section 3.0 of the text (Figures 10 and 11). The first map was generated from field data taken in fall 1993, and is shown in Figure 13. This map was generated using groundwater elevations from the following monitoring wells:

CEDEMW-1	CEDEMW-6	CED1MW-4
CEDEMW-2	CEDEMW-6A	CED2MW-3
CEDEMW-3	CEDEMW-6B	CED2MW-4
CEDEMW-4	CEDEMW-6C	CED2MW-5
CEDEMW-5	CEDEMW-7	CED4MW-1
		CED4MW-2

A second piezometric surface map was developed using data generated by Grubbs, Garner, and Hoskyn, Inc. from August 1988 to February 1989. Figure 14 shows a second piezometric surface map which represents flow data from August 15, 1988. This map was developed from temporary piezometers prior to the installation of monitoring wells onsite. These piezometers were identified as B-1, B-2, B-2A, B-3, B-3A, B-4, B-5, B-6, B-6A, and B-7.

The two SURFER contour maps were developed using the Kriging method of data interpolation. Where necessary, the potentiometric surface map was modified to match actual data presented on manually drawn maps.

The alluvial aquifer, as described in Section 1.3.4, is characterized by hydraulic properties that vary with depth. Slug test data generated during 1988 indicate that the silty, fine-grained sands present in the upper 20 feet of the alluvial aquifer are characterized by hydraulic conductivities of 0.085 to 1.41 ft/day. The lower portions of the aquifer (to 150 ft bgs) are characterized by conductivities of 70.8 ft/day, typical for coarse-grained sand and gravel. Analyses performed in the development of Phase II monitoring well locations focused on shallow zone transport. Phase II field activities will determine the nature and extent of any contamination in the lower portion of the alluvial aquifer.

Porosities were determined from physical analyses performed during the fall 1993 field activities. These values ranged from 0.27 to 0.42 for the shallow portion of the aquifer. Although GW-Path inputs required effective porosities, these data were not available. Minimum total porosities were used instead.

A coordinate system was defined to maintain a consistent grid between SURFER and GW-Path, as well as auxiliary drawings. This grid system was developed using AutoCAD coordinates to facilitate data transfer and presentation.

Data were developed as described above using hand-drawn potentiometric surface maps. These data were then used as the base water level maps for particle tracking in GW-Path. Because of the incompatibility of file formats between export files (XYZ.grd files) and GW-Path import files (row-column-column), it was necessary to use the analytical model CAPZONE to convert files. Conversion was performed using dummy variables and the regional water level map export option. Data integrity was maintained during the conversion process.

The converted potentiometric surface map was imported into GW-Path as a separate file. GW-Path requires inputs for both hydraulic conductivity and porosity. These data were used to calculate horizontal velocity components at each grid node. Particles were then placed in primary areas of concern (using, for example, the coordinates of a highly contaminated monitoring well). Particles were tracked for a 20-year duration to determine direction of flow and ultimate travel distance for contaminants identified on the main facility property. As the

wastewater ponds (Site 1) were not constructed until approximately 1980, a 10-year duration was modeled for particles originating in this area.

2.0 Theory

GW-Path particle tracking is based on Darcy's Law for incompressible fluids, where the average pore groundwater velocity v is calculated using the following equation:

$$v = -\frac{K}{n_e}\frac{dh}{dl}$$

Where K is the hydraulic conductivity of the formation, n_e is the effective porosity of the formation (in this case assumed to be the total porosity), and dh/dl is the hydraulic gradient. GW-Path applies Darcy's Law to the individual velocity components, v_x and v_y, which are calculated for each node in the input grid using quadratic fit methodology. Pathlines are determined within GW-Path using a fourth-order Runge-Kutta numerical integration scheme. A detailed explanation of the theory may be found in the user's document *GW-Path: Ground-Water Pathline and Travel Time Analysis*, Version 4.0 (Shafer 1992).

Use of Darcy's Law assumes that flow in the alluvial aquifer occurs under laminar conditions.

3.0 Results

Data generated using GW-Path were used to approximate the movement of affected groundwater during a 10- or 20-year period. Multiple pathlines were generated in the vicinity of each monitoring well to determine potential groundwater flow paths. A distinct difference in contaminant transport is evident because of the two piezometric surface scenarios. This difference is evident both in migration distance and direction. In general, pathlines generated using the 1993 surface indicate more rapid advection of groundwater due to steeper gradients; pathlines generated using the 1988 surface move more slowly because of the extremely shallow gradient. Pathlines tend to follow flowlines in accordance with the piezometric surface maps. Therefore, pathlines generated using the 1993 surface demonstrated bidirectional flow, while pathlines on the 1988 surface flow towards the south.

Pathline analyses were then compared to analytical contaminant data to evaluate potential data gaps with respect to contaminant migration. The primary constituents assessed in groundwater were 1,2-dichloroethane and dinoseb. Groundwater data gaps were evaluated on a site-by-site basis with respect to the following criteria:

- Potential groundwater pathlines beneath the site.
- Presence of existing monitoring wells at the site or adjacent to the site.
- Groundwater analytical data at the site or adjacent to the site.
- Potential trends within analytical data at or adjacent to the site.

The transport data presented using GW-Path were developed assuming no dilution or attenuation of contaminants in the alluvial aquifer. This assumption was made to approximate the worst-case transport scenario for the COCs (dinoseb and 1,2-dichloroethane). Dilution and dispersion are anticipated in the aquifer for both dinoseb and 1,2-dichloroethane. Attenuation processes are expected for 1,2-dichloroethane.

Transport assessments and suggested monitoring well locations are discussed on a site by site basis in the main text.