REMEDIAL INVESTIGATION/FEASIBILITY STUDY PROJECT

FEASIBILITY STUDY REPORT

WORK ASSIGNMENT D003825-29

CHEM-CORE
CITY OF BUFFALO (C)

SITE NO. 9-15-176
ERIE COUNTY, NY

Prepared for:
NEW YORK STATE
DEPARTMENT OF ENVIRONMENTAL CONSERVATION
50 Wolf Road, Albany, New York

Erin M. Crotty, Commissioner

DIVISION OF ENVIRONMENTAL REMEDIATION

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Final
November 2002

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282 DELAWARE AVENUE

BUFFALO, NEW YORK 14202

NOVEMBER 2002

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ACRONYMS

ARARs	Applicable or Relevant and Appropriate Requirements
BEHP	bis-2 (ethylhexyl) phthalate
bgs	below ground surface
C&D	construction and demolition (debris)
CFM	cubic feet per minute
COC	chemical of concern
CPC	chemical of potential concern
1,1-DCA	1,1-Dichloroethane
1,2-DCA	1,2-Dichloroethane
1,1-DCE	1,1-Dichloroethene
1,2-DCE	1,2-Dichloroethene
DNAPL	dense non-aqueous phase liquid
EISB	enhanced in-site bioremediation
FWIA	Fish and Wildlife Impact Analysis
HRA	health risk assessment
HRC	hydrogen release compound
IIWA	Immediate Investigation Work Assignment
LDR	Land Disposal Restrictions
MNA	Monitored Natural Attenuation
NCP	National Contingency Plan
NYSDEC	New York State Department of Environmental Conservation
O&M	Operation and Maintenance
OSHA	Occupational Safety and Health Administration
PAHs	Polycyclic Aromatic Hydrocarbons
PCE	perchloroethylene (same as tetrachloroethene)
PID	photoionization detector
POTW	publicly-owned treatment works
ppb	parts per billion (ìg/kg)
ppm	parts per million (mg/kg)
PRAP	Proposed Remedial Action Plan

ACRONYMS (Continued)

RAGS	Risk Assessment Guidance for Superfund
RAO	remedial action objective
RI/FS	remedial investigation/feasibility study
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SCGs	Standards, Criteria, and Guidance Values
SVE	soil vapor extraction
SVOC	Semi Volatile Organic Compound
TAGM	Technical and Administrative Guidance Memorandum
1,1,1-TCA	1,1,1-Trichloroethane
TCE	trichloroethene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TMV	toxicity, mobility, or volume
USEPA	United States Environmental Protection Agency
UTS	Universal Treatment Standards
VOC	volatile organic compound
µg/L	microgram per liter

1.0 INTRODUCTION

This Report has been prepared for the Chem-Core Site, New York State Department of Environmental Conservation (NYSDEC) Site Registry No. 9-15-176, and presents the results of the Feasibility Study (FS) performed for the site. This Class 2 inactive hazardous waste site is located at 1382 Niagara Street in the City of Buffalo (Figure 1-1). Under the State Superfund Standby Contract, Work Assignment D003825-29 URS Corporation (URS) was tasked to perform the Remedial Investigation/Feasibility Study (RI/FS). This FS is based upon the information and data presented in the Phase I and II Remedial Investigation Report for this site, prepared by URS Corporation Group Consultants dated May 2002.

1.1 <u>Purpose and Report Organization</u>

This FS addresses contamination at the Chem-Core site and identifies, develops, screens, and evaluates remedial alternatives to address site contamination in soil and groundwater.

This FS report has been organized and divided into six sections, in a format consistent with the outline described by the United States Environmental Protection Agency ("Guidelines for Conducting Remedial Investigations and Feasibility Studies under CERCLA" USEPA 1988). Site background information, including a discussion of previous investigations, is provided in the following subsections. The remedial action objectives are presented in Section 2.0. Identification and screening of remedial technologies is provided in Section 3.0. Section 4.0 provides the development and screening of alternatives. Section 5.0 describes a detailed analysis and evaluation of alternatives, and Section 6.0 presents the recommended alternative.

The FS report consists of text followed by tables and figures. Supporting documentation is included as appendices.

1.2 Background Information

1.2.1 Site Description and History

Site Description

Chem-Core is a Class 2 site, listed on the NYSDEC Registry of Inactive Hazardous Waste Sites (NYSDEC Site No. 9-15-176). The Chem-Core Buffalo site is a former chemical wholesaling facility located at 1382 Niagara Street in the City of Buffalo, Erie County, New York (Figure 1-1). Situated on a historically industrial corridor, the site is in close proximity to residential neighborhoods to the east and a Rail corridor to the west with both the Interstate I-190 highway and the Black Rock Canal (which leads from Lake Erie to the Niagara River) farther to the west.

The site is occupied by a two-story 39,000 square foot industrial building on approximately 0.5 acres. The facility structure occupies most of the property parcel, with exposed soil in a driveway/yard area at the north end of the site. To the north of the driveway/yard area is a two-story structure which is operated by Great Lakes Pressed Steel Corporation. Just beyond the building to the north is West Delevan Avenue which dead-ends at the rail line and is used as a parking area/driveway. A large storm sewer line passes beneath this street and discharges into the Black Rock Canal. Refer to Figure 1-2 for the location of adjacent properties and other features. Figure 1-3 depicts an aerial view of the site vicinity.

To the south of the site is the former location of the Mentholatum Corporation (new owners, the Garrett Leather Corporation). The western portion of this property has a warehouse building with enclosed loading docks at the north end abutting the Chem-Core building. The eastern part of the property is covered by asphalt parking and driveway areas and various concrete slabs, foundations and sidewalks. An approximate six-inch slab of concrete (without visible existence of rebar) was encountered during installation of the MW-3 at the southeast corner of the site (Figure 1-2). Underground Storage Tanks (USTs) were located at this property when Mentholatum operated a building just south of the Chem-Core site (Figure 1-2). No definite location for the former USTs has been identified, but the NYSDEC has records of their removal. USTs also were removed from a site across Niagara Street to the east/southeast of the site which were part of a former Taxi service.

The Acme Bearing company and a used car lot are located east of the site across Niagara Street (five lane roadway), with residential housing further east (approximately 200 feet from the site). Immediately to the west of the site is an active railway using a single track down the center of the rail right-of-way. An approximate 10-foot tall, concrete retaining wall separates the I-190 highway from the west of the railway. The Black Rock Canal is immediately beyond a concrete and sheet-pile retaining wall to the west of the highway right-of-way.

Site History

The facility has been used for commercial operations since the early 1930s as a chemical-handling facility, with several business and commercial tenants operating from rented portions of the site structure. From the review of an aerial photograph taken in 1938, the on-site building appeared to be constructed similar to the current state. During the initial operation of the company, a significant percentage of the business was related to supplying acids to metal fabrication industries. During the 1950s, sales involved chlorinated solvents for dry cleaning industries. In the 1970s and 1980s, the company sold chlorinated degreasing solvents. Another large percentage of sales involved inert materials such as Diatomaceous Earth, Fuller?s Earth and Bentonite Clay. The company also marketed propylene glycol and glycerine to the hand lotion industry and primary alcohol to the printing industry.

Until 1980, Chem-Core received Diatomaceous Earth via a rail spur located directly west of the building. During the 1970s and until 1988, the company received bulk liquid materials at a receiving station on the north side of the building. The materials were transferred into 55 gallon drums by a gravity operated drum filling machine connected to the truck with a hose. The company had an EPA hazardous waste identification number and was classified as a RCRA small quantity generator.

1.3 Summary of Remedial Investigation

1.3.1 Hydrogeology

The stratigraphic sequence near the site included the following units from the surface down: fill; stratified silts and clay; and bedrock. Bedrock was encountered at depths ranging from 12.8 feet in MW-03 to 30 feet in MW-10 and slopes from the site toward the Black Rock Canal. Figure 1-4 depicts the soil borings, monitoring wells, sampling and cross section locations. Figures 1-5 and 1-6 depict the site geology.

The primary hydrogeologic unit near the site is the unconfined water table aquifer present in the shallow bedrock aquifer. Groundwater was encountered at depths approximately 15 to 20 feet bgs. Groundwater generally flows west toward the Black Rock Canal at a gentle horizontal hydraulic gradient, approximately 0.004 foot per foot. Vertical hydraulic gradients in the existing Phase I RI monitoring well pairs, MW-04S/MW-04D and MW-01S/MW-01D, were slightly downward based upon water level information gathered to date. In the Phase II RI well pairs, MW-08S/MW-08D and MW-13S/MW-13D, the vertical hydraulic gradients were slightly downward and slightly upward, respectively. Hydraulic conductivities of the bedrock monitoring wells ranged from negligible (i.e., estimated to be less than 10^{-6} cm/second) to 6.8 x 10^{-3} cm/second in MW-8D.

1.3.2 Nature and Extent of Contamination

Soil Gas

Volatile organic gases were screened using a combination HNu PID/FID at each of the boring locations and soil samples. Results of the screening indicated a range of concentrations between 0 to 791 ppm. The highest soil gas readings occurred at GB-13 near the former tetrachloroethene (PCE) storage tank. Offsite and most perimeter locations provided little evidence of contamination indicating that migration of the soil gas is limited in extent. Soil gas contamination occurred primarily around the area beneath the former PCE storage tanks and immediately above the bedrock.

Subsurface Soil

Detected compounds included volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), and metals. The primary contaminants are VOCs and includes chlorinated hydrocarbons, benzene, toluene, ethylbenzene, and xylene (BTEX) compounds, and ketones. Secondary contaminants include polycyclic aromatic hydrocarbons (PAHs) and to a lesser extent metals. Volatile organic contamination concentrations ranged from low parts per billion to as high as 38,160,000 ppb (ìg/kg 3.816%). The highest total VOCs detections occurred beneath the former PCE tank near boring GB-13. Samples from four boring locations were found to be characteristically hazardous with carbon tetrachloride, PCE, or TCE exceeding their limits in Toxicity Characteristic Leaching Procedure (TCLP) extracts. These locations occurred beneath the northwest corner of the building, and beneath the courtyard north of the building. The distribution of chlorinated hydrocarbons is concentrated beneath the former PCE tank and extends to the western edge of the building (Figure 1-7). The distribution of BTEX compounds is more concentrated beneath the northwest corner of the building and in the courtyard north of the building. SVOCs were detected most frequently and at the highest concentrations in boring GB-2, located beneath the courtyard north of the building.

Groundwater

Three groundwater sampling events were conducted at the site to date. The first event occurred in February 1999 as part of a separate investigation conducted under an Immediate Investigation Work Assignment (IIWA) when three wells at the site were sampled. The second event took place in October 2001 as part of the Phase I RI when twelve wells were sampled. The third event took place in January/March 2002 as part of the Phase II RI when eighteen bedrock wells and one overburden piezometer were sampled. A wide range of VOCs were detected in the groundwater (Figure 1-7). Several SVOCs, including phenols and phthalates, and metals were also detected in groundwater. Compounds detected in groundwater at concentrations above SCGs included: carbon tetrachloride; PCE; TCE; 1,1,1-trichloroethane (1,1,1-TCA); 1,1-dichloroethane (1,1-DCA); 1,1-dichloroethene (1,1-DCE); 1,2-dichloroethene (1,2-DCE); methylene chloride; chloroethane; chloroform; cis-1,2-DCE; trans-1,2-DCE; chlorobenzene; vinyl chloride; 2-butanone; acetone; benzene; 1,1,2-trichloro-1,2,2-trifluoroethane; toluene; 2-methylphenol; 4-methylphenol; bis-2(ethylhexyl)phthalate (BEHP); iron; magnesium; sodium; and thallium.

The vertical and horizontal extent of contamination was determined as part of the Phase I and II RI. The southern fringe of the dissolved phase plume was delineated during the Phase II RI. The most concentrated portion of the groundwater contaminant plume was determined to exist directly beneath and immediately around the perimeter of the Chem-Core building. Contaminant concentrations decrease in all directions away from the site. The shallow bedrock groundwater zone was determined to be most contaminated. Near the Chem-Core building, the deeper bedrock groundwater zone investigated, approximately 15 feet deeper than the shallow bedrock groundwater zone, was determined to be much less contaminated, although the zone was clearly impacted by site contaminants. South of the site (i.e., near MW-08D) the deeper bedrock zone is more contaminated than the shallow well at this location. However, at the southernmost well pair (MW-13S/MW-13D), no organic contaminants were detected in the deeper bedrock zone and only trace organic constituents were reported in the shallow bedrock zone. The nature of bedrock beneath the deeper zone investigated is characterized as a fairly impermeable shale. This characterization coupled with the weak downward vertical hydraulic gradient and nearby discharge zone (i.e., Black Rock Canal) suggests that contaminant migration to deeper bedrock zones is unlikely. Dense non-aqueous phase liquids (DNAPLs) were not observed during drilling or sampling activities at the site. A slight oily sheen was observed on the groundwater surface in monitoring well MW-02. No other monitoring wells were observed to exhibit a sheen on the groundwater surface.

1.3.3 Contaminant Fate and Transport

Several types of contaminants were detected in site soil, sediment, and groundwater. These chemical compounds are subject to various transport mechanisms that dictate the method in which they will migrate off site and possibly to human/ecological receptors. Contaminants detected in site soils above regulatory criteria include VOCs, PAHs, and metals. The VOCs may volatilize and migrate through the soil pore spaces in the unsaturated zone. They also may be dissolved by infiltrating precipitation and be transported to groundwater. In the saturated zone, VOCs in non-aqueous phase may dissolve and migrate with groundwater and they also may degrade biologically. The presence of parent-daughter chlorinated hydrocarbons is indicative that degradation is occurring at the site. PAHs tend to adsorb onto soils and are relatively resistant to degradation. As a result, they are typically immobile in subsurface soil. Metals are persistent and may complex with other elements.

Contaminants detected in site groundwater above SCGs include VOCs, phenols, phthalates, and several metals. VOCs, specifically chlorinated hydrocarbons, BTEX compounds, ketones, are soluble and transported in the dissolved phase. At the Chem-Core site, dissolved-phase VOCs in groundwater originated from the subsurface soil contamination. Degradation will occur most rapidly for BTEX compounds and ketones. The chlorinated hydrocarbons tend to persist in the groundwater system. SVOCs detected in groundwater may be transported by hydrodynamic dispersion and advection or adsorb to the solid rock matrix and may degrade over a long period of time. Metals may be transported in the dissolved phase or adsorbed to the solid rock matrix.

Groundwater in the bedrock flows generally westerly toward the Black Rock Canal. However, a southwesterly component in the groundwater flow was observed in the shallow bedrock zone. Groundwater flow in the shallow bedrock zone emanating from the site is impeded by a wedge of lacustrine silts and clays that drape over the sloping bedrock surface beneath the I-190 corridor. These confining sediments induce a southwesterly component in the groundwater flow. For this reason, the plume of dissolved groundwater contamination has migrated southwestward from the site.

1.3.4 Qualitative Health Risk Summary

1.3.4.1 Human Health Risk Assessment

The qualitative HRA, evaluating the no-remediation scenario, was performed for the Chem-Core site. Thirty-seven chemicals of potential concern (CPCs) were identified in subsurface soils and groundwater. Under the current land use scenario, there are no media of concern because the pathways of exposure are not complete or the potential of contact is unlikely.

Under the future use scenario, soils and groundwater are media of concern for site residents, industrial/commercial workers, or construction workers. The site may be re-occupied after the building is rehabilitated and groundwater may potentially be used. Although groundwater is not likely to be used, the most conservative approach to human health and the environment is to assume it may be used in the future. The potential exposure pathways are ingestion, dermal absorption and inhalation of VOCs from soils and groundwater. Surface water and sediments are not media of concern because no CPCs were identified in surface water and the sediment pathway is incomplete.

1.3.4.2 FWIA Summary

The results of the Fish and Wildlife Impact Analysis (FWIA) indicate that fishes in the Black Rock Canal are the only ecological resources near the Chem-Core site. The FWIA analysis did not show that surface water or contaminated groundwater from the site are discharging directly into the Black Rock Canal. As part of Step II of the FWIA, it was determined that some chemicals, primarily PAHs and Aroclor 1260, were reported above sediment quality standards. However, Aroclor 1260 was not handled at the Chem-Core site. It does not appear that the chemicals known to have been handled at the Chem-Core site, have migrated to the Black Rock Canal. It is likely that Aroclor 1260 and the PAHs reported above sediment SCGs are attributable to other unknown industrial sources.

1.3.5 Applicable Standards, Criteria, and Guidance (SCGs)

To identify potential impacts, applicable SCGs must be identified. 6 NYCRR Part 375-1.10(c)(1) requires that remedial actions comply with SCGs ?unless good cause exists why conformity should be dispensed with.? Standards and Criteria are cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, or location. Guidance includes non-promulgated criteria and guidelines that are not legal requirements; however, the site?s remedial program should be designed with consideration given to guidance that, based on professional judgement, is determined to be applicable to the site.

SCGs are categorized as chemical specific, location specific, or action specific. These categories are defined as the following:

Chemical Specific: These are health or risk-based numerical values or methodologies which, when applied to site-specific conditions, result in the establishment of numerical values for the chemicals of interest. These values establish the acceptable amount or concentration of a chemical that may be found in or discharged to the environment.

Location Specific: These are restrictions placed on the concentrations of hazardous substances or the conduct of activities solely because they occur in a specific location (e.g., coastal zone, wetlands, etc).

Action Specific: These are usually technology or activity based requirements or limitations on actions taken with respect to hazardous waste management and site cleanup.

The following lists the principal SCGs that have been identified for the Chem-Core site (Table 1-1 lists all of the SCGs for the site):

General- 6 NYCRR Part 375 - Inactive Hazardous Waste Disposal Site Remedial Program

- 6 NYCRR Part 371 - Identification and Listing of Hazardous Wastes

Soil - NYSDEC Division of Hazardous Waste Remediation Technical and Administrative Guidance Memorandum (TAGM) 4046 - Determination of Soil Cleanup Objectives and Cleanup Levels

- 6 NYCRR Part 376 - Land Disposal Restrictions

- NYSDEC Division of Solid and Hazardous Materials TAGM 3028, "Contained-in? Criteria for Environmental Media (8/97)

Water - 6 NYCRR Part 700-705, Water Quality Regulations for Surface Water and Groundwater

- NYSDEC Division of Water TOGS 1.1.1 - Ambient Water Quality Standards and Groundwater Effluent Limitations

Air - Air Guide 1 - Guidelines for the Control of Toxic Ambient Air Contaminants

- 6 NYCRR Part 212 - General Process Emissions Sources

A comprehensive list of all of the potential SCGs for this site is included in Table 1-1 of this report.

1.3.6 Contaminants of Concern

The following volatile organic contaminants (VOCs) and their corresponding SCGs have been found at elevated concentrations above the SCGs (in parentheses below) at the site and are of primary concern:

Soil	Groundwater
Tetrachloroethene (PCE) - [1,400 µg/kg]	Chloroethane [5 µg/L]
Trichloroethene (TCE) - [700 µg/kg]	Tetrachloroethene (PCE) - [5 µg/L]
cis-1,2-Dichloroethene (cis-1,2,DCE) - [200 µg/kg]	Trichloroethene (TCE) - [5 µg/L]
1,1,1-Trichloroethane (1,1,1-TCA) - [800 µg/kg]	1,1,1-Trichloroethane (1,1,1-TCA) - [5 µg/L]
1,1-Dichloroethane (1,1-DCA) - [200 µg/kg]	1,1-Dichloroethane (1,1-DCA) - [5 µg/L]
1,1-Dichloroethene (1,1-DCE) - [400 µg/kg]	1,1-Dichloroethene (1,1-DCE) - [5 µg/L]
2-Butanone - [300 µg/kg]	1,2-Dichloroethane (1,2-DCA) - [0.6 µg/L]
Acetone - [200 µg/kg]	1,2-Dichloroethene (cis) (1,2-DCE) - [5 µg/L]
Methylene Chloride - [100 µg/kg]	1,2-Dichloroethene (trans) (1,2-DCE) - [5 µg/L]
	Benzene - [1 µg/L]
	Xylene - [5 µg/L]
	Toluene - [5 µg/L]
	Acetone - [50 µg/L]
	Methylene Chloride - [5 µg/L]
	Vinyl Chloride - [2 µg/L]
	Chloroform - [7 µg/L]

Figures 1-7 and 1-8 depict the contaminants detected above SCGs in soil and groundwater. The primary COCs are PCE and TCE in soil and groundwater. Remedial objectives will be focused in areas where contaminants exceed SCGs, particularly PCE and TCE. Remedial objectives should be achieved if PCE and TCE concentrations are reduced to their SCGs.

2.0 PROJECT GOALS AND OBJECTIVES

The goal of this FS is to identify and analyze remedial alternatives for the Chem-Core site, consistent with the objectives of 6NYCRR Part 375.

Based upon the results of the RI report, the Remedial Action Objectives (RAOs) for the site are:

- Provide for attainment, to the extent practicable, of NYSDEC Class GA Ambient Water Quality Criteria at the site.

- Reduce, control or eliminate, to the extent practicable off-site migration of groundwater that does not attain NYSDEC Class GA Ambient Water Quality Criteria.

- Remove, control, or eliminate, to the extent practicable, the volatile organic compounds in soil.

- Reduce, control, or eliminate to the extent practicable, migration of volatile organic compounds into the Black Rock Canal.

Any remedial alternative that will be presented as the preferred remedial action must demonstrate that it will be protective of human health and the environment, must comply with applicable or relevant and appropriate standards/criteria, and should comply with appropriate guidance.

3.0 IDENTIFICATION OF REMEDIAL TECHNOLOGIES

The following section presents remedial technologies that are meant to address the remedial goals presented in Section 2.0.

3.1 Presumptive Remedies Directives

The EPA has developed policy and procedures for presumptive remedies at sites where commonly encountered characteristics are present. Presumptive remedies are preferred technologies for common categories of sites, based on historical patterns of remedy selection and EPA?s scientific and engineering evaluation of performance data on technology implementation. The EPA has: evaluated technologies that have been consistently selected at sites using the remedy selection criteria set out in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP); reviewed currently available performance data on the application of these technologies; and, has determined that a particular set of remedies is presumptively the most appropriate for addressing specific types of sites. The objective of the presumptive remedies initiative is to use past experience to speed up evaluation and selection of remedial options, to ensure consistency in remedy selection, and to reduce the time and cost required to clean up similar types of sites. The presumptive remedies directive eliminates the need for the initial step of identifying and screening a variety of alternatives during the Feasibility Study. The NCP states that ?the lead agency shall include an alternatives screening step, when needed, to select a reasonable number of alternatives for detailed analysis.? EPA has analyzed feasibility studies for sites with commonly encountered contamination (i.e., sites with VOC-contaminated soil) and found that certain technologies are routinely screened out based on effectiveness, implementability, or excessive costs, consistent with the procedures set forth in the NCP. Accordingly, EPA has determined that, for sites that meet the requirements of the presumptive remedies directives, site-specific identification and screening of alternatives is not necessary.

This FS will use the following presumptive remedy guidance directives: *Presumptive Remedies: Policies and Procedures*, USEPA Directive 9355.0-47FS, September 1993; *Presumptive Remedies: Site Characterization and Technology Selection for CERCLA Sites with Volatile Organic Compounds in Soils*, USEPA Directive 9355.0-48FS, September 1993; and *Presumptive Response*

Strategy and Ex-situ Treatment Technologies for Contaminated Groundwater at CERCLA Sites, USEPA Directive 9283.1-12, October 1996.

3.2 Identification of Remedial Technologies for Soil

As discussed in the previous section, EPA has determined that, for sites that meet the requirements of the presumptive remedies directives, site-specific identification and screening of technologies is not necessary. This section identifies remedial alternatives for the contaminated soil at the Chem-Core site. These alternatives have been generated based on the guidance included in EPA?s document entitled *Presumptive Remedies: Site Characterization and Technology Selection for CERCLA Sites with Volatile Organic Compounds in Soils*.

3.2.1 No Action

The No Action alternative is included as a procedural requirement and as a baseline to compare to other alternatives. Under this alternative, no additional remedial action would be taken to address contaminated soils present at the site.

3.2.2 Soil Vapor Extraction

Soil vapor extraction (SVE) is an in-situ soil remediation technology, to be used in the unsaturated (vadose) zone, in which a vacuum would be applied to the soil to induce the controlled flow of air and remove volatile contaminants (and some semivolatiles, if present) from the soil. It is possible that the gas leaving the soil would have to be treated to recover or destroy the contaminants, depending on the concentrations of the contaminants present in the discharge. Vapor extraction wells would typically be used at depths of five feet or greater. Groundwater extraction could be incorporated into the system, as necessary, to reduce groundwater upwelling induced by the vacuum or to increase the depth of the vadose zone.

SVE may also be applied ex-situ by first excavating the contaminated soils and then constructing large piles of soil above ground. This method is appropriate when the soils are shallow, below the water table, or have a low permeability. The above ground pile would then be operated in the same manner as the in-situ design.

A pilot test for in-situ SVE was performed in April 2002. The pilot study consisted of a stepped-rate test for four (4) hours and a constant-rate test for approximately 8 hours. The stepped-rate test was conducted to determine the optimal vacuum for the constant-rate test. The initial vacuum pressure was 21.75 inches of mercury and the soil gas flow rate was ~37 cubic feet per minute (cfm). When the test ended, the vacuum decreased to 16.5 inches of mercury vacuum pressure, and the flow rate increased to 81 cubic feet per minute. The vacuum measured at all monitoring locations was low (less than 0.1 inches of water column). The estimated radius of influence for SVE-1 was 5 feet. The relatively small radius of influence is attributable to the hetrogeneity of the unsaturated zone. The upper 1 foot of the unsaturated zone, consisting of fill mixed with sand and gravel, is believed to have a significantly higher permeability than other layers in the unsaturated zone. Because of the higher permeability in the upper zone, it is believed that most air was extracted from the upper zone during the pilot test. This zone was above the screens of the observation wells, so significant vacuum was not recorded in these wells. This preferential high flow in a more permeable zone is called short circuiting, and as a result, additional engineering measures, e.g., air inlet wells screened in less permeable zones, would be needed to ensure that air flows and is extracted in the less permeable lower portion of the unsaturated zones. The pilot test showed that in-situ SVE is feasible; however, it also showed it would be costly because many extraction wells and air inlet wells (to get air to less permeable zones) would be required.

Applicability: The target contaminant groups for SVE are VOCs and some fuels. The technology is best applicable to volatile compounds with a Henry's law constant greater than 0.001 or a pure component vapor pressure greater than 0.5 mm Hg (0.02 inches Hg). Other factors, such as the moisture content, organic content, and air permeability of the soil, will also affect SVE's effectiveness.

Limitations: Factors that may limit the applicability and effectiveness of the process include:

- Soil that is tight or has high moisture content (>50%) has a reduced permeability to air, requiring higher vacuums (increasing costs) and/or hindering the operation of SVE.

- Large screened intervals are required in extraction wells for soil with highly variable permeabilities, which otherwise may result in uneven delivery of soil gas flow from the contaminated regions.

- Soil that has high organic content or is extremely dry has a high sorption capacity of VOCs, which results in reduced removal rates.

- Air emissions may require treatment to eliminate possible harm to the public and the environment. As a result of off-gas treatment, residual liquids and spent activated carbon may require treatment/disposal.

- SVE is not effective in the saturated zone; however, lowering the water table can expose more media to SVE (this may also address concerns regarding LNAPLs, if present).

3.2.3 Thermal Treatment

Thermal treatment, like most other technologies, can fall into two general categories: in-situ and ex-situ. Thermally enhanced extraction refers to a family of in-situ treatment technologies where heat is added to the subsurface in one form or another to enhance the recovery of volatile compounds. Common approaches include electrical resistive heating (including 6-phase electrical heating), steam enhanced extraction, and radio frequency heating. On the other hand, thermal desorption is an ex-situ technology that involves excavation of contaminated soils and on-site treatment of soils using a thermal desorption treatment unit. Once the soils have been treated they are usually backfilled at the site. The process uses heat to vaporize organic contaminants from the soil. The vapors are then condensed or otherwise collected for treatment.

Low temperature thermal desorption (LTTD) systems are physical separation processes and are not designed to destroy organics. Wastes are heated to between 200 - 600 ?F to volatilize water and organic contaminants. Volatilized water and organics are conveyed to the gas treatment system. The bed temperatures and residence times designed into these systems will volatilize selected contaminants but will typically not oxidize them. Unless being heated to the higher end of the LTTD temperature range, naturally occurring organic components in the soil are not damaged, which enables treated soil to retain the ability to support future biological activity.

An example of a common thermal desorption design is the rotary dryer. Rotary dryers are horizontal cylinders that are normally inclined and rotated. All thermal desorption systems require treatment of the off-gas to remove particulates and contaminants. Particulates can be removed by conventional particulate removal equipment, such as wet scrubbers or fabric filters. Contaminants can be removed through condensation followed by carbon adsorption, or they are destroyed in a secondary combustion chamber or a catalytic oxidizer. Most of these units are transportable.

Applicability: The target contaminant groups for LTTD systems are VOCs and fuels. The technology can be used to treat SVOCs at reduced effectiveness.

Limitations: Factors that may limit the applicability and effectiveness of the process include:

- Because of high capital costs, there is usually minimum volume of soil below which thermal treatment is not cost-effective.
- Thermal treatment units are usually large and their use may be limited by the amount of available space at a site.
- Exhaust gases may require treatment before being discharged to the atmosphere.
- Dewatering may be necessary to achieve acceptable soil moisture content levels.
- Highly abrasive feed can potentially damage the processor unit.
- Heavy metals in the feed may produce a treated solid residue that requires stabilization.

3.2.4 Excavation and Off-site Disposal

Contaminated material would be removed and transported to permitted off-site treatment and/or disposal facilities. Some of the soils would not meet Land Disposal Restrictions (LDRs) and would contain contaminant concentrations in excess of ten times Universal Treatment Standards (UTS), associated with 6NYCRR Part 376 prior to land disposal in a hazardous waste landfill along with soils that exhibit a toxicity characteristic. It is assumed that these soils would be treated at an off-site commercial facility. The remainder of the soils would be disposed of in an off-site solid waste landfill.

Excavation/Off-site Landfill

Applicability: Excavation and off-site disposal is applicable to the complete range of contaminant groups with no particular target group.

Limitations: Factors that would limit the applicability and effectiveness of the process include:

- Generation of fugitive emissions may be a problem during operations.
- The distance from the contaminated site to the nearest disposal facility with the required permit(s) will affect cost.
- Overall costs to implement this technology are usually relatively high.
- Some pre-treatment may be necessary in order to meet the requirements of the Land Disposal Restrictions (LDRs), as discussed above.

3.2.5 Excavation/Off-site Treatment

This approach would involve the excavation and off-site transport of the on-site soils to a permitted thermal treatment facility. An LTTD unit, as discussed above, would be used to volatilize halogenated and other organics in contaminated soil. The contaminants in the soils would need to be reduced to ten times the UTS before they could be disposed in a landfill.

Applicability: Low temperature thermal desorption is a viable treatment alternative for volatile organics such as those at the Chem-Core site.

Limitations: Factors that may limit the applicability and effectiveness of the process include:

- Off-site treatment is an additional expense due to shipping and to the already high cost of off-site landfilling.

3.3 Identification of Remedial Technologies for Groundwater

This section identifies remedial technologies for the contaminated groundwater at the Chem-Core site. While the EPA presumptive remedies guidance allows for the identification of treatment technologies based on the EPA document entitled *Presumptive Response Strategy and Ex-situ Treatment Technologies for Contaminated Groundwater at CERCLA Sites*, the DEC has determined that additional technologies not included in the EPA guidance also warrant consideration at this site.

3.3.1 No Action/Groundwater Monitoring

The No Action alternative is included as a procedural requirement and as a baseline to compare to other alternatives. Under this alternative, no remedial action would be taken to address contaminated groundwater. Groundwater monitoring would be conducted. It is assumed that a select group of existing monitoring wells would be monitored quarterly for the first year, semi-annually the second year, and annually thereafter.

3.3.2 Air Sparging

Air sparging is an in-situ technology in which air is injected through a contaminated aquifer. Injected air moves horizontally and vertically in channels through the soil, effectively creating an underground stripper that removes contaminants by volatilization. This injected air helps to "flush" the contaminants up into the unsaturated zone where a vapor extraction system is usually incorporated into the system to remove the generated vapor phase contamination. This technology is designed to operate at high flow rates to maintain increased contact between groundwater and soil.

Air sparging has a medium to long duration which may last, generally, up to a few years.

Applicability: The target contaminant groups for air sparging are VOCs and fuels.

Limitations: Factors that may limit the applicability and effectiveness of the process include:

- Air flow through the saturated zone may not be uniform; if this happens it could cause uncontrolled movement of potentially dangerous vapors.
- Depth of contaminants and site-specific geology must be considered.
- Air injection wells must be designed for site-specific conditions.
- Fracture heterogeneity in bedrock may prevent even flow of air through the subsurface and cause some zones to be relatively unaffected.

3.3.3 Monitored Natural Attenuation

Monitored natural attenuation is a non-engineered remedy in which natural subsurface processes, such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface materials, are allowed to reduce contaminant concentrations to acceptable levels. Consideration of this option usually requires evaluation of contaminant degradation rates and pathways and predicting contaminant concentrations at downgradient receptor points. The primary objective of this evaluation would be to demonstrate that natural processes of contaminant degradation will reduce contaminant concentrations below regulatory standards or risk-based levels before potential exposure pathways are completed. In addition, long term monitoring must be conducted throughout the process to confirm that degradation is proceeding at rates consistent with meeting cleanup objectives.

Natural attenuation is not the same as "no action," although it often is perceived as such. CERCLA requires evaluation of a "no action" alternative but does not require evaluation of natural attenuation. Natural attenuation is considered on a case-by-case basis. In all cases where natural attenuation is being considered, extensive site characterization and monitoring would be required, both before and after any potential implementation of this remedial alternative.

Compared with other remediation technologies, natural attenuation has the following advantages:

- Less generation or transfer of remediation wastes.
- It would be less intrusive.
- It may be applied to all or part of a given site, depending on site conditions and cleanup objectives.
- Natural attenuation may be used in conjunction with, or as a follow-up to, other (active) remedial measures.
- Overall cost will likely be lower than active remediation.

Synonyms: Intrinsic Remediation; Bioattenuation; Intrinsic Bioremediation.

Applicability: Target contaminants for natural attenuation are VOCs, SVOCs, and fuel hydrocarbons. Fuel and halogenated VOCs are commonly evaluated for natural attenuation.

Limitations: Factors that may limit applicability and effectiveness include:

- Data used as input parameters for modeling need to be collected.
- Intermediate degradation products may be more mobile and more toxic than the original contaminant.
- Natural attenuation is not appropriate where imminent site risks are present.
- The plume size may expand before steady state is reached (where migration and degradation rates are equal).
- Institutional controls may be required, and the site may not be available for reuse until contaminant levels are reduced.
- It is not meant to address source areas of relatively high contamination
- There are long term monitoring and associated costs associated with this alternative.
- Longer time frames would be required to achieve remediation objectives, compared to active remediation.

3.3.4 In-Well Air Stripping

The intent of in-well stripping would be to greatly increase contact between groundwater and air. In order to achieve equilibrium at the interface of the air and water, VOCs ?move? from the contaminated groundwater to the air.

Air would be injected into a double screened well, lifting the water in the well and forcing it out the upper screen. Simultaneously, additional water would be drawn in the lower screen. Once in the well, VOCs in the contaminated groundwater would be transferred from the dissolved phase to the vapor phase by air bubbles. The contaminated vapors would rise up through the well to the water surface where they would be drawn off and treated by a soil vapor extraction system. This type of system, in addition to collecting the vapors from within the well, would collect vapors from the surrounding unsaturated zone. The partially treated groundwater would not be brought to the surface; it would be forced into the unsaturated zone, and the process would be repeated as water follows a hydraulic circulation pattern or cell that allows continuous cycling of groundwater. As groundwater circulates through the treatment system, contaminant concentrations would gradually be reduced.

The duration of in-well air stripping could be short- to long-term, depending on contaminant concentrations, Henry's law constants of the contaminants, the radius of influence, and site hydrogeology.

Circulating wells (CWs) provide a technique for subsurface remediation by creating a three-dimensional circulation pattern of the groundwater. Groundwater is drawn into a well through one screened section and is pumped through the well to a second screened section where it is reintroduced to the aquifer. The flow direction through the well can be specified as either upward or downward to accommodate site-specific conditions. Because groundwater is not pumped above ground, pumping costs and permitting issues are reduced and eliminated, respectively. Also, the problems associated with storage and discharge are removed. In addition to groundwater treatment, CW systems can provide simultaneous vadose zone treatment in the form of soil vapor extraction.

Applicability: Typically, in-well air stripping systems are a cost-effective approach for remediating VOC-contaminated groundwater at sites with deep water tables because the water does not need to be brought to the surface.

CW systems are most effective at treating sites with volatile contaminants with relatively high aqueous solubility and strong biodegradation potential (e.g., halogenated and non-halogenated VOCs).

Limitations: The following factors may limit the applicability and effectiveness of the process:

- In general, in-well air strippers are more effective at sites containing high concentrations of dissolved contaminants with high Henry's law constants.
- Fouling of the system may occur by infiltrating precipitation containing oxidized constituents.
- Shallow aquifers may limit process effectiveness.
- Effective CW installations require a well-defined contaminant plume to prevent the spreading or smearing of the contamination.
- CWs are limited to sites with horizontal hydraulic conductivities greater that 10^{-5} cm/sec and should not be utilized at sites that have lenses of low-conductivity deposits.
- In well air stripping may not be efficient in sites with strong natural flow patterns.
- Only a small number of licensed vendors are available to obtain competitive bids.

3.3.5 Groundwater Containment, Extraction, and Treatment

Groundwater pumping systems are used to remove dissolved contaminants from the subsurface as well as to contain contaminated groundwater to prevent its migration.

Synonyms: Pump and treat.

Applicability: Site characteristics, such as hydraulic conductivity, will determine the range of remedial options possible. Chemical properties of the site and plume need to be determined to characterize transport of the contaminant and evaluate the feasibility of groundwater pumping. To determine if groundwater pumping is appropriate for a site, one needs to know the history of the contamination event, the properties of the subsurface, and the biological and chemical contaminant characteristics. Identifying the chemical and physical site characteristics are necessary in designing an effective groundwater pumping strategy. Hydraulic containment features, such as grout curtains or slurry walls, may also be used to help contain and control the lateral flow of contaminated groundwater at a site.

The use of grout curtains is a common approach to limiting water seepage through bedrock. A grout curtain involves drilling numerous borings into the formation and then pressure injecting grout or cement to fill the subsurface fractures and permeabilities.

Limitations: The following factors may limit the applicability and effectiveness of groundwater pumping as part of the remedial process:

- It is possible that a long time may be necessary to achieve the remediation goal.
- Residual saturation of the contaminant in the soil pores cannot be removed by groundwater pumping. Contaminants tend to be sorbed in the soil matrix. Groundwater pumping is not applicable to contaminants with high residual saturation, contaminants with high sorption capabilities, and homogeneous aquifers with hydraulic conductivity less than 10^{-5} cm/sec.
- The cost of procuring and operating treatment systems can be high, in the long term. Additional cost may also be attributed to the disposal of spent carbon and handling other treatment residuals and wastes.
- Bio-fouling of the extraction wells, and associated treatment stream, is a common problem which can severely affect system performance. The potential for this problem should be evaluated prior to the installation.

The following factors may limit the applicability and effectiveness of surfactant-enhanced recovery:

- Subsurface heterogeneities, as with most groundwater remediation technologies, present challenges to successfully implementing surfactant-enhanced recovery.
- Potential toxic effects of residual surfactants in the subsurface.
- Off-site migration of contaminants due to increased solubility achieved with surfactant injection.

There are a number of water treatment options that would be available after removing of contaminated groundwater from the subsurface. The EPA directive, entitled *Presumptive Response Strategy and Ex-situ Treatment Technologies for Contaminated Groundwater at CERCLA Sites*, dated October 1996, has been used to identify the following treatment options for extracted groundwater:

3.3.5.1 Air Stripping

Air stripping involves mass transfer of volatile contaminants from water to air. For groundwater remediation, this process is typically conducted in a packed tower or shallow tray tower. The typical packed tower air stripper introduces contaminated water at the top of the tower, and has a fan to force air countercurrent to the water flow, and a sump at the bottom of the tower to collect decontaminated water. Auxiliary equipment that can be added to the basic air stripper includes an air heater to improve removal efficiencies; automated control systems with sump level switches and safety features, such as differential pressure monitors, high sump level switches, and explosion-proof components; and air emission control and treatment systems, such as activated carbon units, catalytic oxidizers, or thermal oxidizers. Air strippers are installed either as permanent installations on concrete pads or on a skid or a trailer.

Air strippers can be operated continuously or in a batch mode where the air stripper is intermittently fed from a collection tank. The batch mode ensures consistent air stripper performance and greater energy efficiency than continuously operated units because mixing in the storage tanks eliminates any inconsistencies in feed water composition. The batch mode also reduces the time that the feed pump and the fan operate.

The eventual duration of cleanup using an air stripping system may be tens of years and depends on the capture of the groundwater contamination from the pumping system.

Applicability: Air stripping is used to separate VOCs from water. Henry's law constant is used to determine whether air stripping will be effective. Some examples of compounds that can be successfully separated from water using air stripping include BTEX, chloroethane, TCE, DCE, and PCE.

Limitations: The following factors may limit the applicability and effectiveness of the process:

- The potential exists for inorganic (e.g., iron greater than 5 ppm, hardness greater than 800 ppm) or biological fouling of the equipment, requiring pretreatment or periodic column cleaning.
- Most effective for contaminated water with VOC or semivolatile concentrations with a dimensionless Henry's constant greater than 0.01.
- Water miscible compounds like alcohols and ketones are difficult to remove.. · Conside tower.
- Process energy costs are high.
- Compounds with low volatility at ambient temperature may require preheating of the groundwater.
- Off-gases may require treatment based on mass emission rate.

3.3.5.2 Granular Activated Carbon

Liquid phase carbon adsorption is a technology in which groundwater is pumped through one or more vessels containing activated carbon to which dissolved organic contaminants adsorb. When the concentration of contaminants in the effluent from the bed exceeds a certain level, the carbon can be removed and regenerated at an off-site facility; or removed and disposed. Adsorption by activated carbon has a long history of use in treating municipal, industrial, and hazardous wastes.

The two most common reactor configurations for carbon adsorption systems are the fixed bed and the pulsed or moving bed. The fixed-bed configuration is the most widely used for adsorption from liquids. Pretreatment for removal of suspended solids from streams to be treated is an important design consideration. If not removed suspended solids in a liquid stream may accumulate in the column, causing an increase in pressure drop. When the pressure drop becomes too high, the accumulated solids must be removed, for example, by backwashing. The solids removal process necessitates adsorber downtime and may result in carbon loss and disruption of the mass transfer zone.

The duration of GAC is usually short-term; however, if concentrations are low enough, the duration may be long-term. The duration of operation and maintenance is dependent on the capture of the groundwater contamination from the pumping system.

Applicability: The target contaminant groups for carbon adsorption are hydrocarbons. Liquid phase carbon adsorption is effective for removing contaminants at low concentrations (less than 10 mg/L) from water at nearly any flow rate, and for removing higher concentrations of contaminants from water at low flow rates (typically 0.5 to 1 gpm). Carbon adsorption is particularly effective for polishing water discharges from other remedial technologies to attain regulatory compliance. Carbon adsorption systems can be deployed rapidly, and contaminant removal efficiencies are high. Logistic and economic disadvantages arise from the need to transport and decontaminate spent carbon.

Limitations: The following factors may limit the applicability and effectiveness of the technology:

- The presence of multiple contaminants can impact process performance.
- Streams with high suspended solids (> 50 mg/L) and/or oil and grease (> 10 mg/L) may cause fouling of the carbon and may require frequent treatment. In such cases, pretreatment is generally required.
- Costs are high if used as the primary treatment on wastestreams with high contaminant concentration levels.
- The quality of the carbon, as well as the operating temperature, will impact process performance.

- All spent carbon will eventually need to be properly regenerated or disposed.

3.3.5.3 Ultraviolet (UV) Oxidation

UV oxidation is a destruction process that oxidizes organic constituents in water by the addition of strong oxidizers and irradiation with UV light. Oxidation of target contaminants is caused by direct reaction with the oxidizers, UV photolysis, and through the action of UV light, in combination with ozone (O_3) and/or hydrogen peroxide (H_2O_2). The main advantage of UV oxidation is that it is a destruction process, as opposed to air stripping or carbon adsorption, for which contaminants are extracted and concentrated in a separate phase. UV oxidation processes can be configured in batch or continuous flow modes, depending on the throughput under consideration.

The UV oxidation process is generally done with low pressure lamps operating at 65 watts of electricity. Ozone systems and lamps operate at 15,000 watts and hydrogen peroxide systems operate at 60,000 watts.

Applicability: Practically any organic contaminant that is reactive with the hydroxyl radical can potentially be treated. A wide variety of organic contaminants are susceptible to destruction by UV/oxidation, including chlorinated hydrocarbons used as industrial solvents and cleaners. Typically, easily oxidized organic compounds, such as those with double bonds (e.g., TCE, PCE, and vinyl chloride), as well as simple aromatic compounds (e.g., toluene, benzene, xylene, and phenol), are rapidly destroyed in UV/oxidation processes.

Limitations: Limitations of UV oxidation include:

- The aqueous stream being treated must provide for good transmission of UV light (high turbidity causes interference).
- Free radical scavengers can inhibit contaminant destruction efficiency. Excessive dosages of chemical oxidizers may act as a scavenger.
- The aqueous stream to be treated by UV oxidation should be relatively free of heavy metal ions (less than 10 mg/L) and insoluble oil or grease to minimize the potential for fouling.

- When UV/O_3 is used on certain volatile organics, such as TCA, the contaminants may be volatilized (e.g., "stripped") rather than destroyed. They would then have to be removed from the off-gas by activated carbon adsorption or catalytic oxidation.
- Costs may be higher than competing technologies because of energy requirements.
- Pretreatment of the aqueous stream may be required to minimize ongoing cleaning and maintenance.
- Handling and storage of oxidizers require special safety precautions, although ozone can be generated on site.

Another component of any groundwater extraction system is a groundwater monitoring program to verify its effectiveness. Monitoring the remedy with wells and piezometers allows the operator to make continuous adjustments, as necessary, to the system in response to changes in subsurface conditions caused by the remediation.

3.3.6 Enhanced In-situ Bioremediation

Enhanced in-situ bioremediation (EISB) of chlorinated solvents in groundwater involves the input of an organic carbon source, nutrients, electron acceptors, and/or microbial cultures to stimulate degradation. The major biological processes by which chlorinated compounds degrade include anaerobic reductive dechlorination, aerobic cometabolism, and oxidation. Anaerobic reductive dechlorination involves the replacement of chlorine atoms in the chlorinated compound by hydrogen. An electron donor, either hydrogen gas or a precursor organic compound, is necessary for reduction to occur. Aerobic cometabolism involves the fortuitous degradation of chlorinated solvents by enzymes intended to metabolize compounds such as toluene, phenol, or methane. The organisms gain no benefit from the cometabolic degradation and may be harmed. Direct degradation of some chlorinated solvents can occur in either aerobic or anaerobic environments.

A key factor in the design of EISB systems is the mechanism for delivering amendments and nutrients to the target portion of the groundwater plume. For sites in which treatment of high concentration portions of a plume is the goal, systems with multiple injection and extraction wells may provide semi-closed recirculation loops in the groundwater which reduce downgradient flow and allow for greater biodegradation of the contaminants.

A variety of amendments may be added to EISB systems. For reductive dechlorination and cometabolic degradation, other organic materials must be present. Common carbon sources for anaerobic or cometabolic degradation include lactic acid, sodium benzoate, methanol, yeast extract, or proprietary slow release compounds. Most sites require nutrients as well, including phosphate, nitrate, or potassium.

Applicability: EISB systems are appropriate for sites in which natural biological activity has been confirmed. Anaerobic conditions are generally required for heavily chlorinated compounds including PCE, TCE, 1,1,1-TCA, and DCE. Because naturally occurring bacteria are the primary degradation mechanism, EISB systems can be much less expensive than chemical or physical treatment technologies.

Limitations: EISB systems are susceptible to the following limitations:

- Restrictive regulatory issues may apply if the system includes reinjection of hazardous substances into the groundwater.
- When adding nutrients, biofouling of the injection wells can be a nuisance.
- Not all compounds are equally amenable to biological degradation.
- Some intermediate compounds in the biodegradation pathway are more mobile and/or toxic than their parent compounds (i.e., vinyl chloride is an anaerobic degradation product of PCE).
- EISB systems are limited to how quickly organisms can degrade the target compounds. These systems can take a significantly longer time to remediate an area compared to physical or chemical treatment technologies.

3.3.7 **Steam Injection/Stripping**

Steam injection/stripping is an innovative remedial alternative developed primarily for recovering NAPL, but is also amenable to treating adsorbed and dissolved phase contaminants. The technology involves the addition of heat in the form of low pressure steam to the subsurface. The superheated steam raises the temperature of the subsurface to approximately 100? C, rapidly boiling groundwater and volatile contaminants. The evaporated vapors are collected by a vacuum system similar to a vapor extraction technology. The collected steam and vapors are condensed to recover a liquid waste product for off-site disposal. The total treatment time varies depending on the size of the contaminated area and the amount of contaminants to be extracted; it can range from a few months to two years. Once the entire subsurface has been raised above 100E C, the steam injection can be discontinued with continuing vapor extraction while the subsurface cools. Steam stripping can remove 80 to 90 or more percent of contaminants from the subsurface.

Applicability: Steam stripping is appropriate for the recovery of NAPLs from the subsurface, both above and below the water table. It is best applied to concentrated sources of VOCs, although some SVOCs have been successfully recovered using steam. Because it volatilizes and boils contaminants out of the subsurface, the technology has much higher extraction efficiencies and recovery rates than a traditional pump and treat system.

Limitations: Steam stripping may be subject to the following limitations:

- Steam systems require a large vapor collection system to ensure that the evaporated contaminants do not condense in the subsurface, possibly contaminating a previously clean area.
- The technology will produce a liquid hazardous waste which must be transported off-site for proper treatment and disposal.
- Steam systems are not appropriate for compounds with a boiling point greater than approximately 200? C.
- Steam stripping is considered efficient when addressing source areas; remediation of dissolved phase plumes is not cost-effective when using steam.

3.4 Summary of Identified Remedial Technologies

The following is a summary of the remedial alternatives that have been identified for the Chem-Core site:

Remedial Technologies Identified for Soil

- No Action
- Soil Vapor Extraction
- Thermal Treatment - Low Temperature Thermal Desorption (LTTD)
- Excavation and Off-site Disposal Landfill
- Excavation and Off-site Disposal - Off-site Treatment

Remedial Technologies Identified for Groundwater

- No Action/Groundwater Monitoring
- Air Sparging
- Monitored Natural Attenuation
- In-Well Air Stripping
- Groundwater Containment, Extraction, and Treatment (Pump and Treat)
  Air Stripping or Granular Activated Carbon, or Ultraviolet Oxidation
- Enhanced In-situ Biodegradation
- Steam Stripping

4.0 DEVELOPMENT AND SCREENING OF ALTERNATIVES

This section includes a screening of technologies to eliminate those that are not appropriate for the site. The remaining feasible technologies are used to develop appropriate remediation alternatives that will be used for detailed analysis (Section 5.0).

4.1 Screening of Soil Technologies

As discussed in the presumptive remedy guidance for soils entitled *Presumptive Remedies: Site Characterization and Technology Selection for CERCLA Sites with Volatile Organic Compounds in Soils* (summarized in Section 3.1); EPA has determined that, for sites meeting the requirements of the presumptive remedies directives, site specific screening of alternatives is not necessary. However, at this site, one of the presumptive remedies for soil (thermal treatment) identified for soils has been eliminated based on one of the preliminary screening criteria for alternatives (implementability) as described below.

Thermal desorption involves the excavation of contaminated soil, staging of soil, processing of the soil through the treatment unit, and backfilling of the treated soil. The Chem-Core site is a 0.5 acre site occupied mostly by an industrial building. The site is in close proximity to residential neighborhoods to the east and a rail corridor to the west with both interstate I-190 highway and the Black Rock Canal (which leads from Lake Erie to the Niagara River) further to the west. There would not be enough space to treat on-site soils by thermal desorption. As a result, thermal desorption has been eliminated from further consideration based on the evaluation of this alternative using the ?implementability? screening criteria.

4.2 Screening of Groundwater Technologies

Groundwater technologies were screened with respect to technical feasibility. Based on the screening, four of the seven technologies identified in Section 3.4 were eliminated from consideration. The basis for their elimination is discussed below.

Air sparging and in-well stripping are in-situ technologies that requires homogeneous or nearly homogeneous subsurface conditions in order to be effective. At the Chem-Core site, groundwater contamination is in fractured bedrock which is extremely heterogeneous. Because of this limitation, air sparging and in-well stripping were eliminated from consideration.

Enhanced in-situ biodegradation is appropriate for sites where natural attenuation processes have been identified. The appearance of the daughter products of tetrachloroethene (i.e., trichloroethene, dichloroethene, and vinyl chloride) indicate natural attenuation processes are underway. However, like air sparging, and in well stripping in-situ biodegradation is limited in effectiveness by the heterogeneity of fractured bedrock. Biodegradation processes require that sufficient electron donor compounds are present. Enhanced in-situ biodegradation involves the introduction of additional electron donor compounds to the plume to promote the dechlorination of solvents. Because of the heterogeneous and unpredictable nature of the bedrock fractures within which the plume is located, it is difficult to inject electron donors into the plume. Without direct and intimate mixing of the contaminants and the electron donors, enhanced in-situ biodegradation is not effective. Because of the unknowns associated with injection of electron donors and subsequent biodegradation in bedrock, immediate implementation of this technology would not be recommended. However, because the groundwater data indicates that natural biodegradation may be occurring, it would be prudent to pilot test this technology. An effective approach would be to implement the pilot scale study in downgradient, less contaminated areas and use the study results to scale up use for other downgradient areas and/or the source. A phased approach to groundwater remediation, which includes a downgradient bioremediation pilot study, and pump and treat remedy at the source with possible future expansion of bioremediation into the source area, is discussed in Section 4.3.

Steam stripping is a relatively new technology which has not been implemented in fractured bedrock. Because of the heterogenieity of fractured bedrock, steam and contaminants can migrate offsite. The close proximity of residences and the Niagara River cause significant concern with regard to this outward migration of contamination. Therefore, steam stripping was not considered further.

4.3 Development of Alternatives

The majority of the Chem-Core site is covered by a building that has not been used since the late 1990s. Remediation of soil (by SVE or excavation/disposal) could be implemented after the existing building is demolished or while the structure is still standing. However excavation/disposal of soil while the building is standing was not used in the development of alternatives for the following reasons. Excavation while the building is standing would be difficult to implement and would likely not be as effective as excavation after building demolition. Excavation of large quantities of soil could undermine the system foundation and could lead to building collapse. It would also be difficult to excavate in the building using large equipment. Because of potential limitations during construction, complete removal of contaminated soil under the building would be unlikely, i.e. a significant quantity of contaminated soil might remain on site after excavation.

One alternative was developed for monitored natural attenuation (MNA). For this alternative, groundwater is remediated using MNA, and the source is controlled using containment. Containment is accomplished by leaving the existing concrete building foundation in place. The concrete acts as a cover that reduces infiltration of rain and reduces migration of contamination from soil in the unsaturated zone to groundwater. It also prevents direct contact with contaminated soil by humans.

Alternatives were also developed based on EPA?s guidance for groundwater remediation entitled *Presumptive Response Strategy and Ex Situ Treatment Technologies for Contaminated Groundwater at CERCLA Sites.* Groundwater remediation is divided into two phases. The first phase will focus on contaminated groundwater at the source area. The second phase will focus on contaminated groundwater downgradient of the source area.

Remediation of groundwater at the source area will also be implemented using a phased approach. In the phased approach, the long term remedy is implemented in more than one design and construction phase. The phased approach for the Chem-Core site includes a combination of pump and treat and in-situ treatment. The first phase includes groundwater extraction and treatment for approximately five years. The second phase includes in-situ treatment by enhanced in-situ biodegradation.

During the first phase of remediation, data will be collected and remediation progress will be evaluated. It is possible, after completion of the first phase, that data will indicate that the strategy for the second phase will need to be modified. Potential alternative technologies for phase two include continued pump and treat, MNA, or an alternate in-situ treatment technology. Remediation of contaminated groundwater downgradient of the source area will include enhanced in-situ biodegradation. Implementation of remediation of downgradient contamination will be a pilot phase and a full scale phase. The pilot scale phase will be implemented initially in the downgradient area. The pilot scale phase will be implemented to obtain data to determine the effectiveness of in-situ bioremediation. The data will be evaluated prior to implementing the in-situ bioremediation remedy in other downgradient areas or in the source area. Results of the pilot test will be evaluated to determine the requirements for full scale operation. It is possible that pilot scale results may show that enhanced biodegradation is not a viable option. Further investigation and evaluation of technologies will be required if pilot scale test results are not favorable.

4.4 Alternatives Identified For Detailed Analysis

Based on the above, the following alternatives will be used in the detailed analysis of remedial alternatives presented in Section 5.0.

Remedial Alternatives

1. No Action/Groundwater Monitoring
2. Monitored Natural Attenuation and Containment
3. Building Demolition, Excavation of Soil and Off-Site Disposal, and Phased Approach of Groundwater Pump and Treat
4. Building Demolition, Soil Vapor Extraction, and Phased Approach of Groundwater Pump and Treat
5. Soil Vapor Extraction and Phased Approach of Groundwater Pump and Treat

5.0 DETAILED ANALYSIS OF ALTERNATIVES

5.1 Description of Evaluation Criteria

In Sections 5.2 and 5.3, each of the alternatives is analyzed with respect to the criteria outlined in the 6 NYCRR Part 375, which defines the selection process for remedial actions at inactive hazardous waste sites. Each alternative is analyzed with respect to:

1. **Overall Protection of Human Health and the Environment**: This criterion serves as a final check to assess whether each alternative meets the requirement that are protective of human health and the environment. The overall assessment of protection is based on a composite of factors assessed under other evaluation criteria; especially long-term effectiveness and permanence, short-term effectiveness, and compliance with SCGs. This evaluation focuses on how a specific alternative achieves protection over time and how site risks are reduced. The analysis includes how each source of contamination is to be eliminated, reduced or controlled for each alternative.

2. **Compliance with SCGs**: This evaluation criterion determines how each alternative complies with applicable or relevant and appropriate SCGs, as discussed and identified in Section 1.7. The actual determination of which requirements are applicable or relevant and appropriate is made by the NYSDEC in consultation with the NYSDOH. If an SCG is not met, the basis for one of the four waivers allowed under 6 NYCRR Part 375-1.10(c)(i) is discussed. If an alternative does not meet the SCGs and a waiver is not appropriate or justifiable, such an alternative should not be considered for detailed analysis.

3. **Short-term Impacts and Effectiveness**: This evaluation criterion assesses the effects of the alternative during the construction and implementation phase. Alternatives are evaluated with respect to their effects on human health and the environment during implementation of the remedial action. The aspects evaluated include: protection of the community during remedial actions, environmental impacts as a result of remedial actions, time until the remedial response objectives are achieved, and protection of workers during the remedial action.

4. **Long-term Effectiveness and Permanence**: This evaluation criterion addresses the results of a remedial action in terms of its permanence and quantity/nature of waste or residual remaining at the site after response objectives have been met. The primary focus of this evaluation is the extent and effectiveness of the controls that may be required to manage the waste or residual remaining at the site and operating system necessary for the remedy to remain effective. The factors being evaluated include the permanence of the remedial alternative, magnitude of the remaining risk, adequacy of controls used to manage residual waste, and the reliability of controls used to manage residual waste.

5. **Reduction of Toxicity, Mobility and Volume**: This evaluation criterion assesses the remedial alternatives use of the technologies that permanently and significantly reduce toxicity, mobility, or volume of the hazardous wastes as their principal element. The NYSDEC?s policy is to give preference to alternatives that eliminate any significant threats at the site through destruction of toxic contaminants, reduction of the total mass of toxic contaminants, irreversible reduction in the contaminants mobility, or reduction of the total volume of contaminated media. This evaluation includes: the amount of the hazardous materials that would be destroyed or treated, the degree of expected reduction in toxicity, mobility, or volume measured as a percentage, the degree in which the treatment would be irreversible, and the type and quantity of treatment residuals that would remain following treatment.

6. **Implementability**: This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation. The evaluation includes: feasibility of construction and operation; the reliability of the technology; the ease of undertaking additional remedial action; monitoring considerations; activities needed to coordinate with other offices or agencies; availability of adequate off-site treatment, storage, and disposal services; availability of equipment; and the availability of services and materials.

7. **Cost**: Cost estimates are prepared and evaluated for each alternative. The cost estimates include capital costs, operation and maintenance costs, and future capital costs. A cost sensitivity analysis is performed which includes the following factors: the effective life of the remedial action, the O&M costs, the duration of the cleanup, the volume of contaminated material, other design parameters, and the discount rate. A summary of costs are presented in Table A-1 (Appendix A).

8. **Community Acceptance**: After completion of the FS, a Proposed Remedial Action Plan (PRAP) is prepared by NYSDEC and released to the public for comment. A public meeting will be held by the NYSDEC in the City of Buffalo to present the results of the RI study and FS evaluation. Concerns of the community regarding the RI/FS reports and the PRAP will be evaluated. A ?Responsiveness Summary? will be prepared that presents the public comments received and how the Department will address the concerns raised. If the final remedy selected differs significantly from the proposed remedy, notice to the public will be issued describing the differences and reasons for the changes.

5.2 Detailed Analysis of Remedial Alternatives

5.2.1 No Action/Groundwater Monitoring

The no action alternative is evaluated as a procedural requirement and as a basis for comparison. It requires continued groundwater monitoring only, allowing the site to remain in an unremediated state. This alternative would leave the site in its present condition and would not provide any additional protection to human health or the environment.

Present Worth	\$84,000
Capital Cost	\$0
Annual O&M	\$20,000 (1st year)
	\$10,000 (year 2)
	\$5,000 (years 3-30)

O&M Present Cost	$84,000
Time to Implement	NA
Estimated Time to Completion	NA

Overall Protection of Human Health and the Environment: Although this alternative does not result in any increased short-term risks, it does not comply with chemical-specific SCGs, and is not effective in the long term. No completed exposure pathways currently exist. However, future risks may be realized if the site is re-occupied after rehabilitation or if groundwater were to be used in the future. Should these scenarios come to fruition, this alternative would not be protective of human health or environment within an acceptable time frame.

Compliance with SCGs: Since high concentrations of contaminants of concern remain on site, this alternative would not meet chemical-specific SCGs in a reasonable time frame. No location specific SCGs have been identified. Since no action is being taken, action-specific SCGs do not apply.

Short-Term Impacts and Effectiveness: Since the only action would be groundwater monitoring, the only short-term impact would be the possibility of exposure of the samplers to the groundwater. Exposure would be significantly reduced through the use of appropriate levels of personal protective equipment and health and safety procedures. It is unlikely that there would be any increased risk to the public or impacts to the environment during monitoring. SCGs would be exceeded throughout the foreseeable future.

Long-Term Effectiveness and Permanence: Since no active remediation would take place, this alternative would not be effective in reducing contaminant concentrations in soil or groundwater in a reasonable time frame. This is not a permanent remedy. The potential risk caused by remaining waste is not addressed by this alternative.

Reduction of Toxicity, Mobility, and Volume: This alternative would not significantly reduce the toxicity, mobility, or volume of contamination in soil or groundwater. Only some reduction of toxicity would occur through ongoing biodegradation. Biodegradation without sufficient electron donors has the potential to increase toxicity through the accumulation of vinyl chloride.

Implementability: This alternative would be easily implemented. There would be no activities that would need coordination with other agencies during implementation. However, other agencies, such as the Department of Health, may not approve of no action being taken due to the potential future health risks. This alternative would require sampling of groundwater for an extended period of time (30 years is assumed for cost purposes).

Cost: There would be no capital cost for this alternative. The annual O&M cost (for sampling) is $20,000 for the first year, $10,000 for the second year, and $5,000 for each year thereafter based on a total of 30 years. The present worth value of this alternative is $84,000 using a 6% discount rate for 30 years. A summary of costs are presented in Table A-1 (Appendix A).

5.2.2 Monitored Natural Attenuation and Containment

This alternative would include the installation of approximately 5 monitoring wells on site, monitoring of the 5 new wells and 12 existing wells, development of a fate and transport model for natural attenuation, and development and implementation of operations, maintenance, monitoring plan for the MNA alternative, and five year data evaluation to evaluate the progress of MNA. In addition, the building (or at least the concrete floor) would remain in place to reduce infiltration and migration of contamination from soil to groundwater.

Present Worth	$400,000
Capital Cost	$130,000
Annual O&M	$64,400 (year 1), $32,200 (year 2), $16,100 (remaining years)
O&M Present Cost	$270,000
Time to Implement	Approximately 3 months
Estimated Time to Completion	Indefinite (20 years used for cost estimate)

Overall Protection of Human Health and the Environment: This alternative would be protective of human health and the environment if natural attenuation reduces groundwater concentrations to chemical-specific SCGs in an acceptable time frame. However, additional data collection, and modeling is required to estimate the time frame from MNA. At this stage, the protectiveness of this alternative is unknown.

Compliance with SCGs: This alternative is expected to comply with SCGs for groundwater over time since data collected to date indicates biodegradation is occurring. However, the time frame for compliance is unknown at this time.

Short-Term Impacts and Effectiveness: Minimal short-term impacts are possible for workers installing wells and sampling groundwater. Exposure would be significantly reduced through the use of appropriate levels of personal protective equipment and health and safety procedures. It is unlikely that here would be any increased risk to the public or impacts to the environment during groundwater monitoring or well installation.

Long-Term Effectiveness and Permanence: There is no active remediation under this alternative, however, it is substantially different than no action. MNA includes extensive monitoring and modeling which will determine the speed of remediation and extent of the plume over time. The effectiveness and permanence of the remedy, however, can only be evaluated after further data is collected.

Reduction of Toxicity, Mobility, and Volume: Leaving the building (or at least the concrete floor) onsite covering the source area would reduce the mobility of soil contamination. This cover would reduce infiltration which would in turn reduce contaminant migration from soil to groundwater.

Implementability: This alternative would be easily implemented. This alternative would require sampling of groundwater for an extended period of time (30 years is assumed for cost purposes). Long-term access agreements with off site property owners would be needed for groundwater sampling.

Cost: The estimated capital cost for monitored natural attenuation is $130,000. The present O&M cost is $270,000. The present worth cost of this alternative is $400,000 using a 6% discount rate. A summary of costs are presented in Table A-1 (Appendix A).

5.2.3 Building Demolition, Excavation of Soil and Off-Site Disposal, and Phased Approach of Groundwater Pump and Treat

This alternative would involve the demolition of on-site structures and the excavation of 7,700 cubic yards of contaminated soil beneath the site down to the bedrock surface. Land Disposal Restrictions (LDRs) prevent landfilling of contaminated material that exceeds certain concentrations listed by contaminant. These concentrations are called Universal Treatment Standards (UTSs). Treatment standards for hazardous wastes are found in 40 CFR 268.40. This code shows the applicable standards for both nonwastewater and wastewater forms for each hazardous waste, by USEPA waste code. Soil that exhibits a hazardous waste characteristic when removed from the land may be disposed of in a non-hazardous waste landfill providing the soil is treated and subsequently meets applicable treatment standards and no longer exhibits a hazardous waste characteristic. When applying the soil treatment standards, both criteria (i.e., 10 times the UTS and waste characteristic) must be met prior to land disposal. Sometimes soils that exhibit a toxicity characteristic may be treated to the alternative soil treatment standards yet still be characteristic since 10 times the UTS can sometimes be above the waste characteristic level (USEPA 2001). All soils that exceed ten times the UTSs prior to land disposal in a hazardous waste landfill along with soils that exhibit a toxicity characteristic.

For cost estimating purposes, it is assumed that 10% of the soil at the Chem-Core site exceeds ten times the UTS criteria and cannot be landfilled. On this basis, it is estimated that this alternative would require the excavation, transportation, and off-site treatment of 770 yd^3 of soil. The remainder (6,930 yd^3) would be excavated and transported to an off-site landfill for disposal. It is estimated that 1,540 yd^3 will be disposed of in a hazardous waste landfill and 5,390 yd^3will be disposed in a nonhazardous waste landfill.

This alternative includes phased groundwater remediation at the source area. The first phase will involve the installation of approximately 8 pumping wells, installed to a depth of 50 feet. It is estimated that the system would operate at an average withdrawal rate of approximately 40 gallons per minute from an estimated period of 5 years. At the end of the first phase, data collected during the 5 year period will be evaluated and the second phase will be implemented. The technology used for the second phase of groundwater remediation will depend on the success of the first phase. For the FS (mainly for cost purposes) it is assumed that enhanced in-situ bioremediation will be used for the second phase of groundwater remediation. During the second phase, a proprietary organic material source, such as hydrogen release compound (HRC) by Regenesis, Inc., would be injected into the groundwater to promote biodegradation of groundwater contamination by reductive chlorination. Groundwater would be recirculated using existing extraction wells and 8 newly installed reinjection wells.

During the first phase of groundwater remediation, extracted groundwater would be treated on site and discharged to either surface water or sanitary sewers, as necessary and appropriate. As discussed in Section 3.3.5, there are three options for groundwater treatment (air stripping, carbon adsorption, and UV oxidation). For the FS, so that a cost could be developed, air stripping was used in the detailed analysis. It was further assumed that carbon would be placed after the air stripper to ?polish? the groundwater before discharge, and that emissions from the air stripper would be treated using a catalytic oxidizer. If groundwater treatment is included in the preferred remedy, the final decision on the method of treatment for extracted groundwater would be deferred until the Remedial Design.

This alternative also includes groundwater remediation downgradient of the source area by using enhanced biodegradation. The downgradient remediation includes a pilot scale study followed by full scale implementation of the enhanced biodegradation technology.

Present Worth	$3,170,000
Capital Cost	$2,800,000
Annual O&M	$88,726
O&M Present Cost	$370,000
Time to Implement	Approximately 6 months
Estimated Time to Completion	5+ years

Overall Protection of Human Health and Environment: The short-term risks associated with this alternative would be mitigated with proper controls. This alternative would remove all site related contaminants at concentrations exceeding the soil SCGs, and therefore would be protective of human health and the environment. This alternative, in the long term, would reduce contaminant concentrations in groundwater by eliminating the source of contamination. This alternative would reduce the possibility of exposure to contaminated groundwater by treating it on site, and preventing migration away from the source area, and by reducing contamination downgradient of the source area using enhanced biodegradation.

Compliance with SCGs: Since this alternative would eliminate all site-related soil contamination at concentrations exceeding the cleanup objective, chemical-specific soil SCGs would be met. No location specific SCGs have been identified. Action-specific SCGs for this alternative apply to the excavation and handling of site soils, well installation, monitoring requirements, and OSHA health and safety requirements (e.g., 29 CFR 1910). Compliance with these SCGs would be achieved by following a site-specific health and safety plan. The treatment system would produce air emissions that would be subject to New York regulations to 6 NYCRR 200, 201, and 212, and the New York Air Guide 1, Guidelines for the Control of Toxic Ambient Air Contaminants. Since the air emissions would be treated, as appropriate, these regulatory requirements would be met. The treatment system would also result in a water discharge. This water would either be discharged to surface waters or to the local publicly owned treatment works (POTW). If discharged to surface water, it would be subject to New York regulations for SPDES discharges; if discharged to the POTW, coordination with the local municipality would be required. Since the water discharge would be treated, these requirements would be met.

6 NYCRR Part 703, Groundwater Quality Standards, would apply to groundwater. The history of groundwater extraction and treatment shows that overall, time is needed for this technology to lower contaminant concentrations, and that it is difficult to achieve groundwater standards. By hydraulically containing the plume in the source area, the continued migration of contaminants would be controlled, thereby preventing the volume of contaminated groundwater from increasing. Additionally, if groundwater extraction and treatment is not showing sufficient progress at the end of the first phase of groundwater remediation at the source area, the second phase will include methods (e.g., enhanced bioremediation) to accelerate groundwater remediation. Downgradient of the source area, enhanced bioremediation will be used to prevent further migration of contamination.

Short-term Impacts and Effectiveness: There would be a potential for worker and residential exposure to fugitive emissions during excavation and transportation of contaminated soil. A risk to the public would be present during the hauling of contaminated soil for off-site treatment and disposal. Exposure would be significantly reduced through the use of dust suppression measures, proper covering of trucks, and personal protection equipment. These dust suppression measures, as well as site access restrictions and air monitoring, would eliminate or greatly reduce any increased risk to the public or impacts to environment during construction. Another potential concern is the impact that the additional construction traffic would have on the occupant of adjacent commercial properties. However, the use of traffic control measures and planned traffic flow patterns would minimize any impacts caused by the heavy traffic during the implementation of the remedy.

There would also be a potential for worker exposure during well construction. This exposure could be significantly reduced through the use of personal protection equipment. Air and water emission controls would prevent worker and resident exposure to airborne and waterborne contaminants.

Long-Term Effectiveness and Permanence: Contaminants at concentrations exceeding Universal Treatment Standards (UTSs) would be permanently treated, and contaminants at concentrations exceeding the cleanup objective would be removed from the site, eliminating the need for any future monitoring. Therefore, this alternative would be effective for soil remediation.

Groundwater concentrations would be expected to gradually decrease with time as a result of the extraction and treatment of contaminated groundwater. Although pump and treat remedies usually require a long time, the use of enhanced bioremediation (or similar technology) would be expected to accelerate this process.

Reduction of Toxicity, Mobility, and Volume: Contaminated soil at the site would be removed. Since soil containing contaminants at concentrations exceeding UTSs would be treated, the volume of contamination and toxicity of soil would be reduced. Since contaminated soil with concentrations less than the UTSs would be placed in a landfill, the mobility of these contaminants would be reduced.

By removing contaminants from groundwater and treating the removed contaminants, the toxicity and volume of the contaminants in the groundwater would be reduced. Hydraulic containment (by groundwater extraction) would prevent further migration, and thereby reduce mobility. Enhanced bioremediation would further reduce the toxicity and volume of contaminants.

Implementability: Adequate commercial disposal capacity is available for wastes to be treated offsite. The equipment and material needed to install groundwater extraction and treatment system are commercially available from several vendors. There are no anticipated administrative or legal barriers to the implementation of this alternative.

Cost: This alternative would require capital costs of $2,800,000. The annual O&M cost is $88,726. The total present worth value of the alternative is $3,170,000. A summary of costs are presented in Table A-1 (Appendix A).

5.2.4 Building Demolition, Soil Vapor Extraction, and Phased Approach to Groundwater Pump and Treat

This alternative would include the installation of approximately 144 extraction wells to the top of the bedrock. The wells would be installed in a grid across the site on approximately 10 foot centers. The SVE treatment unit would be installed along with all the associated piping and an air treatment unit (some form of air treatment would be installed to prevent unacceptable air emissions).

This alternative would also include phased groundwater remediation which would be identical to the previous alternative as described in Section 5.2.3.

Present Worth	$3,400,000
Capital Cost	$2,100,000
Annual O&M	$310,000
O&M Present Cost	$1,300,000
Time to Implement	Approximately 6 months
Estimated Time to Completion	5+ years

Overall Protection of Human Health and the Environment: The short-term risks associated with this alternative could be easily mitigated with proper controls. This alternative reduces the possibility of exposure to contaminated soils, and in the long term would reduce contaminant concentrations in groundwater by controlling the source of contamination. This alternative would also reduce the possibility of exposure to contaminated groundwater by controlling and treating it on site, thus minimizing it as a continuing source for all off site areas, and by reducing contamination downgradient of the source area using enhanced biodegradation.

Compliance with SCGs: Soil vapor extraction (SVE) would significantly reduce the majority of the contaminants of concern at the site, and could meet chemical SCGs for the VOCs in soil. However, there is the possibility that concentrations of all contaminants would not drop below the TAGM 4046 Soil Cleanup objectives. The history of groundwater extraction and treatment shows that overall, time is needed for this technology to lower contaminant concentrations, and that it is difficult to achieve groundwater standards. However, by hydraulically containing the plume the continued migration of contaminants would be controlled, thereby preventing the volume of contaminated groundwater from increasing. Additionally, if groundwater extraction and treatment is not showing sufficient progress at the end of the first phase, the second phase will include methods (e.g., enhanced bioremediation) to accelerate groundwater remediation. Downgradient of the source area, enhanced bioremediation will be used to prevent further migration of contamination.

Action-specific SCGs for this alternative apply to the excavation and handling of site soils during well installation (monitoring requirements, and OSHA health and safety requirements). Compliance with these SCGs would be achieved by following a site-specific health and safety plan. The treatment system would produce air emissions that would be subject to New York regulations 6 NYCRR 200, 201, and 212, and the New York Air Guide 1, Guidelines for the Control of Toxic Ambient Air Contaminants. Since the air emissions would be treated, as appropriate, these regulatory requirements would be met. The groundwater treatment system would also result in a water discharge. This water would either be discharged to surface waters or to the local publicly owned treatment works (POTW). It is discharged to surface waters, it would be subject to New York regulations for SPDES discharges; if discharged to the POTW, coordination with the municipality would be required since the water discharge would be treated, these requirements would be met.

Short-Term Impacts and Effectiveness: There is a potential for exposure during installation of vapor and groundwater extraction wells. This exposure would be reduced through the use of personal protection equipment. Air and water emission controls would prevent worker and resident exposure to airborne and waterborne contaminants.

Long-Term Effectiveness and Permanence: Soil vapor extraction (SVE) has been shown to be effective at remediating volatile organic contamination. However, the heterogenicity of subsurface soils at the site could limit the effectiveness of SVE in some areas. Groundwater concentrations would be expected to gradually decrease with time as a result of the extraction and treatment of the contaminated groundwater. Nevertheless, experience has shown that pump and treat remedies require long periods of time before groundwater standards are achieved. As a result, groundwater remediation will be phased. If pump and treat is not sufficiently effective in the first phase of groundwater remediation, another technology (e.g., enhanced bioremediation) will be used in the second phase to accelerate the remediation process.

Reduction of Toxicity, Mobility and Volume: By removing contaminants from soil and groundwater, and treating the removed contaminants, the toxicity and volume of contaminants in soil and groundwater would be reduced. Removing contaminants from the soil in the source area and hydraulically containing the source would also significantly reduce the mobility of contamination, and prevent further contamination of downgradient groundwater.

Implementability: The equipment and material needed to install the SVE and groundwater extraction and treatment system are commercially available from several vendors. There are not administrative or legal barriers to the implementation of this alternative.

Cost: The estimated capital cost for SVE and pump and treat is $2,100,000. The annual O&M cost would be $310,000. The present worth value of this alternative would be $3,400,000 using a 6% discount rate for the O&M costs over a five year period. A summary of costs are presented in Table A-1 (Appendix A).

5.2.5 <u>Soil Vapor Extraction and Phased Approach of Groundwater Pump and Treat</u>

This alternative is identical to the previous alternative (Section 5.2.4) except that the existing building would remain in place during remediation rather than being demolished prior to remediation.

Present Worth	$3,300,000
Capital Cost	$2,200,000
Annual O&M (SVE)	$310,000
O&M Present Cost	$1,300,000
Time to Implement	Approximately 6 months
Estimated Time to Completion	5+ years

Overall Protection of Human Health and the Environment: The short-term risks associated with this alternative could be easily mitigated with proper controls. This alternative reduces the possibility of exposure to contaminated soils, and in the long term would reduce contaminant concentrations in groundwater by controlling the source of contamination. This alternative would also reduce the possibility of exposure to contaminated groundwater by treating it on site, thus minimizing it as a continuing source for all off site areas, and by reducing contamination downgradient of the source area using enhanced biodegradation.

Compliance with SCGs: Soil vapor extraction (SVE) would significantly reduce the majority of the contaminants of concern at the site, and could meet chemical SCGs for the VOCs in soil. However, there is the possibility that concentrations of all contaminants would not drop below the TAGM 4046 Soil Cleanup objectives. The history of groundwater extraction and treatment shows that overall, time is needed for this technology to lower contaminant concentrations, and that is difficult to achieve groundwater standards. However, by hydraulically containing the plume the continued migration of contaminants would be controlled, thereby preventing the volume of contaminated groundwater from increasing. Additionally, if groundwater extraction and treatment is not showing sufficient progress at the end of the first phase of source area remediation, the second phase will include methods (e.g., enhanced bioremediation) to accelerate groundwater remediation. Downgradient of the source area, enhanced bioremediation will be used to prevent further migration of contamination.

Action-specific SCGs for this alternative apply to the excavation and handling of site soils during well installation (monitoring requirements, and OSHA health and safety requirements). Compliance with these SCGs would be achieved by following a site-specific health and safety plan.

The treatment system would produce air emissions that would be subject to New York regulations 6 NYCRR 200, 201, and 212, and the New York Air Guide 1, Guidelines for the Control of Toxic Ambient Air Contaminants. Since the air emissions would be treated, as appropriate, these regulatory requirements would be met. The groundwater treatment system would also result in a water discharge. This water would either be discharged to surface waters or to the local publicly owned treatment works (POTW). If it is discharged to surface waters, it would be subject to New York regulations for SPDES discharges; if discharged to the POTW, coordination with the municipality would be required since the water discharge would be treated, these requirements would be met.

Short-Term Impacts and Effectiveness: There is a potential for exposure during installation of vapor and groundwater extraction wells. This exposure would be reduced through the use of personal protection equipment. Air and water emission controls would prevent worker and resident exposure to airborne and waterborne contaminants.

Long-Term Effectiveness and Permanence: Soil vapor extraction (SVE) has been shown to be effective at remediating volatile organic contamination. However, the heterogenicity of subsurface soils at the site could limit the effectiveness of SVE in some areas. Groundwater concentrations would be expected to gradually decrease with time as a result of the extraction and treatment of the contaminated groundwater. Nevertheless, experience has shown that pump and treat remedies require long periods of time before groundwater standards are achieved. As a result, groundwater remediation will be phased. If pump and treat is not sufficiently effective in the first phase of groundwater remediation, another technology (e.g., enhanced bioremediation) will be used in the second phase to accelerate the remediation process.

Reduction of Toxicity, Mobility and Volume: By removing contaminants from soil and groundwater, and treating the removal contaminants, the toxicity and volume of contaminants in soil and groundwater would be reduced. Removing contaminants from the soil in the source area and hydraulically containing the source would also significantly reduce the mobility of contamination, and prevent further contamination of downgradient groundwater.

Implementability: The equipment and material needed to install the SVE and groundwater extraction and treatment system are commercially available from several vendors. There are not administrative or legal barriers to the implementation of this alternative.

Cost: The estimated capital cost for this alternative is \$2,000,000. The total annual O&M cost would be \$310,000. The present worth value of this alternative would be \$3,300,000 using a 6% discount rate for O&M over a period of 5 years. A summary of costs are presented in Table A-1 (Appendix A).

5.3 <u>Comparative Analysis of Alternatives</u>

Overall Protection of Human Health and the Environment: The no action alternative would not be protective of human health and the environment. The restoration time frame for the MNA alternative is unknown, however; it would certainly be longer than the three alternatives that include removal of contamination from the source rather than containment. The excavation/pump and treat alternative would offer the most protection to human health and the environment since the source of contamination would be totally removed from the site. The two SVE/pump and treat alternatives would address most of the contamination in the soil, although there would be some residual contamination left in place.

Compliance with SCGs: The no action alternative would not meet SCGs. The MNA alternative would not comply with chemical-specific SCGs for soil; however, the concrete cap over the source area would mitigate the impact of contaminated soil on groundwater. MNA would comply with chemical-specific groundwater SCGs only after a long period of time. For the excavation/pump and treat alternative, SCGs for soil would be met in a reasonable period of time. Compliance with groundwater SCGs under the excavation/pump and treat alternative would take longer than the soil to reach SCGs; however, SCGs would be met sooner than with any of the other alternatives. For the two SVE/pump and treat alternatives, SCG compliance would take longer than for excavation/pump and treat, but sooner than MNA.

Short-Term Impacts and Effectiveness: The no action alternative would have the fewest short term impacts since no work would take place. If RAOs were met with this alternative, it would take quite a few years.

Short-term impacts for the MNA alternative are minimal. Potential worker exposure during sampling activities could easily be reduced through use of personal protective equipment. Increased risks to the public or environment are unlikely. This alternative, like no action, would take quite a few years to meet RAOs. Along with no action, this alternative would take the longest duration before meeting RAOs.

The excavation/pump and treat alternative involves handling of contaminated media which could potentially have the greatest short term impact on worker health and safety, the environment, and the local community. However, the use of engineering controls, including air monitoring and dust suppression measures, would minimize or eliminate any possible impact during excavation. Pump and treat would involve air emissions and a water discharge, however, air emissions and the water discharge would be treated to prevent worker and resident exposure to contaminants. This alternative would take the shortest amount of time to meet RAOs.

The SVE/pump and treat alternatives would result in air emissions that would require treatment, posing a short-term risk should the air emissions control device fail. The risk would be reduced through the proper use of air treatment devices.

The length of time over which short-term impacts would occur would be less for excavation than SVE. The SVE alternatives would have less of a short-term impact than the excavation alternative, but they would be a longer duration. However, all impacts should be controlled through the proper use of engineering controls.

Long-Term Effectiveness and Permanence: The no action alternative would not provide long-term effectiveness or permanence. The long-term effectiveness of the MNA alternative cannot be properly evaluated without further data. However, it would almost certainly be less effective than other alternatives that include active remedial measures as it would likely allow the plume to grow somewhat before steady state conditions are reached. The remaining alternatives include soil remediation technologies (excavation/disposal or SVE) that would be permanent remedies. The excavation alternative would effectively eliminate all soil above remedial goals. With SVE, some residual contamination would remain, and it is possible that some of the residual contamination could be above remedial goals. However, these last three alternatives all include pump and treat which would provide, eventually, a permanent remedy to the groundwater contamination.

Reduction of Toxicity, Mobility, and Volume: With the no action alternative, reduction in the toxicity, mobility, and volume would occur slowly. For the MNA alternative, the site would remain covered (by the existing building floor), so that the mobility (transfer of contamination from soil to groundwater) would be reduced. The SVE alternatives would effectively treat most of the site related contamination. SVE reduces the volume of contamination by cleaning the soil, while also reducing toxicity when the extracted contamination is destroyed upon carbon regeneration or by direct thermal oxidation. The excavation and off-site disposal alternative removes all of the soil exceeding the cleanup objective. When placed in a landfill, the mobility of the contaminants is reduced by the liner and leachate collection systems. Furthermore, addressing contaminated soil would result in a decrease in the migration of soil contaminants to the groundwater. As a result, the SVE and excavation/off site disposal alternatives would reduce contaminant mobility in this way with SVE achieving this to a lesser degree compared to excavation/off-site disposal.

SVE and excavation/disposal alternatives also include pump and treat that would remove contaminants from the subsurface and treat them and enhanced biodegration that would degrade contaminants, thereby reducing the toxicity and volume of contaminants in the groundwater.

Implementability: The no further action alternative would be the easiest to implement, since no construction would be necessary. The MNA alternative would involve only minimal construction so it would also be easy to implement. The excavation/disposal alternatives, although more difficult to implement than no action and MNA, would be easily implemented since it is easily engineered, technologies are readily available from many sources, and regulatory requirements are easily met. SVE alternatives could also be relatively easily implemented, however, they would require more engineering. Pump and treat technologies are also routinely used and can be easily implemented at this site.

Cost: A summary of costs are presented in Table A-1 (Appendix A). The costs are present worth based on a 6% discount rate over the estimated life of the project.

6.0 RECOMMENDED REMEDIAL ALTERNATIVE

Alternative 3 (Building Demolition, Excavation of Soil and Offsite Disposal, and Phased Approach of Groundwater Pump and Treat) is the preferred alternative for the Chem-Core site. Details about the recommended alternative are provided in Appendix A. Figures A-1 through A-4 show the area of contaminated soil to be removed (Figure A-1), the depth of soil removal (Figure A-2), the area of groundwater extraction near the source (Figure A-3), and the proposed pilot study area for in-situ bioremediation. Alternative 3 was selected based upon the following:

- It is protective of human health and the environment and complies with all ARARs.

- It includes complete soil source removal so there is the greatest reduction in site contamination. Groundwater extraction and treatment would be effective at containing the plume and treating the area of contaminated groundwater, but pump and treat alone may not achieve groundwater ARARs. The second phase of groundwater remediation includes methods (enhanced bioremediation) to accelerate groundwater remediation in both the source and downgradient areas.

- The no action alternative is not protective of human health or the environment, does not meet SCGs, and does not satisfy the RAOs and would leave in place a volume of contaminated soil that would act as a continuing source of contamination to the groundwater.

- Alternatives 4 and 5, SVE/pump and treat alternatives would address most of the contamination in soil, but would leave some residual contamination in place. Alternative 3 is slightly lower in cost compared to alternatives 4 and 5 and is better because it would remove all soil contamination.

- The MNA alternative would achieve SCGs only after a long period of time which makes this alternative not effective.

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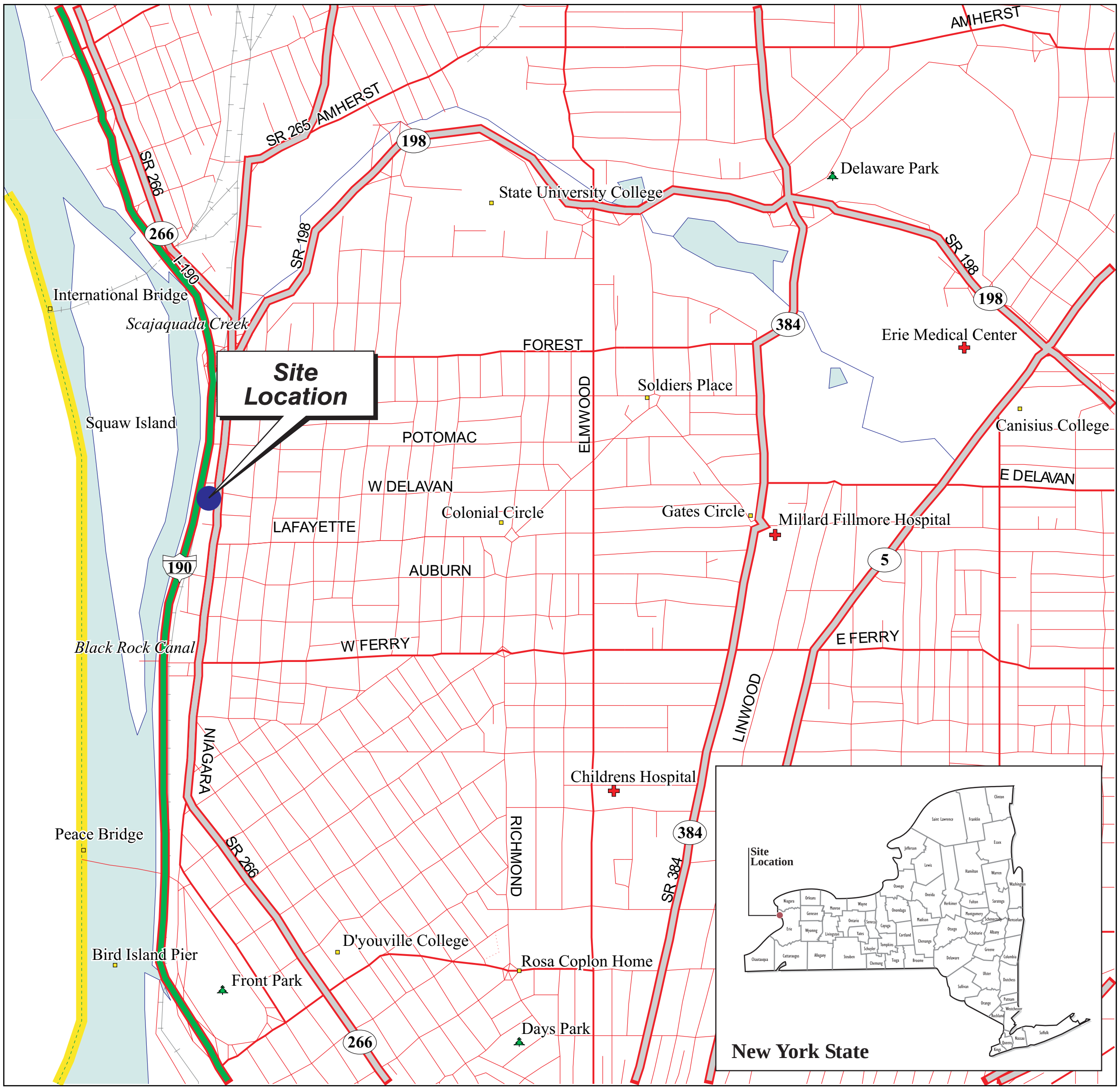
USEPA, 1993. Presumptive Remedies: Site Characterization and Technology Selection for CERCLA Sites with Volatile Organic Compounds in Soils. USEPA Directive 9355.0-48 FS. September 1993.

USEPA, 1996. Presumptive Response Strategy and Ex-situ Treatment Technologies for Contaminated Groundwater at CERCLA Sites. USEPA Directive 9283.1-12. October 1996.

USEPA, 2001. Land Disposal Restrictions: Summary of Requirements. EPA 530-R-01-007.

FIGURES

N



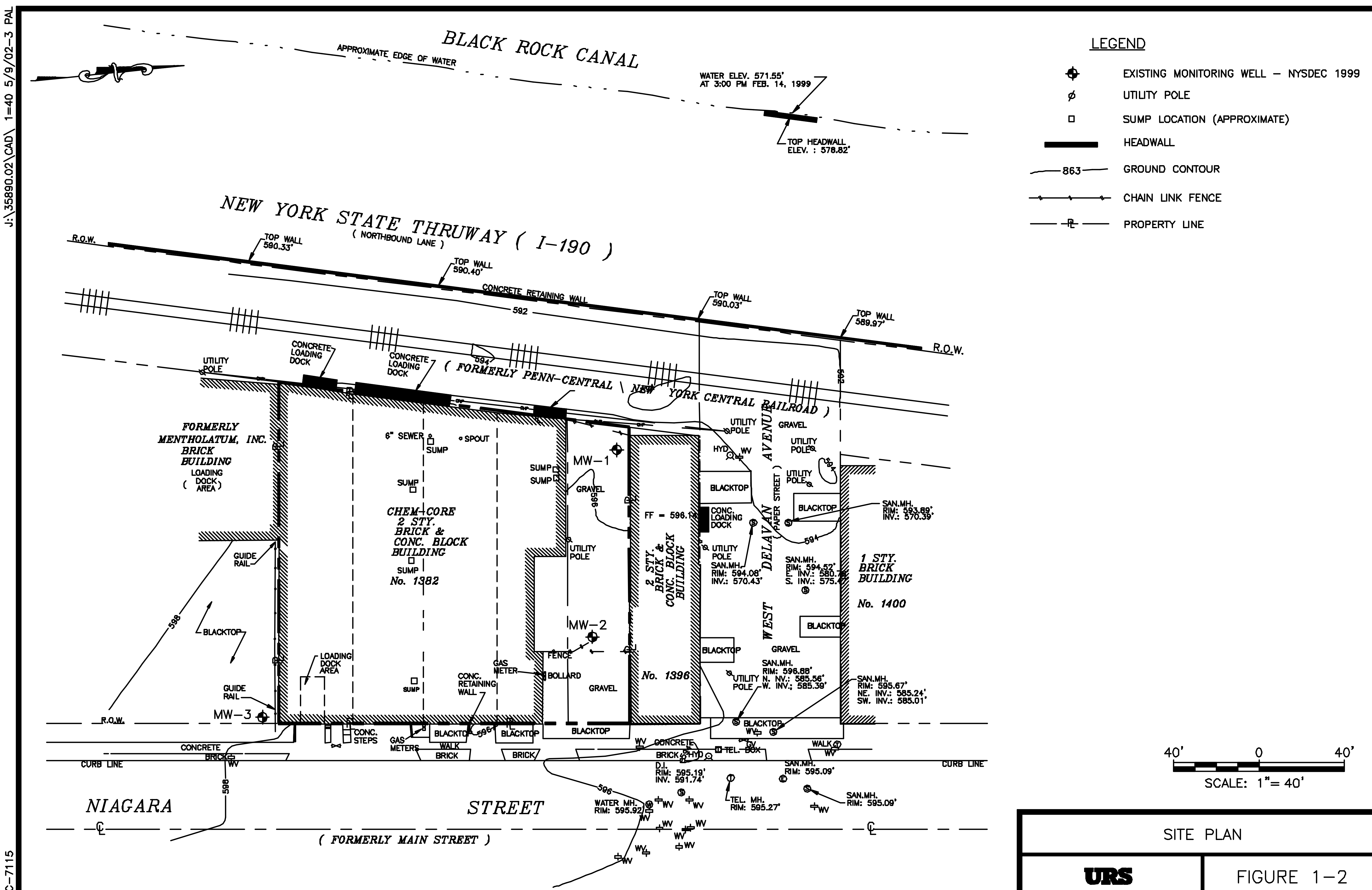
© 1993 DeLorme Mapping

APPROXIMATE SCALE IN FEET

2500 0 2500

AG16357-35890.01-030201-GCM

URS	CHEM-CORE FACILITY SITE LOCATION MAP	FIGURE 1-1



SITE PLAN

URS

FIGURE 1-2

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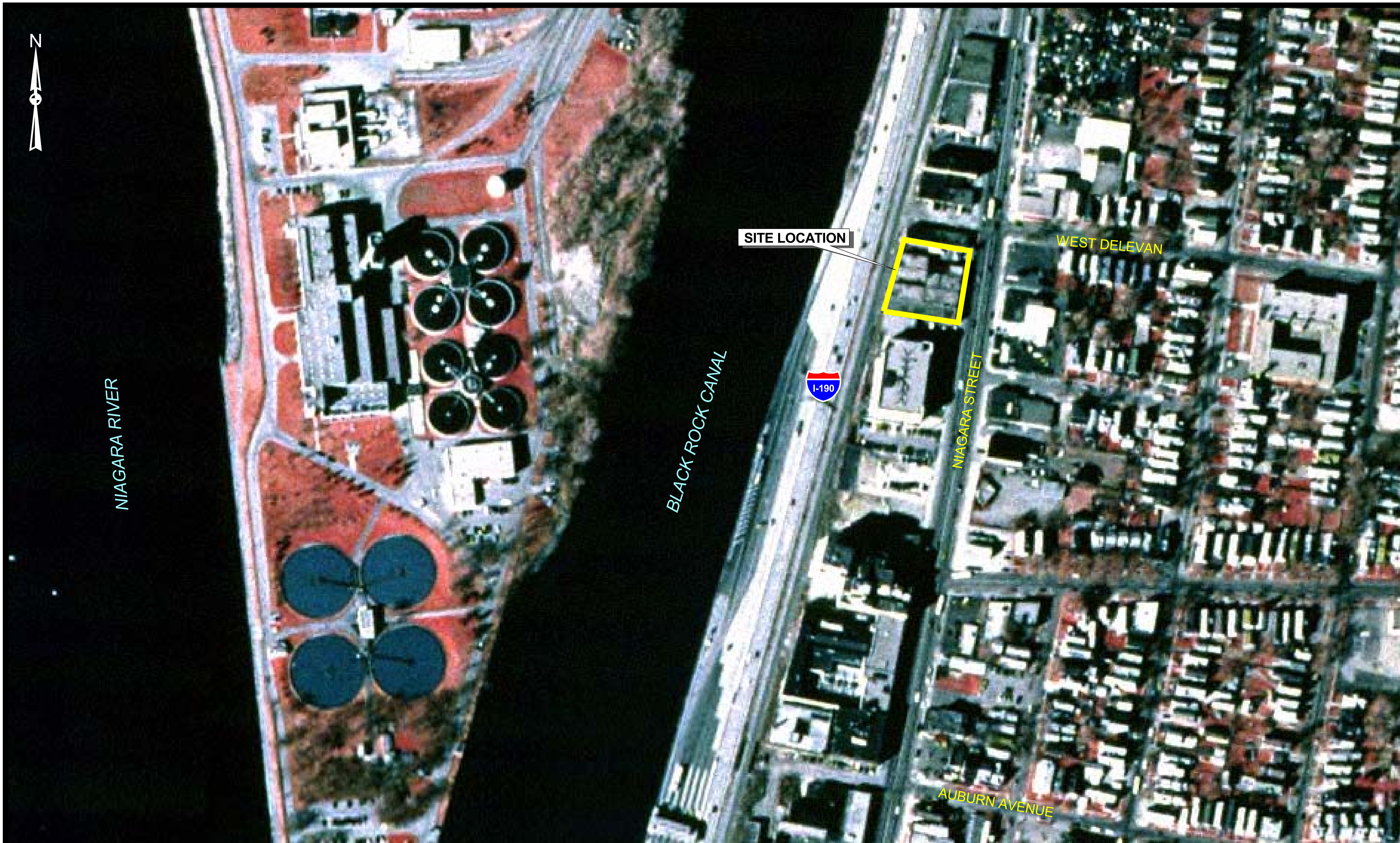
4/25/2002



SOURCE: New York State GIS Clearinghouse Digital Ortho Quarterquadrangle Application; Buffalo, Northeast-Northwest Quarterquad, 1995.

300 0 300 Feet

URS	CHEM CORE SITE FEATURES	FIGURE 1-3

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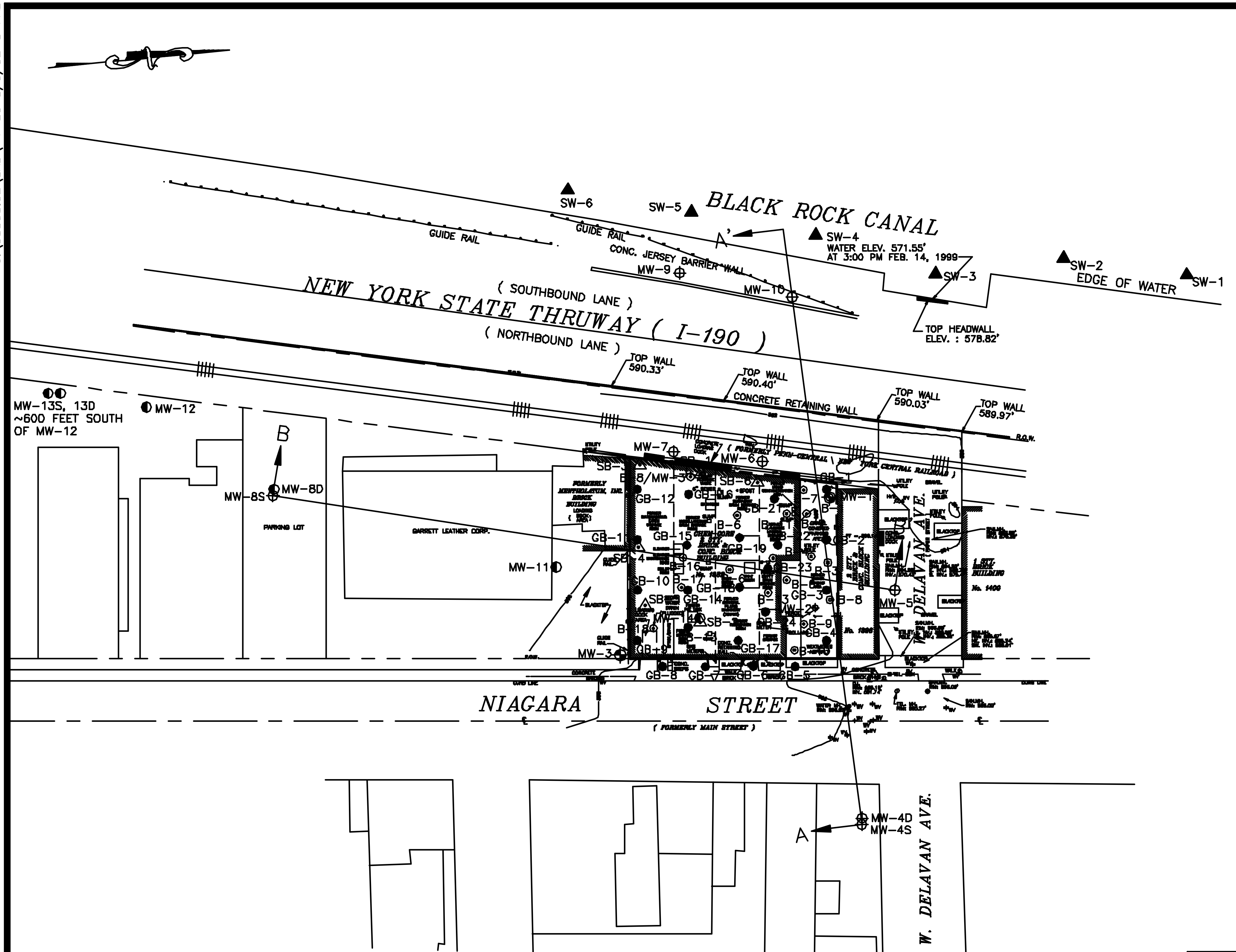


LEGEND

- MONITORING WELL – NYSDEC 1999
- UTILITY POLE
- SUMP LOCATION (APPROXIMATE)
- HEADWALL
- 863 GROUND CONTOUR
- CHAIN LINK FENCE
- PROPERTY LINE
- B-1 PHASE II SOIL BORING (MAXIM, 1997)
- GB-1 PHASE I RI SOIL BORING (URS, 2001)
- SW-1 SURFACE WATER/SEDIMENT SAMPLING LOCATIONS (URS, 2001)
- MW-1 PHASE I RI MONITORING WELL LOCATIONS (URS, 2001)
- MW-11 PHASE II RI MONITORING WELL LOCATION (URS, 2002)
- S SHALLOW MONITORING WELL
- D DEEP MONITORING WELL
- SB-1 GEOPROBE SOIL BORING (NYSDEC, 1999)
- MONITORING WELL (NYSDEC, 1999)
- A A' CROSS-SECTION LOCATION

NOTES:

1. THIS BASEMAP WAS DEVELOPED FROM A BOUNDARY SURVEY PERFORMED BY URS CORP. ON FEBRUARY 10, 1999, DRAWING NO. 1, JOB NO. 35616.01.
2. HORIZONTAL CONTROL IS BASED UPON THE NEW YORK STATE PLANE COORDINATE SYSTEM, WESTERN ZONE, 1983 ADJUSTMENT NAD 83 (1992).
3. REFERENCED CITY OF BUFFALO ATLAS MAP REPRODUCED BY "THE SANBORN LIBRARY, LLC".
4. SEE FIGURE 1-4A FOR ENLARGED SITE PLAN OF CONJESTED BUILDING AREA.

80' 0 80'

SCALE: 1"= 80'

SOIL BORINGS, MONITORING WELLS, SAMPLING AND CROSS SECTION LOCATIONS

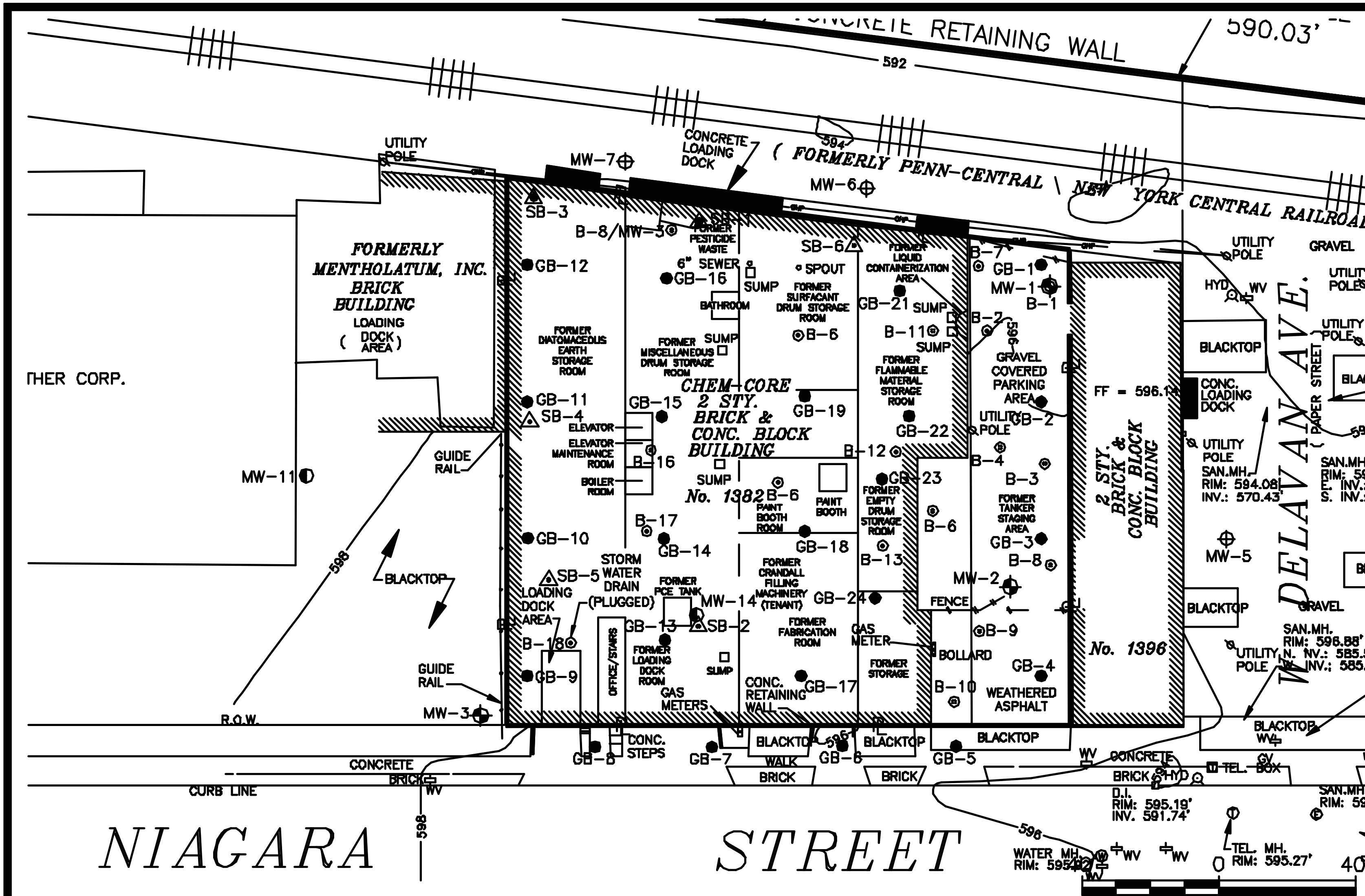
URS

FIGURE 1-4

CC-7117

AC-17279

35890.02\CAD 1=1 5/9/02-4 PAL



NOTE: SEE FIGURE 1-4 FOR OVERALL SITE PLAN.

SCALE: 1"= 40'

URS

SOIL BORINGS, MONITORING WELLS, SAMPLING LOCATIONS
ENLARGED AREA

FIGURE 1-4A

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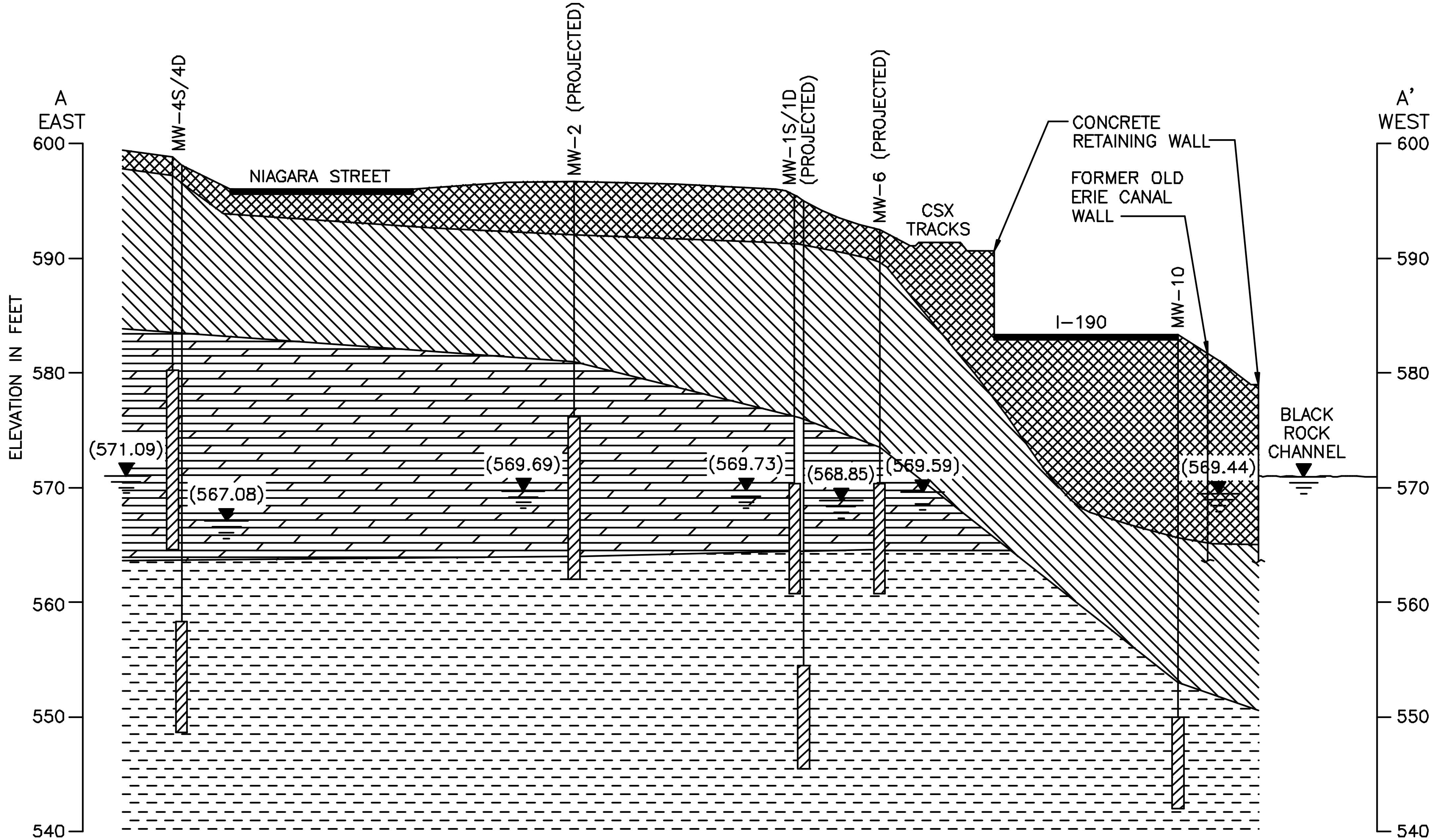


LEGEND

MW-6 ← MONITORING WELL NUMBER

(569.59) POTENTIOMETRIC SURFACE (569.59) GROUNDWATER ELEVATION (11/02/01) UNLESS OTHERWISE SPECIFIED

SCREENED INTERVAL OF MONITORING WELL

BOREHOLE TERMINATION

FILL

SILTY CLAY/ CLAYEY SILT

DOLOMITE AND SHALE

SHALE AND ARGILLACEOUS DOLOMITE

NOTES:

1. GEOLOGIC CONDITIONS SHOWN ARE REPRESENTATIVE OF CONDITIONS ENCOUNTERED AT EACH BORING LOCATION TO THE DEPTH DRILLED. EXTRAPOLATIONS BETWEEN BORINGS HAVE BEEN INTERPRETED USING STANDARD ACCEPTED GEOLOGIC PRACTICES AND PRINCIPLES. ACTUAL CONDITIONS MAY VARY BETWEEN BORINGS FROM THOSE SHOWN.
2. ELEVATIONS BASED ON THE NORTH AMERICAN VERTICAL DATUM, 1988.

50' 0 50'
SCALE: 1"=50' HORIZONTAL

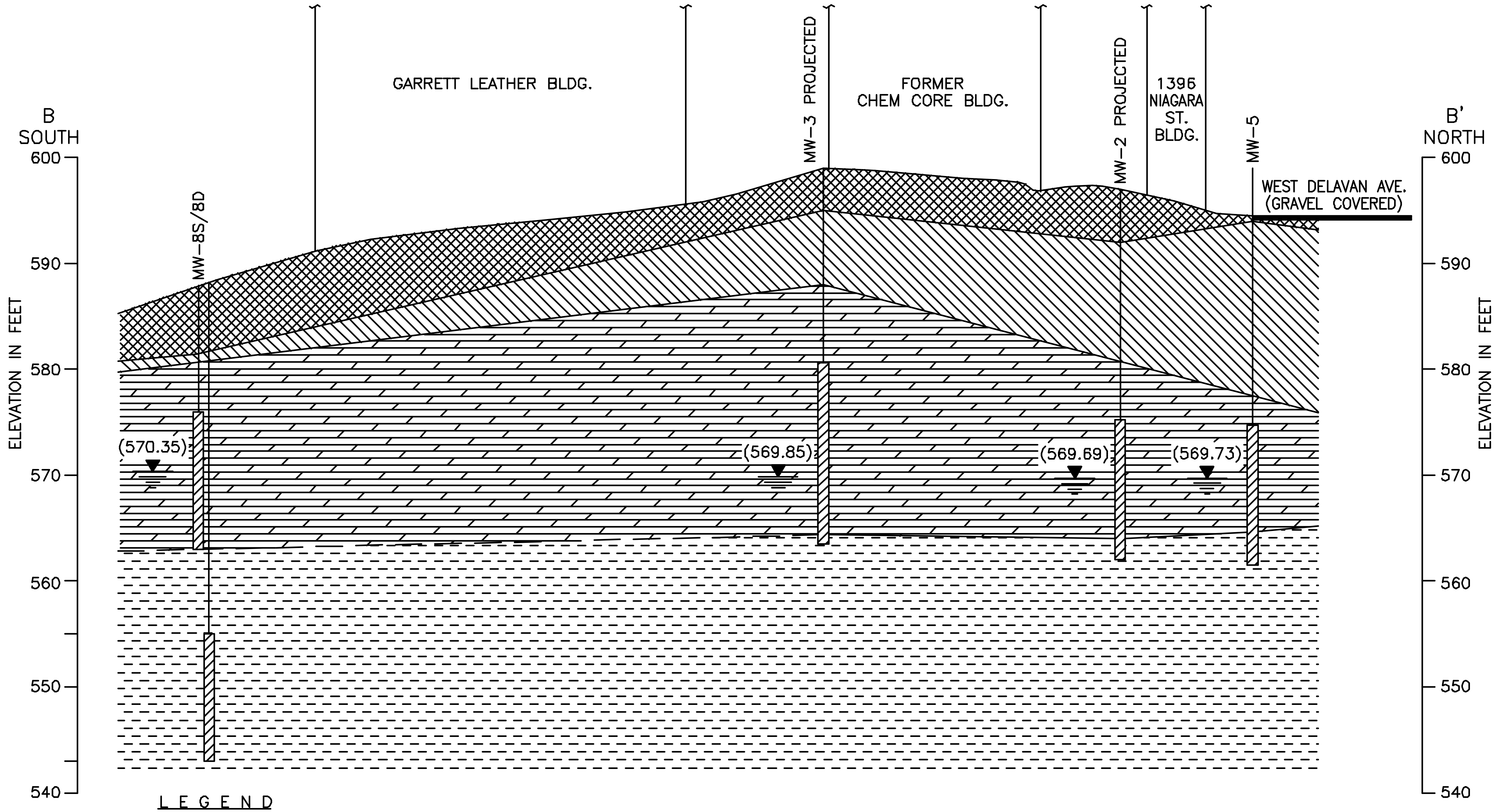
10' 0 10'
SCALE: 1"=10' VERTICAL

CHEM-CORE
GEOLOGICAL CROSS-SECTION A-A'

URS

FIGURE 1-4

CC-7091



LEGEND

MW-3 ← MONITORING WELL NUMBER

(569.85) POTENTIOMETRIC SURFACE (569.85) GROUNDWATER ELEVATION (11/02/01) UNLESS OTHERWISE SPECIFIED

SCREENED INTERVAL OF MONITORING WELL

BOREHOLE TERMINATION

FILL

SILTY CLAY/ CLAYEY SILT

DOLOMITE AND SHALE

SHALE AND ARGILLACEOUS DOLOMITE

50' 0 50'

SCALE: 1"=50' HORIZONTAL

10' 0 10'

SCALE: 1"=10' VERTICAL

NOTES:

1. GEOLOGIC CONDITIONS SHOWN ARE REPRESENTATIVE OF CONDITIONS ENCOUNTERED AT EACH BORING LOCATION TO THE DEPTH DRILLED. EXTRAPOLATIONS BETWEEN BORINGS HAVE BEEN INTERPRETED USING STANDARD ACCEPTED GEOLOGIC PRACTICES AND PRINCIPLES. ACTUAL CONDITIONS MAY VARY BETWEEN BORINGS FROM THOSE SHOWN.
2. ELEVATIONS BASED ON THE NORTH AMERICAN VERTICAL DATUM, 1988.

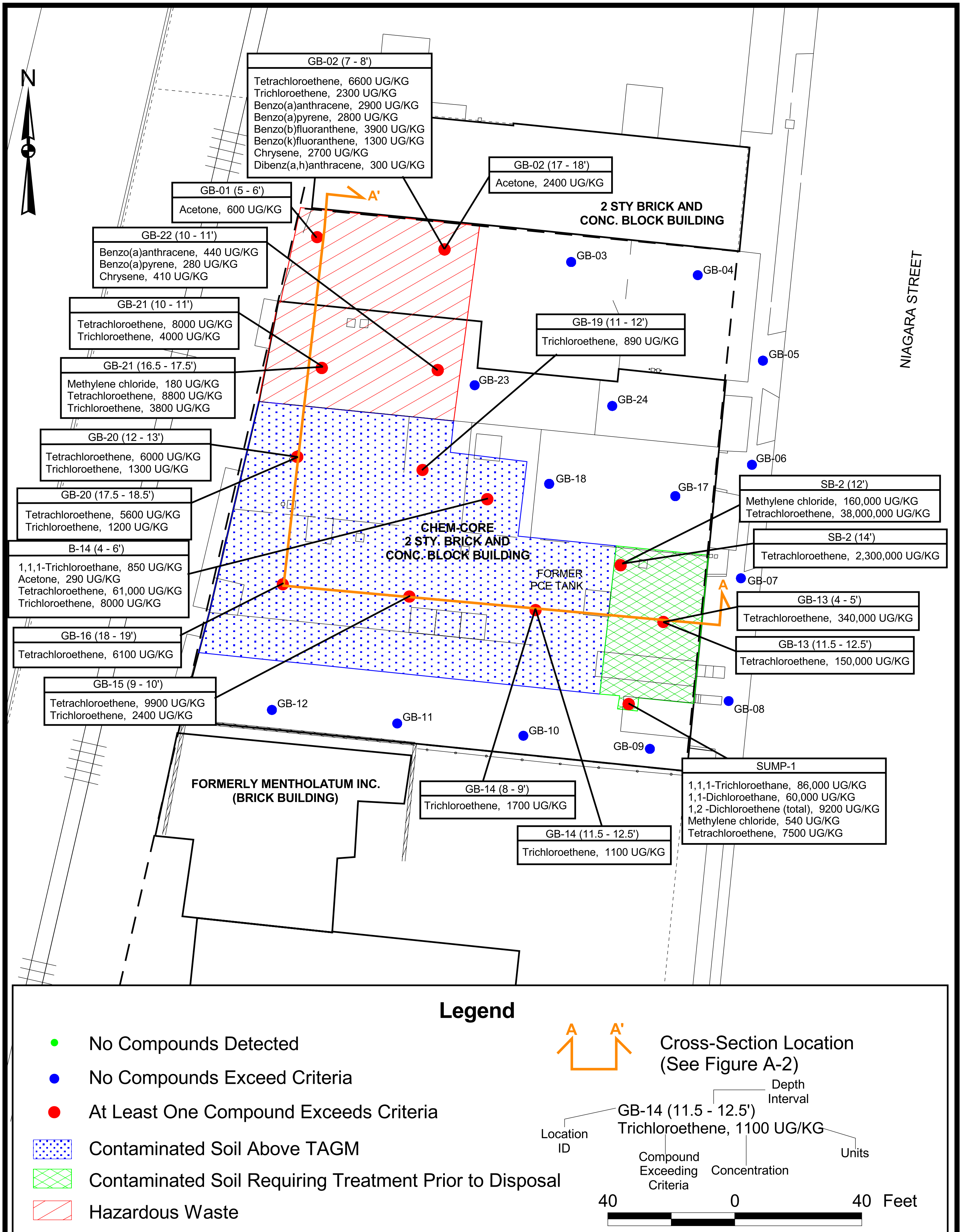
CHEM-CORE
GEOLOGICAL CROSS-SECTION B-B'

URS

FIGURE 1-5

J:\35890.02\CAD\ 1=50 7/1/02-3 PAL

CC-7092

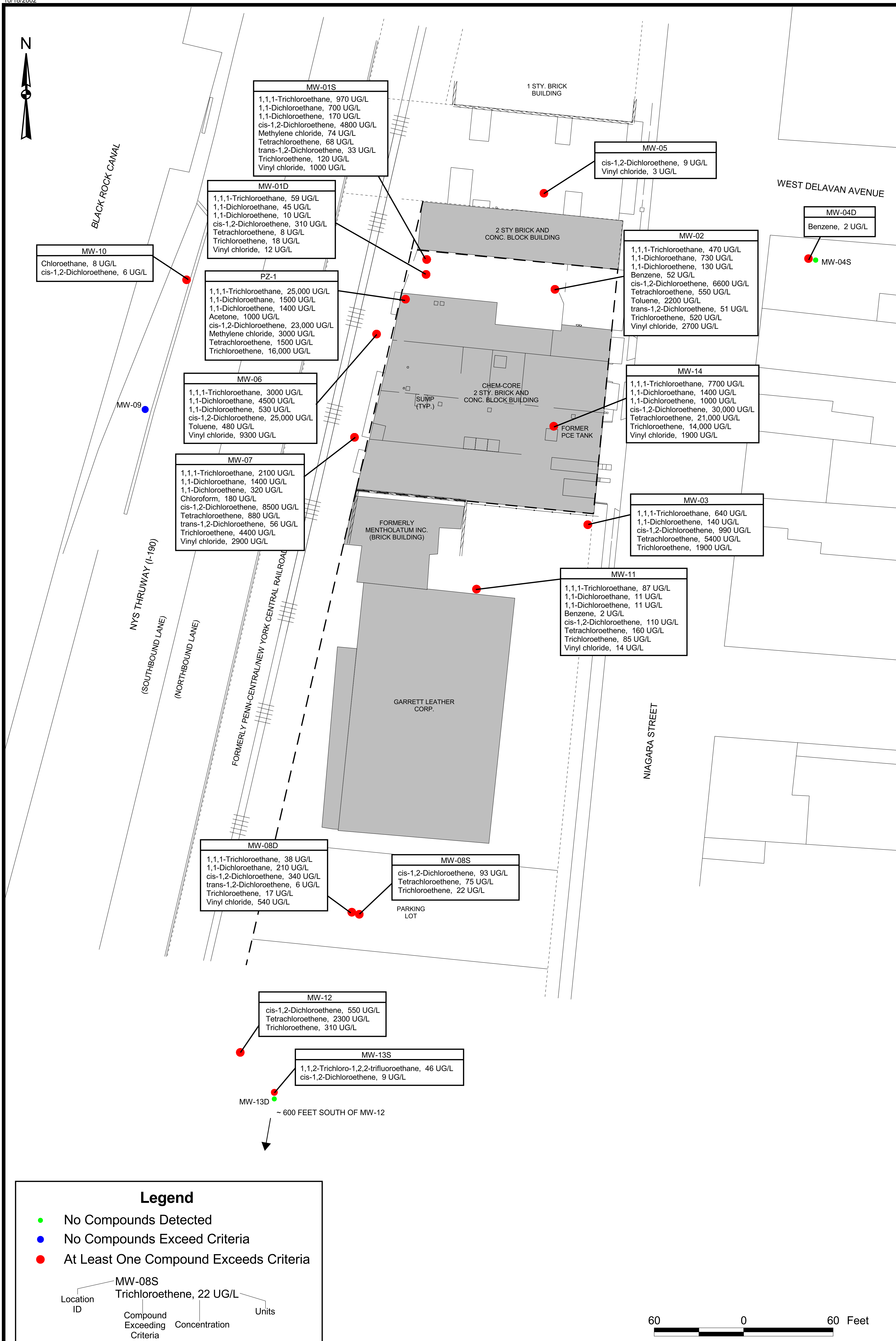


URS

CHEM CORE
CONTAMINATED SOIL

FIGURE 1-7

J:\35890.00\GIS\chemical.apr CONTAMINATED SOIL
10/17/2002



URS

CHEM CORE
GROUNDWATER CONTAMINANTS ABOVE SCGs (2002)

FIGURE 1-8

TABLES

TABLE 1-1
STANDARDS, CRITERIA, & GUIDANCE
CHEM-CORE SITE - NO. 9-15-176

Div./ Agcy.*	Title	Std./ Guid.	Requirements
DAR	Air Guide 1 - Guidelines for the Control of Toxic Ambient Air Contaminants	G	< control of toxic air contaminants < screening analysis for ambient air impacts < toxicity classifications < ambient standards - short term/annual
DAR	6 NYCRR Part 200 (200.6) - General Provisions; 1/29/93	S	< prohibits contravention of AAQS or causes air pollution
DAR	6 NYCRR Part 201 - Permits & Certificates; 3/31/93	S	< prohibits construction/operation w/o permit/certificate
DAR	6 NYCRR Part 211 (211.1) - General Prohibitions	S	< prohibits emissions which are injurious to human, plant, or animal life or causes a nuisance
DAR	6 NYCRR Part 212 - General Process Emission Sources	S	< establishes control requirements
DAR	6 NYCRR Part 257 - Air Quality Standards	S	< applicable air quality standards
DFW	Fish and Wildlife Impact Analysis for Inactive Hazardous Waste Sites (FWIA); 10/94	G	< habitat assessments < contaminant impact assessments < ecological effects of remedies < remedial requirements < monitoring < checklist
DFW	Technical guidance for screening contaminated sediments; 7/94	G	< sediments screening levels
DER	TAGM HWR-89-4031 Fugitive Dust Suppression and Particulate Monitoring Program at Inactive Hazardous Waste Sites; 10/27/89	G	< dust suppression during IRM/RA

TABLE 1-1
STANDARDS, CRITERIA, & GUIDANCE
CHEM-CORE SITE - NO. 9-15-176

Div./ Agcy.*	Title	Std./ Guid.	Requirements
DER	TAGM HWR-92-4030 Selection of Remedial Actions at Inactive Hazardous Waste Sites; 5/90	G	< remedy selection criteria/evaluations
DER	TAGM HWR-92-4042 Interim Remedial Measures; 6/1/92	G	< define and track IRMs
DER	TAGM HWR-92-4046 Determination of Soil Cleanup Objectives and Cleanup Levels; 1/24/94	G	< soil cleanup goals
DER	TAGM HWR-92-4048 Interim Remedial Measures - Procedures; 12/9/92	G	< identifying and implementing IRMs
DER	6 NYCRR Part 375 - Inactive Hazardous Waste Disposal Site Remedial Program; 5/92	S	< requirements regarding remedial programs < private party programs, state funded programs, state assistance to municipalities
DOW	Analytical Services Protocols (ASP); 11/91	G	< analytical procedures
DOW	TOGS 1.1.2 - Groundwater Effluent Limitations; 8/94	G	< guidance for developing effluent limits for groundwater
DOW	TOGS 1.1.1 - Ambient Water Quality Standards & Guidance Values; 10/93	G	< compilation of ambient water quality stds. and guidance values
DOW	TOGS 1.2.1 -Industrial SPDES Permit Drafting Strategy for Surface Waters; 4/90	G	< guidance for developing effluent and monitoring limits for point source releases to surface water
DOW	TOGS 1.3.8 - New Discharges to Publicly Owned Treatment Works;	G	< limits on new or changed discharges to POTWs strict requirements regarding bioaccumulative and persistent substances

TABLE 1-1
STANDARDS, CRITERIA, & GUIDANCE
CHEM-CORE SITE - NO. 9-15-176

Div./ Agcy.*	Title	Std./ Guid.	Requirements
	10/26/94		plus other considerations
DOW	6 NYCRR Part 702-15(a), (b), (c), (d) & (e) -	S	< Empowers DEC to Apply and Enforce Guidance where there is no Promulgated Standard
DOW	6 NYCRR Part 700-705 - NYSDEC Water Quality Regulations for Surface Waters and Groundwater; 9/1/91	S	< 700 - Definitions, Samples and Tests; 701 - Classifications Surface Waters and Groundwaters; 702 - Derivation and Use of Standards and Guidance Values; 703 - Surface Water and Groundwater Quality Standards and Groundwater Effluent Standards;
DOW	6 NYCRR Part 750-757 - Implementation of NPDES Program in NYS	S	< regulations regarding the SPDES program
DRS	6 NYCRR Part 364 - Waste Transporter Permits; 1/12/90	S	< regulates collection, transport, and delivery of regulated waste
DSHM	TAGM 3028 "Contained In" Criteria for Environmental Media; 11/92	G	< Soil Action Levels
DSHM	6 NYCRR Part 360 - Solid Waste Management Facilities; 10/9/93	S	< solid waste management facility requirements landfill closures; C&D landfill requirements; used oil; medical waste; etc.
DSHM	6 NYCRR Part 370 - Hazardous Waste Management System: General; 1/14/95	S	< definitions of terms and general standards applicable to Parts 370-374 & 376
DSHM	6 NYCRR Part 371 - Identification and Listing of Hazardous Wastes; 1/14/95	S	< haz. waste determinations
DSHM	6 NYCRR Part 372 -	S	< manifest system and record keeping,

TABLE 1-1
STANDARDS, CRITERIA, & GUIDANCE
CHEM-CORE SITE - NO. 9-15-176

Div./ Agcy.*	Title	Std./ Guid.	Requirements
	Hazardous Waste Manifest System and Related Standards for Generators, Transporters and Facilities; 1/14/95		certain management standards
DSHM	6 NYCRR Part 376 - Land Disposal Restrictions - 1/14/95	S	< identifies hazardous waste restricted from land disposal
DSHM	6 NYCRR Subpart 373-1 - Hazardous Waste Treatment, Storage and Disposal Facility Permitting Requirements; 1/14/95	S	< hazardous waste permitting requirements: includes substantive requirements
DSHM	6 NYCRR Subpart 373-2 - Final Status Standards for Owners and Operators of Hazardous Waste Treatment Storage and Disposal Facilities; 1/14/95	S	< hazardous waste management standards e.g., contingency plan; releases from SWMUs; closure/post-closure; container/management; tank management; surface impoundments; waste piles; landfills; incinerators; etc.
DSHM	6 NYCRR Subpart 373-3 - Interim Status Standards for Owners and Operators of Hazardous Waste Facilities - 1/14/95	S	< similar to 373-2
OSHA/ PESH	29 CFR Part 1910.120; Hazardous Waste Operations and Emergency Response	S	< health and safety
USEP A	Integrated Risk Information System (IRIS)	G	< verified RfDs and cancer slope factors
USEP A	Risk Assessment Guidance for Superfund - Volume 1 - Human Health Evaluation Manual; 12/89	G	< human health risk assessments

TABLE 1-1
STANDARDS, CRITERIA, & GUIDANCE
CHEM-CORE SITE - NO. 9-15-176

DAR:	Division of Air Resources
DEP:	Division of Environmental Permits
DER:	Division of Environmental Remediation
DFW:	Division of Fish and Wildlife
DOH:	Department of Health
DOW:	Division of Water
DSHM:	Division of Solid and Hazardous Materials
USEPA:	US Environmental Protection Agency

APPENDIX A

COST ESTIMATES FOR REMEDIAL ALTERNATIVES

Cost estimates for the five alternatives used for detailed analysis are summarized in Table A-1. More detailed cost estimates for all alternatives presented in Tables A-2 through A-6. The basis for cost estimates is explained below.

<u>No Action/Groundwater Monitoring (Table A-2)</u>

- No remedial action will be implemented.
- Groundwater sampling will be performed quarterly for the first year, semi-annually the second year, and annually in years 3 through 30.
- Each monitoring well will be sampled for TCL VOCs.
- Twelve existing monitoring wells will be sampled during each event
- Well sampling requires 20 manhours per event (2 man crew at 10 hours/day)

<u>Monitored Natural Attenuation and Containment (Table A-3)</u>

- The existing building will be left in-place.
- Five new bedrock monitoring wells will be installed.
- Each well will be sampled for TCL VOCs and MNA parameters (methane/ethane/ethene, nitrate, total organic carbon (TOC) sulfide, sulfate, alkalinity, and chloride).
- A groundwater model will be prepared to evaluate natural attenuation.
- It is assumed that groundwater will be restored to acceptable levels after 20 years.
- Groundwater sampling will be performed quarterly for the first year, semi-annually for the second year, and annually in years 3 through 20.
- Seventeen monitoring wells (five new and twelve existing) will be sampled during each event.
- Well sampling requires 30 hours per event

Building Demolition, Excavation of Soil and Offsite Disposal, and Phased Approach of Groundwater Pump and Treat (Table A-4)

$ On site building will be demolished and debris will be disposed of in C & D landfill.

$ Asbestos investigation and removal will be performed prior to demolition.

$ The volume of soil to be excavated is approximately 7,700 cubic yards. It is estimated that 10% (770 cubic yards) of the soil will exceed ten times the LDR-UTS, and 20% (1,540 cubic yards) will be classified as hazardous waste (see Figure A-1). It is estimated that approximately 70% (5,110 cubic yards) will be classified as non-hazardous waste. Soil will be excavated down to the bedrock surface (see Figure A-2).

$ Excavation sidewalls to be stabilized with sheet piles.

$ Soil exceeding UTSs will be treated and disposed off-site.

$ 8 pumping wells will be installed to extract groundwater. Wells will be 50 feet deep, and 6 inches in diameter (see Figure A-3).

$ Estimated groundwater extraction rate is 40 gpm.

$ Treatment system will be air stripper with carbon adsorption used to polish the effluent from the air stripper prior to discharge (see Figure A-3).

$ A catalytic oxidizer will be used to treat air emissions from air stripper.

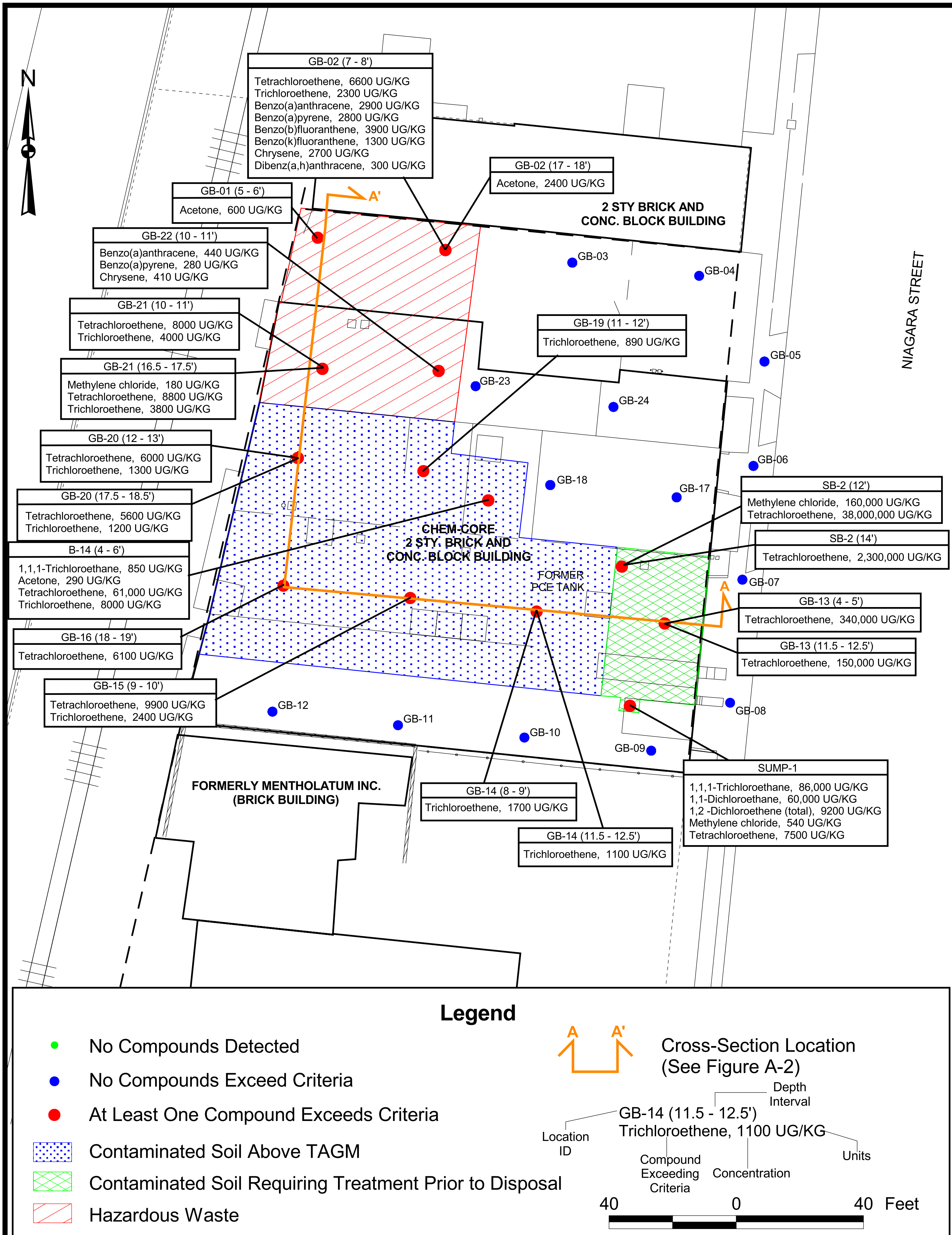
$ Enhanced in-situ bioremediation at the source using HRC will be implemented after 5 years of pump and treat (O&M cost is assumed to be negligible).

$ 8 injection wells will be constructed to recirculate water during in-situ bioremediation at the source.

$ HRC will be injected at approximately 70 points inside the source area.

$ Enhanced in-situ bioremediation will be used for downgradient groundwater remediation. Cost is based on the following:

1. Pilot scale test will be performed before full scale. Pilot scale area is 10,000 square feet, radius of injection well influence is about 10 feet, depth of injection points is approximately 50 feet, and 200 pounds of HRC will be injected at each point (see Figure A-4).
2. Full scale cost is estimated at twice the pilot scale cost.



URS

CHEM CORE
CONTAMINATED SOIL

FIGURE A-1

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10/17/2002

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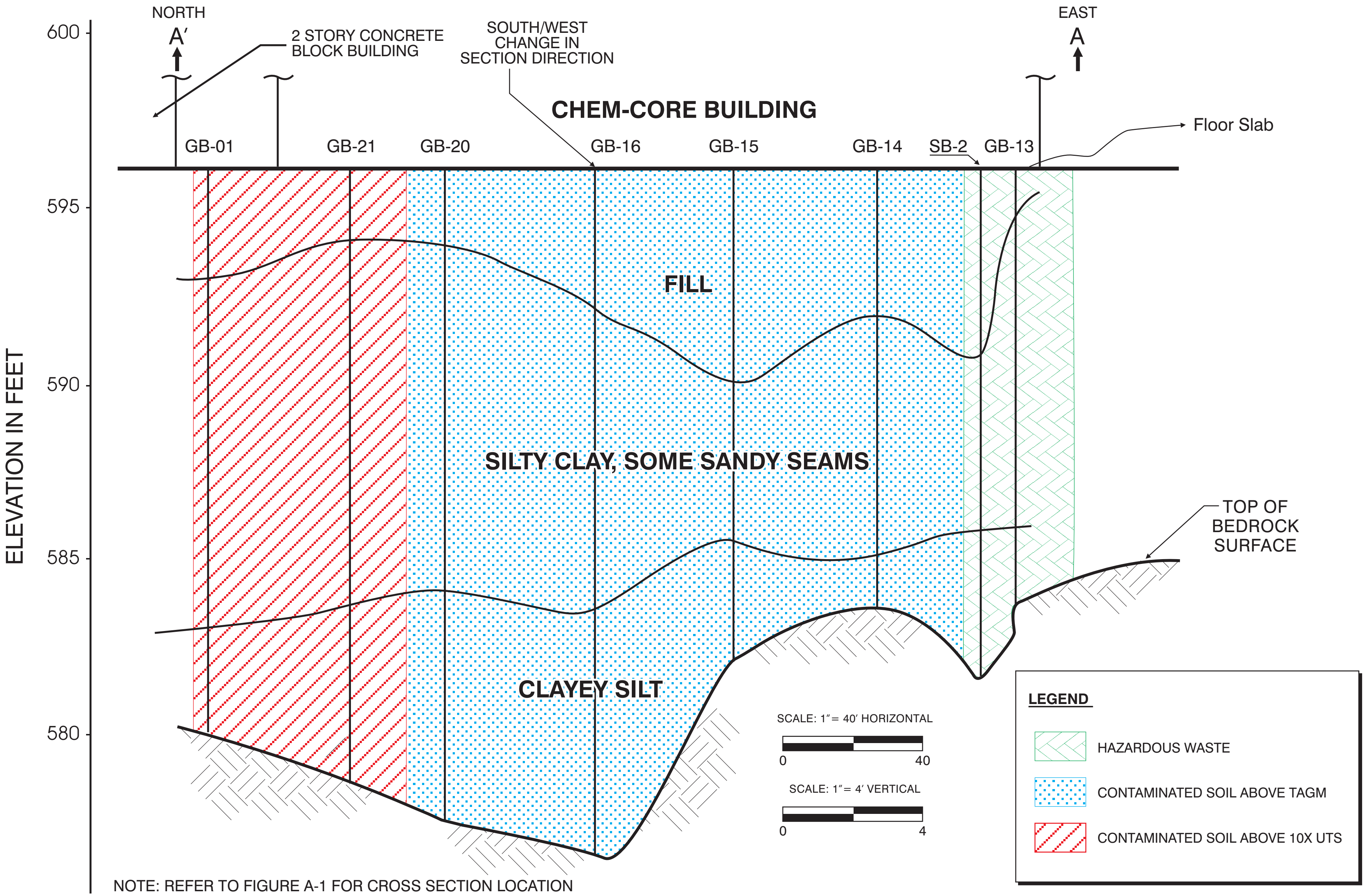
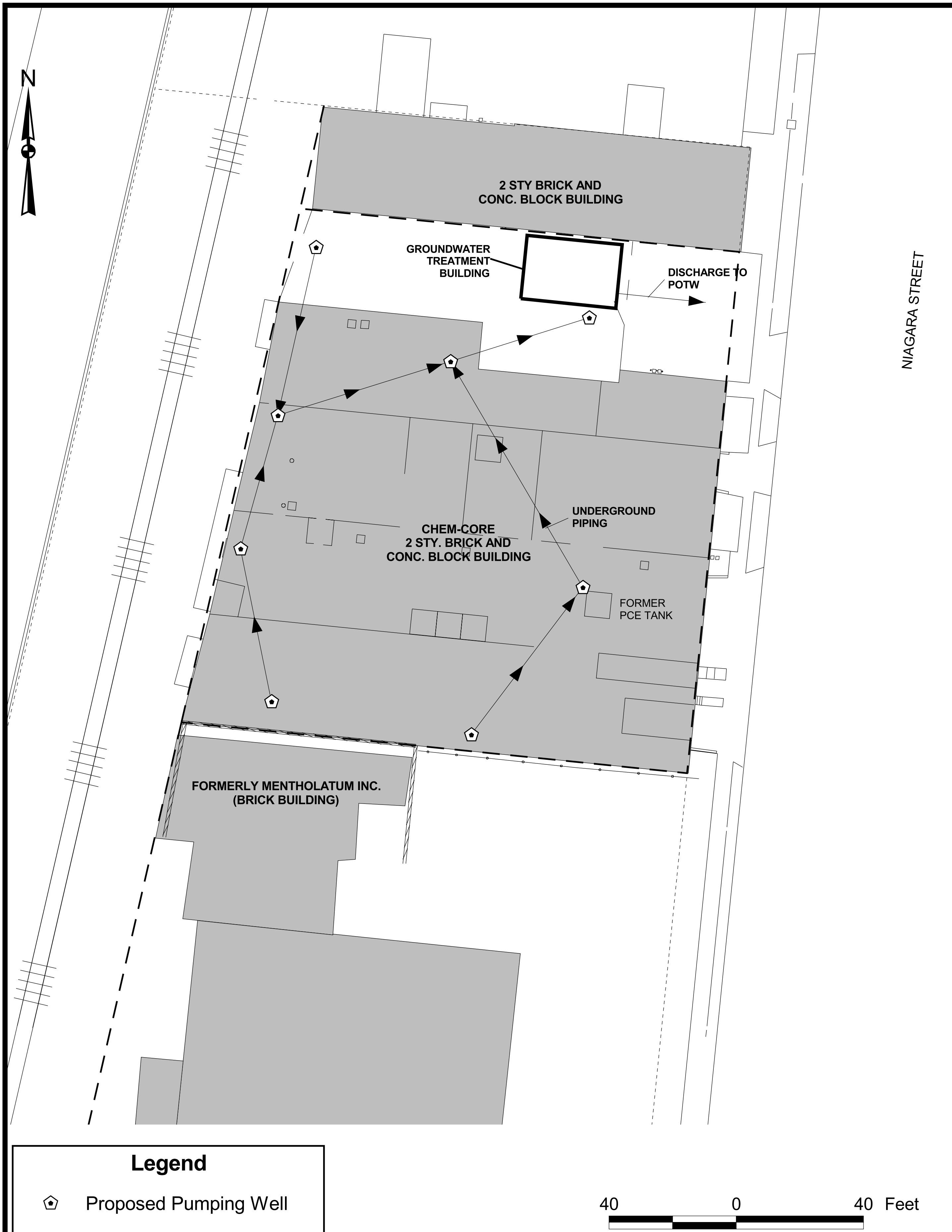


URS

CHEM CORE(A-A') CROSS SECTION

FIGURE A-2



J:\35890.00\GIS\chemical.apr CONCEPTUAL GROUNDWATER EXTRACTION SYSTEM
10/16/2002

URS

CHEM CORE
CONCEPTUAL GROUNDWATER
EXTRACTION/TREATMENT SYSTEM

FIGURE A-3

URS

CHEM CORE
CONCEPTUAL GROUNDWATER PILOT TEST PLAN
FOR IN-SITU BIOREMEDIATION

FIGURE A-4

Building Demolition, Soil Vapor Extraction and Phased Approach Groundwater Pump and Treat (Table A-5)

The basis for the estimate for this alternative is the same as the previous alternative except for the following:

$ Soil will not be excavated or disposed of.
$ An SVE system will be used to remediate soil. The SVE system will consist of 144 vapor extraction wells, a 150 hp blower and associated piping and instrumentation.
$ The pump and treat and enhanced bioremediation for this alternative are the same as for the alternative described above except that a catalytic oxidizer will be used to treat air emissions from both the pump and treat and SVE systems.

Soil Vapor Extraction and Phased Approach of Groundwater Pump and Treat (Table A-6)

The basis for the estimate for this alternative is the same as the previous alternative except for the following:

$ The building will not be demolished. The SVE system will be installed in the building.

Most unit prices included in the cost estimates were obtained from *RS Means Environmental Remediation Cost Data-Unit Price (ECHOS)* for the year 2002.

TABLE A-1

SUMMARY OF COST ESTIMATES

Alternative	Capital Cost	O&M Present Cost	Total Present Cost
1. No Action/Groundwater Monitoring	$0	$84,000	$84,000
2. Monitored Natural Attenuation and Containment	$130,000	$270,000	$400,000
3. Building Demolition, Excavation of Soil and Offsite Disposal, and Phased Approach of Groundwater Pump and Treat	$2,800,000	$370,000	$3,170,000
4. Building Demolition, Soil Vapor Extraction and Phased Approach of Groundwater Pump and Treat	$2,100,000	$1,300,000	$3,400,000
5. Soil Vapor Extraction and Phased Approach of Groundwater Pump and Treat	$2,000,000	$1,300,000	$3,300,000

TABLE A-2

NO ACTION/GROUNDWATER MONITORING

Item	Quantity	Unit Cost	Total Cost
Year 1			
Analytical Cost	48	$150	$7,200
Labor	80 hours	$60	4,800
Reporting	4	$2,000	8,000
		Subtotal Year 1	$20,000
		Present Cost Year 1	$18,868
Year 2			
Analytical Cost	24	$150	$3,600
Labor	40 hours	$60	2,400
Reporting	2	$2,000	4,000
		Subtotal Year 2	$10,000
		Present Cost Year 2	$8,900
Years 3-30			
Analytical Cost	12	$150	$1,800
Labor	20 hours	$60	1,200
Reporting	1	$2,000	2,000
		Annual Cost	$5,000
		Present Cost Years 3 - 30	$56,279
		TOTAL PRESENT COST	$84,047
		SAY	$84,000

TABLE A-3
MONITORED NATURAL ATTENUATION AND CONTAINMENT

CAPITAL COSTS

Item	Quantity	Unit Cost	Total Cost
Mobilization	1	$500	$500
Well Installation	5	$4,000	$20,000
Groundwater Model	1	$80,000	$80,000
		Subtotal Capital Cost	$100,500
		Contingency 25%	$25,125
		Total Capital Cost	$125,625
		SAY	$130,000

ANNUAL OPERATION AND MAINTENANCE (O&M) COSTS

Item	Quantity	Unit Cost	Total Cost
Year 1			
Analytical Cost	68	$400	$27,200
Labor	120 hours	$60	7,200
Reporting	4	$7,500	30,000
		Subtotal Year 1	$64,400
		Present Cost Year 1	$60,755
Year 2			
Analytical Cost	34	$400	$13,600
Labor	60 hours	$60	3,600
Reporting	2	$7,500	15,000
		Subtotal Year 2	$32,200
		Present Cost Year 2	$28,658
Year 3 - 20			
Analytical Cost	17	$400	$6,800
Labor	30 hours	$60	1,800
Reporting	1	$7,500	7,500
		Annual Cost	$16,100
		Present Cost Year 3 - 20	$181,219
		TOTAL PRESENT COST OF O&M	$270,632
		SAY	$270,000

TOTAL ALTERNATIVE COST	=	CAPITAL COST	+ PRESENT COST OF O&M
	=	$130,000	+ $270,000
	=	$400,000	

TABLE A-4
BUILDING DEMOLITION, EXCAVATION OF SOIL, AND OFF-SITE DISPOSAL, AND PHASED APPROACH OF GROUNDWATER PUMP AND TREAT

CAPITAL COST - SOIL REMEDIATION

Item	Quantity	Unit Cost	Total Cost	Reference
Demolition				
- Concrete Footing Removal	1,920 CF	$3.53	$6,778	ECHOS-16010102
- Remove Slab on Grade	19,500SF	$0.66	$12,870	ECHOS-16010124
- Building Demolition	78,000CF	$0.07	$5,460	ECHOS-17020103
- Concrete Disposal	430 CY	$10.03	$4,313	ECHOS-17020401
- Construction Debris Disposal	2,900 CY	$6.47	$18,763	ECHOS-17020408
Asbestos Abatement	1 LS		$57,856	See Attachment A-1
Excavation				
- 4 CY Hydraulic Excavator	10,000 CY	$2.49	$24,900	ECHOS-17030729
Sheet Piling	Lump Sum	C	$350,000	Engineer/Means 02250-400-1300/1600
- Dewatering Pump	7 Day	$47.94	$336	ECHOS-17031002
- Health and Safety	1 LS	$5,000	$5,000	Allowance
Transportation (haz and pretreated only)	2,190 CY	$17.50	$38,325	Quote
Disposal				
- Nonhazardous (includes transportation)	8,085 ton	$26.50	$214,253	Quote
- Hazardous	2,310 ton	$79.50	$183,645	Quote
- Pretreated	1,155 ton	$132.50	$153,038	Quote
Fill				
- Excavated Material	2,700 CY	$1.07	$2,889	ECHOS-17030401
- Clean Fill	7,300 CY	$7.90	$57,670	ECHOS-16010106
- Compaction	10,000 CY	$0.40	$4,000	ECHOS-17030513
		Subtotal Soil Remediation	$1,140,096	

TABLE A-4 (CONTINUED)

CAPITAL COST - PUMP AND TREAT AT SOURCE

Item	Quantity	Unit Cost	Total Cost	Reference
Extraction Well	8	$5,000	$40,000	Engineer
Groundwater Pump	8	$2,324	$18,592	ECHOS-33230601
Tank	1	$2,000	$2,000	Engineer
Centrifugal Pump	2	$2,500	$5,000	Engineer
Air Stripper	1	$15,526	$15,526	ECHOS-33130716
Carbon Adsorber	2	$13,618	$27,236	ECHOS-33132027
Catalytic Oxidizer	1	$74,337	$74,337	ECHOS-33070404
Filter	2	$316	$632	ECHOS-33132041
2" PVC Piping	500 LF	$8.67	$4,335	ECHOS-33260404
Instrumentation	1 LS	$20,000	$20,000	Allowance
Electrical	1 LS	$15,000	$15,000	Allowance
Building	500 SF	$73.00	$36,500	ECHOS-33430101
Utilities	1 LS	$10,000	$10,000	Allowance
		Subtotal Pump and Treat	$269,158	

TABLE A-4 (CONTINUED)

CAPITAL COST - ENHANCED BIOREMEDIATION DOWNGRADIENT PILOT TEST

Item	Quantity	Unit Cost	Total Cost	Reference
HRC Injection Wells	2,100 LF	$26.84	$56,364	ECHOS-33232505
Monitoring Wells	5	$4,000	$20,000	Engineer
HRC	8,400 LB	$6	$50,400	Quote
Analytical	60	$150	$9,000	Quote
Labor	200 HR	$60	$12,000	Engineer
Report	1	$10,000	$10,000	Engineer
Subtotal Pilot Test			$157,724	

Assume full scale enhanced bioremediation cost is two times the pilot scale test.

Subtotal Full Scale=$315,448
Total Downgradient Enhanced Bioremediation=$473,172

CAPITAL COST - ENHANCED BIOREMEDIATION AT SOURCE

Item	Quantity	Unit Cost	Total Cost	Reference
Full-Scale Study	1	$15,000	$15,000	Engineer
Groundwater Injection Wells	8	$5,000	$40,000	Engineer
HRC Injection Wells	1,000 LF	$26.84	$26,840	ECHOS-33232505
HRC	7,000 LB	$6	$42,000	Quote
Labor for Injections	80 HR	$60	$4,800	Engineer
2" PVC Piping	500 LF	$8.67	$4,335	ECHOS-33260404
Subtotal Enhanced Bioremediation			$132,975	
Present Cost Enhanced Bioremediation			$99,372	

The enhanced bioremediation at source will be completed after the pilot scale in the downgradient area and will be implemented only if the pilot is successful.

TABLE A-4 (CONTINUED)

Total Direct Capital Cost	$1,981,798	
Mobilization/Demobilization (5% of Capital Cost)	$99,090	
Design (10% of Capital Cost)	$198,180	
Contingency (25% of Capital Cost)	$495,450	
Total Capital Cost	$2,774,518	
SAY	$2,800,000	

ANNUAL OPERATION AND MAINTENANCE (O&M) COSTS

Item	Quantity	Unit Cost	Total Cost
Operator	416 Hours	$50	$20,800
Supervisor	100 Hours	$80	$8,000
Maintenance and Repairs	1 LS	$5,000	$5,000
Carbon	4,000 LB	$1	$4,000
Power	160,000 KWH	$0.06	$9,600
Gas	4,600 MCF	$5.81	$26,726
Vapor Analysis	12	$300	$3,600
Water Analysis	40	$150	$6,000
Reporting	1 LS	$5,000	$5,000
Total Annual O&M Cost			$88,726

Present Cost of O&M =$88,726 x 4.2124 (present worth factor for 5 years at 6% interest rate)
Present Cost of O&M =$373,749 (SAY $370,000)
Total Alternative Cost =Capital Cost + Present Cost of O&M
= $2,800,000 + $370,000
= $3,170,000

TABLE A-5

BUILDING DEMOLITION SOIL VAPOR EXTRACTION, AND PHASED APPROACH TO GROUNDWATER PUMP AND TREAT

CAPITAL COST - SOIL REMEDIATION

Item	Quantity	Unit Cost	Total Cost	Reference
Demolition				
- Concrete Footing Removal	1920 CF	$3.53	$6,778	ECHOS-16010102
- Remove Slab On Grade	19,500 SF	$0.66	$12,870	ECHOS-16010124
- Building Demolition	78,000 SF	$0.07	$5,460	ECHOS-17020103
- Concrete Disposal	430 CY	$10.03	$4,313	ECHOS-17020401
- Construction Debris Disposal	2,900 CY	$6.47	$18,763	ECHOS-17020408
Asbestos Abatement	1 LS	$57,856	$57,856	See Attachment A-1
20 mil PVC Liner	13,125 SF	$0.66	$8,663	ECHOS-38080561
Vapor Extraction Wells	144	$1,275	$183,600	Pilot Test
Air Inlet Wells	144	$1,025	$147,600	Pilot Test
Pressure Monitoring Wells	12	$1,025	$12,780	Pilot Test
Blower, 150 HP, 5000 cfm	1	$33,670	$33,670	Quote
Catalytic Oxidizer, 6000 cfm	1	$185,000	$185,000	ECHOS-33070459
4" PVC Piping	1,000 LF	$12.34	$12,340	ECHOS-33260406
Instrumentation	1 LS	$10,000	$10,000	Allowance
Electrical	1 LS	$10,000	$10,000	Allowance
Building	200 SF	$73	$14,600	ECHOS-33430101
Subtotal Soil Remediation			$724,293	

TABLE A-5 (Continued)

CAPITAL COST - PUMP AND TREAT AT SOURCE

Item	Quantity	Unit Cost	Total Cost	Reference
Extraction Well	8	$5,000	$40,000	Engineer
Groundwater Pump	8	$2,324	$18,592	ECHOS-33230601
Tank	1	$2,000	$2,000	Engineer
Centrifugal Pump	2	$2,500	$5,000	Engineer
Air Stripper	1	$15,526	$15,526	ECHOS-33130716
Carbon Adsorber	2	$13,618	$27,236	ECHOS-33132027
Catalytic Oxidizer	1	$0	$0	Included in cost of SVE
Filter	2	$316	$632	ECHOS-33132041
2" PVC Piping	500 LF	$8.67	$4,335	ECHOS-33260404
Instrumentation	1 LS	$20,000	$20,000	Allowance
Electrical	1 LS	$15,000	$15,000	Allowance
Building	500 SF	$73	$36,500	ECHOS-33430101
Utilities	1 LS	$10,000	$10,000	Allowance
Subtotal Pump and Treat			$194,821	

CAPITAL COST-ENHANCED BIOREMEDIATION AT SOURCE

Item	Quantity	Unit Cost	Total Cost	Reference
Treatability Study	1	$15,000	$15,000	Engineer
Groundwater Injection Wells	8	$5,000	$40,000	Engineer
HRC Injection Wells	1,000 LF	$26.84	$26,840	ECHOS-33232505
HRC	7,000 LB	$6	$42,000	Quote
Labor for Injectors	80 HR	$60	$4,800	Engineer
2" PVC Piping	500 LF	$8.67	$4,335	ECHOS-33260404
Subtotal Enhanced Bioremediation			$132,975	
Present Cost Enhanced Bioremediation			$99,372	

TABLE A-5 (Continued)

CAPITAL COST - ENHANCED BIOREMEDIATION DOWNGRADIENT PILOT TEST

Item	Quantity	Unit Cost	Total Cost	Reference
HRC Injection Wells	2,100 LF	$26.84	$56,364	ECHOS-33232505
Monitoring Wells	5	$4,000	$20,000	Engineer
HRC	8,400 LB	$6	$50,400	Quote
Analytical	60	$150	$9,000	Quote
Labor	200 HR	$60	$12,000	Engineer
Report	1	$10,000	$10,000	Engineer
		Subtotal Pilot Test	$157,724	

Assume full scale enhanced bioremediation cost is two times the pilot scale test.

Subtotal Full Scale=$315,448
Total Downgradient Enhanced Bioremediation=$473,172

Total Direct Capital Cost		$1,491,658
Mobilization/Demobilization (5% of Capital Cost)		$ 74,583
Design (10% of Capital Cost)		$ 149,166
Contingency (25% of Capital Cost)		$ 372,915
		$2,088,322
	SAY	$2,100,000

TABLE A-5 (Continued)

ANNUAL OPERATION AND MAINTENANCE (O&M) COSTS

Item	**Quantity**	**Unit Cost**	**Total Cost**
Operator	624 HRS	$50	$31,200
Supervisor	150 HRS	$80	$12,000
Maintenance & Repairs	1 LS	$10,000	$10,000
Carbon	4,100 LBS	$1	$4,100
Power	1,100,000 KWH	$0.06	$66,000
Gas	27,600 MCF	$5.81	$160,356
Vapor Analysis	36	$300	$10,800
Water Analyses	40	$150	$6,000
Reporting	1 LS	$10,000	$10,000
Total Annual O&M Cost			$310,456

Present Worth Cost of O&M = $310,456 X 4.2124 (present worth factor for 5 years at 6% interest rate)
Present Cost of O&M = $1,307,765 (SAY $1,300,000)
Total Alternative Cost = Capital Cost + Present Cost of O&M
= $2,100,000 + $1,300,000
= $3,400,000

TABLE A-6

SOIL VAPOR EXTRACTION AND PHASED APPROACH TO GROUNDWATER PUMP AND TREAT

CAPITAL COST - SOIL REMEDIATION AT SOURCE

Item	Quantity	Unit Cost	Total Cost	References
Vapor Extraction Wells	144	$1,500	$216,000	Pilot Test
Air Inlet Wells	144	$1,200	$172,800	Pilot Test
Pressure Monitoring Wells	12	$1,200	$14,400	Pilot Test
Blower 150 HP, 5000 cfm	1	$33,670	$33,670	Quote
Catalytic Oxidizer, 6,000 cfm	1	$185,000	$185,000	ECHOS-3770459
4" PVC Pipe	1,000 LF	$12.34	$12,340	ECHOS-33260404
Instrumentation	1 LS	$10,000	$10,000	Allowance
Electrical	1 LS	$10,000	$10,000	Allowance
Subtotal Soil Remediation			$654,210	

CAPITAL COST - PUMP AND TREAT AT SOURCE

Item	Quantity	Unit Cost	Total Cost	Reference
Extraction Well	8	$5,000	$40,000	Engineer
Groundwater Pump	8	$2,324	$18,592	ECHOS-33230601
Tank	1	$2,000	$,200	Engineer
Centrifugal Pump	2	$2,500	$5,000	Engineer
Air Stripper	1	$15,526	$15,526	ECHOS-33130716
Carbon Adsorber	2	$13,618	$27,236	ECHOS-33132027
Catalytic Oxidizer	1	$0	$0	Included in cost of SVE
Filter	2	$316	$632	ECHOS-33132041
2" PVC Piping	500 LF	$8.67	$4,335	ECHOS-33260404
Instrumentation	1 LS	$20,000	$20,000	Allowance
Electrical	1 LS	$15,000	$15,000	Allowance
Building	500 SF	$73	$36,500	ECHOS-33430101
Utilities	1 LS	$10,000	$10,000	Engineer
Subtotal Pump and Treat			$194,821	

TABLE A-6 (Continued)

CAPITAL COST-ENHANCED BIOREMEDIATION

Item	Quantity	Unit Cost	Total Cost	Reference
Treatability Study	1	$15,000	$15,000	Engineer
Groundwater Injection Wells	8	$5,000	$40,000	Engineer
HRC Injection Wells	1,000 LF	$26.84	$26,840	ECHOS-33232505
HRC	7,000 LB	$6	$42,000	Quote
Labor for Injectors	80 HR	$60	$4,800	Engineer
2" PVC Piping	500 LF	$8.67	$4,335	ECHOS-33260404
Subtotal Enhanced Bioremediation			$132,975	
Present Cost Enhanced Bioremediation			$99,372	

CAPITAL COST-ENHANCED BIOREMEDIATION DOWNGRADIENT PILOT TEST

Item	Quantity	Unit Cost	Total Cost	Reference
HRC Injection Wells	2,100 LF	$26.84	$56,364	ECHOS-33232505
Monitoring Wells	5	$4,000	$20,000	Engineer
HRC	8,400 LB	$6	$50,400	Quote
Analytical	60	$150	$9,000	Quote
Labor	200 HR	$60	$12,000	Engineer
Report	1	$10,000	$10,000	Engineer
Subtotal Pilot Test			$157,724	

Assume full scale enhanced bioremediation cost is two times the pilot scale test.

Subtotal Full Scale=$315,448
Total Downgradient Enhanced Bioremediation=$473,172

Total Direct Capital Cost		$1,421,575
Mobilization/Demobilization (5% of Capital Cost)		$ 71,079
Design (10% of Capital Cost)		$ 142,158
Contingency (25% of Capital Cost)		$ 355,394
		$1,990,206
	SAY	$2,000,000

TABLE A-6 (Continued)

ANNUAL OPERATION AND MAINTENANCE (O&M) COSTS

Item	**Quantity**	**Unit Cost**	**Total Cost**
Operator	624 HRS	$50	$31,200
Supervisor	150 HRS	$80	$12,000
Maintenance & Repairs	1 LS	$10,000	$10,000
Carbon	4,100 LBS	$1	$4,100
Power	1,100,000 KWH	$0.06	$66,000
Gas	27,600 MCF	$5.81	$160,356
Vapor Analysis	36	$300	$10,800
Water Analyses	40	$150	$6,000
Reporting	1 LS	$10,000	$10,000
		Total Annual O&M Cost	$310,456

Present Worth Cost of O&M = $310,456 X 4.2124 (present worth factor for 5 years at 6% interest rate)

Present Cost of O&M = $1,307,765 (SAY $1,300,000)

Total Alternative Cost = Capital Cost + Present Cost of O&M
= $2,000,000 + $1,300,000
= $3,300,000