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GROUNDWATER
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FINAL FEASIBILITY STUDY

OSMOSE WOOD PRESERVING, INC.
980 ELLICOTT STREET
BUFFALO, NEW YORK

NYSDEC SITE No. 915143

GTI Project: 011108061

December 22, 1995

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ABBREVIATIONS

ARAR	applicable or relevant and appropriate requirement
ASC	acceptable soil concentrations
BRA	baseline risk assessment
BSA	Buffalo Sewer Authority
BTEX	benzene, toluene, ethylbenzene, and xylene
CAA	Clean Air Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm/sec	centimeters per second
CFR	Code of Federal Regulations
COI	chemicals of interest
CWA	Clean Water Act
ECL	Environmental Conservation Law
EPA	Environmental Protection Agency
FS	feasibility study
IRM	interim remedial measure
LDR	load disposal restrictions
MCL	maximum contaminant level
ug/L	micrograms per liter
mg/kg	milligrams per kilogram
NCP	National Contingency Plan
NFTA	Niagara Frontier Transit Authority
NYSDEC	New York State Department of Environmental Conservation
OSHA	Occupational Safety and Health Administration
PAH	polycyclic aromatic hydrocarbon
POTW	publicly owned treatment works
PPM	parts per million
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RIFS	remedial investigation/feasibility study
RAO	remedial action objectives
ROD	record of decision
SARA	Superfund Amendments and Reauthorization Act
SB	soil borings
SCGs	standards, criteria, and guidance
TBC	to be considered
SDWA	Safe Water Drinking Act
SPDES	State Pollution Discharge Elimination Systems
TCLP	toxicity characteristic leaching procedure
TSD	treatment, storage, and disposal
UST	underground storage tank
VOCs	volatile organic compounds

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1

1.0 INTRODUCTION

1.1 Purpose and General Approach

This feasibility study presents an evaluation of remedial alternatives which was used to aid in documenting the selection of a remedial strategy to treat medias impacted by hydrocarbon wastes at the Osmose Wood Preserving, Inc. site in Buffalo, New York. On February 14, 1995, Osmose received notification of the re-classification of the site on the New York State Registry of Inactive Hazardous Waste Sites from a Class 2a to a Class 2 site. The site identification number is 915143. Osmose has voluntarily entered into a formal Order on Consent (Index No. B9-0314-90-01) with the New York State Department of Environmental Conservation (NYSDEC). As part of the Order on Consent, Osmose has agreed to prepare and submit to the NYSDEC a feasibility study which evaluates on-site and off-site remedial actions. Osmose submitted to the NYSDEC a Table of Contents outline for the development and performance of the feasibility study. The Table of Contents was approved by the NYSDEC and incorporated in the Order.

The purpose of this report is to define a preferred remedial action strategy which could be used to recover and mitigate the impacts of historical subsurface hydrocarbon releases to the environment. This feasibility study has been conducted following the procedures for performing feasibility studies as outlined in the Environmental Protection Agency's (EPA's) document *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA*, EPA/540/G-8-9/004 (October, 1988) and the NYSDEC's guidance document titled *Selection of Remedial Actions at Inactive Hazardous Waste Sites* (TAGM No. HWR-90-4030, May 15, 1990). The analysis and conclusions in this report are based on data collected since August 1990.

Based on the extent of work conducted and previously reported for the site, including identification of general response actions and preliminary screening of remedial alternatives, and the performance of three interim remedial measures (IRMs), including one treatability study, the intention of the feasibility study report is to focus on the detailed analysis of alternatives, while providing less detail in the general response and preliminary screening sections. This approach meets the requirements of the NYSDEC as discussed during a project status meeting conducted on July 5, 1994 at the Region 9 office in Buffalo, New York, and the intent of the outline incorporated into the Order.

A brief history of previous investigations performed at the site and a description of the geologic and hydrogeologic settings are presented below in this section. Section 2.0 presents a summary of the hydrocarbon source description including an estimate of the volumes of impacted media. Section 3.0 presents the remedial action objectives (RAOs) for the impacted medias. Section 4.0 briefly presents a preliminary screening of various remedial alternatives based on implementability, effectiveness, and cost. The results of the IRMs conducted (and ongoing) at the Osmose site are included in section 5.0. Section 6.0 presents the detailed analysis of retained alternatives and section 7.0 presents the preferred remedial strategy for the Osmose site.

Due to the volume of data collected at the Osmose site, data tables are presented in the Tables section at the end of the report. Where appropriate, summary tables are included in the text.

1.2 Site Background

The Osmose site is located at 980 Ellicott Street, Buffalo, New York, and serves as the executive and accounting offices, along with research and product production (figure 1-1, Site Location Map). Osmose manufactures a variety of preservatives used in the treatment of lumber and wood products. The facility employs approximately 110 people from Buffalo and the surrounding communities.

Osmose purchased the site in the winter of 1951. City directories indicate that residential and automotive repair facilities were located on the property as early as 1910. Between 1910 and 1950 several automotive repair shops were listed on Ellicott Street beginning at the Osmose site's northern boundary and extending southward to Best Street. Other operations reported to exist on, or bordering the site, include a florist (circa 1930 - 1940), a sheet metal works (circa 1930), a plumbing supplier (circa 1946), and a letter service company (circa 1950 - 1960).

Other manufacturing or industrial operations bordering the site include P & R Wire Forming, Inc. (Southeast of Osmose on Ellicott Street) and a Niagara Mohawk Power Corporation substation located south of the site on Best Street.

The source of the subsurface hydrocarbon impacts identified at the Osmose site are believed to be associated with a former underground storage tank (UST) system. Prior to the UST's closure by removal in August 1989, three compartmentalized tanks were used for the storage of bulk deliveries of raw materials required in the manufacture of wood preservatives. The following materials were previously stored in the USTs:

- Brushing grade creosote; stored until August 1989
- No. 2 fuel oil; stored until August 1989
- Mineral spirits; stored until 1986
- Isopropyl alcohol and diacetone mixture; stored until 1984
- Coal tar; stored until 1964

Preliminary subsurface investigation of the site began in August 1990. Several subsequent investigations of the site were conducted to better delineate the extent of hydrocarbon impacts. A summary of the previously submitted work plans, and subsequent reports of the findings, along with the results of remedial activities conducted at the site include the following:

- *Subsurface Investigation Work Plan for Osmose Wood Preserving, Inc.*, Buffalo, New York, June 7, 1990.
- *Subsurface Investigation Report*, Osmose Wood Preserving, Inc., 980 Ellicott Street, Buffalo, New York, June 28, 1991.
- *Supplemental Investigation Work Plan*, Osmose Wood Preserving, Inc., Buffalo, New York, March 9, 1992.
- *Supplemental Investigation Report*, Osmose Wood Preserving, Inc., Buffalo, New York, June 23, 1992.
- *Supplemental Investigation (Phase II) Work Plan*, Osmose Wood Preserving, Inc., Buffalo, New York.
- *Supplemental Investigation (Phase II) Report*, Osmose Wood Preserving, Inc., Buffalo, New York, August 31, 1993.
- *Off-Site Surface Soil Excavation Work Plan*, Osmose Wood Preserving, Inc., August 12, 1994.
- *Off-Site Surface Soil Removal Report*, Osmose Wood Preserving, Inc., January 31, 1995.
- *Sewer Sampling Work Plan,* Osmose Wood Preserving, Inc., July 19, 1995.
- *Sewer Sampling Results,* Osmose Wood Preserving, Inc., August 18, 1995.

Bench- and pilot-scale studies and field demonstration studies are almost invariably required to adequately assess the feasibility of innovative or emerging technologies. Treatability studies are typically conducted during the investigation phase so that all necessary information is available prior to the preparation of the feasibility study. Work plans and reports associated with the IRMs conducted at the site include the following:

- *Design of Biocell for* In Situ *Bioremediation of Soils*, Osmose Wood Preserving, Inc., Buffalo, New York. January 4, 1990.
- *Ozone Pilot Test Work Plan*, Osmose Wood Preserving, Inc., Buffalo New York, September 25, 1992.

- *Ozone Injection Feasibility Study Report*, Osmose Wood Preserving, Inc., 980 Ellicott Street, Buffalo, New York, April 5, 1994.
- *LNAPL IRM Upgrade Work Plan*, Osmose Wood Preserving, Inc., September 7, 1994.

Site information collected and reported in the above referenced documents is presented in the following sections, where required.

2

2.0 SOURCE DESCRIPTION

Presented in the following sections is a summary of the characterization of hydrocarbon impacts at the Osmose site. Mass balance calculations, which estimates the relative distribution of hydrocarbons in the subsurface media, are also presented.

2.1 Summary of Source Characterization

A summary of the nature and extent of impacts to soil and groundwater at the site is summarized in this section based on the results of the previous site investigations (section 1.2). These investigations determined that volatile organic compounds (VOCs) specifically benzene, toluene, ethylbenzene, and xylene (BTEX) and polycyclic aromatic hydrocarbon (PAH) compounds are considered the chemicals-of-interest (COI) at the site. These COIs are present at the site at varying concentrations as adsorbed, dissolved, and separate phases. The data presented below and the associated discussions focuses on these COIs.

Figures 2-1, 2-2, and 2-3 illustrate the distribution of adsorbed and dissolved PAHs at the site. Figures 2-4, 2-5, and 2-6 illustrate the distribution of adsorbed and dissolved VOCs. The distribution of light nonaqueous phase liquid (LNAPL) is presented in figure 2-7.

As can be seen from the figures, the hydrocarbon impacts exist primarily around and downgradient of the former tank farm.

Data tables, which summarize all associated data collected to date for the COIs, are included in the table section at the end of the report. Specifically, adsorbed VOCs on soils is presented in table 2-1, dissolved VOCs in groundwater are presented in table 2-2, while adsorbed and dissolved PAH data are presented in tables 2-3 and 2-4, respectively.

Wastes associated with the Osmose site have been determined to be classified as Code U051, per the Resource Conservation and Recovery Act (RCRA) 40 CFR Part 261.33, Identification and Listing of Hazardous Wastes. The listing basis for creosote is its toxicity characteristic. Residues or contaminated soil, water, or other debris resulting from the clean up of a spill of creosote into or on any land or water are also held by Part 261.33 to be U051-listed hazardous wastes.

Interpretation of 40 CFR Parts 261 and 266 indicated that unless and until a listed hazardous waste meets the criteria of paragraph (d) of Part 261.3 (relating to the removal of a hazardous characteristic), the hazardous waste will remain a hazardous waste. Therefore, the only way to make a listed hazardous waste non-hazardous would be to delist it, which is an extremely involved and expensive process. For this reason, recycling of wastes at the Osmose site was interpreted to be not feasible.

2.2 Affected Soil Volumes and Mass

A hydrocarbon mass estimate for each media impacted was developed for the *Supplemental Investigation (Phase II) Report*. The mass estimate has been revised to reflect additional data collected subsequent to publication of the Phase II report. The mass balance estimate of the relative distribution of hydrocarbons is presented in table 2-5. A pie chart, which pictorially summarizes the results from table 2-5, is included as figure 2-8. An estimated 10,500 pounds (1,250 gallons) of fugitive hydrocarbons existed in the subsurface at the site. This estimate does not include any hydrocarbons which may exist under the southeastern corner of the Osmose facility. The major assumptions used when calculating the hydrocarbon mass estimates are presented in appendix A.

A summary discussion of the hydrocarbon mass distribution for each phase is presented below.

2.2.1 Adsorbed Phase

During the course of the investigation, 56 subsurface soil samples were collected and sent for laboratory analysis during the installation of 2 soil borings and 25 monitoring wells. Additional soil samples were collected during the ozone feasibility study. The data quality objectives for these samples, however, did not require extensive QA/QC or data validation, and many samples were collected once the feasibility study treatment had begun. For these reasons, those data are not included in tables 2-1 through 2-4. A complete discussion of the analytical data can be found in the site investigation reports referenced above. The subsurface soil samples were analyzed for volatile organics by EPA Modified Method 8020 for either BTEX or BTEX plus chlorobenzenes. Soil samples were analyzed by EPA Method 8310 for PAHs, or EPA Method 8270 for semivolatiles. Tables 2-1 and 2-3, included in the tables section, present a summary of the analyses for adsorbed volatiles and semivolatiles, respectively. The sum of the individual PAHs refers to the 16 PAH analytes on the EPA's priority pollutant list given in table 2-6. The table also identifies those PAHs considered possible human carcinogens by the EPA.

The maximum adsorbed concentrations detected during the site investigations were 9.1 ppm VOCs and 640 ppm PAHs (locations: MW-16, MW-13). Adsorbed-phase hydrocarbons make up approximately 24 percent of the total hydrocarbons present at the site, with an estimated mass of approximately 2,500 pounds (300 gallons). Adsorbed-phase hydrocarbons in the saturated zone account for about 21 percent of total hydrocarbons, while those in the unsaturated zone account for only about 3.3 percent of total hydrocarbons.

An important factor controlling the movement of hydrocarbons on site is the presence of a clay layer approximately 3 to 8 feet below grade in the plume area (see figures 2-9 and 2-10, Geologic Cross Sections). The upper boundary of the clay layer is sharply defined, while the lower boundary consists of a gradational change with increasing depth to silt and eventually to fine sand. The clay itself is highly impermeable to both air and water, as observed during soil boring events and demonstrated by the results of permeability testing and soil vapor extraction testing performed as part of the ozone injection feasibility study. Hydraulic conductivity ranged from 10^{-3} to $<10^{-7}$ cm/sec while air conductivity ranged from 10^{-4} to 10^{-10} cm/sec. As the silt content of the clay increases with depth, there is a corresponding increase in permeability. At approximately 7 feet below grade, the clay becomes silty enough that groundwater can penetrate from the aquifer beneath. This boundary at the 7 foot level provides an important constraint on the migration of hydrocarbon compounds. Almost no hydrocarbons were found in the clay layer between 3 feet and 6 feet; intermediate concentrations were found between 6 feet and 7 feet.

Estimates of the distribution of adsorbed-phase hydrocarbons within the clay layer indicate that approximately 1,000 pounds of hydrocarbons (120 gallons) are adsorbed in the clay layer, representing about 9 percent of total hydrocarbons (or approximately 40% of the total adsorbed loading). These hydrocarbons are believed to be adsorbed on the outer surface of the clay layer.

The areal extent of VOCs and PAHs has been well defined. Figure 2-4 presents the horizontal and vertical distribution of VOCs in the subsurface. Additionally, figures 2-9 and 2-10 present the horizontal and vertical distribution of PAHs along an east-west axis and along a north-south axis respectively.

2.2.2 Dissolved Phase

A total of 23 fiberglass reinforced epoxy (FRE) monitoring wells and 9 FRE recovery wells were installed at the Osmose site between October 1990, and May 1995. Although the screened intervals at each monitoring well varies slightly based on variations in stratigraphy, all monitoring wells, with the exception of deep wells MW-14, MW-18, MW-19 and cluster well CW-1, are screened between 1.5 to 28 feet below grade in the shallow aquifer. The four deep wells are screened from bedrock to 5 feet above bedrock.

Four groundwater samplings were conducted as part of the investigations (November 1990, January 1991, December 1992, and March 1993). A complete summary of the analytical data can be found in the site investigation reports referenced above. The collected groundwater samples were analyzed for volatile organics by either Modified EPA Method 602 (Purgeable Aromatics), EPA Method 8010 (Purgeable Halocarbons), or EPA Method 8020 (Aromatic Volatile Organics). Groundwater samples were analyzed for PAHs by either EPA Method 610 or EPA Method 8310. Tables 2-2 and 2-4 , included in the tables section, presents a summary of the dissolved VOCs and semivolatiles in groundwater from the December 1992 and March 1993 sampling events.

The maximum dissolved concentrations detected during the site investigation were 2.4 ppm volatiles (at MW-13) and 12 ppm PAHs (at MW-17). Dissolved-phase hydrocarbons make up about 0.2 percent of the total hydrocarbons present at the site, with an estimated mass of approximately 20 pounds (2.3 gallons).

During the most recent groundwater sampling event, dissolved VOCs were detected in the shallow aquifer from MW-17 on the north to MW-9 on the south, and from MW-24 on the west to the sewer line on the east (figure 2-5). Dissolved PAHs were detected over the same general area, with the southern edge of the plume located in the vicinity of MW-15. Low levels of dissolved PAHs (<5 ppb) were detected in several wells outside of the main plume area (figure 2-2). It appears that the municipal sewer line owned and operated by the Buffalo Sewer Authority (BSA) which is located beneath Ellicott Street has acted as a barrier, preventing migration of the shallow dissolved plume to the east.

During the same sampling event, the four deep groundwater monitoring wells were sampled. Low levels of volatile compounds (<15 ppb) and PAHs (<250 ppb) were detected in monitoring wells CW-1 and MW-18 (see figures 2-3 and 2-6).

2.2.3 Separate Phase

Separate-phase, light non-aqueous phase liquids (LNAPL) account for the majority of the hydrocarbon mass in the subsurface at the site. The task of estimating LNAPL volumes based on monitoring well observations is difficult, and therefore the separate-phase mass estimate represents the largest uncertainty in the total hydrocarbon mass estimate. Subsequent to the Supplemental (Phase II) Report, observations of LNAPL thicknesses made during the ozone injection feasibility study and the LNAPL recovery IRM were used to adjust the hydrocarbon mass estimate for the site. The estimated average LNAPL thickness across the plume area was changed from 0.02 feet to 0.05 feet.

Based on these observations, an estimated 8,000 pounds (950 gallons) of LNAPL exist in the subsurface at the site. This represents about 75 percent of the hydrocarbons present at the site. These separate-phase hydrocarbons reside primarily in the silt/sand layer directly beneath the clay layer, from approximately 8 to 12 feet below grade.

The areal extent of LNAPL has been estimated and is presented in figure 2-7, Areal Extent of LNAPL. As shown in the figure, the BSA municipal sewer line appears to act as a barrier and inhibit the downgradient migration of LNAPL. Construction drawings obtained from the City of Buffalo indicate that the sewer's dimensions are 4.5 feet in width and 7 feet in height.

2.2.4 Municipal Sewer Sampling

In January 1993, water samples were collected from the BSA's combined sanitary/storm sewer which exists beneath Ellicott Street in front of the Osmose facility. Two samples were collected: one upstream from Osmose at an access manway located at the intersection of Best and Ellicott Streets; and one located in front of the Osmose facility at the intersection of Ellicott Street and Edna Place.

The municipal sewer water samples were analyzed for PAHs by EPA Method 8310. Total compounds detected by these analyses included 20 ppb total PAHs at the location upstream from the Osmose facility, and 1,400 ppb total PAHs (including 1-, and 2-Methylnapthalene) at the location adjacent to the Osmose facility. These results were included within the *Supplemental Investigation (Phase II) Report* submitted to the NYSDEC on August 31, 1993.

Sediments from the sanitary/storm sewer system were collected on November 29, 1993, from the same two sampling locations from which the water samples were collected. Analysis was once again performed by EPA Method 8310. Results indicated that 146.6 parts per million (ppm) total PAHs were detected upgradient of the Osmose facility and 56.9 ppm were detected from the location in front of the facility.

A second sewer sampling event was conducted on July 24, 1994. A total of six water samples and four sediment samples (plus QA/QC samples) were collected and sent for laboratory analysis. As referenced in the *Sewer Sampling Results* report dated August 18, 1995, both dissolved PAHs in sewer water and adsorbed PAHs on sewer sediments were higher upgradient of the Osmose site than downgradient. The report concluded that COIs from the Osmose site are not infiltrating the sewer and therefore no remedial action within the sewer is required. Consideration of the combined sewer system as part of the remedial actions for the site is therefore not warranted.

3

3.0 REMEDIAL ACTION OBJECTIVES

3.1 Applicable Standards, Criteria, and Guidelines

The Osmose site is currently listed on the New York State Registry of Inactive Hazardous Waste Disposal Sites as a Class 2 site. As an inactive hazardous waste site, potential remedial actions must be evaluated for conformance with environmental standards and criteria. The NYSDEC document *Inactive Hazardous Waste Disposal Site Remedial Program, 6 NYCRR Part 375* dated May 1992 was promulgated to promote the orderly and efficient administration of ECL Article 27, Title 13. Specifically, this part pertains to the development and implementation of remedial programs under authority of ECL Article 27. Subpart 375-1.10(c)(1) applies specifically to the consideration of "standards, criteria and guidance" (SCGs) when selecting a remedy for a site.

This section identifies New York State SCGs and federal applicable or relevant and appropriate requirements (ARARs) which provide numerical criteria which may be compared to COI concentrations found on site. SCGs are evaluated throughout the feasibility study process. Initial evaluation occurs during the development of the remedial action objectives (RAOs) for each media. Subsequent evaluations occur during the screening of preliminary site remedial alternatives and later during the detailed analysis of retained alternatives.

Federal ARARs are those standards, guidance or requirements that implement the statutes of the . Federal government. Examples of ARARs include the Clean Air Act (CAA), the Clean Water Act (CWA), or the Solid Waste Disposal Act (SWDA). Review of applicable ARARs was completed for criteria which are more stringent than New York State SCGs. The review did not identify more stringent cleanup criteria for the identified COIs at the Osmose site.

An evaluation of the chemical-specific, location-specific, and action-specific SCGs which are potentially applicable to the site is presented. Chemical-specific SCGs may be used to establish action levels for impacted site media (e.g., groundwater standards) which are protective of human health or the environment. Chemical-specific SCGs are also used to establish acceptable standards which may apply to the treatment process, such as permitted discharge levels of pumped water. As determined during the previous investigations, the COI for the site are-the PAHs and VOCs (specifically BTEX). Potential chemical-specific SCGs have been identified for soil, groundwater, air, and solid waste. The chemical-specific SCGs for air and solid waste may be applicable during disturbance activities associated with remedial actions.

Location-specific SCGs are applicable if the site is located on, or proximate to, floodplains, fault zones, wetlands, historic areas, critical habitats for endangered species, coastal areas, etc. Location-specific SCGs reviewed are not applicable at the Osmose site.

Table 3-1 presents a summary of the primary state SCGs and federal ARARs for soil, groundwater, air and solid waste at the Osmose site.

In summary, the SCGs as determined for the Osmose site include the following:

Soil

- NYSDEC Determination of Soil Cleanup Objectives and Cleanup Levels, TAGM HWR-94-4046
- SWDA/RCRA, Identification and Listing of Hazardous Wastes, 40 CFR Part 261
- SWDA/RCRA, Land Disposal Restrictions, 40 CFR Part 268

Groundwater

- NYSDEC Ambient Water Quality Standards and Guidance Values, TOGS 1.1.1
- State Pollution Discharge Elimination System (SPDES), 6NYCRR Parts 750-758

Air

- NYSDEC Air Guide 1 (Draft), 6NYCRR Part 212

Solid Waste

- SWDA/RCRA, Identification and Listing of hazardous Wastes, 40 CFR Parts 261 - 261.4.

The review of applicable SCGs, together with the results of a site specific baseline risk assessment (section 3.2, below) provide a framework for determination of site action levels and remediation clean-up goals. This information forms the basis for evaluating the need to conduct remedial action, and the extent of treatment, if required.

TABLE 3-1
Standards, Criteria, and Guidelines Evaluation

Requirements Criteria	Citation	Description	Evaluation Decision	Evaluation Comment
Federal				
Solid Waste Disposal Act (SWDA)/Resource Conservation and Recovery Act (RCRA)	40 U.S.C §6901-6987			
Identification and Listing of Hazardous Wastes	40 CFR Part 261	Outlines criteria for determining if a solid waste is a hazardous waste and is subject to regulation under 40 CFR Parts 260-266.	Applicable	Site wastes have been determined to be listed hazardous wastes. These regulations do not set clean up standards, but would apply during various remedial actions.
Land Disposal Restrictions	40 CFR Part 268	Establishes constituent-specific standards to which hazardous wastes must be treated prior to land disposal.	Applicable	These requirements would be applicable to hazardous wastes that are land disposed as part of a remedial action.
Clean Air Act (CAA)	42 U.S.C §7401-7642			
National Primary and Secondary Ambient Air Quality Standards (NAAQS)	40 CFR Part 50	Establishes ambient air quality standards for protection of public health.	Potentially applicable	NAAQS may be applicable in evaluating whether there are air impacts at a site prior to remediation, or during long-term remediation programs.
Clean Water Act (CWA)	33 U.S.C. §1251-1376			
Ambient Water Quality Criteria Guidelines	40 CFR Part 141	Establishes MCLs for the treatment of groundwater for public potable water supplies.	Relevant and appropriate	Ambient quality criteria would be relevant and appropriate criteria for remedial actions resulting in discharges to groundwater.
Safe Drinking Water Act (SDWA)	40 U.S.C. §300			
National Primary Drinking Water Standards	40 CFR Part 141	Establishes maximum contaminant levels or MCLs, which are health-based standards for public water systems.	Relevant and appropriate	These standards are relevant and appropriate because of the potential for future use of groundwater.
Maximum-Contaminant Level Goals (MCLGs)	40 CFR 141.50-141.51	Non-enforceable health goals for public water systems.	To be considered	These are advisories rather than standards and will be treated as TBC criteria

TABLE 3-1

Standards, Criteria, and Guidelines Evaluation

Requirements Criteria	Citation	Description	Evaluation Decision	Evaluation Comment
STATE				
New York State Pollution Discharge Elimination System	6 NYCRR parts 750-758	Defines permitting requirements for discharges.	Potentially applicable	The regulations would be applicable for alternatives that include discharge to surface water.
Ambient Water Quality Standards and Guidance Values	6 NYCRR §700-705 TOGS 1.1.1	Establishes quality standard for groundwater and incorporates federal MCLs and standards from other state regulations.	Potentially applicable	These standards apply to all fresh waters found in the saturated zone.
Groundwater Effluent Standards	6 NYCRR §700-705	Establishes effluent standards and/or limitations for discharges to Class GA groundwater.	Potentially applicable	These regulations would be applicable for alternatives that include discharges to groundwater.
New York State Environmental Conservation Law	Article 27, Title 13		Applicable	The Osmose site is listed on the state inactive hazardous waste site registry as a Class 2 site.
Determination of Soil Clean-Up Objectives and Clean-Up Levels	TAGM HWR-94-4046	Establishes general clean-up goals for environmental media, to levels that will eliminate a significant threat to the environment.		
New York State Air Guide 1	6 NYCRR §212	Provides guidance for permitting emissions from new or exiting sources.	Applicable	These regulations would be applicable for alternatives that include off-gas discharges to the atmosphere

3.2 Baseline Risk Assessment

Envirologic Data, a former division of Groundwater Technology, was contracted to perform a baseline risk assessment (BRA) for the site. The BRA was based on data collected during the subsurface investigation conducted between August 1990 and January 1991. The BRA report, including rational, methodology, calculations, and conclusions, were included in section 6.0 of the *Subsurface Investigation Report*. A brief summary is presented below.

The BRA is used as part of the overall regulatory evaluation process, the purposes of the BRA:

- provide an analysis of baseline risks to help determine the need for remedial action at the site
- provide a basis for determining levels of chemicals that can remain on site and still be protective of human health and the environment
- provide a basis for comparing potential health impacts of various remedial alternatives
- provide a process for evaluating and documenting site specific potential health threats at the site

The specific objectives of the BRA were to assess the magnitude and probability of actual or potential harm to the public health and the environment caused by releases of hydrocarbons from the Osmose site. In the report, three areas were addressed relative to soil conditions and potential exposure to COI in the soil. Additionally, potential health risks associated with exposure to on- and off-site groundwater were evaluated. Specifically, these media included the following:

- on- and off-site groundwater
- the on-site soil bioremediation treatment cell (biocell)
- on-site, non-biocell soils (on-site)
- off-site locations along Ellicott Street adjacent to the site (off-site)

3.2.1 Summary of Results

Envirologic Data applied accepted quantitative risk assessment methodology to evaluate the COI detected in soils and groundwater, and potential exposure to those compounds associated with hypothetical future exposure scenarios to characterize baseline risks associated with a no-action alternative. The results of the baseline analysis were applied in conjunction with site-specific environmental conditions to derive risk-based clean-up objectives for soils and groundwater.

Groundwater

Relative to groundwater, exposure and risk evaluations were conducted based on data collected during the subsurface investigation from shallow monitoring wells. The BRA identified dermal contact with impacted groundwater by utility workers as the only substantive exposure scenario. Revised risk calculations, based on additional data collected during the supplemental investigation, were prepared. The total potential carcinogenic risk associated with the exposure to on- and off-site groundwater was estimated to be approximately 2×10^{-6}, which is within the EPA target range for acceptable risk (1×10^{-4} to 1×10^{-6}). Likewise, the total hazard index for non-carcinogenic risks was calculated to be approximately 4×10^{-1}, below the EPA-defined criterion of 1.0 for acceptable risk.

Soil

Based upon the analyses conducted for inorganic compounds, Envirologic Data concluded that metals in the soils are generally low as compared with background levels (Kingsbury and Ray, 1986) and that there were no known site-related activities which might be a source of metal contaminants. For these reasons, metals were not selected for quantitative exposure and risk assessment.

Presented in table 3-2 below is a summary of the sum of the total hazard indices associated with non-carcinogenic health effects and cumulative risk estimates for carcinogenic health effects from on-site (biocell) soils, on-site (non-biocell) soils, off-site soils, and groundwater.

For calculation of acceptable soil concentrations (ASCs), potentially carcinogenic PAHs were evaluated individually based on the interim EPA oral cancer potency factor for benzo{a}pyrene and using estimates for relative potency for other carcinogenic PAHs. Naphthalene was selected as the representative indicator compound for non-carcinogenic PAHs. Assuming an acceptable risk level of 1×10^{-5}, the calculation indicated that a total potentially carcinogenic PAH concentration of 473 ppm or less is protective of human health. The calculation for non-carcinogenic health effects indicated that a total PAH concentration of 3,182 ppm or less in soils is health-protective.

TABLE 3-2
Hazard Indices and Risk Estimates

Media	Hazard Index	Risk Estimate
On-site, Biocell Soils	1.0×10^{-1}	9.07×10^{-6}
On-site, Non-biocell Soils	4.6×10^{-2}	1.01×10^{-6}
Off-site Soils	1.8×10^{-6}	2.07×10^{-10}
Groundwater	4.0×10^{-1}	2.0×10^{-6}

3.3 Remedial Action Objectives

The remedial action objectives (RAOs) for the site were developed based on an evaluation of the data from the various investigation studies, the site risk assessment, and from the review of the applicable SCGs. Discrete areas and impacted medias at the Osmose site have been identified and therefore individual RAOs are presented below. The objective of remedial action at the Osmose site is to protect human health and the environment by remediating the source of contamination and eliminating potential exposure pathways.

In a correspondence dated March 28, 1994 (Doster to Ahrens), the NYSDEC had identified the following media which require remediation:

- Off-site Surface Soils
- LNAPL
- On-site Subsurface Soils
- Groundwater

The RAO for each of these media is discussed in the paragraphs below.

3.3.1 Off-Site Surface Soils

In the March 28, 1994, correspondence, the NYSDEC indicated that PAHs in shallow soil on the property south of the site, which is owned by the Niagara Frontier Transit Authority (NFTA), were attributed to the Osmose site. Osmose has maintained that sufficient technical data has been submitted in the *Supplemental Feasibility Report*, the *Supplemental Investigation (Phase II) Report*, and a letter (Ahrens to Doster) dated April 12, 1994, that the origin of the PAHs detected in the off-site surface soils are not from the Osmose site, but rather from anthropogenic and other non-Osmose related sources. Based on discussions during a project meeting in the NYSDEC's Buffalo office in July 1994, Osmose agreed to prepare a work plan for the excavation of surface soils from the NFTA property.

As stated during the referenced meeting, and again in the *Off-Site Surface Soil Excavation Work Plan*, the work plan to perform a limited excavation did not imply that Osmose accepts responsibility for the origin of the PAHs, but rather the excavation of soils was seen as a mechanism to expedite the site remediation activities. The objective was to excavate until testing indicated that PAH concentrations reached background levels, or until the NYSDEC and Osmose personnel on-site were satisfied.

The surface soil excavation was performed on November 30, 1994. The procedures and results of the excavation activities were presented in the *Off-Site Surface Soil Removal* report dated January 31, 1995. Excavation was performed with a front-end loader. Soils were placed directly into dump trucks and transported to an approved landfill for disposal. A total of nine soil samples from the excavated area were analyzed using an immunoassay test kit. The field testing results, along with visual observations, were used to determine the extent of excavation. As per the work plan, two endpoint soil samples were collected for laboratory analysis to confirm the field testing results. A total of approximately 37 tons of soils were removed during the excavation activities.

When the results of the laboratory analysis of the endpoint samples became available, they were forwarded to the NYSDEC, who, upon review, gave Osmose permission to backfill the shallow excavation. Backfilling with clean fill and seeding was completed on December 27, 1994.

Based on the removal and disposal of the subject soils, the RAO has been achieved. No further RAOs for off-site surface soils exist.

3.3.2 LNAPL

As indicated in section 2.2.3, an LNAPL plume exists adjacent to and immediately downgradient of the former tank pit. The LNAPL is believed to be a mixture of No. 2 fuel oil and brushing grade creosote. The proposed RAO is recovery of the LNAPL.

3.3.3 On-Site Subsurface Soils

In the risk assessment performed by Envirologic Data, a residual chemical concentration in soil, or ASC, was developed for on-site subsurface PAHs. Because the potential exposure scenarios are similar, these ASCs represent both on-site biocell soils and on-site non-biocell soils. Using conservative assumptions, and the assumption of an acceptable risk level of 1×10^{-5}, the calculation indicated that a total carcinogenic PAH concentration of 473 ppm or less is protective of human health. For non-carcinogenic health effects, the calculation indicated that a total PAH concentration of 3,182 ppm or less in the soil is health-protective.

In the March 28, 1994, letter from the NYSDEC (Doster to Ahrens), remedial action objectives for on-site subsurface soils were stated. According to the letter, on-site soils above the following levels will require remediation:

Total PAHs	473 ppm
Total Carcinogenic PAHs	50 ppm
Total Benzo{a}pyrene	10 ppm
Total VOCs	10 ppm

Additionally, these RAOs require that Osmose maintain cover (e.g., asphalt) over the affected soils and file appropriate deed notifications on the subject property.

As identified in section 3.1, the NYSDEC has provided recommended soil clean-up objectives which are included in TAGM HWR-94-4046. These general soil clean-up objectives are similar to the proposed RAOs included in the NYSDEC's March 28, 1994, correspondence (Doster to Ahrens). Both the TAGM and the proposed RAOs in the March 28, 1994, correspondence, however, are below the site-specific ASCs developed by the BRA. The RAOs presented for on-site subsurface soils in the March 28, 1994, correspondence from the NYSDEC, however, are consistent with Osmose's objectives for the site. This 473 ppm total PAH objective will be based on the 16 PAH analytes on the EPA's priority pollutant list given in table 2-6.

As presented in section 2.2.1, hydrocarbon impacts have not been identified within the clay layer on site; the impacts have primarily been located on the surface on the clay. For this reason, along with the physical properties of the clay, *in situ* treatment options (after source removal is completed) will not address treatment of the clay layer.

The presence of the COI has not been confirmed beneath the Osmose facility. However, it would appear that to some extent, LNAPL, and therefore adsorbed COI, may exist beneath the southeast corner of the Osmose facility. Once LNAPL recovery has been completed, the existing facility's concrete foundation will serve as an effective barrier (i.e., cap) to eliminate any potential exposure to employees, workers, and residents to residual COI that may exist after any LNAPL is removed. It is anticipated that in the absence of LNAPL, natural biodegradation will occur and eventually reduce the concentration of the lighter fractions of any hydrocarbons that may exist. A Declaration of Covenants and Restrictions (deed restriction) has been filed by Osmose (dated July 20, 1995), which defines the portion of the site affected by the release (operable unit) and defines conditions, covenants, and restrictions for that area. Treatment of these soils on–site subsurface is neither feasible nor proposed for the following reasons:

- Delineation of the extent of soils above the RAO, if any, is not feasible and therefore neither is delineation of an associated treatment area, if required.
- A rubble stone foundation is present beneath this portion of the Osmose facility; no additional information is known about the subsurface geology.
- Excavation beneath the facility is not feasible as well as monitoring the effectiveness or efficiency of any *in situ* treatment, including any vapors created as part of a treatment process.

Based on the above RAO for on-site soils, an estimated total of approximately 720 yd^3 of soil exist which requires remediation.

3.3.4 Groundwater

The results of the calculation of risk-based groundwater concentration levels showed that the estimated potential carcinogenic risk associated with exposure to on- and off-site groundwater was approximately 2×10^{-6}, which is within the EPA's target risk range. Likewise the total hazard index for non-carcinogenic risks was calculated to be 4×10^{-1}, below the EPA criterion for acceptable risk.

Although risk estimates associated with exposure to groundwater are within the EPA's target risk range, concentrations of several analytes exceed NYS Class GA Ambient Groundwater Standards at several locations. Groundwater Class GA, as defined in TOGS 1.1.1, is water whose best usage is a source of drinking water. No public use of groundwater wells exists within a 0.5-mile radius of the site. Municipal water is supplied for drinking.

The dissolved plume is centered in the Ellicott Street entrance gate area immediately downgradient of the former tank pit. Mass balance calculations indicate that the dissolved constituents total less than 1% of all hydrocarbons at the site.

The RAO for groundwater at the Osmose site includes maintaining groundwater standards as identified in the NYSDEC's *Ambient Water Quality Standards and Guidance Values*, TOGS 1.1.1, at three point-of-compliance wells located immediately downgradient of the Osmose site. Existing shallow monitoring well MW-11 and a proposed new shallow monitoring well MW-28 are proposed as the point-of-compliance wells for shallow groundwater. The proposed location of MW-28 would be in the right-of-way on the east side of Ellicott Street adjacent to MW-14. Monitoring well MW-14 is proposed for use as a point-of-compliance well for deep groundwater. Monitoring well MW-14 is screened in the deep portion of the aquifer (from 57 to 62 feet below grade).

Monitoring wells MW-21 and MW-22 are not proposed for use as point-of-compliance wells for shallow groundwater due to their locations within Ellicott Street. Maintenance of these two wells has been difficult due to damage caused by snow removal and heavy traffic. The possibility of surface infiltration and run-off, coupled with the safety aspects of sampling wells located in a roadway, also preclude recommending monitoring wells MW-21 and MW-22.

Monitoring wells MW-9, MW-16, and MW-25 will not be included in the point-of-compliance well network, because of sampling interferences that may result from the presence of LNAPL at these locations. Additionally, it is doubtful that groundwater at these locations will attain compliance with drinking water standards with residual total PAH concentrations of 473 mg/kg (RAO for subsurface soils). However, these wells will be monitored for parameters that indicate the effectiveness (i.e., performance) of the selected remedial alternative. These parameters, and the monitoring frequency, will be determined and set forth within the *Effectiveness Monitoring Plan* or *Operation and Maintenance Plan*, to be completed as a component of the *Remedial Design*.

Monitoring wells MW-21 and MW-22 are also not proposed for use as point-of-compliance wells for shallow groundwater due to their locations within Ellicott Street. Maintenance of these two wells has been difficult due to damage caused by snow removal and heavy traffic. The possibility of surface infiltration and runoff, coupled with the safety aspects of sampling wells located in a roadway, also preclude recommending wells MW-21 and MW-22 as point of compliance wells.

4

4.0 DEVELOPMENT AND PRELIMINARY SCREENING OF REMEDIAL ALTERNATIVES

4.1 Purpose of Alternative Development and Screening

The primary objective of this portion of the *Feasibility Study* is to develop an appropriate range of remedial alternatives that will be evaluated fully in section 6.0, Detailed Analysis of Retained Alternatives. Depending on site conditions, alternatives that are appropriate to ensure the protection of human health and the environment may include response actions that eliminate or destroy hazardous substances, response actions that reduce concentrations of hazardous substances to acceptable health-based levels, response actions that prevent exposure to hazardous substances by engineering or institutional controls, "No Action", or a combination of more than one of these responses.

During the completion of the subsurface investigation activities at the Osmose site, pilot testing and other data has been collected to support the evaluation of potential remedial alternatives for the site. Similarly, the list of potential remedial alternatives included in the *Subsurface Investigation Work Plan* has been updated based on gaining a better understanding of the data available for the site. This iterative process is recognized and encouraged in *Guidance for Conducting Remedial Investigations and Feasibility Under CERCLA* (EPA, October 1988) and *Selection of Remedial Actions at Inactive Hazardous Waste Sites* (NYSDEC, May 15, 1990). Section 4.2 contains a listing of general response actions and a screening of the potential remedial alternatives based on the site data collected.

As discussed in section 2.1, solid wastes associated with the Osmose site have been determined to be classified as code U051 listed waste, and therefore not considered for recycling.

4.2 General Response Actions

Response actions were considered for impacted soils, LNAPL, and groundwater, as specific remedial objectives for these media were described in the RAOs (section 3.0). The following general response actions were considered for these media at the Osmose site:

- **No Action**: Under this scenario the site would be left in its present state. Guidance specifies that this action is to be considered as a baseline general response against which other actions can be measured.
- **Institutional Actions**: Institutional actions, such as limiting access to the site or restricting future usage of the property, could potentially be feasible.

- **Containment**: Containment actions, which would physically limit exposures to contaminated media by capping the site or placing vertical or horizontal barriers to impacted areas, are considered potentially feasible.
- **Removal/*Ex Situ* Treatment or Disposal**: Response actions that would remove, treat (if necessary), and dispose of impacted media are considered potentially feasible.
- ***In Situ* Treatment**: Response actions that would biologically or chemically treat soils and groundwater in place are considered potentially feasible.

Any response action considered for one media has the potential for affecting other media, because all media are in physical contact with each other. Therefore, these interactions were considered and discussed in the *Subsurface Investigation Work Plan* during the process of screening and evaluating response actions.

These general response actions were listed with potential technologies and process options to establish the range of remedial alternatives to be evaluated for the site (tables 4-1, 4-2, and 4-3). Options and technologies that were clearly not technically feasible for the site based on chemical characteristics of the waste or physical characteristics of the site were discarded at this stage.

4.3 Development of Remedial Alternatives

Preliminary alternatives for the site were assembled from each group of general response actions and potentially feasible technologies. Technologies were combined to form several alternatives that addressed each of the contaminated media.

The list of remedial alternatives assembled for screening included the following:

Alternative No. 1.	**"No Action"; Monitoring**
Alternative No. 2.	**Source Containment; Monitoring**
Alternative No. 3.	**Source Removal and Groundwater Collection; Soil Incineration; Monitoring**
Alternative No. 4.	**Source Removal and Groundwater Collection; *Ex Situ* soil treatment; Monitoring**
Alternative No. 5.	**Source Removal and Groundwater Collection; *In Situ* Soil Chemical Treatment; Monitoring**

TABLE 4-1
General Response Actions for Soil

General Response Action	Remedial Technology	Process Options	Description of Applicability
"No Action"	None	Not applicable	Required for baseline consideration by NCP
Institutional Actions	Access restrictions	Deed restrictions	Potentially applicable
		Fencing	Not applicable: site is active facility; worker access cannot be prevented
	Monitoring	Monitoring of soil vapor, groundwater quality as indicators	Potentially applicable
Containment	Capping	Asphalt	Potentially applicable
		Clay liner	Potentially applicable
	Vertical Barriers	Slurry wall	Potentially applicable
		Sheet piling	Potentially applicable
Excavation/*Ex Situ* Treatment or Disposal	Chemical treatment	Ozone	Potentially applicable: would require NYSDEC approval in lieu of permit
	Biological treatment	Slurry phase	Potentially applicable: would require NYSDEC approval in lieu of permit
		Landfarm	Potentially applicable: would require NYSDEC approval in lieu of permit
		Biocell	Potentially applicable: would require NYSDEC approval in lieu of permit
	Stabilization	Aggregate batching at off site facility	Not applicable: EPA does not support this option for this waste
	Incineration	Permitted hazardous waste incinerator	Potentially applicable
	Disposal	RCRA-permitted landfill	Not applicable: EPA does not permit land disposal of this material
In Situ Treatment	Chemical	Ozone injection treatment	Potentially applicable
	Biological	Passive	Not applicable at contaminant concentrations present
		Enhanced with vapor extraction, air injection	Potentially applicable
	Thermal	Steam injection/recovery	Potentially applicable
		Hot air injection/recovery	Not applicable: inadequate heat transfer capacity

TABLE 4-2
General Response Actions for LNAPL

General Response Action	Remedial Technology	Process Options	Description of Applicability
"No Action"	None	Not Applicable	Required for baseline consideration by NCP
Institutional Actions	Access restrictions	Deed restrictions	Potentially applicable
		Fencing	Not applicable: site is active facility; worker access cannot be prevented
	Monitoring	Monitoring of soil vapor, groundwater quality as indicators.	Potentially applicable
Containment	Capping	Asphalt	Potentially applicable
		Clay liner	Potentially applicable
	Vertical barriers	Slurry wall	Potentially applicable
		Sheet piling	Potentially applicable
	Hydraulic control (water table depression)	Pumping wells or total fluids extraction.	Potentially applicable
Excavation/*Ex Situ* Treatment or Disposal	Incineration	Permitted hazardous waste incinerator	Potentially applicable
	Disposal	RCRA-Permitted Landfill	Not applicable: EPA does not permit land disposal of this material
Extraction (pumping or vacuum extraction)/*Ex Situ* Treatment or Disposal	Recycling	Incorporation into process	Not applicable: No RCRA exemption for this material
	Incineration	Permitted hazardous waste incinerator	Potentially applicable
	Disposal	RCRA-permitted landfill	Not applicable: EPA does not permit land disposal of this material
In Situ Treatment	Chemical	Ozone injection treatment	Potentially applicable
	Biological	Passive	Not applicable to liquid-phase product (concentration too high)
		Enhanced through vapor extraction, air injection	Potentially applicable
	Thermal	Steam injection/recovery	Potentially applicable
		Hot air injection/recovery	Not applicable: inadequate heat transfer capacity

TABLE 4-3

General Response Actions for Groundwater

General Response Action	Remedial Technology	Process Options	Description of Applicability
"No Action"	None	Not Applicable	Required for baseline consideration by NCP
Institutional Actions	Access restrictions	Deed restrictions	Potentially applicable
		Fencing	Not applicable: site is active facility; worker access cannot be prevented
	Monitoring	Monitoring	Potentially applicable
Containment	Capping	Asphalt	Potentially applicable
		Clay liner	Potentially applicable
	Vertical Barriers	Slurry wall	Potentially applicable
		Sheet piling	Potentially applicable
	Hydraulic control (water table depression)	Pumping wells or total fluids extraction	Potentially applicable
Extraction (Pumping or Vacuum Extraction)/*Ex Situ* Treatment or Disposal	Physical	Air Stripping	Potentially applicable
	Chemical	Ozone/UV Perox	Potentially applicable
	Biological	Bioreactor	Potentially applicable
	Disposal	RCRA-permitted TSD	Potentially applicable
In Situ Treatment	Chemical	Ozone injection treatment	Potentially applicable
	Biological	Passive	Potentially applicable
		Enhanced with vapor extraction, air injection	Potentially applicable
	Thermal	Steam injection/recovery	Potentially applicable
		Hot air injection/recovery	Not applicable: inadequate heat transfer capacity

Alternative No. 6. **Source Removal and Groundwater Collection; *In Situ* Soil Biological Treatment; Monitoring**

Alternative No. 7. **Source Removal and Groundwater Collection; *In Situ* Thermal Treatment of Soil; Monitoring**

It should be noted that certain responses such as monitoring have been included as a component in all alternatives. A deed restriction will be required ultimately as a component of the final remedial alternative selection. For the above alternatives, source removal is defined as the removal of LNAPL.

4.4 Preliminary Screening of Remedial Alternatives

The assembled remedial alternatives were screened based on three screening criteria: effectiveness, implementability, and cost. This process was performed in accordance with guidance contained in *Selection of Remedial Actions at Inactive Hazardous Waste Sites* (TAGM HWR-89-4030, NYS DEC, May 1990). The objective of the remedial alternatives screening is to narrow the list of potential alternatives that are retained for detailed evaluation. A summary of the preliminary alternative screening process is presented below.

4.4.1 Preliminary Screening Criteria

The basis for use of each criteria in the screening evaluation is discussed below.

Effectiveness. Process options for the Osmose site were evaluated based on their ability to achieve the RAOs in a reasonable time frame and how proven and reliable the process is with respect to the contaminants of concern. The basis for the evaluation of effectiveness during the preliminary screening includes the following:

- protection of community during remedial actions
- short-term environmental impacts
- time frame for implementation of the remedy
- permanence of the remedial alternative
- if not permanent, expected lifetime of effectiveness of the remedy
- quantity and nature of residual left after site remediation
- adequacy and reliability of controls

A quantitative scoring approach was used for this evaluation, as described in *Selection of Remedial Actions at Inactive Hazardous Waste Sites* (NYSDEC, September 1989).

Implementability. Implementability encompasses the technical and institutional feasibility of constructing, operating, and maintaining a remedial alternative. This evaluation was used to eliminate process options that were ineffective and clearly not applicable to the site conditions. The basis for the evaluation included the following:

- ability to construct and operate the process option
- reliability of the technology
- potential for delays due to material handling difficulties or other technical problems
- potential for additional remedial action being required
- coordination with other agencies required
- availability of prospective technology
- availability of necessary equipment and specialists

The quantitative scoring approach referenced above was also used for this evaluation.

Cost. Cost played a limited role at this stage of the screening process. Remedial alternatives were rated subjectively on an estimated order-of-magnitude basis. No remedial alternatives were eliminated because of cost.

4.4.2 Results of Preliminary Alternative Screening

The screening rationale and the recommended action for each alternative is summarized below. A soil biotreatment interim remedial measure (IRM) has been implemented and is in process at the site (see section 5.1).

Alternative No. 1: "No Action"; Monitoring. The "no action" alternative was included in the preliminary remedial alternatives screening as a baseline from which to analyze the other remedial processes. Monitoring of groundwater and the soil biotreatment area were included. A deed restriction would be required for this alternative.

- Effectiveness: This option does not result in any further reduction (other than natural attenuation) of the toxicity, mobility, or mass of wastes at the site, and was, therefore, eliminated from further consideration.

- Implementability: This option was not evaluated for this criteria.

- Relative Cost: This option would have the lowest capital and overall cost.

- Conclusion: This alternative will not be effective in reducing the toxicity, mobility, or mass of waste present or reliably preventing exposures, and will not meet the remedial action goals. However, the alternative was retained as a baseline for comparison of the other alternatives, in accordance with state and federal guidance for the completion of RI/FS.

Alternative No. 2: Source Containment; Monitoring. Containment actions include paving the site and installing vertical barriers to prevent contaminant migration and physically limit contact with affected media. The existing soil biotreatment area would be included within the contained area, and would not be monitored separately. Monitoring of groundwater would be included. A deed restriction would be required for this alternative.

- Effectiveness: This alternative reduces the potential for direct contact exposures (prevents pedestrian, resident or employee contact with contaminated soils), and could restrict LNAPL migration.
- Implementability: This alternative would be extremely difficult to implement due to space limitations at the site and the presence of the existing (and fully operational) manufacturing facility on-site, and was therefore eliminated from further consideration.
- Relative Cost: This criteria was not evaluated for this option.
- Conclusion: This alternative was not considered for further evaluation on its own because it did not appear that it could be implemented in a manner that will reliably reduce the toxicity, mobility, or mass of wastes present. Maintaining the pavement of the site, however, is a viable component in the ultimate remedy selection, and will mitigate the potential for direct contact exposure, as well as reduce the potential for constituent leaching to groundwater due to precipitation infiltration.

Alterative No. 3: Source Removal and Groundwater Collection; Soil Incineration; Monitoring. This alternative would remove the LNAPL fuel oil and creosote source by vacuum-enhanced pumping and sending the recovered material off-site for incineration. Additionally, excavation, transportation, and off-site disposal of contaminated soils by incineration is included. Extracted groundwater from the LNAPL recovery process would be treated and discharged to the Buffalo Sewer Authority (BSA) POTW. Upon completion of the recovery of LNAPL, groundwater quality would be monitored. The existing soil biotreatment area would be excavated during the soil removal stage of the project. The pavement covering the site would be replaced following excavation. A deed restriction would be required for this alternative.

- Effectiveness: This alternative would result in a permanent reduction of the toxicity, mobility, and mass of the waste on-site.

- Implementability: This alternative would be somewhat difficult to implement due to the space limitations on excavation and soil staging posed by the site. However, this could be facilitated through the design of proper engineering controls and scheduling.
- Relative Cost: This alternative would have a high cost due to the logistical considerations described above and the cost of hazardous waste incineration.
- Conclusion: This alternative will be considered for further evaluation.

Alternative No. 4: Source Removal and Groundwater Collection; Ex Situ Soil Treatment; Monitoring. This alternative would remove the LNAPL fuel oil and creosote source by vacuum-enhanced pumping and sending the recovered material off-site for incineration. Contaminated soil would be excavated and treated on-site. Soil treatment process options include chemical, biological, and combined chemical-biological treatment. Extracted groundwater from the LNAPL recovery process would be treated and discharged to the BSA POTW. Upon completion of the recovery of LNAPL, groundwater quality would be monitored. The existing soil biotreatment area would be also be excavated and treated during the soil treatment stage of the project. The pavement covering the site would be replaced following excavation. A deed restriction would be required for this alternative.

- Effectiveness: This alternative would result in a permanent reduction of the toxicity, mobility, and mass of the waste on-site.
- Implementability: This alternative would not be feasible to implement due to the space limitations on excavation and soil staging posed by the site.
- Relative Cost: This alternative would generally have a moderate cost; however, it could not be evaluated in a site-specific context due to the space constraints posed by the site.
- Conclusion: This alternative will not be considered for further evaluation due to the implementation difficulties.

Alternative No. 5: Source Removal and Groundwater Collection; In Situ Soil Chemical Treatment; Monitoring. This alternative would remove the fuel oil and creosote LNAPL source by vacuum-enhanced pumping and sending the recovered material off-site for incineration. Soils with residual concentrations of the COI remaining above the RAO after LNAPL recovery is completed would then be treated *in situ* by injection and recovery of ozone. Ozone would cause the chemical destruction of fuel oil and creosote residuals in the soils and groundwater. Extracted groundwater from the enhanced recovery of LNAPL would be treated and discharged to the BSA POTW. Upon completion of the recovery of LNAPL, groundwater quality would be monitored. The existing soil biotreatment area would also be treated during the ozone injection stage of the project. The pavement covering the site would be maintained. A deed restriction would be required for this alternative.

- Effectiveness: This alternative would result in a permanent reduction of the toxicity, mobility, and mass of the waste on-site.
- Implementability: This alternative could be implemented readily within the confines of the site.
- Relative Cost: It is anticipated that the overall cost of this alternative would be moderate.
- Conclusion: This alternative will be considered for further evaluation. It would reduce the toxicity, mobility, and mass of wastes and provide a dependable, permanent remedy.

Alternative No. 6: Source Removal and Groundwater Collection; In Situ Soil Biological Treatment. This alternative would remove the fuel oil and creosote LNAPL source by vacuum-enhanced pumping and sending the recovered material off-site for incineration. It would also promote biological treatment of contaminated soils *in situ* by injection/recycling of air and nutrients. Extracted groundwater associated with the enhanced recovery of LNAPL would be treated and discharged to the BSA POTW. Upon completion of the LNAPL recovery, groundwater quality would be monitored. The soil biotreatment area would continue to operate and be monitored during the *in situ* soil biotreatment stage of the project. The pavement covering the site would be maintained. A deed restriction would be required for this alternative.

- Effectiveness: This alternative would result in a permanent reduction of the toxicity, mobility, and mass of the waste on-site.
- Implementability: This alternative could be implemented readily within the confines of the site. The treatment of high-molecular weight PAH compounds is expected to occur relatively slowly, and may require additional chemical or nutrient addition to proceed to acceptable levels.
- Relative Cost: It is anticipated that the overall cost of this alternative would be moderate to high.
- Conclusion: This alternative will be considered for further evaluation.

Alternative No. 7: Source Removal and Groundwater Collection; In Situ Soil Thermal Treatment. This alternative would remove the fuel oil and creosote LNAPL source by vacuum-enhanced pumping and sending the recovered material off-site for incineration. Contaminated soil would be treated *in situ* by injection of steam and recovery of constituent-laden vapor. Extracted groundwater associated with the enhanced recovery of LNAPL would be treated and discharged to the Buffalo Sewer Authority POTW. Upon completion of the LNAPL recovery, groundwater quality would be monitored. The existing soil biotreatment area would also be treated with steam during the thermal treatment stage of the project. The pavement covering the site would be maintained. A deed restriction would be required for this alternative.

- Effectiveness: This alternative would result in a permanent reduction of the toxicity, mobility, and mass of the waste on-site.
- Implementability: This alternative could be implemented readily within the confines of the site.
- Relative Cost: It is anticipated that the overall cost of this alternative would be moderate to high.
- Conclusion: This alternative will be considered for further evaluation.

The results of the preliminary screening of alternatives are presented in table 4-4.

TABLE 4-4

Preliminary Screening of Assembled Remedial Alternatives

Assembled Remedial Alternatives	Description of Representative Technology or Application	Effectiveness[1]	Implementability[1]	Cost	Screening Action
1. "No Action"; Deed Restriction; Monitoring	Leave site in present condition; monitor IRM soil biotreatment area; restrict future usage of site through deed encumbrance	Not effective	Implementable	Low	Retained
2. Source containment; no groundwater control; monitoring	Install impermeable cap and slurry wall to contain LNAPL migration; monitor groundwater; restrict future usage of site	Potentially effective	Not implementable	Not evaluated	Eliminated
3. Source removal and groundwater collection; soil incineration; monitoring	Vacuum-enhanced LNAPL recovery and off-site incineration; treat impacted groundwater during LNAPL removal; excavation and off-site incineration of soil (including IRM biotreatment area); monitor groundwater; restrict future usage of site	Potentially effective	Implementable	High	Retained
4. Source removal and groundwater collection; ex-situ soil treatment; monitoring	Vacuum-enhanced LNAPL recovery and off-site incineration; treat impacted groundwater during LNAPL removal; excavation and on-site treatment of soil (including IRM biotreatment area); monitor groundwater; restrict future usage of site	Potentially effective	Not implementable	Not evaluated	Eliminated
5. Source removal and groundwater collection; *in situ* soil chemical treatment; monitoring	Vacuum-enhanced LNAPL recovery and off-site incineration; treat impacted groundwater during LNAPL removal, *in situ* ozone treatment of soil (including IRM biotreatment area); monitor groundwater; restrict future usage of site	Potentially effective	Implementable	Moderate	Retained
6. Source removal and groundwater collection; *in situ* soil biological treatment; monitoring	Vacuum-enhanced LNAPL recovery and off-site incineration; treat impacted groundwater during LNAPL removal; *in situ* biological treatment of soil using air sparging/vapor extraction; continue operation and monitoring of IRM biotreatment area; monitor groundwater; restrict future usage of site	Potentially effective	Implementable	Moderate to high	Retained
7. Source removal and groundwater collection; *in situ* thermal treatment of soil; monitoring	Vacuum-enhanced LNAPL recovery and off-site incineration; treat impacted groundwater during LNAPL removal; *in situ* thermal treatment of soil using steam injection/vapor extraction (including IRM biotreatment area); monitor groundwater; restrict future usage of site	Potentially effective	Implementable	High	Retained

[1] Refer to New York State Department of Environmental Conservation, Department of Hazardous Waste Remediation. *Selection of Remedial Actions at Inactive Hazardous Waste Sites*, TAGM HWR-89-4030. September 13, 1989.

4.4.3 *Summary of Retained Alternatives*

Based on the screening process, five alternatives were retained for detailed evaluation:

Alternative No. 1:	**"No Action"; Monitoring**
Alternative No. 3:	**Source Removal and Groundwater Collection; Soil Incineration; Monitoring**
Alternative No. 5:	**Source Removal and Groundwater Collection; *In Situ* Soil Chemical Treatment; Monitoring**
Alternative No. 6:	**Source Removal and Groundwater Collection; *In Situ* Soil Biological Treatment; Monitoring**
Alternative No. 7:	**Source Removal and Groundwater Collection; *In Situ* Thermal Treatment of Soil; Monitoring**

These alternatives were retained because they were considered potentially effective and implementable in achieving the remedial action alternatives. Costs were estimated, but not used to eliminate any alternative from further evaluation. As defined above, source removal is defined as the removal of LNAPL.

5

5.0 INTERIM REMEDIAL MEASURES

The results and/or status of the three IRMs conducted at the Osmose site are summarized in the following sections. IRMs conducted include the installation and operation of a soil treatment biocell, installation and operation of an LNAPL recovery system, and the performance of an ozone injection pilot test which included a soil treatment feasibility study.

5.1 Soil Treatment Biocell IRM

As mentioned in section 1.2, three compartmentalized USTs at the Osmose facility were closed by removal during August 1989. During the tank removal, approximately 600 cubic yards of soil impacted with creosote and No. 2 fuel oil were removed from the subsurface near the tanks. The *Design of Biocell for In Situ Bioremediation of Soils Work Plan* dated January 4, 1990, (revised), was submitted to the NYSDEC for approval. The soil treatment biocell was constructed in March 1990 as an IRM, and has been operated and maintained since that date.

Soil has been sampled to evaluate the effectiveness of the soil treatment biocell. Closure criteria have been established for the biocell soils as follows:

- 10 ppm total VOCs
- 10 ppm benzo{a}pyrene
- 50 ppm total carcinogenic PAHs
- 473 ppm total PAHs

The analytical methods specified are EPA Method 8020 for VOCs and EPA Method 8270 (base/neutrals only) for PAHs. Total PAHs are determined by adding the concentrations of the 16 PAH analytes that are included on the EPA priority pollutant list (table 2-6).

The most recent round of soil sampling conducted for the biocell was completed on December 13, 1993. The results were described in a letter report from Groundwater Technology to the NYSDEC, and can be summarized as follows:

- The soils at all five sampling locations were at or below the closure criterion for VOCs.
- The soils at all five locations were below the closure criterion for benzo{a}pyrene.

- Total carcinogenic PAH concentrations ranged from 27 ppm to 79 ppm, with four of the five locations above the 50 ppm closure criterion.
- Total PAH concentrations ranged from 300 ppm to 932 ppm, with four of the five locations above the 473 ppm closure criterion.

In general, PAH concentrations were lowest at the southwest sampling location, intermediate at the northwest and northeast locations, and highest at the southeast and central-east locations. Historically, PAH concentrations in the southeast portion of the biocell had been lowest among the five locations.

A trend graph showing biocell soil PAH concentrations since June 1990, is included as figure 5-1. Several conclusions can be drawn from the trends that have emerged over that period of time:

1. The biocell was effective in reducing total PAH concentrations between 1990 and 1991.
2. After the October 1991, sampling event, PAHs apparently were reintroduced into the biocell by an unknown mechanism.
3. The wide range of adsorbed PAH concentrations exhibited at the five sampling locations during the June 21, 1990, sampling event indicates that the biocell soils (and, therefore, the distribution of PAHs) were initially heterogeneous. This was followed by a convergence of concentrations toward a single value as biodegradation progressed (July 11, 1991 and October 17, 1991, sampling events). Subsequently, as concentrations rose, the soils again exhibited a wider range of PAH concentrations. This indicates that the process by which PAHs were reintroduced into the biocell was not affecting all locations equally.
4. The locations exhibiting the highest concentrations during the last two sampling events were the locations along the eastern edge of the biocell (CE, SE, and NE). This suggests that the source of the infiltrating PAHs is located east of the biocell.

Site data collected during the ozone injection pilot test (section 5.2) indicated that a significant amount of light nonaqueous-phase liquid (LNAPL) is present in the soils north and east of the biocell. The evidence discussed above suggests that infiltration of PAHs into the biocell occurred from the east. It is possible that the infiltration is related to the presence of the LNAPL. One possible scenario that would explain the increase in PAHs in the biocell soils is that the liner of the biocell has been breached.

It appears that the rate of introduction of PAHs into the biocell is currently greater than the rate of biodegradation. In a project status meeting held at the NYSDEC offices in Buffalo on July 5, 1994, it was agreed that Groundwater Technology would continue operation of the Soil Treatment Biocell

IRM as a control and containment measure while the LNAPL Recovery IRM (section 5.3) is operated in the area east of the biocell. Operation and maintenance of the biocell consists of continued aeration and dewatering, along with collection of CO_2 and PID data from the soil ventilation (aeration) system. While the LNAPL is present adjacent to the biocell, it is unlikely that closure criteria will be met within the biocell. Therefore, no additional soil sampling is being performed during the control and containment period.

5.2 Ozone Injection Feasibility Study IRM

An ozone injection pilot test was conducted to evaluate the feasibility of remediating adsorbed PAHs in both the saturated and vadose zones. As previously referenced, in a letter dated March 28, 1994, the NYSDEC proposed a RAO for on-site subsurface soils of 473 ppm total PAHs. Based on this proposed RAO for on-site soil, it was estimated that approximately 720 cubic yards of soil contain total PAH concentrations above the 473 ppm level. To assess the applicability of an emerging technology for *in situ* oxidation of PAH compounds in the soil and groundwater at this site, Groundwater Technology developed an *Ozone Pilot Test Work Plan*, which was submitted to the NYSDEC on September 25, 1992.

In accordance with the work plan, an ozone injection pilot test was conducted as an IRM from May through October 1993. The pilot test was completed in two phases: ozone injection into the vadose zone (Area 1 test), and ozone sparging in the saturated zone beneath the on-site clay layer (Area 2 test). The results are described in the *Ozone Injection Feasibility Study Report*, dated April 5, 1994, and are summarized in the following paragraphs.

The Area 1 results indicated reductions in PAH concentrations of approximately 94% over the 4-week pilot test. The Area 1 test also showed that the highly reactive ozone can both be controlled in the subsurface and can be captured and removed by GAC if unreacted.

In Area 2, groundwater pumping was initiated to create a dewatered zone beneath the clay layer. The dewatered zone was the target zone for the capture of unreacted ozone. The depression of the water table caused a previously underestimated quantity of LNAPL to enter the test area. This created a number of complications for the Area 2 study. At the two sampling locations farthest from the ozone injection point, PAH concentrations increased throughout the test as LNAPL entered the test area. At the sampling location an intermediate distance from the injection point, PAH concentrations decreased through the midpoint sampling event, but increased again by the endpoint sampling. This indicates that initially the ozone was oxidizing the adsorbed PAHs, but eventually the rate of LNAPL infiltration exceeded the rate of oxidation. At the injection point itself, PAH concentrations decreased throughout the test. Based on the results from the Area 1 test, and the initial (midpoint) results from the Area 2 test, it was determined that ozone sparging to remove high residual concentrations of PAHs in the saturated zone is feasible, provided that the LNAPL is removed first.

5.3 LNAPL Recovery IRM

As mentioned in section 5.2, groundwater pumping was initiated during the ozone pilot test in September, 1993 to depress the water table, which creates an unsaturated zone beneath the on-site clay layer. After the conclusion of the pilot test, groundwater recovery was continued on a limited basis through the winter months. During this time, the total fluids pumps installed for the ozone pilot test were changed to a top-loading model for improved LNAPL recovery. Osmose started the new pumping system in March 1994, upon receipt of the required discharge permit from the BSA. The LNAPL recovery system was upgraded during May and June 1995, in accordance with the work plan prepared by Groundwater Technology dated September 7, 1994. The pumping system was upgraded to address the additional areas identified as containing LNAPL and to increase the efficiency of LNAPL recovery through vacuum enhancement. To assist in the design of the upgraded system, operational data from groundwater pumping performed during the ozone injection pilot test was entered into the modeling program CAPZONE. The CAPZONE modeling output helped in the determination of the number of recovery wells, the locations, and the pumping rates needed to achieve the objectives of the upgrade.

The LNAPL recovery system consists of vacuum-enhanced total fluids recovery from eight recovery wells. Three recovery wells are operated using down-well, top-loading pneumatic pumps. An additional three recovery wells are operated using surface-mounted, double-diaphragm pneumatic pumps. The remaining two recovery wells are former monitoring wells, which are operated using extraction stringers. Extracted fluids are pumped into a holding tank that acts as an oil-water separator. The water discharge is treated through three activated carbon vessels in series and discharged to the sanitary sewer system. In addition to the pumping system, product is recovered by manual bailing from six monitoring wells on a weekly basis. Operation of the upgraded pumping system began in June 1995. As of this date, the system is in a startup-shakedown phase, and data on the effectiveness of the upgraded system is not yet available.

The total amount of LNAPL recovered from November 1993 through March 1995 was approximately 270 gallons (table 5-1, LNAPL Recovery Data). Including the hydrocarbons removed from the dissolved phase, approximately 291 gallons of product have been recovered. To date, manual bailing has been the primary means of recovering the LNAPL which is being drawn into the vicinity of the recovery wells. This is partially the result of the placement of the recovery wells installed for the ozone injection pilot test in relation to the LNAPL plume. The placement of the new recovery wells installed during the LNAPL recovery IRM upgrade, as well as the change to vacuum-enhanced recovery, is expected to significantly increase LNAPL recovery by the pumping system.

6

6.0 DETAILED ANALYSIS OF RETAINED ALTERNATIVES

After the development and preliminary screening of alternatives but before the actual selection of a remedy, selected alternatives are analyzed in detail. This phase incorporates any treatability and feasibility study data and additional site characterization data that has been collected. The detailed analysis documents the evaluation of retained alternatives and provides the basis for selecting a site remedy.

6.1 Purpose and Description of Evaluation Criteria

The detailed analysis of alternatives consists of analyzing and presenting the relevant information required to allow final selection of a site remedy. During the detailed analysis, each retained alternative is assessed against seven evaluation criteria. These evaluation criteria serve as the basis for conducting the detailed analyses and for subsequently selecting the most appropriate remedial action. These seven evaluation criteria include:

1. **Short-term impacts and effectiveness.** Evaluates the effectiveness of each alternative in its ability to protect human health and the environment during the construction and implementation stages until the RAO has been met.

2. **Long-term effectiveness and performance.** Evaluates the long-term effectiveness of each alternative and its ability to maintain protection of human health and the environment after the RAO has been met.

3. **Reduction of toxicity, mobility, or mass.** Evaluates the anticipated performance of each specific treatment technology in its ability to significantly reduce toxicity, mobility, or mass of the site wastes.

4. **Implementability.** Evaluates the technical and administrative feasibility of implementing an alternative, including the availability of materials and services required during implementation.

5. **Compliance with SCGs.** Evaluates each alternative relative to compliance with the relevant and appropriate SCGs.

6. **Overall protection of human health and the environment.** Evaluates how each alternative maintains the protection of human health and the environment.

7. **Cost.** Evaluates the present worth comparison of the capital and operation and maintenance (O&M) costs associated with each alternative.

The above criteria are not listed in their relative order of consideration. Each of the seven evaluation criteria has been divided into specific weighted factors to allow thorough analysis of the alternatives according to the NYSDEC TAGM 4030.

Because cost does represent an important screening criteria, some additional comments are offered regarding the way costs have been derived. First, the costs presented represent order-of-magnitude estimates. It is expected that these estimates are accurate between +50% and -30% of the reported cost, once implemented. An interest rate of 3% was assumed for present worth calculations.

Second, the actual costs of each alternative depends heavily on the final scope, schedule, labor requirements and materials costs at the time of implementation of the remediation action, as well as other variable factors. Included in table 6-1, Procedures and Assumptions for Development of Cost Estimates, is an outline of the assumptions and elements considered when developing the cost estimates for each alternative.

The five site remedial alternatives that were retained for detailed analysis include:

Alternative No. 1:	"No Action"; Monitoring
Alternative No. 3:	Source Removal and Groundwater Collection, Soil Incineration, Monitoring
Alternative No. 5:	Source Removal and Groundwater Collection, *In Situ* Chemical Treatment, Monitoring
Alternative No. 6:	Source Removal and Groundwater Collection, *In Situ* Biological Treatment, Monitoring
Alternative No. 7:	Source Removal and Groundwater Collection, *In Situ* Thermal Treatment, Monitoring

Each alternative is described below, followed by a detailed evaluation of that alternative based on the seven evaluation criteria.

6.2 Alternative No. 1; "No Action"; Monitoring

6.2.1 Description of Alternative

This alternative would consist of monitoring groundwater samples collected from the compliance wells and several additional monitoring wells at the site. Soils and groundwater containing hydrocarbons above the RAO would be left in place, and therefore it is anticipated that groundwater monitoring would continue for an extended period of time. (A 30-year monitoring period was used for the Net Present Worth calculation for this alternative.)

6.2.2 Detailed Evaluation of Alternative No. 1

6.2.2.1 Short-Term Effectiveness. The "No Action" monitoring alternative would not produce any short-term impacts to the community; however, the alternative would not abate short-term environmental impacts such as the presence of LNAPL and impacted groundwater.

6.2.2.2 Long-Term Effectiveness and Permanence. No significant long-term benefits would occur without the passage of an extended time period, required for biodegradation of the contaminants and dispersion of groundwater residuals.

6.2.2.3 Reduction of Toxicity, Mobility, and Mass. Reduction of contaminant mass and mobility would only occur over an extended time period. However, no short-term community impacts or off-site liabilities would be created.

6.2.2.4 Implementability. The protocols for monitoring are well established, and technology and service vendors for this alternative are plentiful. Therefore, this alternative is implementable.

6.2.2.5 Compliance with SCGs. Chemical-specific SCGs (such as groundwater standards) would not be achieved until biological degradation has reduced the contaminant mass, and natural dispersive mechanisms have reduced downgradient dissolved levels.

6.2.2.6 Cost. Table 6-2 shows the cost estimate for Alternative No. 1. The estimated annual cost for monitoring and reporting is approximately $ 30,000. The present worth of this alternative therefore is approximately $ 415,000.

6.2.2.7 Overall Protection of Human Health and the Environment. Alternative No. 1 does not provide protection of human health and the environment because LNAPL, impacted groundwater, and impacted soils would remain without adequate safeguards to prevent future exposures to these media.

6.3 Alternative No. 3; **Source Removal and Groundwater Collection, Soil Incineration, Monitoring**

6.3.1 Description of Alternative

The primary components of this alternative would consist of a vacuum-enhanced, dual-phase LNAPL recovery system for source removal followed by the excavation, transportation, and off-site disposal by incineration of impacted soils. Because the waste is classified as U051, Land Disposal Restrictions (LDRs) prohibit disposal of the waste at secured landfills. The existing vacuum-enhanced LNAPL recovery system, described in the *LNAPL IRM Upgrade Work Plan*, and installed in June 1995, has been designed to accomplish the source removal. It is anticipated that the LNAPL recovery system will require operation for a period of 4 to 5 years. An evaluation of the recovery system's effectiveness in recovering LNAPL will be conducted after operation for 1 to 2 years, to allow sufficient operational data to be collected.

Groundwater collection and treatment will be accomplished as part of the enhanced LNAPL recovery system. Six to eight total fluids recovery pumps will be maintained, which will create a combined area of influence that encompasses both the known LNAPL and dissolved plumes. The separated groundwater will be treated by liquid-phase granular activated carbon (LGAC) and discharged under permit to the combined sewer system operated by the BSA.

After the source has been removed, soils containing hydrocarbons above the RAO would be excavated, transported, and incinerated for disposal. Soils containing hydrocarbons below the RAO would be returned to the excavation. Soils underneath the Osmose facility would not be included in the excavation activities; however, soils within the existing biocell would be included. After the monitoring wells will continue. A deed restriction will also remain in effect for the site. It is anticipated that the excavation and removal of soils can be accomplished in less than 3 months.

6.3.2 *Detailed Evaluation of Alternative No. 3*

6.3.2.1 Short-Term Effectiveness. The vacuum-enhanced source removal system is currently in place and operational. During the excavation and transportation phase, the possibility exists for substantial impacts, which cannot easily be controlled. Noise, traffic, dust and potential odors during excavation activities would need to be addressed to protect the public.

6.3.2.2 Long-Term Effectiveness and Permanence. LNAPL removal and excavation, transportation, and incineration of impacted soils is effective and permanent. Off-site treatment (incineration) is required. Potentially untreated soils would be left beneath the Osmose facility.

6.3.2.3 Reduction of Toxicity, Mobility, and Mass. Groundwater control during LNAPL removal would significantly reduce the mobility of the source and dissolved constituents. Excavation and incineration would permanently and irreversibly reduce the toxicity and mass of residual adsorbed constituents at the site.

6.3.2.4 Implementability. As mentioned above, the vacuum-enhanced source removal system is currently in place and operational. The excavation of soils is technically feasible; however, it is potentially difficult to complete. Sheet piling or shoring may be required to support the facility, which has a rubble-stone foundation, and several utilities would require rerouting. Traffic and odor controls could be implemented. Noise constraints would require construction activities to be limited to normal working hours. Administrative feasibility requires a normal effort and numerous equipment subcontractors and specialists are available to perform the work.

6.3.2.5 Compliance with SCGs. Chemical-specific SCGs (such as groundwater standards) would be maintained at point-of-compliance locations. Once the source of constituents in groundwater has been removed, natural attenuation and degradation will eventually reduce residual downgradient dissolved levels.

Action-specific SCGs would be met by incineration of the liquid and solid wastes. Also, treatment of collected groundwater and air during the source removal phase with LGAC will satisfy the BSA requirement for discharge into the combined sewer system and the NYSDEC air quality regulations. OSHA requirements would be maintained at all times via monitoring and planning.

Location-specific SCGs do not directly apply to the site.

6.3.2.6 ***Cost.*** Table 6-3 provides the cost estimate for Alternative No. 3. The estimated annual operation and maintenance of the existing enhanced, dual-phase recovery system is approximately $50,000 per year. The capital cost for excavation, transportation, and disposal, including engineering and administrative costs and the installation of sheet piling is estimated at $2,454,000. The present worth of this alternative is therefore approximately $2,200,000.

6.3.2.7 ***Overall Protection of Human Health and the Environment.*** Alternative No. 3 protects both human health and the environment by removing and permanently destroying the waste. Future exposure to residual constituents would be eliminated through institutional controls such as deed restrictions regarding future site development.

6.4 Alternative No. 5; Source Removal and Groundwater Collection, *In Situ* Chemical Treatment, Monitoring

6.4.1 Description of Alternative

The primary components of this alternative would consist of a vacuum-enhanced, dual-phase LNAPL recovery system for source removal followed by the injection of ozone into the subsurface to oxidize organic compounds. The existing vacuum enhanced LNAPL recovery system, as described in the *LNAPL IRM Upgrade Work Plan*, and installed in June 1995, has been designed to accomplish the source removal. It is anticipated that the LNAPL recovery system will require operation for a period of 4 to 5 years. An evaluation of the recovery system's effectiveness in recovering LNAPL will be conducted after operation for 1 to 2 years to allow sufficient operational data has been collected.

An ozone feasibility study was completed at the site. The results presented in the *Ozone Injection Feasibility Study Report* dated April 5, 1994, indicate that once LNAPL was removed, ozone is a viable *in situ* treatment. Ozone would be injected into the saturated soils, and unreacted ozone will be recovered via soil vapor extraction (SVE) within a dewatered zone below the existing clay layer. As discussed above in section 4.0, it is anticipated that the soils beneath the Osmose facility would not be included in the ozone treatment; however, soils within the biocell would. The pilot test showed that vapor-phase GAC (VGAC) is effective in removing unreacted ozone from the effluent discharge of the SVE system. It is anticipated that ozone treatment will require 1 to 2 years to complete. As required by the Department, on July 20, 1995, Osmose filed a deed restriction defining, and limiting the future use of, the "operable unit" portion of the site.

Groundwater collection and treatment would be accomplished as part of both the enhanced LNAPL recovery system and the dewatering required during ozone injection to create an unsaturated zone to recover unreacted ozone. Six to eight total fluids recovery pumps would be maintained which would create a combined area of influence. The separated groundwater would be treated by LGAC and discharged under permit to the combined sewer system operated by the BSA.

After the ozone treatment is completed, groundwater recovery would be terminated and monitoring of selected monitoring wells would continue. A deed restriction would also remain in effect for the site.

6.4.2 *Detailed Evaluation of Alternative No. 5*

6.4.2.1 Short-Term Effectiveness. As with Alternative No. 3, the vacuum-enhanced source removal system is currently in place and operational. During the construction and installation of the ozone treatment system, no significant short-term potential risks to the community would exist. Minor noise disruption during construction activities at the site could occur.

6.4.2.2 Long-Term Effectiveness and Permanence. LNAPL removal and oxidation of adsorbed constituents is effective and permanent. Off-site treatment (incineration) for the recovered LNAPL is required; however, the toxicity and mass of the constituents are permanently reduced. Ozone treatment is an emerging technology and will require more intensive maintenance to ensure performance. The duration of the ozone treatment is anticipated to be approximately 1 to 2 years.

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6.4.2.3 Reduction of Toxicity, Mobility, and Mass. Groundwater control during LNAPL removal would significantly reduce the mobility of the source and dissolved constituents. Oxidation of residual hydrocarbons to the RAO will permanently and irreversibly reduce the toxicity and mass of residual adsorbed COIs at the site.

*6.4.2.4 **Implementability**.* As mentioned above, the vacuum enhanced source removal system is currently in place and operational. The subsurface installation and above grade construction represent a normal level of effort to complete. Several utilities would require rerouting due to their incompatibility with ozone. Administrative feasibility requires a normal effort and several equipment subcontractors and specialists are available to perform the work.

*6.4.2.5 **Compliance with SCGs**.* Chemical-specific SCGs (such as groundwater standards) would be maintained at point-of-compliance locations. Once the source of constituents in groundwater has been removed, natural attenuation and degradation will eventually reduce residual downgradient dissolved levels.

Action-specific SCGs would be met by off-site incineration of the recovered LNAPL. Also, treatment of collected groundwater and air during the source removal phase with LGAC will satisfy the BSA requirement for discharge into the combined sewer system and the NYSDEC air quality regulations. OSHA requirements would be maintained at all times via monitoring and planning.

Location-specific SCGs do not directly apply to the site.

*6.4.2.6 **Cost**.* Table 6-4 provides the cost estimate for Alternative No. 5. The estimated annual operation and maintenance of the existing enhanced dual phase recovery system is $50,000 per year. The installed capital cost for the ozone treatment system, including construction, engineering and administrative costs is approximately $370,000. The present worth of this alternative therefore is $650,000.

*6.4.2.7 **Overall Protection of Human Health and the Environment**.* Alternative No. 5 provides protection to both human health and the environment to the same extent as the other alternatives by removing and permanently destroying the waste. Future exposure to residual constituents would be eliminated through institutional controls such as deed restrictions on future site development.

6.5 Alternative No. 6; Source Removal and Groundwater Collection, *In Situ* Biological Treatment, Monitoring

6.5.1 Description of Alternative

The primary components of this alternative would consist of a vacuum-enhanced, dual-phase LNAPL recovery system for source removal followed by the *in situ* biological treatment of impacted soils above the RAO. The existing dual-phase, vacuum-enhanced LNAPL recovery system, as described in the *LNAPL IRM Upgrade Work Plan*, and installed in June 1995, has been designed to accomplish the source removal. It is anticipated that the LNAPL recovery system will require operation for a period of 4 to 5 years. An evaluation of the recovery system's effectiveness in recovering LNAPL will be conducted after operation for 1 to 2 years to allow sufficient operational data to be collected.

Groundwater collection and treatment would be accomplished as part of the enhanced LNAPL recovery system. Six to eight total fluids recovery pumps, which would create a combined area of influence, would be maintained. The separated groundwater would be treated by LGAC and discharged under permit to the combined sewer system operated by the BSA. Groundwater recovery would be terminated at the completion of source removal, and monitoring of selected monitoring wells would be conducted.

After the source has been removed, soils containing hydrocarbons above the RAO would be treated *in situ* by enhanced bioremediation. Naturally occurring indigenous bacteria will be stimulated through the injection of oxygen and nutrients via vertical wells. Soils underneath the Osmose facility can be included in the biological treatment. After the LNAPL has been removed, biological treatment within the existing soil treatment biocell will be continued. A deed restriction will also be required for this alternative. It is anticipated that the bioremediation of on-site soils to the RAO will take 3 to 5 years to complete.

6.5.2 Detailed Evaluation of Alternative No. 6

6.5.2.1 Short-Term Effectiveness. As with the other alternatives, the vacuum-enhanced source removal system is currently in place and operational. During the construction and installation of the *in situ* biological treatment system, no significant short-term potential risks to the community would exist. Construction requirements and techniques would be similar for all three *in situ* treatment alternatives, and, therefore, all have similar short-term risk levels. Minor noise disruption during construction activities at the site could occur.

6.5.2.2 Long-Term Effectiveness and Permanence. LNAPL removal and biological degradation of adsorbed constituents is effective and permanent. Off-site treatment (incineration) for the recovered LNAPL is required; however, the toxicity and volume of the constituents are permanently reduced. Similar to Alternative No. 5 in its application to PAHs, biological treatment is an emerging technology and will require more intensive maintenance to ensure performance. The duration of the biological treatment is anticipated to be approximately 3 to 5 years. Biodegradation has been shown to be effective in reducing the quantity of the lighter, less condensed PAHs; however, the bacteria's ability to metabolize the highly condensed PAH analytes is questionable.

Denial

6.5.2.3 Reduction of Toxicity, Mobility, and Mass. Groundwater control during LNAPL removal would significantly reduce the mobility of the source and dissolved constituents. Bioremediation of residual hydrocarbons to the RAO will permanently and irreversibly reduce the toxicity and mass of residual adsorbed wastes at the site. It is anticipated that a slightly longer time frame would be required to reduce the mass of contaminants than Alternative Nos. 5 and 7 can achieve.

6.5.2.4 Implementability. As mentioned above, the vacuum enhanced source removal system is currently in place and operational. The subsurface installation and above grade construction represent a normal level of effort to complete. Utilities would not require rerouting. Administrative feasibility requires a normal effort and several equipment subcontractors and specialists are available to perform the work.

6.5.2.5 Compliance with SCGs. Chemical-specific SCGs (such as groundwater standards) would be maintained at point-of-compliance locations. Once the source of constituents in groundwater has been removed, natural attenuation and degradation will eventually reduce any residual downgradient dissolved levels.

Action-specific SCGs would be met by off-site incineration of the recovered LNAPL. Also, treatment of collected groundwater and air during the source removal phase with LGAC will satisfy both the

Action-specific SCGs would be met by off-site incineration of the recovered LNAPL. Also, treatment of collected groundwater and air during the source removal phase with LGAC will satisfy both the BSA requirement for discharge into the combined sewer system and the NYSDEC air quality regulations. OSHA requirements would be maintained at all times via monitoring and planning.

Location-specific SCGs do not directly apply to the site.

6.5.2.6 ***Cost.*** Table 6-5 provides the cost estimate for Alternative No. 6. The estimated annual operation and maintenance of the existing enhanced, dual-phase recovery system is $50,000 per year. The capital cost for the bioremediation treatment system, including engineering, installation, and administrative costs has been estimated at $215,000. The present worth of this alternative therefore was calculated to be approximately $653,000.

6.5.2.7 ***Overall Protection of Human Health and the Environment.*** Alternative No. 6 provides protection to both human health and the environment to the same extent as the other alternatives by removing and permanently destroying the waste. Future exposure to residual constituents would be eliminated through institutional controls such as deed restrictions on future site development.

6.6 Alternative No. 7; Source Removal and Groundwater Collection, *In Situ* Thermal Treatment, Monitoring

6.6.1 Description of Alternative

The primary components of this alternative would consist of a vacuum-enhanced, dual-phase LNAPL recovery system for source removal coupled with the addition of steam injection to raise the temperature of the soil and groundwater in the affected areas. This temperature increase would decrease the viscosity of the LNAPL and increase the volatility of the PAHs. The existing dual-phase, vacuum-enhanced LNAPL recovery system, described in the *LNAPL IRM Upgrade Work Plan* and installed in June 1995, would be augmented to achieve the desired effects. It is anticipated that the LNAPL recovery system will require operation for a period of 3 to 4 years. An evaluation of the recovery system's effectiveness in recovering LNAPL will be conducted after operation for 1 to 2 years, to allow sufficient operational data has been collected.

Groundwater collection and treatment would be accomplished as part of the enhanced LNAPL recovery system. Six to eight total fluids recovery pumps, which will create a combined area of influence, will be maintained. The separated groundwater will be treated by LGAC and discharged under permit to the combined sewer system operated by the BSA.

After the source (LNAPL) has been removed, soils containing hydrocarbons above the RAO would continue to be treated *in situ* by the steam injection, groundwater recovery, and SVE portions of the treatment system. Soils underneath the Osmose facility can be included in the thermal treatment. Treatment of soils inside the existing biocell would be included in the thermal treatment. It is anticipated that the thermal treatment of on-site soils to the RAO will take 2 to 4 years to complete.

After the *in situ* thermal treatment is completed, groundwater recovery would be terminated, and monitoring of selected monitoring wells would continue. A deed restriction would also remain in effect for the site.

6.6.2 Detailed Evaluation of Alternative No. 7

6.6.2.1 ***Short-Term Effectiveness.*** As with the other alternatives, the vacuum-enhanced source removal system is currently in place and operational. During the construction and installation of the thermal treatment system no significant short-term risks to the community would exist. Construction requirements and techniques would be similar for all three *in situ* treatment alternatives, and, therefore, all have similar short-term potential risk levels. Minor noise disruption during construction activities at the site could occur.

6.6.2.2 ***Long-Term Effectiveness and Permanence.*** Enhanced LNAPL and adsorbed hydrocarbon removal by steam is permanent. Off-site treatment (incineration) for the recovered LNAPL is required; however, the toxicity and mass of the constituents are permanently reduced. Similar to Alternative Nos. 5 and in its application to PAHs, thermal treatment is an emerging technology and will require more intensive maintenance to ensure performance. The duration of the thermal treatment is anticipated to be approximately 3 to 4 years. Thermal treatment has been shown to be effective in reducing the viscosity of LNAPL to enhance recovery; however, laboratory bench testing would be required to confirm that adsorbed concentrations of PAHs can be reduced to the RAO.

6.6.2.3 Reduction of Toxicity, Mobility, and Mass. Groundwater control during enhanced LNAPL removal would significantly reduce the mobility of the source and dissolved constituents. Enhanced thermal recovery of adsorbed hydrocarbons to the RAO will permanently and irreversibly reduce the toxicity and mass of residual adsorbed wastes at the site. It is anticipated that a slightly longer time frame than that estimated for Alternative No. 5 would be required to reduce the mass of constituents.

6.6.2.4 Implementability. As mentioned above, the vacuum-enhanced source removal system is currently in place and operational. Augmentation of the existing system would require subsurface installation and abovegrade construction. These activities represent a normal level of effort to complete. Utilities would not require rerouting. Administrative feasibility requires a normal effort, and several equipment subcontractors and specialists are available to perform the work.

6.6.2.5 Compliance with SCGs. Chemical-specific SCGs (such as groundwater standards) would be maintained at point-of-compliance locations. Once the source of constituents in groundwater has been removed, natural attenuation and degradation will eventually reduce residual downgradient dissolved levels.

Action-specific SCGs would be met by off-site incineration of the recovered LNAPL. Also, treatment of collected groundwater and air during the source removal phase with LGAC will satisfy both the BSA requirement for discharge into the combined sewer system and the NYSDEC air quality regulations. OSHA requirements would be maintained at all times via monitoring and planning.

Location-specific SCGs do not directly apply to the site.

6.6.2.6 Cost. Table 6-6 provides the cost estimate for Alternative No. 7. The estimated annual operation and maintenance of the existing enhanced dual phase recovery system is $50,000 per year. The capital cost for the thermal-enhanced recovery system, including engineering and administrative costs has been estimated to be $260,000. The present worth of this alternative therefore is $636,000.

6.6.2.7 Overall Protection of Human Health and the Environment. Alternative No. 7 provides protection to both human health and the environment to the same extent as the other alternatives by removing and permanently destroying the waste. Future exposure to residual constituents would be eliminated through institutional controls such as deed restrictions on future site development.

6.6.2.4 Implementability. As mentioned above, the vacuum-enhanced source removal system is currently in place and operational. Augmentation of the existing system would require subsurface installation and abovegrade construction. These activities represent a normal level of effort to complete. Utilities would not require rerouting. Administrative feasibility requires a normal effort, and several equipment subcontractors and specialists are available to perform the work.

6.6.2.5 Compliance with SCGs. Chemical-specific SCGs (such as groundwater standards) would be maintained at point-of-compliance locations. Once the source of constituents in groundwater has been removed, natural attenuation and degradation will eventually reduce residual downgradient dissolved levels.

Action-specific SCGs would be met by off-site incineration of the recovered LNAPL. Also, treatment of collected groundwater and air during the source.removal phase with LGAC will satisfy both the BSA requirement for discharge into the combined sewer system and the NYSDEC air quality regulations. OSHA requirements would be maintained at all times via monitoring and planning.

Location-specific SCGs do not directly apply to the site.

6.6.2.6 Cost. Table 6-5 provides the cost estimate for Alternative No. 7. The estimated annual operation and maintenance of the existing enhanced dual phase recovery system is $50,000 to $80,000 per year. The installed cost for the thermal-enhanced recovery system, including engineering and administrative costs, range from $435,000 to $525,000. The present worth of this alternative therefore ranges from $428,000 to $510,000.

6.6.2.7 Overall Protection of Human Health and the Environment. Alternative No. 7 provides protection to both human health and the environment to the same extent as the other alternatives by removing and permanently destroying the waste. Future exposure to residual constituents would be eliminated through institutional controls such as deed restrictions on future site development.

7

7.0 SELECTION OF PREFERRED ALTERNATIVE

The comparative analysis of retained alternatives using the seven NYSDEC criteria is summarized below, and a preferred remedial alternative selected.

7.1 Overview of Selected Alternative

Table 7-1, Detailed Evaluation of Retained Remedial Alternatives, summarizes the numerical evaluations conducted as outlined in NYSDEC TAGM 4030. Remedial Alternative No. 5 (Source Removal and Groundwater Collection, *In Situ* Chemical Treatment, Monitoring) was selected as the alternative of choice for the Osmose site by the Detailed Evaluation process described above.

The analysis determined that Alternative No. 1, "No Action," would not result in compliance with SGCs, and would be significantly less protective of health and the environment than other alternatives. All the other alternatives were equal in relation to compliance with SCGs. Implementability and cost precluded Alternative No. 3 from final selection. Alternative No. 7 was eliminated based on its long-term effectiveness and potential inability to reduce COI concentrations to the RAOs. The primary components of the selected alternative would consist of a vacuum-enhanced, dual-phase LNAPL recovery system for source removal followed by the injection of ozone into the subsurface to oxidize organic compounds. During completion of the source removal and soil treatment actions, groundwater would be monitored to ensure it met the RAOs stated earlier.

7.2 Process Components of Selected Alternative

Major process components of the selected remedial alternative are described below.

LNAPL Recovery System. A vacuum-enhanced LNAPL recovery system, described in the *LNAPL IRM Upgrade Work Plan* and installed in June 1995, was designed and is presently accomplishing contaminant source removal. It is anticipated that the LNAPL recovery system will require operation for 4 to 5 years. An evaluation of the recovery system's effectiveness in recovering LNAPL will be conducted after operation for 1 to 2 years, until sufficient operating data has been collected. At that time, actions to enhance or modify the system, if required, will be evaluated.

TABLE 7-1

Detailed Evaluation of Retained Remedial Alternatives

Assembled Remedial Alternatives	Compliance with SGCs	Protection of Health and Environment	Short-Term Effectiveness[1]	Long-Term Effectiveness	**Reduction** of Toxicity, Mobility, or Volume	Implementability[1]	Cost	Evaluation Score
1. "No Action"; Monitoring	0	5	4	0	3	13	13	38
3. Source Removal and groundwater treatment; soil incineration; monitoring	10	20	4	15	17	11	10	87
5. Source Removal and groundwater treatment; *in situ* soil chemical treatment; monitoring	10	17	8	15	16	10	13	89
6. Source removal and groundwater treatment; *in situ* soil biological treatment; monitoring	10	17	8	15	14	11	13	88
7. Source Removal and groundwater treatment; *in situ* collection treatment of soil; monitoring	10	17	8	12	13	9	15	84

[1] Refer to New York State Department of Environmental Conservation, Department of Hazardous Waste Remediation. *Selection of Remedial Actions at Inactive Hazardous Waste Sites*, TAGM HWR-89-4030. September 13, 1989.

Components of the system include:

- Eight vertical extraction wells (one 6-inch-diameter well, five 4-inch-diameter wells, two 2-inch-diameter wells), constructed of fiberglass reinforced epoxy. The locations of the wells are shown on figure 7-1.
- Six pneumatic total fluids pumps are used (three double-diaphragm, surface-mounted pumps and three submersible pumps).
- The combined area of influence created by the pumping wells is illustrated in figure 7-1, and in figure 7-2 which illustrates the results of drawdown as modeled by the computer program CAPZONE.
- A 5-hp, 230-V, three-phase, rotary, positive-displacement blower provides vacuum to enhance the recovery of total fluids and vapors from the wells.
- A 2,000-gallon settling tank is installed in the liquid stream to accomplish primary separation of liquid-phase creosote and oil.
- Three 200 pound granular activated carbon canisters are installed in series to remove emulsified oil and dissolved-phase organic compounds.
- Treated groundwater is discharged to the BSA POTW by permit.

As stated above in section 3.3.3, the presence of the COI has not been confirmed beneath the Osmose facility. However, LNAPL, and therefore adsorbed COI, may exist to some extent beneath the southeast corner of the facility. For this reason, the LNAPL recovery system was designed to collect potential LNAPL that may exist beneath the facility (recovery wells RW-7, RW-8, and RW-9 are located along the southern end of the building). Figures 7-1 and 7-2 represent CAPZONE modeling software output which shows that the influence of the LNAPL recovery system extends below the southeast corner of the facility and that potential LNAPL that may exist in this area will be recovered.

Ozone Injection System. Upon completion of the removal of measurable LNAPL using the enhanced recovery system described above, ozone will be injected to chemically degrade residual creosote adsorbed to soils. An ozone feasibility study was completed at the site demonstrating the effectiveness of this process. The results of the treatability test were presented in the *Ozone Injection Feasibility Study Report*. The selected remedial alternative would be effective throughout the zone of soils identified by the soil RAO, including within the soil biocell. Ozone would be injected into the saturated soil, and unreacted ozone would be recovered via soil vapor extraction (SVE) within a dewatered zone below the existing clay layer. To introduce ozone into the subsurface, a network of steel lines and injection wells will be installed. The following components are anticipated:

- Approximately twenty to twenty-six 1.25-inch-diameter vertical ozone injection wells, constructed of stainless steel. A schematic of the conceptual ozone system well network and its anticipated zone of influence is included as figure 7-3.
- A 25-hp, 230-V, three-phase blower will provide pressurized air to transport the ozone.
- An ozone generator will be installed.
- Vapor capture will be provided by the 5-hp, 230-V, three-phase, rotary, positive-displacement vacuum blower currently operational at the site.
- Two 500 pound vapor-phase granular activated carbon (VGAC) canisters will treat residual ozone in the captured vapor prior to atmospheric discharge.

It is anticipated that ozone treatment will require 1 to 2 years to complete. After the ozone treatment is completed, groundwater recovery will be terminated and monitoring of selected monitoring wells will continue to ensure the groundwater RAO is attained.

Section 3.3.3 (page 17), explains why delineation and/or remediation of soils beneath the facility was neither feasible nor proposed. The conceptual layout of the ozone injection system shown on figure 7-3 will therefore not address impacted soils, if any, beneath the facility. The existing facility's concrete foundation will serve as an effective barrier (i.e., cap) to eliminate any potential exposure of employees, workers, and residents to residual COI that may exist after any LNAPL is removed. It is anticipated that in the absence of LNAPL, natural biodegradation will occur and eventually reduce the concentration of the lighter fractions of any hydrocarbons which may exist.

Additionally, as required as part of the risk-derived RAOs for the site, a deed restriction has been filed by Osmose which identifies the "operable unit" portion of the site and restricts use of that portion of the property to activities which will not change the exposure scenarios used when developing the BRA.

7.3 Remedial Design Basis

After incorporation of comments from the NYSDEC, the selected remedial alternative as described above will become the basis for the project Remedial Design/Remedial Action for the project.

8

8.0 REFERENCES

EPA. October 1988. *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA.* EPA/540/G-8-9/004.

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NYSDEC. May 15, 1990. *Selection of Remedial Actions at Inactive Hazardous Waste Sites*, TAGM No. HWR-90-4030.

NYSDEC. *Air Guide 1 (Draft)*, 6NYCRR Part 212.

NYSDEC. *Ambient Water Quality Standards and Guidance Values*, TPGS 1.1.1.

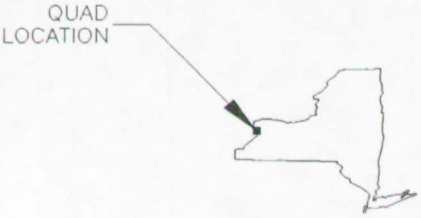
NYSDEC. *Determination of Soil Cleanup Objectives and Cleanup Levels*, TAGM HWR-94-4046.

FIGURES

GROUNDWATER
TECHNOLOGY

FIGURES

SOURCE: N.Y.S.D.O.T. TOPOGRAPHIC QUADRANGLE
BUFFALO NE QUADRANGLE
7.5 MINUTE SERIES
DATE: 1989



SCALE 1:24,000

0 2,000 4,000

SCALE FEET

N

GROUNDWATER
TECHNOLOGY

1245 KINGS ROAD
SCHENECTADY, NY 12303
(518) 370-5631

DESIGNED: JOG

DETAILED: DEO

CHECKED:

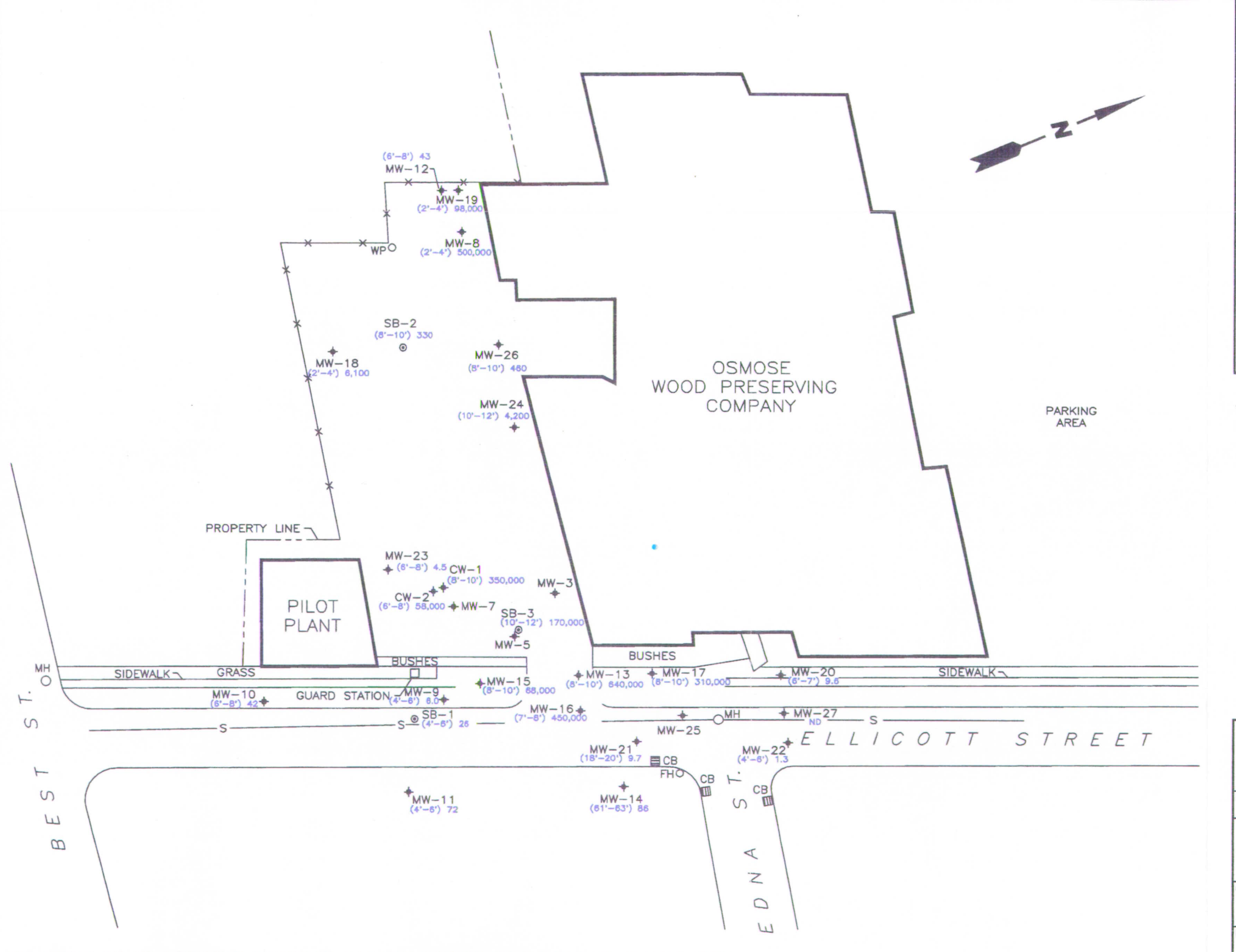
SITE LOCATION MAP

CLIENT: OSMOSE WOOD PRESERVING

DRAWING DATE: 8/13/93

LOCATION: 980 ELLICOTT STREET
BUFFALO, NEW YORK

FIGURE: **1-1**



LEGEND

✦	MONITORING WELL
✦	INJECTION POINT
⊗	MONITORING POINT
■	VAPOR EXTRACTION POINT
⊙	SOIL BORING
○ MH	MANHOLE
○ FH	FIRE HYDRANT
—×—×—	FENCE
—S—	SEWER LINE
(6'–7') 9.6	(DEPTH) TOTAL PAHs (ppb)

NOTE:
THE HIGHEST CONCENTRATION DETECTED IS REPORTED FOR EACH BORING LOCATION.

0 50 100
SCALE FEET

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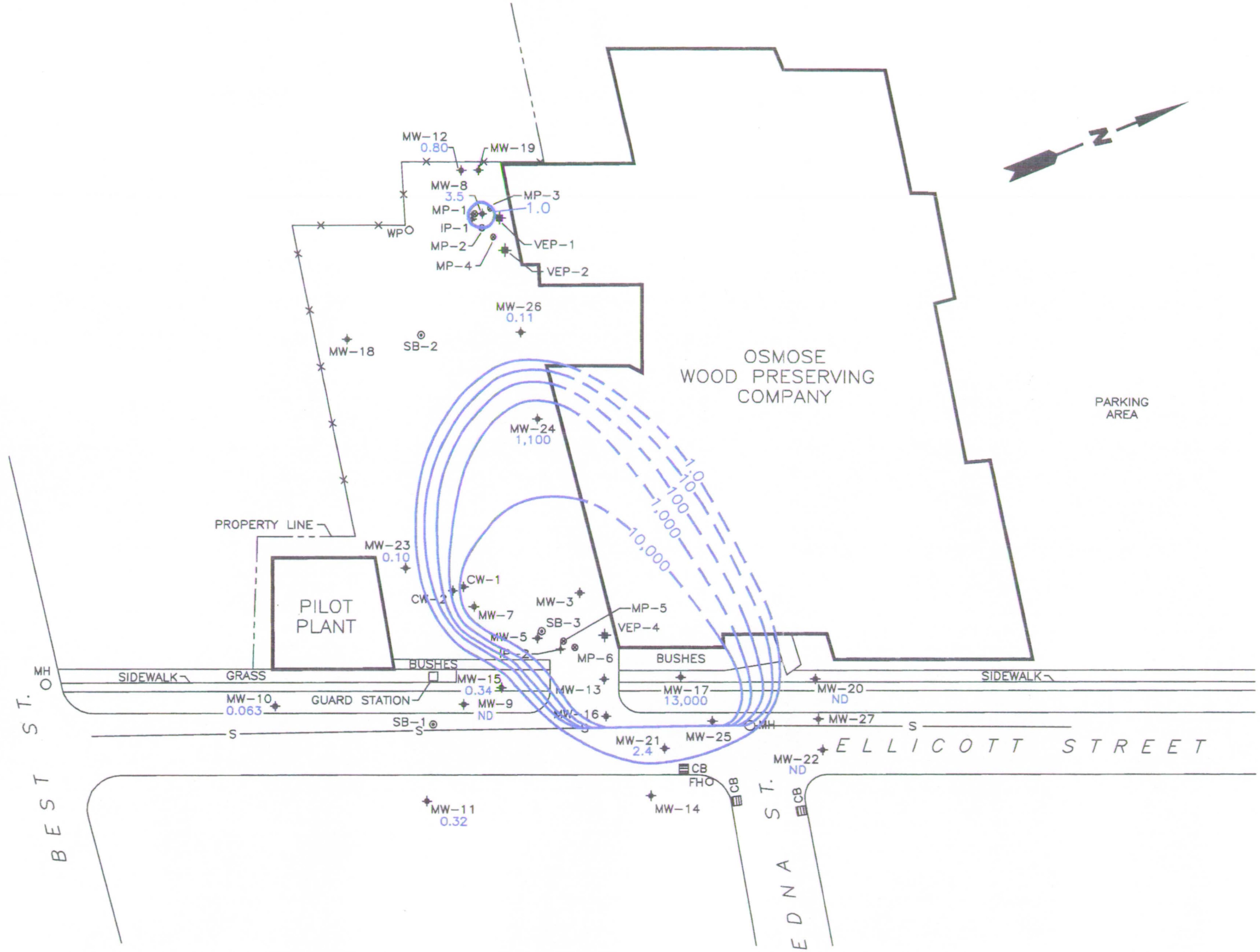
REV. NO.:
DRAWING DATE: 8/15/95
ACAD FILE: 8061–PAH

PAHs IN SUBSURFACE SOILS

CLIENT: OSMOSE WOOD PRESERVING COMPANY
PM: BWA
LOCATION: ELLICOTT STREET
BUFFALO, NEW YORK
PE/RG: JOG
DESIGNED: JOG
DETAILED: GMC
PROJECT NO.: 01110–8061
FIGURE: **2-1**



LEGEND

✦	MONITORING WELL
+	INJECTION POINT
⊗	MONITORING POINT
■	VAPOR EXTRACTION POINT
⊙	SOIL BORING
○ MH	MANHOLE
○ FH	FIRE HYDRANT
—	FENCE
—S—	SEWER LINE
—10—	DISSOLVED PAH CONTOUR (ppb)
220	DISSOLVED PAH (ppb)
ND	NOT DETECTED

MONITORING DATES: 2/18/93 AND 3/10/93

0 50 100
SCALE FEET

GROUNDWATER TECHNOLOGY

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(518) 370-5631

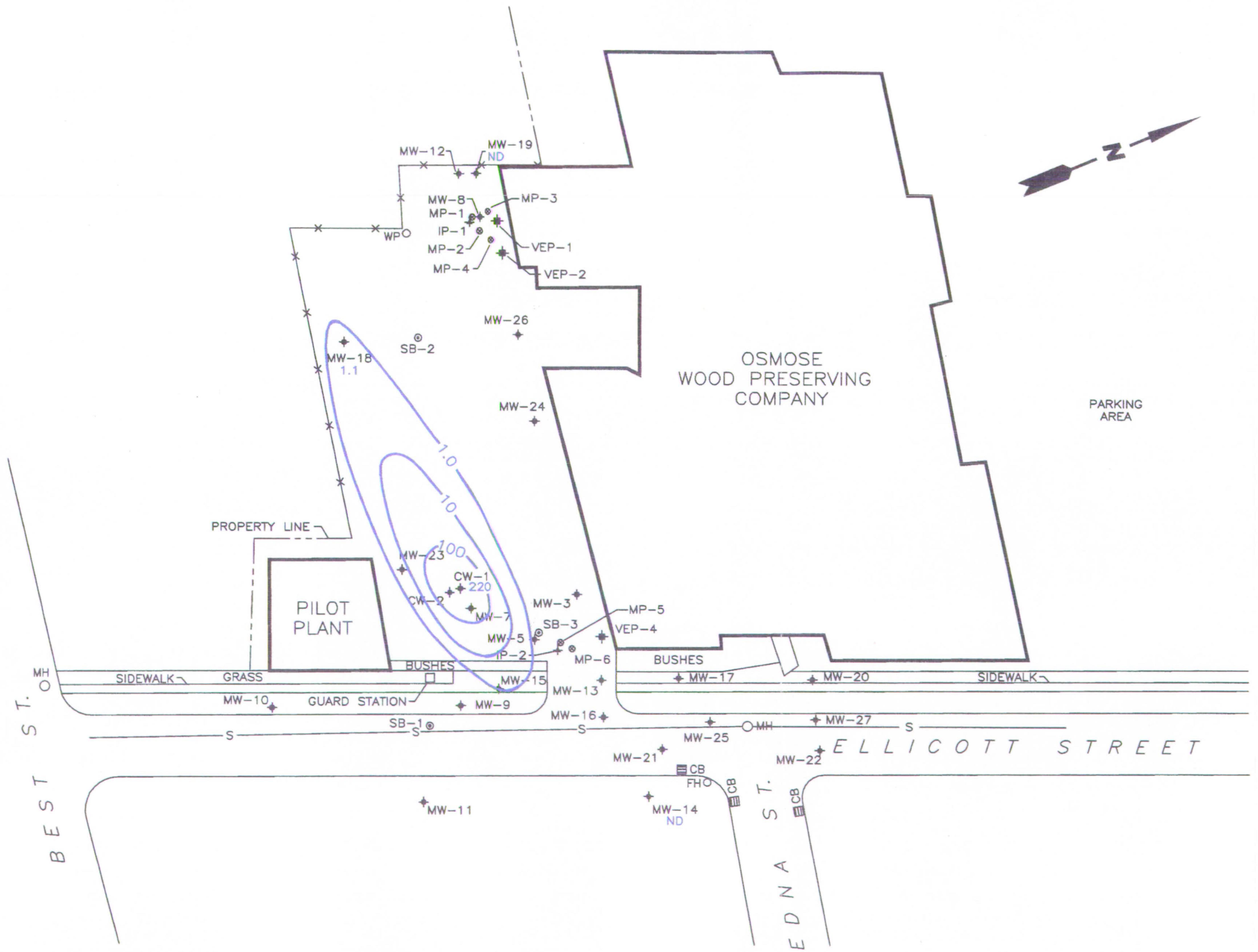
REV. NO.:	DRAWING DATE:	ACAD FILE:
	4/26/93	DPSMAR93

DISSOLVED PAHs IN GROUNDWATER (SHALLOW WELLS)

CLIENT: OSMOSE WOOD PRESERVING COMPANY
PM: BWA

LOCATION: ELLICOTT STREET
BUFFALO, NEW YORK
PE/RG: JOG

DESIGNED:	DETAILED:	PROJECT NO.:	FIGURE:
JOG	DEO	01110-5307	**2-2**



LEGEND

✦	MONITORING WELL
+	INJECTION POINT
⊗	MONITORING POINT
✚	VAPOR EXTRACTION POINT
⊙	SOIL BORING
○ MH	MANHOLE
○ FH	FIRE HYDRANT
———	FENCE
—S—	SEWER LINE
—10—	DISSOLVED PAH CONTOUR (ppb)
220	DISSOLVED PAH (ppb)
ND	NOT DETECTED

MONITORING DATES: 2/18/93

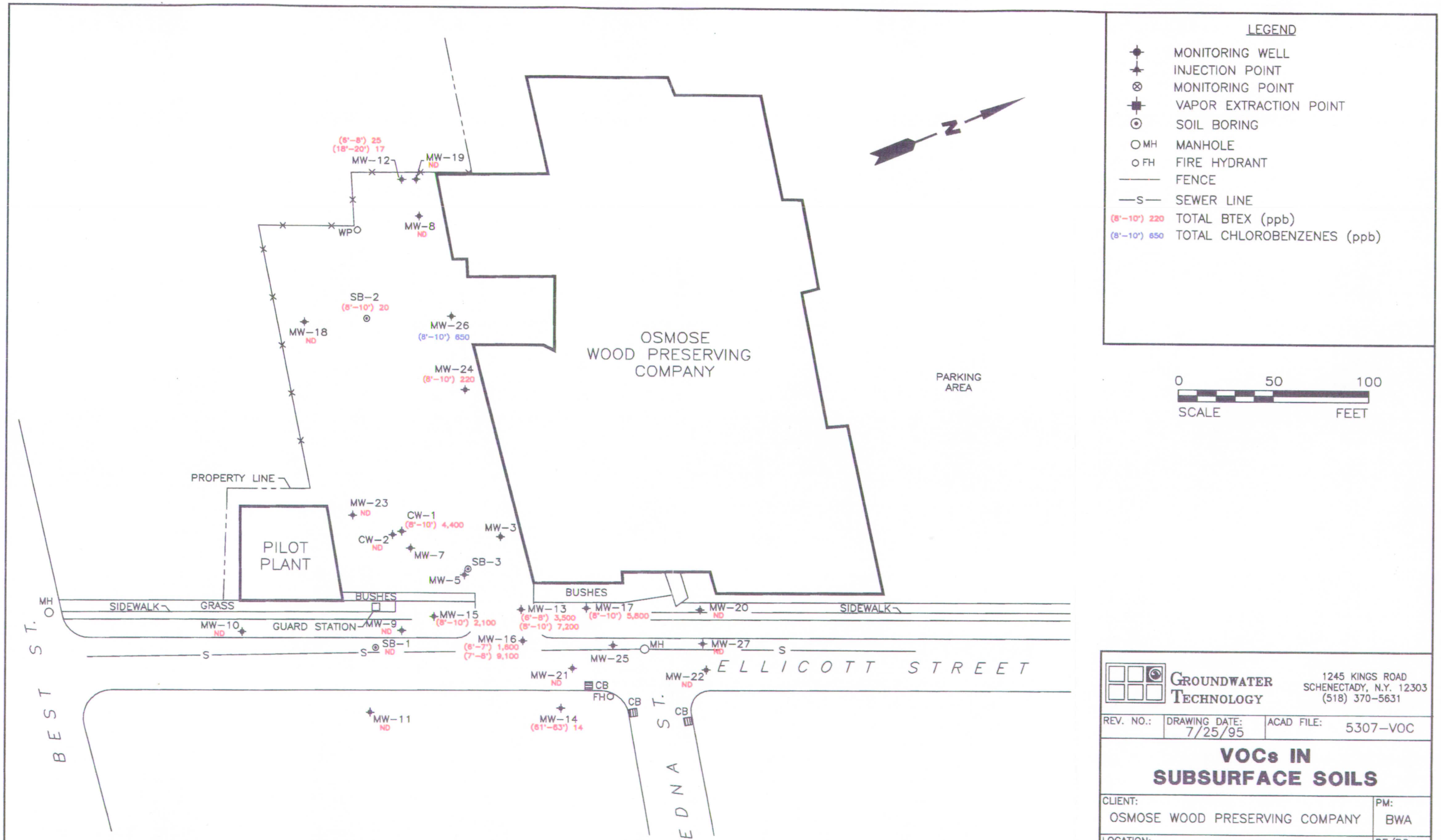
0 50 100
SCALE FEET

GROUNDWATER TECHNOLOGY
1245 KINGS ROAD
SCHENECTADY, N.Y. 12303
(518) 370-5631

REV. NO.:	DRAWING DATE: 4/26/93	ACAD FILE: DPDFEB93

DISSOLVED PAHs IN GROUNDWATER (DEEP WELLS)

CLIENT: OSMOSE WOOD PRESERVING COMPANY			PM: BWA
LOCATION: ELLICOTT STREET BUFFALO, NEW YORK			PE/RG: JOG
DESIGNED: JOG	DETAILED: DEO	PROJECT NO.: 01110-5307	FIGURE: **2-3**



GROUNDWATER TECHNOLOGY

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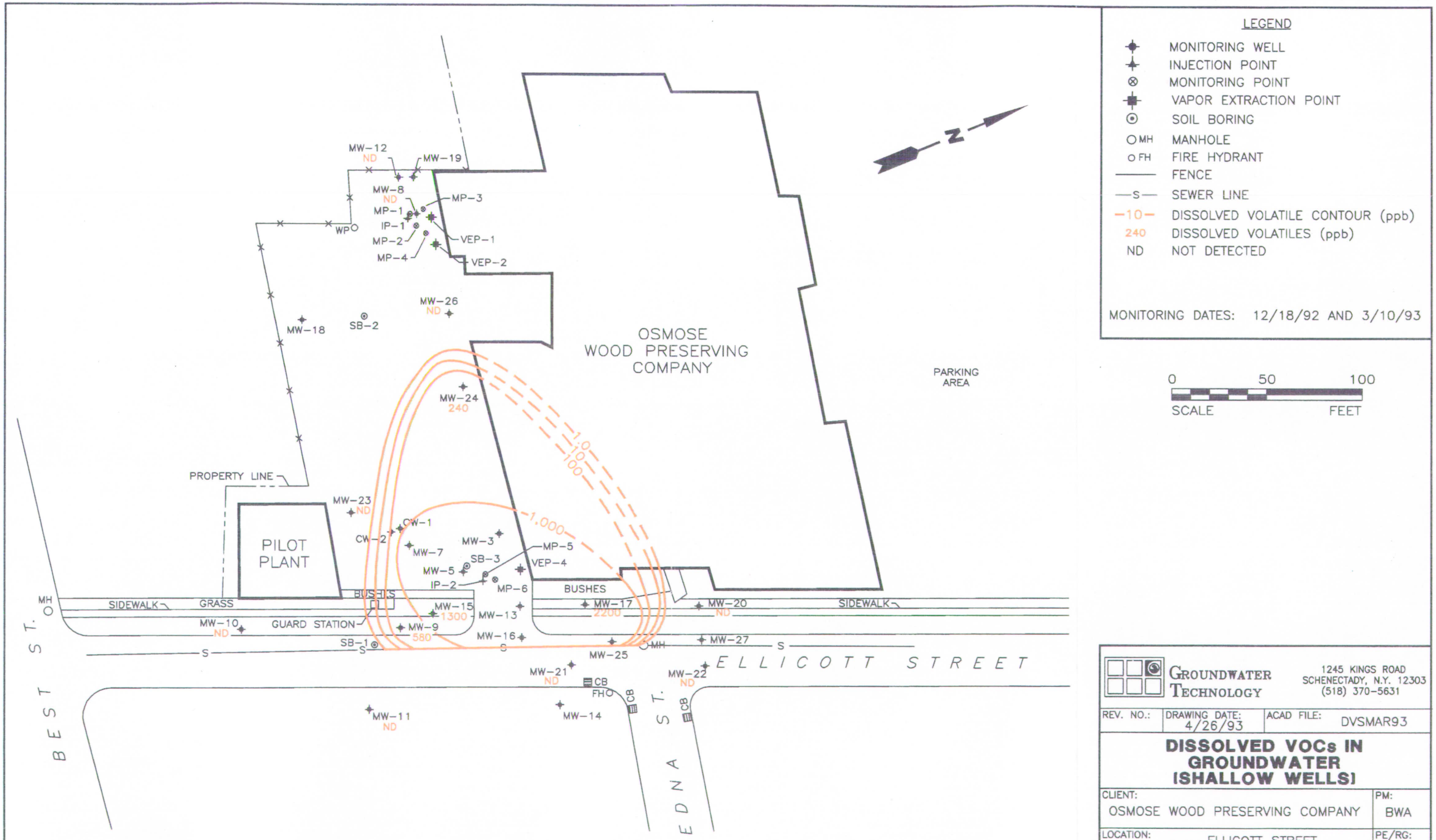
(518) 370–5631

REV. NO.:	DRAWING DATE:	ACAD FILE:
	7/25/95	5307–VOC

VOCs IN SUBSURFACE SOILS

CLIENT: OSMOSE WOOD PRESERVING COMPANY	PM: BWA
LOCATION: ELLICOTT STREET BUFFALO, NEW YORK	PE/RG: JOG

DESIGNED:	DETAILED:	PROJECT NO.:	FIGURE:
JOG	DEO	01110–5307	**2–4**



GROUNDWATER TECHNOLOGY

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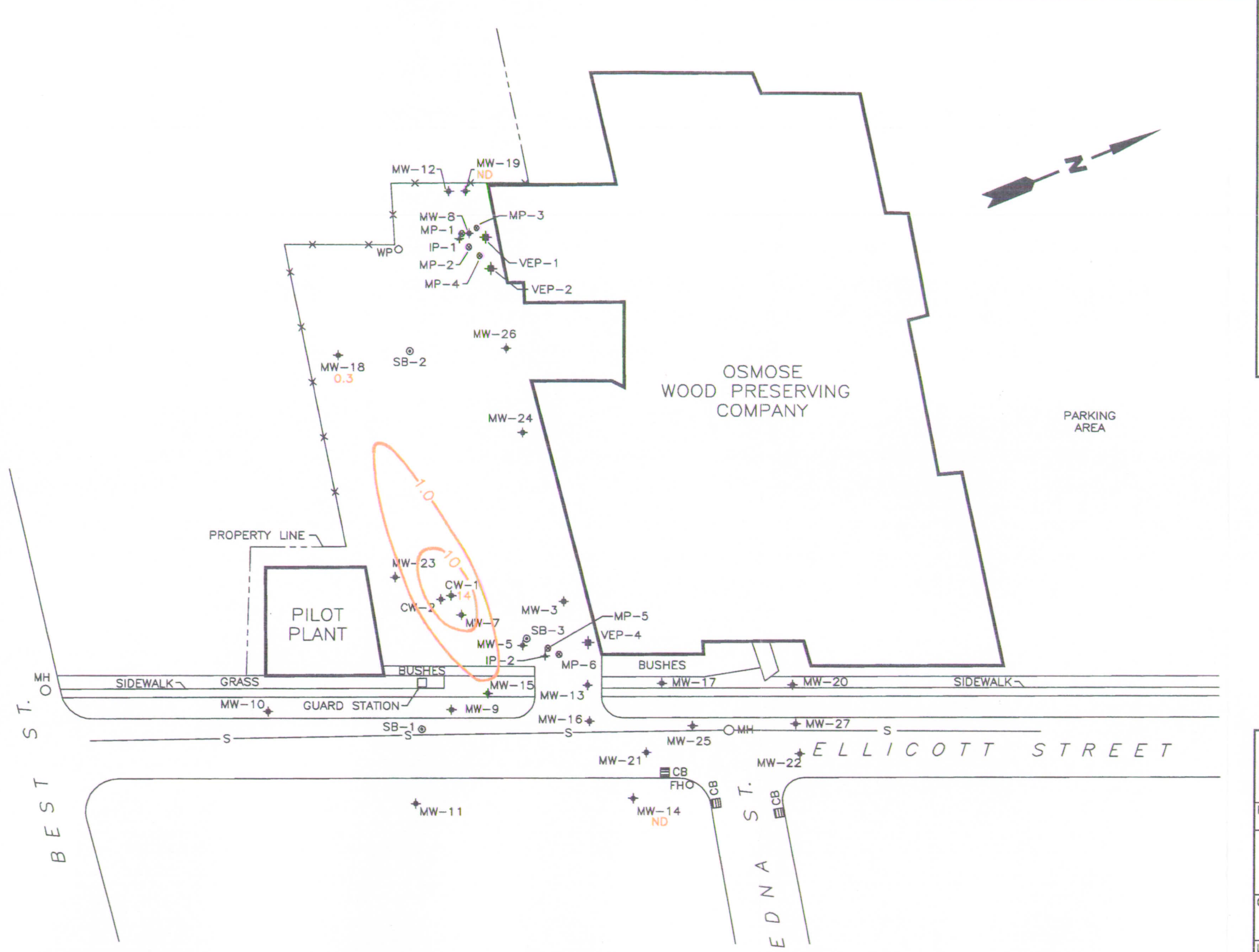
(518) 370-5631

REV. NO.:	DRAWING DATE: 4/26/93	ACAD FILE: DVSMAR93

DISSOLVED VOCs IN GROUNDWATER (SHALLOW WELLS)

CLIENT: OSMOSE WOOD PRESERVING COMPANY	PM: BWA
LOCATION: ELLICOTT STREET BUFFALO, NEW YORK	PE/RG: JOG

DESIGNED: JOG	DETAILED: DEO	PROJECT NO.: 01110-5307	FIGURE: **2-5**



LEGEND

✦	MONITORING WELL
+	INJECTION POINT
⊗	MONITORING POINT
■	VAPOR EXTRACTION POINT
⊙	SOIL BORING
○ MH	MANHOLE
○ FH	FIRE HYDRANT
——	FENCE
—S—	SEWER LINE
—10—	DISSOLVED VOLATILE CONTOUR (ppb)
240	DISSOLVED VOLATILES (ppb)
ND	NOT DETECTED

MONITORING DATES: 2/18/93

0 50 100
SCALE FEET

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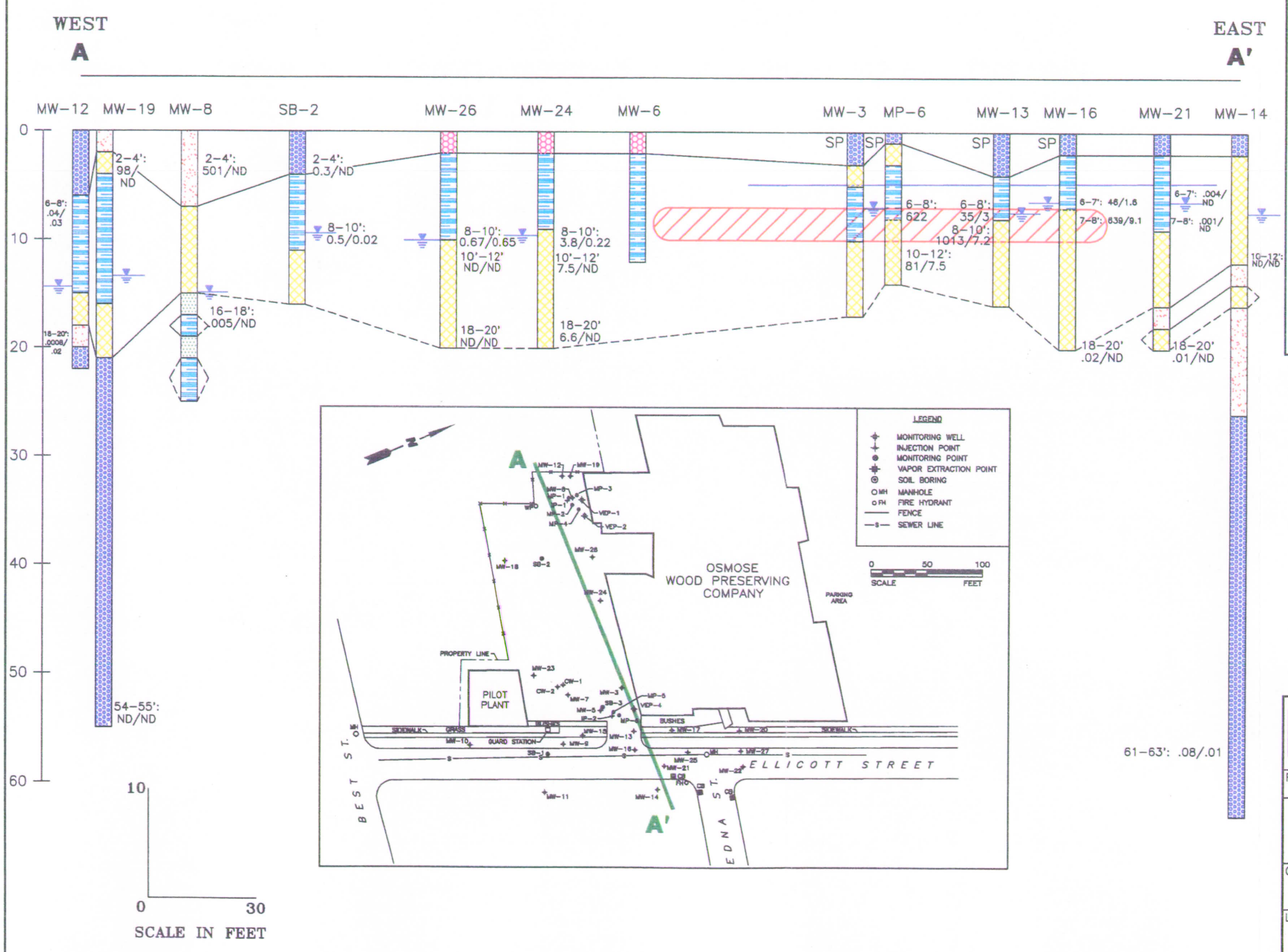
REV. NO.:	DRAWING DATE: 4/26/93	ACAD FILE: DVDFEB93

DISSOLVED VOCs IN GROUNDWATER (DEEP WELLS)

CLIENT: OSMOSE WOOD PRESERVING COMPANY	PM: BWA
LOCATION: ELLICOTT STREET BUFFALO, NEW YORK	PE/RG: JOG

DESIGNED:	DETAILED:	PROJECT NO.:	FIGURE:
JOG	DEO	01110-5307	**2-6**



LEGEND

GLACIAL OUTWASH DEPOSITS AND FILL
- ▨ FINE SANDS
- ▨ FINE TO COARSE SANDS WITH SILT/CLAY
- ▨ COARSE SANDS WITH GRAVEL
- ▨ SILTY SANDS WITH GRAVEL

GLACIAL LAKE DEPOSITS
- ▨ SILTY SANDS, SILTS, CLAYEY SANDS
- ▨ CLAY

6-7': .004/ND DEPTH: PAHs/VOCs (FT.) (ppm)

SP- SEPARATE PHASE PRESENT IN WELL (ppm)

▽ DEPTH THAT SATURATED SOILS WERE ENCOUNTERED DURING DRILLING

— STATIC WATER TABLE (12/17/92)

▨ APPROXIMATE EXTENT OF SOILS > 473 ppm PAHs

GROUNDWATER TECHNOLOGY
1245 KINGS ROAD
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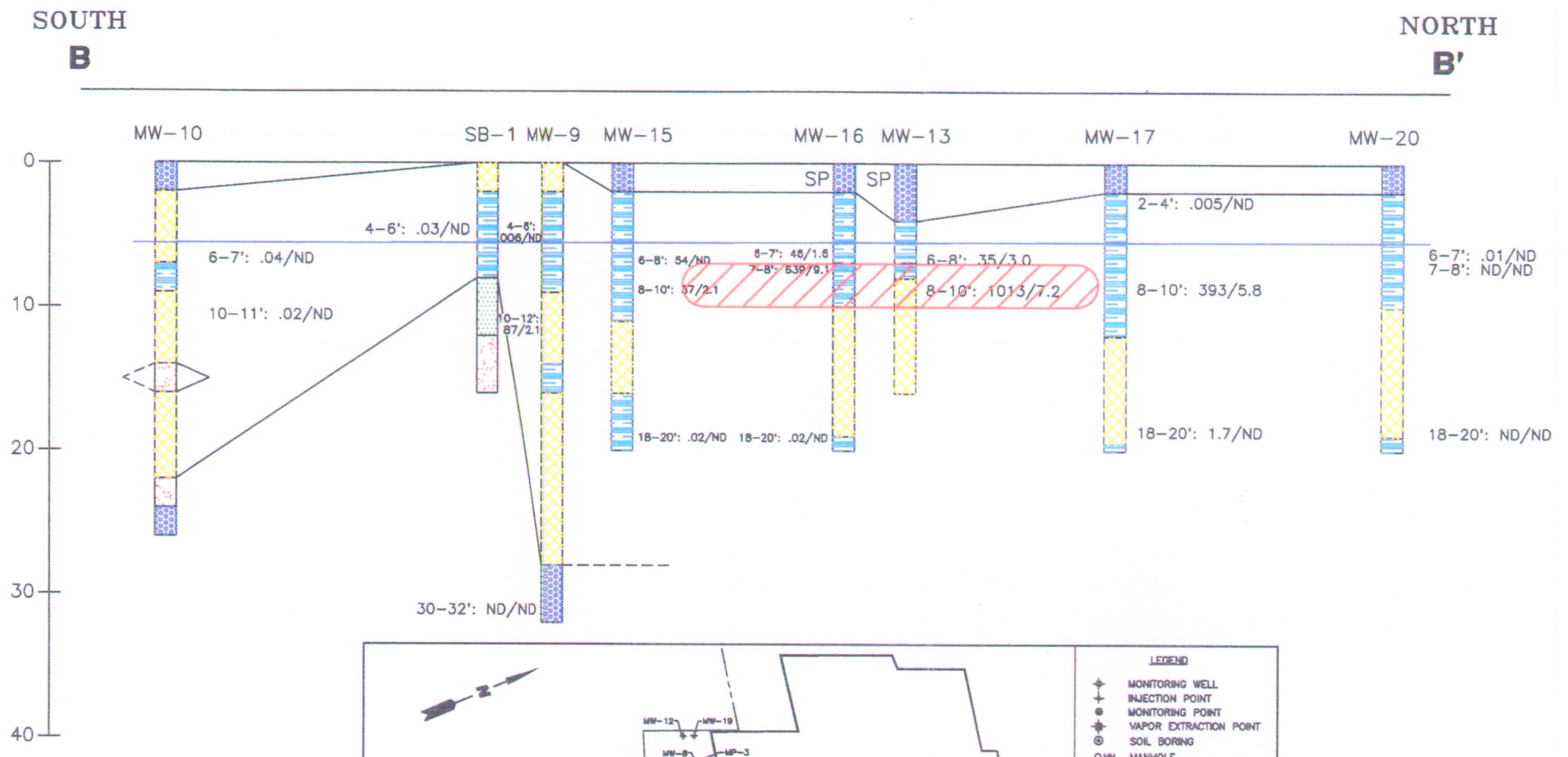
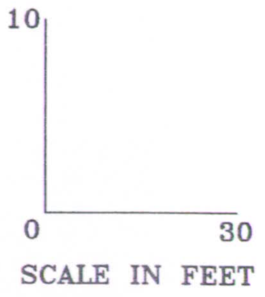
(518) 370-5631

REV. NO.:
DRAWING DATE: 8/17/93
ACAD FILE: 5307-16X

SOILS ABOVE 473 ppm PAHs CROSS-SECTION A - A'

CLIENT: OSMOSE WOOD PRESERVING INC.
PM: BWA
LOCATION: 980 ELLICOTT STREET
BUFFALO, NEW YORK
PE/RG: JOG
DESIGNED: JOG
DETAILED: DEO
PROJECT NO.: 01110-5307
FIGURE: 2-9





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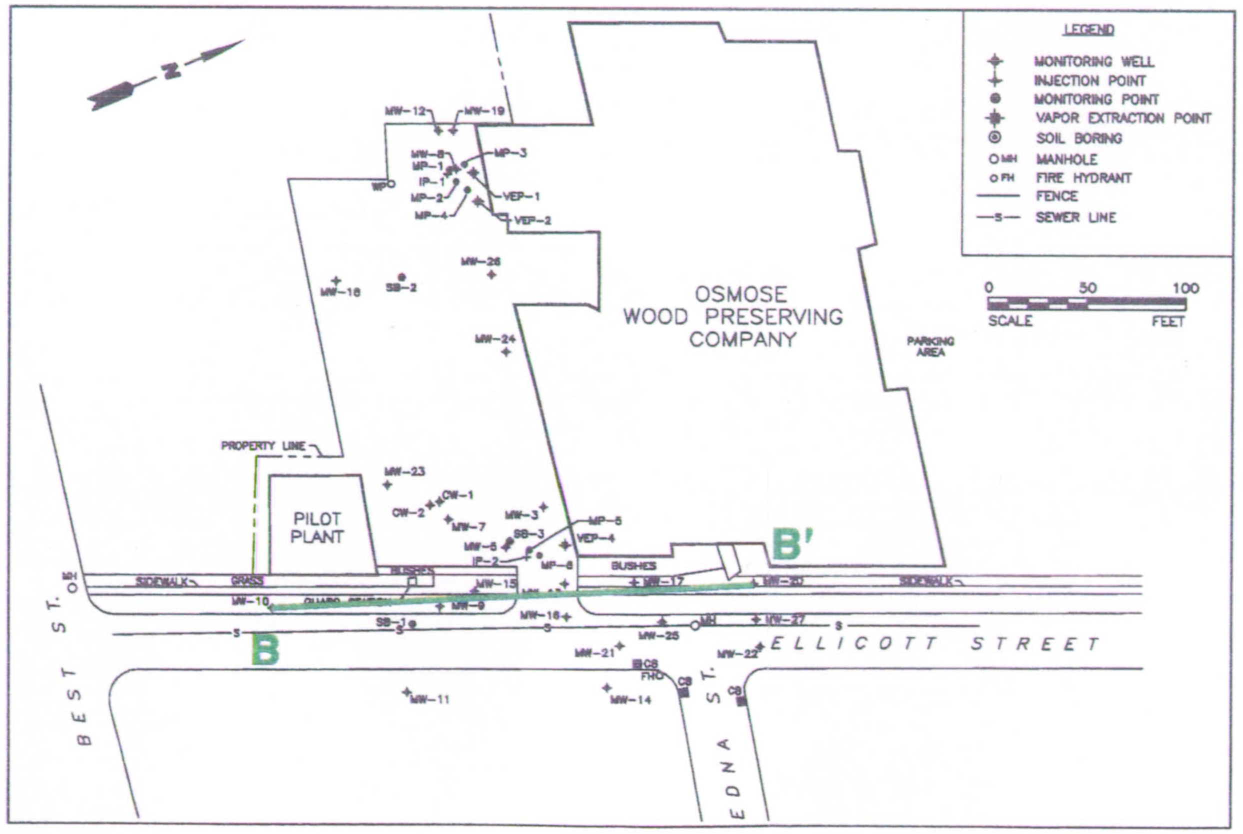


LEGEND

GLACIAL OUTWASH DEPOSITS AND FILL
- ▨ FINE SANDS
- ▨ FINE TO COARSE SANDS WITH SILT/CLAY
- ▨ COARSE SANDS WITH GRAVEL
- ▨ SILTY SANDS WITH GRAVEL

GLACIAL LAKE DEPOSITS
- ▨ SILTY SANDS, SILTS, CLAYEY SANDS
- ▨ CLAY

2-4': .005/ND DEPTH: PAHs/VOCs (FT.) (ppm) (ppm)

SP– SEPARATE PHASE PRESENT IN WELL
ND– NONE DETECTED

— STATIC WATER TABLE (12/17/92)

▨ APPROXIMATE EXTENT OF SOILS > 473 ppm PAHs

GROUNDWATER TECHNOLOGY

1245 KINGS RD
SCHENECTADY, NY 12303
(518) 370-5631

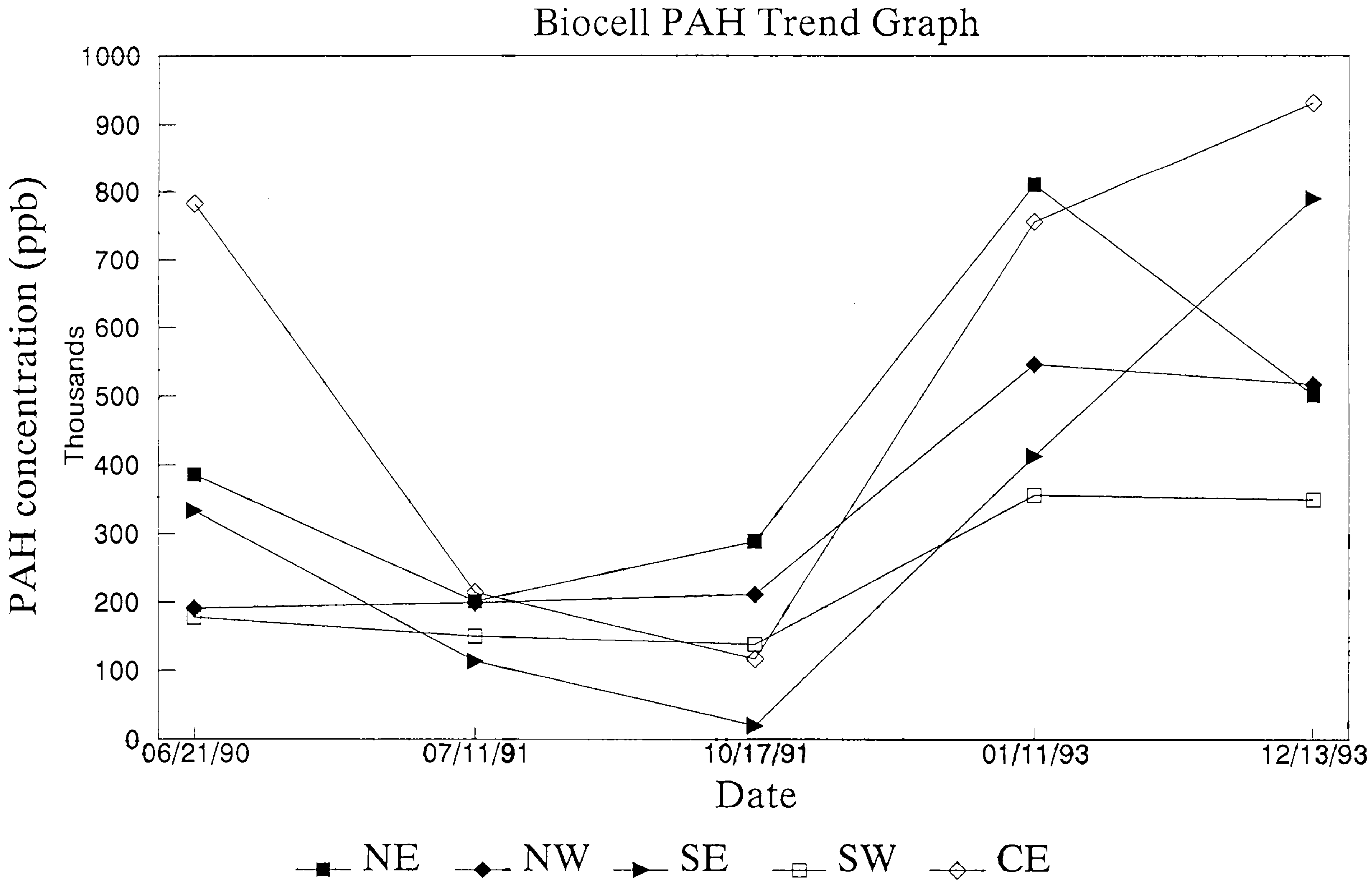
REV. NO.:	DRAWING DATE: 8/17/93	ACAD FILE: 5307-17X

SOILS ABOVE 473 ppm PAHs CROSS-SECTION B - B'

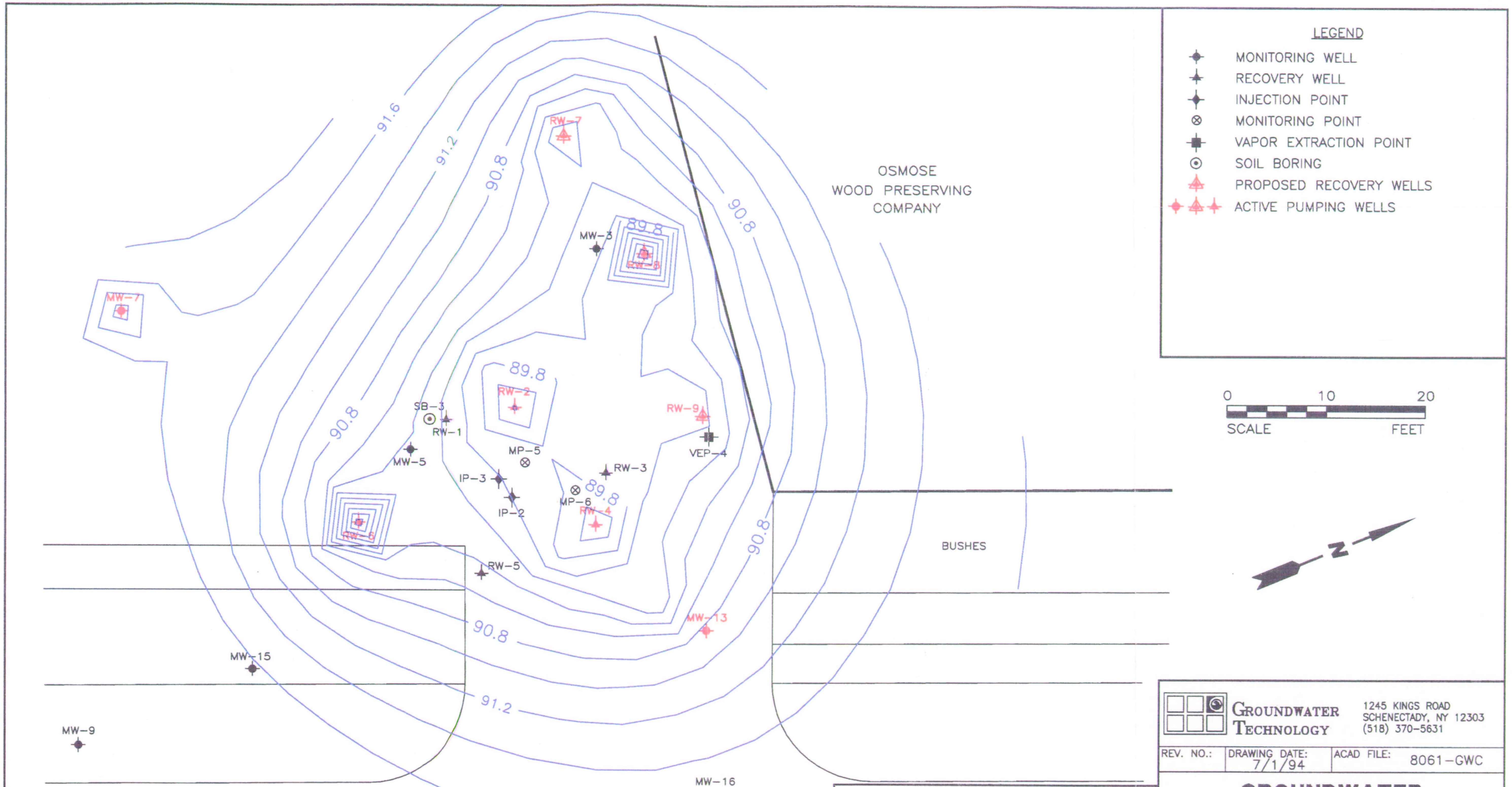
CLIENT: OSMOSE WOOD PRESERVING INC.	PM: BWA
LOCATION: 980 ELLICOTT STREET BUFFALO, NEW YORK	PE/RG: JOG

DESIGNED:	DETAILED:	PROJECT NO.:	FIGURE:
JOG	MET/DEO	01110-5307	**2-10**

FIGURE 5-1



Biocell PAH Trend Graph
1000
900
800
700
600
500
400
300
200
100
0
PAH concentration (ppb)
Thousands
06/21/90
07/11/91
10/17/91
01/11/93
12/13/93
Date
NE
NW
SE
SW
CE



LEGEND

- MONITORING WELL
- RECOVERY WELL
- INJECTION POINT
- ⊗ MONITORING POINT
- VAPOR EXTRACTION POINT
- ⊙ SOIL BORING
- PROPOSED RECOVERY WELLS
- ACTIVE PUMPING WELLS

T = 30 gpd/ft
S = 0.25
b = 17'

FLOW RATES	
RW-2	0.06 GPM
RW-4	0.06 GPM
RW-6	0.06 GPM
RW-7	0.06 GPM
RW-8	0.06 GPM
RW-9	0.06 GPM
MW-7	0.04 GPM
MW-13	0.02 GPM

30 DAYS OF PUMPING
STATIC GROUNDWATER GRADIENT 0.7%

GROUNDWATER TECHNOLOGY
1245 KINGS ROAD
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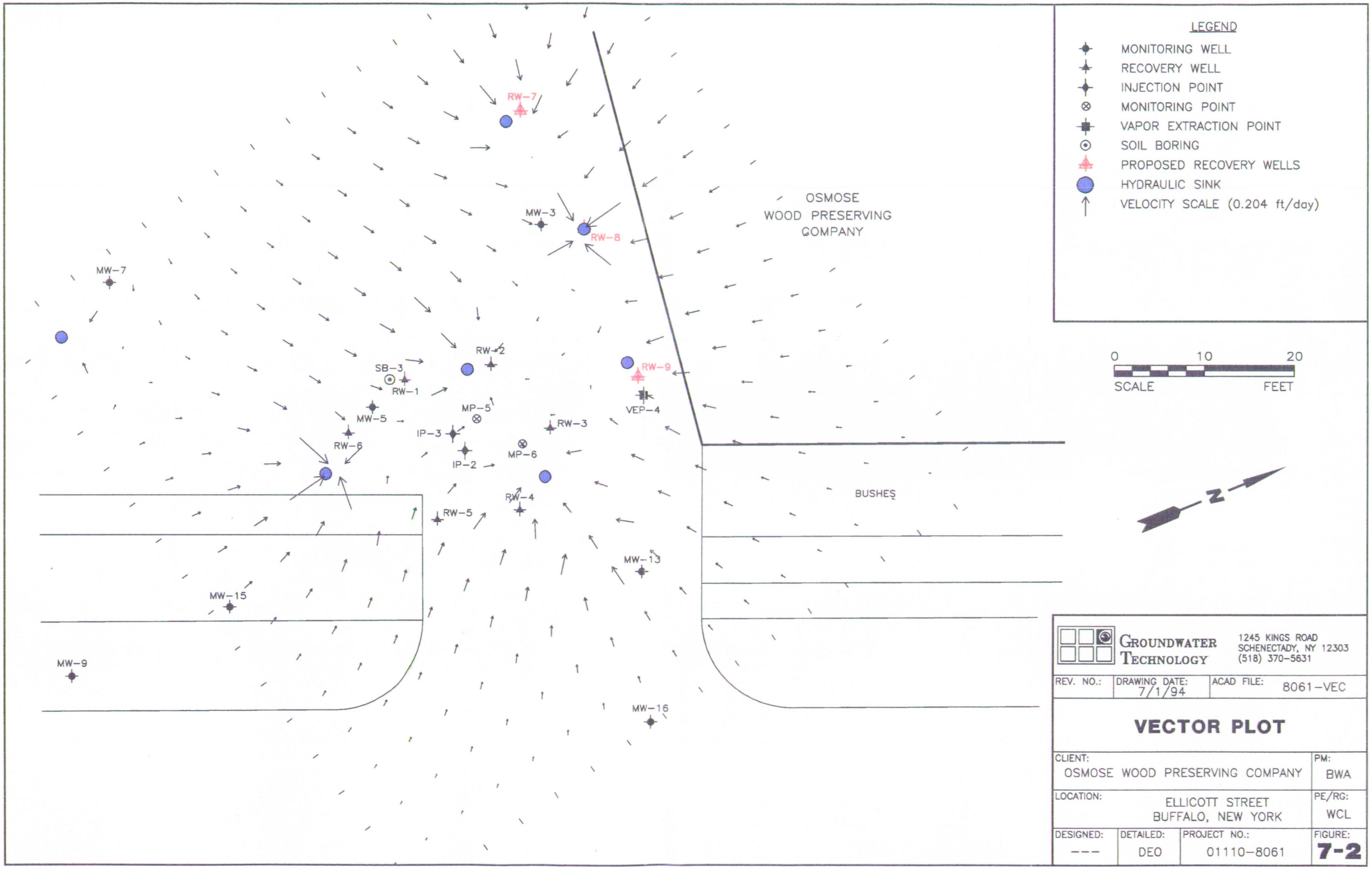
(518) 370-5631

REV. NO.:	DRAWING DATE: 7/1/94	ACAD FILE: 8061-GWC

GROUNDWATER ELEVATION MAP

CLIENT: OSMOSE WOOD PRESERVING COMPANY	PM: BWA
LOCATION: ELLICOTT STREET BUFFALO, NEW YORK	PE/RG: WCL

DESIGNED:	DETAILED:	PROJECT NO.:	FIGURE:
---	DEO	01110-8061	7-1



GROUNDWATER TECHNOLOGY

1245 KINGS ROAD
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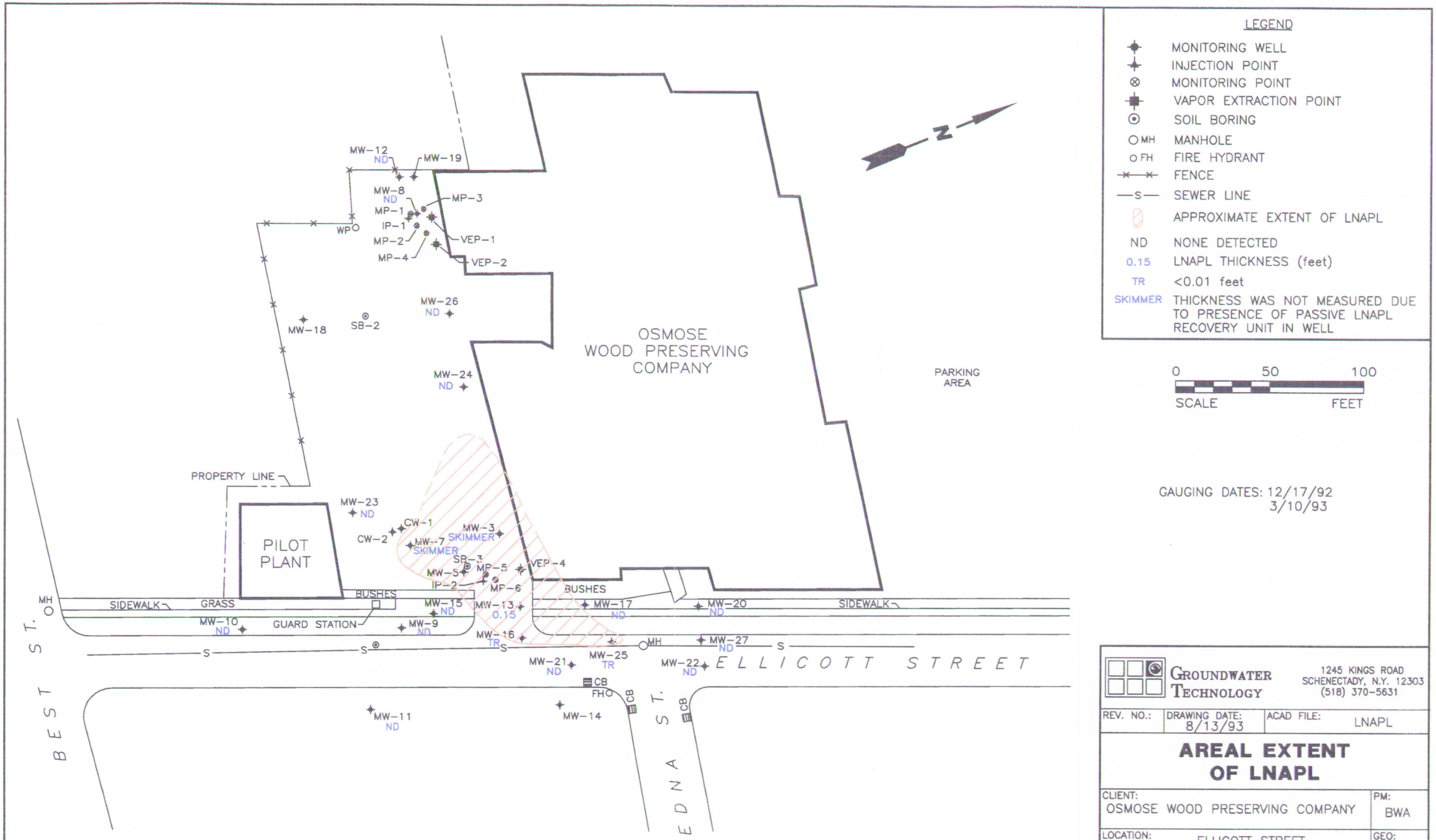
(518) 370-5631

REV. NO.:
DRAWING DATE: 7/1/94
ACAD FILE: 8061-VEC

VECTOR PLOT

CLIENT: OSMOSE WOOD PRESERVING COMPANY
PM: BWA
LOCATION: ELLICOTT STREET
BUFFALO, NEW YORK
PE/RG: WCL
DESIGNED: ---
DETAILED: DEO
PROJECT NO.: 01110-8061
FIGURE: **7-2**



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GROUNDWATER TECHNOLOGY

1245 KINGS ROAD
SCHENECTADY, N.Y. 12303
(518) 370-5631

REV. NO.:	DRAWING DATE: 8/13/93	ACAD FILE: LNAPL

AREAL EXTENT OF LNAPL

CLIENT: OSMOSE WOOD PRESERVING COMPANY

PM: BWA

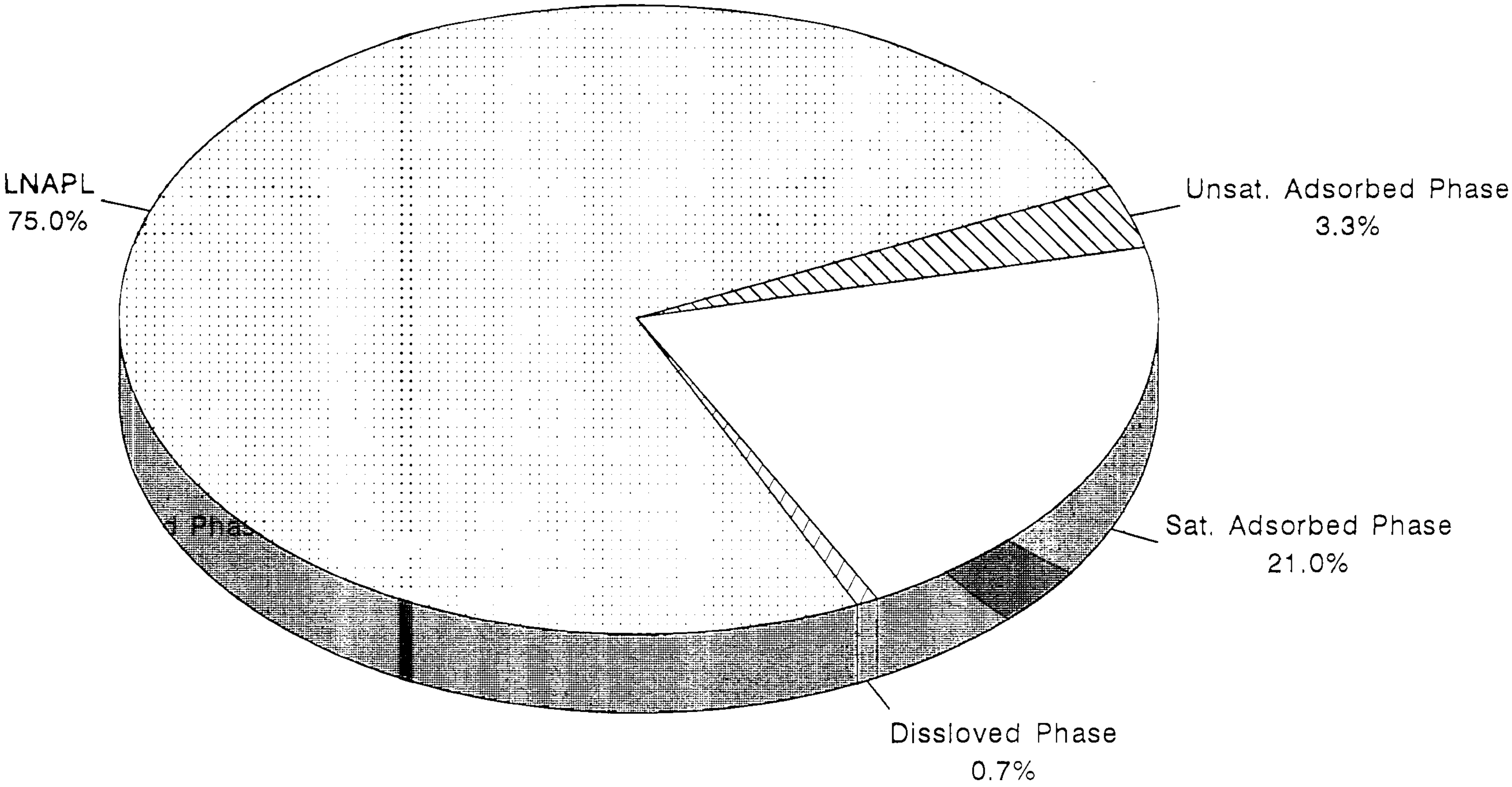
LOCATION: ELLICOTT STREET
BUFFALO, NEW YORK

GEO: JOG

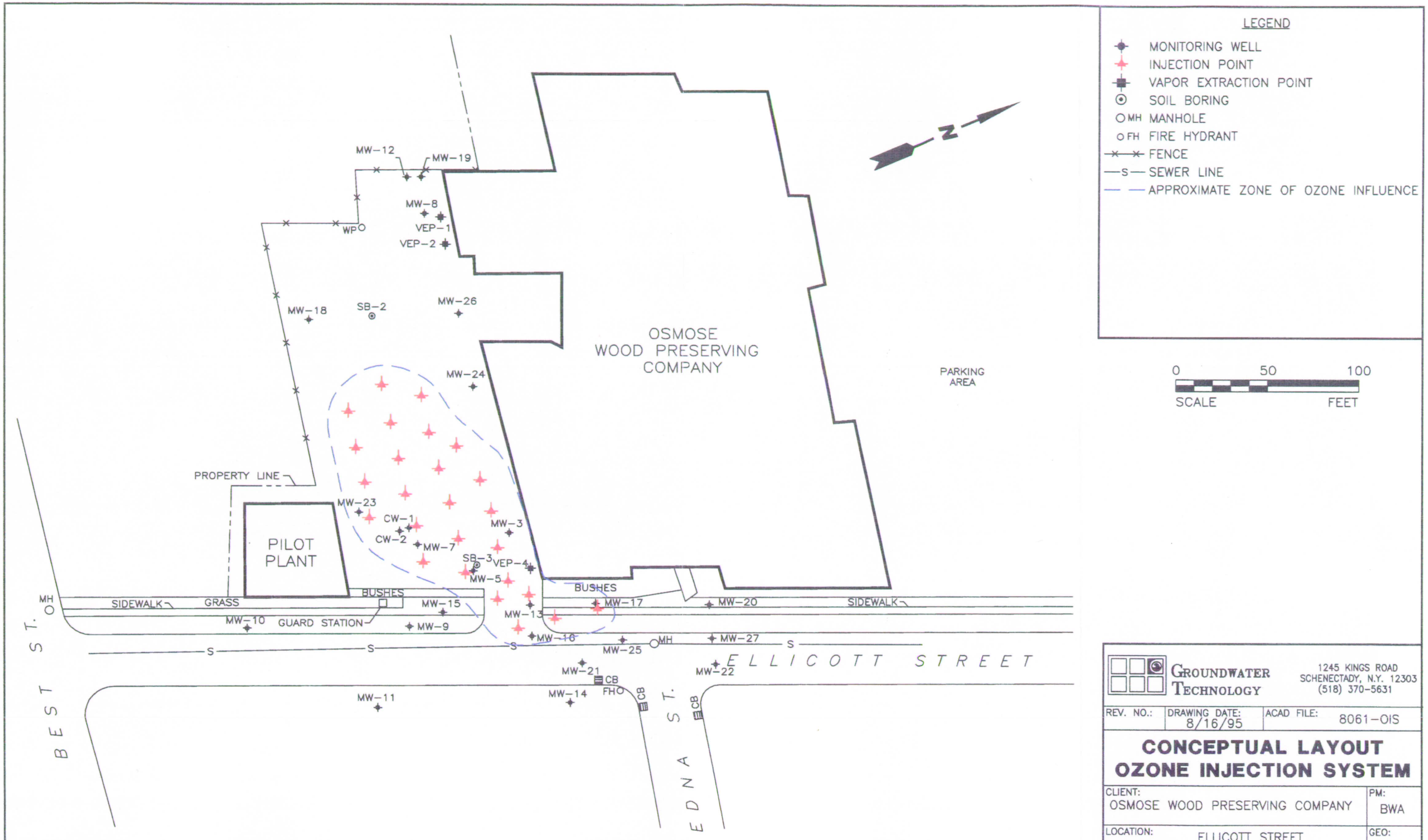
DESIGNED:	DETAILED:	PROJECT NO.:	FIGURE:
JOG	MET/DEO	01110-5307	2-7

Figure 2-8

Hydrocarbon Mass Balance Distribution



Approximately 40% of the adsorbed phase hydrocarbons exist on the clay layers.



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GROUNDWATER TECHNOLOGY
1245 KINGS ROAD
SCHENECTADY, N.Y. 12303
(518) 370-5631

REV. NO.:	DRAWING DATE: 8/16/95	ACAD FILE: 8061-OIS

CONCEPTUAL LAYOUT OZONE INJECTION SYSTEM

CLIENT: OSMOSE WOOD PRESERVING COMPANY			PM: BWA
LOCATION: ELLICOTT STREET BUFFALO, NEW YORK			GEO: JOG
DESIGNED: JOG	DETAILED: DEO\GMC	PROJECT NO.: 01110-8061	FIGURE: **7-3**

TABLES

TABLES

The following tables are located in their respective sections of the report text:

TABLE 2-1
Adsorbed VOCs on soils (ug/kg)
EPA Method 8020

	SB-1	SB-2		CW-1				CW-2	MW-8		MW-9			MW-10		MW-11		MW-12	
Interval Sampled	4'-6'	2'-4'	8'-10'	6'-8'	8'-10'	30'-32'	62'-64'	6'-8'	2'-4'	16'-18'	4'-6'	10'-12'	30'-32'	6'-8'	10'-12'	4'-6'	10'-12'	6'-8'	18'-20'
Date Sampled	10/90	3/92	3/92	10/90	10/90	10/90	10/90	10/90	10/90	10/90	10/90	10/90	10/90	10/90	10/90	10/90	10/90	3/92	3/92
benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
toluene	ND	ND	6.8	ND	250	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	7.5	5.8
ethyl benzene	ND	ND	2.3	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3.2	2.0
xylenes (total)	ND	ND	11	ND	4,200	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	14	9.3
chlorobenzene	-	ND	ND	-	-	-	-	-	-	-	-	-	-	-	-	-	-	ND	ND
1,2-dichlorobenzene	-	ND	ND	-	-	-	-	-	-	-	-	-	-	-	-	-	-	ND	ND
1,3-dichlorobenzene	-	ND	ND	-	-	-	-	-	-	-	-	-	-	-	-	-	-	ND	ND
1,4-dichlorobenzene	-	ND	ND	-	-	-	-	-	-	-	-	-	-	-	-	-	-	ND	ND
Total Volatiles	ND	ND	20	ND	4,400	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	25	17

	MW-13		MW-14		MW-15			MW-16			MW-17			MW-18			MW-19		MW-20		
Interval Sampled	6'-8'	8'-10'	10'-12'	81'-83'	6'-8'	8'-10'	18'-20'	6'-7'	7'-8'	18'-20'	2'-4'	8'-10'	18'-20'	2'-4'	39'-41'	57'-58'	2'-4'	54'-55'	6'-7'	7'-8'	18'-20'
Date Sampled	3/92	3/92	3/92	3/92	12/3/92	12/3/92	12/3/92	12/3/92	12/3/92	12/3/92	12/2/92	12/2/92	12/2/92	11/17/92	11/17/92	11/17/92	11/19/92	11/19/92	12/4/92	12/4/92	12/4/92
benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
toluene	ND	380	ND	4.1	ND	ND	ND	ND	ND	ND	ND	380	ND	ND	ND	ND	ND	ND	ND	ND	ND
ethyl benzene	ND	520	ND	2.0	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
xylenes (total)	3,000	6,300	ND	8.3	ND	2,100	ND	1,600	9,100	ND	ND	5,400	ND	ND	ND	ND	ND	ND	ND	ND	ND
chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,3-dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Volatiles	3,000	7,200	ND	14	ND	2,100	ND	1,600	9,100	ND	ND	5,800	ND	ND	ND	ND	ND	ND	ND	ND	ND

ug/kg = micrograms per kilogram
ND = not detected

TABLE 2-1 (cont'd)
Adsorbed VOCs on Soils (ug/kg)
EPA Method 8020

	MW-21			MW-22			MW-23			MW-24			MW-26			MW-27	DUP-2
Interval Sampled	6'-7'	7'-8'	18'-20'	4'-6'	10'-12'	23'-25'	6'-8'	16'-18'	18'-20'	8'-10'	10'-12'	18'-20'	8'-10'	10'-12'	18'-20'	7'-9'	MW-18 2'-4'
Date Sampled	12/4/92	12/4/92	12/4/92	2/18/93	2/18/93	2/18/93	2/17/93	2/17/93	2/17/93	2/16/93	2/16/93	2/16/93	2/17/93	2/17/93	2/17/93	2/19/93	11/20/92
benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
toluene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ethyl benzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
xylenes (total)	ND	ND	ND	ND	ND	ND	ND	ND	ND	220	ND	ND	ND	ND	ND	ND	ND
chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	220	ND	ND	ND	ND
1,3-dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	430	ND	ND	ND	ND
Total Volatiles	ND	ND	ND	ND	ND	ND	ND	ND	ND	220	ND	ND	650	ND	ND	ND	ND

ug/kg = micrograms per kilogram
ND = not detected

TABLE 2-2
Dissolved VOCs in Groundwater (ug/l)
EPA Method 8020

ANALYTE	MW-8	MW-9	MW-10	MW-11	MW-12	MW-15	MW-17	MW-20	MW-21	MW-22	MW-23	MW-24	MW-26
Date Sampled	12/18/92	12/18/92	12/18/92	12/18/92	12/18/92	12/18/92	12/18/92	12/18/92	12/18/92	3/10/93	3/10/93	3/10/93	3/10/93
Benzene	ND	230	ND	ND	ND	110	190	ND	ND	ND	ND	13	ND
Toluene	ND	150	ND	ND	ND	210	330	ND	ND	ND	ND	15	ND
Ethyl Benzene	ND	31	ND	ND	ND	40	65	ND	ND	ND	ND	38	ND
Xylenes (total)	ND	150	ND	ND	ND	530	930	ND	ND	ND	ND	170	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	ND	15	ND	ND	ND	440	720	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Total Volatiles	ND	580	ND	ND	ND	1,300	2,200	ND	ND	ND	ND	240	ND

ANALYTE	CW-1	CW-1	MW-14	MW-14	MW-18	MW-19	MW-19
Date Sampled	12/18/92	2/18/93	12/18/92	2/18/93	2/18/93	12/18/92	2/18/93
Benzene	9.8	8.3	ND	ND	0.3	0.6	ND
Toluene	1.4	1.4	ND	ND	ND	0.9	ND
Ethyl Benzene	ND	ND	ND	ND	ND	ND	ND
Xylenes (total)	3.5	3.9	ND	ND	ND	ND	ND
Chlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	3.9	ND	ND	ND	ND	ND	ND
1,3-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND
1,4-Dichlorobenzene	ND	ND	ND	ND	ND	ND	ND
Total Volatiles	19	14	ND	ND	0.3	1.5	ND

ug/l = micrograms per liter
ND = not detected

GROUNDWATER
TECHNOLOGY

TABLE 2-3

ADSORBED PAHS ON SOILS (ug/kg)

EPA Method 8310

ANALYTE	CN	MW-8	MW-8	MW-9	MW-9	MW-9	MW-10	MW-10	MW-11	MW-11	MW-12	MW-12	MW-13	MW-13	MW-14	MW-14	MW-15	MW-15
Interval Sampled		2'-4'	16'-18'	4'-6'	10'-12'	30'-32'	6'-8'	10'-12'	4'-6'	10'-12'	6'-8'	18'-20'	6'-8'	8'-10'	10'-12'	61'-63'	6'-8'	8'-10'
Date Sampled																		
Naphthalene	C10	12000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	7000	230000	ND	ND	2600	10000
Acenaphthylene	C12	ND	ND	ND	ND	ND	ND	.ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	180
1-Methylnaphthalene	C11	1200	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2000	57000	ND	ND	990	1800
2-Methylnaphthalene	C11	4000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9100	300000	ND	ND	8400	17000
Acenaphthene	C12	3200	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	3000	120000	ND	ND	3000	6300
Fluorene	C13	3200	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2200	68000	ND	ND	2600	4800
Phenanthrene	C14	36000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	9000	150000	ND	ND	17000	23000
Anthracene	C14	180000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	320	10000	ND	ND	2100	2200
Fluoranthene	C16	43000	ND	ND	ND	ND	ND	ND	11	ND	18	ND	1900	59000	ND	32	5700	6800
Pyrene	C16	120000	ND	ND	ND	ND	27	16	28	ND	ND	ND	ND	ND	ND	ND	11000	11000
Benzo{a}anthracene	C18	17000	1.8	1.7	ND	ND	3.8	1.7	4.9	ND	4.1	ND	230	7500	ND	11	ND	1300
Chrysene	C18	15000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	72	2600	ND	ND	ND	1800
Benzo{b}fluoranthene	C20	14000	1.5	1.7	ND	ND	4.9	2.2	6.6	ND	5.8	.78	75	2700	ND	9.5	270	270
Benzo{k}fluoranthene	C20	7600	ND	.88	ND	ND	2	ND	2.9	ND	3.4	ND	62	1800	ND	8.3	120	130
Benzo{a}pyrene	C20	16000	1.6	1.7	ND	ND	4.6	.88	6.2	ND	6.0	ND	92	2900	ND	12	220	240
Dibenzo{a,h}anthracene	C22	3700	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	200	ND	1.2	9	6 9
Benzo{g,h,i}perylene	C22	13000	ND	ND	ND	ND	ND	2.8	6.3	ND	.3.5	ND	43	1100	ND	8.6	51	66
Indeno{1,2,3-cd}pyrene	C22	10000	ND	ND	ND	ND	ND	ND	5.9	ND	2.4	ND	ND	450	ND	5.1	59	61
TOTAL PAHs*		500000	4.9	6.0	0	0	42.	24.	72	0	43	0.78	24000	640000	0	88	45000	68000

ND = not detected

CN = carbon number

* total PAHs includes only the 16 compounds listed on table 2-6

GROUNDWATER
TECHNOLOGY

TABLE 2–3 (cont'd)

ADSORBED PAHS ON SOILS (ug/kg)

EPA Method 8310

ANALYTE	CN	MW–15	MW–16	MW–16	MW–16	MW–17	MW–17	MW–17	MW–18	MW–18	MW–18	MW–19	MW–19	MW–20	MW–20	MW–20	MW–21	MW–21
Interval Sampled		18'–20'	6'–7'	7'–8'	18'–20'	2'–4'	8'–10'	18'–20'	2'–4'	39'–41'	57'–58'	2'–4'	54'–55'	6'–7'	7'–8'	18'–20'	6'–7'	7'–8'
Date Sampled																		
Naphthalene	C10	ND	4800	90000	ND	ND	68000	1200	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthylene	C12	ND	130	2100	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1–Methylnaphthalene	C11	ND	1200	24000	ND	ND	8500	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2–Methylnaphthalene	C11	ND	10000	170000	ND	ND	69000	190	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Acenaphthene	C12	ND	3200	61000	ND	ND	25000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	C13	ND	2800	41000	ND	ND	20000	48	ND	ND	ND	3100	ND	ND	ND	ND	ND	ND
Phenanthrene	C14	ND	14000	94000	ND	ND	100000	110	800	ND	32	14000	ND	ND	ND	ND	ND	ND
Anthracene	C14	ND	850	15000	ND	ND	8500	35	1100	ND	40	19000	ND	ND	ND	ND	ND	ND
Fluoranthene	C16	ND	3500	51000	13	ND	30000	48	1000	ND	31	19000	ND	ND	ND	ND	ND	ND
Pyrene	C16	ND	3300	68000	ND	ND	53000	37	800	ND	10	8800	ND	ND	ND	ND	ND	ND
Benzo{a}anthracene	C18	.72	540	5400	2	1	3100	6.7	400	1.3	9.9	7000	ND	7.4	ND	ND	.81	ND
Chrysene	C18	ND	650	11000	ND	ND	4400	11	360	ND	16	7000	ND	2.2	ND	ND	ND	ND
Benzo{b}fluoranthene	C20	.81	140	2100	2.8	2.2	1200	2.7	370	1.8	11	6100	ND	ND	ND	ND	1.4	.84
Benzo{k}fluoranthene	C20	ND	67	1000	1.5	ND	580	1.5	160	1	6.3	2900	ND	ND	ND	ND	.75	.65
Benzo{a}pyrene	C20	ND	120	1900	2	ND	1000	2.3	400	1.7	11	6400	ND	ND	ND	ND	1.1	ND
Dibenzo{a,h}anthracene	C22	ND	4.8	73	ND	ND	45	ND	65	ND	2.4	700	ND	ND	ND	ND	ND	ND
Benzo{g,h,i}perylene	C22	ND	35	500	ND	ND	340	ND	210	ND	6.9	3600	ND	ND	ND	ND	ND	ND
Indeno{1,2,3–cd}pyrene	C22	ND	28	450	ND	2.2	280	ND	360	ND	7.7	ND	ND	ND	ND	ND	ND	ND
TOTAL PAHs*		1.5	35000	450000	21	5.4	310000	1500	6100	5.8	160	98000	0	9.6	0	0	4.1	1.5

ND = not detected

CN = carbon number

* total PAHs includes only the 16 compounds listed on table 2–6

GROUNDWATER TECHNOLOGY

TABLE 2-3 (cont'd)

ADSORBED PAHS ON SOILS (ug/kg)

EPA Method 8310

ANALYTE	CN	MW-21	MW-22	MW-22	MW-22	MW-23	MW-23	MW-23	MW-24	MW-24	MW-24	MW-26	MW-26	MW-26	MW-27	SB-1	SB-2	SB-2
Interval Sampled		18'-20'	4'-6'	10'-12'	23'-25'	6'-8'	16'-18'	18'-20'	8'-10'	10'-12'	18'-20'	8'-10'	10'-12'	18'-20'	7'-8'	4'-6'	2'-4'	8'-10'
Date Sampled			2/18/93	2/18/93	2/18/93	2/17/93	2/17/93	2/17/93	2/16/93	2/16/93	2/16/93	2/17/93	2/17/93	2/17/93	2/19/93		:	
Naphthalene	C10	ND	ND	ND	ND	ND	ND	ND	790	1200	ND	ND	ND	ND	ND	ND	ND	320
Acenaphthylene	C12	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1-Methylnaphthalene	C11	ND	ND	ND	ND	ND	ND	ND	800	910	ND	210	ND	ND	ND	ND	ND	ND
2-Methylnaphthalene	C11	ND	ND	ND	ND	ND	ND	ND	700	2400	ND	ND	ND	ND	ND	ND	ND	150
Acenaphthene	C12	ND	ND	ND	ND	ND	ND	ND	150	310	ND	ND	ND	ND	ND	ND	ND	ND
Fluorene	C13	ND	ND	ND	ND	ND	ND	ND	180	290	ND	21	ND	ND	ND	ND	10	8.7
Phenanthrene	C14	ND	ND	ND	ND	ND	ND	ND	600	850	ND	230	ND	ND	ND	ND	ND	ND
Anthracene	C14	ND	ND	ND	ND	ND	ND	ND	210	1100	ND	80	ND	ND	ND	ND	92	ND
Fluoranthene	C16	ND	ND	ND	ND	ND	ND	ND	180	210	ND	30	ND	ND	ND	ND	74	ND
Pyrene	C16	ND	ND	ND	ND	ND	ND	ND	110	110	ND	ND	ND	ND	ND	14	ND	ND
Benzo{a}anthracene	C18	2.2	ND	ND	ND	ND	ND	ND	25	27	1.5	16	ND	ND	ND	2.7	26	.9
Chrysene	C18	ND	ND	ND	ND	ND	ND	ND	23	42	ND	27	ND	ND	ND	ND	9	ND
Benzo{b}fluoranthene	C20	2.6	1.3	ND	ND	4.5	ND	ND	17	14	2.2	16	ND	ND	ND	3.7	21	ND
Benzo{k}fluoranthene	C20	1.1	ND	ND	ND	ND	ND	ND	8.4	6.1	1.2	3.7	ND	ND	ND	1.5	14	ND
Benzo{a}pyrene	C20	1.9	ND	ND	ND	ND	ND	ND	14	11	1.7	12	ND	ND	ND	4 1	26	ND
Dibenzo{a,h}anthracene	C22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.6	ND	ND	ND	ND	2.2	ND
Benzo{g,h,i}perylene	C22	ND	ND	ND	ND	ND	ND	ND	18	6 6	ND	30	ND	ND	ND	ND	15	ND
Indeno{1,2,3-cd}pyrene	C22	2	ND	ND	ND	ND	ND	ND	7.2	4.6	ND	7.9	ND	ND	ND	ND	6.3	ND
TOTAL SEMIVOLATILES		9.7	1.3	0	0	4.5	0	0	2300	4200	6.6	460	0	0	0	26	290	330

ND = not detected

CN = carbon number

* total PAHs includes only the 16 compounds listed on table 2-6

TABLE 2-4
DISSOLVED PAHS IN GROUNDWATER (ug/l)
EPA Method 8310

ANALYTE	CN	MW-8	MW-9	MW-10	MW-11	MW-12	MW-15	MW-17	MW-20	MW-21	MW-22	MW-23	MW-24	MW-26	CW-1	MW-14*	MW-19	CW-1	MW-14	MW-18	MW-19
Date Sampled		12/18/92	12/18/92	12/18/92	12/18/92	12/18/92	12/18/92	12/18/92	12/18/92	12/18/92	3/10/93	3/10/93	3/10/93	3/10/93	12/18/92	12/18/92	12/18/92	2/18/93	2/18/93	2/18/93	2/18/93
Naphthalene	C10	ND	ND	ND	ND	ND	ND	11,000	ND	ND	ND	ND	660	ND	89	4200	ND	88	ND	ND	ND
Acenaphthylene	C12	ND	ND	ND	ND	ND	ND	260	ND	ND	ND	ND	2.8	ND	ND	110	ND	ND	ND	ND	ND
1-Methylnaphthalene	C11	ND	ND	ND	ND	ND	ND	290	ND	ND	ND	ND	160	ND	ND	170	ND	18	ND	ND	ND
2-Methylnaphthalene	C11	ND	ND	ND	ND	ND	ND	1,100	ND	2.4	ND	ND	170	ND	46	660	ND	69	ND	ND	ND
Acenaphthene	C12	ND	ND	ND	ND	ND	ND	330	ND	ND	ND	ND	35	ND	ND	240	ND	27	ND	ND	ND
Fluorene	C13	ND	ND	ND	ND	ND	0.22	130	ND	ND	ND	ND	18	ND	6.3	91	ND	8.0	ND	ND	ND
Phenanthrene	C14	ND	ND	ND	ND	ND	ND	110	ND	ND	ND	ND	28	ND	ND	66	ND	4 0	ND	ND	ND
Anthracene	C14	ND	ND	ND	ND	ND	ND	30	ND	ND	ND	ND	5.3	ND	ND	13	ND	ND	ND	ND	ND
Fluoranthene	C16	1.2	ND	ND	ND	0.37	ND	10	ND	ND	ND	ND	5.6	ND	25	7.1	0.34	0.92	ND	0.53	ND
Pyrene	C16	ND	ND	ND	ND	ND	ND	5.9	ND	ND	ND	ND	0.95	ND	14	3.0	ND	0.34	ND	ND	ND
Benzo(a)anthracene	C18	0.21	ND	0.018	0.056	0.070	0.032	0.75	ND	ND	ND	0.023	1.0	0.024	5.9	0.46	0.043	0.21	ND	0.073	ND
Chrysene	C18	0.48	ND	ND	ND	ND	ND	0.89	ND	ND	ND	ND	1.5	ND	11	0.48	ND	0.30	ND	ND	ND
Benzo(b)fluoranthene	C20	0.47	ND	0.021	0.087	0.12	0.033	0.23	ND	0.021	ND	0.037	1.1	0.044	11	0.23	0.079	0.34	ND	0.15	ND
Benzo(k)fluoranthene	C20	0.20	ND	ND	0.038	0.056	0.019	0.14	ND	ND	ND	0.018	0.50	0.018	4.7	0.11	0.039	0.14	ND	0.068	ND
Benzo(a)pyrene	C20	0.31	ND	0.026	0.061	0.089	0.033	0.22	ND	ND	ND	0.027	1.0	0.028	8.2	0.21	0.057	0.25	ND	0.10	ND
Dibenzo(a,h)anthracene	C22	0.059	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.11	ND	0.72	ND	ND	0.030	ND	ND	ND
Benzo(g,h,i)perylene	C22	0.20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.55	ND	6.2	ND	ND	0.20	ND	0.096	ND
Indeno(1,2,3-cd)pyrene	C22	0.33	ND	ND	0.080	0.10	ND	0.073	ND	ND	ND	ND	1.1	ND	8.8	0.092	0.060	0.25	ND	0.12	ND
TOTAL PAHs**		3.5	ND	0.063	0.32	0.80	0.34	12,000	ND	0.021	ND	0.10	760	0.11	190	4800	0.62	130	ND	1.1	ND

ND = not detected

CN = carbon number

* Results from this sample are considered erronious

** total PAHs includes only the 16 compounds listed on table 2-6

GROUNDWATER TECHNOLOGY

TABLE 2-5
MASS BALANCE ESTIMATE

LIQUID PHASE HYDROCARBONS — Percent of Total = 75.70%

Area	Area (ft*ft)	Thickness (ft)	Volume (ft*ft*ft)	Porosity	Pore Volume (ft*ft*ft)	Volume (gallons)	Hydrocarbons (lbs.)	
L-1	6,450	0.05	323	0.4	129	965	8057.1	creosote = 8.35 lbs/gal
Totals	6,450		323		129	965	8057	

DISSOLVED PHASE HYDROCARBONS — Percent of Total = 0.18%

Area	Area (ft*ft)	Thickness (ft)	Volume (ft*ft*ft)	Porosity	Pore Volume (ft*ft*ft)	Volume (liters)	HC conc. (mg/l)	Hydrocarbons (mg)	Hydrocarbons (lbs.)	
D-1	8,900	5	44,500	0.4	17,800	504,025	15.000	7,560,372	16.7	Volatiles and PAHs
D-2	3,700	5	18,500	0.4	7,400	209,538	5.000	1,047,692	2.3	Volatiles and PAHs
Totals	12,600		63,000		25,200	713,563			19	

UNSATURATED ADSORBED PHASE HYDROCARBONS — Percent of Total = 3.28%

Area	Area (ft*ft)	Thickness (ft)	Volume (ft*ft*ft)	Volume (cc)	Soil Density (g/cc)	Soil Wt. (g)	HC conc. (mg/kg)	Hydrocarbons (mg)	Hydrocarbons (lbs.)	
U-1	6,450	1	6,450	182,644,753	1.99	363,463,059	400	145,385,224	321	Area 2, 6'-7', (400 ppm)
U-2	3,800	1	3,800	107,604,661	1.99	214,133,275	50	10,706,664	24	Expanded Area 2, 50 ppm, 6'-7'
U-3	10,250	1	10,250	290,249,414	1.99	577,596,334	1.5	866,395	1.9	Volatiles, expanded area 2, 6'-7', 1.5 ppm
U-4	400	2	800	22,653,613	1.99	45,080,689	25	1,127,017	2.5	Area 1, 2'-4', 25 ppm
Totals	11,201,966		21,300						349	

SATURATED ADSORBED PHASE HYDROCARBONS — Percent of Total = 20.85%

Area	Area (ft*ft)	Thickness (ft)	Volume (ft*ft*ft)	Volume (cc)	Soil Density (g/cc)	Soil Wt. (g)	HC conc. (mg/kg)	Hydrocarbons (mg)	Hydrocarbons (lbs.)	
S-1	6,450	3	19,350	547,934,260	1.99	1,090,389,177	750	817,791,882	1,803	Area 2 soils, 7'-10', 750 ppm
S-2	6,450	2	12,900	365,289,506	1.99	726,926,118	100	72,692,612	160	Area 2, 100 ppm soils 10'-12'
S-3	3,800	5	19,000	538,023,304	1.99	1,070,666,375	100	107,066,637	236	Wider area, 100 ppm, 7'-12'
S-4	10250	3	30,750	870,748,242	1.99	1,732,789,002	5	8,663,945	19	Volatiles (entire area, 7'-10'), 5 ppm
Totals	26,950		82,000						2,219	

TOTAL 10,643 lbs.

ADSORBED PHASE HYDROCARBONS IN THE CLAY LAYER — Percent of Total = 9.40%

Area	Area (ft*ft)	Thickness (ft)	Volume (ft*ft*ft)	Volume (cc)	Soil Density (g/cc)	Soil Wt. (g)	HC conc. (mg/kg)	Hydrocarbons (mg)	Hydrocarbons (lbs.)	
U-1	6,450	1	6,450	182,644,753	1.99	363,463,059	400	145,385,224	321	Area 2, 6'-7', (400 ppm)
U-2	3,800	1	3,800	107,604,661	1.99	214,133,275	50	10,706,664	24	Expanded Area 2, 50 ppm, 6'-7'
U-3	10,250	1	10,250	290,249,414	1.99	577,596,334	1.5	866,395	1.9	Volatiles, expanded area 2, 6'-7', 1.5 ppm
S-1	6,450	1	6,450	182,644,753	1.99	363,463,059	750	272,597,294	601	Area 2 soils, 7'-8', 750 ppm
S-3	3,800	1	3,800	107,604,661	1.99	214,133,275	100	21,413,327	47	Wider area, 100 ppm, 7'-8'
S-4	10250	1	10,250	290,249,414	1.99	577,596,334	5	2,887,982	6	Volatiles (entire area, 7'-8'), 5 ppm
Totals	268,100		41,000						1,001	

TABLE 2-6

List of PAHs on EPA'S
Priority Pollutant List

TWO-RING

- Naphthalene

THREE-RING

- Acenaphthene
- Acenaphthylene
- Anthracene
- Fluorene
- Phenanthrene

FOUR-RING

- Benzo{a}anthracene*
- Chrysene*
- Fluoranthene
- Pyrene*

FIVE-RING

- Benzo{b}fluoranthene*
- Benzo{k}fluoranthene*
- Benzo{a}pyrene*
- Dibenzo{a,h}anthracene*

SIX-RING

- Benzo{g,h,i}perylene*
- Inden{1,2,3-cd}pyrene*

*Indicates potentially carcinogenic compound by U.S. EPA.

TABLE 5-1
LNAPL Recovery Data

Date	Gallons Pumped	Average GPM	Influent Hydrocarbon Concentration	Dissolved Hydrocarbons Removed	LNAPL Bailed (gallons)	LNAPL Pumped* (gallons)
11/93-11/94	138,970	0.36	77 ppm (avg)	97.4 lbs	202.3	53.5
12/7/94	11,150	0.26	203 ppm	13.3 lbs	4.6	–
1/25/95	15,225	0.22	187 ppm	24.8 lbs	6.6	–
2/8/95	16,500	0.82	93 ppm	19.2 lbs	3.3	–
3/8/95	23,420	0.58	140 ppm	22.7 lbs	0.0	–
TOTALS	205,265	0.37 (avg)	101 ppm (avg)	177.3 lbs	216.4	53.5

* LNAPL pumped totals include compounds which separated as a DNAPL layer in the oil/water separator.

TABLE 6-1

Procedures and Assumptions for Development of Cost Estimates

Cost Estimate Procedure

- Estimation of Capital Costs
- Estimation of Annual Operation and Maintenance Costs
- Present Work Analysis

Definition of Elements

- Capital Cost (material, labor, and equipment)

  - Construction (material, labor, and equipment)
  - Buildings
  - Site Preparation
  - Disposal Costs
  - Engineering Design and Administration (25% of total installed costs)
  - Legal Fees and License or Permit Costs
  - Start-Up and Shakedown Costs

- Operation and Maintenance Costs

  - Operating and Labor Supplies, Electric Utilities
  - Ancillary Materials and Energy
  - Transport and Disposal of Any Wastes Generated from the Treatment
  - System
  - Purchased Services
  - Replacement Costs

- Present Worth Analysis

  - Capital Costs Occur in Year 0 for Alternative #7, year 5 for Alternative #3, 5 and 6
  - Operation and Maintenance Costs Occur for the Life of Remedial Action
  - Discount Rate
  - Interest Rate
  - Life of Project

Assumptions

- Cost Estimates: +50% to -30% accuracy in 1995 Dollars
- Economic Life of Remedial Action: 20 years
- Interest Rate: 6%
- Inflation Rate: 0%

TABLE 6-2

Cost for Alternative No. 1

Definition of Elements

- Capital Cost (material, labor, and equipment)

– Construction (material, labor, and equipment)	$ 0
– Buildings	0
– Site Preparation	0
– Disposal Costs	0
– Engineering Design and Administration	0
– Legal Fees and License or Permit Costs	0
– Start-Up and Shakedown Costs	0
Subtotal =	0

- Total Operation and Maintenance Costs — Subtotal = $ ~~900~~ 30,000/per year
  - Quarterly sampling of 10 monitoring wells
  - Ancillary Materials and Energy
  - Transport and Disposal of any Wastes Generated from the Treatment System
  - Purchased Services
  - Replacement Costs
- Present Worth Analysis — Total = $ 412,950

Assumptions

- Cost Estimates: +50% to -30% accuracy in 1995 Dollars
- Interest Rate: 6%
- Operation and Maintenance Costs assume 30 years of monitoring at $ 30,000/year

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TABLE 6-3

Cost for Alternative No. 3

Definition of Elements

- Capital Cost (material, labor, and equipment)

–	Construction (material, labor, and equipment)	$ 70,000
–	Buildings	0
–	Site Preparation	40,000
–	Disposal Costs	2,304,000
–	Engineering Design and Administration	25,000
–	Legal Fees and License or Permit Costs	5,000
–	Start-Up and Shakedown Costs	10,000
	Subtotal =	**$ 2,464,000** ✓

[illegible]

- Operation and Maintenance Costs **Subtotal = $ 525,000**

$ 353,007

26,[illegible]

  - Operating and Labor Supplies, Electric Utilities
  - Ancillary Materials and Energy
  - Transport and Disposal of Any Wastes Generated from the Treatment System
  - Purchased Services
  - Replacement Costs

- Present Worth Analysis **Total = $ 2,194,415** X

Assumptions

- Cost Estimates: +50% to -30% accuracy in 1995 Dollars
- Interest Rate: 6%
- Operation and Maintenance Costs Assume 5 Years of Operation of the Existing LNAPL Recovery System and 25 Years of Compliance Monitoring

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TABLE 6-4

Cost Estimate for Alternative No. 5

Definition of Elements

- Capital Cost (material, labor, and equipment)

– Construction (material, labor, and equipment)	$ 250,000
– Buildings	25,000
– Site Preparation	40,000
– Disposal Costs	5,000
– Engineering Design and Administration	25,000
– Legal Fees and License or Permit Costs	5,000
– Start-Up and Shakedown Costs	20,000
	Subtotal = $ 370,000

[illegible]

P.W. = 276501

- Operation and Maintenance Costs — Subtotal = $ 520,000

P.W. 373,500

  - Operating and Labor Supplies, Electric Utilities
  - Ancillary Materials and Energy
  - Transport and Disposal of Any Wastes Generated from the Treatment System
  - Purchased Services
  - Replacement Costs

- Present Worth Analysis — Total = $ 650,000 ✓

Assumptions

- Cost Estimates: +50% to -30% accuracy in 1995 Dollars
- Interest Rate of 6%
- Operation and Maintenance Costs Assume 5 Years of Operation of the Existing LNAPL Recovery System, 2 Years Operation of the Ozone System, and 10 Years of Compliance Monitoring
- Assumes Purchase of Ozone Generation Equipment

TABLE 6-5

Cost Estimate for Alternative No. 6

Definition Elements

- Capital Cost (material, labor, and equipment)

– Construction (material, labor, and equipment)	$ 140,000
– Buildings	15,000
– Site Preparation	0
– Disposal Costs	5,000
– Engineering Design and Administration	20,000
– Legal Fees and License or Permit Costs	5,000
– Start-Up and Shakedown Costs	25,000
Subtotal =	**$ 215,000**
	P.W = 160,670

- Operation and Maintenance Costs — **Subtotal = $ 735,000**

P.W = 491930

  - Operating and Labor Supplies, Electric Utilities
  - Ancillary Materials and Energy
  - Transport and Disposal of Any Wastes Generated from the Treatment System
  - Purchased Services
  - Replacement Costs

- Present Worth Analysis — **Total = $ 652,600**

Assumptions

- Cost Estimates: +50% to -30% accuracy in 1995 Dollars
- Interest Rate of 6%
- Operation and Maintenance Costs Assume 5 Years of Operation of the Existing LNAPL Recovery System, 5 Years of Bioremediation Operation and Maintenance, and 10 Years of Compliance Monitoring

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TABLE 6-6

Cost Estimate for Alternative No. 7

Definition of Elements

- Capital Cost (material, labor, and equipment)

– Bench/Pilot Testing	$ 25,000
– Construction (material, labor, and equipment)	150,000
– Buildings	10,000
– Site Preparation	10,000
– Disposal Costs	5,000
– Engineering Design and Administration	30,000
– Legal Fees and License or Permit Costs	5,000
– Start-Up and Shakedown Costs	25,000
Subtotal =	$ 260,000

- Operation and Maintenance Costs — Subtotal = $ 470,000

[illegible] 5,000

  - Operating and Labor Supplies, Electric Utilities
  - Ancillary Materials and Energy
  - Transport and Disposal of Any Wastes Generated from the Treatment System
  - Purchased Services
  - Replacement Costs

- Present Worth Analysis — Total = $ 635,000

Assumptions

- Cost Estimates: +50% to -30% Accuracy in 1995 Dollars
- Interest Rate of 6%
- Use of Steam Boiler from Osmose
- Operation and Maintenance Costs Assume 4 Years of Operation of the Existing LNAPL Recovery System Which will be Augmented with Steam, and 10 Years of Compliance Monitoring

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A

APPENDIX A

HYDROCARBON MASS ESTIMATE ASSUMPTIONS

HYDROCARBON MASS ESTIMATE – ASSUMPTIONS

Liquid-Phase

1) LNAPL thickness was assumed to average 0.05 feet across the area shown in figure 2-7. True LNAPL thickness is very hard to estimate from monitoring well observations.

Adsorbed-Phase

2) Across the area shown in figure 2-7, adsorbed PAHs were approximated by zones of 400 ppm from 6 to 7 feet below grade, 750 ppm from 7 to 10 feet below grade, and 100 ppm from 10 to 12 feet below grade.

3) A second zone of lower concentration soils surrounding the area described above was included in the calculation, extending beyond the area shown in figure 2-7 to the north and south to surround monitoring wells CW-2, MW-15, and MW-17. This zone was defined as containing 50 ppm PAHs from 6 to 7 feet below grade, and 100 ppm PAHs from 7 to 12 feet below grade.

4) Volatile compounds in soils were approximated by two zones across the entire area described above in No. 2 and No. 3: one from 6 to 7 feet below grade (1.5 ppm volatiles), and one from 7 to 10 feet below grade (5 ppm volatiles).

Dissolved-Phase

5) Dissolved-phase hydrocarbon mass was estimated by assigning an average concentration of 15 ppm total hydrocarbons to the area within the 10 ppm contour on figure 2-2, and an average concentration of 5 ppm total hydrocarbons to the area within the 1 ppm contour but outside the 10 ppm contour. These concentrations were assumed to apply to the upper 5 feet of the aquifer.

6) Volatile concentrations in groundwater were much lower than PAH concentrations; therefore volatile and PAH concentrations were combined in the calculation.

General

7) Hydrocarbon concentrations below 10 ppm in soils and below 1 ppm in groundwater were not included in the calculation, since the amount of hydrocarbon mass they represent is small.

8) An average soil porosity of 0.40 was chosen, based upon the predominant soil type in the impacted zone (a fairly uniform silt with some fine sand).

9) An average soil density of 2 g/cc was chosen, once again based on the soil type.