
JAN, 1996

REVISED

WORK PLAN

VOC REMOVAL FOR OPERABLE UNITS S-1 AND S-2

UNION PACIFIC RAILROAD YARD


SACRAMENTO, CALIFORNIA

FOR

UNION PACIFIC RAILROAD COMPANY



 **DAMES & MOORE**

 **DAMES & MOORE**

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January 30, 1996

Ms. Frances E. Anderson
Site Mitigation
Region 1, Department of Toxic Substances Control
10151 Croydon Way, Suite 3
Sacramento, CA 95827

Attention: Mr. Fernando A. Amador
Project Manager

**Re: Revised Work Plan
VOC Removal Systems for Operable Units S-1 and S-2
Union Pacific Railroad Yard
Sacramento, California
Dames & Moore Project No. 00173-080-044**

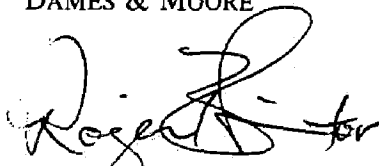
Dear Mr. Amador:

The enclosed work plan has been revised, based on comments summarized in the January 4, 1996 letter to Rick Eades of the Union Pacific Railroad Company (UPRR). The revised work plan is being submitted to you for your approval. The schedule has also been revised, as shown in Figure 9.

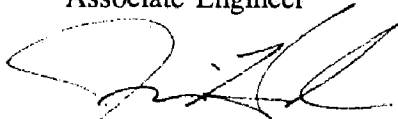
If you have any questions or comments regarding this work plan, please call us at (916) 387-8800.

Sincerely,

DAMES & MOORE



John Fawcett, P.E.
Associate Engineer



Jim Brake, R.G. #5753
Project Manager

Enclosure

SAC187.06

 **DAMES & MOORE**

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January 29, 1996

Mr. Harry Patterson, Manager
Environmental Site Remediation
Union Pacific Railroad Company
1416 Dodge Street, Room 930
Omaha, NE 68129-0930

**Re: Revised Work Plan
VOC Removal Systems for Operable Units S-1 and S-2
Union Pacific Railroad Sacramento Yard
Project No. 00173-080-044**

Dear Mr. Patterson:

Enclosed for your review and comment is the Revised Work Plan based on the comments from Department of Toxic Substances Control (DTSC) presented in the letter dated January 4, 1996.

Upon receipt of your comments, the revised work plan will be finalized and transmitted to the DTSC at your direction. If you have any questions about the work plan, please call Jim Brake at (916) 387-7530.

Sincerely,

DAMES & MOORE



Jim Brake, R.G.
Project Manager



John Fawcett, P.E.
Associate Engineer

Enclosure

SAC187.06

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WORK PLAN
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SACRAMENTO, CALIFORNIA
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TABLE OF CONTENTS

<u>SECTION</u>	<u>PAGE</u>
1.0 <u>INTRODUCTION</u>	1
2.0 <u>BACKGROUND</u>	2
3.0 <u>DESIGN APPROACH</u>	4
3.1 <u>CENTRAL FILL AREA</u>	4
3.2 <u>FORMER OIL HOUSE AREA</u>	5
4.0 <u>VOC REMOVAL SYSTEM DESIGN</u>	7
4.1 <u>CENTRAL FILL AREA</u>	7
4.1.1 <u>SVE System</u>	7
4.1.2 <u>Air Sparging System</u>	8
4.2 <u>OIL HOUSE AREA</u>	9
4.2.1 <u>SVE System</u>	9
4.2.2 <u>Air Sparging System</u>	10
4.3 <u>CENTRAL PUMPING AND TREATMENT SYSTEM</u>	10
5.0 <u>PERMITTING AND SCHEDULING</u>	13
6.0 <u>START-UP AND MONITORING</u>	14
6.1 <u>START-UP ACTIVITIES</u>	14
6.2 <u>PERMIT MONITORING</u>	14
6.3 <u>ROUTINE MONITORING</u>	15
6.4 <u>OPERATION AND MAINTENANCE MONITORING</u>	16
6.5 <u>VERIFICATION OF CLEANUP AND SYSTEM DECOMMISSIONING</u>	16
7.0 <u>REFERENCES</u>	18

**REVISED
WORK PLAN
VOC REMOVAL FOR OPERABLE UNITS S-1 AND S-2
UNION PACIFIC RAILROAD YARD
SACRAMENTO, CALIFORNIA**

LIST OF FIGURES

- Figure 1 — Site Index Map
- Figure 2 — Lateral Extent of VOC-Impacted Soils and Groundwater Plume — Central Fill Area
- Figure 3 — Cross Section — Central Fill Area
- Figure 4 — Lateral Extent of BTEX- and TPH-Impacted Soils and Associated Groundwater Plume — Oil House Area
- Figure 5 — Cross Section — Oil House Area
- Figure 6 — Extraction Well and Air Sparging Treatment Plant — Central Fill Area
- Figure 7 — Typical SVE Well with Air Sparging Capability
- Figure 8 — Extraction Well and Air Sparging Network and Treatment Plant — Oil House Area
- Figure 9 — VOC Removal Design/Implementation Schedule

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SACRAMENTO, CALIFORNIA**

1.0 INTRODUCTION

This work plan presents a proposed plan for cleanup of volatile organic compounds (VOCs) in soil and the capillary fringe within Operable Units (OUs) S-1 and S-2 at the Union Pacific Railroad Sacramento Shops Site. In accordance with the Final Remedial Action Plan for the Site (Dames & Moore, 1995c) these impacts will be addressed as interim remedial measures prior to site-wide remedial action for soil. Specifically, this work plan presents a plan for removal of chlorinated solvent impacts in the Central Fill Area (OU S-2), and benzene, ethylbenzene, toluene, and xylene (BTEX) and gasoline-range petroleum hydrocarbons (TPH-g) impacts in the former Oil House Area portion of OU S-1. The two subject areas are shown on Figure 1.

Background information pertaining to development of this work plan is discussed in Section 2.0. VOC removal system design criteria and the technical feasibility of available VOC extraction and treatment technologies with respect to site-specific conditions is described in Section 3.0. Section 4.0 presents conceptual designs for VOC removal systems in each area. Section 5.0 discusses permitting issues and the proposed scheduling for design, construction, start-up, and initial operations of the VOC removal systems. System start-up activities, permit monitoring, routine system monitoring, and a strategy for confirming cleanup goal attainment are presented in Section 6.0. Section 7.0 presents references used in development of this work plan.

2.0 BACKGROUND

The Final Remedial Action Plan (RAP) for the site was issued in June 1995. As described in the RAP and other technical reports prepared for the site, VOCs are found in both soil and groundwater at the site in excess of allowable concentrations. Specifically, chlorinated volatile organic compounds (CVOCs) have been detected in both soil vapor and groundwater in the Central Fill Area (Operable Unit S-2), and the former Oil House Area exhibits benzene, toluene, ethylbenzene, xylene, gasoline-range petroleum hydrocarbons (TPH-g), as well as diesel-range TPH (TPH-d). In this area, TPH-g is found in both the soil matrix and groundwater, whereas BTEX are detected in soil vapor and groundwater. The selected remedy for Operable Units S-1 and S-2 consists of excavation and off-site disposal to address TPH-d, asbestos, PCBs, and metals. Removal of VOCs via soil vapor extraction prior to excavation was included in the selected remedy.

The Final RAP presented remedial action cleanup levels for VOCs in both liquid and vapor phases in soil, as shown in the table below.

RAP CLEAN-UP LEVELS FOR VOCs

Constituent	Applicable Medium	Remedial Action Objective
Gasoline (Oil House Area)	soil matrix	100 mg/Kg
Benzene	soil matrix	0.3 mg/Kg
Toluene	soil matrix	0.3 mg/Kg
Ethylbenzene	soil matrix	1.0 mg/Kg
Xylenes	soil matrix	1.0 mg/Kg
Total Chlorinated Volatile Organic Compounds	soil vapor	0.5 µg/L

The distinction between clean-up levels for a constituent present in soil vapor and one present in the soil matrix is necessary because the CVOCs and BTEX were generally not detected in soil matrix samples tested during various phases of the Remedial Investigation, whereas TPH-g was frequently detected in soil samples. The extent of CVOC and BTEX impacts was therefore not known until completion of an extensive soil gas survey conducted in 1994 (Dames & Moore, 1994).

Following completion of the 1994 soil gas survey, soil vapor extraction (SVE) and in-situ bioremediation (ISB) pilot tests were conducted in November and December 1994. The results of these tests were presented in a technical report titled *Soil Vapor Extraction and In-Situ Bioremediation Pilot Test Report* (Dames & Moore, 1995a), and will be used for design of the VOC removal system.

3.0 DESIGN APPROACH

This section presents the VOC removal systems conceptual design and design basis for the Central Fill and the former Oil House areas based on SVE, air sparging and ISB pilot testing performed as part of a predesign study.

3.1 CENTRAL FILL AREA

As discussed in the SVE pilot study report (Dames & Moore, 1995a), soil in the Central Fill Area has been impacted by CVOCs. Due to site-specific conditions and the nature and extent of the impacts, CVOCs are generally detected only in soil gas in this area. Based on data obtained during the 1994 soil gas survey and the subsequent SVE/ISB pilot test, there are two areas where CVOCs are present in soil vapor (see Figure 2). Portions of these impacts overlie the apparent head of the Operable Unit GW-1 groundwater contaminant plume, also shown on Figure 2. The overlapping portions of CVOC soil vapor impacts are inferred to extend into the capillary fringe to form the source of the GW-1 plume.

To reduce this ongoing source of groundwater impacts, design of the proposed VOC removal system will focus on removing CVOCs in both the vadose zone and the capillary fringe to meet the cleanup levels set forth in the RAP. Figure 3 is a conceptual cross section showing the approximate vertical extent of CVOCs in soil vapor, and the inferred interaction between CVOC-impacted soil vapor, the capillary fringe, and the GW-1 groundwater plume.

Figure 3 also shows generalized stratigraphy in the Central Fill Area. Based on data obtained during the Remedial Investigation, soil in the vicinity of CVOC impacts in soil vapor consists of 3 to 9 feet of fill underlain by native alluvium. The fill is known to contain debris, such as old railroad ties, brick, concrete, wood, drywall, and metal (Dames & Moore, 1991). Native soil below the fill generally consists of interbedded sandy clay, silt, and silty sand to a depth of approximately 20 feet below ground surface (bgs). Silty clays and clayey silts predominate from about 20 to 30 feet bgs, and shallow ground water occurs approximately 25 feet bgs. Based on soil types present in this zone, the thickness of the capillary fringe is estimated to be about 4 feet (Driscoll, 1986).

Soil vapor extraction technologies are more effective in removing VOCs from the unsaturated zone and less effective in removing VOCs from the capillary fringe. Therefore, air sparging (injection of air into the groundwater plume) will be used to assist in removing contaminants from the capillary fringe by two mechanisms: 1) stripping VOCs and moving them into the overlying unsaturated zone where they can be collected by a SVE system, and 2) through enhanced natural

biodegradation due to increased oxygen concentrations. An air sparging system will also provide the added benefit of stripping and biodegrading VOCs in groundwater, thereby reducing the mass of groundwater contaminants. This will reduce both the time and corresponding cost of operating groundwater pump and treat systems. It is anticipated that low concentrations of methane (natural gas) will be bled into the air sparging system to increase the methanotrophic bacterial populations. Methanotrophic bacteria are capable of degrading CVOCs through a process known as cometabolism.

3.2 FORMER OIL HOUSE AREA

Soil in the former Oil House Area is impacted with TPH-d, TPH-g and BTEX. Based on previous studies, soil impacts in this area probably resulted from operation of the former Oil House and associated underground fuel storage tanks. BTEX and gasoline-range hydrocarbons have impacted this portion of the GW-1 plume. Based on monitoring well, soil boring, and test pit logs presented in the Addendum Remedial Investigation/Feasibility Study Report (Dames & Moore, 1991) and the RAO development report (Dames & Moore, 1994), as well as groundwater monitoring data from the First Quarter 1995 Groundwater Monitoring Data Summary (Dames & Moore, 1995b), the approximate lateral extents of BTEX in soil gas, TPH-g in soil matrix, and BTEX in groundwater were delineated (see Figure 4). As shown on Figure 4, soil vapor impacts are believed to be concentrated around the previous underground storage tank excavation, which was backfilled with sand. It appears that the resulting BTEX groundwater impacts originated from this area. The impacts appear to be ongoing based on monitoring data for MW-4, and currently extend downgradient to well MW-13 and beyond.

Figure 5 shows a conceptual cross section depicting the vertical extent of BTEX and TPH-g in soil vapor, and the inferred interaction between soil impacts, the capillary fringe, and the groundwater plume. Based on the results of the 1994 soil gas survey, TPH-g is found in soil vapor throughout the soil profile from SVE-5 to MW-12, with the highest concentrations in the lower section of the vadose zone below the tank excavation.

Also shown on Figure 5 is a conceptual model of the stratigraphy in the former Oil House Area. The fill thickness in this area is about 8 feet (Dames & Moore, 1991). A distinct hardpan layer has been observed at depths ranging from 7 to 10 feet bgs outside of the tank backfill area. The hardpan is approximately 1 to 3 feet thick, and is believed to provide a barrier to migration of soil gas and infiltrating water. Silty clays and clayey sands underlie the fill to depths of up to 35 feet bgs. Interbedded sandy clays, silts, and silty sands are encountered from about 30 to 45 feet bgs.

First groundwater in this area is generally encountered approximately 25 feet bgs, and the capillary fringe is estimated to be about 4 feet thick based on the predominant soil type near the water table (Driscoll, 1986).

The main objective of VOC removal in the former Oil House Area is cleanup of the source of BTEX and TPH-g groundwater contamination in the capillary fringe and vadose zone. As in the Central Fill Area, air sparging is proposed to both strip and biodegrade the contaminants in the capillary fringe; however, the addition of methane to stimulate methanotrophs will not be needed because the constituents of concern are not CVOCs. Stripped VOCs will transfer to soil vapor in the vadose zone, where they can be collected by the SVE system. The extraction system will consist of a series of nested extraction wells screened in different portions of the subsurface to ensure that all portions of the vadose zone are effectively targeted. This depth-specific extraction approach is necessary to account for the non-homogeneous nature of the subsurface in the former Oil House Area. The deepest SVE well will be screened in the lower vadose zone, and the shallower wells will be screened in the sandy upper layer above the hardpan. A plastic ground cover may be required to eliminate short circuiting (air intrusion from the atmosphere) between the shallower SVE wells and the surface.

4.0 VOC REMOVAL SYSTEM DESIGN

This section introduces specific VOC removal system elements and design parameters to be used for design of the SVE and air sparging systems for the Central Fill and the former Oil House areas. Details on the vapor treatment system are also included.

4.1 CENTRAL FILL AREA

The Central Fill Area VOC removal system will include both SVE and air sparging with granular activated carbon (GAC) off-gas treatment. As discussed above, the system will be designed to target VOCs present in both soil vapor (in the vadose zone) and in the capillary fringe. The design basis for the primary system elements is presented below, and the following table summarizes primary system parameters.

CENTRAL FILL AREA SVE/SPARGING SYSTEM DESIGN PARAMETERS

Design Parameter	Central Fill Area (Northern Impacted Area)	Central Fill Area (Southern Impacted Area)
Number of Combination Sparging/SVE Wells	9	13
SVE Only Wells	18	12
SVE Flow Rate (per well)	20 cfm	10 cfm
SVE Vacuum Pressure	120 inches of water	120 inches of water
Sparging Flow Rate (per well)	3 cfm	3 cfm
Sparging Pressure	20 psi	20 psi

4.1.1 SVE System

The proposed soil vapor extraction well field conceptual layout shown on Figure 6 was developed based on the 1994 soil vapor extraction pilot test results. The radius of vacuum influence in the Central Fill Area was observed to range between 30 and 50 feet at a flow rate of approximately 20 cubic feet per minute (cfm).

Both horizontal and vertical wells were considered as possible vapor extraction methods for this area, and initial capital costs for installation of horizontal and vertical wells were developed for comparison. Because air sparging points can be nested inside vertical SVE well borings, this approach is expected to be more cost-effective than a horizontal well network. A typical SVE well with air sparging capability is shown on Figure 7.

The network of 52 vertical vapor extraction wells will be placed on 50 foot centers covering the two areas of VOC soil impacts, as shown on Figure 6. This corresponds to a design radius of vacuum influence of 25 feet. The wells will be screened across the capillary fringe, and will have a minimum of 10 feet of screening in the vadose zone. Each vapor extraction well will be piped to a common header, which will be connected to the vacuum blower located at the treatment plant (also shown conceptually on Figure 6).

Extracted vapors will be routed through a vapor phase GAC system to remove VOCs, and treated air will be discharged to the atmosphere under the conditions of an air emissions permit.

4.1.2 Air Sparging System

Air sparging in the Central Fill Area will focus on the two areas believed to comprise the source of CVOC groundwater impacts in Operable Unit S-2. These target areas, shown on Figure 6, are the overlap between the lateral extent of CVOCs in soil vapor and the GW-1 groundwater plume. A total of 22 sparging points are proposed for the two areas.

The total air sparging flow rate will be determined based on a flow rate of 3 cfm per sparge point. This rate has been found to be appropriate for the 50-micron micro-bubble sparge points proposed for the system. The air sparging point will be positioned inside the sparging/extraction well boring approximately 15 feet below the groundwater table. The pressure required to overcome the static groundwater head and head losses in the pipe and the air sparging point is approximately 12 psi.

As discussed in Section 3.1, low concentrations of methane will be intermittently introduced into the air sparging system to stimulate methanotrophic bacterial growth, thereby further enhancing biodegradation of VOCs in the capillary fringe and groundwater. The concentration of methane in the sparging air will not exceed 1% by volume. This concentration is well below the lower explosive limit (LEL) for methane of 5%. The source of methane will be either a pressurized tank or, if feasible, it will be piped from an existing underground natural gas main near the site (natural gas is approximately 95% methane).

Pressurized air will be delivered to the air sparging points via a network of piping connected to an air compressor. Flow rate and pressure will be regulated as needed to achieve the desired sparging effect.

4.2 OIL HOUSE AREA

The former Oil House Area VOC removal system will also include both SVE and air sparging with GAC off-gas treatment, using the same treatment unit as the Central Fill Area. The design basis for the system is presented below, and the following table summarizes primary system parameters.

FORMER OIL HOUSE AREA SVE/SPARGING SYSTEM DESIGN PARAMETERS

Design Parameter	Oil House Area
Number of Combination Sparge Points/SVE Wells	10
SVE Only Wells	0
SVE Flow Rate (per well)	10 cfm
SVE Vacuum Pressure	120 inches of water
Sparging Flow Rate (per well)	3 cfm
Sparging Pressure	20 psi

4.2.1 SVE System

The design for the SVE extraction well network in the former Oil House Area is based on the SVE pilot test results for this area, site stratigraphy and soil properties, and the horizontal and vertical extent of contaminants in soil and groundwater. Based on pilot test data, the radius of vacuum influence in the Oil House Area ranges from 7 to 30 feet at flow rates between 6 and 9 cfm. Based on a 15-foot design radius of vacuum influence, a total of 10 vapor extraction wells will be installed 30 feet apart, as shown on Figure 8.

A low permeability (hardpan) layer is present at approximately 7 to 12 feet bgs across much of the Oil House Area. To accommodate this layer, the proposed network will consist of nested vertical wells. The deeper SVE wells will be screened from the groundwater to a height of

approximately 10 feet above groundwater (below the hardpan), and the shallow SVE wells will be screened in the interval of approximately 7 to 12 feet bgs (above the hardpan).

Since shallow subsurface soil in the former Oil House Area typically has a high sand content, preferential paths could develop through the sandier materials to the surface. If necessary, a plastic cover may be installed on the ground surface to prevent infiltration of air from the surface.

4.2.2 Air Sparging System

Based on similarities in saturated zone geology for the Oil House and Central Fill Areas, air sparging design parameters of 3 cfm at 20 psi and sparge point locations of 15 feet below groundwater surface will also be used for the former Oil House Area. The BTEX/TPH-g portion of the GW-1 plume in the former Oil House area extends from well SVE-5 to downgradient of MW-12, and is believed to originate from the former underground tanks. Air sparging in this area should strip contaminants and encourage biodegradation of BTEX and TPH-g due to increased oxygen levels in groundwater and the vadose zone. Sparge points will be located at each SVE well. Therefore, ten air sparging points are proposed. This corresponds to a system flow rate of 30 cfm. The planned sparging configuration, including pressure line alignment, is shown on Figure 8.

4.3 CENTRAL PUMPING AND TREATMENT SYSTEM

One centralized pumping station with a GAC vapor treatment unit will serve the Central Fill and Oil House area SVE/sparging networks. The system will be designed with sufficient sparging and vapor extraction capability to operate the largest well network at the design flow rates and pressures (i.e., the northernmost impacted portion of the Central Fill Area). The system will be modular so that additional pumps blowers, and/or carbon canisters can be added as needed. Initially, the system will be capable of operating one SVE/sparging network at a time. Instrumentation and control valves will be designed to allow fine-tuning of flow rates. Observations during the initial operating period will determine whether additional pumps and blowers need to be added to optimize VOC recovery rates.

Vapors will be extracted from the vadose zone through the vapor extraction well system and transported to the centralized treatment unit, where the pumps and blowers will also be housed. Based on the design flow rates summarized in the tables above, a 700-cfm blower at a vacuum pressure of 120 inches will be required for the northern portion of the Central Fill Area, and the air sparging compressor will have a design capacity of 60 cfm at 20 psi.

Treatment of extracted vapors will be accomplished by vapor phase GAC, and the off-gas will be discharged to the atmosphere. GAC was selected as the most cost-effective treatment system due to the relatively low influent vapor concentrations expected.

The GAC canisters will be preliminarily sized based on estimated influent concentrations for the northernmost portion of the Central Fill Area at the full design vapor extraction rate. Total chlorinated hydrocarbon concentrations in extracted vapor in the Central Fill Area noted during the SVE pilot test ranged from 2,500 to 10,000 parts per billion (ppb) (Dames & Moore, 1994). However, the total influent CVOC concentration for the proposed final configuration is expected to be less than that observed during the pilot test due to dilution from peripheral wells. During the SVE pilot test, the VOC vapor concentration from well SVE-5 in the former Oil House Area was reported to be as high as 2,500 parts per million (ppm) (Dames & Moore, 1995a). However, VOC vapors in extracted gas from this area are also expected to be less concentrated.

Condensate from the extracted vapors may be generated at the inlet of the SVE vacuum blower. It will be collected and periodically transported to the existing on-site groundwater treatment unit. All condensate will be placed into the groundwater influent holding tank, and will be routed through the groundwater treatment system prior to discharge.

Electrical service for operation of the blowers and compressors will be obtained from existing on-site electrical service, and will be routed through a new circuit box to be installed at the treatment unit area.

4.3 PLANS, SPECIFICATIONS, AND DESIGN REPORT

One set of documents comprising project plans, construction specifications, and a design report will describe VOC removal systems for both the Central Fill and former Oil House Areas. The final drawings are expected to include the following sheets:

- G100 Title Sheet
- G101 Process Flow Diagram
- C100 Site Plan
- C101 Piping Plan - Central Fill Area
- C102 Piping Plan and Profile - Oil House Area
- C103 Miscellaneous Civil Details
- M101 Equipment Layout - Central Fill Area
- M102 Equipment Layout - Oil House Area

- M103 Sections and Details - Central Fill Area
- M104 Sections and Details - Oil House Area
- E100 Piping and Instrumentation Diagram
- E101 Electrical Site Plan
- E102 Electrical Single Line Diagram and Details
- E103 Electrical Controls Wiring Diagram

Technical specifications will be prepared using the standards developed by the Construction Specifications Institute (CSI). The specifications will include all technical sections required for civil, structural, mechanical and electrical construction of the project.

The VOC removal system design report will be submitted to the DTSC. Comments received from DTSC will be addressed and incorporated into the final document as appropriate. The final design report will include final plans and specifications for the VOC removal systems.

5.0 PERMITTING AND SCHEDULING

Permits required for construction and operation of the proposed VOC removal and treatment systems include an air permit and a building permit. The building permit will be obtained from the City of Sacramento Building Department. The air permit (Authority to Construct and Permit to Operate) will be obtained from the Sacramento Metropolitan Air Quality Management District (SMAQMD), and will cover air emissions from the soil vapor treatment system.

The schedule for implementation of the proposed VOC removal systems is driven by an objective to initiate operation of the systems by mid-June 1996. Figure 9 presents the tentative schedule for implementation of the VOC removal systems. Design activities should be completed by the first week in February, and construction will be completed as early as June 1996.

The duration of systems operation needed to achieve the clean-up goals for VOCs is not currently known. This is primarily due to the lack of information regarding total VOC mass in the unsaturated zone. An estimate of total operations duration will be made after the first few months of operations, and periodically thereafter.

6.0 START-UP AND MONITORING

Once system construction is completed, system start-up activities will commence. Upon completion of the start-up phase, routine operation and maintenance (O&M) and treatment system monitoring will begin. This section includes a description of system start-up activities, system monitoring, and permit monitoring. A rationale and approach for verifying that cleanup goals have been met is also included.

6.1 START-UP ACTIVITIES

As discussed in Section 4.3, the treatment system will initially have the capacity to run only one SVE/sparging well network at a time. One objective of the start-up period is to allow optimization of flows and pressures for each network area. This information will be used to determine whether additional pumps, blowers, and/or GAC canisters need to be added.

During the initial start-up of the SVE and air sparging systems, all elements of the two systems will be closely monitored to identify and resolve any operational problems, calibrate system flows to achieve the desired extraction rates, verify the design radius of influence for both sparging and vapor extraction, and troubleshoot the treatment system as necessary. Mechanical, electrical or operational problems encountered will be resolved prior to commencing with routine O&M and monitoring. At the end of the start-up period, vapor samples will be collected from selected vapor extraction wells and analyzed for the appropriate VOCs. This data will serve as a baseline to assess removal efficiency and, ultimately, the end of systems operations. Start-up activities are expected to last about 3 weeks.

6.2 PERMIT MONITORING

The vapor phase GAC treatment system will be monitored to ensure that permit requirements are being met, and to assess the need for GAC change-out. The GAC off-gas discharge point will be monitored for compliance with the conditions set forth in the air permit. Influent vapor concentrations will also be monitored to assess mass removal rates and predict the frequency of GAC change-out. Specific monitoring schedules and parameters will be developed in accordance with the permit requirements.

6.3 ROUTINE MONITORING

The purpose of system monitoring is to verify that the VOC removal systems are functioning as designed, and to ensure that the clean-up objectives set forth in the RAP are being met to the maximum practical extent. System monitoring will also be used to evaluate progress in remediation of soil (i.e., estimate cumulative VOC mass removal). The following table outlines the proposed routine monitoring program for the VOC removal systems.

PROPOSED ROUTINE VOC REMOVAL SYSTEM MONITORING PROGRAM

Parameter	Monitoring Frequency
Vapor Extraction Wells	
Flow Rates	Weekly for the first two months, then monthly for the next 6 months.
Pressures	
Extracted Air Quality ¹	Weekly for the first month, twice per month for one month, then monthly for the next 6 months.
Air Sparging Wells	
Flow Rates	Weekly for the first two months, then monthly for the next 6 months.
Pressures	
Treatment System	
SVE Influent Air Quality ^{1,2}	Weekly for the first two months, then monthly for the next 6 months.
SVE Effluent Air Quality ^{1,2}	
Air Sparging Air Quality ³	
Groundwater	
Groundwater levels	Weekly for the first two months, then monthly for the next 6 months.
Groundwater Quality ^{4,5}	Monthly for 6 months.

KEY TO NOTES:

- 1 Concentration of O₂, CO₂, VOCs, CH₄ (Central Fill Area Only), and total hydrocarbons will be monitored using field instruments. Selected samples will be submitted for laboratory analytical testing to correlate with and verify field test results.
- 2 SVE air quality will be monitored as required under the terms of the SMAQMD emissions permit.
- 3 Concentration of CH₄ (Central Fill Area only) using field instrument.
- 4 If feasible, groundwater samples will be obtained via vacuum extraction through the sparge points of selected wells.
- 5 Monitoring parameters will include dissolved oxygen (field test), and VOCs and bacterial plate counts (laboratory analyses).

This information will be used to assess whether system on-off cycling will be advantageous, and will ultimately be used to determine when the VOC removal systems have reached the limits of their effectiveness.

Routine status reports will be submitted to the DTSC project manager on a quarterly basis. The report will include summary of monitoring, laboratory data sheets, evaluation, and, and a brief summary of results, conclusions and recommendations.

6.4 OPERATION AND MAINTENANCE MONITORING

Following the 8-month start-up monitoring period, operation and maintenance monitoring will continue, if necessary, on a quarterly basis until cleanup is achieved. Quarterly status reports will be submitted to the DTSC project manager.

The report will include a brief summary of the monitoring event, laboratory data sheets, evaluation and summary of results, conclusions, and recommendations.

6.5 VERIFICATION OF CLEANUP AND SYSTEM DECOMMISSIONING

Systems will be designed to permit monitoring of discrete subareas within each SVE/sparging network. This will be accomplished through strategic placement of valves in the vapor collection header pipe. Routine monitoring, as described in the previous section, will be used to determine whether a resting period is desirable for a given network of wells. When field monitoring results indicate that total VOCs in extracted vapor for one or more SVE wells has dropped off, the entire system may be shut down temporarily, and then restarted after a resting period. The purpose of the resting period is to allow VOCs to diffuse back into the extraction zone. The VOC removal systems may therefore be operated intermittently as needed to optimize VOC removal with energy usage. As cleanup progresses, some individual SVE wells (or subgroups of wells) will probably show longer required resting periods, and ultimately will yield little or no VOCs in extracted vapor. These wells will be taken off line as the limit of their effectiveness is reached.

For the Central Fill Area system, when all wells consistently cease to exhibit CVOC concentrations in excess of the clean-up goal, a soil gas survey of the treated area will be performed to determine whether the cleanup goals have been met.

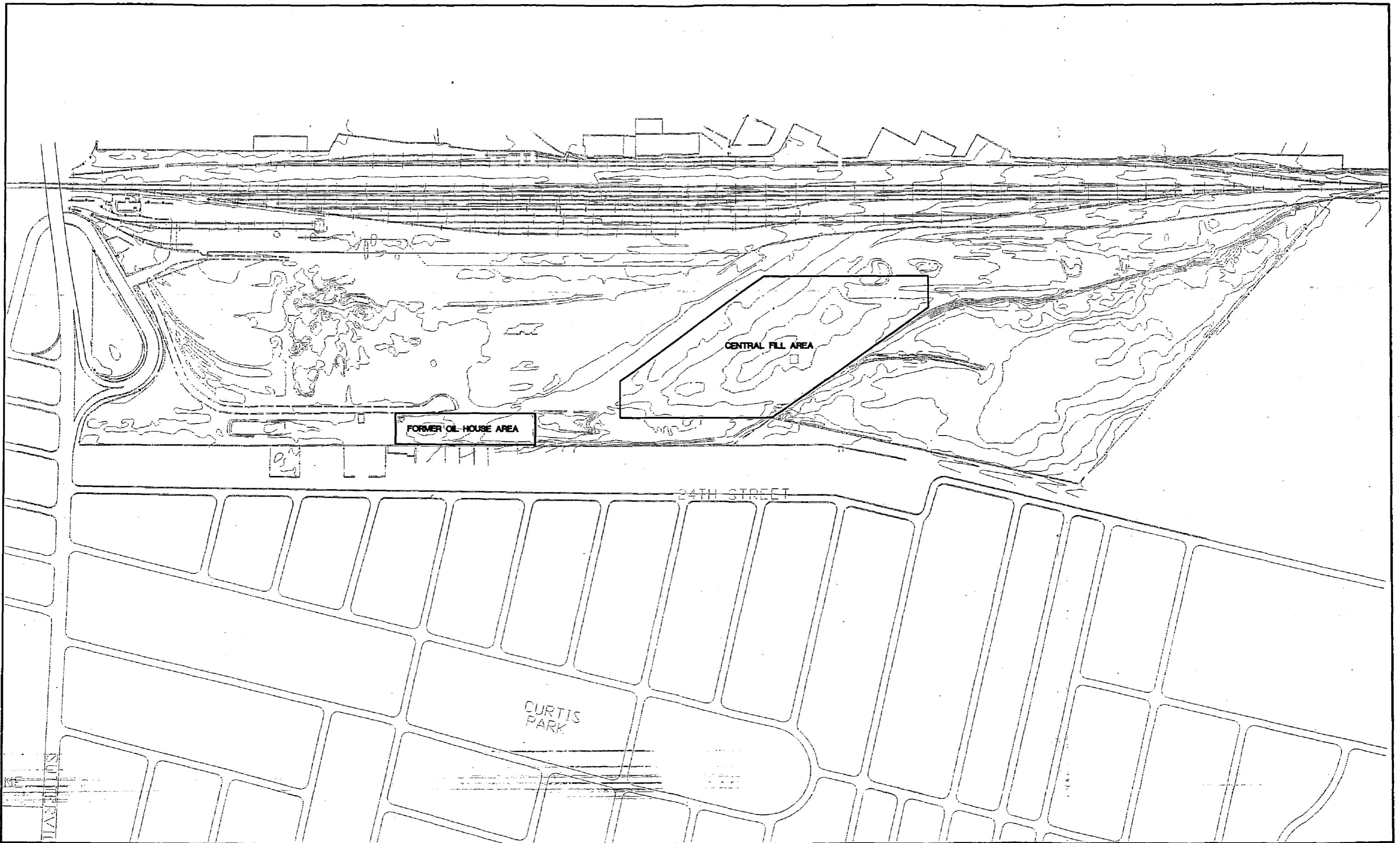
A similar approach will be used for the former Oil House Area. However, due to the fact that the clean-up objectives for TPH-g and BTEX are based on soil matrix concentrations, final

verification of attainment of clean-up goals will be determined by soil sampling and analysis performed following excavation of TPH-d impacted soils in this area.

A detailed verification sampling and analysis plan (SAP) will be developed and presented to DTSC for review and approval prior to its implementation to verify cleanup. The SAP is expected to be submitted to the DTSC in May 1996.

7.0 REFERENCES





- Dames & Moore, November 1991, Addendum Remedial Investigation/Feasibility Study Report, Union Pacific Railroad Yard, Sacramento, California.
- Dames & Moore, October 1992, Feasibility Study Supplement, Union Pacific Railroad Yard, Sacramento, California.
- Dames & Moore, November 1994, Draft Report Development of Remedial Action Objectives for Volatile Organic Compounds in Soil in the Central Fill and Oil House Areas, Union Pacific Railroad Yard, Sacramento, California.
- Dames & Moore, May 1995a, Draft Soil Vapor Extraction and In-Situ Bioremediation Pilot Test Report for Union Pacific Railroad Yard, Sacramento, California.
- Dames & Moore, May 1995b, Transmittal of First Quarter 1995 Groundwater Monitoring Data, Union Pacific Railroad Yard, Sacramento, California
- Dames & Moore, June 1995c, Final Remedial Action Plan, Union Pacific Railroad Yard, Sacramento, California.
- Driscoll, 1986, Groundwater and Wells, Johnson Division, St. Paul.

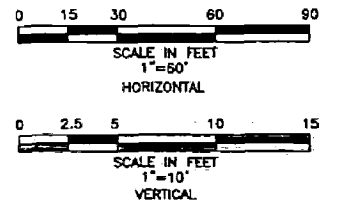
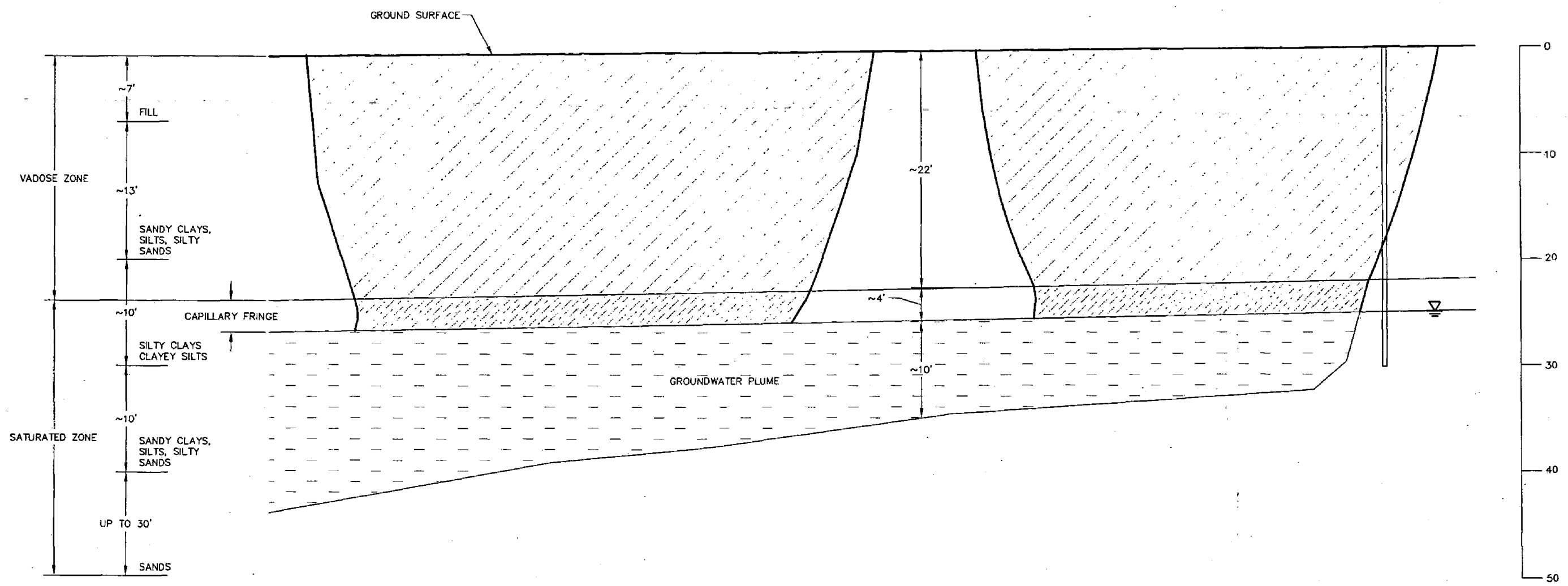


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LEGEND

-  APPROXIMATE EXTENT OF VOCs IN SOIL VAPOR
-  GROUNDWATER PLUME (OPERABLE UNIT GW-1)
-  INFERRED CAPILLARY FRINGE IMPACTS
-  GROUNDWATER TABLE

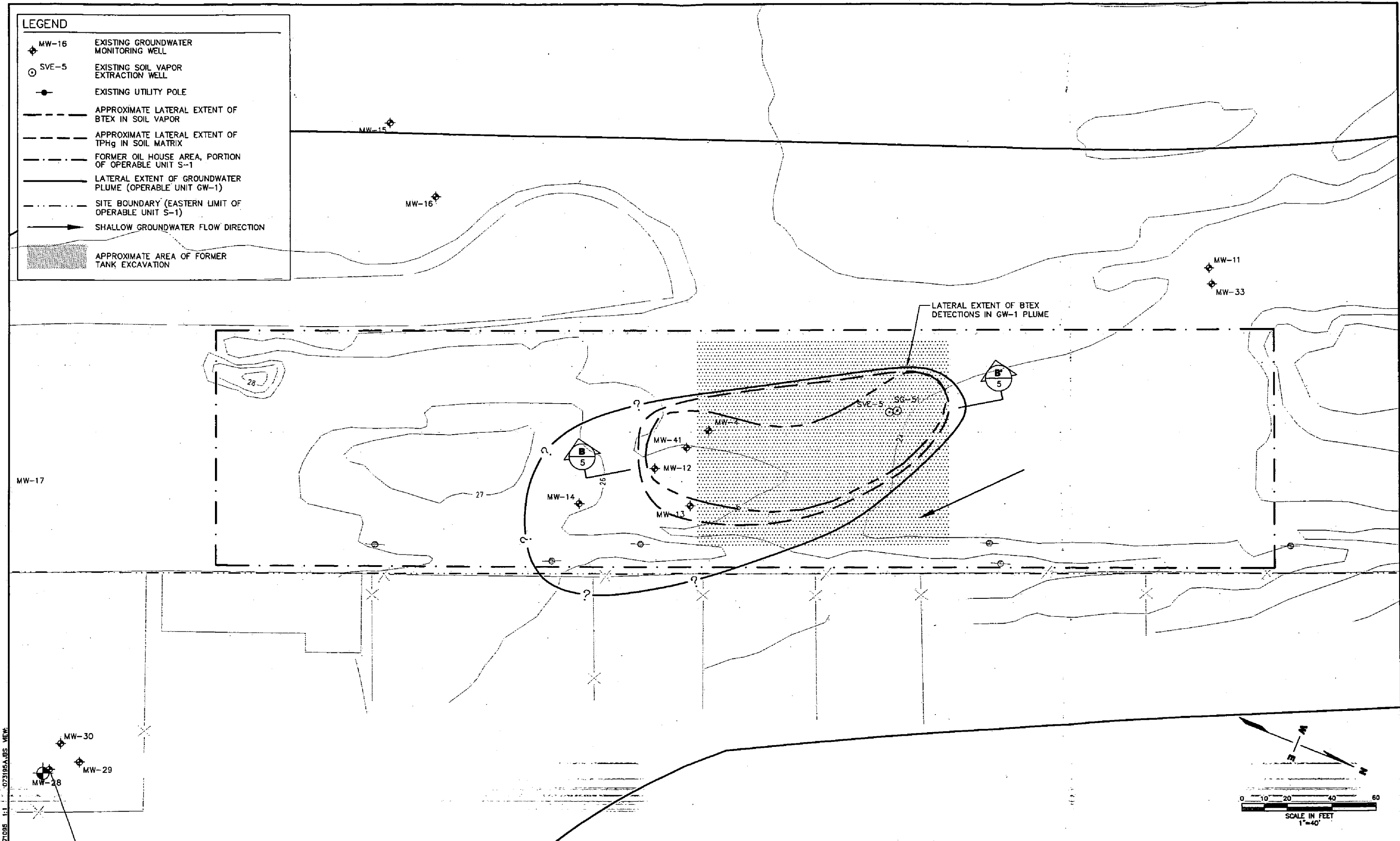


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CONCEPTUAL CROSS SECTION A-A' CENTRAL FILL AREA											SHEET NO.				
											3				

LEGEND

- ◆ MW-16 EXISTING GROUNDWATER MONITORING WELL
- ⊙ SVE-5 EXISTING SOIL VAPOR EXTRACTION WELL
- EXISTING UTILITY POLE
- - - - - APPROXIMATE LATERAL EXTENT OF BTEX IN SOIL VAPOR
- - - - - APPROXIMATE LATERAL EXTENT OF TPHg IN SOIL MATRIX
- - - - - FORMER OIL HOUSE AREA, PORTION OF OPERABLE UNIT S-1
- LATERAL EXTENT OF GROUNDWATER PLUME (OPERABLE UNIT GW-1)
- · - · - · - SITE BOUNDARY (EASTERN LIMIT OF OPERABLE UNIT S-1)
- SHALLOW GROUNDWATER FLOW DIRECTION
- ▨ APPROXIMATE AREA OF FORMER TANK EXCAVATION



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REFERENCES

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REVISIONS

DESCRIPTION	NO.	BY	DATE

REVISIONS

DESCRIPTION	NO.	BY	DATE

DRAWING SCALE

AS NOTED	DATE







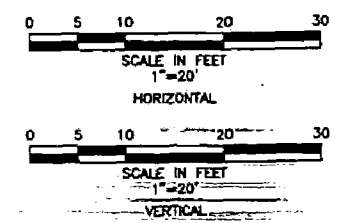
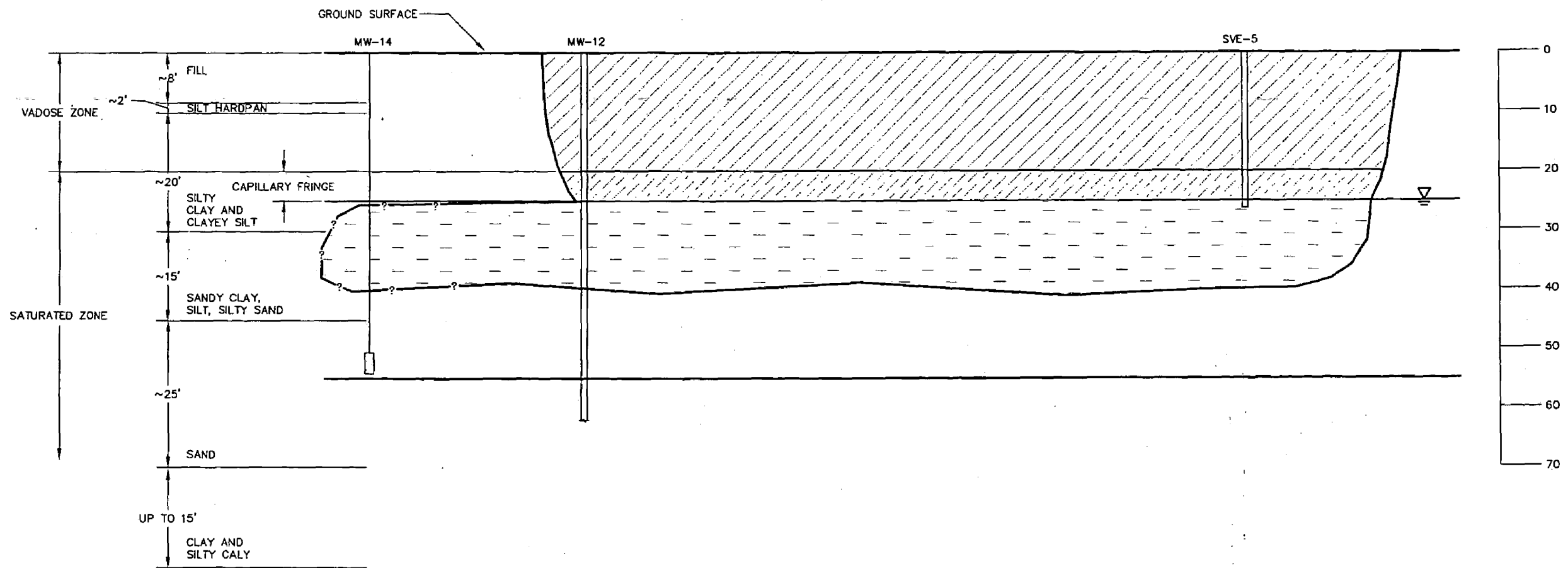
**UNION PACIFIC RAILROAD YARD
VOC REMOVAL SYSTEMS
SACRAMENTO, CALIFORNIA**

**LATERAL EXTENT OF BTEX AND TPH
IMPACTED SOILS AND ASSOCIATED
GROUNDWATER PLUME OIL HOUSE AREA**


JOB NO. 00173080
REVISION
SHEET NO. 4

LEGEND

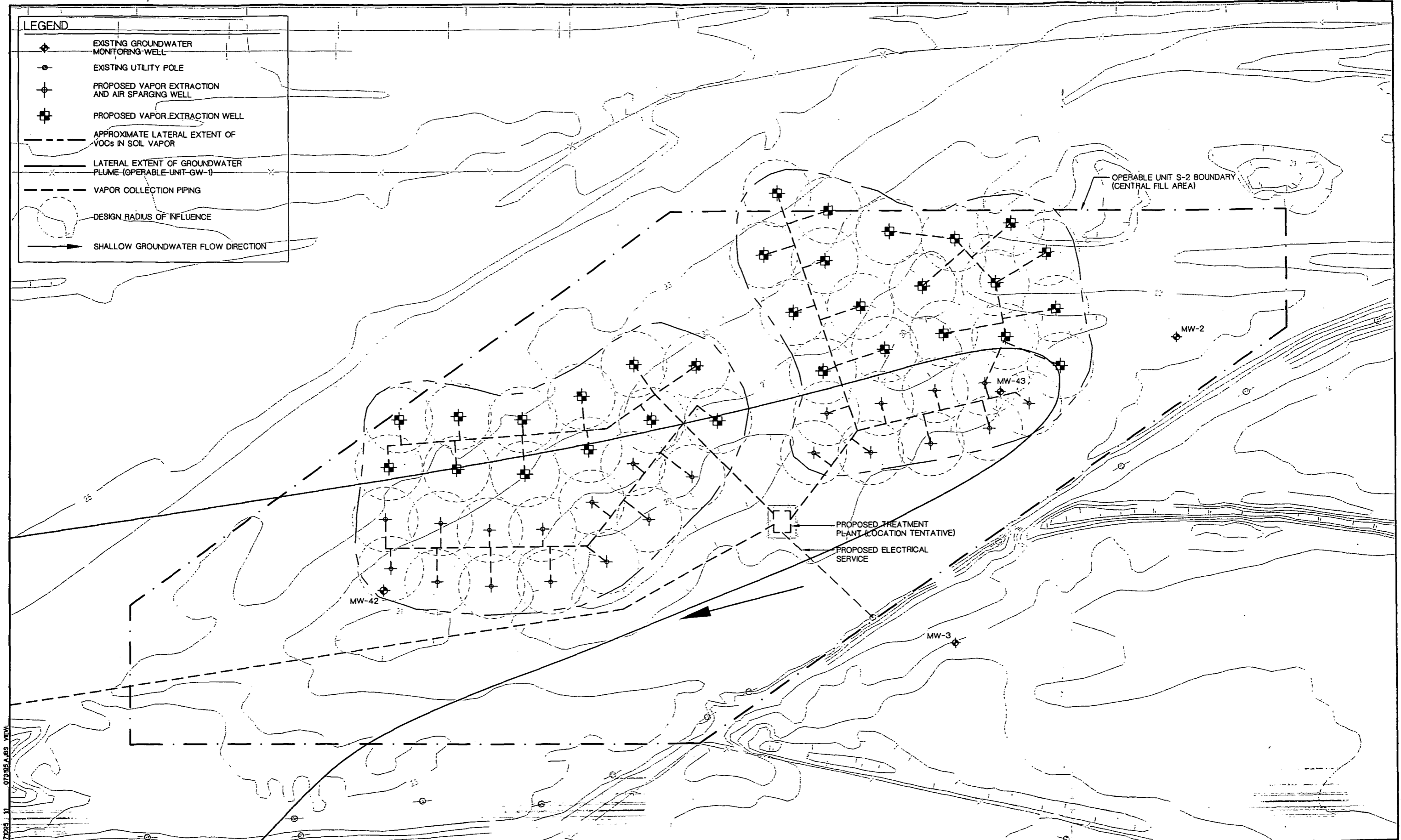
-  APPROXIMATE EXTENT OF BTEX IN SOIL VAPOR
-  INFERRED BTEX CAPILLARY FRINGE IMPACTS
-  INFERRED EXTENT OF BTEX PORTION OF GROUNDWATER PLUME GW-1
-  GROUNDWATER TABLE



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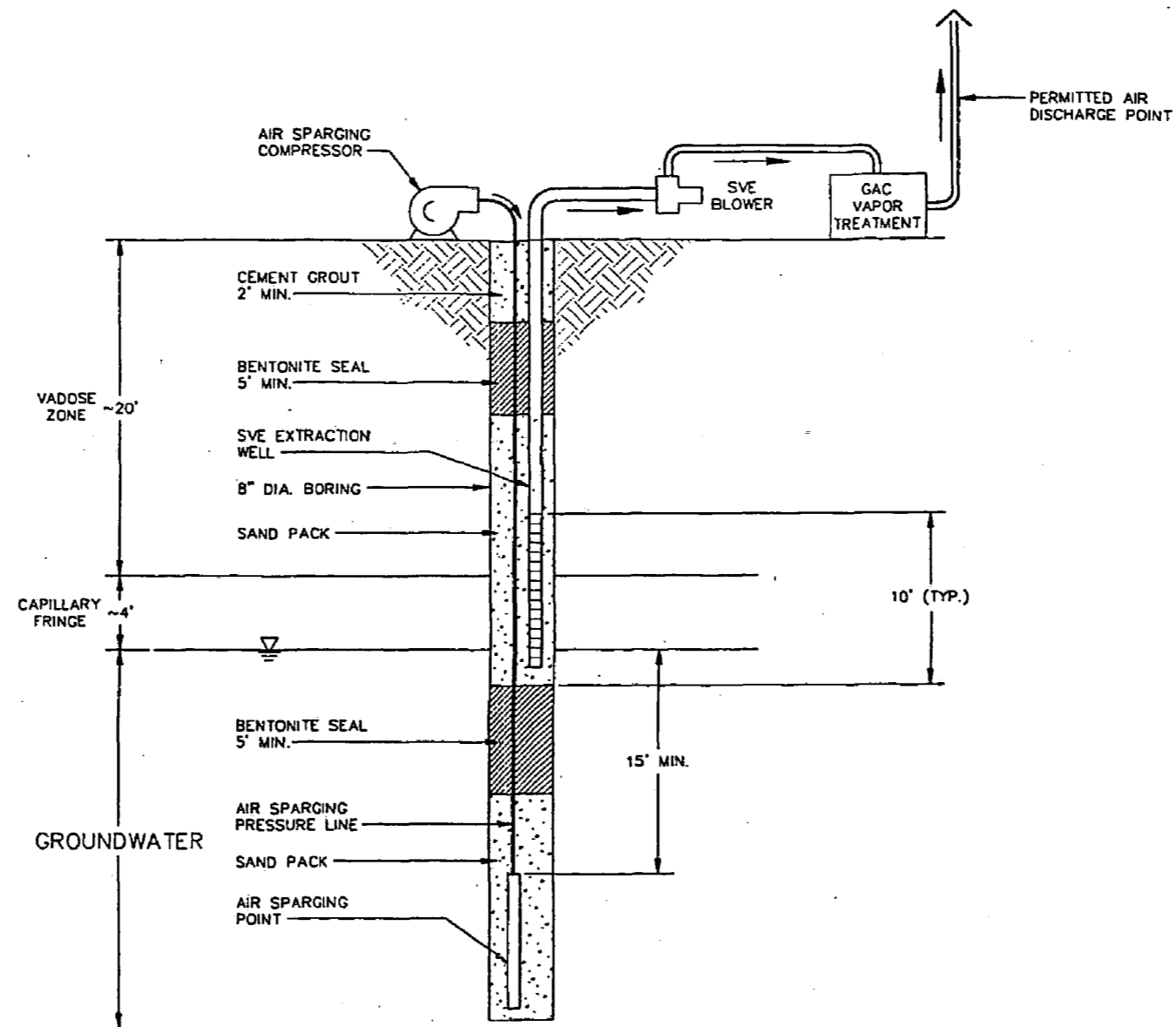
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CONCEPTUAL CROSS SECTION B-B' FORMER OIL HOUSE AREA											SHEET NO.				
											5				

LEGEND	
	EXISTING GROUNDWATER MONITORING WELL
	EXISTING UTILITY POLE
	PROPOSED VAPOR EXTRACTION AND AIR SPARGING WELL
	PROPOSED VAPOR EXTRACTION WELL
	APPROXIMATE LATERAL EXTENT OF VOCs IN SOIL VAPOR
	LATERAL EXTENT OF GROUNDWATER PLUME (OPERABLE UNIT GW-1)
	VAPOR COLLECTION PIPING
	DESIGN RADIUS OF INFLUENCE
	SHALLOW GROUNDWATER FLOW DIRECTION



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REFERENCES		REVISIONS		REVISIONS		DRAWING SCALE	AS NOTED	DATE	DAMES & MOORE	UNION PACIFIC RAILROAD YARD VOC REMOVAL SYSTEMS SACRAMENTO, CALIFORNIA	JOB NO. 00173080
TITLE	NO. BY DATE	DESCRIPTION	NO. BY DATE	DESCRIPTION	DESIGNED BY:						
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DRAWING SCALE AS NOTED

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CHECKED BY:	
APPROVED BY:	

DAMES & MOORE

**UNION PACIFIC RAILROAD YARD
VOC REMOVAL SYSTEMS
SACRAMENTO, CALIFORNIA**

**CONCEPTUAL SVE/AIR
SPARGING WELL**

JOB NO. 00173080

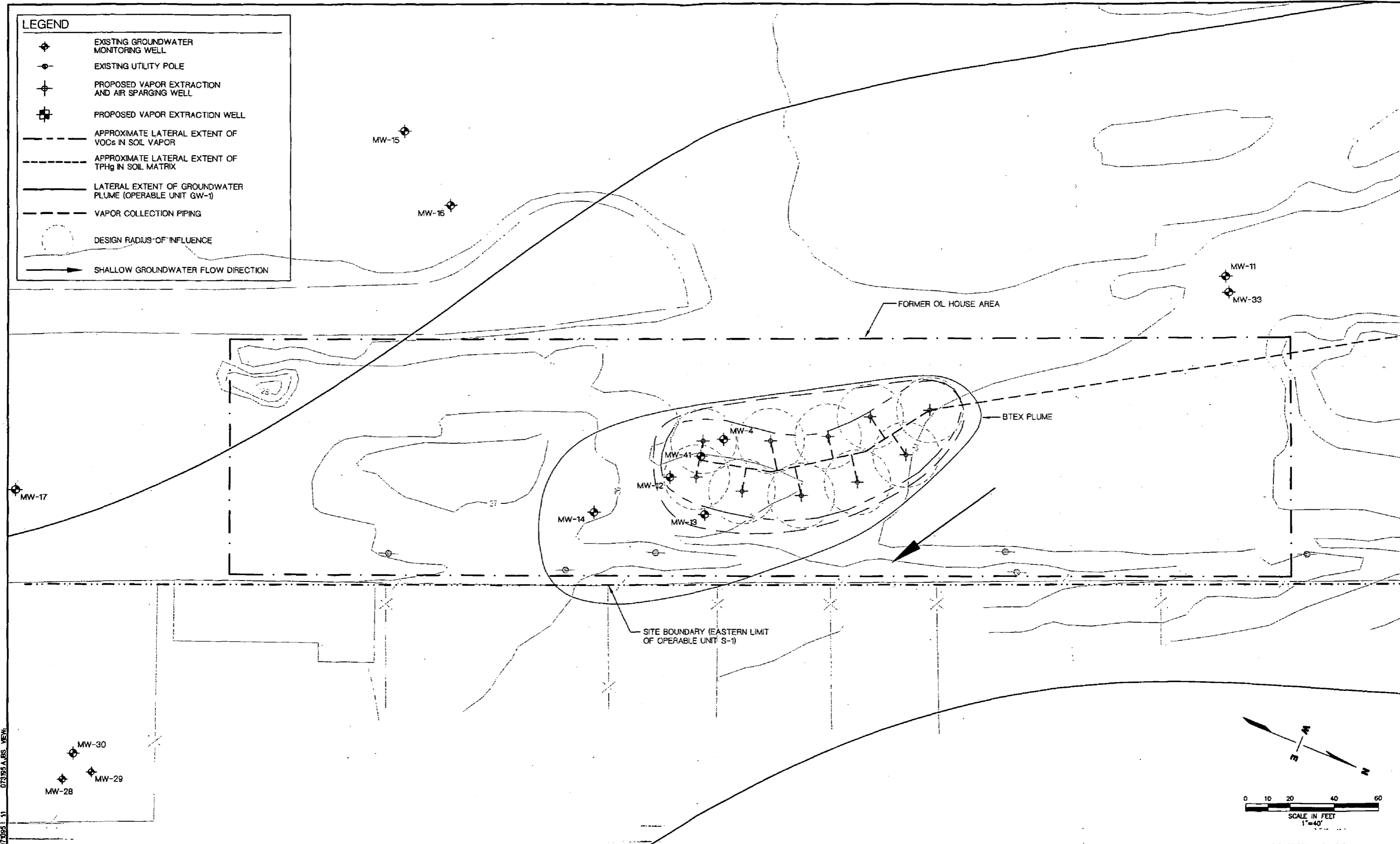
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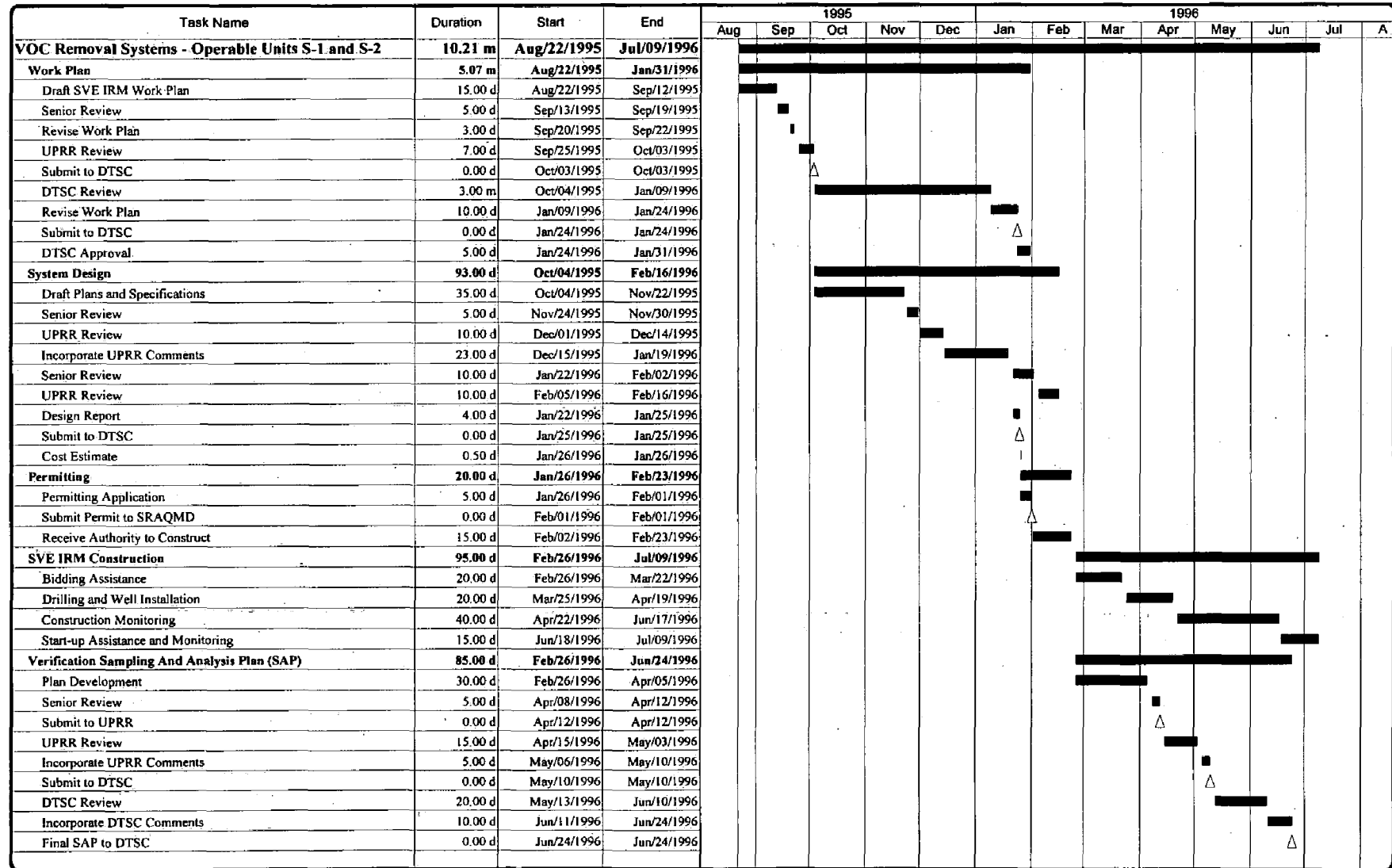
- EXISTING GROUNDWATER MONITORING WELL
- EXISTING UTILITY POLE
- PROPOSED VAPOR EXTRACTION AND AIR SPARGING WELL
- PROPOSED VAPOR EXTRACTION WELL
- APPROXIMATE LATERAL EXTENT OF VOCs IN SOIL VAPOR
- APPROXIMATE LATERAL EXTENT OF TPHg IN SOIL MATRIX
- LATERAL EXTENT OF GROUNDWATER PLUME (OPERABLE UNIT GW-1)
- VAPOR COLLECTION PIPING
- DESIGN RADIUS OF INFLUENCE
- SHALLOW GROUNDWATER FLOW DIRECTION



00173080, BLS BASED, 07/20/05 11

REFERENCES		REVISIONS		REVISIONS		DRAWING SCALE	AS NOTED		URBAN PACIFIC RAILROAD YARD VOC REMOVAL SYSTEMS SACRAMENTO, CALIFORNIA	JOB NO. 00173080	
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	△		△			CHECKED BY:				8	
	△		△			APPROVED BY:					

**FIGURE 9
REVISED VOC REMOVAL SYSTEMS DESIGN AND IMPLEMENTATION SCHEDULE
UNION PACIFIC RAILROAD SACRAMENTO YARD SITE**



Revised: Jan/29/1996
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