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RCRA Corrective Measures Study Report
Sites 3, 10, and 13

Niagara Falls IAP-ARS
Niagara Falls, New York

March 1996

Prepared for:

UNITED STATES DEPARTMENT OF THE AIR FORCE
Air Force Reserve, 914th Airlift Wing/LGC

RCRA Corrective Measures Study Sites 3, 10, and 13 Niagara Falls IAP-ARS Niagara Falls, New York

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1 Introduction

Ecology and Environment, Inc., (E & E) has prepared this report for the United States Department of the Air Force (USAF), 914th Airlift Wing of the United States Air Force Reserve (AFRES). The report was prepared under Contract F30617-94-D-0008 in support of the United States Department of Defense (DoD) Installation Restoration Program (IRP) at the Niagara Falls International Airport - Air Reserve Station (IAP-ARS). In accordance with the installation's draft hazardous waste storage permit, AFRES is required to conduct Resource Conservation and Recovery Act (RCRA) Facility Investigations (RFIs) and Corrective Measures Studies (CMSs) at sites where previous studies identified releases of hazardous waste constituents to the environment. E & E has conducted RFIs at IRP Sites 3, 10, and 13. A draft RFI report was submitted to the New York State Department of Environmental Conservation (NYSDEC) and the United States Environmental Protection Agency (EPA) in July 1995, and an addendum to the RFI, "Supplemental Sampling and Comment Responses," was submitted in February 1996. These two documents comprise the Final RFI Report. The draft CMS Report was prepared and submitted to the agencies in September 1995. A proposal to conduct an Interim Corrective Measure (ICM) addressing contaminated soils at Site 10 was presented in the AFRES letter dated February 27, 1996. This correspondence has been included as an addendum to the CMS Report. The Final CMS Report comprises the present document, which includes responses to the agencies' comment on the draft report, and the addendum.

This document was developed in conformance with the CMS work plan submitted to NYSDEC and EPA in December 1994, revised in April 1995, and approved in June 1995. The work plan was designed to be consistent with the scope of work for a CMS, as outlined in the draft permit.

1.1 Purpose and Objectives

The purpose of this report is to identify and develop alternative corrective measure strategies for three solid waste management units (SWMUs) at the Niagara Falls IAP-ARS, to evaluate each alternative based on specific criterion, and to recommend the corrective measure to be undertaken at each site. The primary goal of the CMS process was to select the corrective measure that would most likely attain the corrective action objectives at each SWMU.

1.2 Report Organization

This document consists of six major sections. The introductory section briefly discusses the purpose, primary objectives, and organization of the report. Section 2 provides a summary of background information describing the installation. This section also includes detailed investigative information, analytical results, and conclusions for the installation and the three IRP sites.

Section 3 lists and describes the corrective measure technologies for all pertinent media that may be applicable to one or all three sites. Sections 4, 5, and 6 present the CMS for IRP Sites 3, 10, and 13, respectively. References used in the preparation of this document are listed in Section 7.

Each CMS establishes site-specific corrective action objectives, screens the technologies to eliminate those that contain severe limitations, and identifies the corrective measure alternative(s) that appear most suitable. A summary of the alternatives retained for detailed evaluation is provided for each media of concern within each site-specific CMS.

In general, the detailed evaluation of the alternative(s) are based on technical, environmental, human health, and institutional concerns. Cost estimates (i.e., capital, operation and maintenance costs) were also developed and considered during this process. The recommended alternative for each media is then presented at the conclusion of the detailed evaluation, including a justification for the chosen alternative and a description of the associated performance monitoring program.

2 Background

2.1 Location and Description

The Niagara Falls IAP-ARS is located approximately 5.4 miles northeast of Niagara Falls in Niagara County, New York (see Figure 2-1). This 547-acre installation lies in the Town of Wheatfield to the east and the Town of Niagara to the west (see Figure 2-2). The installation is situated in an area of multiple land uses, including predominantly rural/agricultural and some commercial areas to the north, east, and west of the facility, and industrial, commercial, and urban areas to the south.

The IAP-ARS consists predominantly of airfield runways and taxiways in the central and southern portions, which are shared by IAP and AFRES, and a developed area in the northern portion occupied by AFRES. The IAP portion of the site is used by commercial and private aviation companies; the ARS is presently occupied by the 914th Airlift Wing (host unit) and the 107th Air Refueling Group (main tenant). The developed area of the IAP-ARS consists of numerous buildings used for base operations and maintenance, administration, medical, housing, industry, community service, and community commercial. There are numerous underground and aboveground storage tanks and buried utilities. In addition to man-made features, Cayuga Creek bisects the installation from northeast to southwest, predominantly through the airfield and open area in the northeast corner. The natural creek channel was diverted and trenched during the construction of the airfield.

2.2 Previous Investigations

The IRP began in 1983 when the Phase I Records Search was completed (Engineering-Science 1983). This study identified 13 sites where past waste disposal/storage activities indicated a potential for environmental contamination. These sites were ranked according to the Hazard Assessment Ranking Methodology (HARM) in order to prioritize the sites. The numbers associated with each of the sites are based on the HARM scores. Site 1 (Building

600 JP-4 Pipeline Leak) received the highest priority and Old Site 13 (AFRES Hazardous Waste Drum Storage) received the lowest priority.

Twelve of the 13 sites were recommended for further action (excluding Old Site 13) and were subsequently incorporated into the IRP Phase II Confirmation/Quantification Stage I Investigation. The report for this investigation was submitted in April 1986 and recommended additional investigation at each of the 12 sites based on the presence of contaminants in the environmental media sampled (Science Application International Corporation [SAIC] 1986).

A comprehensive Remedial Investigation (RI) and Feasibility Study (FS) were performed at the installation between 1987 and 1990 (SAIC 1991). The RI/FS Report was intended to expand upon the earlier investigations in order to identify and quantify the extent of environmental contamination at each of the sites. At sites exhibiting contaminant migration, FS alternative screening and selection processes would be undertaken. Otherwise, no further action would be recommended. In April 1990, a Decision Document was written and approved by USAF and NYSDEC closing Old Site 13. Subsequently, a new Site 13 (Underground Tank Pit) was discovered and incorporated into the RI/FS. Under the corrective action program, these 13 sites (12 recommended for further action and new Site 13) are referred to as SWMUs.

Since 1991, several other focused investigations have been performed for many of the sites. This includes the following:

- RD for Sites 8 and 13 (GZA GeoEnvironmental of New York [GZA] 1992a);
- Long-term groundwater monitoring at Site 3 (GZA 1992b, 1993a, 1993b, 1994a, 1994b);
- Limited RI/FS at Site 7 (GZA 1992c);
- Limited RI/FS at Site 10 (Wehran-New York, Inc. and Babinsky-Klein Engineering [Wehran] 1992a, 1992b);
- Additional RI/FS groundwater sampling at Sites 2, 4, 5, and 9 (E & E 1992);
- Well Inspection and Maintenance at Sites 1, 2, 3, 4, 5, 7, 8, 9, 10, and 13 (E & E 1993);
- Focused RI for Site 10 (E & E 1994a);

- Supplemental Environmental Studies at Sites 8 and 13 (GZA 1994c); **and**

- Limited RI/FS at Site 1 (E & E 1994b).

Based on the results of these investigations, no further action has been determined for three SWMUs, groundwater monitoring has been warranted for ten SWMUs, and RFIs/CMSs have been required for three SWMUs. A list of the SWMUs at the installation and their current status is provided in Table 2-1. A summary of results from previous investigation for the three SWMUs requiring RFIs/CMSs are presented in the following sections.

2.2.1 Site 3

Site 3 was originally identified during the Phase I records search, which concluded that potential for environmental contamination and contaminant migration existed (Engineering-Science 1983). A subsequent Phase II Confirmation/Quantification Stage I investigation concluded that an RI/FS was warranted at this site in order to characterize up- and downgradient water quality (SAIC 1986). A comprehensive RI/FS was performed at the installation between 1987 and 1990 and included Site 3 in an attempt to characterize the extent of contamination (SAIC 1991). Based on these investigations, a Decision Document was prepared in 1990 recommending long-term groundwater monitoring. Four rounds of ground-water, surface water, and sediment samples were subsequently collected between June 1992 and January 1994 by GZA GeoEnvironmental of New York.

Results of the above investigations have shown that the surface water and sediment contain elevated levels of common, naturally occurring metals but also contain low levels of site-related contaminants including trichloroethene (TCE), vinyl chloride, and benzene. The types of contaminants detected at elevated levels in the groundwater at Site 3 include halogenated volatile organic compounds (VOCs) such as tetrachloroethene (PCE), vinyl chloride, and carbon tetrachloride; aromatic halocarbons such as benzene; and metals, including zinc and lead. Throughout the four rounds of groundwater sampling conducted, concentrations of these contaminants have varied widely. A summary of previous analytical results for parameters of concern (i.e., exceeding guidance values) is presented in Table 2-2.

2.2.2 Site 10

Previous investigations conducted at Site 10 include the Phase I: Records Search (Engineering-Science 1983), Phase II: Confirmation/Quantification Study (SAIC 1986), an IRP RI/FS (SAIC 1991), Limited RI/FS (Wehran 1992b), and a Focused RI (E & E 1994a).

Results of these investigations indicate the presence of contaminants in soils, sediments, surface water, and groundwater. Trichloroethene and its biodegradation products were found in the soils; elevated levels of oil and grease were present in the surface water and sediment samples. Several volatile organics, including both chlorinated and aromatic compounds, were found in the groundwater (see Table 2-3).

2.2.3 Site 13

Site 13 was added to the Niagara Falls IAP-ARS IRP when NYSDEC requested that water and soil samples be collected during underground storage tank (UST) excavation and removal in 1986. The water and soil samples indicated VOC contamination (see Table 2-4). Four overburden monitoring wells were installed and sampled. Analytical data indicated the presence of benzene, toluene, ethylbenzene, and xylenes (BTEX), PCE, TCE, vinyl chloride, and various metals in the groundwater. No liquid-phase organics have been detected at the site. The tank pit was backfilled in 1987. Groundwater monitoring determined contaminant migration had occurred from the tank pit prior to its removal. A decision document was prepared in 1990. A remedial design was developed but determined to be inappropriate by the base. Supplemental investigations were conducted in 1993 that included the installation of two bedrock monitoring wells.

Table 2-1

LIST OF SWMUs, DESCRIPTION, AND CURRENT STATUS

Site Number	Description	Status
1	Building 600 JP-4 pipeline leak	Groundwater monitoring under installation-wide study
2	POL JP-4 Tank C leak	Groundwater monitoring under installation-wide study
3	Landfill	RFI/CMS currently being conducted. Groundwater monitoring under installation-wide study
4	BX Mogas tank leak	Groundwater monitoring under installation-wide study
5	Former NYANG hazardous waste drum storage area	Groundwater monitoring under installation-wide study
6	POL JP-4 Tank A leak	No further action
7	JP-4 tank truck spill	Groundwater monitoring under installation-wide study
8	Former Building 202 drum storage yard	Groundwater monitoring under installation-wide study
9	Former fire training area No. 3	Groundwater monitoring under installation-wide study
10	Former fire training area No. 1	RFI/CMS currently being conducted. Groundwater monitoring under installation-wide study
11	Former fire training area No. 2	No further action
12	Former Building 850 drum storage yard	No further action
13	Closed 4,000-gallon underground storage tank	RFI/CMS currently being conducted. Groundwater monitoring under installation-wide study

Note: SWMUs are also referred to as IRP sites.

Key:

BX = Base exchange.
CMS = Corrective Measure Study.
JP = Jet Petroleum.
MOGAS = Motor gasoline.
NYANG = New York Air National Guard.
POL = Petroleum, oils, and lubricants.
RFI = RCRA Facility Investigation.

Table 2-2

SUMMARY OF PREVIOUS ANALYTICAL RESULTS IRP SITE 3 NIAGARA FALLS IAP-ARS

Parameters of Concern	Observed Range[a]
Soil (mg/kg)	
Beryllium	ND - 0.596
Cadmium	ND - 2.8
Chromium	5.8 - 20.4
Copper	6.6 - 28.8
Lead	15.1 - 60.7
Nickel	7.1 - 27.9
Zinc	59.9 - 687
Sediment (mg/kg)	
Arsenic	3.7[b]
Cadmium	ND - 4.36
Chromium	3.06 - 13.7
Copper	4.07 - 9.29
Lead	ND - 41.3
Nickel	7.35 - 21.2
Zinc	19.2 - 1,070
Groundwater (μg/L)	
Arsenic	ND - 20
Cadmium	ND - 64
Chromium	ND - 150
Copper	ND - 857
Lead	ND - 841
Mercury	ND - 0.2
Nickel	ND - 233
Zinc	ND - 2,770
Benzene	ND - 2.5
Carbon tetrachloride	ND - 750
Chloroform	ND - 1,100

Key at end of table.

Table 2-2

SUMMARY OF PREVIOUS ANALYTICAL RESULTS
IRP SITE 3
NIAGARA FALLS IAP-ARS

Parameters of Concern	Observed Range[a]
Chloroethane	ND - 4.3
1,2-Dichloroethane	ND - 4.3
1,1-Dichloroethene	ND - 1.1
1,1,2,2-Tetrachloroethene	ND - 0.10
Tetrachloroethene	ND - 0.83
Toluene	ND - 0.39
trans-1,2-Dichloroethene	ND - 170
Trichloroethene	ND - 900
Vinyl chloride	ND - 55
Surface Water (µg/L)	
Arsenic	ND - 52
Zinc	551 - 1,320

Note: Ranges include duplicate sample data and results from wells not sampled during the RFI effort.

[a] SAIC 1991 and GZA 1994 data.
[b] Only one sample analyzed for arsenic.

Key:

ND = Not detected.

Table 2-3

SUMMARY OF PREVIOUS ANALYTICAL RESULTS
IRP SITE 10
NIAGARA FALLS IAP-ARS

Parameters of Concern	Detected Range[a]
Soil (μg/kg except where noted)	
Beryllium (mg/kg)	ND - 0.556
Cadmium (mg/kg)	ND - 1.55
Chromium, total (mg/kg)	6.5 - 650
Copper (mg/kg)	7.17 - 37
Lead (mg/kg)	2.8 - 57
Nickel (mg/kg)	7.2 - 48
Zinc (mg/kg)	30 - 640
Acetone	ND - 100
Carbon disulfide	ND - 17
Chlorobenzene	ND - 3.0
Ethylbenzene	ND - 1,100
Methylene chloride	ND - 34
Toluene	ND - 16
total-1,2-Dichloroethene	ND - 2,100
Trichloroethene	ND - 14,000
Vinyl chloride	ND - 38
Xylenes, total	ND - 3,600
bis(2-Ethylhexyl)phthalate	ND - 220
Di-n-butyl phthalate	ND - 160
Fluorene	ND - 210
2-Methylnaphthalene	ND - 900
Naphthalene	ND - 1,000
Phenanthrene	ND - 300
Pyrene	ND - 39
Sediment (mg/kg)	
TRPH	51 - 192
Pyrene	ND - 0.34
Groundwater (μg/L)	
Chromium, total	ND - 51
Copper	ND - 107
Lead	ND - 206
Nickel	ND - 79
Zinc	87 - 3,750[b]

Key at end of table.

Table 2-3

SUMMARY OF PREVIOUS ANALYTICAL RESULTS
IRP SITE 10
NIAGARA FALLS IAP-ARS

Parameters of Concern	Detected Range[a]
TRPH	ND - 1,680
Benzene	ND - 3
bis(2-Ethylhexyl)phthalate	ND - 4.7
Carbon disulfide	ND - 3.3
Carbon tetrachloride	ND - 9.96
Chloroform	ND - 42.6
cis-1,2-Dichloroethene	ND - 13,100[b]
1,2-Dichloroethane	ND - 4.4
1,1-Dichloroethene	ND - 4.1
1,2-Dichloropropane	ND - 3.17
Ethylbenzene	ND - 3.7
Hexachlorobenzene	ND - 64
Methylene chloride	ND - 4,160
Tetrachloroethene	ND - 1.78
Toluene	ND - 4.7
Total-1,2-Dichloroethene	ND - 9,800
1,1,1-Trichloroethane	ND - 1.97
Trichloroethene	ND - 28,000[b]
Vinyl chloride	ND - 1,160[b]
Xylenes, total	ND - 2.2

Notes: Parameters of concern include those analytes found to exceed TAGM standards (NYSDEC 1994) or guidance values (Shacklette and Boerngen 1984) in previous sampling efforts and/or the RFI sampling effort. Ranges include duplicate sample data and results from wells not sampled during the RFI effort.

a SAIC 1991, Wehran 1992, and E & E 1994.
b Includes elevated data collected in SAIC 1991.

Key:

ND = Not detected.

Table 2-4

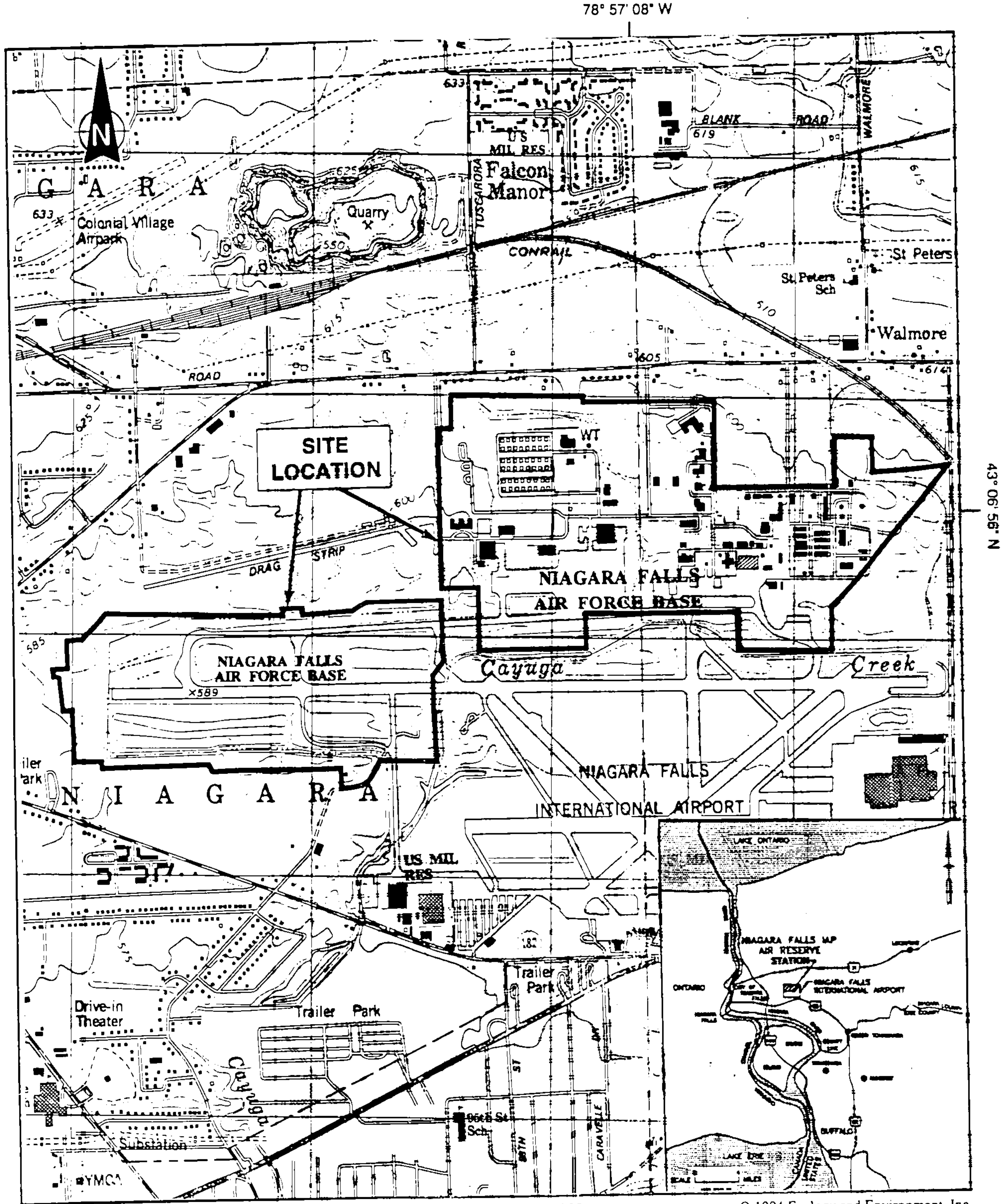
SUMMARY OF PREVIOUS ANALYTICAL RESULTS
IRP SITE 13
NIAGARA FALLS IAP-ARS

Parameters of Concern	Detected Range[a]
Soil (mg/kg)	
Chromium, total	7 - 18.2
Copper	8.3 - 22.2
Lead	12.4 - 27.9
Nickel	9.4 - 35.9
Zinc	59.4 - 514
Groundwater (μg/L)	
Arsenic	ND - 15
Chromium, total	ND - 100
Copper	ND - 112
Lead	3 - 79
Nickel	ND - 125
Zinc	120 - 1,310
Benzene	ND - 2.98
Chlorobenzene	ND - 9.1
1,2-Dichlorobenzene	ND - 3.6
1,3-Dichlorobenzene	ND - 1.1
1,4-Dichlorobenzene	ND - 9.7
1,2-Dichloroethane	ND - 2.3
Ethylbenzene	ND - 3.6
Toluene	ND - 15
Total-1,2-dichloroethene	ND - 4.1
Trichloroethene	ND - 14
Vinyl chloride	ND - 1,600
Xylenes, total	ND - 7.6

Note: Ranges include duplicate sample data.

[a] SAIC 1991 and GZA 1994 data.

Key:
ND = Not detected.



SOURCE: USGS 7.5 Minute Series (Topographic) Quadrangle: Ransomville, NY, 1980;
Tonawanda West, NY, 1980.

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Figure 2-1 SITE LOCATION MAP NIAGARA FALLS IAP-ARS

NM9S005B

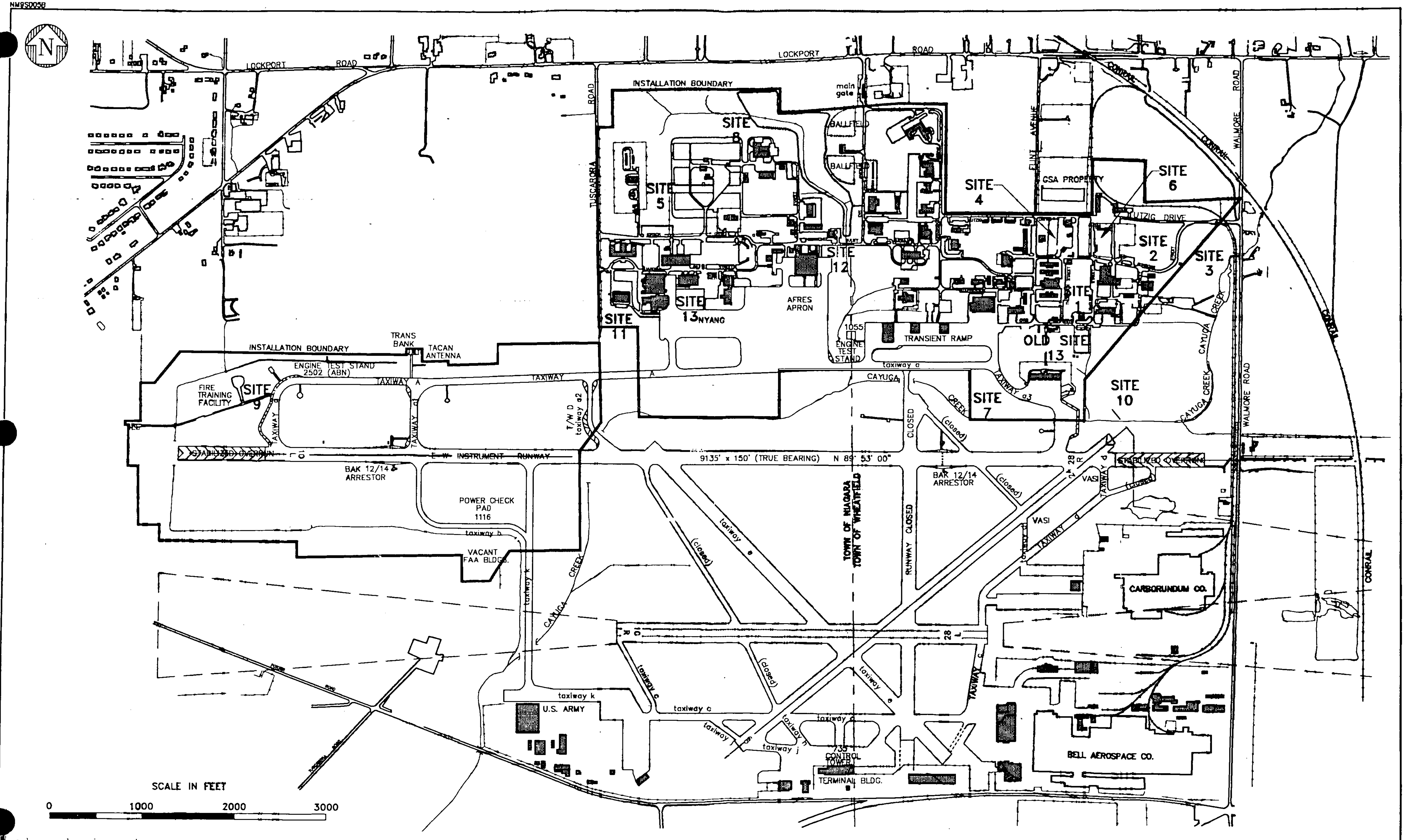

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Figure 2-2 INSTALLATION PLAN
NIAGARA FALLS IAP-ARS

3 Potential Corrective Measure Technologies

In this section, potential medium-specific corrective action technologies are identified and described. Some of the identified corrective action technologies may not be applicable for corrective action at Sites 3, 10, and 13. Identified corrective action technologies were screened on a site-specific basis considering site and waste characteristics and technology limitations. A list of all medium-specific technologies is presented in Table 3-1.

3.1 Soil/Fill and Sediment Corrective Measure Technologies

Corrective measure technologies for soil/fill and sediment are similar. Therefore, corrective measure technologies for these media are presented together. Corrective measure technologies for contaminated soil/fill and sediment are used to contain, treat, or remove and dispose of the contaminated media. These technologies are presented below.

3.1.1 Capping

Capping or surface sealing is applicable to land disposal sites and can be performed over existing in-place contamination. Capping consists of either impermeable capping, which acts to prevent surface water infiltration and eliminates direct hazardous constituent contact, or permeable capping, which allows surface water infiltration. In general, capping isolates wastes from contact with surface runoff and infiltration, controls off-site transport of contaminated soils, and prevents surface leaks of leachate. Capping techniques utilize materials such as synthetic membranes, clay, asphalt, concrete and chemical sealants.

Capping techniques that are presently used include single-layered and multi-layered caps. The most effective single-layered caps are composed of concrete or asphalt. However, single-layered caps are usually not acceptable unless the cap is continually maintained. Multi-layered caps are more common and are required for RCRA land disposal facilities. These caps can be composed of natural soils, mixed soils, a synthetic liner, or any combination thereof.

Single-Layered Caps

The following are examples of single-layered caps:

- **Sprayed asphalt membrane.** This technology involves clearing, grubbing, surface grading, and spray application of a ¼- to ½-inch thick layer of asphalt.

- **Portland cement concrete.** This technology involves clearing, grubbing, surface grading, and placement of a 6-inch thick base course and a 4- to 6-inch-thick concrete slab (with minimum steel mesh).

- **Asphalt.** This technology involves clearing, grubbing, surface grading, and placement of a 6-inch-thick base course and 2- to 6-inch-thick asphalt pavement.

Multi-Layered Caps

The following are examples of multilayered caps:

- **Loam Over Clay Over Sand.** This technology involves clearing and grubbing, grading, and covering site soils with a 12-inch sand layer (the gas-venting layer) overlain by 18 inches of compacted clay to minimize infiltration and eliminate particulate emissions from the soil surface. The clay is covered with a 24 inches of loam (topsoil) to control moisture and protect the integrity of the clay layer to allow revegetation. This final cover system meets the requirements of 6 NYCRR Part 360. This technology is effective and has longevity and durability, assuming proper design, installation, and maintenance. Although it is susceptible to cracking from settlement and frost heave, it tends to be self-repairing. Long-term maintenance is required to prevent growth of deep-rooting trees and shrubs that could penetrate the clay seal.

- **Loam Over Synthetic Membrane Over Sand.** 6 NYCRR Part 360 allows substitution of a synthetic membrane for the clay layer. Thus, this technology involves clearing and grubbing, surface grading, and covering site soils with a 12-inch-thick blanket of sand (the gas-venting layer) overlain by an impermeable synthetic membrane that is covered by 24 inches of loam (topsoil) to allow revegetation. The seams in the membrane require careful installation and sealing. Flexibility of the membrane makes this technology relatively less susceptible to cracking from influences such as settlement and frost heave; however, the self-repairing capability of clay is lost. There is limited long-term experience with synthetic membranes.

- **Loam Over Sand Over Synthetic Membrane Over Clay.** This technology involves clearing and grubbing, grading, and covering site soils with a 12-inch-thick sand layer (the gas-venting layer) overlain by compacted clay (its thickness depends on the slope of the cap) and an impermeable synthetic membrane. The compacted clay and synthetic membrane act as barriers to the infiltration of water. Overlying this sequence of materials is 24 inches of loam (topsoil) to allow revegetation. This sequence of materials meets RCRA requirements for final covers and exceeds 6 NYCRR Part 360 requirements for a composite final cover. This technology takes advantage of the self-repairing properties of clay, along with the impermeable nature of a synthetic membrane. The seams in the membrane require careful installation and sealing.

3.1.2 Consolidation

Consolidation entails moving contaminated materials from areas within a SWMU and placing them on top of existing contaminated material in order to decrease the spatial expanse of the SWMU. This would decrease the cost of subsequent corrective action technologies, such as a cap. Consolidation is accomplished through the use of excavators and/or loaders, dump trucks, and compaction equipment. Consolidation may involve excavation in areas that are below the groundwater table, which may require engineering controls to lower the groundwater table. Despite the difficulties, removal of contaminated material from beneath the groundwater table may be desirable because this will eliminate the production of leachate caused by the movement of groundwater through the contaminated materials. Soil remaining in the areas of excavation must then be tested to determine if it is contaminated. After it has been determined that the bottom soils are below cleanup goals, the area should be filled to grade with clean soils.

3.1.3 Excavation

Excavation is widely used for removing surface and subsurface contaminated soils. Conventional heavy construction equipment is generally used for excavation, removal, and hauling of contaminated soils. Excavation is typically followed by land disposal or treatment. Excavation is usually adopted to remove contaminant "hot spots," and other corrective measures (i.e., in situ treatment) are used for the less contaminated soils and sediments.

3.1.4 Dredging

The process of removing bottom sediments from a water body is known as dredging. This process has been used for many years to widen or deepen harbors and navigable waters. In recent years, dredging has been employed in the removal of sediments that are contaminated. Dredging of contaminated sediments involves the use of conventional heavy construction equipment (e.g., backhoes, clamshells, dump trucks, etc.). Dredging of contaminated sediments is typically followed by land disposal or treatment of sediments.

3.1.5 On- and Off-Site Disposal

Land disposal of contaminated materials was a popular remedial action because it often represented the quickest, most direct corrective action at a site. Land disposal is now more difficult because of the enactment of the Hazardous and Solid Waste Amendment (HSWA) to RCRA, which mandated stringent new land disposal restrictions known as the Land Disposal Restrictions (LDRs). The two disposal options, on-site disposal in a constructed landfill, or off-site disposal in a commercial facility, are discussed below.

On-Site Disposal

The construction of a secure landfill that meets RCRA and state requirements is required for on-site disposal of hazardous material generated by excavation of contaminated soil and fill material or by an on-site treatment or pre-treatment process. Several criteria are associated with the construction of a RCRA hazardous waste landfill, including the following:

- The landfill should be designed so that the local groundwater table will not be in contact with the facility;
- The landfill should be constructed of, or lined with, natural or synthetic material of low permeability to inhibit leachate migration;
- An impermeable cover is required to minimize infiltration and leachate productions;
- A leachate and runoff collection must be provided; and
- Periodic monitoring of surface water, groundwater, and soils adjacent to the facility must be conducted to determine the integrity of the liner and leachate collection system.

An on-site landfill, which will contain only low hazard or detoxified wastes not specifically designated by RCRA as hazardous, does not necessarily have to meet all the RCRA requirements.

Off-Site Disposal

. Off-site disposal of contaminated materials and soil involves hauling excavated material to a commercial disposal facility. The type of facility chosen would depend on whether material is classified as hazardous under RCRA and New York's hazardous waste regulations. Hazardous waste may only be disposed of at a RCRA-permitted hazardous/solid waste facility. Prior to land disposal, most hazardous wastes must meet specific treatment standards codified in Title 40 Code of Federal Regulations (CFR), Part 268.

3.1.6 On- and Off-Site Treatment

On-site and off-site treatment of contaminated soils, sediments, and waste materials includes techniques falling into three major categories:

- Thermal treatment;
- Physical/chemical treatment; and
- Biological treatment.

A description of each of the available corrective action technologies follows.

Thermal Treatment (Destruction)

Thermal treatment technologies use high-temperature oxidation (except pyrolysis which operates in the absence of oxygen) under controlled conditions to degrade a substance into products that generally include carbon dioxide, water vapor, sulfur dioxide, nitrogen oxides, gases, and ash. Thermal destruction methods can be used to destroy organic contaminants in liquid, gaseous, and solid waste streams. Thermal destruction technologies available are listed below:

- Incineration;
- Pyrolysis;
- Molten salt treatment;
- Plasma arc pyrolysis; and
- Microwave discharge systems.

Pyrolysis, plasma arc pyrolysis, and microwave discharge systems are not well developed at this time. Molten salt destruction is principally for concentrated organic liquids, and is also not well developed at this time. Thermal treatment can be performed on or off site. Several types of incinerators are technically feasible and have been used to treat contaminated soils and sediments. In general, only multiple-hearth, fluidized bed, and rotary kiln incinerators are applicable for the incineration of solids. Each of these systems would reduce the waste volume at high capital and energy costs.

Thermal Treatment (Desorption)

Thermal desorption is a relatively new thermal treatment technology that uses low to medium temperatures to transfer volatile and semivolatile organic contaminants from a solid matrix into a gas stream, using heat and mechanical agitation. The organic compounds transferred into the gas stream are then subjected to further treatment (e.g., carbon adsorption or high-temperature incineration). Thermal desorption is not effective for inorganic contaminants such as lead, zinc, and iron. Clean soils could be backfilled at the site depending on the metals concentrations.

Physical/Chemical Treatment

Physical/chemical treatment technologies utilize physical or chemical alterations to the soil or waste matrix or to the contaminants. The contaminants may be changed by a chemical reaction, so that the contaminant is less toxic or more amenable to physical treatment, or the contaminants may be completely destroyed and rendered harmless. Physical/chemical treatment techniques are applicable to both organic and inorganic contaminated soils or materials. Physical/chemical technologies are discussed below:

- **Ultraviolet/Photolysis (UV)** is an innovative treatment technology employing UV radiation to destroy or detoxify hazardous organic compounds. UV radiation cannot penetrate through soils or highly turbid solutions; therefore, this process requires extraction of the organic contaminant(s) into a solution free of suspended solids. UV technology is well developed and has been used on full scale.

- **Solidification/Stabilization (S/S)** is a technique wherein the contaminants are bound in a solid matrix through the addition of solidifying agents such as pozollonic ash, cement, or other admixtures. Solidification of wastes typically produces a monolithic block with high structural integrity. Typically stabilizing agents are also added with solidification chemicals to chemically convert hazardous contaminants to less toxic forms. For example, metal species are typically precipitated to respective hydroxides, which are less mobile. Solidification/stabilization involves excavation, screening, addition of solidification/stabilization agents, and curing of the monoliths.

- **Soil washing** is a volume reduction technology that separates the fine solid fractions from the coarser soils through an aqueous washing process and washing water treatment system. This technology is based on the observation that the vast majority of contaminants are found adsorbed to the fine soils due to their greater specific surface area. The coarser, clean soils could be backfilled on site while the fine fractions would require further treatment/disposal.

- **Solvent extraction** uses a chemical leaching process to desorb the contaminant(s) from the soil matrix into solution. The liquid waste stream is then treated to remove the contaminants and the washing solution is recycled, if possible. Soil washing solutions with greatest potential for soil remediation generally include water; water augmented with an acidic or chelating agent to remove organics and heavy metals; and water augmented with a basic or surfactant agent to remove organics. Soils are excavated, screened, and mixed thoroughly with the solvent. After mixing, the solids are dewatered and are rinsed with a neutralizing agent (if needed), dried, and placed back on site or otherwise disposed.

Biological Treatment

Biological treatment processes use indigenous or selectively cultured bacteria, yeast, or fungi to decompose hazardous organic compounds. Biological treatment processes are sensitive to temperature, pH, oxygen concentration, moisture content, availability of nutrients, and concentrations of inhibitory substances (e.g., metals). Biological treatment can be accomplished in one of several types of aboveground biological treatment techniques including landfarming, composting, and slurry phase biotreatment. With landfarming, the amended and inoculated soils are spread in a thin (1- to 2-foot) layer to allow adequate oxygen transfer. Treatment time may be as long as 6 to 12 months. With composting, the soils are treated in piles. Soils are mixed with a composting mixture consisting of substances rich in organic content. Bulking agents such as wood chips, hay, alfalfa are added to the compost mix to aid in providing porosity to the composting pile. Composting time may be as long as 2 to 6 months. Slurry phase biodegradation calls for the mixing of soils with water and nutrients for treatment in an aerated bioreactor. Much more rapid degradation rates are realized in slurry phase bioreactor as compared to landfarming and composting, although duration of treatment is limited by the throughput of the bioreactor.

3.1.7 In Situ Treatment

A number of technologies have been developed that employ physical-chemical or biological means in the subsurface environment to immobilize or remove waste constituents. In situ treatment technologies are discussed below.

Soil Flushing

Soil flushing is an in situ technology in which organic and inorganic constituents are desorbed from contaminated subsurface soils by means of an extraction process using a suitable extractant. The process essentially consists of injecting an aqueous solution into the area of contamination. The contaminant elutriate is then pumped to the surface for removal, recirculation, or on-site treatment and reinjection. During elutriation, sorbed contaminants are mobilized into solution because of solubility, formation of an emulsion, or chemical reaction with the flushing solution. An in situ soil-flushing system includes a network of aqueous solution injection and extraction wells.

In Situ Bioremediation

In situ bioremediation refers to the breakdown of organic compounds by action of micro-organisms in the subsurface environment. In situ bioremediation is initiated by the addition of water enriched with nutrients and oxygen into the subsurface. Occasionally, naturally occurring micro-organisms are augmented by specialized contaminants-specific micro-organisms to accelerate the restoration process. In situ bioremediation involves designing a nutrient and oxygen injection system that will allow for the availability of nutrients and oxygen in zones of contamination. The extent and the rate of bioremediation is also controlled by mass-transfer rates, which will be controlled by the efficiency of the injection and extraction systems and the characteristics of the soil media. Environmental factors like soil pH, water salinity, and concentration of toxic metals also control the extent and rate of in situ bioremediation.

In situ bioremediation in the vadose zone is also called bioventing. Bioventing is similar to soil vapor extraction (explained later); however, bioventing uses low air flow rates to provide only enough oxygen to sustain microbial activity. Oxygen is most commonly supplied through direct air injection. Two basic criteria must be satisfied for successful bioventing (EPA 1994). First, air must be able to pass through the soil in sufficient quantities to maintain aerobic conditions. Soil grain size and soil moisture significantly influence soil gas permeability. Second, hydrocarbon-degrading micro-organisms must be present in concentrations large enough to obtain reasonable biodegradation rates. Besides the presence of bacterial populations, soil pH, moisture, and basic nutrients, nitrogen, phosphorus, and temperature impact microbial activity.

In Situ Solidification/Stabilization

The solidification/stabilization technology was detailed previously. Solidification/stabilization is available as an in situ or ex situ process. In situ solidification/stabilization uses specialized equipment to deliver solidifying/stabilizing agents. The in situ solidification/stabilization process is more applicable for sites where extensive contamination exists at greater depths and excavation of contaminated materials would be costly and environmentally unsafe. The long-term durability of the solidified/stabilized media in the subsurface environment is under investigation. The immobilization of organics, especially volatile organics, remains questionable.

Soil Vapor Extraction (SVE)

SVE, also referred to as vacuum extraction, is an in situ technique used to remove volatile and semivolatile organics from the vadose (or unsaturated) zone of soils. The basic components of the system include extraction wells, monitoring wells, and high vacuum pumps. The system operates by applying a vacuum through the production wells. Induced vacuum causes air flow in the interstitial pores, volatilizing and stripping the organics from the soil matrix into the air stream. The extracted air stream is then typically treated by using an activated carbon bed. Several other geometries for soil vapor extraction (trenches, horizontal drilling) are also available. In general, SVE is applicable for volatile and semivolatile organic contaminants only. In addition, the subsurface must be sufficiently permeable to permit the vapor extraction wells to draw air through all of the contaminated domain at a reasonable rate. SVE is not applicable to remove metals and pesticides because their vapor pressures are too low.

In Situ Vitrification (ISV)

In situ vitrification is a technology developed for the stabilization of transuranic-contaminated wastes and is conceivably applicable to other hazardous waste. The technology is based upon electric melter technology, and the principle of operation is joule heating, which occurs when an electrical current is passed through a medium. Contaminated soil is converted into durable glass, and wastes are pyrolyzed or crystallized. ISV involves heating the waste to 1,350°C or greater, until the solids are molten, then cooling the molten mass to form a stable, glassy end product. The end product is extremely stable. It is projected that materials so treated will remain totally isolated for greater than 10,000 years. ISV involves placement of an array of four graphite electrodes in the area to be treated. To initiate the process, a path of conducting material (graphite) is placed on the surface of the soil so that current can flow in the soil beyond the boiling temperature of water to the melting point of the soil. The joule heating of the starter path achieves temperatures high enough to melt the soil, at which point the soil becomes conductive. This molten zone then grows downward and outward. At the end of heating, electric current is shut off and the media is allowed to cool down and form the glossy matrix.

In Situ Radio-Frequency Heating

In situ radio-frequency uses electromagnetic (EM) wave energy (radio frequency) to heat soils in place to the point where volatile and semivolatile contaminants are vaporized from the soil matrix. Gases created in the soil matrix during the heating process are captured and subsequently treated using high-temperature incineration or carbon adsorption. This process is not applicable for metals contamination. In addition, the technology is limited by its depth of penetration.

In Situ Steam-Enhanced Vacuum Extraction

In situ stream-enhanced vacuum extraction is a technique for the removal of less volatile organic compounds (Henry's Law Constant less than 3×10^{-3} atm-m^3/mole) from the vadose or unsaturated zone of soils. The basic components of the system include extraction wells, monitoring wells, steam injection wells, and high vacuum pumps. The system operates by applying a vacuum through the extraction wells. The vacuum system induces air flow through the soil, stripping and volatilizing the volatile and semivolatile organic compounds from the soil matrix into the air stream. Concurrently, steam is injected into the vadose zone through the steam injection wells to enhance the movement and facilitate the collection of the less volatile organic compounds. The extracted contaminated air stream is then typically treated by utilizing an activated carbon bed.

Pneumatic Fracturing

Pneumatic fracturing is an enhancement technology for other in situ technologies (for example, SVE, bioventing, soil flushing). Pneumatic fracturing injects pressurized air (less than 200 pounds per square inch) in short bursts (approximately 20 seconds) using a packer system in fracture wells that are drilled in the contaminated vadose zone. This process extends fracturing and enlarges existing fissures in low permeability and over-consolidated soils. New fractures and fissures enhance the availability of contaminants by increasing the mass-transfer surface areas. The technology is primarily used to fracture silts, clays, shale, and bedrock.

3.2 Groundwater Corrective Measures Technologies

Corrective measure technologies for groundwater involve one of the following four options:

- Active treatment of the plume;
- Containment of the plume;
- Diversion of groundwater to mitigate the further contamination of "clean" groundwater; and
- Prevention of leachate formation by lowering the groundwater table beneath a source of contamination.

Based on these corrective action options, groundwater corrective measure technologies are generally classified in the following groups:

- Groundwater extraction;
- Groundwater on- and off-site treatment;
- Subsurface containment;
- In situ treatment; and
- Groundwater disposal.

Groundwater corrective measure technologies are presented below.

3.2.1 Groundwater Extraction

Groundwater extraction involves the active manipulation and management of groundwater in order to contain or remove a plume or to adjust groundwater levels in order to prevent formation of a plume. Groundwater extraction can be achieved by using the following:

- **Extraction Wells.** Extraction wells can be used to withdraw groundwater from shallow, unconfined aquifers or from deep aquifers located at depths of up to several hundred meters. The groundwater extraction system may consist of a number of closely spaced shallow wells that are connected to a main header or a network of wells, with each well built to house a submersible pump. Extraction wells are designed so that the drawdown and well spacing are sufficient to intercept the plume of hazardous contaminants or that groundwater does not contact contaminated materials. Frequently, extraction wells are used in combination with injection wells, where the hydraulic gradient is relatively flat, hydraulic conductivities are only moderate, and contaminants are not or slightly miscible with water.

- **Subsurface drains** include any type of buried conduit used to convey and collect groundwater by gravity flow. Subsurface drains essentially function like an infinite line of extraction wells. They create a continuous zone of influence in which groundwater within this zone flows toward the drain. Therefore, subsurface drains can be used to contain or remove a plume, or to lower the groundwater table to prevent contact of water with the waste material. Frequently, subsurface drains are used together with a barrier wall to preferentially collect contaminated groundwater.

- **Horizontal wells** are an alternative to conventional vertical well system. Horizontal wells or directional wells are positioned horizontally or at an angle by using specialized directional boring equipment including wireline coring rigs, hydraulic thrust systems, electric cone penetrometers, steering tracking hardware, and push coring systems (EPA 1994). Hydraulically activated thrust equipment capable of exerting more than 40 tons of thrust is used to push the directional boring heads into the earth. A single horizontal well can recover very large volumes of water in a more timely manner as compared to a vertical well system. Additionally, horizontal wells can reach areas of the aquifer that are otherwise inaccessible to vertical well systems (for example, beneath a waste management unit, or contamination plume beneath an existing building).

3.2.2 Subsurface Containment

Subsurface containment is a technology that adopts hydraulic barriers in the subsurface environment to intercept the groundwater flow. Hydraulic barriers serve the function of diverting groundwater so that it does not contact waste materials and become contaminated, and/or mitigate contaminated groundwater from migrating off site. Subsurface containment includes the following technology types:

- Slurry walls;
- Liner panel walls;
- Jet grouting; and
- Sheet piling.

These technologies are presented below.

Slurry Walls

Slurry walls are nonstructural barriers constructed to intercept and impede the groundwater flow. This barrier can be used both to redirect the groundwater leaving the site on the downgradient side and to contain groundwater leaving the site on the downgradient side. Slurry walls are commonly constructed using either a soil-bentonite or cement bentonite slurry.

Liner Panel Walls

Liner panel walls consist of high-density polyethylene (HDPE) sheets welded to a locking profile, which are installed with a vibratory hammer and insertion plate. Each panel wall is interlocked with each proceeding panel by an HDPE interlock system with a hydrophilic gasket. HDPE provides long-term durability against chemical attack by a variety of chemicals in the subsurface environment. Liner panel walls can be constructed to reach a depth of up to 100 feet. However, it is not possible to drive the sheets through cobbly or bouldery soils, gravels, and other well-compacted dense material.

Jet Grouting

Jet grouting is, in general, the pressure injection of one of a variety of special fluids into a rock or soil body to seal and strengthen it. Once in place, the fluids set or gel into the rock or soil voids, greatly reducing the permeability of and impacting increased mechanical strength to the grouted mass. Grouting is best suited for sealing voids in rocks. Because of costs, grouted barriers are seldom used for containing groundwater flow in unconsolidated materials around hazardous waste sites. Cement, clays, bentonite, alkali silicates, and some organic polymers have been used as grouts.

Sheet Piling

Sheet piling can be made of wood, precast concrete, or steel. Sheet piling are installed by driving interlocking piles into the ground with a pneumatic or steamdriven pile driver. Sheet piling walls have been installed in various types of soils providing long-term durability against chemical attack. Sheet piling serve the dual function of providing a barrier against seepage and soil retention.

3.2.3 On- and Off-Site Treatment

Potential groundwater treatment can be accomplished either on or off site using one of the following four general approaches:

- On-site treatment using mobile treatment systems;
- On-site construction and operation of treatment systems;
- Pretreatment followed by discharge to a publicly owned treatment works (POTW) facility; and
- Transportation of collected groundwater to an off-site treatment facility.

Treatment processes that may be incorporated into any of these approaches include the following.

Biological Treatment

Biological treatment processes are designed to expose contaminated media containing biologically degradable organic compounds to a suitable population of micro-organisms in an engineered environment that contains sufficient nutrients for biological growth to proceed.

Biological treatment is based on the ability of micro-organisms to use organic carbon as an energy source or to otherwise break down or transform the contaminants through the catalyzing actions of their enzymes. The treatment is classified as either aerobic, anaerobic, or facultative. Aerobic treatment requires the availability of free dissolved oxygen for the biochemical oxidation of the contaminants. Anaerobic treatment is intolerant of free dissolved oxygen; however, it does not lead to complete oxidation of contaminants to carbon dioxide and water. Facultative biological treatment can proceed under both the presence or absence of free dissolved oxygen. Typical biological treatment systems include activated sludge, sequencing batch reactors, aerobic or anaerobic fluidized bed reactors, rotating biological contactor, trickling filters or fixed-film reactors, and aerated lagoons.

In recent years, advanced research conducted in the field of microbiology has led to the development of biological treatment techniques for a variety of hazardous contaminants. For example, chlorinated organics like trichloroethene have been shown to be biologically oxidized by methanotrophic bacteria in the presence of oxygen and methane. This process is also referred to as co-metabolism. Co-metabolism is one form of secondary substrate transformation in which enzymes produced for the oxidation of the primary source of energy (substrate) are capable of degrading other organic species present in the medium, even though the other species (secondary substrates) do not afford sufficient energy to sustain the microbial population. However, a principal impediment to using this technique for treatment of chlorinated organics is the fact that contaminant removal by stripping occurs at levels comparable to rates of biodegradation.

Physical/Chemical Treatment

Physical/chemical groundwater corrective measures technologies include the following:

- **Carbon adsorption** is a phase-transfer technology, in which dissolved organic contaminants are transferred from the aqueous phase to the solid carbon phase. Carbon adsorption can be an effective process for the removal of a variety of dissolved organic compounds (for example, chlorinated pesticides, phenols, aliphatic chlorinated hydrocarbons, and aromatic such as benzene, toluene, and xylene). Carbon adsorption can be designed for either column or batch applications however, groundwater treatment generally utilizes carbon columns. In column applications, adsorption involves the passage of contaminated water through a bed of activated carbon, which selectively adsorbs the hazardous constituent onto the carbon. When the activated carbon has been used to its maximum adsorptive capacity (i.e., spent), it is then replaced by fresh supply and the spent carbon is disposed of, destroyed, or regenerated.

- **Air stripping** is also a phase-transfer process in which volatile organic contaminants are transferred to the vapor phase by pumping the contaminated groundwater through an air-stripping tower. The organic-laden vapor or air stream from the tower is then typically treated using carbon adsorption or vented to the atmosphere, depending on the concentration of organics. Besides an air-stripping tower, shallow-tray air strippers, diffused aeration, and jet stripping are also used for air-stripping operations.

- **UV/Ozonation** uses a combination of ultraviolet (UV) light and ozone to chemically oxidize organic contaminants in the groundwater. Organic contaminants may be completely oxidized to carbon dioxide, water, and hydrogen chloride or may be oxidized to a series of less-complex species that may be more amenable to treatment (for example, biological treatment). UV/ozonation is effective in the absence of suspended solids, turbidity, and other interfering organics. Occasionally, UV/ozone oxidation is supplemented by hydrogen-peroxide to enhance chemical oxidation.

- **Wet Air Oxidation** is a process whereby elevated temperatures and pressures are applied to the waste to oxidize the organic compounds completely to water, carbon dioxide, and hydrogen chloride (for chlorinated organics). Wet air oxidation is particularly well suited for treatment of organic compounds in aqueous waste streams that are too dilute to treat economically by incineration, and yet too toxic to be biologically oxidized.

- **Ion-exchange** is a phase-transfer process in which ionic species are transferred from the aqueous phase to the ion-exchange resin. Transferred ionic species in the aqueous phase are replaced by relatively harmless ions held by the ion exchange resin. Ion exchange process can be used to remove species like metals, chlorides, nitrates, sulfates and ammonium compounds from contaminated groundwater. The ion-exchange resin is "spent" after its ion-exchange capacity is exhausted. Ion-exchange resin can be easily regenerated by exposing the resin to a second aqueous solution of a different composition. A variety of ion-exchange materials are available (e.g., naturally and synthetically produced zeolites, and organic resins).

- **Membrane separation** technologies separate solutes or contaminants from liquids through the use of semipermeable membranes. Semipermeable membranes function by selectively rejecting contaminants based on pore size, charge, or through coprecipitation. Membrane separation technologies include ultrafiltration and reverse osmosis.

- **Filtration** is a physical process whereby suspended and particulate solids are separated from the groundwater by forcing the groundwater through a porous filtering medium. The porous medium may be a bed of granular material, fibrous fabric (e.g., cloth) or a screen. Fluid flow through the filtering medium may be accomplished by gravity, by inducing a partial vacuum on one side of the medium, or by exerting a pressure on one side of the medium. Filtration is typically used as a pretreatment process for air-stripping, carbon adsorption, or ion exchange to reduce the potential for clogging.

- **Sedimentation** is a physical process and is used to remove solids that are denser than water and materials less dense than water (for example, oil and grease). Polymers may be used in the sedimentation process to aid in the removal process. Settled solids are collected at the bottom of the process tank and lighter materials are skimmed off from the surface of the process tank.

- **Precipitation/coagulation/flocculation** process is used to remove colloidal and dissolved species from extracted groundwater. Precipitation converts soluble species (for example, metals) to their insoluble forms (for example, metal hydroxides) for subsequent removal. Coagulation involves the addition of chemical agents which enhance the removal process of precipitated species. Typical agents used for coagulation are alum, ferric chloride, sodium sulfide, and organic polymers. Flocculation involves the formation of floc particles that are large in size and are easy to be separated by processes like filtration or sedimentation.

3.2.4 In Situ Treatment

In situ treatment of contaminated groundwater allows groundwater to be treated without being brought to the surface. In situ treatment employs a combination of biological, physical, and chemical technologies, which are described below.

In Situ Bioremediation

As presented earlier, bioremediation refers to destruction techniques directed toward stimulating intrinsic microbial populations to grow and use the contaminants as a food and energy source by creating a favorable environment for the micro-organisms. Generally, a favorable environment is created by delivering a combination of oxygen, nutrients, or co-metabolites to the subsurface and controlling the groundwater pH and temperature within the optimum range. Occasionally, intrinsic microbial populations may be supplemented by microbial cultures that have been specially bred for degradation of a particular variety of contaminants. Co-metabolism and nitrate enhancement are two relatively new in situ biological treatment technologies, and are described below.

- **Co-Metabolism**. Co-metabolism has been used to biodegrade chlorinated chemical species like vinyl chloride and TCE. Co-metabolism is one form of secondary substrate transformation in which enzymes produced for primary substrate oxidation are capable of degrading the secondary substrate, even though the secondary substrate do not afford sufficient energy to sustain the microbial population. Using co-metabolism, methanotrophic bacteria utilize the injected dissolved methane and oxygen as a primary substrate, and also co-metabolize chlorinated compounds (i.e., vinyl chloride and TCE).

- **Nitrate Enhancement**. Nitrate enhancement relies on the greater solubility of nitrate in water as compared to oxygen solubility in water. Solubilized nitrate is circulated through groundwater contamination zones to provide electron acceptors for biological activity and enhance the rate of anaerobic biodegradation by naturally occurring microbes. Toluene, ethylbenzene, and xylene compounds are known to degrade under aerobic conditions as well as under anaerobic conditions. However, the rate of aerobic biodegradation is often limited by the inability to provide sufficient oxygen to the contaminated zones as a result of the low water solubility of oxygen (maximum 9.3 mg/L at standard temperature and pressure). Nitrates, on the other hand, have very high solubility and can be delivered efficiently to the subsurface environment.

In situ bioremediation systems for corrective measures for groundwater consist of supplying the above-described key elements to the subsurface environment, and monitoring of the subsurface environment for process control. The rate at which micro-organisms degrade contaminants is influenced by specific contaminants present, temperature, oxygen concentration, nutrient supply, pH, the availability of contaminants to the micro-organisms, and the concentration of contaminants and microbial growth inhibitors (e.g., mercury).

Air Sparging

Air sparging, an in situ technology, uses compressed air which is delivered to the subsurface environment at one or more air injection wells. Air bubbles emanating from one or more injection wells, traverse horizontally and vertically through the soil and water column, creating an in situ air-stripper that removes contaminants from the groundwater by volatilization. The air injection well may or may not be coupled with an air extraction well, positioned in the vadose zone. The air extraction well acts as a recovery well to capture volatilized contaminants. Because contaminants are removed by volatilization mechanisms, air sparging is applicable for VOCs and fuels. In a modification to the air-sparging technology, steam may be used to replace the compressed air. By using steam, higher temperatures can be achieved that enhance volatilization rates, making some semivolatiles amenable to this technology.

Passive Treatment Walls

Passive treatment walls use trenches filled with reactive permeable medium to act as an in situ reactor, allowing the groundwater plume to passively move through the wall. These walls allow the passage of groundwater while prohibiting the movement of contaminants by employing agents such as chelators, sorbents, catalysts, or microbes. In the passive treatment wall, contaminants will either be destroyed, chemically transformed to a less mobile form, or retained in a concentrated form by the barrier material.

Vacuum Vapor Extraction

In vacuum vapor extraction (well air stripping), compressed air is injected into a specially constructed injection/extraction well. Pressurized air lifts contaminated groundwater inside the well cover, allowing additional groundwater to flow into the well. Strippable contaminants are volatilized inside the well and are transferred to the air phase, which is collected at the top of the well. Partially treated groundwater is forced into the unsaturated zone, and the process is repeated. As groundwater circulates through the treatment system in situ, contaminant concentrations are gradually reduced. Collected air in the well is passed through an on-site treatment unit comprised of, for example, activated carbon or is vented to the atmosphere.

3.2.5 Disposal

Corrective measure technologies available for groundwater disposal include the following:

- **Disposal at a Treatment, Storage, and Disposal Facility (TSDF).** Extracted groundwater may be collected on site, pre-treated (if necessary), and disposed of at a RCRA-permitted TSDF.

- **Disposal to Surface Water.** Extracted groundwater may be discharged to a surface water body after treatment (for example, Cayuga Creek). Disposal to surface water bodies requires a State Pollution Discharge Elimination System (SPDES) permit.

- **Disposal to POTW.** Direct discharge to a POTW may be appropriate for extracted groundwater containing concentrations of contaminants that are amenable to treatment provided by the POTW. Pretreatment may be required for contaminants that are not acceptable by the POTW. Discharge to a POTW may occur by transporting collected groundwater to the POTW or by discharge of collected groundwater into a sewer.

- **Reinjection to Groundwater.** Extracted groundwater after treatment may be reinjected into the aquifer from which it was withdrawn. Reinjection can also help to direct the flow of contaminants towards the extraction wells or recovery trenches.

3.3 Surface Water Corrective Measure Technologies

Corrective measure technologies that may be appropriate for contaminants in surface waters are described in this section. Surface water corrective measure technologies can be grouped into the following categories:

- Source control; and

- Treatment.

3.3.1 Source Control

Source control corrective measures technologies aim to curtail additional releases of hazardous constituents. This may be achieved by the following:

- **Grading** refers to actions that are used to alter the topography and runoff characteristics of a site. Grading includes excavation, spreading, and compaction. Grading may be performed in order to achieve increased surface runoff and decrease infiltration and ponding. This type of action is designed to prevent surface runoff from contacting wastes or contaminated media.

- **Capping** refers to low permeable surface barriers and are commonly used in conjunction with grading and diversions so that the maximum amount of surface water will run off. Capping will also prevent the contamination of surface runoff by eliminating contact with contaminated media or by the erosion of contaminated media with surface runoff. Capping is described in detail in Section 3.1.

- **Diversion and collection** of surface waters away from a site can prevent runoff contamination and direct contact with contaminated media. Diversion and collection includes dikes, berms, channels, chutes and down pipes. Dikes and berms are compacted earthen ridges or concrete structures used to divert or contain surface water flow and can be used to control floodwater and runoff. Channels, chutes and down pipes are used to convey concentrated flows of surface water using gravity flow.

3.3.2 Treatment

Water removed from a surface water body may be treated to separate contaminants from water and/or to transform hazardous compounds to inert or less toxic compounds. A combination of physical, biological, or chemical treatment technologies (described in detail in Section 3.2) may be adopted for surface water treatment.

Table 3-1

CORRECTIVE MEASURE TECHNOLOGIES
IRP SITES 3, 10, AND 13
NIAGARA FALLS IAP-ARS

Media	Corrective Measure Technology
Soil/fill and Sediment	Capping
	Consolidation
	Excavation
	Dredging
	On- and off-site disposal
	On- and off-site treatment Thermal treatment Thermal desorption Physical/chemical treatment Biological treatment
	In-situ treatment Soil flushing In-situ bioremediation In-situ solidification/stabilization Soil vapor extraction In-situ vitrification In-situ radio-frequency heating In-situ steam-enhanced vacuum extraction Pneumatic fracturing
Groundwater	Groundwater extraction
	Subsurface containment
	On- and off-site treatment Biological treatment Physical/chemical treatment
	In-situ treatment In-situ bioremediation Air sparging Passive treatment walls Vacuum vapor extraction
	Disposal

Table 3-1

CORRECTIVE MEASURE TECHNOLOGIES
IRP SITES 3, 10, AND 13
NIAGARA FALLS IAP-ARS

Media	Corrective Measure Technology
Surface Water	Source Control
	Treatment

SITE 3

4 Corrective Measures Study—Site 3

4.1 Identification and Development of the Corrective Measure Alternatives

The objective of this section is to identify the corrective measure technologies for each medium of interest that will eventually be screened and assembled into the corrective measure alternatives. Consistent with the scope of work under the corrective action requirements of the draft hazardous waste storage permit, the process of developing, selecting, and assembling alternatives consists of the following steps:

- Updating the information describing the current site conditions and the known nature and extent of contamination as documented by the RFI reports.
- Developing corrective action objectives specifying the constituents of concern and the medium of interest.
- Identify and screen the technologies applicable to each medium of interest to eliminate those technologies that cannot be implemented.
- Assemble the selected representative technologies into the appropriate alternatives.

This section describes the current conditions, establishes preliminary cleanup goals based on protection of human health and the environment, presents the corrective measure technology screening, and includes a detailed evaluation of the alternatives retained from the screening process.

4.1.1 Description of Current Conditions

4.1.1.1 Site Description

Site 3 is an inactive landfill located on the eastern side of the installation in a gently sloping, grassy area with several small trees (see Figure 4-1). The landfill extends beyond the installation's eastern boundary onto Niagara Frontier Transit Authority (NFTA) property. Access to Site 3 is limited by a 4- to 6-foot-high, chain-link fence that borders the landfill's eastern boundary.

The landfill operated from the early 1950s until 1969. Originally, the landfill was a depressed, marshy area adjacent to Cayuga Creek. It was reportedly filled to a thickness of 8 to 10 feet with solid wastes and potentially hazardous wastes, which were sporadically burned. Burning ceased in 1966 and subsequent wastes were disposed along the southern edge of the landfill. In 1969, the landfill was regraded, capped with topsoil, and seeded (USAF 1994).

The RFI conducted at Site 3 defined the boundaries of the landfill (E & E 1995). The landfill has an areal extent of 9.4 acres, of which approximately 7.5 to 8 acres appear to consist of soil/fill, i.e., disturbed or regraded soil containing small amounts of debris with fill thicknesses ranging to over 8 feet. In addition to the RFI, E & E performed a supplemental investigation in October 1995 to determine the extent of contamination in an area on the landfill near the intersection of Kinross Street and Utzig Drive. A saturated black material was encountered in this area during utility pole installation in August 1995.

The geology of Site 3 can be summarized as having a relatively thin overburden cover made up of fill material, lacustrine sediments, and glacial till on top of a fractured dolostone bedrock. A generalized geologic cross section of Site 3 is presented in Figure 4-2. The overburden ranges in thickness from approximately 3 feet in the south and southeast portion of the site near Cayuga Creek to approximately 14 feet in the northwest corner of the site. Two wells (MW3-6D and MW3-1E) installed during the RFI in the upper and deep bedrock water-producing zones show that the upper portion of the bedrock is relatively highly fractured to a depth of approximately 10 feet below bedrock surface. Below this region, fractures are less abundant and less significant. Hydraulic conductivities as measured by the slug test are an average of 5×10^{-4} centimeters per second (cm/sec) for the overburden, 1×10^{-3} cm/sec for the shallow bedrock, and 6×10^{-3} cm/sec for the deep bedrock.

Overburden and shallow bedrock aquifer contours in the vicinity of the site are presented in Figures 4-3 and 4-4, respectively. Based on the overburden contours, a general groundwater flow to the southeast can be interpreted with a gradient of 2.4 feet per 100 feet. The contours of the shallow bedrock aquifer potentiometric surface (see Figure 4-4) show a very flat surface with a slight gradient to the southeast, south, and southwest. Groundwater elevation data recorded at the site indicate that seasonal changes do not seem to affect the groundwater flow characteristics at the site (E & E 1995).

The flow rate in Cayuga Creek near monitoring well location MW3-3 was 0.3 cubic feet per second (ft^3/sec) with a average depth of flow of 0.63 foot and mean flow velocity of 0.04 foot per second (ft/sec), which are probably representative of low-flow conditions (SAIC 1991). Flow rates of 0.735 ft^3/sec have been reported by the United States Geologic Survey (USGS) at the station just east and upstream of the MW3-3 location (SAIC 1991). The stream bed consists of exposed dolomitic bedrock with occasional thin patches of lag sands and gravels along most of the length of Cayuga Creek in the vicinity of Site 3 (SAIC 1991).

4.1.1.2 Site-Wide Contamination Summary

As part of the RFI, various field activities were completed to characterize the nature and extent of contamination associated with the site. Samples were collected from the following media:

- Soil gas (as part of the installation-wide groundwater monitoring project);
- Subsurface soils from the borings on and around the site;
- Groundwater from monitoring wells on and around the site;
- Surface water from Cayuga Creek; and
- Sediments from Cayuga Creek.

There is no leachate seepage from the surface of the landfill. Any leachate that may be produced is uncontrolled and released to groundwater.

Figure 4-1 shows monitoring wells, RFI sampling locations, and locations of the 16 boreholes that were drilled as part of the supplemental sampling in October 1995. Tables 4-1 through 4-4 summarize contaminants detected at the site during the RFI sampling and during the supplemental investigation.

Soil Gas

The soil gas survey results indicate the presence of a number of volatile emissions in the vicinity of the landfill. Low levels and limited distributions of TCE, PCE, trichloroethane (TCA), BTEX, and total petroleum hydrocarbons (TPH) were detected at the site. Most of the soil gas response levels were found to be low and representative of background concentrations. Soil gas survey results reveal that most of the responses are isolated and generally located outside the suspected landfill boundary. The most prevalent responses were for contaminants (i.e., BTEX, PAHs) that are typically found at Air Fore installations. Furthermore, based on the low levels of contamination detected in soil and groundwater samples (presented later in this section), it can be concluded that the low soil gas response levels do not appear to be directly related to the landfill.

Subsurface Soils and Fill

Site 3 was originally a depressed, marshy area adjacent to Cayuga Creek. Wastes disposed of in this landfill include garbage, ash from coal stores, waste oil, shop wastes, batteries, and scrap electrical parts. During road construction at the Walmore Road entrance gate, car parts, construction debris, and a flowing black material were discovered (USAF 1994).

The boundaries of the landfill were identified using aerial photos, geophysical investigations, test pits, soil borings, and existing and new monitoring well borings. A geophysical survey conducted at the site detected various magnetic anomalies at the site, indicating that various large ferrous objects may be buried in the landfill (E & E 1995).

As part of the RFI, fifteen pits were excavated on and around the landfill. The fill encountered in test pits consisted primarily of disturbed soil with occasional fragments of wood, ceramic drain tile, nails, and glass fragments. Some of the test pits exhibited soil over or mixed with black carbonaceous fill/slag. This soil/fill appeared to be construction spoils spread in this area after being excavated from other areas of the installation. All 16 borings drilled as part of the supplemental investigations were saturated. The dark material encountered in these borings was dark gray to black and ranged from gray-to-black sticky clay to a mixture of black sewage/oily material with soil.

During the RFI, twelve subsurface soil samples were collected for the purpose of assessing the lateral and vertical extent of landfilled material and to assess the environmental impact associated with landfill operations at the site. In addition, three subsurface samples were collected as part of the supplemental investigation. Table 4-1 provides a summary of RFI and supplemental investigation sampling results. Of the 12 samples collected during the RFI, only one soil sample, SB3-7, contained VOCs (carbon tetrachloride, chloroform, and TCE) above the soil guidance values presented in NYSDEC Technical and Administrative Guidance Memorandum (TAGM) 4046, which were used as benchmarks for screening site soil analytical data. Sample SB3-7 was collected at a depth of 6 to 9.5 feet BGS from the northeast corner of the landfill. Trace amounts of other VOCs were detected in these and some other samples, but at levels below the guidance values. Of the three samples collected during the supplemental investigation, none exceeded TAGM 4046 guidance values for VOCs.

None of the RFI samples exceeded TAGM 4046 guidance values for base neutral/acid extractables (BNAs). Of the three samples collected during the supplemental investigation, only one soil sample, SB3-13, contained BNAs (benzo[a]anthracene, benzo[b]fluoranthene, benzo[a]pyrene, chrysene, and dibenzo[a,h]anthracene) above the TAGM 4046 guidance values.

The duplicate of the RFI sample SB3-1 contained 0.297 μg/kg of 1, 2, 3, 6, 7, 8, 9-OCDD, a polychlorinated dibenzo-p-dioxin/polychlorinated dibenzofuran (PCDD/PCDF) compound. Duplicate SB3-1 was collected from a depth of 4 to 8.3 feet BGS. Supplemental investigation samples, SB3-S0, SB3-13-S0, and SB3-16-S0, also contained low levels of various PCDD/PCDF compounds. However, no guidance values are provided for PCDD/PCDF compounds in TAGM 4046.

As per TAGM 4046, site background levels are used to determine soil guidance values for metals. The site background metals concentrations were determined by using the upper limit of the 90th percentile of metals concentrations of eastern United States soils and other surficial materials calculated from the data of Shacklette and Boerngen (1984) (except for cadmium; cadmium concentrations are not reported by Shacklette and Boerngen). For cadmium, the guidance value was determined by using the higher end (7 mg/kg) of the range of the observed values (0.01 to 7 mg/kg) published by Dragun (1988). Zinc, selenium, lead, and mercury were detected above the site background levels in a total of 10, six, three, and one samples, respectively. Metals analyses was not performed on samples collected during the supplemental investigations.

Samples collected as part of the RI/FS (SAIC 1991) did not contain VOCs at levels exceeding TAGM 4046 values. Samples collected during the RI/FS (SAIC 1991) were not submitted for semivolatile analyses; therefore, no comparison can be made. Of the metals, zinc and lead exceeded the corresponding site background levels.

Groundwater

During the RFI, unfiltered groundwater samples were collected from 10 wells including eight existing wells and the two new installed wells. No groundwater samples were collected as part of the supplemental investigation conducted at the site. A summary of the RFI sampling results are presented in Table 4-2. Of the total 10 wells at the site, five wells are screened in the overburden, four are screened in the shallow bedrock, and one well is screened in the deep bedrock at the site. NYSDEC Class GA groundwater standards were used to evaluate analytical data.

VOCs and semivolatiles were not detected in any overburden well sampled at the site. Polychlorinated biphenyls (PCBs) (Aroclor 1254) were detected in one overburden well (MW3-1) at a concentration above the NYSDEC Class GA standard. Lead was detected above NYSDEC Class GA standard in three of the five overburden wells (MW3-1, MW3-2, and MW3-6A). Zinc was detected above the NYSDEC Class GA standard only in one overburden well (MW3-6A).

Semivolatiles were not detected in any shallow bedrock wells at the site. VOCs (carbon tetrachloride, chloroform, cis-1,2-dichloroethene, methylene chloride, toluene, and TCE) above the NYSDEC Class GA standards were detected in only one shallow bedrock well (MW3-3). Vinyl chloride was detected above the NYSDEC Class GA standards in two shallow bedrock wells (MW3-3 and MW3-4). Lead and zinc were the only metals detected above NYSDEC Class GA standards in two of the four shallow monitoring wells (MW3-3 and MW3-6A).

Groundwater sampling in the deep bedrock well at the site did not detect any VOCs, semivolatiles, or PCBs. Of the metals, only zinc and lead were detected. However, the levels are below NYSDEC Class GA standards.

In previous investigations, VOCs and metals have been detected above the Class GA standards in monitoring wells at the site. The following VOCs exceeded Class GA standards: TCE, vinyl chloride, carbon tetrachloride, chloroform, trans-1,2-dichloroethene, and benzene. Of the metals, the following exceeded the Class GA standards: cadmium, chromium, copper, lead, and zinc.

Surface Water

Three surface water samples were collected from Cayuga Creek: one as a background sample (SW3-1), one upstream of the site (SW3-2), and another downstream of the site (SW3-3). A summary of the RFI sampling results is presented in Table 4-3.

NYSDEC Class C surface water standards were used to screen analytical data. The best usage of Class C surface waters is fishing, so these waters will be suitable for fish propagation and survival (6 NYCRR, Part 701). The Class C standards are further designated as to "Type." For Class C waters, standards for protection of human consumption of fish, designated as Type Health (Bioaccumulation) and noted by H(B) were used for screening analytical data. Where Type H(B) Class C standards were not available, Type A Class C standards for protection of fish propagation and for wildlife consumption were used.

VOCs were not detected in any of the surface water samples. The semivolatile compound (bis[2-ethylhexyl]phthalate) was detected above the NYSDEC Class C standard in two surface water samples (SW3-1 and SW3-3). This compound is not considered site-related contamination (E & E 1995). Zinc was the only metal above the NYSDEC Class C surface water standards.

In previous investigations, no semivolatiles were detected in any surface water samples collected from the site. The metals arsenic and zinc were detected; however, only zinc exceeded the NYSDEC Class C standards. Three VOCs, chloroform, tetrachloroethene, and trichloroethene were detected in Cayuga Creek. These VOCs were detected only once during the July 1993 sampling round (GZA 1993b). However, none of the VOCs exceeded the NYSDEC Class C standards (there are no Class C standards for chloroform, tetrachloroethene, and trichloroethene).

Sediments

Three sediment samples were collected: background (SD3-1), upstream of the site (SD3-2), and downstream of the site (SD3-3). A summary of the RFI sampling analytical results are presented in Table 4-4. Sediment analytical results were compared to lowest and severe effect levels as developed by Persaud *et al.* (1992) and Long and Morgan (1990) and presented in NYSDEC's Technical Guidance for Screening Contaminated Sediments (1993).

Only one sediment sample (SD3-1, the background sample) contained the polynuclear aromatic hydrocarbons (PAHs) phenanthrene and anthracene above the corresponding lowest effect levels. No other organic compounds exceeded guidance values in any of the sediment samples. Metals concentrations exceeded the lowest effect levels for cadmium (in samples SD3-1 and SD3-2 [upstream sample]), and lead (in SD3-2). In addition, all three sediment samples exceeded the lowest effect levels for silver and zinc. However, none of the sediment samples contained analytes at concentrations exceeding the severe effect levels.

In previous investigations, no semivolatiles were detected in sediment samples collected from the site. One VOC, methylene chloride, was reported at 14 μg/kg during the June 1992 sampling round (GZA 1992). The metals cadmium, lead, nickel, and zinc exceeded their corresponding lowest effect levels.

4.1.1.3 Current and Potential Exposure Pathways

The current and potential exposure pathways to human and environmental receptors at Site 3 that need to be addressed by the CMS were identified in the work plan (E & E 1995) and are presented below:

- Ingestion of groundwater and ingestion/adsorption of site soils by installation personnel; and

- Exposure of flora and fauna in Cayuga Creek to site-related contaminants.

4.1.2 Establishment of Corrective Action Objectives

Contamination at Site 3 is present in the following media: soil, groundwater, surface water, and sediment. Corrective action objectives (CAOs) protective of human health and the environment were established for each media by comparing observed concentrations to existing standards and guidance. The site cleanup objectives were then used to identify areas requiring corrective action and in selecting and evaluating corrective action alternatives (see Sections 4.2 and 4.3, respectively). Site cleanup objectives were developed for all contaminants detected during the RFI as well as all previous investigations conducted at Site 3.

4.1.2.1 Soils

The soil guidance values presented in NYSDEC TAGM 4046, dated January 24, 1994, were evaluated as potentially applicable for determining soil cleanup objectives for the site soils and fill material. Using TAGM 4046 is a conservative approach to determining soil cleanup objectives. According to the TAGM, attainment of the recommended generic soil cleanup objectives will, at a minimum, eliminate all significant threats to human health and/or the environment posed by the inactive hazardous waste site. TAGM values for organic compounds are set considering the following:

- Human health-based levels that correspond to excess lifetime cancer risks of one in a million for Class A (proved human carcinogens) and Class B (probable human carcinogens) carcinogens, or one in 100,000 for Class C (possible human carcinogens). These levels are calculated assuming a generic exposure route and are contained in the EPA Health Effects Assessment Summary Tables (HEASTs), which are compiled and updated quarterly by NYSDEC;

- Human health-based levels for systemic toxicants, calculated from Reference Doses (RfDs). RfDs are an estimate of the daily exposure an individual (including sensitive individuals) can experience without appreciable risk of health effects during a lifetime. A generic scenario of exposure in which children ages one to six using an intake rate of 0.2 gram of soil/day for a five-year exposure period for a 16-kg child is assumed;

- Soil concentrations that are protective of groundwater/drinking water quality, based on promulgated New York Sate Class GA groundwater standards. A water/soil partitioning model is used to determine these soil concentrations. The model used is conservative in nature, and predicts the maximum amount of contamination that may remain adsorbed in soil so that leachate from the contaminated soil will not violate groundwater standards. A correction factor of 100 is used to establish soil cleanup objectives to account for various mechanisms that occur during transport and may work simultaneously and include the following: volatility, sorption and desorption, leaching and diffusion, transformation and degradation, and change in concentration of contaminants after reaching and/or mixing with the groundwater table. Soil cleanup objectives are calculated by multiplying the allowable soil concentration by the correction factor. In addition, soil cleanup objectives are limited to the following maximum values:

- Total VOCs - ≤ 10 ppm.
- Total semivolatiles - ≤ 500 ppm.
- Individual semivolatiles - ≤ 50 ppm.
- Total pesticides - ≤ 10 ppm.

- Background values for contaminants; and
- Detection limits.

The TAGM recommends using the most stringent cleanup level using human health and groundwater quality criteria for organic chemicals, and human health and background criteria for heavy metals. If the health-based criteria are below the background level for a contaminant, background value should be used as the cleanup objective. However, cleanup objectives developed using this approach must be, at a minimum, above the method detection limit (MDL).

This approach is not used for heavy metals, which do not partition appreciably into soil organic matter. According to the TAGM, eastern United States or New York State soil background values may be used as soil cleanup objectives for heavy metals. Soil background data near the site, if available, is preferable and should be used as the cleanup objective for such metals.

The current and potential exposure routes at Site 3 consist of ingestion/adsorption of site soils by installation personnel. Contaminants from site soils and fill material are leaching into the groundwater, a potential future source of drinking water. Soil/fill contaminants observed at the site have also been detected in groundwater. Therefore, the above alternative bases of TAGM 4046 (i.e., human exposure scenarios and leaching mechanisms of contaminants from soil to groundwater) are applicable to Site 3. For most organics, the guidance values listed in TAGM 4046 are based on leaching to groundwater. For many sites, the generic leaching model may overestimate the amount of contaminants transferred to the water, even with the use of the 10^2 recommended correction factor. However, Site 3 contaminated soils are located directly in the water table, and the same contaminants found in the soils are also found in adjacent groundwater. Because of these conditions, TAGM 4046-recommended soil cleanup objectives will be used as soil cleanup objectives at Site 3.

TAGM 4046 does not provide soil cleanup objectives for some chemicals, including 1,1,2,2-tetrachloroethane, cis-1,2-dichloroethene, carbazole, and PCDD/PCDF compounds. For such chemicals, EPA Region III risk-based concentrations (RBCs) (dated March 7, 1995) were used. Region III RBCs have been calculated by EPA Region III for nearly 600 chemicals. These toxicity constants have been combined with generic exposure scenarios to calculate chemical concentrations corresponding to a hazard quotient of 1 or lifetime cancer risk of 10^{-6}, whichever occurs at a lower level.

The area occupied by the site has been classified as an "industrial" functional land use area under the Management Action Plan (USAF 1994). The industrial functional land use category is defined as areas with civil engineering, transportation, non-destructive investigation, laboratory, and supply uses. Therefore, the RBCs selected were for industrial soils. The RBC calculations are based on adult occupational exposure.

According to TAGM 4046, site background levels were used to determine soil cleanup objectives for metals. The site background metals concentrations were determined by using the upper limit of the 90th percentile of metals concentrations in eastern United States soils and other surficial materials (calculated from the data of Shacklette and Boerngen 1984). The study conducted by Shacklette and Boerngen (1984) does not report values for cadmium. For cadmium, the cleanup objective was determined by using the higher end (7 mg/kg) of the range of the observed values (0.01 to 7 mg/kg) published by Dragun (1988).

Although the evaluation criteria are for soils, the associated human exposure mechanisms and leaching mechanisms are also applicable for fill material consisting predominantly of construction debris found at the site (E & E 1995). Therefore, TAGM 4046 soil cleanup objectives will be also used for fill material at Site 3.

Table 4-5 lists all the detected contaminants in all the investigations conducted at the site, the maximum concentration detected, and soil cleanup objective. A site soil cleanup objective is established for a contaminant if its maximum concentration was higher than the soil cleanup objective. Figure 4-5 shows RFI and supplemental investigation soil samples above site cleanup objectives. Based on Table 4-5, the following was concluded:

- For the RFI sampling results, only four metals (lead, mercury, selenium, and zinc) exceeded the soil cleanup objectives. Only lead and zinc were present above the soil cleanup objectives in the earlier investigations (SAIC 1991). The frequency of exceedance of each metal at the site is provided in Table 4-10. The bedrock at the installation is the Lockport dolomite. Pyrite (iron sulfide), sphalerite (zinc sulfide), and galena (lead sulfide) particles and other minerals and mineral complexes are disseminated throughout the dolomite (SAIC 1991). Thus, the metals lead and zinc are believed to be naturally existing at the site. (Appendix A compares soil metals data at Site 3 with other sites at the installation and further supports this explanation.) Mercury exceeded the soil cleanup objectives only in one sample out of the 10 samples collected during the RFI. Mercury was not detected in earlier investigations. Based on the low frequency of exceedance, mercury contamination will not be addressed in the CMS. Selenium exceeded the soil cleanup objectives in six samples out of the 10 samples collected during the RFI. Selenium was not detected in earlier investigations. The range of detection of selenium was 0.59 mg/kg to 3.5 mg/kg. The cleanup objective for selenium is 0.941 mg/kg, which is the upper limit of the 90th percentile of metals concentrations in eastern United States soils and other surficial materials (calculated from the data of Shacklette and Boerngen 1984). For comparison purposes, the EPA RBC of selenium for industrial soils is 5,100 mg/kg and for residential soils is 390 mg/kg. Based on the low levels of selenium concentrations detected at site, selenium contamination will not be addressed in the CMS.

- None of the samples collected during the RFI (E & E 1995) exceeded the soil cleanup objectives for semivolatiles. Only one soil sample (SB3-13-SO) of the total three collected as part of the supplemental investigation exceeded the site cleanup objectives for semivolatiles (SVOCs). The SVOCs are: benzo(a)pyrene, chrysene, benzo(b)fluoranthene, benzo(a)anthracene, and dibenzo(a,h)anthracene. These compounds are polyaromatic hydrocarbons (PAHs) that are widely found in urban and rural settings due to wide variety of human activities, and are not necessarily due to waste disposal activities. As presented earlier, site cleanup objectives for these compounds are protective of the groundwater/drinking water quality based on the water/soil partitioning theory. However, none of these compounds were detected in the groundwater samples collected at the site. In addition, none of the soil samples collected during the RFI exceeded the soil cleanup objectives. In earlier studies, SVOCs were not analyzed. Based on the low SVOCs exceedance frequency, probable SVOCs presence due to wide variety of human activities, and the absence of SVOCs in groundwater samples collected from the site, no corrective actions are recommended for SVOCs contamination of site soils.

- PCDD/PCDF compounds were detected in three of five soil samples collected from the landfill that were analyzed for PCDDs/PCDFs.. The 2, 3, 7, 8—TCDD equivalent concentrations detected in the three samples ranged from 0.024 μg/kg to 0.129 μg/kg, the higher end of which is approximately three times EPA Region III's risk-based concentration (RBC) for 2,3,7,8-TCDD in soil in an industrial setting (0.04 μg/kg). Note that the industrial soil RBC is based on an assumption of everyday worker exposure (250 days per year for

25 years), far greater than any exposure that would realistically be expected given the location of the contamination in subsurface soil within the landfill boundaries. Based on the low concentrations detected in landfill soils and the low likelihood of exposure, PCDD/-PCDF compounds appear to pose negligible health risks. In addition, PCDD/PCDF compounds were not detected in the groundwater samples collected at the site. Therefore, no corrective actions are recommended for PCDD/PCDF contamination of site soils. However, under the Installation-wide Groundwater Monitoring Program, groundwater from several select wells will be analyzed periodically for PCDD/PCDF compounds.

- None of the analytical results for samples collected during the supplemental investigation exceeded the site cleanup objectives for PCBs. PCBs analyses were not conducted during previous investigations.

- Only three VOCs, carbon tetrachloride, chloroform, and TCE, exceeded the soil cleanup objectives. Only one RFI sample (SB3-7) collected and analyzed for VOCs exceeded the objective. This sample was collected in the northeast corner of the landfill at a depth of 6 to 9.5 feet below ground surface. In soil samples collected during the RI/FS (SAIC 1991), the only VOCs detected were methylene chloride and acetone. The levels are, however, below the TAGM 4046 soil cleanup objectives. As mentioned above, no semivolatile analyses were conducted during the RI/FS. Based on the limited analyses conducted during the RI/FS, there was no sample results exceeding the TAGM 4046 soil cleanup objectives.

- One sample (SB7-7) exceeded the TAGM 4046 guidance limit in total VOCs of 10 ppm.

One sample (SB3-7) exceeding cleanup objectives for VOCs is not considered to be a significant source of groundwater contamination and pose any significant exposure concerns to human receptors. Rather, it would indicate an isolated pocket that would be too small to warrant or implement a soil remediation plan. Therefore, no corrective actions are recommended for soil contamination at Site 3.

Based on information collected during the RFI, the existing cover at the site effectively isolates all landfill waste materials. Of the total 9-acre areal extent of the landfill, approximately 7.5 to 8 acres apparently consist of soil/fill, i.e., disturbed or regraded soil containing small amounts of debris. At the site, cap materials include clay loam, loam, sandy loam, brown loam, sandy silt and clay, clay, slag, and disturbed soil, with thicknesses ranging from 6 inches to several feet. In addition, no surface water ponding or cracks in the cap materials, which could expose waste materials, have been observed at the site.

However, a regular maintenance program for the existing cover at Site 3 would preserve the integrity of the cover soils. This program would include at a minimum the following:

- Semiannual mowing, and semiannual inspections for cracks, water ponding, and soils erosion;

- Removal of existing trees and shrubs from Site 3, and these areas backfilled and seeded with grass; and

- Institutional controls implemented along with this program.

These actions for soil/fill media would be integrated with the other corrective measures for Site 3.

4.1.2.2 Groundwater

NYSDEC Class GA groundwater standards were used as the groundwater cleanup objectives. Although the groundwater at the installation is not currently used as a water supply source, it is suitable as a source of drinking water. For some chemicals, like carbon disulfide, chloromethane, 2-chloroethylvinylether, and nickel, NYSDEC Class GA standards are not established. EPA Region III RBCs for tap water criteria were used as groundwater cleanup objectives for such chemicals. In the RBCs, the toxicity constants for each chemical have been combined with generic exposure scenarios to calculate chemical concentrations corresponding to a hazard quotient of 1 or lifetime cancer risk of 10^{-6}, whichever occurs at a lower level. Therefore, by using the above-described groundwater cleanup objectives, the potential threat to human health arising from the potable use of groundwater at the site is eliminated.

Table 4-6 lists all the detected contaminants, maximum concentration detected, and groundwater cleanup objectives. A site cleanup objective was then established if the contaminant concentration was higher than the groundwater cleanup objective. Figure 4-6 shows RFI groundwater samples above groundwater cleanup objectives. Based on Table 4-6, the following was concluded:

- During the RFI sampling, only two metals, lead and zinc, exceeded the groundwater cleanup objectives. Lead exceeded the groundwater cleanup objective in 12 of 38 samples collected during the RI/FS

(SAIC 1991) and groundwater monitoring conducted at the site (GZA 1993, 1994). Zinc also exceeded the groundwater cleanup objective in nine of 38 samples collected during these investigations. Chromium, cadmium, and copper exceeded the groundwater cleanup objectives in four, one, and one samples, respectively, out of a total of 38 samples collected during the RI/FS and groundwater monitoring conducted at the site.

During the RFI, chromium did not exceed the groundwater objectives and was detected in one sample only. However, concentrations of metals in groundwater correlate with turbidity (field measured at site during RFI sample collection) at a 95% confidence level. Similar observations correlating turbidity with metals concentrations at a high confidence level were reported during the RI/FS and groundwater monitoring conducted at the site. Thus, it appears that observed metal concentrations in groundwater and soils are a natural occurrence and are believed to be attributable to the naturally occurring metals found in the suspended particulate clastic materials and not site-related contamination. (Appendix B compares groundwater metals data from other sites on the base and supports this view. Metals concentrations in filtered and unfiltered groundwater samples are also compared.) Thus, metals contamination of groundwater at the site will not be addressed in the CMS.

- No semivolatiles were detected in the groundwater samples. Therefore, no site cleanup objectives have been established. No semivolatiles were detected in earlier sampling conducted at the site.

- RFI groundwater samples exceeded the NYSDEC Class GA standards for carbon disulfide, carbon tetrachloride, chloroform, cis-1,2-dichloroethene, methylene chloride, toluene, trichloroethene, and vinyl chloride in one (except vinyl chloride) of 10 samples. Exceedance frequency for vinyl chloride was two samples out of 10. During the RI/FS and groundwater monitoring at the site, the following additional VOCs exceeded the Class GA standards: benzene and trans-1-2-dichloroethene. Site cleanup objectives for these VOCs are listed in Table 4-6. VOC contamination of groundwater at Site 3 will be addressed by appropriate corrective action.

- During the RFI, PCBs (Aroclor 1254) were detected at concentrations exceeding the groundwater cleanup objectives in only one of 10 samples collected at the site. Based on the low frequency of PCB detections in site groundwater, the CMS at Site 3 will not address groundwater PCB contamination. However, PCBs will be monitored periodically under the Installation-Wide Groundwater Monitoring Program.

In some cases, it may not be technically feasible to achieve through corrective actions the site groundwater cleanup objectives developed above. A well-designed corrective action system that has been operational for several years initially would lead to a decrease in groundwater contaminant concentrations. After a period, however, the concentration of contaminants may not decrease further. This condition, commonly referred to as "zero-slope," is often observed during corrective action implementation. Under such conditions, and if the groundwater contaminant concentrations are sufficiently low, the Base may petition the regulatory agencies for alternative concentration limits and a post-termination monitoring program. These issues are presented in detail in Section 4.4.

Corrective action appropriate for the contaminated groundwater at the site may consist of groundwater extraction, containment, in situ or ex situ treatment, and disposal. The applicable corrective measure technologies are identified and screened in Section 4.1.3.

4.1.2.3 Surface Water

Cayuga Creek is classified as a Class C surface water body. As per NYSDEC Part 701, the best usage of Class C waters is fishing and such waters shall be suitable for fish propagation and survival. The water quality for Class C water bodies shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes (6 NYCRR Part 701).

There are current and potential exposure pathways for flora and fauna in Cayuga Creek. No on-site recreational activities exist on the installation; however, access to Cayuga Creek is unrestricted as it enters and exits the base. Based on the exposure routes and the classification of Cayuga Creek as a Class C surface water body, NYSDEC Class C surface water standards were used as the surface water cleanup objectives for the Cayuga Creek.

Table 4-7 lists all the detected contaminants, maximum concentrations detected, and surface water cleanup objectives. The NYSDEC Class C standards, which are used as surface water cleanup objectives are further designated as to type. For Class C waters, standards for protection of human consumption of fish, designated as Type Health (Bioaccumulation) and noted by H(B) were used as surface water cleanup objectives for Cayuga Creek. Where Type H(B) Class C standards were not available, Type A Class C standards for protection of fish propagation and for wildlife consumption of fish were used. However, no Class C standards have been established for chloroform, tetrachloroethene, and trichloroethene. Class C, Type H(B) guidance values have been provided in 6 NYCRR for tetrachloroethene and trichloroethene.

Although guidance values have not been formally adopted as standards by NYSDEC, the adoption of guidance values as cleanup objectives for Site 3 surface waters would be protective for human consumption of fish. There are no NYSDEC Class C guidance value for chloroform. As per 6 NYCRR Part 701, both NYSDEC Class C and Class A surface water quality is suitable for fish propagation and survival and fishing. In addition, the best usage of Class C waters could be for drinking purposes. Hence, the Class A standard was used as cleanup objective for chloroform. The type of Class A standard for chloroform is Health (Water Source) for protection of sources of drinking water, and is designated as H(WS). A site cleanup objective was then established if a contaminant concentration was higher than the surface water cleanup objective. Figure 4-6 shows RFI surface water samples above the surface water cleanup objectives. Based on Table 4-7, the following was concluded:

- During the RFI sampling, zinc was the only metal that exceeded the cleanup objective; it exceeded the objective in all three samples collected. In earlier studies, zinc was also the only metal that exceeded the cleanup objective; it exceeded the objective in five of five samples. However, as was discussed earlier, zinc is considered to be naturally occurring at the site. Therefore, zinc in Cayuga Creek surface water will not be considered for corrective action.

- No VOCs were detected in any of the RFI surface water samples collected from Cayuga Creek. During the sampling round of July 1993, three VOCs, chloroform, tetrachloroethene, and trichloroethene were detected in one surface water sample collected from Cayuga Creek at Site 3. However, only tetrachloroethene exceeded the site cleanup objectives. A dry summer was experienced in Western New York during 1993. GZA reported the lowest water levels in monitoring wells at Site 3 during this sampling round. Because reduced flows in Cayuga Creek would diminish its dilution and mixing capacity, it is very likely that the VOCs were detected due to low flow conditions caused by the dry weather. The exceedance of tetrachloroethene will be addressed by appropriate corrective action.

- Only one semivolatile, bis(2-ethylhexyl)phthalate, was detected and exceeded the site cleanup objective at two of three samples collected during the RFI. Bis(2-ethylhexyl)phthalate detected at the low concentrations detected at the site is typically considered to be attributable to laboratory contamination arising from the use of rubber gloves. Therefore, surface water will not be considered for corrective action due to semivolatiles contamination.

Corrective action appropriate for Cayuga Creek at the Site 3 consists of source control. By implementing groundwater corrective action, VOCs release to the Cayuga Creek could be eliminated or minimized. The applicable groundwater corrective measure technologies are identified and screened in Section 4.1.3.

4.1.2.4 Sediments

Sediment screening criteria presented in the Technical Guidance for Screening Contaminated Sediments (NYSDEC 1993) was used as the cleanup objectives for sediments at the site. Consistent with the guidance document and other guidance documents as referenced below, the cleanup objectives are identified below.

Non-polar Organics

Non-polar organic compounds are substances that contain carbon and do not exhibit a net electrical (ionic) charge. For non-polar organics, the equilibrium partitioning (EP) theory was used to determine the sediment criteria in the guidance document. This is based on the approach that contaminants would partition from the sediments to the pore water. Water quality criterion developed to protect aquatic life from contaminants dissolved in the water column should also protect benthic life from contaminant concentrations dissolved in pore water (NYSDEC 1993). The four criteria are:

- Protection of human health from toxic effects of bioaccumulation;
- Protection of aquatic life from acute toxicity;
- Protection of aquatic life from chronic toxicity; and
- Protection of wildlife from toxic effects of bioaccumulation.

The guidance document lists 52 non-polar organic compounds for which sediment criteria has been provided. Thus, sediment criteria for the non-polar compounds detected at the site and listed in the guidance document are the respective cleanup objectives. The site sediment cleanup objectives were adjusted to the observed concentration of the average organic carbon in the sediments.

For non-polar organic compounds that are detected in the sediments but are not listed in the guidance document, the effect range-low summarized by Long and Morgan (1990) and listed in the guidance document were used as the site sediment cleanup objectives. The effect range-low, based on field studies, indicates a level of sediment contamination that can be tolerated by the majority of benthic organisms, but is still toxic to a few species.

For other non-polar compounds that are not listed by the above two sources, TAGM 4046 soil cleanup levels were used as the sediment cleanup objectives.

Polar Organics

The technical guidance does not list any sediment criteria for polar organics. Therefore, the effect level-low presented by Long and Morgan (1990) for polar organics are used as the site cleanup objectives. If a polar organic was detected at the site and is not listed by Long and Morgan (1990), TAGM 4046 soil cleanup objectives were used as the sediment cleanup objectives.

Metals

Lowest effect level for each metal as listed in the technical guidance was used as the sediment cleanup objectives.

Table 4-8 lists all detected contaminants, the maximum concentration detected, and sediment cleanup objectives. A site cleanup objective was then established if a contaminant concentration was higher than the sediments cleanup objective. Figure 4-5 shows RFI sediment samples above sediment cleanup objectives. Based on Table 4-8, the following was concluded:

- Only the metals cadmium, lead, nickel, silver, and zinc exceeded the sediment cleanup objectives. The metals lead and zinc are believed to exist naturally and are not considered to be site related. Silver was not detected in any other media at the site (soil, groundwater, and surface water). Therefore, it is apparent that the source of silver in the sediments is some other upstream facility. (It is known that other industrial facilities are located in the vicinity of the base and upstream of Site 3.) The background values for cadmium and nickel, which are based on the upper limit of the 90th percentile of metals concentration in eastern United States soils and surficial materials (calculated from the data of Shacklette and Boerngen 1984), is 7 mg/kg and 38.2 mg/kg, respectively. The maximum concentrations of cadmium and nickel in site sediments were 4.36 mg/kg and 21.2 mg/kg, respectively. These maximum concentrations are below the background levels. In addition during the RFI sampling, concentrations of cadmium and nickel in upstream sediments was higher when compared to the concentrations in downstream sediment samples. Based on these observations, cadmium and nickel contamination of sediments will not be addressed in the CMS. Therefore, metals contamination of sediments at the site will not be addressed in the CMS.

- None of the VOCs exceeded the site cleanup objectives.

- Three semivolatiles—benzo(a)anthracene, benzo(a)pyrene, and benzo(b)fluoranthene—exceeded the site cleanup objectives. PAHs at such low concentrations (56 to 310 μg/kg) are typical in urban and industrial areas. PAHs in site sediments may be attributable to the nearby railroad tracks and/or Walmore Road. Therefore, PAH contamination of sediments at the site will not be addressed in the CMS.

Based on the above discussion, it can be concluded from above that Cayuga Creek sediment quality has not been impacted by site-related activities.

A portion of Site 3 is located in the 100-year and 500-year floodplain of Cayuga Creek. It may be possible that during a flood, site soil and fill material on the site could be mobilized by the flood waters and introduced into Cayuga Creek as sediments.

To ascertain the possible impact on sediment quality during floods, the analytical results of three site soil/fill samples located in the floodplain portion of the site were compared to the sediment cleanup objectives used above. The soil/fill samples used were SB3-4, SB3-5, and MW3-1E. Figure 4-1 shows the location of the samples. Table 4-9 lists all the detected contaminants and sediment cleanup objectives. Based on Table 4-9, the following was concluded:

- Only two metals, cadmium and zinc, exceeded the sediment cleanup objectives. However, zinc is considered to be existing naturally. The background value for cadmium, which is based on the upper limit of the 90th percentile of metals concentration in eastern United States soils and surficial materials (calculated from the data of Shacklette and Boerngen 1984), is 7 mg/kg. The maximum concentration of cadmium in site soils located in the floodplains was 2.3 mg/kg. This maximum concentration is below the background value. In addition, there appears to be no widespread source of metals contamination at the site.

- No VOCs or semivolatiles exceeded the sediment cleanup objectives.

Based on these conclusions, during a 100-year or 500-year flood, no significant environmental impact to the Cayuga Creek is expected. Therefore, the CMS will not address sediment and soil/fill erosion issues for the site.

4.1.3 CMS Field Activities

As part of the CMS, additional field activities were conducted for selected corrective measure technologies identified in the CMS work plan (E & E 1995). In order to evaluate the effectiveness of groundwater extraction at Site 3, a pump test was conducted. This pump test was conducted at well MW3-5AA to determine well yield, well capture zone, and the concentration of inorganics and organics in groundwater during extraction. Two surface soil samples were collected and were tested to determine soil density, moisture content, plasticity indices, and grain-size distribution. To determine the applicability of subsurface containment at the site, two soil samples were collected and tested to determine the shear strength and bearing capacity of subsurface soils. Results of these field activities are presented in Appendix C. In addition, it was determined that the discharge from the storm water collection system is not located within the landfill, and, therefore, would not create any additional quantities of leachate.

4.1.4 Screening of Corrective Measures Technologies

In this section, corrective measure technologies identified in the CMS Work Plan (E & E 1995) and Section 3 are screened and assessed specifically for implementation feasibility at Site 3. Screened corrective measure technologies were combined into corrective measure alternatives (CMAs) in Section 4.1.5.

Identified corrective measure technologies were screened to eliminate those that may prove infeasible to implement. Each technology's implementation feasibility at Site 3 was assessed by using the following site, waste, and technology limitations criteria:

- Site conditions and characteristics that may affect implementability of the technology;
- Physical and chemical characteristics of contaminants that determine the effectiveness of various technologies; and
- Level of technology development, and performance and operating reliability of technology.

As discussed in Section 4.1.2, the groundwater medium will be addressed in the CMS. Table 4-11 lists chemical and physical properties (molecular formula, molecular weight, water solubility, log K_{OW}, vapor pressure, and Henry's law constant) of all chemicals found in Site 3 groundwater.

4.1.4.1 Groundwater Medium Corrective Measure Technologies

Corrective action for groundwater at the site may consist of groundwater extraction, containment, ex situ or in situ treatment, and disposal. Appropriate corrective action technologies were identified in Section 4 and the CMS work plan (E & E 1995). These technologies are screened in Table 4-12.

Capping was identified as a corrective measure technology for Site 3 in the CMS work plan (E & E 1995). Capping would reduce infiltration into the landfill, thereby reducing the generation of leachate. In addition, capping would eliminate the potential for exposure to site soils/fill materials at Site 3. As presented earlier, soil/fill contamination levels are too low to present human exposure concerns. Only one soil sample (collected during the RFI) exceeded the site cleanup objectives which are based on NYSDEC Class GA groundwater standards and are protective of groundwater/drinking water quality. Capping of Site 3 based on one soil sample exceeding the soil cleanup objectives would not be appropriate. In addition, because groundwater at the installation occurs at shallow depths, contaminated soil/fill materials at Site 3 are probably in contact with the groundwater. Although capping would reduce infiltration, significant quantities of leachate would still be formed because of the shallow water table at the installation. Based on these site-specific hydrogeologic conditions and the low levels of localized contamination, capping would not be considered an applicable corrective measure technology at Site 3.

Retained corrective action technologies were combined into corrective measure alternatives in Section 4.1.5. As presented in Table 4-12, filtration technology is not applicable for organics present in the groundwater. However, this technology may be required as pre-treatment technology for implementing organics treatment technology. Thus, this technology has been retained, although it is not directly applicable at the site.

4.1.5 Selection of Corrective Measure Alternatives

In this section, retained corrective measure technologies were developed into comprehensive medium-specific corrective action alternatives. Each alternative consists of an individual technology or a combination of technologies. As presented in Section 4.1.2.1, a maintenance program for the existing cover soils at Site 3 would be implemented. This would include removal of existing trees and shrubs, backfilling and seeding of these areas, and mowing. This soil cover maintenance program is included in all CMAs developed below.

The no-action alternative is included to provide a baseline with which other alternatives may be compared. The following CMAs were developed for the groundwater medium at Site 3:

- **Alternative 1:** No action and natural attenuation;
- **Alternative 2:** Institutional actions and natural attenuation;
- **Alternative 3:** Groundwater removal by extraction wells, on-site treatment, and discharge to Cayuga Creek;
- **Alternative 4:** Groundwater removal by extraction wells and discharge to publicly owned treatment works (POTW); and

- **Alternative 5:** Groundwater removal by trenches and discharge to POTW.

4.2 Evaluation of the Corrective Measure Alternatives

In this section, CMAs developed in Section 4.1 are described and evaluated on the basis of technical, environmental, human health, and institutional concerns. Cost estimates are also developed for each alternative.

Each CMA was individually analyzed with regard to the following concerns:

- **Technical.** This concern encompasses the technical effectiveness, reliability, implementability, and safety issues of the CMAs and their components.

- **Environmental.** The environmental analyses of each CMA, will address facility conditions and pathways of contamination actually addressed by the CMA or its component. Short- and long-term beneficial and adverse effects of the alternatives are considered including any adverse impacts on environmentally sensitive areas.

- **Human health.** The human health analyses considers the extent to which an alternative mitigates short- and long-term potential exposure to any residual contamination and the extent to which the CMA protects human health both during and after the implementation. Each alternative is evaluated to determine the level of exposure to contaminants and reductions over time.

- **Institutional.** This concern analyses the effects of federal, state, and local environmental and public health standards, regulations, guidance, advisories, ordinances or community relations on the design, operation, and timing of each alternative.

Costs were developed for each alternative, including capital, operation and maintenance costs. Based on the availability of the information for each site and the numerous design assumptions that were utilized for estimating the cost of each alternative, the CMS cost estimates are estimated to be accurate within the range of +50% to -30% of the true cost of the alternative.

4.2.1 Alternative 1: No Action and Natural Attenuation

Alternative Definition/Description

This alterative considers natural subsurface processes such as dispersion, diffusion, volatilization, biodegradation, and adsorption to reduce contaminant concentrations to site cleanup objectives. Under the no-action alternative, no corrective action would be taken to minimize the potential of exposure to the contaminated groundwater at the site. However, groundwater, surface water, and sediment quality at the site would be monitored. On-site monitoring wells, and Cayuga Creek surface water and sediments would be sampled on a semi-annual basis and analyzed for VOCs. Semi-annual sampling would continue until sufficient data are gathered regarding contaminant migration (including seasonal fluctuations in groundwater concentrations) to permit less-frequent sampling or until it is demonstrated that the chemical concentrations no longer exceed groundwater cleanup objectives. In addition, existing trees and shrubs at the site would be removed and areas backfilled and seeded. Mowing would be conducted on a regular basis at the site.

Technical Concerns

Over the long term, this alternative may be effective in reducing the groundwater contamination.

- **Effectiveness.** Research conducted in the field of aerobic and anaerobic biodegradation has shown that chlorinated organics found at the site groundwater are biodegradable. A variety of chlorinated organics are biologically transformed by indigenous micro-organisms to stable nontoxic end products like carbon dioxide and water. Transformation reactions for various chlorinated organics that occur in soil-water systems are shown in Figure 4-7. Since vinyl chloride was never used as a raw product on the base (SAIC 1991), the presence of vinyl chloride in site groundwaters further supports that natural biodegradation is converting compounds like TCE to vinyl chloride. Because high levels of vinyl chloride are not found throughout the installation, it is apparent that this compound is being further degraded anaerobically to the non-toxic end products ethene and chloride. In addition, other processes like diffusion, dispersion, volatilization and adsorption are naturally occurring phenomena that reduce the contaminant concentrations. However, these natural processes have limited capacity to reduce contaminant concentrations and would possess small capacity to arrest the spread of contamination. Introduction of large amounts of contaminants from the landfill may exceed the natural capacity of the attenuation processes to decrease the levels.

- **Reliability.** Only qualitative information is available about the existence of natural attenuation processes at the site; therefore, this alternative may be unreliable. Attenuation processes occur naturally and do not possess any flexibility to adapt to unanticipated changes (e.g., any increase in contaminant concentrations due to additional releases from the landfill). However, based on the age of the landfill, the likelihood of any further unexpected release of contaminants is small.

- **Implementability.** Attenuation processes are naturally occurring; therefore, this alternative has no implementability concerns.

- **Safety.** During implementation, the alternative and its components will not involve any threat to the community, environment, or workers.

Environmental Concerns

This alternative does not address any exposure pathways to human or environmental receptors. According to the RFI (E & E 1995), some of the contaminants from Site 3 may eventually migrate into Cayuga Creek. Both natural attenuation processes occurring in the subsurface at Site 3 and dilution occurring in Cayuga Creek, however, decrease the level of any contaminants introduced. RFI sampling has shown that sediment and surface water quality in Cayuga Creek has not been impacted from site-induced contamination. Therefore, no short-term adverse environmental effects are expected. With time, contaminant concentrations in the groundwater would decrease due to natural attenuation processes. Therefore, the concentration of contaminants introduced from the site into the creek are expected to decrease. However, any large unexpected releases that occur from the landfill may expose environmental receptors in Cayuga Creek. However, based on its age, the likelihood of a large release from the landfill is small, surface water and sediment sampling would be continued to monitor Cayuga Creek quality. No federal- or state-listed threatened or endangered species are reported to exist at the Niagara Falls IAP-ARS, and there are no critical on-site habitats for listed species that might occur at the base (SAIC 1991).

Human Health Concerns

Contamination levels in the site groundwater are above the NYSDEC Class GA drinking water standards. Currently, the groundwater at the site is not used for drinking purposes. Therefore, no short-term exposure is expected. Through natural attenuation, contaminant levels are expected to decrease with time. Groundwater sampling at the site would monitor groundwater quality and attainment of site cleanup goals. However, the alternative provides no protection of human health until groundwater cleanup objectives are attained.

Institutional Concerns

Contaminant levels in groundwater beneath the site and in the vicinity would continue to exceed the site cleanup objectives for a long time. In addition, the spatial expanse of the groundwater contamination exceeding site cleanup objectives may increase. The exposure potential for humans and environmental receptors in Cayuga Creek would remain for the long term.

Cost

Estimated costs for this alternative arise from monitoring costs and implementing the maintenance program for cover soils. The cost of implementing the cover soils maintenance program is estimated at $6,000 (see Table 4-13). The operation and maintenance (O & M) and net worth present worth are presented in Table 4-13. O & M costs are estimated assuming that 12 existing wells would be sampled, and three surface water and three sediment samples would be collected semi-annually and analyzed for VOCs. Annual O & M costs are estimated at $51,000. The net present worth of this alternative, assuming a discount rate of 6% and monitoring time for 30 years, is estimated at $0.7 million.

Summary

This alternative considers natural subsurface processes to reduce groundwater contaminants to site cleanup objectives. Natural attenuation has limited capacity, like all natural processes, and therefore the performance of this alternative under unanticipated circumstances would be uncertain. No short-term exposure to human receptors or environmental receptors in Cayuga Creek is expected; however, the long-term exposure potential would remain.

4.2.2 Alternative 2: Institutional Actions and Natural Attenuation

Alternative Definition/Description

Similar to Alternative 1, this alternative considers natural subsurface processes such as dispersion, diffusion, volatilization, biodegradation, and adsorption to reduce contaminant concentrations to site cleanup objectives in the vicinity of the site. Through natural attenuation processes, contaminants levels in the groundwater would decrease over time and distance, so that they would not migrate to or represent a threat to off-site receptors. Until concentrations in the groundwater drop to Class GA standards, institutional actions would be implemented, including regulatory restrictions on installing private wells on and in the vicinity of the site. Recommendations regarding the type or extent of such restrictions would be made to the appropriate agencies or boards (i.e., local planning or zoning boards) as the final project plan develops. Groundwater monitoring would be undertaken to record groundwater quality until site cleanup objectives are met. In addition, surface water and sediment quality in Cayuga Creek would be monitored. Therefore, although no active management of the groundwater contamination is provided, human exposure to groundwater contamination would be minimized by implementing institutional actions and allowing natural attenuation processes.

Technical Concerns

By natural attenuation processes, this alternative would be effective in reducing the groundwater contamination. In addition, by implementing institutional controls at the site, this alternative would minimize the potential for human exposure to contaminated groundwater.

- **Effectiveness.** Section 4.2.1 discussed in detail that microbial transformations can naturally biodegrade contaminants found at the site. In addition, other processes such as diffusion, dispersion, volatilization, and adsorption are naturally occurring phenomena that reduce the contaminant concentrations. However, these natural processes have limited capacity to reduce contaminant concentrations and would possess small capacity to arrest the spread of contamination. Introduction of large amounts of contaminants from the landfill may exceed the natural capacity of the attenuation processes to decrease the levels.

  Institutional controls can be very effective in preventing potable use of groundwater on and in the vicinity of the site. The effectiveness of institutional controls in preventing the use of site groundwater is further aided by the existence of a municipal water supply in the area.

- **Reliability.** Reliability issues of natural attenuation processes at the site were discussed in detail in Section 4.2.1. Institutional controls, if enforced properly by local agencies, are reliable in minimizing human exposure to site contaminants because they would prevent the installation of wells.

- **Implementability.** Attenuation processes are naturally occurring. Implementability of institutional controls will follow the standard application procedures to local and state regulatory agencies, and may take several months. Implementability of institutional controls preventing installation of private wells may be aided by the presence of a municipal drinking water supply.

- **Safety.** During implementation, the alternative and its components will not involve any threat to the community, environment, or workers.

Environmental Concerns

According to the RFI (E & E 1995), some of the contaminants from Site 3 may eventually migrate into Cayuga Creek. Both natural attenuation processes occurring in the subsurface at Site 3 and dilution occurring in Cayuga Creek, however, decrease the level of any contaminants introduced. RFI sampling has shown that sediment and surface water quality in Cayuga Creek has not been impacted from site-induced contamination. Therefore, no short-term adverse environmental effects are expected. With time, contaminant concentrations in the groundwater would decrease due to natural attenuation processes. Therefore, the concentration of contaminants introduced from the site into the creek are expected to decrease. However, any large unexpected releases that occur from the landfill may expose environmental receptors in Cayuga Creek. However, based on its age, the likelihood of a large release from the landfill is small. Institutional controls cannot prevent the exposure of flora and fauna in Cayuga Creek to site contaminants. However, surface water and sediment sampling would be continued to monitor Cayuga Creek quality. No federal- or state-listed threatened or endangered species are reported to exist at the Niagara Falls IAP-ARS, and there are no critical on-site habitats for listed species that might occur at the base (SAIC 1991).

Human Health Concerns

By virtue of institutional actions, this alternative would prevent any human exposure to contaminated groundwater. No short-term exposure is expected because no wells are currently used for drinking water. Through natural attenuation, contaminant levels are expected to decrease with time. Groundwater sampling at the site would monitor groundwater quality and attainment of site cleanup goals.

Institutional Concerns

Contaminant levels in groundwater beneath the site and in the vicinity would continue to exceed the site cleanup objectives for a long time. In addition, the spatial expanse of the groundwater contamination exceeding site cleanup objectives may increase. Although institutional actions would minimize human exposure to site contaminants, the exposure potential for environmental receptors in Cayuga Creek would remain for the long term.

Cost

Cost for this alternative arises from implementing the institutional actions and cover soils maintenance program, and from monitoring expenses. The cost of implementing Alternative 2 is estimated at $15,000 (see Table 4-14). This includes the cost of preparing requests and coordinating and implementing institutional actions at Site 3. The annual O & M costs are estimated at $51,000 (see Table 4-14). These costs are based on similar sampling protocol as adopted for Alternative 1. The net present worth of this alternative, assuming a 6% discount rate and 30-year monitoring period, is estimated at $0.7 million.

Summary

This alternative minimizes protection to human health by implementing institutional actions that would prevent constructing private wells on and in the vicinity of the site. Natural attenuation would gradually decrease contaminant levels. Until acceptable groundwater concentrations are reached, groundwater quality monitoring would be conducted. Natural attenuation has limited capacity like all natural processes, and therefore the performance of this alternative under unanticipated circumstances would be uncertain. No short-term exposure to environmental receptors in Cayuga Creek is expected; however, the long-term exposure potential would remain.

4.2.3 Alternative 3: Groundwater Removal by Extraction Wells, On-site Treatment, and Discharge to Cayuga Creek

Definition/Description

This alternative consists of groundwater removal by the use of one or more wells, on-site treatment of extracted groundwater by air stripping, and discharge of the treated groundwater to Cayuga Creek. The discharge to the creek would be performed under a SPDES permit. An air permit may also be required for discharge of off-gas from the air stripper to the ambient atmosphere. Until groundwater cleanup objectives are attained, institutional controls that would prevent the construction of drinking water wells on and in the vicinity of the site would be required. Groundwater sampling would be conducted on a routine basis to monitor the efficacy of the alternative and progress towards attainment of cleanup objectives. Surface water and sediment samples from Cayuga Creek would be sampled on a routine basis. A cover soils maintenance program would also be implemented.

Based on the observed contamination existing at the site, two areas at the site will be considered for groundwater extraction. The first area for groundwater extraction is located in the vicinity of well MW3-3, and the second area is located in the vicinity of well MW3-4. During the RFI (E & E 1995), long-term groundwater monitoring (GZA 1992, 1993, 1994), and the RI/FS (SAIC 1991), groundwater contamination above site cleanup goals had been observed only in these two areas (see Figure 4-8). Vinyl chloride at a concentration of 20 μg/L was the only contaminant detected in monitoring well MW3-1D (SAIC 1991). Therefore, the area in the vicinity of the MW3-1D will not be an candidate for groundwater removal.

As presented in Section 4.1.1, organic contamination above site cleanup objectives have been detected in wells MW3-3 and MW3-4, which are screened in the shallow bedrock (a small screen interval of well MW3-3 also projects into the overburden). The shallow bedrock is the upper 10 to 15 feet of bedrock at the site. The bedrock at the site is the Lockport dolomite formation and is historically known to be water producing. With little to virtually no primary porosity in the dolostone rock matrix itself, groundwater flow in the bedrock is directly related to the number, size, and interconnection of the fractures in the rock. Most of these fractures occur in the uppermost 10 to 15 feet of bedrock (called the upper bedrock). Slug test data from wells screened in the upper 10 feet of bedrock (MW3-3, MW3-4, and MW3-6D) resulted in an average hydraulic conductivity of 1 x 10^{-3} cm/sec.

No contamination was detected in the well MW3-1E screened in the deeper bedrock. The well is located adjacent to the shallow bedrock well MW3-4 (where vinyl chloride was detected at site cleanup goals during the RFI). No major aquitard was encountered between the upper and deeper bedrock, which indicates a hydraulic connection between at least the first 35 feet of bedrock (approximate depth of the well MW3-1E in bedrock). The hydraulic gradient at the site is generally downward from shallow to deep bedrock. An exception to this is well MW3-1E, where an upward vertical hydraulic gradient was observed between this well and the clustered well MW3-4 in the shallow bedrock, causing local artisan conditions. This observed anomaly could be due to the proximity of the well to Cayuga Creek.

The pump test at the site was conducted in the shallow bedrock at well MW3-5AA (see Figure 4-1). This well is located close to well MW3-3, which showed the maximum levels of contamination at the site. During the pump test, a sustainable groundwater extraction rate of 5.0 gallons per minute (gpm) was achieved. However, no drawdown was observed in any wells and the well recharged quickly (within 15 to 20 minutes) after the pump was shut off. The absence of drawdown in the observation wells is either explained by the greater distance of some wells to the extraction well, or by the limited connectedness of the bedrock aquifer fracture system. Fracture recharge from the nearby creek appears to be a major contributor to the water level stability at observation wells, and most probably explains the very rapid recovery of the static water level in the extraction well after pumping. This shows that perhaps well MW3-5AA was being recharged from a fracture in the bedrock and was not hydraulically connected to the region of contamination. Additionally, fracture recharge from the nearby creek was also very likely given that bedrock is exposed at the stream bed in many areas.

Based on the extraction flow rates achieved in the pump test and observed contamination zones, the shallow bedrock zone appears to be the most promising candidate for groundwater extraction. By suitably positioning shallow bedrock extraction wells, groundwater contamination that exists in this zone can be intercepted and recovered. In addition, a zone of influence (or drawdown) can possibly be created that would prevent migration of the contaminants off site and into Cayuga Creek. Typically, field observations like slug tests, pump tests, and piezometric levels and computer simulation of the hydrogeology at a site is used to aid in the selection, design, and operation of extraction well locations and groundwater extraction flow rates. However, the hydrogeology of the site is very complex due to the highly heterogenous subsurface conditions. It would be very difficult, if not impossible, to develop and calibrate a computer groundwater model of the site. Under this limitation, field observations (possibly including trial-and-error well placement) would be used to locate and optimize the groundwater extraction wells in the shallow bedrock.

Highly heterogenous subsurface conditions at the site warrant that an observational approach be taken at the site to locate the optimum groundwater extraction wells at the site. The optimal groundwater extraction locations would recover the contaminants from the groundwater and simultaneously create a drawdown that would arrest the off-site transport of contaminants. Initially, areas in the vicinity of wells MW3-3 and MW3-4 would be tested for groundwater extraction by conducting pump tests. Drawdown and contaminant concentrations in the monitoring wells, as well as contaminant concentrations in the effluent of pump test wells, would be monitored to determine the need for additional extraction wells. The region between monitoring wells MW3-3 and MW3-4 could also be tested for groundwater extraction. Therefore, for the CMS, it will be assumed that six locations in the shallow bedrock would have to be tested to optimally locate three extraction wells. Figure 4-9 shows the recommended locations for groundwater extraction wells. The actual groundwater extraction would also be determined during the pump tests. Groundwater extraction well locations and extraction flow rates would be selected so as to minimize the collection of creek water. For the CMS, a total groundwater flow rate of 15 gpm was assumed.

Extracted groundwater would be treated by an on-site treatment system consisting of filtration and air stripping processes. A flow diagram for the treatment process is presented in Figure 4-10. The treatment system would be enclosed in a building, probably located close to Building 413 (see Figure 4-9). Extracted groundwater from each well would be pumped by submersible pumps to the treatment building. One groundwater storage tank would be provided ahead of the filtration process. The storage tank would have water level alarms to automatically switch the treatment process on and off. Following treatment, treated groundwater would be discharged through an outfall to Cayuga Creek, downgradient of the site.

As apparent from the high-to-moderate Henry's Constants (presented in Table 4-11), all the VOCs at the site are readily strippable. Therefore, removal of VOCs from the groundwater be conducted primarily by the air-stripping process. For costing purposes, a shallow tray-type air stripper has been selected due to its low profile, low capital cost, and ease of maintenance and operation. The air stripper was designed preliminarily using a flow rate of 15 gpm (see Appendix D for preliminary design of air stripper). For a conservative preliminary design, the maximum concentration of contaminants present above cleanup goals was used as the influent levels to the air stripper. The preliminary design shows that effluent levels for all VOCs (except carbon disulfide) would be in the range of 1 μg/L or less. These levels are far below the corresponding Class C surface water standards for each contaminant. Although effluent levels provided in the SPDES permit are determined by NYSDEC on a case-by-case basis, Class C surface water standards are used for comparison purposes because the SPDES permit levels are likely to be as stringent as Class C standards. Carbon disulfide cannot be easily stripped, because of its low Henry's Constant (see Table 4-11). However, a Class C surface water standard does not exist for carbon disulfide. In addition, carbon disulfide was only detected in well MW3-3 during the RFI. Therefore, its concentration in the influent to the on-site treatment system is expected to be very low.

Air stripping alone, however, would not permanently destroy the chlorinated organics. Air stripping is a mass-transfer process in which the volatile compounds are transferred to the air flowing in the stripper. During the design phase, an application for off-gas discharge would be submitted to NYSDEC. Under the air permit, if treatment of the off-gas would be required, a vapor-phase carbon adsorption unit would most likely be used to remove the chlorinated organics from the effluent air. The activated carbon in the unit would require replacement and/or regeneration, contributing to the total treatment cost. Depending on the arrangements made for the activated carbon disposal, the chlorinated organics adsorbed to the carbon may be permanently destroyed. A likely disposal option would be off-site regeneration in which the desorbed organics vapors are incinerated, resulting in their destruction.

Filtration is typically provided in groundwater treatment systems to protect treatment systems from suspended solids in the groundwater. High suspended solids have been observed in the groundwater at the site, which may clog the air stripper. Sand filters are convenient and easy to operate and maintain for the low-flow rates and high suspended solids expected at the site. Therefore, sand filters will be installed ahead of the air stripping process. A concentrated solids suspension would be formed during the backwash cycle of the sand filter. This suspension would need proper disposal. It is anticipated that the solids slurry could be disposed of as nonhazardous waste. Treated groundwater would be discharged to Cayuga Creek. A SPDES permit would be required to discharge to Cayuga Creek.

Technical Concerns

Groundwater extraction and treatment are often used to remediate contaminated groundwater. By actively extracting the groundwater contaminants at the site, contamination levels in the groundwater can be decreased and site cleanup objectives can be attained in an accelerated manner. In addition, by extracting groundwater, a groundwater drawdown can be created that would arrest the transport of contaminants off site and into Cayuga Creek.

- **Effectiveness**. Groundwater extraction and treatment is a widely applied corrective action technology. Based on the relatively small zone of contamination at the site, wells would be effective for groundwater extraction.

  The effectiveness of groundwater extraction will depend on well location. Ideal well location would be determined by pump tests and some trial and error. The ideal location would extract the contaminants and favorably create an drawdown that would act as an hydraulic boundary to prevent the transport of contaminants off site and into Cayuga Creek. In addition, the vertical downward movement of contaminants into the deeper bedrock would be minimized by creating an upward gradient towards the well because of groundwater extraction. For the CMS, it is assumed that six locations would require pump tests (see Figure 4-9) and finally three wells would be used for groundwater extraction.

  At the site, highly heterogenous conditions exist and it may not be possible for an extraction well at a given location to remove all the groundwater contamination. The presence of directional fissures and fractures at the site may not connect the entire contaminated area to the groundwater extraction well. For the same reason, an observation well where the drawdown would be observed may not hydraulically connect to the extraction well. This uncertainty as to the effectiveness of this alternative would exist even after wells are located that may extract the groundwater contaminants; the zone of influence created by extraction of groundwater may not be ascertained. However, the extraction of some contaminants from the groundwater would reduce the total amount of contaminants that may otherwise be transported off site and into Cayuga Creek.

The groundwater treatment system consists of effective processes that can function on an intermittent basis with minimal adjustments or operator attention. The air stripping process is very effective for VOC treatment. Sand filtration is also an effective pre-treatment technique for solids removal. Sand filtration systems come with in-built alarms that operate the filter backwash cycle once a pre-set pressure drop limit is reached.

- **Reliability.** Groundwater extraction by wells and treatment by air stripping are reliable technologies. The groundwater treatment and extraction system is typically designed to handle a wide variety of flow and organic-loading conditions. In addition, to provide continuous monitoring, the system can be connected to an off-site monitoring station through a telemeter system. If site conditions change, additional wells can be easily installed and existing wells easily decommissioned. This is important because of the proximity of site to Cayuga Creek. Some groundwater extraction well locations could drain excessive amounts of water from Cayuga Creek, causing an adverse impact to it. However, such extraction wells could be easily replaced by groundwater extraction wells in other locations. Also, the treatment system capacity can be easily augmented. Decreased groundwater flow rates may affect air stripper performance for certain configurations (like a packed tower stripper) because of decreased wetting of the packing. This can be avoided by recycling treated water across the air stripper to maintain the required wetting of the media or by adopting other stripper configurations (e.g., shallow tray-style strippers which are not affected by decreases in groundwater flow rates below the design flow rate).

  The O & M requirements include routine maintenance of the system (for example air stripper trays, pumps, pipes and pipe fittings), replacement of vapor-phase carbon (if required), and off-site disposal of used carbon and solids slurry from the sand filter backwash.

- **Implementability.** Highly heterogenous conditions at the site may pose problems in the location of extraction well(s). The pump test conducted at the site did not yield any detectable levels of contamination, nor was any drawdown observed in any nearby wells. Additional pump tests would be required to locate extraction wells. To account for these additional wells, it has been assumed that at least six well locations will have to be installed and tested. Figure 4-9 shows the recommended locations for the pump tests. It is assumed that three wells will be sufficient for groundwater extraction at the site. A conservative design flow rate of 15 gpm has been selected for the preliminary design of air stripper. The influent concentrations were selected based on the maximum concentration of each contaminant detected at the site (see Table 4-6). These contaminants would be removed to meet NYSDEC Class C surface water quality standards. If required, off-gas from the air-stripper would be treated by vapor-phase carbon.

A SPDES permit from NYSDEC will be required for discharge of treated groundwater to Cayuga Creek and as will its frequent monitoring.

Alternative 3 can be implemented within several months. It is estimated that approximately six months would be required for conducting pump tests, design, procurement, installation, and start-up of the groundwater extraction and treatment system. Procurement of a SPDES permit typically takes two to six months. For Alternative 3, the time needed to achieve site cleanup goals cannot be estimated. This is primarily because of the complex hydrogeology of the site. Under analogous conditions, attainment of cleanup objectives by groundwater extraction and treatment has taken a few to several years (sometimes decades or longer). Furthermore, after groundwater has been treated and CAOs attained, contamination sometimes reestablishes once continual extraction is ceased. For this reason, it is assumed that Alternative 3 would need to be operated and maintained for a period of 30 years (the same as for Alternative 1 and Alternative 2).

- **Safety.** Implementation of this alternative is not expected to create health risks or threats to the safety of nearby communities or cause exposure concerns to environmental receptors. Minimal or no dust generation and VOC release is expected during the construction of wells and the treatment system. During construction of wells and routine maintenance of the treatment system, protective clothing and equipment for on-site workers would effectively minimize the potential short-term exposure to VOCs in groundwater.

Environmental Concerns

By properly positioning groundwater extraction wells, Alternative 3 would actively extract groundwater contaminants. However, the area of influence may not extend far enough to extract contaminants from all contaminated subsurface areas. Extraction would still reduce the levels of contamination in the subsurface, which would also reduce the levels of contaminants reaching Cayuga Creek and long-term exposure of environmental receptors in the creek to site-related contaminants. But the level of contamination that would be extracted from the subsurface and the anticipated decrease in the level of groundwater contamination cannot be currently estimated. Some groundwater extraction wells may drain excessive amounts of water from Cayuga Creek, causing an adverse impact to the creek. However, such extraction wells can be easily decommissioned and suitable sites for other extraction wells can be located. Groundwater and treatment system sampling would monitor groundwater quality. No federal- or state-listed threatened or endangered species are reported to exist at the installation, and no critical on-site habitats exist for listed species that might occur (SAIC 1991).

Human Health Concerns

No short-term exposure to site contaminants is expected because no drinking water wells currently exist on or in the vicinity of the site. In the long term, by actively extracting and treating site contaminants, this alternative would accelerate the attainment of site cleanup goals. By restoring groundwater quality to meet or exceed NYSDEC Class GA standards, human and environmental exposure to site contaminants would be eliminated. However, the rate of reduction of contamination or the time when cleanup goals would be attained cannot be determined. Institutional actions would be implemented until site cleanup objectives are attained.

Institutional Concerns

This alternative would attain NYSDEC Class GA standards, and therefore the concerns for human consumption of contaminated groundwater would be eliminated. Institutional actions would be implemented until Class GA standards are attained. By extracting contaminants from the subsurface, the amounts of contaminants released into Cayuga Creek would be minimized. Other institutional concerns related to this alternative would be compliance with the SPDES permit for discharge to Cayuga Creek and release of off-gas from the air stripper to the atmosphere. Preliminary design calculation have shown that effluent from the treatment system would meet or exceeds NYSDEC Class C surface water standards.

Cost

Table 4-15 presents the capital and annual O & M costs for Alternative 3. The capital cost of this alternative is estimated at $240,000. The annual O & M costs are estimated at $71,000. Based on an assumed 30-year operation period and 6% discount rate, the total net present worth of this alternative is estimated at $1.2 million.

Summary

In this alternative, groundwater contamination would be actively managed at the site. Contaminated groundwater would be extracted by one or more wells, treated on site by filtration and air-stripping processes, and discharged to Cayuga Creek under a SPDES permit.

Until site groundwater cleanup objectives were attained, institutional controls that would prevent the construction of drinking water wells on and in the vicinity of the site would be implemented. Groundwater quality and the treatment system influent and effluent would be routinely sampled to monitor the efficacy of this alternative. By extracting contaminants from the subsurface, site cleanup objectives can be achieved in an accelerated manner. In addition, release of contaminants to Cayuga Creek would be minimized. An observational approach would have to be adopted to select optimal groundwater extraction wells. Groundwater extraction and treatment systems are typically designed to handle a wide range of groundwater extraction rates. Additional extraction wells or treatment system capacity can be easily augmented or reduced. By virtue of this feature, this alterative has the capacity to handle unexpected circumstances. Limited exposure concerns are expected during implementability of this alternative. Routine maintenance of the treatment system would require Level D personnel protection equipment. Because no drinking wells currently exist and Cayuga Creek surface water and sediment quality has not been impacted, no short- term risks exist. In addition, the long-term risks both to human and environmental receptors will be minimized by this alternative.

4.2.4 Alternative 4: Groundwater Removal by Extraction Wells and Discharge to POTW

Definition/Description

This alternative consists of groundwater removal by the use of wells and discharge of extracted groundwater to POTW. Alternative 4 is similar to Alternative 3; however, there is no on-site treatment before discharge to the POTW in Alternative 4. Treatment and disposal would be through the POTW. Until groundwater cleanup objectives are attained, institutional controls would be required that would prevent construction and use of drinking water wells on and in the vicinity of the site. Groundwater sampling would be conducted on a routine basis to monitor the efficacy of the alternative and attainment of cleanup objectives. In addition, surface water and sediment quality in Cayuga Creek would be monitored and a cover soils maintenance program would be implemented.

Similar to Alternative 3, two regions in the shallow bedrock zone at the site would be considered for groundwater extraction. The first region for groundwater extraction is located in the vicinity of well MW3-3, and the second region is located in the vicinity of well MW3-4. An observational approach, similar to that recommended in Alternative 3, will be adopted to locate optimum locations for groundwater extraction wells. The optimal groundwater extraction locations would recover the contaminants from the groundwater and simultaneously create a zone of influence that would prevent transport of contaminants off site and into Cayuga Creek. For costing purposes, it was assumed that six well locations would have to be tested to optimally locate three extraction wells. As discussed earlier, actual groundwater extraction rates would be determined during the pump tests. For costing purposes, a total groundwater flow rate of 15 gpm was assumed.

For the extraction wells, submersible pumps with float levels and alarms would be installed. Water pumped from the extraction wells would be stored on site in one aboveground double-walled storage tank. The aboveground storage tank would be installed in an enclosed building and would be properly vented to the atmosphere. A double-walled flexible polyvinyl chloride (PVC) hosing would be used to discharge collected water from the storage tank to the designated sewer. The hosing would be embedded beneath the frost line to prevent freezing.

Niagara County Sewer District No. 1 (NCSD) presently services the installation. NCSD has been contacted regarding the possibility of discharging groundwater to its treatment plant. Specifically, the installation has requested permission to discharge up to 15 gpm of extracted groundwater containing the contaminants observed at the site. The groundwater would be treated by the POTW. NCSD had agreed to accept the extracted groundwater during the pump test conducted at the site. In addition, permission to discharge to NCSD No. 1 POTW has been conditionally granted (see Appendix E).

Technical Concerns

Groundwater extraction and discharge to an off-site facility are often used to remediate contaminated groundwater. By actively extracting the contaminated groundwater at the site, contaminant levels can be decreased and site cleanup objectives attained in an accelerated manner.

- **Effectiveness**. Groundwater extraction and discharge to an off-site facility is a widely applied corrective action technology. Based on the relatively small zone of contamination at the site, wells would be effective for groundwater extraction. However, the effectiveness of groundwater extraction will depend on well location. Ideal well location would be determined by pump tests. The ideal location would extract the groundwater contaminants and favorably create an drawdown that prevents transport of contaminants off site and into Cayuga Creek. In addition, the vertical downward movement of contaminants into the deeper bedrock would be minimized by creating an upward gradient towards the well because of groundwater removal. For costing purposes, it is assumed that a maximum of six wells will be installed at locations near MW3-3 and MW3-4 (see Figure 4-9). Each of the six wells would require pump tests, and based on this data, three wells would be identified for extraction.

At the site, highly heterogenous conditions exist and it may not be possible for an extraction well at a given location to remove the groundwater contaminants and also create drawdown to prevent off-site transport of contaminants. Similar to Alternative 3, the creation of a drawdown would depend on the continuity of the shallow bedrock fractures and groundwater extraction flow rates. Therefore, similar to Alternative 3, uncertainty as to the extent of the drawdown may remain even after wells are located that will extract groundwater contamination. However, the extraction of contaminants from the groundwater would help in the attainment of the cleanup objectives and reduce the total amount of contaminants that may otherwise be transported off site and into Cayuga Creek.

Discharge of extracted groundwater to POTW would be very effective. Discharge to a POTW would accomplish two objectives: treatment of extracted groundwater and discharge to surface water (i.e., to the Niagara River via the POTW's effluent). No specific testing has been conducted on the effectiveness of the NCSD plant's treatment of the groundwater from the site. However, the NCSD has been treating chlorinated organics contaminated groundwater from a facility near the installation. Chlorinated organics are probably treated by a combination of physical (volatilization and adsorption) and biological processes, resulting in their removal from the water. Therefore, the POTW would be considered effective for the treatment of groundwater from the site. Regarding the disposal function of the POTW, the effluent is discharged to the Niagara River, thereby providing effective disposal of the treated groundwater.

- **Reliability.** Groundwater extraction by wells and discharge to POTW are very reliable technologies. The groundwater extraction and discharge systems are typically designed to handle a wide variety of flow and organics-loading conditions, and a similar procedure would be followed in the design phase of the treatment system. In addition, to provide continuous monitoring the system could be connected to an off-site monitoring station through telemetry systems. To address changed or unexpected conditions, additional wells could be easily installed and existing wells could be easily decommissioned. This is important because of the proximity of the site to Cayuga Creek. Some groundwater extraction well locations may drain excessive amounts of water from Cayuga Creek, causing an adverse impact to it. However, such extraction wells could be easily replaced by groundwater extraction wells at other locations. Also, the discharge system capacity could be easily altered.

  The O & M requirements include routine maintenance of the system (for example pumps, pipes, and pipe fittings). Typically, minimal or no maintenance would be required for the groundwater discharge system.

- **Implementability.** This alternative has implementability concerns similar to Alternative 3. Highly heterogenous conditions at the site may pose problems in the location of extraction well(s). The pump test conducted at the site did not yield any detectable levels of contamination, and drawdown was not observed in any nearby wells. Additional pump tests would be required to locate extraction wells. However, this alternative does not retain implementability concerns for the design, construction of the treatment system, or procurement of SPDES and air permit for Alternative 4.

  Alternative 4 could be implemented within several months. It is estimated that approximately 6 months would be required for conducting pump tests, design, procurement, installation, and start-up of the groundwater extraction system. Similar to other alternatives, the time needed to achieve site cleanup goals cannot be determined for Alternative 4. For this reason, it is assumed that Alternative 4 would need to be operated and maintained for a period of 30 years (the same is true for other alternatives).

- **Safety.** Implementation of this alternative is not expected to create health risks or threats to the safety of nearby communities or cause exposure concerns to environmental receptors. Minimal or no dust generation and VOC release is expected during construction of the wells and the treatment system. During construction of wells, protective clothing and equipment for on-site workers, would effectively minimize the potential short-term exposure to VOCs in the groundwater.

Environmental Concerns

Alternative 4 would actively extract groundwater contaminants and create a drawdown that may arrest the transport of contaminants off site and into Cayuga Creek. Even if a drawdown is not created by groundwater extraction, the levels of contaminants released to Cayuga Creek and the long-term exposure of environmental receptors to site-related contaminants would be reduced. However, the amount of contaminants that would be extracted from the subsurface and the expected decrease in the level of groundwater contamination cannot be currently estimated. Some groundwater extraction wells could drain excessive amounts of water from Cayuga Creek, causing an adverse impact to the creek. However, such extraction wells can be easily decommissioned and suitable sites for other extraction wells located. Groundwater and discharge system sampling would monitor groundwater quality. No federal- or state-listed threatened or endangered species were reported to exist at the installation, and no critical on-site habitats exist for listed species that might occur at the base (SAIC 1991).

Human Health Concerns

No short-term exposure to site contaminants is expected, because no drinking water wells currently exist on or in the vicinity of the site. In the long term, this alternative would accelerate the attainment of site cleanup goals by actively extracting and treating site contaminants. By restoring groundwater quality to meet or exceed NYSDEC Class GA Standards, human and environmental exposure to site contaminants would be eliminated. The rate of reduction of contamination or the time need to achieve cleanup goals, however, cannot be determined. Institutional actions would be implemented until site cleanup objectives are attained. By eliminating on-site treatment of extracted groundwater, this alternative eliminates human exposure concerns during routine maintenance of the treatment system.

Institutional Concerns

This alternative would attain NYSDEC Class GA standards, and concerns for human consumption of contaminated groundwater would be eliminated. Institutional actions would be implemented until Class GA standards are attained. By extracting contaminants from the subsurface, the amounts of contaminants released into Cayuga Creek would be minimized. Other institutional concerns related to this alternative would be to meet the groundwater discharge limitations to the POTW as determined by NCSD.

Cost

Estimated capital and annual O & M costs for Alternative 4 are presented in Table 4-16. Capital costs of this alternative are estimated at $185,000. The annual O & M costs are estimated at $66,000. Based on the assumed 30-year operating period and a 6% discount rate, the total net present worth of this alternative is estimated at $1.1 million.

Summary

This alternative provides active management of groundwater contamination at the site. Contaminated groundwater would be extracted by one or more wells, and discharged to the POTW for treatment and disposal. Until site groundwater cleanup objectives are attained, institutional controls that would prohibit the construction of drinking water wells on and in the vicinity of the site would be implemented. Groundwater quality and the discharge effluent to the POTW will be routinely sampled to monitor the efficacy of this alternative. By extracting contaminants from the subsurface, site cleanup objectives can be achieved in an accelerated manner. In addition, release of contaminants to Cayuga Creek would be minimized. An observational approach will have to be adopted to select optimal groundwater extraction wells. By virtue of its modular design (i.e., wells can be installed or decommissioned and discharge capacity can be altered), the alternative has the capacity to handle unanticipated site conditions. Limited exposure concerns are expected during implementation of this alternative. Because no drinking water wells currently exist at the site and Cayuga Creek surface water and sediment quality has not been impacted, no short-term risks exist. In addition, the long-term risks both to human and environmental receptors will be minimized by this alternative.

4.2.5 Alternative 5: Groundwater Removal by Trench and Discharge to POTW

Definition/Description

This alternative consists of contaminated groundwater removal by the use of subsurface trenches and the discharge of extracted groundwater to POTW. Alternative 5 is different from Alternative 3 and Alternative 4 in the groundwater extraction technology. In addition, similar to Alternative 4, Alternative 5 affords no groundwater treatment before disposal to the POTW. Until groundwater cleanup objectives are attained, institutional controls that would prevent construction and use of drinking water wells on and in the vicinity of the site would be required. Groundwater and discharge system sampling would be conducted on a routine basis to monitor the efficacy of the alternative and attainment of cleanup objectives. In addition, surface water and sediment quality in Cayuga Creek would be monitored, and a cover soils maintenance program implemented.

Based on the observed contamination existing at the site and groundwater flow, two areas at the site will be considered for groundwater extraction. The first area for groundwater extraction is located in the vicinity of well MW3-3, and the second area is located in the vicinity of well MW3-4. As discussed earlier, groundwater contamination above the site cleanup goals has been observed only in these locations (see Figure 4-8). Vinyl chloride was detected in monitoring well MW3-1D, only during the RI/FS (SAIC 1991). Therefore, the area in the vicinity of MW3-1D will not be a candidate for groundwater removal.

Subsurface drains include any type of buried conduit used to convey and collect aqueous discharges by gravity flow. Subsurface trenches essentially function like an infinite line of extraction wells. They create a continuous zone of influence in which groundwater flows toward the drain. For shallow contamination, drains can be more effective in contaminant removal than pumping, particularly in strata with low or variable hydraulic conductivity. Under these conditions, it difficult to design and cost-prohibitive to operate a pumping system to maintain a continuous hydraulic boundary. At the site, contamination exists at a relatively shallow depth, and the low or variable hydraulic conductivity, in particular, would make trenches more effective in intercepting the contaminants and preventing off-site transport.

A relatively thin overburden (approximately 3 to 4 feet) exists in the southern portion of the site adjacent to Cayuga Creek. As discussed earlier, seasonal fluctuations in water levels may result in the overburden being completely dry. The shallow bedrock, which is the upper 10- to 15-foot portion of the bedrock, is historically known to be water producing. With little to virtually no primary porosity in the dolostone rock matrix itself, groundwater flow in the bedrock is directly related to the number, size, and interconnection of the fractures in the rock. Most of the fractures are located in the uppermost 10 to 15 feet of the bedrock. Therefore, a trench installed in the shallow bedrock would intercept these fractures and extract groundwater contaminants. The trench would be installed perpendicular to the groundwater flow. By doing so, the trench would also create an continuous hydraulic boundary along its length that would prevent the off-site transport of contaminants. The hydraulic boundary would also extend some distance beyond its two ends.

The location of the trench in the shallow bedrock would also be consistent with the observed contamination in wells MW3-3 and MW3-4, which are screened in the shallow bedrock (see Figure 4-8). Because the shallow bedrock and the deeper bedrock appear to be existing in an continuity, by extracting groundwater from the shallow bedrock, an upward groundwater flow gradient (towards the trench) can be created. The upward gradient would prevent any vertical migration of contaminants.

Construction of trenches in the shallow bedrock at the site would require bedrock excavation. Bedrock would require fragmentation before it could be excavated. The most common method for fragmenting rock in hazardous waste site work involves the use of rotary or percussion drills, backhoe-mounted pneumatically driven impact tools, and tractor-mounted mechanical rippers. Pneumatically driven tools have very low production rates and mechanical rippers have depth limitations. Blasting is used commonly in the construction industry for rock fragmentation. Because of the proximity of the trench to the landfill and to environmental receptors in Cayuga Creek, blasting is not recommended for the site. Beneath the groundwater table, trench excavation would require groundwater dewatering. In addition, site soils and fill materials that would be encountered during excavation and would need shoring.

To minimize bedrock excavation and associated construction problems of shoring and dewatering, a shallow trench extending into the shallow bedrock to a depth of 5 feet measured from the top of the bedrock would be constructed. One trench, extending from MW3-3 to MW3-4, is proposed for the site (see Figure 4-11). In the overburden, each trench would have a trapezoidal cross section, approximately 3 feet wide at the bottom and 15 feet wide at the top. Additional boring taken during the design phase would be used to shift the alignment of the trench to intercept groundwater flow and minimize rock fragmentation.

Gravel would be used in each trench for collection of removed groundwater. A flexible corrugated PVC pipe will be placed in the gravel bed for conveyance of collected groundwater. Gravel would be embedded to the top of the bedrock in each trench (see Figure 4-11). Therefore, no filter fabric is proposed for the drain pipe. However, a filter fabric layer would be provided at the interface of backfill and gravel layers. This would prevent any filtering of fines from the backfill to the gravel layer. The trench would be backfilled with clean fill above the gravel layer to grade. At grade, each trench would be covered with an high-density polyethylene (HDPE) membrane to minimize recharge of the trench from infiltration. Because the trench would be extracting groundwater from the bedrock, minimal or no fines are expected in the removed groundwater.

To minimize excavation into the bedrock, each trench will function as a collection component. No manholes or wet wells will be installed for the collection of groundwater. Perforated pipe in each trench would extend into an vertical main. A submersible pump would be placed in the vertical main and connected to the force main. Water pumped from the trench would discharge directly to the POTW. A double-walled flexible PVC hosing would be used to discharge collected water from each trench to the designated sewer. The hosing will be embedded beneath the frost line to prevent freezing. In addition, the trench main connection to the force main would be housed in an enclosure.

Along its length, the trench would reverse the groundwater flow direction. Rather than flowing to Cayuga Creek, groundwater would flow away from the creek, possibly and cause a prohibitively large volume of clean water to be collected. To minimize collection of clean water from Cayuga Creek, an HDPE membrane would be placed on the downgradient face of the trench. Because a trench would intersect more fractures along its length, the trench would collect more groundwater as compared to an extraction well. However, in the absence of site-specific data, a groundwater extraction rate of 5 gpm was used for costing purposes.

As presented earlier in Section 4.2.4, NCSD has conditionally granted permission to discharge groundwater to its treatment plant. Specifically, the installation has requested permission to discharge up to 15 gpm of extracted groundwater containing the maximum levels of contaminants detected at the site. The groundwater would be treated by the POTW.

Technical Concerns

Groundwater extraction and discharge to an off-site facility are often used to remediate contaminated groundwater. By actively extracting the groundwater plume at the site, contamination levels in the groundwater can be decreased and site cleanup objectives can be attained in an accelerated manner. In addition, extracting groundwater by trench can create a hydraulic boundary that would arrest the transport of contaminants off site and into Cayuga Creek.

- **Effectiveness.** Groundwater extraction and discharge to an off-site facility is a widely applied corrective action technology. Based on the heterogenous hydrogeologic conditions at the site, trenches would be more effective for groundwater extraction in comparison to extraction wells.

  Trenches, which act as a continuous line of well points, are most suitable for groundwater extraction at the site and create a hydraulic boundary along their length that would minimize the off-site transport of contaminant. A trench would intercept many fractures and fissures along its length and, therefore, would be more effective in extracting groundwater than a well. Wells MW3-3 and MW3-4 have shown the highest levels of contamination. By installing a trench in the vicinity of MW3-3 and MW3-4, the groundwater contamination can be successfully extracted.

  To reduce the collection of Cayuga Creek water by the trench, an HDPE barrier would be installed on the downgradient side. Additional borings would be installed in the design phase to locate the most optimum alignment of the trench.

  As discussed in Section 4.2.4, discharge of extracted groundwater to POTW would be very effective. Discharge to a POTW would accomplish two objectives: treatment of extracted groundwater and discharge to surface water (i.e., to the Niagara River via the POTW's effluent).

- **Reliability.** Groundwater extraction by trenches and discharge to POTW are very reliable technologies. However, due to the proximity of the site to Cayuga Creek, a subsurface trench would collect large volumes of water from the creek, which may cause an adverse impact on Cayuga Creek. The groundwater extraction and discharge systems are typically designed to handle a wide variety of flow and organics-loading conditions. In addition, the system can be connected to an off-site monitoring station through telemetering systems to provide continuous monitoring. If conditions change, additional trenches can be installed. Also, the discharge capacity to the POTW can be easily augmented.

The O & M requirements include routine maintenance of the groundwater extraction system and discharge outfall (trenches, pumps, pipes, and pipe fittings).

- **Implementability.** Construction of the trench at the site would require excavation into bedrock. Bedrock would require fragmentation before it can be excavated. The most common method for fragmenting rock in hazardous waste site work involves the use of rotary or percussion drills, backhoe-mounted pneumatically driven impact tools (Hobgoblin), and tractor-mounted mechanical rippers (EPA 1985). The Hobgoblin has a low production rate of about 6 cubic yards per hour. Mechanical rippers have considerably higher production rates than the other methods, but they are limited to depths of 6 feet or less and are not suitable for highly consolidated rock. The depth limitation can be overcome if the ripper can enter the trench to rip lower lifts, but this would require additional soil/fill material to be excavated and stabilized. To minimize these implementability concerns, the depth and width of the trench has been limited to 5 and 3 feet, respectively.

  Alternative 5 can be implemented within several months. It is estimated that approximately six months would be required for installing additional borings, design, procurement, trench construction, discharge system installation, and start-up of the groundwater extraction and discharge system. Final approval from the NCSD will have to be obtained before groundwater can be discharged to the POTW. For Alternative 5, the time to achieve site cleanup goals cannot be estimated. This is primarily due to the complex hydrogeology of the site. Under similar conditions, attainment of cleanup objectives by groundwater extraction and discharge to POTW has taken few to several years (sometimes decades or longer). Furthermore, after groundwater has been extracted and contaminants found to be below cleanup levels, contamination sometimes re-establishes once continual extraction is ceased. For this reason, it is assumed that Alternative 5 would need to be operated and maintained for a period of 30 years (same as for Alternative 3 and 4).

- **Safety.** Because open excavation will have to be undertaken, implementation of this alternative may create health risks or threats to the safety of nearby communities or cause exposure concerns to environmental receptors. Construction of the trench will require bedrock fragmentation and groundwater dewatering, both of which slow down construction. Minimal dust generation is expected; however, VOC release is expected during construction of the trench. During construction of the trench, protective clothing and equipment would be required for on-site workers. Construction of the trench would have to be conducted in Level C personnel protection equipment.

Environmental Concerns

Alternative 5 would actively extract groundwater contaminants and reduce the transport of contaminants off site and into Cayuga Creek. With the use of trenches, an continuous hydraulic boundary would be created. Therefore, long-term exposure for environmental receptors in Cayuga Creek would be reduced. However, the amount of contaminants that would be extracted from the subsurface and the anticipated decrease in the level of groundwater contamination cannot be currently estimated. Because of the proximity of the site to Cayuga Creek, a subsurface trench would drain large amounts of water from the creek, which may cause adverse impacts to flora and fauna in the creek. Sampling of the groundwater and discharge to the POTW would monitor groundwater quality. No federal- or state-listed threatened or endangered species are reported to exist at the installation, and no critical on-site habitats exist for listed species that might potentially occur at the base (SAIC 1991).

Human Health Concerns

No short-term exposure to site contaminants is expected, since no drinking water wells currently exist on or in the vicinity of the site. In the long term, this alternative would accelerate the attainment of site cleanup goals by actively extracting and treating site contaminants. By restoring groundwater quality to meet or exceed NYSDEC Class GA Standards, human and environmental exposure to site contaminants would be eliminated. The rate of reduction of contamination or the time needed to meet cleanup goals, however, cannot be determined. Institutional actions would be implemented until site cleanup objectives are attained.

Institutional Concerns

Alternative 5 would attain NYSDEC Class GA standards and the threat to environmental receptors in Cayuga Creek would be eliminated. Other institutional concerns related to this alternative would be to meet the groundwater discharge limitations to the POTW as determined by the NCSD.

Cost

Capital costs of this alternative consists of design and installation of the groundwater extraction and discharge system to the POTW and is estimated at $356,000 (see Table 4-17). The annual O & M costs comprise groundwater disposal at the POTW, groundwater and discharge system sampling, and routine maintenance of the extraction system. The annual O & M costs are estimated at $59,000 (see Table 4-17). Based on the assumed 30-year operation period and 6% discount rate, the total net present worth of this alternative is estimated at $1.2 million.

Summary

Alternative 5 provides active management of groundwater contamination at the site using a combination of subsurface trenches and disposal at a POTW. Because of the heterogeneous geologic conditions at the site, groundwater extraction by trenches would be more effective in comparison to groundwater extraction by wells. The installation of trenches in the vicinity of wells MW3-3 and MW3-4, would extract contaminated groundwater and create an hydrologic boundary to minimize the off-site transport of contaminants. However, due to the proximity of the site to Cayuga Creek, a subsurface trench could drain large volumes of water from the creek, which may cause adverse impacts to the creek. Until site groundwater cleanup objectives are attained, institutional controls that would prohibit the construction of drinking water wells on and in the vicinity of the site will be implemented. Groundwater quality and the effluent to the POTW will be routinely sampled to monitor the efficacy of this alternative. By extracting contaminants from the subsurface, site cleanup objectives can be achieved in an accelerated manner. In addition, release of contaminants to Cayuga Creek would be minimized. By virtue of its in-built design capacity, the alternative has the capacity to handle unexpected circumstances. Because of open excavation, exposure concerns are expected during implementability of this alternative. Construction of the trench would require Level C and possibly Level B worker protection. Because no drinking water wells currently exist and Cayuga Creek surface water and sediment quality have not been impacted, no short-term risks exist. In addition, the long-term risks both to human and environmental receptors would be minimized by this alternative.

4.2.6 Comparative Analyses of Alternatives

In this section, all the alternatives are compared by addressing the technical, environmental, human health, and institutional concerns. Capital and O & M costs are also compared for each alternative.

Groundwater contamination exceeds the cleanup objectives for the site. Alternatives 1 and 2 include no corrective action technology and, therefore, would not address these exceedances. Alternative 2, however, minimizes the exposure to human receptors. Alternatives 1 and 2 have limited capacity to handle unanticipated conditions at the site. Alternatives

3, 4, and 5 all provide corrective action by actively extracting groundwater contamination. Alternative 3 provides on-site treatment and disposal to Cayuga Creek; whereas Alternatives 4 and 5 provide treatment and disposal by discharging the extracted groundwater to the POTW.

Highly heterogeneous conditions exist at the site, which may pose a problem in optimally locating groundwater extraction wells. The development and calibration of a groundwater-flow computer model will be very difficult, if not impossible. Therefore, an observational approach will have to be adopted in the selection of well locations. Therefore, uncertainty exists as to the effectiveness of Alternatives 3 and 4. In addition, due to the heterogeneous nature of the bedrock fractures, wells that may extract groundwater contamination may not be effective in creating a drawdown that would minimize the off-site transport of contaminants. Alternative 5 provides better effectiveness by using subsurface trenches for groundwater extraction in the vicinity of wells MW3-3 and MW3-4. However, due to the proximity of the site to Cayuga Creek, subsurface trenches would drain large amounts of water from the creek. The construction of trenches would require bedrock excavation, soil and landfill material shoring and stabilization, and groundwater dewatering. These conditions may cause a long construction time and short-term exposure concerns to workers and environment receptors. Alternative 5 would also include the excavation of landfill materials and their proper disposal following characterization. No construction and implementability concerns are expected with Alternatives 3 and 4.

Alternative 3 consists of on-site treatment processes and disposal to Cayuga Creek under an SPDES permit. Alternative 3 would also produce off-gas that might need treatment. Vapor-phase carbon by Alternative 3 would need proper handling and disposal at a TSDF. Alternatives 4 and 5 afford effective treatment and disposal by discharging to the POTW. Operating and maintaining the on-site treatment system under Alternative 3 could cause safety concerns because of the presence of vinyl chloride in the groundwater.

No short-term risks are anticipated from the contaminated groundwater at the site. Alternatives 3, 4, and 5 would reduce the long-term risks by actively extracting groundwater contaminants from the subsurface. For Alternatives 3 and 4, wells that may extract contaminants from the groundwater, may not create a drawdown that would minimize the off-site transport of contaminants. However, because of site conditions, it appears that Alternative 5 would be more effective than Alternatives 3 and 4 in extracting the subsurface contaminants and creating an hydraulic boundary that would minimize the off-site transport of contaminants. Alternative 5 would, however, drain large amounts of water from Cayuga Creek, which may cause adverse impacts to flora and fauna in the creek.

Capital costs, annual O & M costs, and total present worths of all the Alternatives are presented in Figure 4-12.

4.3 Justification and Recommendation of the Corrective Measure

As per the installation's permit, the following criteria are used to justify and recommend the CMA:

Technical Criteria

These criteria encompass the CMA's performance, reliability, implementability, and safety issues.

Human Health Criteria

CMAs must comply with existing EPA and/or state criteria, standards, or guidelines for the protection of human health. The CMA that provides the minimum level of exposure to contaminants and the maximum reduction in exposure with time is to be preferred.

Environmental Criteria

The CMA that poses the least adverse impact (or greatest improvement) over the shortest period of time on the environment is to be preferred.

4.3.1 Selection of Recommended CMA

Based on the detailed analysis of the Site 3 CMAs presented in Section 4.2, Alternative 4 has been recommended for use as a corrective measure for the remediation of contaminated groundwater. Table 4-18 summarizes the evaluation of each CMA for suitability at Site 3, and provides the rationale for selection of the recommended CMA.

4.3.2 Justification of Selected CMA

Alternatives 1 and 2 do not address groundwater contamination above NYSDEC Class GA standards and have limited capacity to handle changes in conditions at the site. Alternatives 3, 4, and 5 would accelerate the attainment of groundwater cleanup goals and minimize the off-site transport of contaminants. An observational approach would have to be adopted in the selection of extraction well locations for Alternatives 3 and 4. Alternative 5 includes groundwater extraction by the use of subsurface trenches.

Alternative 5 would be more effective than Alternatives 3 and 4 in extracting contaminants and creating an hydraulic boundary that would minimize the off-site transport of contaminants. However, a subsurface trench could drain large amounts of clean water from Cayuga Creek, which may adversely impact flora and fauna in the creek. In addition, implementability of Alternative 5 would require excavation of contaminated soil/fill materials and bedrock, groundwater dewatering, soil/fill material shoring and stabilization, and off-site disposal of soil/fill materials. There are no construction and implementability concerns with installation of extraction wells as part of Alternatives 3 and 4. Therefore, Alternative 5 is rejected.

Alternative 3 includes on-site treatment of extracted groundwater. Alternative 4 includes extracted groundwater discharge at a POTW. Discharge of extracted groundwater at a POTW would provide effective treatment and disposal and would also eliminate operation and maintenance of the on-site treatment system associated with Alternative 3. Based on this analysis, the recommended CMA for Site 3 is Alternative 4: Groundwater extraction by wells and discharge of extracted groundwater to a POTW.

4.4 Performance Monitoring Program

In order to evaluate the effectiveness of the pumping system for the selected CMA, performance goals and preliminary requirements for hydraulic and chemical monitoring have been developed for Site 3. This program will include the following:

- The performance goal for the selected CMA at Site 3 is to either reverse the hydraulic gradient to Cayuga Creek, thus completely eliminating the release of contaminants to Cayuga Creek, or to attain a 50% or more reduction in contaminant loading to Cayuga within five years and 75% or more reduction in contaminant loading to Cayuga Creek within ten years from the actual startup of the corrective action system.

- To demonstrate the capture zone of the corrective action system, hydraulic monitoring will be conducted on a weekly basis for the first month of the system's operation and monthly thereafter for the following two years; this will be followed by semi-annual monitoring. Hydraulic monitoring would be performed at selected wells at the site.

- Chemical monitoring will be performed on a monthly basis at the system effluent, and on a semi-annual basis at selected wells at the site for the first year of operation. Subject to an evaluation of the system's performance and NYSDEC's approval, the system effluent sampling could eventually be cut back to a quarterly and then a semi-annual basis.

For Site 3, the Base may petition the Agencies to terminate the groundwater extraction system if (1) the groundwater extraction system is functioning as designed, and (2) the groundwater contamination levels are above the NYSDEC Class GA standards, but the levels are not decreasing further. This "zero-slope" condition will be determined as follows:

1. The sum of the concentration of hazardous waste constituents resulting from eight consecutive quarterly sampling events will be plotted versus time.

2. If the curve that best fits these data points is linear, a straight line will be fitted to the data through the use of a least squares regression model; the slope of the fitted curve will be computed and designated as the estimated slope.

3. If the data points fit a non-linear form, then an exponential curve will be fitted to the data through the use of a least squares regression model. The estimated slope will be the first derivative of the curve at a value of time halfway between the last two sampling points.

4. The estimated slope shall be considered zero if that slope is less than or equal to zero (i.e., the concentration is stable) or the yearly decrease of the total concentration of hazardous waste constituents is less than the average overall precision of the analytical methods used.

In addition, the spatial and temporal distributions of the concentrations of compounds will be assessed to provide additional information regarding trends. If these concentrations are sufficiently low, the Base may petition the Agencies for permission to terminate the groundwater extraction system and propose a post-termination monitoring program. However, the groundwater extraction system will remain in place during the post-termination monitoring period. The purpose of the post-termination monitoring program will be to demonstrate to the Agencies that the groundwater contamination levels remain sufficiently low and are in a "zero-slope" condition.

Table 4-1

SUMMARY OF RFI AND SUPPLEMENTAL INVESTIGATION
SOIL SAMPLING ANALYTICAL RESULTS
IRP SITE 3
NIAGARA FALLS IAP-ARS

Analyte	Detection Frequency	Range of Detected Concentrations		Guidance Value[a]	Exceedance Frequency
		Minimum	Maximum		
Metals (mg/kg)					
Arsenic	10/10	1.1	8.4	16	0/10
Beryllium	2/10	0.74	0.89	1.81	0/10
Cadmium	10/10	1.5	5.8	7[b]	0/10
Chromium, total	10/10	3.5 B	27	112	0/10
Copper	10/10	4.1 B	26	48.7	0/10
Lead	10/10	4.1	68	33	3/10
Mercury	3/10	0.21	0.30	0.265	1/10
Nickel	10/10	5.8 B	29	38.2	0/10
Selenium	6/10	0.59	3.5	0.941	6/10
Zinc	10/10	84 J	410 J	104	10/10
VOCs (μg/kg)					
1,1,1-Trichloroethane	1/13	98	98	800	1/13
1,1,2,2-Tetrachloroethane	1/13	2 J	2 J	600	1/13
Acetone	13/13	3 B	160	200	0/13
Benzene	1/13	2.4 J	2.4 J	60	0/13
Carbon disulfide	2/13	3 J	9	2,700	0/13
Carbon tetrachloride	4/13	1 J	26,000 J	600	1/13
Chloroform	3/13	10	660 J	300	1/13
cis-1,2-Dichloroethene	2/13	1 J	19 J	NV	0/13
Ethylbenzene	2/13	1.8 J	12 J	5,500	0/13
Methylene chloride	3/13	1 J	6 J	100	0/13
Tetrachloroethene	2/13	6	7	1,400	0/13
Toluene	4/13	2.6 J	9	1,500	0/13
Trichloroethene	3/13	5 J	3,000 J	700	1/13
Xylenes (total)	1/13	1 J	53 J	1,200	0/13

Key at end of table.

Table 4-1

SUMMARY OF RFI AND SUPPLEMENTAL INVESTIGATION SOIL SAMPLING ANALYTICAL RESULTS IRP SITE 3 NIAGARA FALLS IAP-ARS

Analyte	Detection Frequency	Range of Detected Concentrations		Guidance Value[a]	Exceedance Frequency
		Minimum	Maximum		
SVOCs (μg/kg)					
2-Methylnaphthalene	3/13	51 J	2,600 J	36,400	0/13
Acenaphthene	3/13	48 J	3,200 J	50,000	0/13
Acenaphthylene	2/13	100 J	390 J	41,000	0/13
Anthracene	3/13	56 J	2,700 J	50,000	0/13
Benzo(a)anthracene	3/13	58 J	3,000 J	330	1/13
Benzo(a)pyrene	5/13	110 J	1,500 J	330	1/13
Benzo(b)fluoranthene	5/13	100 J	3,200 J	1,100	1/13
Benzo(g,h,i)perylene	4/13	93 J	720 J	50,000	0/13
Benzo(k)fluoranthene	3/13	52 J	380 J	1,100	0/13
bis(2-Ethylhexyl)phthalate	9/13	61 J	1,000	50,000	0/13
Butylbenzylphthalate	2/13	36 J	67 J	50,000	0/13
Carbazole	1/13	59 J	59 J	NV	0/13
Chrysene	3/15	63 J	1,600 J	400	1/15
Di-n-butylphthalate	3/13	27 J	99 J	8,100	0/13
Dibenzo(a,h)anthracene	2/13	43 J	390 J	330	1/13
Dibenzofuran	2/13	54 J	2,900	6,200	0/13
Diethylphthalate	2/10	760	3,000	7,100	0/10
Fluoranthene	3/13	87 J	8,000 J	50,000	0/13
Fluorene	3/13	63 J	3,300 J	50,000	0/13
Indeno(1,2,3-cd)pyrene	4/13	84 J	750 J	3,200	0/13
Naphthalene	2/13	370	9,600	13,000	0/13
Pentachlorophenol	1/13	71 J	71 J	1,000	0/13
Phenanthrene	5/13	64 J	13,000 J	50,000	0/13
Pyrene	3/13	100 J	5,700 J	50,000	0/13
PCDD/PCDF (μg/kg)					
2,3,7,8-TCDD	1/5	0.0159	0.0159	NV	0/5

Key at end of table.

Table 4-1

SUMMARY OF RFI AND SUPPLEMENTAL INVESTIGATION SOIL SAMPLING ANALYTICAL RESULTS IRP SITE 3 NIAGARA FALLS IAP-ARS

Analyte	Detection Frequency	Range of Detected Concentrations		Guidance Value[a]	Exceedance Frequency
		Minimum	Maximum		
1,2,3,7,8-PeCDD	1/5	0.0345	0.0345	NV	0/5
1,2,3,6,7,8-HxCDD	1/5	0.202	0.202	NV	0/5
1,2,3,7,8,9-HxCDD	2/5	0.0704	0.178	NV	0/5
1,2,3,4,6,7,8-HpCDD	3/5	0.494	3.78	NV	0/5
1,2,3,4,6,7,8,9-OCDD	4/5	0.297	23.1	NV	0/5
2,3,7,8-TCDF	2/5	0.0095	0.088	NV	0/5
2,3,4,7,8-PeCDF	1/5	0.0352	0.0352	NV	0/5
1,2,3,4,6,7,8-HxCDF	1/5	0.181	0.181	NV	0/5
1,2,3,4,6,7,8-HpCDF	2/5	0.144	1.14	NV	0/5
1,2,3,4,6,7,8,9-OCDF	3/5	0.171	1.30	NV	0.5
PCBs (mg/kg)					
Aroclor 1242	1/3	0.016	0.016	10.0	0/3
Aroclor 1254	3/3	0.014	0.032	10.0	0/3
Aroclor 1260	2/3	0.015	0.020	10.0	0/3

a Metals guidance values are based on upper limit of the 90th percentile of the observed range as calculated from the data of Shacklette and Boerngen 1984, excepted as noted. Guidance values for VOCs and BNAs are based on TAGM 4046 (NYSDEC 1994).

b Upper end of cadmium range as stated in Dragun 1988.

Key:

B = Present in blank.
J = Estimated.
NV = No value in TAGM 4046.

Table 4-2

SUMMARY OF RFI GROUNDWATER SAMPLING ANALYTICAL RESULTS
IRP SITE 3
NIAGARA FALLS IAP-ARS

Analyte	Detection Frequency	Range of Detected Concentrations		Guidance Value[a]	Exceedance Frequency
		Minimum	Maximum		
Metals (µg/L)					
Arsenic	1/10	17	17	25	0/10
Chromium (total)	1/10	23	23	50	0/10
Copper	2/10	22	33	200	0/10
Lead	10/10	6.9	100	25	4/10
Nickel	1/10	41	41	NV	0/10
Zinc	9/10	15	1,700	300	2/10
VOCs (µg/L)					
Carbon disulfide	1/10	110	110	NV	0/10
Carbon tetrachloride	1/10	2,400	2,400	5.0	1/10
Chloroform	1/10	1,000	1,000	7.0	1/10
cis-1,2-Dichloroethene	1/10	36	36	5.0	1/10
Methylene chloride	1/10	6	6	5.0	1/10
Toluene	1/10	5	5	5.0	1/10
trans-1,2-Dichloroethene	1/10	2 J	2 J	5.0	0/10
Trichloroethene	1/10	920	920	5	1/10
Vinyl chloride	2/10	2	11	2	2/10
PCBs (µg/L)					
Aroclor 1254	1/10	0.61	0.61	0.1	1/10

[a] NYSDEC Class GA groundwater standards.

Key:

J = Estimated.
NV = No Class GA standard.

Table 4-3

SUMMARY OF RFI SURFACE WATER SAMPLING ANALYTICAL RESULTS
IRP SITE 3
NIAGARA FALLS IAP-ARS

Analyte	Detection Frequency	Range of Detected Concentrations		Guidance Value[a]	Exceedance Frequency
		Minimum	Maximum		
Metals (µg/L)					
Zinc	3/3	180	190	30	3/3
Semivolatiles (µg/L)					
bis(2-Ethylhexyl)phthalate	2/3	2 J	7 J	0.6	2/3

[a] NYSDEC Class C surface water standards.

Key:

J = Estimated.

Table 4-4

SUMMARY OF RFI SEDIMENT SAMPLING ANALYTICAL RESULTS
IRP SITE 3
NIAGARA FALLS IAP-ARS

Analyte	Detection Frequency	Range of Detected Concentrations		Lowest Effect Level [a]	Severe Effect Level[b]	Exceedance Frequency
		Minimum	Maximum			
Metals (mg/kg)						
Arsenic	3/3	1.6	1.9	6.0	33	0/3
Cadmium	2/3	0.82 J	1.6 J	0.6	9.0	2/3
Chromium, total	3/3	2.1 J	12 J	26	110	0/3
Copper	3/3	3.4 J	6.7 J	16	110	0/3
Lead	3/3	13	34	31	110	1/3
Nickel	3/3	13	7.7	16	50	0/3
Silver	3/3	2.3	4.1	1.0	2.2	3/3
Zinc	3/3	590 J	900 J	120	270	3/3
VOCs (µg/kg)						
1,1,1-Trichloroethane	1/3	3 J	3 J	NV	NV	0/3
4-Methyl-2-pentanone	2/3	3 B	11 B	NV	NV	0/3
Acetone	2/3	3 B	5 B	NV	NV	0/3
Methylene chloride	1/3	1 J	1 J	NV	NV	0/3
Semivolatiles (µg/kg)						
Benzo(a)anthracene	2/3	30 J	120 J	230	1,600	0/3
Benzo(a)pyrene	2/3	40 J	100 J	400	2,500	0/3

Key at end of table.

Table 4-4

SUMMARY OF RFI SEDIMENT SAMPLING ANALYTICAL RESULTS
IRP SITE 3
NIAGARA FALLS IAP-ARS

Analyte	Detection Frequency	Range of Detected Concentrations		Lowest Effect Level [a]	Severe Effect Level[b]	Exceedance Frequency
		Minimum	Maximum			
Benzo(b)fluoranthene	2/3	32 J	200 J	NV	NV	0/3
Benzo(g,h,i)perylene	1/3	29 J	62 J	NV	NV	0/3
Chrysene	2/3	31 J	120 J	400	2,800	0/3
Fluoranthene	3/3	43 J	170 J	600	3,600	0/3
Indeno(1,2,3-cd)pyrene	1/3	78 J	78 J	NV	NV	0/3
Phenanthrene	2/3	36 J	84 J	225	1,380	1/3
Pyrene	3/3	36 J	150 J	350	2,200	0/3
bis(2-ethylhexyl)phthalate	1/3	110 J	110 J	NV	NV	0/3
Diethylphthalate	1/3	2,400	2,400	NV	NV	0/3

a Lowest of either Persaud *et al.* (1992) Lowest Effect Level or Long and Morgan (1990) Effect Range-Low.
b Lowest of either Persaud *et al.* (1992) Severe Effect Level or Long and Morgan (1990) Effect Range-Moderate.

Key:

J = Estimated.
NV = No value.

Table 4-5

SOIL CLEANUP OBJECTIVES
IRP SITE 3
NIAGARA FALLS IAP-ARS

Analyte	NYSDEC TAGM 4046 Soil Cleanup Objective[c]	EPA Region III RBC[d]	Candidate Cleanup Objective	Maximum Concentration Detected	Site Cleanup Objective
Metals (mg/kg)					
Arsenic	16	610	16	8.4	NA
Beryllium	1.81	1.3	1.81	0.89	NA
Cadmium	7[a]	1,000	7	5.8	NA
Chromium, total	112	10,000	112	27	NA
Copper	48.7	76,000	48.7	28.8	NA
Lead[b]	33	—	33	68	33
Mercury[b]	0.265	610	0.265	0.30	0.265
Nickel	38.2	41,000	38.2	29	NA
Selenium[b]	0.941	10,000	0.941	3.5	0.941
Zinc[b]	104	610,000	104	687	104
VOCs (μg/kg)					
1,1,1-Trichloroethane	800	180,000,000	800	98	NA
1,1,2,2-Tetrachloroethane	—	29,000	29,000	2	NA
Acetone	200	200,000,000	200	160	NA
Benzene	60	200,000	60	2.4	NA
Carbon disulfide	2,700	200,000,000	2,700	9	NA
Carbon tetrachloride	600	44,000	600	26,000	600
Chloroform	300	940,000	300	660	300
cis-1,2-Dichloroethene	—	200,000,000	200,000,000	19	NA
Ethylbenzene	5,500	200,000,000	5,500	12	NA
Methylene chloride	100	760,000	100	6	NA
Tetrachloroethene	1,400	110,000	1,400	7	NA
Toluene	1,500	410,000,000	1,500	9	NA
Trichloroethene	700	520,000	700	3,000	700
Xylenes (total)	1,200	1×10^9	1,200	53	NA

Key at end of table.

Table 4-5

SOIL CLEANUP OBJECTIVES
IRP SITE 3
NIAGARA FALLS IAP-ARS

Analyte	NYSDEC TAGM 4046 Soil Cleanup Objective[c]	EPA Region III RBC[d]	Candidate Cleanup Objective	Maximum Concentration Detected	Site Cleanup Objective
Semivolatiles (μg/kg)					
2-Methylnaphthalene	36,400	—	36,400	2,600	NA
Acenaphthylene	41,000	—	41,000	390	NA
Acenaphthene	50,000	120,000,000	50,000	3,200	NA
Anthracene	50,000	610,000,000	50,000	2,700	NA
Benzo(a)anthracene	330	7,800	330	3,000	330
Benzo(a)pyrene	330	780	330	1,500	330
Benzo(a)fluoranthene	1,100	—	1,100	3,200	1,100
Benzo(g,h,i)perylene	50,000	—	50,000	720	NA
Benzo(k)fluoranthene	1,100	78,000	1,100	380	NA
bis(2-Ethylhexyl)phthalate	50,000	410,000	50,000	1,000	NA
Butylbenzylphthalate	50,000	410,000,000	50,000	67	NA
Carbazole	—	290,000	290,000	59	NA
Chrysene	400	780,000	400	1,600	400
Di-n-butylphthalate	8,100	200,000,000	8,100	99	NA
Dibenzo(a,h)anthracene	330	780	330	390	330
Dibenzofuran	6,200	8,200,000	6,200	2,900	NA
Diethyl phthalate	7,100	1,000,000,0 00	7,100	3,000	NA
Fluoranthene	50,000	82,000,000	50,000	8,000	NA
Fluorene	50,000	82,000,000	50,000	3,300	NA
Indeno(1,2,3-cd)pyrene	3,200	7,800	3,200	750	NA
Phenanthrene	50,000	—	50,000	13,000	NA
Pyrene	50,000	61,000,000	50,000	5,700	NA
PCDD/PCDF (μg/kg)					
Total-2,3,7,8-TCDD Toxicity Equivalent	—	0.04	0.04	0.04	0.04
2,3,7,8-TCDD	—	0.04	0.04	0.0159	NA

Key at end of table.

Table 4-5

SOIL CLEANUP OBJECTIVES
IRP SITE 3
NIAGARA FALLS IAP-ARS

Analyte	NYSDEC TAGM 4046 Soil Cleanup Objective[c]	EPA Region III RBC[d]	Candidate Cleanup Objective	Maximum Concentration Detected	Site Cleanup Objective
PCBs (mg/kg)					
Aroclor 1242	10	—	10	0.016	NA
Aroclor 1254	10	20	10	0.032	NA
Aroclor 1260	10	—	10	0.02	NA

Note: Cleanup objectives for metals are based on the upper limit of the 90th percentile as calculated from the data of Shacklette and Boerngen 1984, except as noted.

a Upper limit of observed range for cadmium as stated in Dragun 1988.
b Does not warrant corrective measure because of the low frequency of detection and/or its presence is believed to be naturally occurring or not attributable to site-related activities.
c NYSDEC TAGM dated January 24, 1994.
d EPA Region III RBC dated March 7, 1995.

Key:

— = No value.
NA = Not applicable; maximum concentration detected does not exceed candidate cleanup objectives.

Table 4-6

GROUNDWATER CLEANUP OBJECTIVES FOR IRP SITE 3 NIAGARA FALLS IAP-ARS

Analyte	NYSDEC Class GA Standards	EPA Region III RBCs	Candidate Cleanup Objective	Maximum Concentration Detected	Site Cleanup Objective
Metals (µg/L)					
Arsenic	25	11	25	20	NA
Cadmium[a]	10	18	10	64	10
Chromium, total[a]	50	180	50	150	50
Copper[a]	200	1,400	200	857	200
Lead[a]	25	—	25	841	25
Mercury	2	11	2	0.2	NA
Nickel	—	730	730	2.33	NA
Zinc[a]	300	11,000	300	2,770	300
VOCs (µg/L)					
Benzene	0.7	0.36	0.7	2.5	0.7
Carbon disulfide	—	21	21	110	21
Carbon tetrachloride	5	0.16	5	2,400	5
Chloroform	7.0	0.15	7.0	1,100	7.0
Chloroethane	5.0	—	5.0	4.3	NA
1,2-Dichloromethane	5.0	—	5.0	4.3	NA
1,1-Dichloroethene	5.0	0.044	5.0	1.1	NA
cis-1,2-Dichloroethene	5.0	61	5.0	36	5.0

Key at end of table.

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Table 4-6

GROUNDWATER CLEANUP OBJECTIVES FOR IRP SITE 3 NIAGARA FALLS IAP-ARS

Analyte	NYSDEC Class GA Standards	EPA Region III RBCs	Candidate Cleanup Objective	Maximum Concentration Detected	Site Cleanup Objective
Methylene chloride	5.0	4.1	5.0	6	5.0
1,1,2,2-Tetrachloroethane	5.0	0.41	5.0	0.10	NA
Tetrachloroethene	5.0	1.1	5.0	0.83	NA
Toluene	5.0	750	5.0	5.0	5.0
trans-1,2-Dichloroethene	5.0	120	5.0	170	5.0
Trichloroethene	5.0	1.6	5.0	920	5.0
Vinyl chloride	2.0	0.019	2.0	55	2.0
PCBs (μg/L)					
Aroclor 1254[a]	0.1	0.73	0.1	0.61	0.1

a Does not warrant corrective measure because of the low frequency of detection and/or its presence is believed to be naturally occurring or not attributable to site-related activities.

Key:

— = No value.
NA = Not applicable; maximum concentration detected does not exceed candidate cleanup objective.

Table 4-7

SURFACE WATER CLEANUP OBJECTIVES
IRP SITE 3
NIAGARA FALLS IAP-ARS

Contaminant	NYSDEC Class C Surface Water Standard or Guidance Value	NYSDEC Class A Surface Water Standard or Guidance Value	Candidate Cleanup Objective	Maximum Concentration Detected	Site Cleanup Objective
Metals (μg/L)					
Arsenic	190[a]	190[a]	190	52	NA
Zinc[c]	30	30	30	1,320	30
VOCs (μg/L)					
Chloroform	—	7.0[b]	7.0	2.3	NA
Tetrachloroethene[c]	1[b]	1[b]	1	6.6	1
Trichloroethene	11[b]	11[b]	11	3.6	NA
Semivolatiles (μg/L)					
bis(2-Ethylhexyl)phthalate[c]	0.6[a]	0.6[a]	0.6	1.0	0.6

[a] Standard value.
[b] Guidance value.
[c] Does not warrant corrective measure because of the low frequency of detection and/or its presence is believed to be naturally occurring or not attributable to site-related activities.

Key:

— = No value.
NA = Not applicable; maximum concentration detected does not exceed candidate cleanup objective.
VOCs = Volatile organic compounds.

Table 4-8

SEDIMENT CLEANUP OBJECTIVES
IRP SITE 3
NIAGARA FALLS IAP-ARS

Analyte	NYSDEC Sediment Technical Guidance	Long and Morgan[a]	NYSDEC TAGM 4046 Soil Cleanup Objective	Candidate Cleanup Objective	Maximum Concentration Detected	Site Cleanup Objective
Metals (mg/kg)						
Arsenic	6.0	—	16	6.0	3.7	NA
Cadmium[b]	0.6	—	7	0.6	4.36	0.6[b]
Chromium	26	—	112	26	13.7	NA
Copper	16	—	48.7	16	9.29	NA
Lead[b]	31	—	33	31	41.3	31[b]
Nickel[b]	16	—	38.2	16	21.2	16[b]
Zinc[b]	120	—	104	120	1,070	120[b]
Silver[b]	—	1.0	—	1.0	4.1	1.0[b]
VOCs (μg/kg)						
1,1,1-Trichloroethane	—	—	800	800	3 J	NA
4-Methyl-2-pentanone	—	—	1,000	1,000	11 B	NA
Acetone	—	—	200	200	5 B	NA
Methylene chloride	—	—	100	100	14	NA
Semivolatiles (μg/kg)						
Benzo(a)anthracene	13	—	224	13	120 J	13[b]
Benzo(a)pyrene	13	—	61	13	100 J	13[b]
Benzo(b)fluoranthene	13	—	1,100	13	200 J	13[b]
Benzo(g,h,i)perylene	—	—	50,000	50,000	62 J	NA
Chrysene	—	—	400	400	120 J	NA
Fluoranthene	10,200	—	50,000	10,200	170 J	NA
Indeno(1,2,3-cd)pyrene	—	—	3,200	3,200	78 J	NA
Naphthalene	—	340	13,000	340	44 J	NA

Key at end of table.

Table 4-8

SEDIMENT CLEANUP OBJECTIVES
IRP SITE 3
NIAGARA FALLS IAP-ARS

Analyte	NYSDEC Sediment Technical Guidance	Long and Morgan[a]	NYSDEC TAGM 4046 Soil Cleanup Objective	Candidate Cleanup Objective	Maximum Concentration Detected	Site Cleanup Objective
bis(2-ethylhexyl)phthalate	1995	—	—	1995	110 J	NA
Diethylphthalate	—	—	7,100	7,100	2,400	NA
Phenanthrene	—	235	50,000	225	84 J	NA
Pyrene	—	350	50,000	350	150 J	NA

a Long and Morgan (1990); NYSDEC Technical Guidance for Screening Contaminated Sediments.
b Does not warrant corrective measure because of the low frequency of detection and/or its presence is believed to be naturally occurring or not attributable to site-related activities.

Key:

— = No value.
NA = Not applicable; maximum concentration detected does not exceed candidate cleanup objective.

Table 4-9

CLEANUP OBJECTIVES FOR SOILS IN FLOODPLAINS
IRP SITE 3
NIAGARA FALLS IAP-ARS

Analyte	Soil Sample (feet BGS)			NYSDEC Sediment Technical Guidance	Long and Morgan[a]	NYSDEC TAGM 4046 Soil Cleanup Objective	Candidate Cleanup Objective	Maximum Observed Soil Concentration
	SB3-4 (2-5.8)	SB3-5 (4-6)	MW3-1E (2-4)					
Metals (mg/kg)								
Arsenic	2.1	1.3	1.1	6.0	—	16	6.0	2.1
Cadmium	2.3	ND	1.7	0.6	—	7	0.6	2.3
Chromium	8.1 B	4.6 B	13	26	—	112	26	13
Copper	13 B	8.4 B	4.1 B	16	—	48.7	16	13
Lead	11	8.8	13	31	—	—	31	13
Nickel	8.1 B	5.8 B	11	16	—	38.2	16	11
Selenium	ND	0.59	ND UJ	—	—	0.941	0.941	0.59
Zinc	230	119	220	120	—	104	120	230
VOCs (μg/kg)								
Acetone	ND	3 B	14 B	—	—	200	200	14
Semivolatiles (μg/kg)								
bis(2-ethylhexyl)phthalate	61 J	130 J	240 B	1,995	—	200	1,995	240
Butylbenzylphthalate	ND	ND	36 J	—	—	50,000	50,000	36

Key at end of table.

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Table 4-9

CLEANUP OBJECTIVES FOR SOILS IN FLOODPLAINS IRP SITE 3 NIAGARA FALLS IAP-ARS

Analyte	Soil Sample (feet BGS)			NYSDEC Sediment Technical Guidance	Long and Morgan[a]	NYSDEC TAGM 4046 Soil Cleanup Objective	Candidate Cleanup Objective	Maximum Observed Soil Concentration
	SB3-4 (2-5.8)	SB3-5 (4-6)	MW3-1E (2-4)					
Di-n-butylphthalate	ND	ND	99 J	—	—	8,100	8,100	99
Diethylphthalate	ND	ND	3,000	—	—	7,100	7,100	3,000

Note: Shaded value represents values that exceed sediment cleanup objectives.

[a] Long and Morgan (1990), NYSDEC Technical Guidance for Screening Contaminated Sediments.

Key:

B = Present in blank.
J = Estimated.
ND = Not detected.

Table 4-10

NUMBER OF SOIL SAMPLES EXCEEDING CLEANUP OBJECTIVES
IRP SITE 3
NIAGARA FALLS IAP-ARS

Analyte	Total Number of Samples	Number of Samples Above Cleanup Objectives	Exceedance Frequency
Lead	19	5	5/19
Mercury	19	1	1/19
Selenium	19	6	6/19
Zinc	19	17	17/19
Carbon tetrachloride	22	1	1/22
Chloroform	22	1	1/22
Trichloroethene	22	1	1/22
Benzo(a)anthracene	13	1	1/13
Benzo(a)pyrene	13	1	1/13
Benzo(a)fluoranthene	13	1	1/13
Chrysene	13	1	1/13
Dibenzo(a,h)anthracene	13	1	1/13
2,3,7,8-TCDD Toxicity Equivalent	5	1	1/5

Table 4-11

PHYSICAL AND CHEMICAL PROPERTIES OF ORGANIC CONTAMINANTS OF CONCERN
IRP SITE 3
NIAGARA FALLS IAP-ARS

Contaminant	Molecular Formula	Molecular Weight	Vapor Pressure (mm Hg)	Water Solubility (mg/L)	Henry's Law Constant (atm-m^3/mol)	Log K_{ow}
Benzene	C_6H_6	78.11	76	1,780	5.43×10^{-3}[a]	2.13
Carbon tetrachloride	CCl_4	153.84	91.3	800	0.02	2.83
Chloroform	$CHCl_3$	119.39	160	8,220	3.75×10^{-3}[a]	1.97
cis-1,2-Dichloroethene	$C_2H_2Cl_2$	96.95	200[a]	3,500	7.5×10^{-3}[a]	1.86
1,1-Dichloroethene	$C_2H_2Cl_2$	96.95	500	400	1.54×10^{-1}[a]	2.13
Methylene chloride	CH_2Cl_2	84.94	350	13,200	2.57×10^{-3}[a]	1.25
trans-1,2-Dichloroethene	$C_2H_2Cl_2$	96.95	265	6,300	6.6×10^{-3}[a]	2.09
Trichloroethene	C_2HCl_3	131.40	58.7	1,000	8.92×10^{-3}[a]	2.42
Vinyl chloride	C_2H_3Cl	62.50	2,300	1,100	0.695	0.60
m-Xylenes	C_8H_{10}	106.16	g	200	6.91×10^{-3}[a]	3.20
Carbon disulfide	CS_2	76.14	297	2,100	1.4×10^{-3}	1.84
1,1,2,2-Tetrachloroethane	$C_2H_2Cl_4$	168	4.9	2,900	5×10^{-4}[a]	2.39
Tetrachloroethene	C_2Cl_4	166	14	1,500	2.27×10^{-2}[a]	3.14
Toluene	C_7H_8	92	22	515	6.61×10^{-3}[a]	2.73
Aroclor 1254	$Cl_x(C_6H_4)(C_6H_4)Cl_y$[c]	327	7.71×10^{-5}	0.012	2.8×10^{-4}	6.03

Notes: Values listed are from EPA 9902.3-1a, Corrective Action Glossary, July 1992. Values are presented at 20°C unless otherwise noted.

[a] Value is at 25°C.

[b] Value is at unknown temperature but is assumed to be 20 to 25°C.

[c] x + y = 0 to 7.

Table 4-12

SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES FOR GROUNDWATER IRP SITE 3 NIAGARA FALLS IAP-ARS

Corrective Measure Technology (CMT)	Preliminary Screening Criteria			Retain Status (Yes/No)
	Site Characteristics	Waste Characteristics	Technology Limitations	
Extraction Wells	Since contamination is relatively localized at the site, well extraction will be suitable for extracting contaminated groundwater. Pump test conducted at the site has shown that groundwater can be extracted at a reasonable flow rate. Additional wells if needed can be easily installed.	Contaminants can be extracted with groundwater.	Groundwater extraction by extraction well is an established technology.	Yes
Trenches	Although trenches are more suitable where contamination is widespread spatially, the complex site hydrogeology and presence of preferential pathways of contaminant transport through bedrock fractures favors the adoption of trenches despite potential challenges of installing trenches within bedrock. Subsurface trenches that act as a line of extraction wells can be installed downgradient of the site and adjacent to the Cayuga Creek.	Contaminants can be extracted by collecting contaminated groundwater in the trenches.	Groundwater collection by trenches is a well established technology.	Yes
Horizontal wells	Horizontal wells are installed where the plume is large in spatial extent and present in a relatively linear configuration. At Site 3, the relatively small area of contamination suggests that it can be well managed by wells or trenches.	Contaminants can be extracted with groundwater.	Relatively new technology.	No

Table 4-12

SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES FOR GROUNDWATER
IRP SITE 3
NIAGARA FALLS IAP-ARS

Corrective Measure Technology (CMT)	Preliminary Screening Criteria			Retain Status (Yes/No)
	Site Characteristics	Waste Characteristics	Technology Limitations	
Containment-slurry walls, liner panel walls, jet grouting, and sheet piling	Based on the shear strength testing done for subsurface soils at Site 3, it appears that the subsurface is suitable for the installation of containment systems. To properly contain groundwater flow, vertical containment systems would need to extend to the bedrock. Construction of vertical containment systems would be difficult due to bedrock excavation. The top 10-15 feet of the bedrock is highly fractured and would not serve as an effective containment key.	Because the contaminants are in the same phase with the groundwater, the contaminants cannot be effectively contained by a vertical wall that is not keyed into a low permeability zone, a condition not present at the site. At the site, directional fractures in the bedrock beneath the containment wall can act as preferential pathways of contaminant transport. Theoretically, a bedrock region of less fractures and fissures can be found at deeper depths. However, the depths could be exceptionally large.	Well established technology.	No
Biological treatment	In the pump test conducted at the site, a maximum flow rate of 4.5 gallons per minute (gpm) could be achieved on an intermittent basis. Biological treatment processes are difficult to maintain under variant and intermittent hydraulic and mass loading conditions.	The majority of contaminants are volatile organic compounds (VOCs), which would be easily stripped in the aeration chamber of the biological treatment system, reducing the effectiveness of biologically mediated removal mechanisms.	Biological treatment is well established technology.	No
Carbon adsorption	None that affect treatment of groundwater by carbon adsorption. Variable flow rates and organics loadings can be handled by the carbon adsorption process. High concentrations of inorganics would blind carbon adsorption systems.	Majority of the contaminants at the site are VOCs which are more amenable for treatment by air stripping technology. Vinyl chloride quickly breaks through carbon adsorption units.	Well established technology. Will require pre-treatment for suspended solids.	No

Table 4-12

SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES FOR GROUNDWATER
IRP SITE 3
NIAGARA FALLS IAP-ARS

Corrective Measure Technology (CMT)	Preliminary Screening Criteria			Retain Status (Yes/No)
	Site Characteristics	Waste Characteristics	Technology Limitations	
Air Stripping	Air stripping can be operated under variable flow and organics loading, and can also be operated intermittently, as expected at the site.	Majority of the organics present in the groundwater can be stripped.	Well established technology. Suspended solids would require pretreatment.	Yes
UV/ Ozonation	Low groundwater flow rates and slow recharge translate to intermittent operation of any treatment system. For the ultraviolet (UV)/ozonation treatment system variant flow, conditions may render system control difficult.	This technology is only effective on double-banded organic compounds, such as aromatics and chlorinated ethenes. Other contaminant types present would not be treated.	UV/ozonation treatment may actually strip out the VOCs from the ground-water, requiring off-gas treatment.	No
Wet air oxidation	Wet air oxidation may need high voltage and/or high amperage power supply, currently not available at the site. Variant flow conditions at the site would require more operator attention.	The relatively low concentration of contaminants and the aqueous matrix would promote other simple and reliable technologies.	It is a complex process and needs skilled operator attention. The technology has high operation and maintenance requirements.	No
Ion-exchange	None that affect treatment of extracted groundwater by ion-exchange technology. Ion-exchange can be used in unsteady flow and influent concentration conditions.	Ion-exchange will not treat organic species at the site.	Relatively simple to operate and maintain.	No
Membrane Separation	Intermittent operating conditions may render membrane separation system difficult to perform efficiently.	Contaminants in the groundwater can be treated by other simple and reliable technologies.	Technical feasibility of using membrane separation system for organics separation at hazardous waste sites is not well demonstrated.	No

Table 4-12

SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES FOR GROUNDWATER
IRP SITE 3
NIAGARA FALLS IAP-ARS

Corrective Measure Technology (CMT)	Preliminary Screening Criteria			Retain Status (Yes/No)
	Site Characteristics	Waste Characteristics	Technology Limitations	
Filtration	Filtration performs effectively under time variant flow conditions expected at site.	Multi-media filtration or bag filtration may be required to effectively separate a wide range of particle size of clay, soil, and metal precipitates.	Well established technology. Separated solids may require further treatment prior to disposal.	Yes
Sedimentation	Sedimentation does not perform effectively under variant flow conditions expected at site. Other technologies (like filtration) for solids removal can be easily implemented.	Fine particle size solids or metals precipitate may not be removed effectively by precipitation alone. Coagulation/flocculation may also be required.	Well established technology. Separated solids may require further treatment prior to disposal.	No
Precipitation/ Coagulation/ Flocculation	This technology does not perform well under fluctuating flow rates or varying concentrations of metal species, expected at site. Various adjustments are required to achieve comparable treatment efficiency under changed conditions.	This technology is not applicable for organic species. Soluble metals are not expected to be present at high concentrations, where this technology is typically used.	Well established technology.	No
In-situ bioremediation	Highly heterogenous subsurface conditions would make the design, implementation, and operation of this technology difficult at the site.	Chlorinated species present in site groundwater can be biodegraded (Natural biodegradation may actually be occurring at the site).	In-situ biodegradation achieves localized results.	No
Air sparging	For effective performance, this technology requires water table depths from moderate to large depths. At Site 3, because of the existence of a shallow water table, this technology cannot be implemented.	Organics present in the site groundwater are amenable to air sparging. In addition, the possible natural biodegradation occurring at the site may get accelerated with the aid of air sparging.	Technology is available at field scale level.	No

Table 4-12

SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES FOR GROUNDWATER
IRP SITE 3
NIAGARA FALLS IAP-ARS

Corrective Measure Technology (CMT)	Preliminary Screening Criteria			Retain Status (Yes/No)
	Site Characteristics	Waste Characteristics	Technology Limitations	
Passive treatment walls	Complex hydrogeology and subsurface conditions may complicate the design and implementation of this technology. Shallow water table depths may limit the effectiveness of this technology. Site groundwaters have high concentrations of inorganics like calcium, magnesium, and iron. Significant pH shifts observed with iron fillings and biofilms can cause calcium carbonate scaling on the media.	A reactive media can be used in the walls to remove the organics from the groundwater. Biofilms can also be used in the passive treatment walls to degrade the organics. Also biological growth can limit the permeability of the wall.	The technology is not available commercially.	No
Vacuum vapor extraction	Shallow water table may limit the implementability of this technology at the site. Artesian conditions exist in some portions of the site that may eliminate this technology.	Technology applicable for majority of the organics present at the site. Fouling of the system may occur by oxidized constituents in the groundwater.	Vacuum vapor extraction is a pilot scale technology.	No
Disposal at a treatment, storage, and disposal facility (TSDF)	None that effect disposal at a TSDF. However other available disposal technologies (like disposal to publicly owned treatment works (POTW), disposal to Cayuga Creek after treatment) can be easily implemented at the site as compared to disposal at a TSDF.	Extracted groundwater could be classified as characteristic hazardous waste due to concentrations of organic compounds higher than the regulatory levels (40 CFR, Section 261.24). This would require handling of extracted groundwater as an hazardous waste and would require manifesting. In addition, presence of highly volatile and toxic vinyl chloride would require additional health and safety precautions during handling and transport of extracted groundwater.	Technology is well developed. A Resource Conservation and Recovery Act (RCRA) permitted TSDF facility that can accept the extracted groundwater exists very close to the site. High operation and maintenance requirements are associated	No

Table 4-12

SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES FOR GROUNDWATER
IRP SITE 3
NIAGARA FALLS IAP-ARS

Corrective Measure Technology (CMT)	Preliminary Screening Criteria			Retain Status (Yes/No)
	Site Characteristics	Waste Characteristics	Technology Limitations	
Disposal to Cayuga Creek	None that effect disposal to Cayuga Creek. A State Pollutant Discharge Elimination System (SPDES) permit will be required before disposal can be commenced.	Organics present in the groundwater will need treatment before disposal to Cayuga Creek. Any other discharge limitations like solids concentrations, metals concentration, pH would also be required to be within the permit limits. However, it is anticipated that these limits can be easily met.	Technology well developed and implemented.	Yes
Reinjection to groundwater	The design and implementation of an groundwater reinjection system at the site will be vary difficult due to the complex, heterogenous subsurface conditions at the site. Other disposal technologies that are simple and easy to implement at the site are available.	Organics present in the groundwater will need treatment to meet Class GA Standards before reinjection. Any other discharge limitations like solids concentrations, metals concentration, pH would also be required to be within the discharge limits. The discharge limits for reinjection are expected to be more stringent than discharge limits to the POTW or to the Cayuga Creek.	Technology well developed and implemented.	No
Discharge to POTW	A number of manholes exist close to the site that can be used for discharge of extracted groundwater.	Chlorinated organic species present in the site groundwater have been earlier accepted from an other facility, for treatment by the Niagara County Sewer District (NCSD).	Technology well developed and implemented. Prior approval from NCSD will be required. Discharge to POTW would afford effective treatment and disposal of groundwater.	Yes

TABLE 4-13
IRP Site 3
Costs for Alternative 1
No Action and Natural Attenuation

Interest rate	6.0%
Operation and Maintenance (years)	30
Legal, Adminstrative, & Eng. Fees	25.0%
Contigencies	20.0%

Item No.	Description	Quantity	Units	Unit Cost	Cost
CAPITAL COSTS					
1	Mobe/demobe (4% of capital subtotal)	1	LS	$158	$158
2	Site services	1	LS	$250	$250
3	Health & Safety	1	LS	$1,000	$1,000
4	Clear and grub trees and remove	0.10	Acres	$3,220	$322
5	Grub stumps and remove	0.10	Acres	$1,438	$144
6	Backfill cleared areas	81	CY	$14	$1,139
7	Seed the cleared areas	484	SY	$2	$1,091
				Subtotal	$4,103
8	Legal, administrative, & eng. costs	25%			$1,026
				Subtotal	$5,129
9	Contingencies	20%			$1,026
	TOTAL CAPITAL COSTS				**$6,155**
OPERATION & MAINTENANCE COSTS					
1	Sample collection - groundwater(14 wells)	28	EA	$250	$7,000
2	Sample collection - surf. water/sed.	12	EA	$250	$3,000
3	VOC analysis	46	EA	$275	$12,650
4	Well maintanence	1	LS	$1,000	$1,000
5	Data validation	46	EA	$35	$1,610
6	Report writing	4	EA	$1,500	$6,000
7	Mowing (Bi-monthly)	9	Acres	$264	$2,482
				Subtotal	$33,742
8	Legal, adminstrative, eng. fees	25%			$8,435
				Subtotal	$42,177
9	Contingencies	20%			$8,435
	TOTAL O & M COSTS				**$50,612**
	TOTAL O & M PRESENT WORTH	30 years			**$696,671**
	TOTAL CAPITAL COSTS				**$6,155**
	GRAND TOTAL COST				**$702,826**

TABLE 4-14
IRP Site 3
Costs for Alternative 2
Institutional Actions and Natural Attenuation

Interest rate	6.0%
Operation and Maintenance (years)	30
Legal Adminstrative, & Eng. Fees	25.0%
Contigencies	20.0%

Item No.	Description	Quantity	Units	Unit Cost	Cost
CAPITAL COSTS					
1	Mobe/demobe (4% of capital subtotal)	1	LS	$398	$398
2	Site services	1	LS	$250	$250
3	Health & Safety	1	LS	$1,000	$1,000
4	Clear and grub trees and remove	0.10	Acres	$3,220	$322
5	Grub stumps and remove	0.10	Acres	$1,438	$144
6	Backfill cleared areas	81	CY	$14	$1,139
7	Seed the cleared areas	484	SY	$2	$1,091
8	Deed restrictions	1	LS	$6,000	$6,000
				Subtotal	$10,343
9	Legal, adminstrative, eng. fees	25%			$2,586
				Subtotal	$12,929
10	Contingencies	20%			$2,586
	TOTAL CAPITAL COSTS				**$15,515**
OPERATION & MAINTENANCE COSTS					
1	Sample collection - groundwater(14 wells)	28	EA	$250	$7,000
2	Sample collection - surf. water/sed.	12	EA	$250	$3,000
3	VOC analysis	46	EA	$275	$12,650
4	Well maintanence	1	LS	$1,000	$1,000
5	Data validation	46	EA	$35	$1,610
6	Report writing	4	EA	$1,500	$6,000
7	Mowing (Bi-monthly)	9	Acres	$264	$2,482
				Subtotal	$33,742
8	Legal, adminstrative, eng. fees	25%			$8,435
				Subtotal	$42,177
9	Contingencies	20%			$8,435
	TOTAL O & M COSTS				**$50,612**
	TOTAL O & M PRESENT WORTH	30 years			**$696,671**
	TOTAL CAPITAL COSTS				**$15,515**
	GRAND TOTAL COST				**$712,186**

TABLE 4-15
IRP Site 3
Costs for Alternative 3
Groundwater Removal by Wells, On-site Treatment, and Discharge to Cayuga Creek

Interest rate	6.0%
Operation & maintenance period (years)	30
Legal Adminstrative, & Eng. Fees	25.0%
Contigencies	20.0%

Item No.	Description	Quantity	Units	Unit Cost	Cost
CAPITAL COSTS					
1	Mobe/Demobe (4% of capital subtotal)	1	LS	$6,093	$6,093
2	Site services	1	MO	$2,500	$2,500
3	Health & Safety	1	LS	$10,000	$10,000
4	Clear and grub trees and remove	0.10	Acres	$3,220	$322
5	Grub stumps and remove	0.10	Acres	$1,438	$144
6	Backfill cleared areas	80.67	CY	$14	$1,139
7	Seed the cleared areas	484.00	SY	$2	$949
8	Shallow bedrock extraction well	6	EA	$7,000	$42,000
9	Pump tests	6	EA	$5,000	$30,000
10	Treatment building	65	SF	$58	$3,775
11	Sand filter	1	EA	$12,000	$12,000
12	Air Stripper	1	EA	$9,000	$9,000
13	Sump tank	1	EA	$5,000	$5,000
14	Misc. Piping and Equipment	1	LS	$7,500	$7,500
15	Well enclosures	3	EA	$3,188	$9,563
16	Trench excavation for influent line	400	LF	$4	$1,688
17	Double wall PVC inlfuent pipe(4")	400	LF	$8	$3,362
18	Backfill trench	400	LF	$0.03	$14
19	4" PVC Schedule 40 effluent pipe	400	LF	$8	$3,362
20	Outfall	1	LS	$1,000	$1,000
21	SPDES Permit	1	LS	$3,000	$3,000
22	Deed restrictions	1	LS	$6,000	$6,000
				Subtotal	$158,410
23	Legal, adminstrative, eng. fees	25%			$39,602
				Subtotal	$198,012
24	Contingencies	20%			$39,602
	TOTAL CAPITAL COSTS				**$237,614**
OPERATION & MAINTENANCE COSTS					
1	Extraction well maintenance	1	LS	$1,750	$1,750
2	G.W. treatment system maintenance	1	LS	$4,940	$4,940
3	Sample collection - groundwater(17 wells)	34	EA	$250	$8,500
4	Sample collection - surf. water/sed.	12	EA	$250	$3,000
5	Sample collection - treatment system	8	EA	$250	$2,000
6	VOC analysis	60	EA	$275	$16,500
7	Data validation	60	EA	$35	$2,100
8	Report writing	2	EA	$3,000	$6,000
9	Mowing (Bi-monthly)	9	Acres	$264	$2,482
				Subtotal	$47,272
10	Legal, adminstrative, eng. fees	25%			$11,818
				Subtotal	$59,090
11	Contingencies	20%			$11,818
	TOTAL O & M COSTS				**$70,908**
	TOTAL O & M PRESENT WORTH	30 years			**$976,037**
	TOTAL CAPITAL COSTS				**$237,614**
	GRAND TOTAL COST				**$1,213,651**

TABLE 4-16
IRP Site 3
Costs for Alternative 4
Groundwater Removal by Extarction Wells, and Discharge to POTW

Interest rate	6.0%
Operation & maintenance period (years)	30
Legal Adminstrative, & Eng. Fees	25.0%
Contigencies	20.0%

Item No.	Description	Quantity	Units	Unit Cost	Cost
CAPITAL COSTS					
1	Mobe/Demobe (4% of capital subtotal)	1	LS	$4,748	$4,748
2	Site services	1	MO	$2,500	$2,500
3	Health & Safety	1	LS	$10,000	$10,000
4	Clear and grub trees and remove	0.10	Acres	$3,220	$322
5	Grub stumps and remove	0.10	Acres	$1,438	$144
6	Backfill cleared areas	80.67	CY	$14	$1,139
7	Seed the cleared areas	484.00	SY	$2	$949
8	Shallow bedrock extraction well	6	EA	$7,000	$42,000
9	Pump tests	6	EA	$5,000	$30,000
10	Misc. Piping and Equipment	1	LS	$7,500	$7,500
11	Well enclosures	3	EA	$3,188	$9,563
12	Trench excavation for influent line	600	LF	$4	$2,532
13	Double wall PVC pipe(4") to sewer	600	LF	$8	$5,043
14	Backfill trench	600	LF	$0.03	$21
15	Sewer outfall	1	LS	$1,000	$1,000
16	Deed restrictions	1	LS	$6,000	$6,000
				Subtotal	$123,461
17	Legal, Administrative, eng. fees	25%			$30,865
				Subtotal	$154,326
18	Contingencies	20%			$30,865
	TOTAL CAPITAL COSTS				**$185,191**
OPERATION & MAINTENANCE COSTS					
1	Extraction well maintenance	1	LS	$1,750	$1,750
2	Disposal at POTW	2,628	K-GAL	$1.37	$3,600
3	Sample collection - groundwater (19 samples)	38	each	$250	$9,500
4	Sample collection - surf. water/sed.	12	each	$250	$3,000
5	VOC analysis	56	each	$275	$15,400
6	Data validation	56	each	$35	$1,960
7	Report writing	2	each	$3,000	$6,000
8	Mowing (Bi-monthly)	9	Acres	$264	$2,482
				Subtotal	$43,692
9	Legal, adminstrative, eng. fees	25%			$10,923
				Subtotal	$54,615
10	Contingencies	20%			$10,923
	TOTAL O & M COSTS				**$65,538**
	TOTAL O & M PRESENT WORTH				**$902,119**
	TOTAL CAPITAL COSTS				**$185,191**
	GRAND TOTAL COST				**$1,087,310**

TABLE 4-17
IRP Site 3
Costs for Alternative 5
Groundwater Removal by Trench, and Discharge to POTW

Interest rate	6.0%
Operation & maintenance period (years)	30
Legal Adminstrative, & Eng. Fees	25.0%
Contigencies	20.0%

Item No.	Description	Quantity	Units	Unit Cost	Cost
CAPITAL COSTS					
1	Mobe/Demobe (4% of capital subtotal)	1	LS	$9,133	$9,133
2	Site services	1	MO	$2,500	$2,500
3	Health & Safety	1	LS	$10,000	$10,000
4	Clear and grub trees and remove	0.10	Acres	$3,220	$322
5	Grub stumps and remove	0.10	Acres	$1,438	$144
6	Backfill cleared areas	80.67	CY	$14	$1,139
7	Seed the cleared areas	484.00	SY	$2	$949
8	Subsurface drain excavation in overburden	300	LF	$119	$35,728
9	Subsurface drain excavation in bedrock	300	LF	$228	$68,310
10	Gravel backfill for sub-surface drain	167	CY	$20	$3,333
11	Groundwater collection pipe	300	LF	$14	$4,140
12	HDPE layer	1002	SY	$18	$18,036
13	Clean backfill for subsurafce drain	789	CY	$9	$6,881
14	Disposal of Soil/fill (Non-haz)	1338	Tons	$32	$42,814
15	Trench excavation for pipe to sewer	600	LF	$4	$2,532
16	Discharge pipe to sewer	600	LF	$30	$17,761
17	Trench backfill	600	LF	$0.41	$248
18	Outfall to sewer	1	LS	$1,500	$1,500
19	Trench enclosures	1	EA	$1,000	$1,000
20	Misc piping and equipment	1	LS	$5,000	$5,000
21	Deed restrictions	1	LS	$6,000	$6,000
				Subtotal	$237,471
22	Legal, adminstrative, eng. fees	25%			$59,368
				Subtotal	$296,838
23	Contingencies	20%			$59,368
	TOTAL CAPITAL COSTS				**$356,206**
OPERATION & MAINTENANCE COSTS					
1	Trench maintenance	1	LS	$1,000	$1,000
2	Disposal at POTW	2,628	K-GAL	$1.37	$3,600
3	Sample collection - groundwater (16 sampels)	32	EA	$250	$8,000
4	Sample collection - surf. water/sed.	12	EA	$250	$3,000
5	VOC analysis	50	EA	$275	$13,750
6	Data validation	50	EA	$35	$1,750
7	Report writing	2	EA	$3,000	$6,000
8	Semi-annual mowing	9	Acres	$264	$2,482
				Subtotal	$39,582
9	Legal, adminstrative, eng. fees	25%			$9,895
				Subtotal	$49,477
10	Contingencies	20%			$9,895
	TOTAL O & M COSTS				**$59,373**
	TOTAL O & M PRESENT WORTH	30 years			**$817,258**
	TOTAL CAPITAL COSTS				**$356,206**
	GRAND TOTAL COST				**$1,173,465**

Table 4-18

EVALUATION OF CORRECTIVE MEASURE ALTERNATIVES
IRP SITE 3
NIAGARA FALLS IAP-ARS

Criteria/ Definition	Alternative				
	1. No Action and Natural Attenuation	2. Institutional Actions and Natural Attenuation	3. Extraction by Well Points; On-site Treatment; and Disposal to Cayuga Creek	4. Extraction by Well Points; and Disposal to POTW	5. Extraction by Trench and Well Points; and Disposal to a POTW
Definition	Alternative 1 calls for the use of natural attenuation processes, including dispersion, diffusion, volatilization, biodegradation, and adsorption, to attain cleanup goals. Sampling would be continued to monitor groundwater, surface water, and sediment quality in Cayuga Creek. To maintain the integrity of cover soils, existing trees and shrubs on the site would be removed and the areas would be seeded. Mowing would be conducted on a regular basis.	Similar to Alternative 1, this alternative utilizes natural attenuation processes to attain site cleanup goals. Institutional actions preventing construction of drinking water wells at the site and in the vicinity of the site would be implemented until site cleanup goals are accomplished. Sampling to monitor groundwater, surface water, and sediment quality in Cayuga Creek would be continued until site cleanup goals are accomplished. To maintain the integrity of cover soils, existing trees and shrubs on the site would be removed and the areas would be seeded. Mowing would be conducted on a regular basis.	Groundwater would be extracted by the use of wells and treated on site in an air-stripping and filtration treatment system. Treated groundwater would be discharged to Cayuga Creek under a SPDES permit. Similar to Alternative 2, institutional actions would be implemented until site cleanup goals are accomplished. Sampling to monitor groundwater, surface water, and sediment quality in Cayuga Creek would be continued until site cleanup goals are accomplished. To maintain the integrity of cover soils, existing trees and shrubs on the site would be removed and the areas would be seeded. Mowing would be conducted on a regular basis.	Groundwater would be extracted by the use of wells, as in Alternative 3. However, extracted groundwater would be discharged to a POTW for treatment and disposal. Institutional actions would be implemented until site cleanup goals are attained. Sampling to monitor groundwater, surface water, and sediment quality in Cayuga Creek would be continued until site cleanup goals are accomplished. To maintain the integrity of cover soils, existing trees and shrubs on the site would be removed and the areas would be seeded. Mowing would be conducted on a regular basis.	Groundwater would be extracted by the use of trenches. A subsurface trench would be constructed bordering the landfill boundary, adjacent to Cayuga Creek. Extracted groundwater from the trench would be discharged for treatment and disposal to the POTW. Institutional actions would be implemented until site cleanup goals are attained. Sampling to monitor groundwater, surface water, and sediment quality in Cayuga Creek would be continued until site cleanup goals are accomplished. To maintain the integrity of cover soils, existing trees and shrubs on the site would be removed and the areas would be seeded. Mowing would be conducted on a regular basis.

Table 4-18

EVALUATION OF CORRECTIVE MEASURE ALTERNATIVES
IRP SITE 3
NIAGARA FALLS IAP-ARS

Criteria/ Definition	Alternative				
	1. No Action and Natural Attenuation	2. Institutional Actions and Natural Attenuation	3. Extraction by Well Points; On-site Treatment; and Disposal to Cayuga Creek	4. Extraction by Well Points; and Disposal to POTW	5. Extraction by Trench and Well Points; and Disposal to a POTW
Technical	Natural attenuation may be technically effective in decreasing contamination levels to site cleanup goals. Natural attenuation processes have limited capacity to reduce contamination levels and do not possess any flexibility to deal with unanticipated releases of contaminants from the landfill. However, the likelihood of an unexpected release is small. Removal of existing trees and shrubs and mowing would maintain the integrity of existing cover soils.	Natural attenuation may be technically effective in decreasing contamination levels to site cleanup goals. Until site cleanup goals are attained, institutional controls would prevent human exposure to site contaminants. Natural attenuation processes have limited capacity to reduce contamination levels and do not possess any flexibility to deal with unanticipated releases of contaminants from the landfill. However, the likelihood of an unexpected release is small. Removal of existing trees and shrubs and mowing would maintain the integrity of existing cover soils.	The technical effectiveness of this alternative depends on the location of the extraction wells. Given the heterogeneity at the site, optimal location of wells may pose a problem. An observational approach would have to be adopted to locate the extraction wells. Optimal wells that may effectively extract contaminants from the subsurface may not effectively minimize the off-site transport of contaminants. Some well locations may also drain clean water from Cayuga Creek. Preliminary design of the on-site treatment system has shown that effective treatment of the extracted groundwater can be afforded to meet Class C surface water standards. The alternative consists of reliable and safely implementable technologies. Removal of existing trees and shrubs and mowing would maintain the integrity of existing cover soils.	The technical effectiveness of groundwater extraction of this alternative is similar to Alternative 3. Discharge to a POTW for treatment and disposal is an effective technology. The alternative consists of reliable and safely implementable technologies.	Trenches would be most effective for groundwater extraction at the site. Trenches, acting as a continuous line of well points, can intercept many fractures and fissures along their length and depth. The trench would effectively collect groundwater and create a hydrologic boundary to minimize off-site contaminant transport. Discharge of extracted groundwater to a POTW would afford effective treatment and disposal. This alternative consists of reliable technologies. The construction of the trench would require excavation into bedrock and groundwater dewatering, which will increase construction time. The design and construction of the trench may be complicated due to the complex hydrogeology at the site and the proximity of the

Table 4-18

EVALUATION OF CORRECTIVE MEASURE ALTERNATIVES
IRP SITE 3
NIAGARA FALLS IAP-ARS

Criteria/ Definition	Alternative				
	1. No Action and Natural Attenuation	2. Institutional Actions and Natural Attenuation	3. Extraction by Well Points; On-site Treatment; and Disposal to Cayuga Creek	4. Extraction by Well Points; and Disposal to POTW	5. Extraction by Trench and Well Points; and Disposal to a POTW
					trench to Cayuga Creek. The subsurface trench could drain large amounts of water from Cayuga Creek.
Human Health	This alternative provides no long-term beneficial effect for the protection of human health. Groundwater quality standards would continue to be exceeded.	Groundwater quality standards would continue to be exceeded. However, by virtue of institutional controls, minimization of human exposure to site contaminants could be attained.	Attainment of cleanup goals can be accelerated by this alternative. Until site cleanup goals are attained, institutional control would be implemented to protect human health. Routine maintenance of the on-site treatment system would be required.	Attainment of cleanup goals can be accelerated by this alternative. Until site cleanup goals are attained, institutional control would be implemented to protect human health.	Attainment of cleanup goals can be accelerated by this alternative. Until site cleanup goals are attained, institutional control would be implemented to protect human health.
Environmental	Long-term exposure risks to environmental receptors in Cayuga Creek may not be reduced and cannot be ruled out. Site contaminants will continue to be introduced into the Creek.	Institutional controls cannot control release of contaminants to Cayuga Creek; thus site contaminants would continue to be introduced into the creek. Long-term exposure risks to environmental receptors in Cayuga Creek may not be reduced and cannot be ruled out.	By extracting contaminants from the subsurface, long-term exposure to environmental receptors in Cayuga Creek would be reduced. Depending on the location of extraction wells, this alternative may be effective in minimizing the off-site transport of contaminants. Some groundwater extraction wells could possibly drain Cayuga Creek.	The environmental analyses of Alternative 4 is similar to Alternative 3.	By extracting contaminants from the subsurface, long-term exposure to environmental receptors in Cayuga Creek would be reduced. A trench would be most effective in minimizing the off-site transport of contaminants. However, a subsurface trench may adversely affect Cayuga Creek by draining prohibitively large amounts of water from it.

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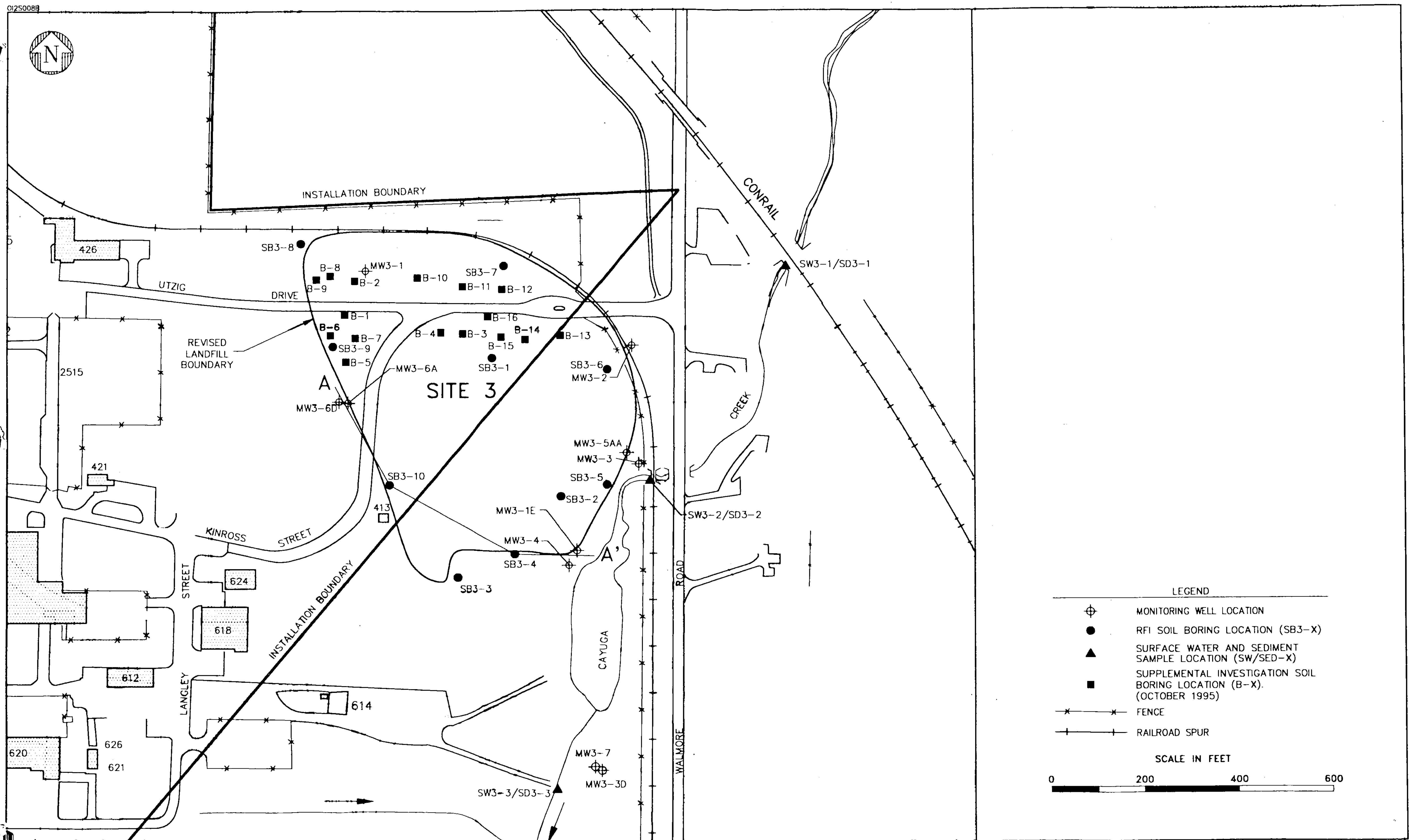
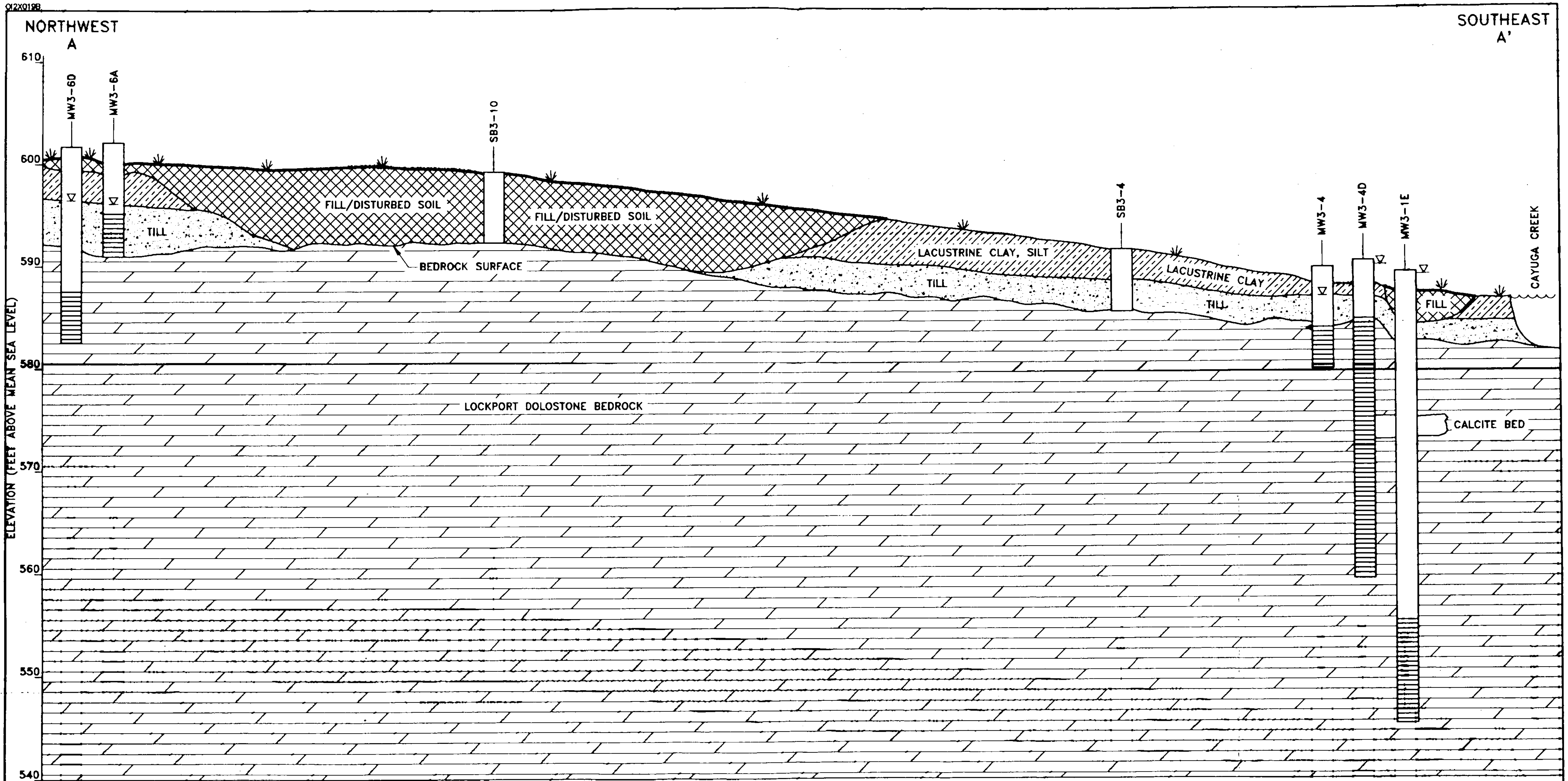


Figure 4-1 IRP SITE 3 - SITE PLAN AND RFI SAMPLE LOCATIONS (INCLUDING SUPPLEMENTAL INVESTIGATION) NIAGARA FALLS IAP-ARS



HORIZONTAL SCALE: 1"=50'
VERTICAL SCALE: 1"=10'
VERTICAL EXAGGERATION: 5x

LEGEND

- FILL MATERIAL/DISTURBED SOIL
- LACUSTRINE CLAY, SILT, AND SAND
- GLACIAL TILL
- LOCKPORT DOLOSTONE BEDROCK
- GROUNDWATER POTENTIOMETRIC SURFACE ON 2-28-95
- SCREENED INTERVAL OF WELL
- COVER SOIL
- GRASS

Figure 4-2 GEOLOGIC CROSS-SECTION A-A'
IRP SITE 3
NIAGARA FALLS IAP-ARS

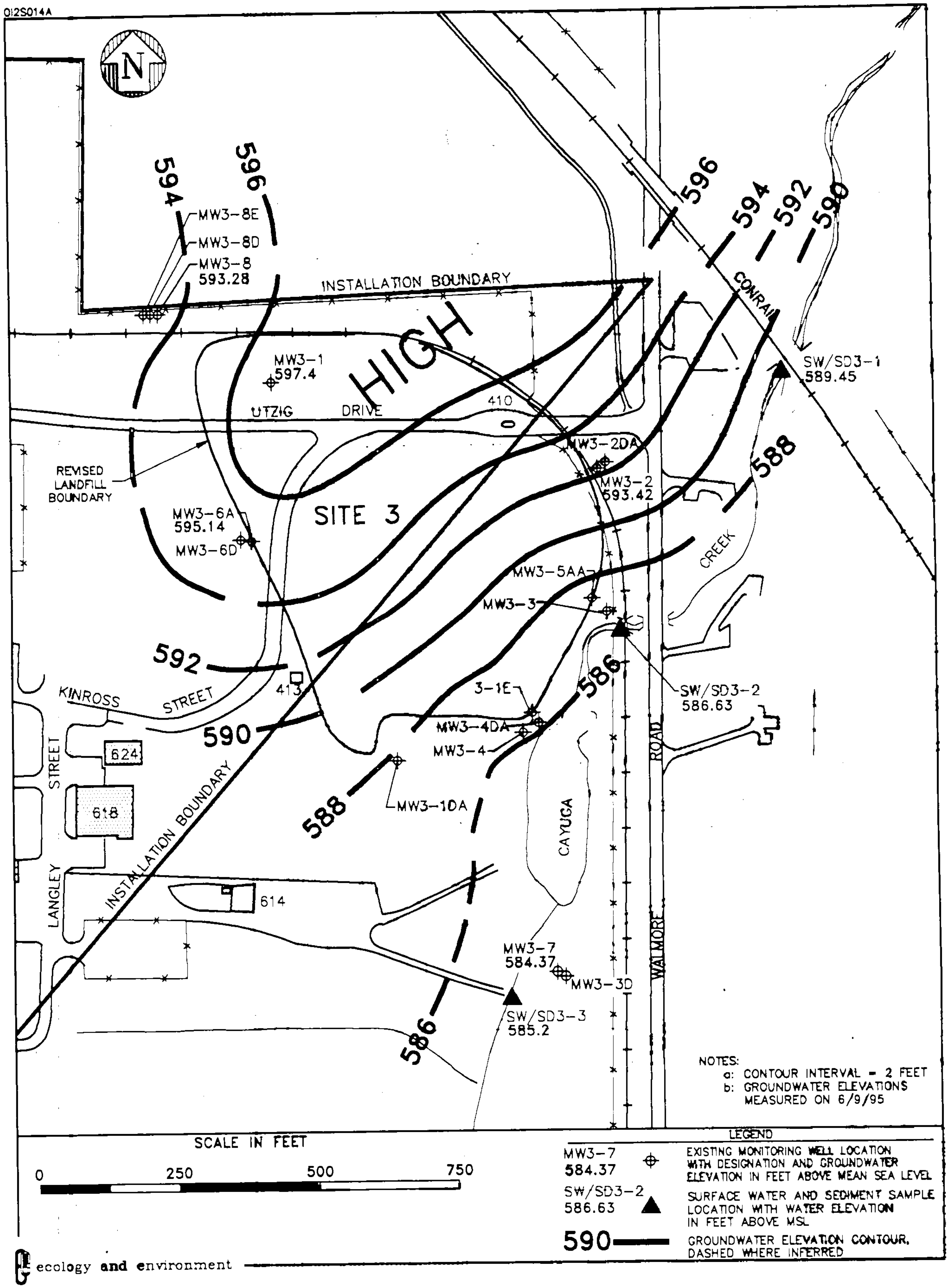


Figure 4-3
OVERBURDEN GROUNDWATER CONTOUR MAP
IRP SITE 3
NIAGARA FALLS IAP-ARS

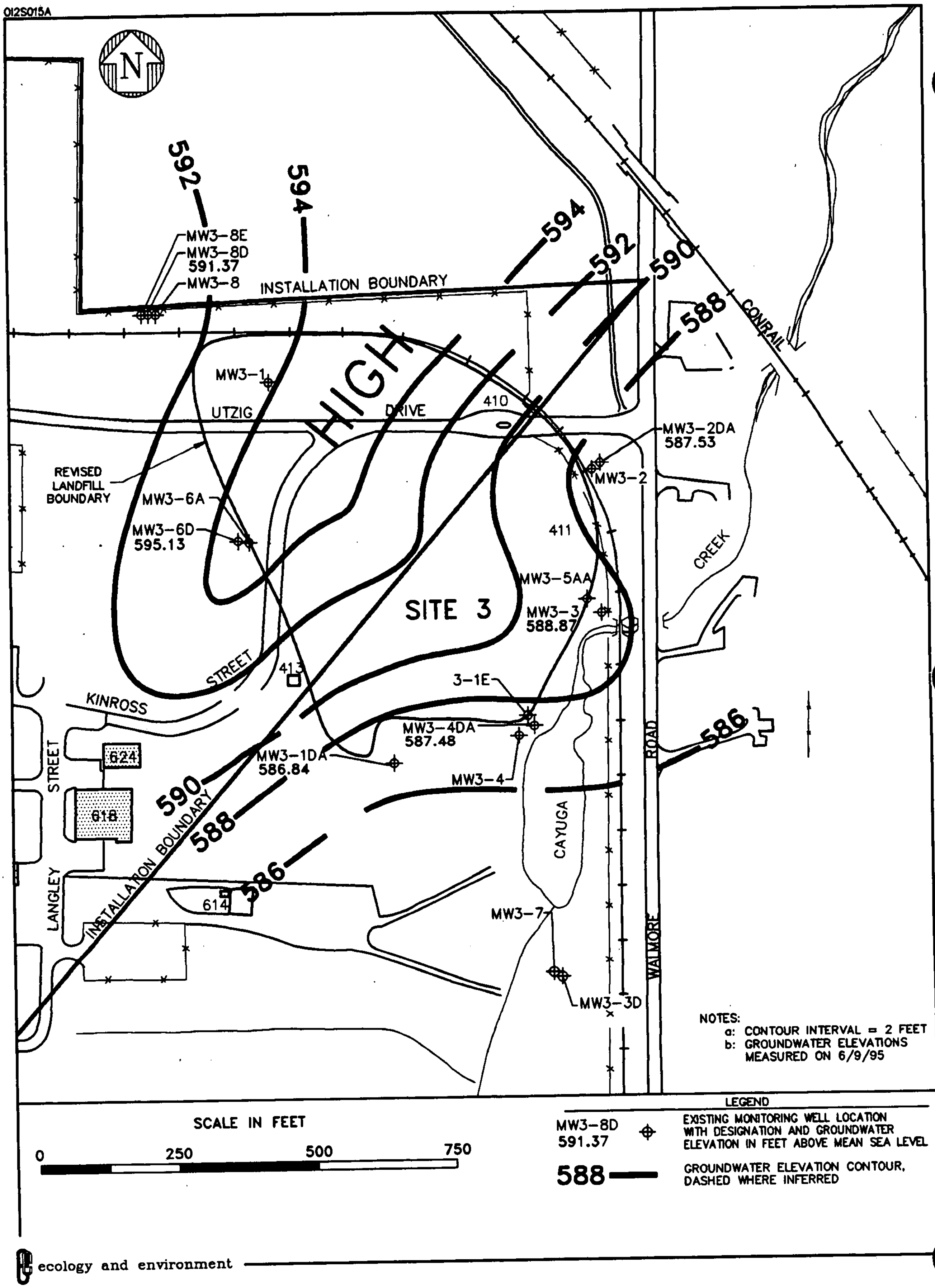


Figure 4-4
BEDROCK GROUNDWATER CONTOUR MAP
IRP SITE 3
NIAGARA FALLS IAP-ARS

012S016B

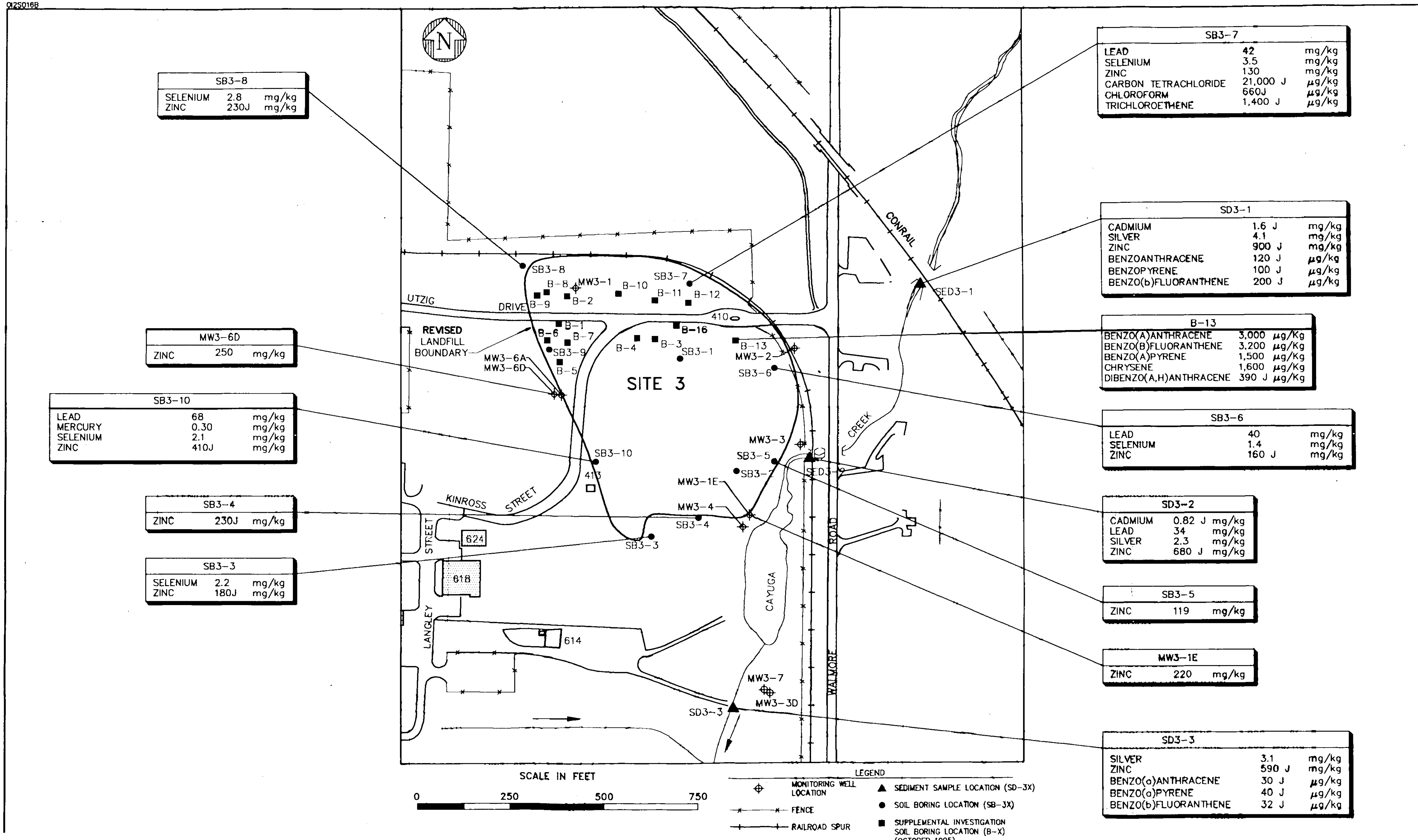


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Figure 4-5 **RFI AND SUPPLEMENTAL INVESTIGATION SOIL AND SEDIMENT SAMPLES ABOVE CLEANUP GOALS – IRP SITE 3 NIAGARA FALLS IAP-ARS**

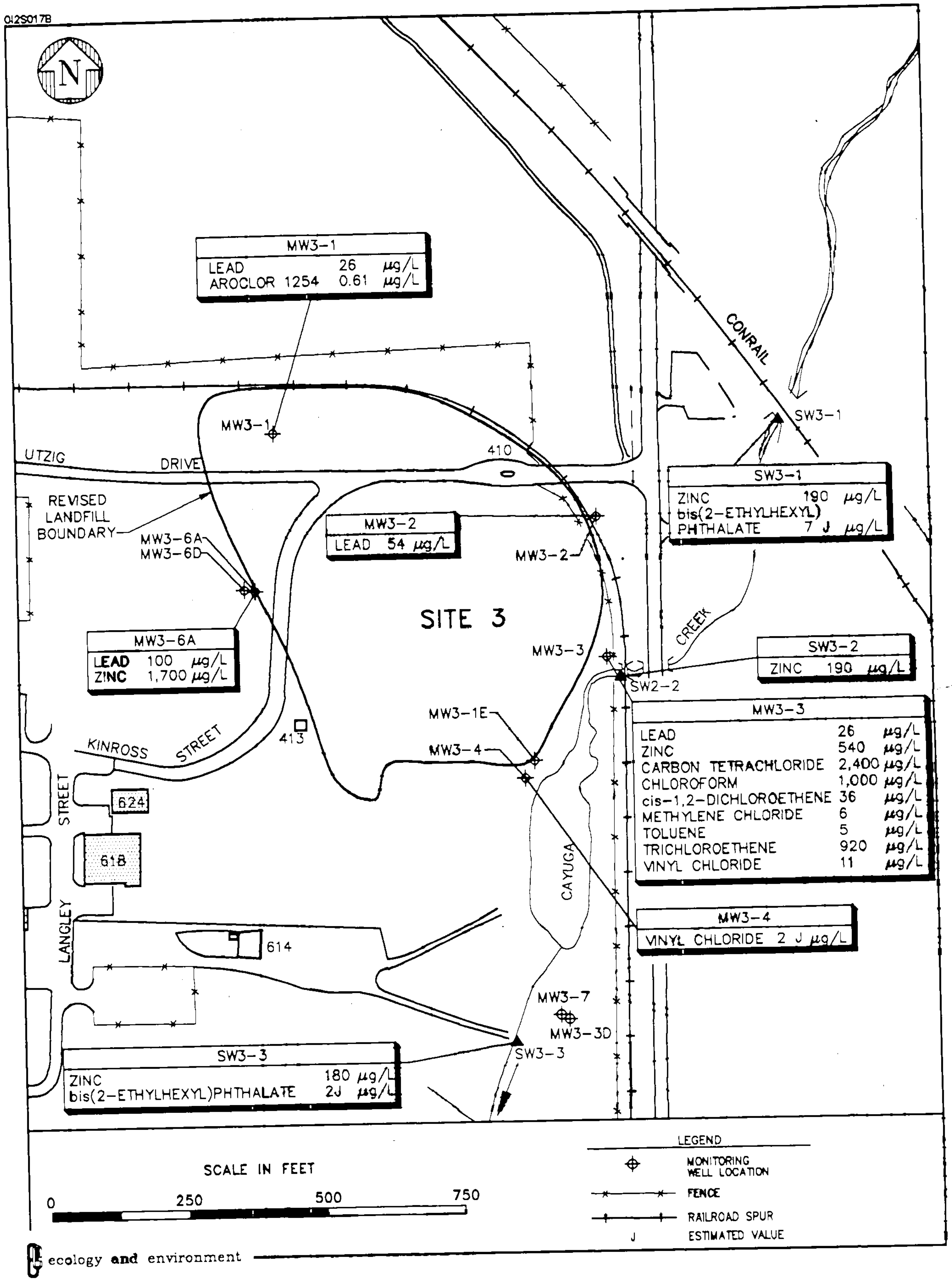
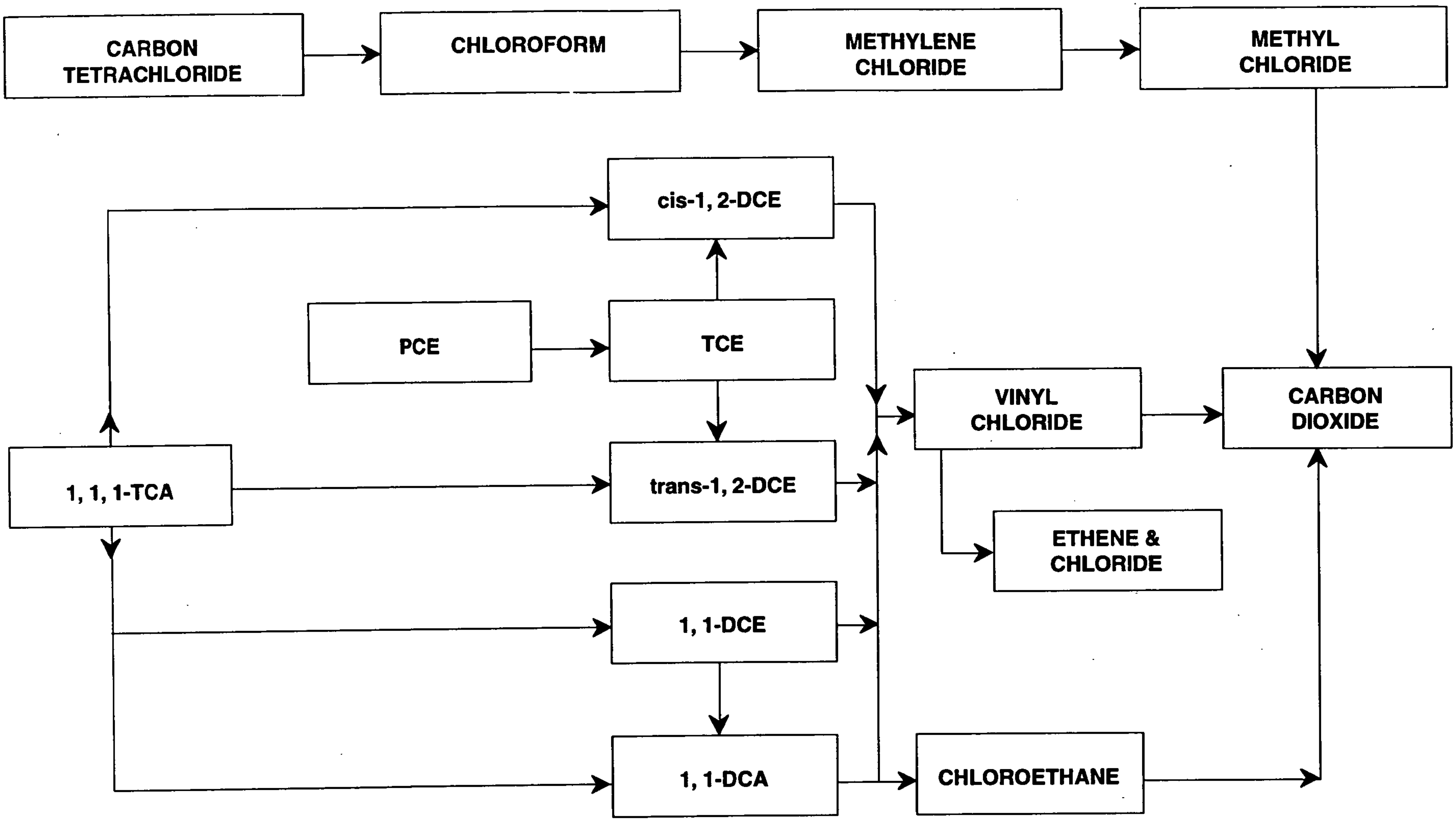


Figure 4-6
RFI GROUNDWATER AND SURFACE WATER SAMPLES ABOVE CLEANUP GOALS
IRP SITE 3
NIAGARA FALLS IAP-ARS



SOURCE: Ecology and Environment 1992; Adapted from Smith and Dragun, 1984.

Figure 4-7 TRANSFORMATION REACTIONS FOR VARIOUS CHLORINATED ORGANICS IN SOIL-GROUNDWATER SYSTEMS

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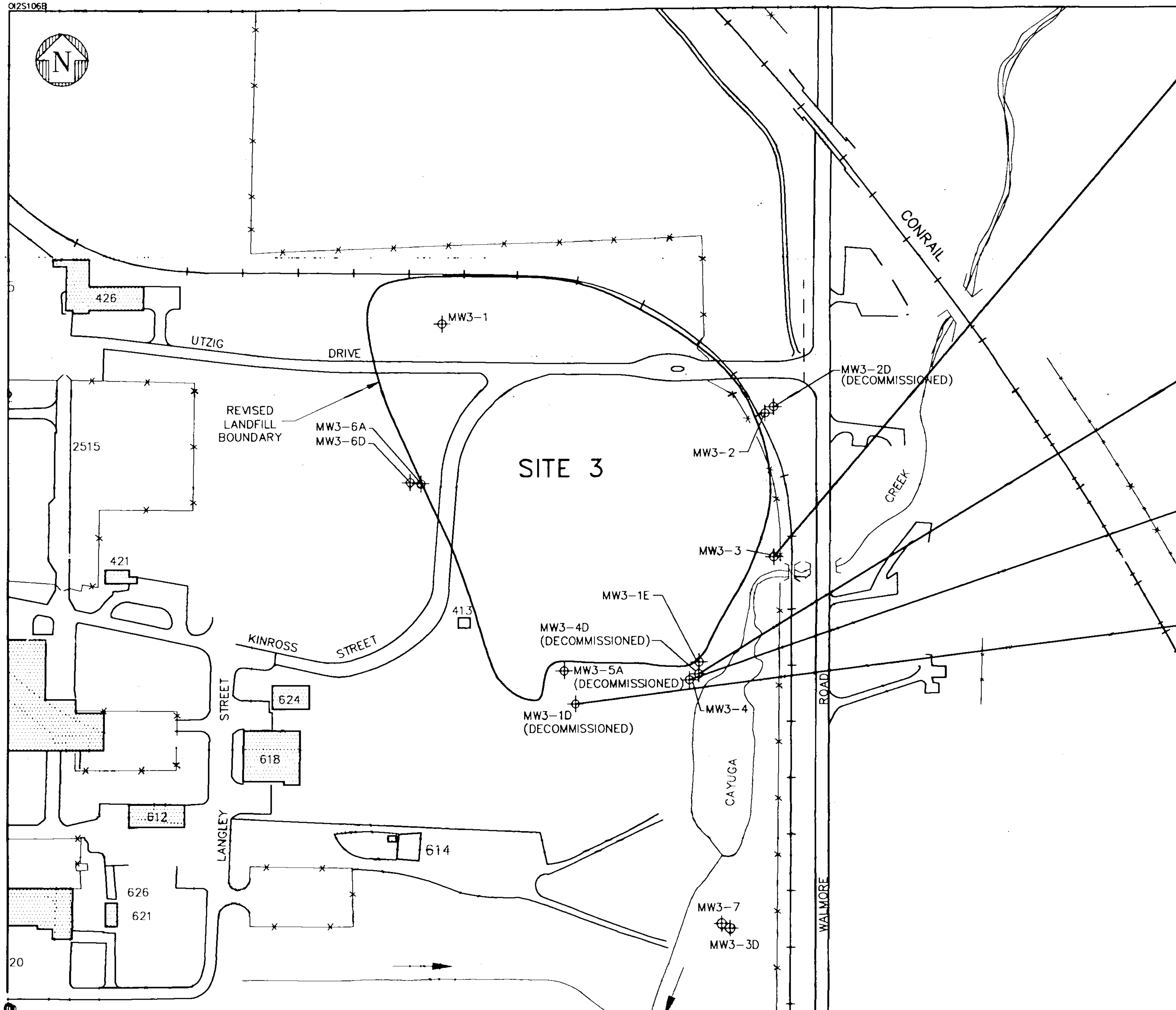

MW3-3						
VOC (µg/L)	SAIC RI/FS 1991	GZA 1992	GZA 1993a	GZA 1993b	GZA 1994	RFI 1995
BENZENE	0.96	ND	ND	ND	ND	ND
CARBON DISULFIDE	ND	ND	ND	ND	ND	110
CARBON TETRACHLORIDE	ND	25	570	750	300	2400
CHLOROFORM	ND	57	580	1100	260	1000
cis,1,2-DICHLOROETHENE	ND	ND	ND	ND	ND	36
METHYLENE CHLORIDE	ND	ND	ND	ND	ND	6
trans 1,2-DICHLOROETHENE	ND	170	40	ND	ND	ND
TRICHLOROETHENE	55	210	580	900	300	920
TOLUENE	ND	ND	ND	ND	ND	5
VINYL CHLORIDE	3.6	2.3	ND	ND	ND	11

MW3-4D (DECOMMISSIONED)						
VOC (µg/L)	SAIC RI/FS 1991	GZA 1992	GZA 1993a	GZA 1993b	GZA 1994	RFI 1995
trans 1,2-DICHLOROETHENE	ND	ND	7.2	ND	ND	NOT SAMPLED
VINYL CHLORIDE	3.1	14	49	55	ND	NOT SAMPLED

MW3-4						
VOC (µg/L)	SAIC RI/FS 1991	GZA 1992	GZA 1993a	GZA 1993b	GZA 1994	RFI 1995
VINYL CHLORIDE	ND	2.1	ND	7.0	ND	2J

MW3-1D (DECOMMISSIONED)						
VOC (µg/L)	SAIC RI/FS 1991	GZA 1992	GZA 1993a	GZA 1993b	GZA 1994	RFI 1995
VINYL CHLORIDE	20	ND	ND	ND	ND	NOT SAMPLED

LEGEND

⊕ MONITORING WELL LOCATION

—x—x— FENCE

—+—+— RAILROAD SPUR

SCALE IN FEET

0 200 400 600

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Figure 4-8 VOC GROUNDWATER CONCENTRATIONS ABOVE SITE CLEANUP GOALS
IRP SITE 3
NIAGARA FALLS IAP-ARS

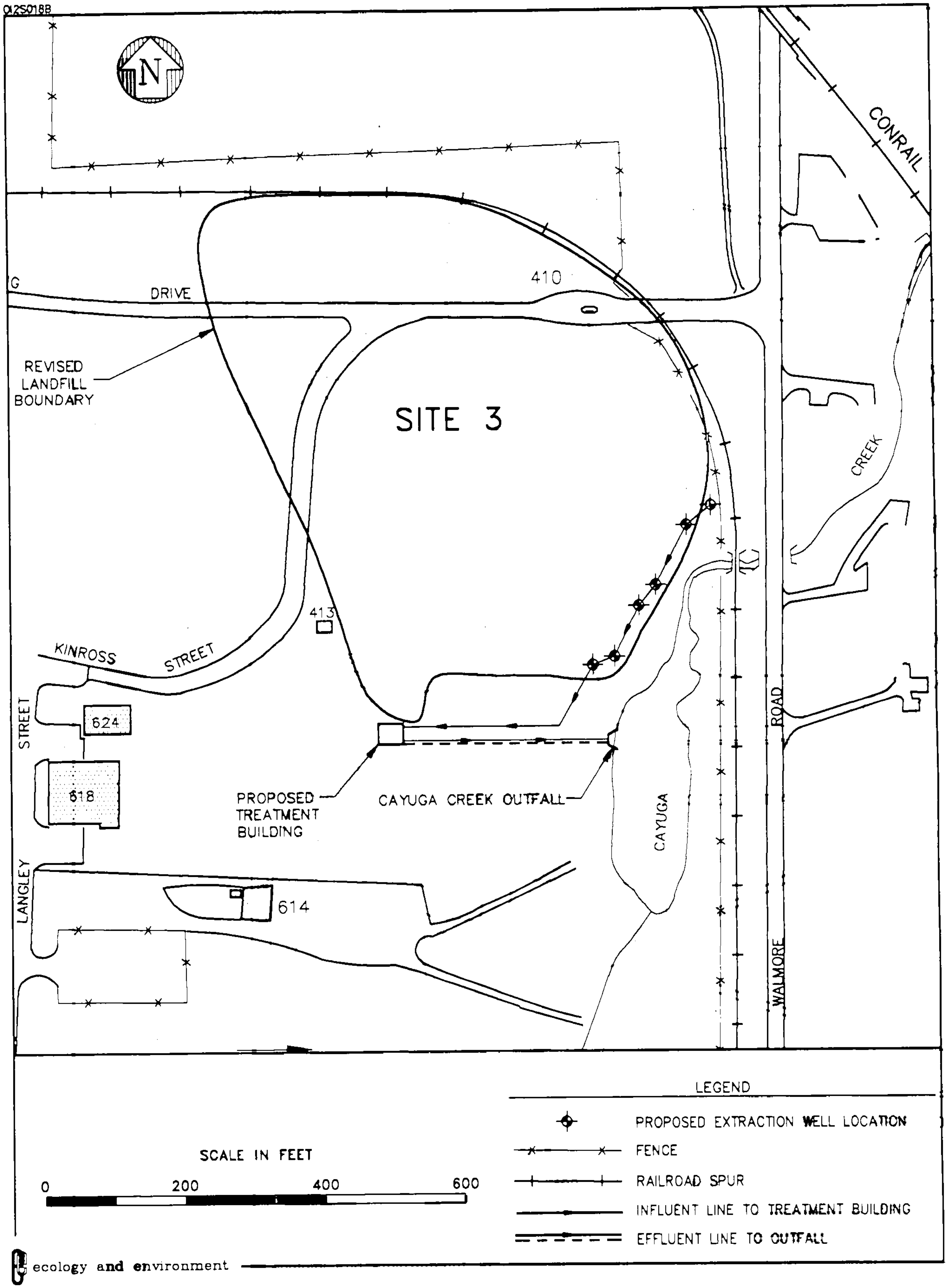

Figure 4-9
ALTERNATIVE 3 LAYOUT
IRP SITE 3
NIAGARA FALLS IAP-ARS

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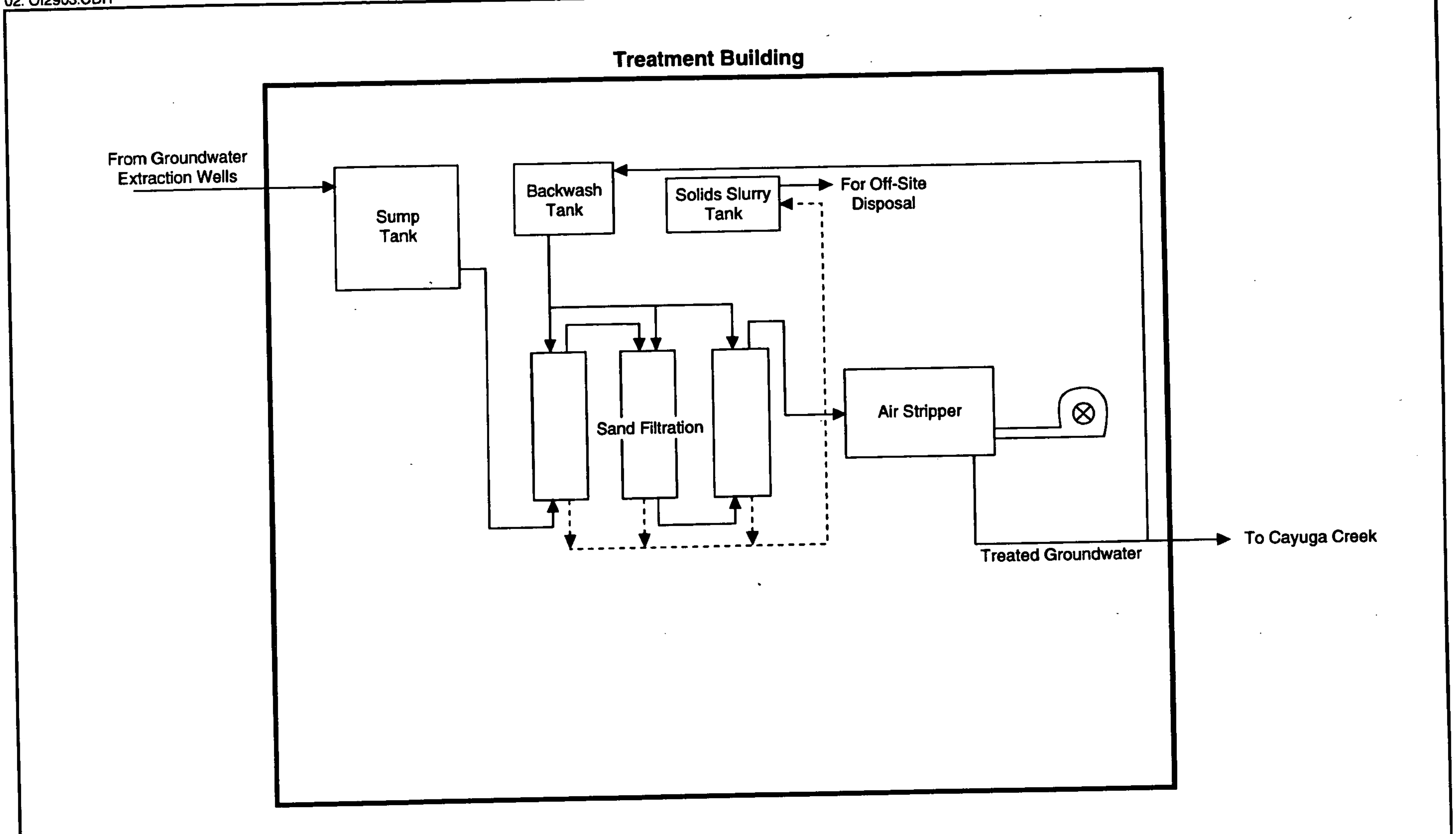
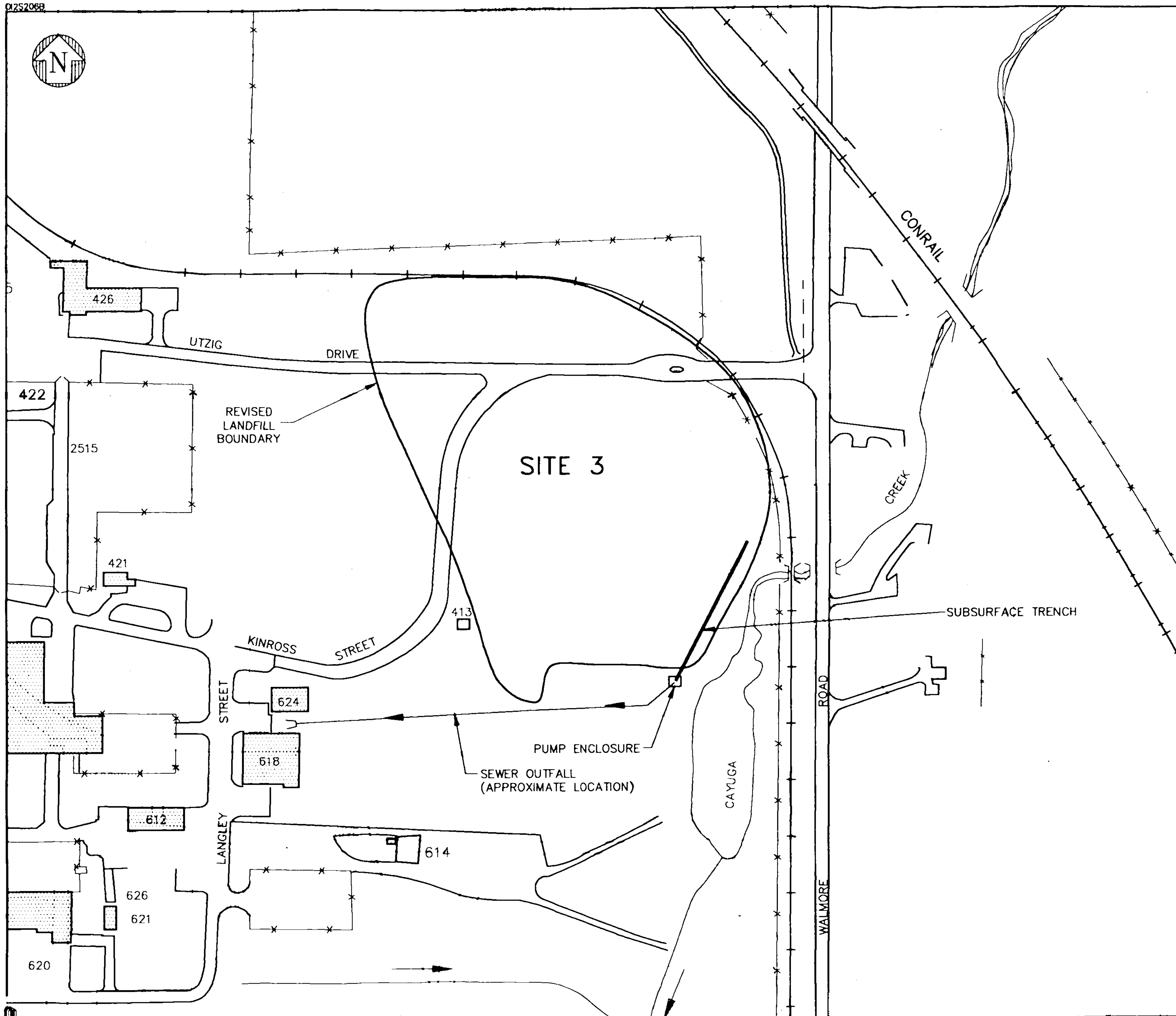
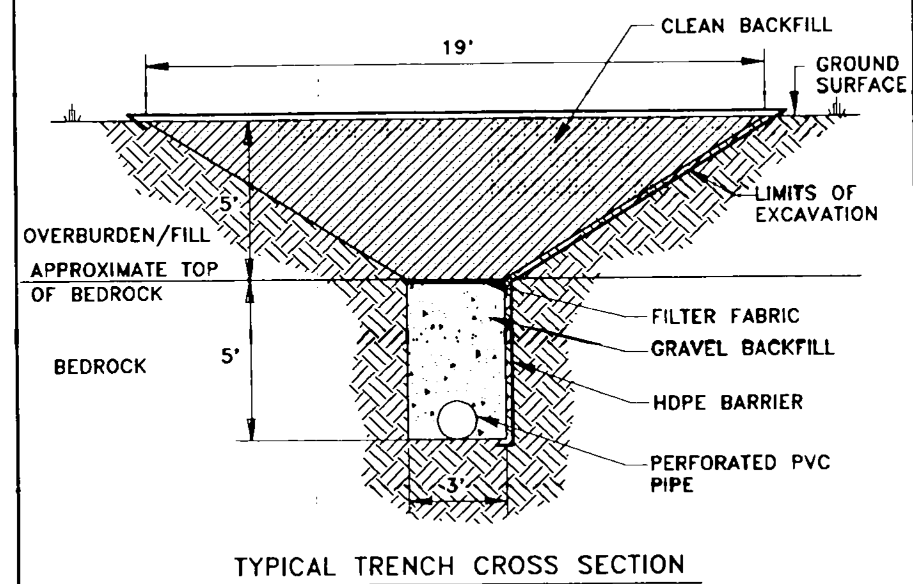


SOURCE: Ecology and Environment, Inc., 1995

Figure 4-10 **PROCESS FLOW DIAGRAM FOR ON-SITE TREATMENT OF GROUNDWATER (ALTERNATIVE 3) IRP SITE 3, NIAGARA FALLS IAP-ARS**





TYPICAL TRENCH CROSS SECTION

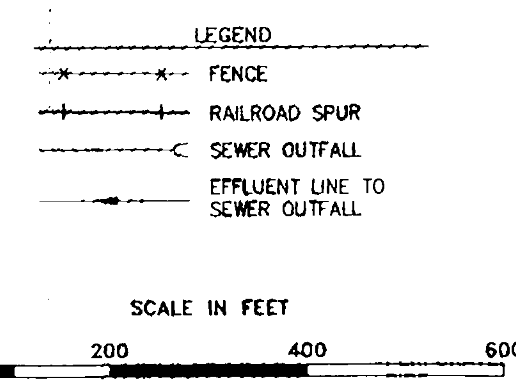


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Figure 4-11 ALTERNATIVE 5 – LAYOUT
IRP SITE 3
NIAGARA FALLS IAP-ARS

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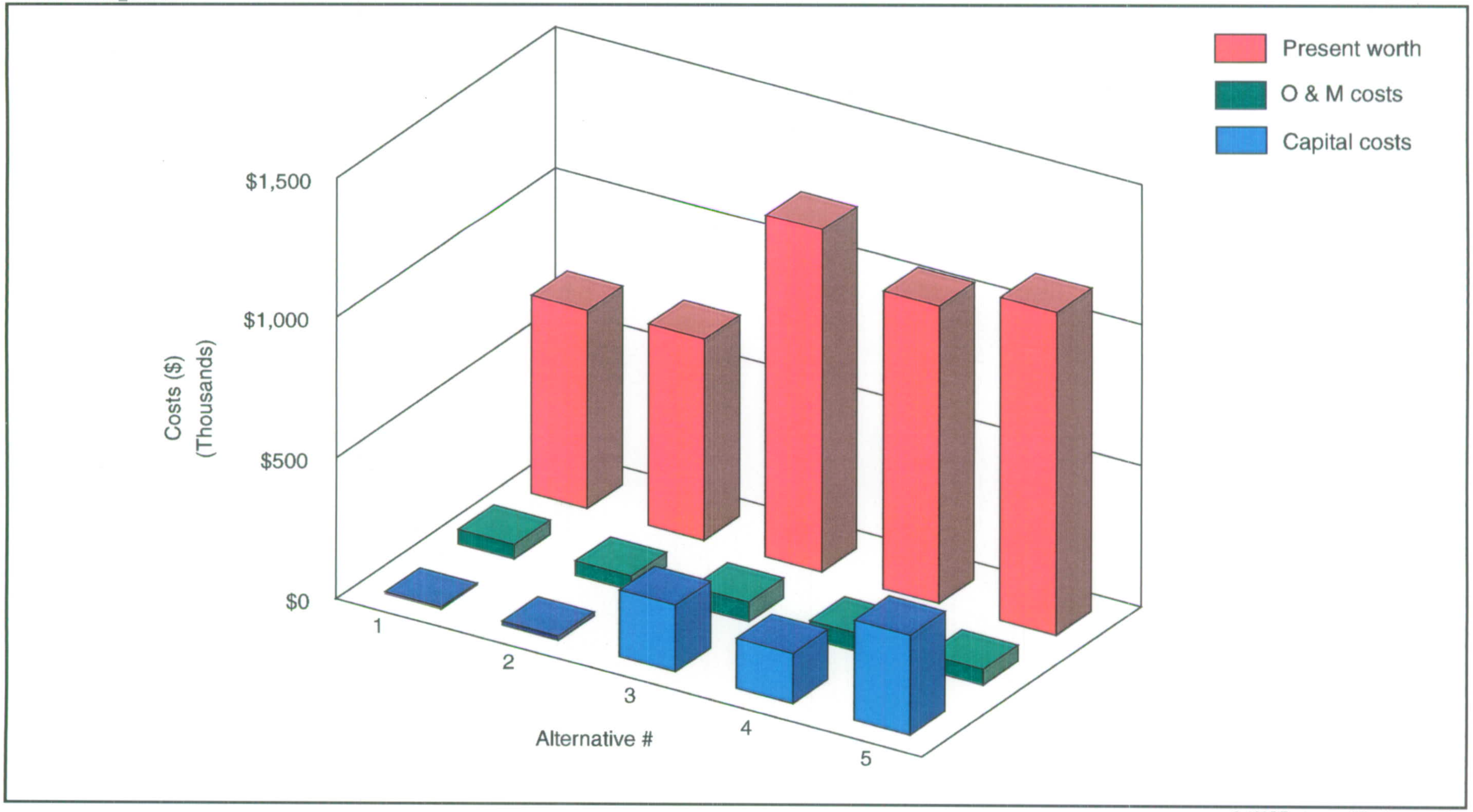

Figure 4-12 CAPITAL, O & M, AND PRESENT WORTH COSTS FOR CMAs
IRP SITE 3
NIAGARA FALLS IAP-ARS

SITE 10

5 Corrective Measures Study - Site 10

5.1 Identification and Development of Corrective Measure Alternatives

The following section details the initial steps required to select an appropriate corrective measure as part of the Niagara Falls IAP-ARS environmental restoration strategy for Site 10. Section 5.1.1 summarizes current site conditions and discusses RFI findings and previous analytical results. The site-specific CAOs are established for all media at this site in Section 5.1.2. Section 5.1.3 provides a comparison of the potential remedial technologies (as listed in Section 3) with the Site 10 CAOs and summarizes the screening process. Section 5.1.4 identifies CMAs found to be potentially feasible at Site 10 and which will be retained for further study.

5.1.1 Description of Current Conditions

5.1.1.1 Site Description

Fire Training Area No. 1, referred to as Site 10, is located near the east end of the Niagara Falls IAP-ARS on NFTA property (see Figure 5-1). The former burn pit is approximately 100 feet in diameter and lies approximately 200 feet east of Building 726. The site, which is generally flat with a gentle slope to the south, is currently unused and covered with heavy grass and weeds. Cayuga Creek passes within 400 feet to the south of the site. A drainage swale runs from north to south approximately 50 feet west of the site. Surface drainage flows to the south in this swale and eventually discharges into Cayuga Creek, which flows west and then south across the Niagara Falls IAP-ARS.

The site served as the installation's principal fire training area during the late 1950s and early 1960s. A variety of combustible materials, including oils, solvents, and jet fuel (JP-4), were ignited and burned in the pit and extinguished with firefighting foam during training exercises. The original burn pit was probably built with an earthen berm, although currently it is difficult to determine the actual pit boundaries (Engineering Science 1983). Site

10 has been designated as an open area to provide a buffer zone between base facilities for safety, security, or utility easements (USAF 1994). The area will essentially remain unused and vacant.

The RFI conducted at Site 10 identified contaminants present in the groundwater and surface water. Based on this and previous investigative data, the burn pit source area covers approximately 0.75 acre and ranges in depth from 6 to 9 feet (bedrock). The groundwater plume starts at the source area and extends toward the southwest (E & E 1995).

The geology of Site 10 is characterized by a relatively thin overburden cover made up of lacustrine sediments and glacial till on top of fractured dolostone bedrock. A generalized geologic cross section of Site 10 is presented on Figure 5-2. The overburden rests on a bedrock surface that is gently sloping to the south and ranges in thickness from approximately 5 feet in the northeast to approximately 12 feet at the southwest portion of the site. Wells on the south side of Cayuga Creek encountered even thicker overburden (up to 16.5 feet), indicating thickening toward the southwest.

The overburden at Site 10 generally consists of two distinct layers as identified from the monitoring wells and boreholes installed at Site 10 during the RFI and previous investigations. The upper overburden is a 4- to 8-foot-thick layer of stratified lacustrine sediments consisting primarily of clay and silty clay. Beneath the lacustrine sediments and resting directly on the bedrock is a 0- to 8-foot- thick-layer of glacial till. The till layer is not continuous across Site 10, and was not encountered at the extreme northern end of the site in well MW10-5D, but was encountered in well MW10-3. The till continued to thicken southward toward wells MW10-3D and MW10-3E.

Both the overburden and bedrock wells produce water at Site 10, and no confining layer was encountered between the overburden and bedrock water-bearing zones; therefore, it can be assumed that the overburden and bedrock zones are hydraulically connected. Aquifer tests were performed on all 15 monitoring wells at the site during the RFI to determine the hydraulic conductivity of the formation around each well. In general, the hydraulic conductivities of the overburden, shallow bedrock, and deep bedrock at Site 10 were similar. Overburden wells averaged 2.8×10^{-4} centimeters per second (cm/s); shallow bedrock wells averaged 5.4×10^{-4} cm/s; the deep bedrock wells averaged 3.7×10^{-5} cm/s (E & E 1995).

The overburden groundwater contour maps of Site 10 show that the overburden water-bearing zone flows to the southwest toward Cayuga Creek at a gradient of ranging from approximately 0.5 foot per 100 feet in the third quarter to 2.0 feet per 100 feet on the second quarter (see Figure 5-3). By comparing the overburden groundwater contours to the surface water elevations of the creek, it was discovered that Cayuga Creek appears to be both a gaining and losing stream at Site 10, depending on seasonal variations of the water table elevations. Based on the measurements taken during the installation-wide groundwater project, the creek was a losing stream in the first and second quarters, and a gaining stream in the third quarter.

The groundwater flow in shallow bedrock is generally to the south-southwest at an average gradient of approximately 0.75 foot per 100 feet. During each quarter of measurement, the shallow bedrock water-bearing zone appeared to flow under Cayuga Creek (see Figure 5-4).

The deep bedrock groundwater contour map shows a flow direction similar to that of the shallow bedrock water-bearing zone, i.e., to the south-southwest (see Figure 5-5). The gradient of this potentiometric surface is approximately 0.75 foot per 100 feet. Like the shallow bedrock, the deep bedrock apparently flows beneath Cayuga Creek. Comparison of the shallow and deep bedrock hydraulic heads at Site 10 confirms that the shallow bedrock water-bearing zone, at least over part of the site, discharges downward to the deep bedrock aquifer.

In the bedrock, water flow is reportedly directly related to the number and interconnection of fractures encountered, with little to virtually no primary porosity in the dolostone rock matrix itself (Miller and Kappel 1987). Groundwater flow direction in the bedrock may be affected by fracture orientation or regional dip of the bedrock.

5.1.1.2 Site-Wide Contamination Summary

As part of the RFI, various field activities were completed to characterize the nature and extent of contamination associated with Site 10. Samples were collected from the following media:

- Soil gas (as part of the installation-wide groundwater monitoring project);
- Subsurface soils from the borings on and around the site;
- Groundwater from monitoring wells on and around the site;
- Surface water from Cayuga Creek and its tributary near Site 10; and
- Sediments from Cayuga Creek and its tributary near Site 10.

Figure 5-1 shows monitoring wells and the RFI sampling locations. Tables 5-1 through 5-4 summarize contaminants detected at the site during RFI sampling.

Soil Gas

The soil gas survey results indicated the presence of a number of volatiles in the vicinity of Site 10. TCE, PCE, and BTEX compounds were the most prominent compounds detected in the soil gas at Site 10. Most of the soil gas response levels were considered low.

Relatively elevated soil gas response levels for TCE were identified east of and along the tributary of Cayuga Creek in the area of the burn pit. Two areas of relatively high response were defined and separated by lower response values. The intermediate and lower response levels adjacent to the higher levels indicate that migration of TCE has occurred to the south.

Isolated occurrences of PCE were identified throughout the survey grid. The response levels are all considered low and, given the discrete nature of the occurrences, they may not represent significant or detectable levels of PCE in subsurface media such as soil or groundwater.

Elevated soil gas response levels for BTEX were detected as isolated occurrences in the southern portion of the grid, south of Building 726, and along the tributary in the vicinity of wells MW10-2 and MW10-3. The lower response values elsewhere imply that migration of BTEX is limited to the areas corresponding to the highest soil gas responses.

The distribution of TPH is similar to that of BTEX, except that an additional area of high soil gas response was detected in the northeast corner of the grid where only a low relative response for BTEX had been detected.

Subsurface Soil

Three subsurface soil samples were collected for the purpose of assessing the lateral and vertical extent of contamination and to assess the environmental impact on nearby soil south of Cayuga Creek. The two soil boring samples (SB10-1 and SB10-2) were analyzed for PCDD/PCDF compounds only; no PCDD/PCDF compounds were detected in either sample. SB10-1 was located near the center of the burn pit; SB10-2 was located approximately 100 feet south of the pit. The one monitoring well soil boring sample (MW10-3D) did not contain VOCs or BNAs above the soil guidance values presented in TAGM 4046, which were used as benchmarks for screening site soil analytical data (see Table 5-1).

In accordance with TAGM 4046, site background levels were used to determine soil guidance values for metals. The site background metals concentrations (except for cadmium) were determined by using the upper limit of the 90th percentile of metals concentrations for eastern United States soils and other surficial materials, as calculated from the data of Shacklette and Boerngen (1984). This study did not include data for cadmium. The guidance value for cadmium was determined by using the higher end (7 mg/kg) of the range of observed values (0.01 to 7 mg/kg) published by Dragun (1988). Sample MW10-3D was found to contain only one metal (zinc) above the site background levels.

Previous investigations reported metals concentrations above the typical values (Shacklette and Boerngen 1984). These metals included barium, calcium, magnesium, nickel, and zinc. Several VOCs and semivolatiles were also detected during previous investigations. However, only TCE and total xylenes were found to exceed TAGM 4046 values.

Groundwater

During the RFI, unfiltered groundwater samples were collected from 14 wells, including nine existing wells and five newly installed wells. A summary of the RFI groundwater sampling results is presented in Table 5-2. Of the 14 wells at the site, six wells are screened in the overburden, five are screened in the shallow bedrock, and three wells are screened in the deep bedrock. NYSDEC Class GA groundwater standards were used to screen analytical data.

Semivolatiles were not detected in any overburden wells at the site. The VOCs benzene, 1,1-dichloroethene (1,1-DCE), and trans-1,2-dichloroethene (trans-1,2-DCE) were detected above the NYSDEC Class GA standards in two overburden wells (MW10-2 and MW10-4). Benzene was detected previously in a sample from MW10-1 (SAIC 1991). Three of the overburden wells contained vinyl chloride above the Class GA standards (MW10-1, MW10-2, and MW10-4). Vinyl chloride was not detected previously in MW10-2 or MW10-4. TCE and cis-1,2-dichloroethene (cis-1,2-DCE) exceeded Class GA standards in wells MW10-2, MW10-3, MW10-4, and MW10-7; the sample from MW10-1 also contained cis-1,2-DCE at a concentration above the NYSDEC Class GA standard. Lead and zinc were the only metals detected above NYSDEC Class GA standards in two of the six overburden monitoring wells (MW10-7 and MW10-8).

Two of the five shallow bedrock monitoring wells contained VOCs; vinyl chloride was found to exceed the standard in well MW10-2D, and cis-1,2-DCE was present in wells MW10-2D and MW10-9D at concentrations above the Class GA standards. Lead exceeded the standard in samples from wells MW10-2D, MW10-5D, and MW10-6D; zinc was the only other metal found to exceed the standard and was detected in wells MW10-2D and MW10-5D. Only one shallow bedrock well (MW10-6D) contained semivolatiles, but at a level below the Class GA standard.

No semivolatiles or metals were detected in any of the deep bedrock wells. Only one well was found to contain VOCs; well MW10-1E contained levels of cis-1,2-DCE, TCE, and vinyl chloride above the Class GA standards.

PCBs were not detected in any of the Site 10 groundwater samples. PCDD/PCDF samples were not present above the detection limits in samples from wells MW10-1 and MW10-7.

Surface Water

Four surface water samples were collected during the RFI. Surface water sample SW10-4 was collected in Cayuga Creek and upstream of Site 10, which is also located downstream of Site 3 and Conrail railroad tracks. Sample SW10-5 was collected in the drainage ditch and was selected as a background sample for Site 10 because it was located upstream of the fire training area. Sample SW10-6 was collected from the drainage ditch located downstream of Site 10, before its confluence with Cayuga Creek. Sample SW10-7 was collected in Cayuga Creek after the confluence as an additional downstream sample to determine whether any Site 10 contamination had impacted Cayuga Creek. A summary of the RFI surface water sampling analytical results is presented in Table 5-3.

Zinc was the only metal detected in surface water samples at concentrations exceeding the NYSDEC Class C surface water standards. Four VOCs (carbon tetrachloride, chloroform, cis-1,2-DCE, and TCE) were detected in sample SW10-6, but no Class C surface water standards have been established for comparison.

The semivolatile compound bis(2-ethylhexyl)phthalate was detected above the surface water standard in sample SW10-6. This compound is not considered site related contamination (E & E 1995). No VOCs or semivolatiles were found to exceed Class C standards in previous surface water data.

Sediments

Three sediment samples and one duplicate sample were collected from Cayuga Creek and its tributary in the vicinity of Site 10 during the RFI. Sediment sample SD10-5 was collected in the tributary upstream of Site 10 as a background sample; sample SD10-6 was collected in the tributary approximately 20 feet upstream of its confluence with Cayuga Creek and downstream of Site 10. Sample SD10-7 was collected in Cayuga Creek approximately 10 feet upstream of the culvert under the taxiway and downstream of where the tributary enters Cayuga Creek. A summary of the RFI sediment sample analytical results is presented in Table 5-4.

Sediment analytical results were compared to "lowest" and "severe" effects levels as developed by Persaud *et al.* (1992) and Long and Morgan (1990) and presented in NYSDEC's Technical Guidance for Screening Contaminated Sediments (NYSDEC 1993b). The guidance values for soil as developed in TAGM 4046 were used when no sediment values for VOCs and semivolatiles were available.

No VOCs were found to exceed TAGM 4046 guidance values in any of the sediment samples. The RFI sediment samples contained several polycyclic aromatic hydrocarbons (PAHs) at concentrations exceeding the lowest effect level. Only one sample (SD10-5) contained PAHs at concentrations exceeding the severe effect level. Since SD10-5 was collected as the site background sample, the contamination present may not be related to Site 10 activities. As mentioned in the RFI, the PAHs detected in the sediment samples are not present in the other Site 10 media sampled.

One or more Site 10 RFI sediment samples contained arsenic, cadmium, copper, lead, mercury, and nickel at concentrations that exceeded the lowest effect levels. Zinc was detected in all four samples at levels exceeding the severe effect level.

5.1.1.3 Current and Potential Exposure Pathways

The current and potential exposure pathways to human and environmental receptors at Site 10 that need to be addressed by the CMS were identified in the work plan (E & E 1995) and include:

- Ingestion of groundwater and ingestion/adsorption of site soils by installation personnel; and

- Exposure of flora and fauna in Cayuga Creek to site-related contaminants.

5.1.2 Establishment of Corrective Action Objectives (CAOs)

Contamination at Site 10 is present in soil, groundwater, surface water, and sediment. CAOs protective of human health and the environment were established for each medium by comparing observed concentrations to existing standards and guidance. The site cleanup objectives were then used to identify areas requiring corrective action and in selecting and evaluating CMAs (see Sections 5.2 and 5.3, respectively). Site cleanup objectives are developed for all contaminants detected during the RFI as well as all previous investigations conducted at Site 10.

5.1.2.1 Soils

The soil guidance values presented in TAGM 4046 (NYSDEC 1994) were evaluated as potentially applicable for determining soil cleanup objectives for the site soils. Using TAGM 4046 is a conservative approach to determining soil cleanup objectives. According to the TAGM, attainment of the recommended soil cleanup objectives will, at a minimum, eliminate all significant threats to human health and the environment posed by inactive hazardous waste sites. The basis upon which TAGM 4046 sets its guidance values is detailed in Section 4.1.2.

The current and potential exposure routes at Site 10 consist of ingestion/adsorption of site soils by installation personnel. Although not detected during RFI sampling, VOC soil contamination was detected during previous investigations (E & E 1994). Contaminants from site soils can leach into the groundwater, a potential future source of potable water. Soil contaminants observed at the site have also been detected in groundwater. Therefore, the primary guidance value bases of TAGM 4046 (i.e., human exposure scenarios and leaching mechanisms of contaminants from soil to groundwater) exist at Site 10. For most organics, the guidance values listed in TAGM 4046 are based on leaching to groundwater. For many sites, the generic leaching model may overestimate the amount of contaminants transferred to the water, even with the use of the recommended correction factor. However, Site 10 contaminated soils are located directly in the water table, and the same contaminants found in the soils are also found in adjacent groundwater. Because of these unique conditions, TAGM 4046-recommended soil cleanup objectives will be used as soil cleanup objectives at Site 10.

TAGM 4046 does not provide soil cleanup objectives for some chemicals, including boron and total-1,2-DCE. For such chemicals, EPA Region III RBCs (dated March 7, 1995) were used as soil cleanup objectives.

The area occupied by the site has been classified as "open space" and "aircraft O&M" functional land use area in the Management Action Plan (MAP) (USAF 1994). The aircraft O&M land use category may include control tower support, flight training, wash racks, fuel maintenance activities, and other aircraft support facilities. Therefore, the RBCs selected were for industrial soils, rather than residential soils. The RBC calculations are based on adult occupational exposure.

For metals, TAGM 4046 calls for site background levels to be used as soil cleanup objectives. The site background metals concentrations (except for cadmium) were determined by using the upper limit of the 90th percentile of metals concentrations of eastern United States soils and other surficial materials (calculated from the data of Shacklette and Boerngen 1984). Cadmium was not included in this study. For cadmium, the cleanup objective was determined by using the higher end (7 mg/kg) of the range of observed values (0.01 to 7 mg/kg) (Dragun 1988).

Table 5-5 lists all contaminants detected during all Site 10 soil sampling events and presents the maximum concentrations detected and soil cleanup objectives. A site soil cleanup objective was established for a contaminant if its maximum concentration was higher than the soil cleanup objective. RFI soil samples above cleanup goals are shown in Figure 5-6. Based on a review of this information, the following was concluded:

- Chromium was found to exceed the cleanup standard in one soil sample. This sample was collected from the 6.9- to 8.1-foot depth interval from the well MW10-1D soil boring. Chromium did not exceed the cleanup standard in another soil sample collected from this boring, or from the groundwater from MW10-1D. It is believed that the chromium exceedance is an isolated occurrence and does not warrant consideration in this CMS. Lead, nickel, and zinc were also found to exceed the soil cleanup objectives (SAIC 1991; Wehran 1992; E & E 1994). The bedrock beneath the installation is Lockport dolomite. Pyrite (iron sulfide), sphalerite (zinc sulfide), and galena (lead sulfide) particles or zones of mineralization are disseminated throughout the dolomite (SAIC 1991). These metals are considered to be naturally occurring.

  The maximum concentration of nickel observed at Site 3 was 48 mg/kg. The soil cleanup objective for nickel is 38.2 mg/kg. This value is the upper limit of the 90th percentile as calculated from the data of Shacklette and Boerngen (1984). For comparison purposes, the EPA Region III RBC for nickel is 20,000 mg/kg. Based on the low observed concentration of nickel at Site 3, the presence of nickel will not be addressed in the CMS. Therefore, none of the soils exceeding cleanup objectives for metals require corrective action.

- None of the samples collected during any of the investigations exceeded the soil cleanup objectives for semivolatiles. Therefore, no site cleanup objectives have been established for semivolatiles.

- Two VOCs (TCE and total xylenes) exceeded the soil cleanup objectives. Other VOCs were detected at concentrations below the TAGM 4046 soil cleanup objectives.

- Total VOCs exceeded the TAGM 4046 guidance limit of 10 ppm in two samples collected during the focused RI. The total VOCs would not exceed 10 ppm if not for extremely high levels of TCE detected in these two samples.

Based on all soil sampling conducted at Site 10, areas of soils contamination above cleanup goals were determined. These areas of soil contamination are shown in Figure 5-7. Based on Figure 5-7, the total volume of contaminated soils present at the site are approximately 2,400 cubic yards. Corrective action appropriate for contaminated soils at the site may consist of capping, excavation, consolidation, on- and off-site disposal, and treatment. The applicable corrective measure technologies are identified and screened in Section 5.1.3.

5.1.2.2 Groundwater

NYSDEC Class GA groundwater standards were used as guidelines to establish the groundwater cleanup objectives. Although the groundwater at the installation is not currently used as a source of drinking water, it is suitable as a source of potable water. For some chemicals, such as carbon disulfide and nickel, NYSDEC Class GA groundwater standards have not been established. EPA Region III RBCs for tap water were used as groundwater cleanup objectives for such contaminants. In the RBCs, the toxicity constants for each contaminant have been combined with generic exposure scenarios to calculate chemical concentrations corresponding to a hazard quotient of 1 or lifetime cancer risk of 10^{-6}, whichever occurs at a lower level. Therefore, by using the groundwater cleanup objectives described above, the potential threat to human health arising from the potable use of groundwater at the site will be minimized.

Table 5-6 lists all contaminants detected during all Site 10 groundwater sampling events, and presents the maximum concentrations detected, and groundwater cleanup objectives. A site cleanup objective was established if a contaminant's maximum concentration was higher than the groundwater cleanup objective. Figure 5-8 presents RFI groundwater samples above site cleanup goals. Based on a review of this information, the following was concluded:

- During the RFI sampling, only two metals (lead and zinc) exceeded the groundwater cleanup objectives in four of the 14 wells sampled. Lead exceeded the NYSDEC Class GA standards in three of 11 samples collected during the RI/FS (SAIC 1991) and limited RI/FS conducted at the site (Wehran 1992). Zinc exceeded the groundwater cleanup objective in six of 11 samples collected during these investigations. However, lead and zinc are considered to be existing naturally at the site (Appendix B compares groundwater metals data from other sites on the base and supports this view. Metals concentrations in filtered and unfiltered samples are also compared in Appendix B). During the RFI, chromium was not detected in any of the groundwater samples. However, chromium slightly exceeded the groundwater cleanup objective in one of the 11 samples collected during the RI/FS and limited RI/FS. Based on the low frequency of exceedance, chromium will not be addressed in the CMS.

Therefore, metals contamination of groundwater at the site will not be addressed in the CMS.

- One semivolatile, bis(2-ethylhexyl)phthalate, was detected in one of the RFI groundwater samples. This is a common laboratory contaminant and does not correlate to known site contaminants. No semivolatiles were detected in previous sampling conducted at the site. Therefore, no site cleanup objectives have been established for semivolatiles.

- RFI groundwater samples exceeded the NYSDEC Class GA standards for 1,1-DCE, benzene, cis-1,2-DCE, trans-1,2-DCE, TCE, and vinyl chloride in nine of the 15 samples. Elevated levels of VOCs were detected in wells MW10-2 and MW10-4. During the RI/FS, limited RI/FS, and focused RI, the following additional VOCs exceeded the Class GA standards: carbon tetrachloride and chloroform in one of 22 samples collected; hexachlorobenzene and methylene chloride in two of 22 samples; and total-1,2-DCE in nine of 22 samples. Site cleanup objectives for all VOCs are listed in Table 5-6.

In some cases, it may not be technically feasible to attain through corrective actions the site groundwater cleanup objectives developed above. A well-designed corrective action system that has been operational for several years would initially achieve a decrease in groundwater contaminant concentrations. After a period of time, however, the concentration of contaminants might not decrease further. This condition, commonly referred to as "zero-slope," is often observed during corrective action implementation. Under such conditions, and if the groundwater contaminant concentrations are sufficiently low, the Base may petition the regulatory agencies for alternate concentration limits and a post-termination monitoring program. These issues are presented in detail in Section 6.4.

Corrective action appropriate for contaminated groundwater at Site 10 may consist of groundwater extraction, containment, in situ or ex situ treatment, and disposal. The applicable corrective measure technologies are identified and screened in Section 5.1.3.

5.1.2.3 Surface Water

Cayuga Creek is classified as a Class C surface water body. Per NYCRR Part 701, the best use of Class C waters is fishing, and such waters should be suitable for fish propagation and survival. The water quality for Class C bodies shall be suitable for primary and secondary contact recreation, although other factors may limit the use for these purposes (6 NYCRR Part 701).

Current and potential exposure pathways exist to flora and fauna in Cayuga Creek. No on-site recreational activities occur at the installation; however, access to Cayuga Creek is unrestricted as it exits the base. Based on the exposure routes and the classification of Cayuga Creek as a Class C surface water body, NYSDEC Class C surface water standards were used as the surface water cleanup objectives for Cayuga Creek. No standards are established for NYSDEC Class C for the following compounds: carbon tetrachloride, chloroform, cis-1,2-DCE, TCE, and butylbenzylphthalate. As per NYCRR Part 701, both Class C and Class A surface waters are suitable for fish propagation and survival. Because current and potential exposure pathways at Site 10 exist for flora and fauna in Cayuga Creek, Class A surface water standards were used when Class C surface water standards were not established. For cis-1,2-DCE, carbon tetrachloride and TCE, no Class A standards are established. However, guidance values have been provided for the above three compounds (NYSDEC 1993). Although guidance values have not been formally adopted as standards, by NYSDEC, the adoption of guidance values as cleanup objectives for Site 10 surface waters would be protective for fish propagation and survival.

Table 5-7 lists the contaminants detected during all previous surface water sampling activities, and presents the maximum concentrations detected, and surface water cleanup objective. A site cleanup objective is then established if a contaminant's maximum concentration was higher than the surface water cleanup objective. Figure 5-8 presents RFI surface water samples above site cleanup goals. Based on a review of this information, the following was concluded:

- During the RFI sampling, zinc was the only metal that exceeded the cleanup objective in all four samples collected. As discussed previously, zinc is considered to be naturally occurring at the site. Therefore, Cayuga Creek surface water will not be considered for corrective action due to the presence of metals.

- During the RFI sampling, VOCs were detected in one out of the four surface water samples collected from the tributary to Cayuga Creek. Because there were no NYSDEC Class C surface water quality standards established for these compounds, the more stringent NYSDEC Class A ambient water quality standards and guidances were used. Carbon tetrachloride, cis-1,2-DCE, and TCE exceeded the cleanup objectives in surface water.

- One semivolatile compound, bis(2-ethylhexyl)phthalate, was detected and exceeded the site cleanup objective at a frequency of one sample of the four samples collected during the RFI. Low concentrations of bis(2-ethylhexyl)phthalate are typically considered laboratory contamination arising from the use of rubber gloves. Therefore, semivolatile contamination is not present in Cayuga Creek surface water and will not be considered for corrective action.

Corrective action appropriate for surface waters are source control and treatment. As was presented earlier in Sections 5.1.2.2 and 5.1.2.3, soil and groundwater medium corrective measures would be implemented at Site 10. By implementing soil and groundwater medium corrective measures, further releases of hazardous constituents to surface waters in the vicinity of Site 10 would be minimized. Soil and groundwater corrective measures would most likely lead to attainment of surface water cleanup goals at Site 10. Thus, surface water medium corrective actions will be addressed by implementing soil and groundwater medium corrective actions at Site 10.

5.1.2.4 Sediment

Sediment screening criteria presented in the Technical Guidance for Screening Contaminated Sediments (NYSDEC 1993) were used as the cleanup objectives for sediments at the site. Consistent with this guidance and other guidance documents referenced below, the cleanup objectives are identified in Section 4.1.2.4.

Table 5-8 lists contaminants detected during all previous sediment sampling activities, and presents the maximum concentrations detected and sediment cleanup objectives. A site cleanup objective was established if a contaminant's maximum concentration was higher than the sediment cleanup objective. RFI sediment samples above site cleanup goals are shown in Figure 5-6. Based on a review of this information, the following was concluded:

- Eight metals (arsenic, cadmium, copper, lead, mercury, nickel, selenium, and zinc) exceeded the sediment cleanup objectives. As presented earlier, the metals lead, nickel, cadmium, and zinc are believed to exist naturally and are not considered site related. Mercury was not detected in Site 10 soil or groundwater samples. This suggests that the source of mercury in the sediments is from an upstream facility (other industrial facilities are located in the vicinity of the installation and upstream of Site 10). Arsenic has also been detected in the groundwater and soil, but below the cleanup objectives. Copper was detected in the soil, but at levels below the cleanup objectives. Selenium was only detected in one sediment sample at a concentration just above the cleanup objective. Selenium was not detected in Site 10 soil or groundwater samples. Therefore, sediments at Site 10 will not be addressed in the CMS.

- None of the VOCs detected exceeded the site cleanup objectives.

- Eleven semivolatiles (acenaphthalene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, carbazole, chrysene, dibenzo(a,h)anthracene, fluorene, indeno(1,2,3-cd)pyrene, and pyrene) exceeded the site cleanup objectives. These compounds (with the exception of carbazole) are PAHs. Carbazole was only detected in one sample. PAHs are typical in industrial areas. The semivolatiles detected in the sediment samples are not consistent with those detected in the other sample media. The upstream sediment sample (SD10-5), which was intended to be a site background sample, contained the highest concentrations and most extensive array of semivolatiles compared to the sediment samples collected adjacent to or downstream of Site 10. These findings suggest another upstream source for these contaminants. Therefore, semivolatile contamination in sediment will not be considered for remediation in this CMS.

It can be concluded that the sediments in the tributary to Cayuga Creek as well as the creek itself are being impacted by a contaminant source other than Site 10. This source should be identified through additional sampling and investigation, which is not within the scope of this project.

5.1.3 Screening of Corrective Measures Technologies

In this section, corrective measures technologies identified in the CMS work plan (E & E 1995) and Section 3 are screened and reassessed for implementation feasibility at Site 10. Screened corrective measure technologies will be combined into CMAs in Section 5.1.5.

Identified corrective measure technologies were screened to eliminate those that may prove not feasible to implement or do not achieve the identified CAOs within a reasonable time frame. Each technology's implementation feasibility at Site 10 was assessed by using the following site, waste, and technology limitations criteria:

- Site conditions and characteristics that may affect implementability of the technology;
- Physical and chemical characteristics of contaminants that determine the effectiveness of various technologies; and
- Performance and operating reliability of technology.

As discussed in Section 5.1.2, both soil and groundwater media will be addressed in the CMS. Table 5-9 lists chemical and physical properties (molecular formula, molecular weight, water solubility, log K_{ow}, vapor pressure, and Henry's law constant) of all chemicals found in Site 10 soil and groundwater.

5.1.3.1 Soil Medium Corrective Measure Technologies

Corrective action for soils at the site may consist of removal, containment, ex situ or in situ treatment, and disposal. Appropriate corrective measure technologies were identified in Section 4 and the CMS work plan (E & E 1995). These technologies are screened in Table 5-10.

Technologies retained as a result of analysis will be combined into CMAs in Section 5.1.4.

5.1.3.2 Groundwater Medium Corrective Measure Technologies

Corrective action for groundwater at the site may consist of groundwater extraction, containment, ex situ or in situ treatment, and disposal. Appropriate corrective action technologies were identified in Section 4 and the CMS work plan (E & E 1995). These technologies are screened in Table 5-11.

Retained corrective action technologies will be combined into corrective measure alternatives in Section 5.1.5.

5.1.4 Selection of Corrective Measure Alternatives

In this section, retained corrective measure technologies were developed into comprehensive medium-specific corrective action alternatives. Each alternative consists of an individual technology or a combination of technologies. The no-action alternative is included to provide a baseline with which other alternatives may be compared. The following CMAs were developed for Site 10:

- Alternative 1: No action and natural attenuation.
- Alternative 2: Institutional actions and natural attenuation.
- Alternative 3: Groundwater extraction by trenches, on-site treatment of extracted groundwater, and disposal of treated groundwater in Cayuga Creek.
- Alternative 4: Soil vapor extraction (SVE); Groundwater extraction by trenches, on-site treatment of extracted groundwater, and disposal of treated groundwater in Cayuga Creek.
- Alternative 5: Contaminated soil excavation and off-site disposal, groundwater extraction by trenches, on-site treatment of extracted groundwater, and disposal of treated groundwater in Cayuga Creek.

- Alternative 6: Contaminated soil excavation and off-site disposal, groundwater extraction by trenches, and disposal of extracted groundwater to POTW.

5.2 Evaluation of the Corrective Measure Alternatives (CMAs)

In this section, the CMAs developed in Section 5.1 are described and evaluated on the basis of technical, environmental, human health, and institutional concerns.

Capital costs and operation and maintenance costs were developed for each alternative. Based on the availability of the information for each site and the design assumptions that will be utilized for estimating the cost of each alternative, the CMS cost estimates are assumed to be accurate within the range of +50% to -30% of the true cost of the alternative.

5.2.1 Alternative 1: No Action and Natural Attenuation

Alternative Definition/Description

This alternative calls for the use of natural processes such as dispersion, diffusion, volatilization, and biodegradation to achieve site cleanup objectives in different media in the vicinity of the site. Through natural attenuation processes, contaminant levels in soils, groundwater, and surface water would decrease over time and distance and would not represent a threat to human and environmental receptors. Groundwater, surface water, and sediment quality in Cayuga Creek would be monitored for progress in attaining of cleanup goals until site cleanup objectives are met.

Alternative 1 is evaluated below.

Technical Concerns

Through natural attenuation processes, this alternative would be effective in reducing soil, groundwater, and surface water contamination. Effectiveness, reliability, implementability, and safety issues of Alternative 1 are presented below.

- **Effectiveness.** As discussed in Section 4.2, anaerobic microbial transformation can naturally biodegrade contaminants found at the site. The decrease in TCE concentrations, and the relative increase in concentrations of biodegradation byproducts with distance from the burn pit, further supports the theory that natural attenuation processes are occurring at the site. Because high levels of vinyl chloride are not found throughout the installation, this compound is likely being further degraded anaerobically to nontoxic end products such as ethene and chloride. In addition, other processes like diffusion, dispersion, volatilization, and adsorption are naturally occurring phenomena that reduce the contaminant concentrations.

At Site 10, natural processes have limited capacity to reduce contaminant concentrations at exposure sites for environmental and human receptors. Site-related contaminants found to exceed the NYSDEC standards and guidance values (see Section 5.1.2) have been detected in Cayuga Creek. In addition, natural processes would have a small effect in reducing residual contamination (i.e., free organics phase, trapped in smaller pores) that may be present in the site soils. The residual contamination would represent a long-term source of low-level groundwater contamination.

- **Reliability.** Only qualitative information is available regarding the existence of natural attenuation processes at the site; therefore, this alternative may be unreliable. Attenuation processes occur naturally and do not possess the flexibility to deal with unanticipated changes.

- **Implementability.** Attenuation processes are naturally occurring. Therefore, there are no implementability concerns associated with Alternative 1.

- **Safety.** During the implementability, the alternative and its components will not involve any threat to communities, the environment, or workers.

Environmental Concerns

Based on the RFI sampling (E & E 1995), contamination from Site 10 was found in Cayuga Creek above surface water cleanup goals. Although natural attenuation processes are occurring in the subsurface at Site 10 and dilution is occurring in Cayuga Creek, it is apparent that these processes do not have sufficient capacity to diminish contaminant levels in Cayuga Creek. Thus, short-term exposure concerns for environmental receptors can be expected at the site. Continued release of contaminants from the site may present further exposure concerns for environmental receptors in Cayuga Creek. However, no federal- or state-listed threatened or endangered species are reported to exist at the Niagara Falls IAP-ARS, and there are no critical on-site habitats for listed species (SAIC 1991).

Human Health Concerns

This alternative does not provide any protection to human health from contaminated groundwater at the site. No short-term exposure is expected because no drinking water wells currently exist. Groundwater sampling at the site would monitor groundwater quality and attainment of site cleanup goals.

Institutional Concerns

Site-related levels of contaminants in soils, groundwater, and surface water at the site and in its vicinity would continue to exceed the site cleanup objectives for a long period of time. In addition, the spatial expanse of the groundwater plume exceeding site cleanup objectives may increase.

Cost

For Alternative 1, the annual O & M costs are estimated at $53,000 (see Table 5-12). Based on the contaminants that are present above site cleanup goals, only VOC analysis is recommended. The present net worth of this alternative, assuming a 6% discount rate and 30-year monitoring period, is estimated at $0.7 million.

Summary

This alternative calls for the use of natural processes to achieve site cleanup objectives in different media in the vicinity of the site. Natural attenuation would gradually decrease containment levels. Monitoring would be conducted until acceptable groundwater, soil, and surface water concentrations are reached. This alternative does not provide protection to human health or environmental receptors in Cayuga Creek. No short-term human exposure is expected because no drinking water wells currently exist. Environmental receptors in Cayuga Creek are currently exposed to site contaminants and the continued release of contaminants would increase the exposure concerns.

5.2.2 Alternative 2: Institutional Actions and Natural Attenuation

Alternative Definition/Description

Similar to Alternative 1, this alternative calls for the use of natural processes such as dispersion, diffusion, volatilization, and biodegradation to achieve site cleanup objectives in different media in the vicinity of the site. Through natural attenuation processes, contaminant levels in soils, groundwater, and surface water would decrease over time and distance, so that they would not represent a threat to human and environmental receptors. However, until concentrations in groundwater fall to Class GA standards, institutional actions would be implemented, including regulatory restrictions on installing private wells on and in the vicinity of the site. Recommendations regarding the type or extent of such restrictions would be made to the appropriate agencies or boards (i.e., local planning or zoning boards) as the final project plan develops. The levels of soil contamination observed at the site are too low for human exposure concerns (see Table 5-5), soil cleanup objectives are based on the partitioning of contaminants to groundwater. Therefore, institutional controls like fencing, which would prevent human exposure to contaminated soil, are not required. Groundwater, surface water, and sediment quality in Cayuga Creek would be monitored to record progress in attainment of cleanup goals until site cleanup objectives are met.

Technical Concerns

Through natural attenuation processes, this alternative would be effective in reducing soil, groundwater, and surface water contamination. In addition, by implementing institutional controls for preventing installation of drinking wells at the site, this alternative would minimize the potential for human exposure to contaminated groundwater.

- **Effectiveness.** As discussed in Section 5.2.1, anaerobic microbial transformation can naturally biodegrade contaminants found at the site. In addition, other processes like diffusion, dispersion, volatilization, and adsorption are naturally occurring phenomena that reduce the contaminant concentrations. However, as discussed in Section 5.2.1, at Site 10, natural processes have limited capacity to reduce contaminant concentrations at exposure sites for environmental and human receptors. Although institutional controls can be very effective in preventing potable use of groundwater on and in the vicinity of the site, institutional controls cannot prevent exposure to environmental receptors in Cayuga Creek.

- **Reliability.** If enforced properly by local agencies, institutional controls are reliable in minimizing human exposure to site contaminants because they would prevent installation of wells. As discussed in Section 5.2.1, natural attenuation processes may be unreliable and would not possess the flexibility to deal with unanticipated changes.

- **Implementability.** Attenuation processes are naturally occurring. Implementability of institutional controls will depend on the cooperation of local and state regulatory agencies, and may take several months. Implementability of institutional controls preventing installation of private wells would be aided by the presence of a municipal drinking water supply.

- **Safety.** During the implementability, the alternative and its components will not involve any threat to communities, the environment, or workers.

Environmental Concerns

As discussed earlier, short-term exposure concerns to environmental receptors can be expected at the site. Continued release of contaminants from the site may further elevate the exposure concerns to environmental receptors in Cayuga Creek. Institutional controls cannot prevent exposure to site contaminants for the flora and fauna in Cayuga Creek. However, no federal- or state-listed threatened or endangered species are reported to exist at the Niagara Falls IAP, and there are no critical on-site habitats for listed species (SAIC 1991).

Human Health Concerns

Through institutional actions, this alternative would prevent any human exposure to contaminated groundwater. No short-term exposure is expected because no drinking water wells currently exist. Aided with natural attenuation, contaminant levels are expected to decrease with time. Groundwater sampling at the site would monitor groundwater quality and attainment of site cleanup goals.

Institutional Concerns

Although institutional actions would minimize human exposure to site contaminants, short- and long-term exposure concerns for environmental receptors in Cayuga Creek would remain. Site-related levels of contaminants in soils, groundwater, and surface water at the site and in its vicinity would continue to exceed the site cleanup objectives for a long time. In addition, the spatial expanse of the groundwater plume exceeding site cleanup objectives may increase.

Cost

Costs for this alternative arise from implementing the institutional actions and monitoring expenses. The cost of implementing the institutional actions is estimated at $9,000 (see Table 5-13). The annual O & M costs are estimated at $53,000 (see Table 5-13). Based on the contaminants that are present above site cleanup goals, only VOC analysis is recommended. The present net worth of this alternative, assuming a 6% discount rate and 30-year monitoring period, is estimated at $0.7 million.

Summary

Alternative 2 provides protection to human health by implementing institutional actions that would prevent constructing private wells on and in the vicinity of the site.

Natural attenuation would gradually decrease contaminant levels. Monitoring would be conducted until acceptable groundwater, soil, and surface water concentrations are reached. Natural attenuation, like all natural processes, has limited capacity, and, therefore, the performance of this alternative under unanticipated circumstances would be uncertain. Current exposure concerns for environmental receptors in Cayuga Creek are present, and continued release of contaminants would increase the exposure concerns.

5.2.3 Alternative 3: Groundwater Extraction by Trenches; On-Site Treatment of Extracted Groundwater; and Disposal of Treated Groundwater to Cayuga Creek

Definition/Description

Alternative 3 consists of extraction of groundwater at the site via a subsurface trench, on-site treatment, and discharge of treated groundwater to the ditch draining to Cayuga Creek. No direct corrective action would be implemented for site soils and Cayuga Creek surface waters. Soils would continue to act as a long-term source of groundwater contamination at the site. However, by control of the release of contaminants to Cayuga Creek, surface water cleanup objectives could be attained. Until groundwater cleanup objectives are attained, institutional controls that would prevent construction of drinking water wells on and in the vicinity of the site would be required. Recommendations regarding the type or extent of such restrictions would be made to the appropriate agencies or boards (i.e., local planning or zoning boards) as the final project plan develops. Groundwater sampling would be conducted on a routine basis to monitor the efficacy of the alternative and progress towards attainment of cleanup objectives. Surface water and sediment samples from Cayuga Creek would also be sampled on a routine basis.

No corrective measures would be implemented to address soils contaminated above site cleanup goals: the low levels of soil contamination at the site do not present any human exposure concerns. However, soils would continue to act as a long-term source for groundwater contamination at the site. Alternative 3 consists of one subsurface trench to extract the groundwater plume. Subsurface trenches essentially function like an infinite line of extraction wells. One shallow trench, approximately 150 feet long and 3 feet wide, would be installed in the vicinity of well MW10-7. The trench would be installed to the top of the bedrock. The majority of the contamination at the site has been observed in the overburden wells. The depth to bedrock at MW10-7 was observed to be 12 feet. By installing the trench to the bedrock, groundwater contamination in the overburden could be completely intercepted. The trench would be backfilled with gravel to approximately 3 feet BGS. Clean backfill or excavated clean site soils would be used above the gravel to meet the grade. One flexible corrugated PVC pipe would be embedded in the gravel bed (close to the trench bottom), and provided with a submersible pump. The trench would be installed with a HDPE membrane on the downgradient side to minimize collection of Cayuga Creek water.

Existing groundwater contamination between the trench and Cayuga Creek would be allowed to naturally attenuate, and it is expected that groundwater cleanup objectives downgradient of the trench would be readily attained. The overburden and the bedrock are hydraulically connected, and by extracting groundwater in the overburden, an upward groundwater flow gradient in the bedrock would be created. Therefore, bedrock contamination could also be extracted. The zone of influence in the bedrock, however, would depend on the extraction flow rates. However, at Site 10, the majority of the groundwater contamination exists in the overburden. Therefore, to minimize groundwater collection from the shallow bedrock aquifer, a conservative groundwater extraction flow rate of 0.25 gpm has been assumed. Contamination in the shallow bedrock not extracted by the trench would be allowed to naturally attenuate.

Double-walled flexible PVC hosing would be used to deliver extracted groundwater from the trench to the treatment system building. Extracted groundwater would be treated by an on-site treatment system consisting of filtration and air stripping processes. A flow diagram for the treatment process is presented in Figure 4-10. The treatment system would be enclosed in a building, probably located close to Building 726 (see Figure 5-9). Extracted groundwater from the trench would be pumped by a submersible pump to the treatment building. Following treatment, treated groundwater would be discharged through an outfall situated on the ditch located adjacent to the site.

As presented in Table 5-9, all the VOCs at the site are readily strippable. Therefore, removal of VOCs from the groundwater would be afforded primarily by an air stripping process. A shallow tray-type air-stripper was selected because of its low profile, low capital cost, and ease of maintenance and operation. A preliminary design of the air-stripper was undertaken using a flow rate of 10 gpm. For a conservative preliminary design, the maximum concentration of contaminants present above cleanup goals was used as the influent levels to the air stripper. The preliminary design shows that non-detect effluent levels for VOCs can be easily achieved (see Appendix F for preliminary design information for the air-stripper). NYSDEC Class C surface water standards would be the discharge limits for treated groundwater at the site. Therefore, all discharge limits would be easily met. It is anticipated that off-gas from the stripper would not require vapor-phase treatment.

Filtration is typically provided in groundwater treatment systems to protect treatment systems from suspended solids in the groundwater. Sand filters would be convenient and easy to operate and maintain for the low flow rates expected at the site. Therefore, sand filters would be provided ahead of the air stripping process. A solids slurry would be generated during the backwash cycle of the sand filter. It is anticipated that this solids slurry would have minimal organics contamination and could be disposed of by discharge to the POTW. Treated groundwater would be discharged to the ditch, but a SPDES permit would be required from NYSDEC.

Technical Concerns

- **Effectiveness.** Alternative 3 does not address soil contamination at the site. A majority of the contaminated soils exists below the water table. Therefore, soils at the site would continue to act as a long-term source of groundwater contamination. Highly heterogenous conditions exist at the site, and trenches, which essentially act as continuous lines of extraction wells, would be effective in groundwater extraction at the site. Because the majority of the contamination has been observed in the overburden wells, groundwater extraction by trenches installed in the overburden would effectively intercept the contamination. In addition, an upward gradient would be created that would extract groundwater from the bedrock as well. Bedrock contamination not intercepted by the trenches would naturally attenuate.

  Treatment of extracted groundwater by air-stripping and filtration would be very effective, since all contaminants are readily strippable. Preliminary design of the air-stripper has shown that NYSDEC Class C surface water standards would be easily attainable.

- **Reliability.** Groundwater extraction by trenches and treatment by air stripping are very reliable technologies. The groundwater treatment and extraction systems are typically designed to handle a wide variety of flow and organic-loading conditions, and a similar procedure would be followed in the design phase of the treatment system. Because of heterogenous subsurface conditions at the site, groundwater contamination in the overburden would be reliably extracted by trenches. To provide continuous monitoring, the system can be connected to an off-site monitoring station through telemetry systems. Soil conditions are not expected to change. Depending on changed groundwater contamination conditions, additional trenches can be installed and any existing trench can be decommissioned. In addition, the groundwater treatment system capacity can be easily augmented.

The O & M requirements include routine timely maintenance groundwater extraction and treatment system (for example air stripper trays, pumps, pipes, and pipe fittings).

- **Implementability.** Because the observed depth to the top of bedrock (depth of the proposed trench) is 12 feet, standard excavation equipment like backhoes could be used for trench installation. During trench excavation, proper side-slopes would be adopted to ensure stability of open faces. Groundwater dewatering would be required during trench construction. With prior approval from NCSD, collected groundwater could be discharged to the POTW. Approximately 150 cubic yards of excavated soils generated during installation of the trench would need to be disposed of off site. It is anticipated that these soils could be disposed of as non-hazardous soils.

  A preliminary design of an air stripper was conducted assuming a flow rate of 10 gpm (see Appendix F for design calculations). VOCs would be removed to non-detectable levels by the air stripper. Therefore, the effluent would meet NYSDEC Class C surface water quality of Cayuga Creek. The NYSDEC SPDES permit limit would probably be as conservative as the NYSDEC Class C standards; therefore, the groundwater treatment system could be easily implemented. The discharge from the system to Cayuga Creek would be frequently monitored. The solids slurry from the sand-filter would be disposed of off site on a routine basis. During the design phase, the solids slurry disposal frequency could be adjusted to suit O & M requirements of the system.

  It is estimated that approximately six months would be required to conduct design, procurement, installation, and start-up of Alternative 3. Procurement of an SPDES permit typically takes two to six months. The time to achieve groundwater cleanup goals cannot be estimated. This is primarily due to soils contamination that would continue to act as a long-term source of groundwater contamination. Under analogous conditions, attainment of cleanup objectives by groundwater extraction and treatment has taken few to several years (decades or longer). Furthermore, after groundwater has been treated and contamination found to be below cleanup levels, contamination sometimes re-establishes once continual extraction is ceased. For this reason, it is assumed that Alternative 3 would need to be operated and maintained for a period of 30 years (the same as for Alternative 1).

- **Safety.** Implementation of this alternative is not expected to create health risks or threats to the safety of nearby communities or cause exposure concerns to environmental receptors. Standard design and construction techniques would be adequate for trench installation at the site. Minimal dust generation and VOC release is expected during construction of the trench and the treatment system. During construction of the trench and routine maintenance of the treatment system, protective clothing (Level D personal protection) and equipment would effectively minimize the potential short-term exposure of on-site workers to VOCs in groundwater. Solids slurry from the sand filter backwash would require off-site disposal, most probably at the POTW.

Environmental Concerns

Alternative 3 would actively address contamination in the groundwater media only. Site-related contamination above the respective site cleanup objectives has been detected in Cayuga Creek. By extracting groundwater contaminants from the site, the release of contaminants to Cayuga Creek would be minimized. Subsurface trenches would act as an hydraulic boundary to the off-site transport of contaminants from the site to Cayuga Creek. Therefore, long-term exposure of environmental receptors in Cayuga Creek to contaminants would be reduced. The proposed trench would have limited effectiveness in intercepting contamination in the deeper bedrock. In addition, the amount of contaminants that would be extracted from the overburden and the anticipated rate of decrease in the level of Cayuga Creek contamination cannot be currently estimated. It would be some time before a decrease in surface water contamination could be observed. Therefore, short-term exposure concerns would not be eliminated. However, no federal- or state-listed threatened or endangered species are reported to exist at the installation, and there are no critical on-site habitats for listed species that might occur (SAIC 1991).

Human Health Concerns

No short-term exposure to site contaminants is expected because no drinking water wells currently exist on or in the vicinity of the site. Because of the low levels of soils contamination, no short- or long-term human exposure concerns are expected from site soils. In the long term, this alternative would accelerate the attainment of groundwater cleanup goals by actively extracting and treating groundwater contaminants. By restoring groundwater quality to meet or exceed NYSDEC Class GA standards, human exposure to site contaminants would be eliminated. However, because the source of contamination would remain, the rate of reduction of contamination or the time when cleanup goals would be attained cannot be estimated. The proposed trenches would also have limited effectiveness in extracting groundwater contamination from the bedrock. Although, some upward flow from the bedrock to the overburden trench would be achieved by groundwater extraction. Contamination in the bedrock would also be allowed to naturally attenuate. Institutional actions would be implemented up to the time site cleanup objectives are attained.

Institutional Concerns

NYSDEC Class GA standards would be attained, and the threat to human consumption of contaminated groundwater would be eliminated. This alternative would effectively reduce the release of contamination into Cayuga Creek, and NYSDEC Class C surface water standards would be attained. Therefore, exposure concerns to environmental receptors in Cayuga Creek would be eliminated. Other institutional concerns related to this alternative would be compliance with a SPDES permit for discharge to the drainage ditch and release of off-gas from the air stripper to the ambient atmosphere. Preliminary design calculations have shown that effluent from the treatment system would meet or exceed NYSDEC Class C surface water standards. Off-gas from the air-stripper would also meet or exceed NYSDEC air quality standards.

Cost

Capital and annual O & M costs of Alternative 3 are presented in Table 5-14. Capital costs of Alternative 3 consist of design and installation of the groundwater extraction and treatment system and is estimated at $129,000. The annual O & M costs consist of groundwater and treatment system sampling and routine maintenance of the groundwater treatment system. The annual O & M costs are estimated at $66,000. Based on the assumed 30-year operation period and a 6% discount rate, the total present net worth of this alternative is estimated at $1 million.

Summary

Alternative 3 calls for groundwater extraction and on-site treatment, and discharge of treated groundwater to Cayuga Creek. This alternative does not address soil contamination. Contaminated soil at the site is present above the site cleanup objectives. Although contaminant concentrations in soil are too low to cause human exposure concerns, soils at the site would continue to act as a long-term source of groundwater contamination.

Downgradient of the former fire training pit area, one subsurface trench would be installed to extract the groundwater plume. A majority of the groundwater contamination has been observed in wells installed in the overburden. Therefore, the trench would be installed to the top of the bedrock. Because the bedrock and overburden are hydraulically connected, groundwater contamination in the bedrock also could be extracted by the overburden trench.

Groundwater would be treated on site by filtration and air stripping. Preliminary design of the air-stripper has shown that non-detectable levels could be attained in the effluent. Treated groundwater would be discharged to Cayuga Creek via a ditch under a SPDES permit. Off-gas from the air stripper is not anticipated to require treatment. A subsurface trench would be effective in intercepting the groundwater plume, preventing the off-site transport of contaminants to Cayuga Creek. By actively treating groundwater contamination, groundwater cleanup objectives would be attained in an accelerated manner. In addition, by minimizing the release of contaminants to Cayuga Creek, surface water standards would be attained. Because no drinking water wells exist on the site, no short-term exposure for humans receptors is expected. Currently, contaminants levels in surface waters of the Cayuga Creek are above their respective standards (which are protective of fish survival and propagation); therefore, short-term exposure concerns for environmental receptors exist. Long-term exposure concerns for human and environmental receptors would be minimized by this alternative.

5.2.4 Alternative 4: Soil Vapor Extraction; Groundwater Extraction by Trenches; On-Site Treatment of Extracted Groundwater; and Discharge of Treated Groundwater to Cayuga Creek

Definition/Description

This alternative consists of performing in-situ treatment of soils by SVE in the vicinity of the former burn pit area. Groundwater at the site would be extracted via a subsurface trench, treated on site, and discharged to the ditch draining to Cayuga Creek. Alternative 4 is similar to Alternative 3 for groundwater corrective measures. In addition, Alternative 4 would treat contaminated soil by SVE.

No direct corrective action would be implemented for Cayuga Creek surface waters; however, surface water cleanup objectives would be attained by source control. Until groundwater cleanup objectives are attained, institutional controls that would prevent construction of drinking water wells on and in the vicinity of the site would be required. Recommendations regarding the type or extent of such restrictions would be made to the appropriate agencies or boards (i.e., local planning or zoning boards) as the final project plan develops. Groundwater sampling would be conducted on a routine basis to monitor the efficacy of the alternative and progress towards attainment of cleanup objectives. Surface water and sediment samples from Cayuga Creek would also be sampled on a routine basis.

Figure 5-7 shows the areas where soil contamination exceeds soil cleanup objectives. The majority of the soil contamination was detected in the former burn pit area, and some contamination observed downgradient of the site. The soils to be treated by SVE (the entire shaded area shown on Figure 5-7) would cover approximately the area of the former burn pit and additional areas where soil contamination exceeds site cleanup objectives.

Two monitoring wells are located in the area demarcated for SVE. These wells would have to be removed and properly abandoned prior to performing SVE.

At Site 10, soil contamination above cleanup goals has been detected below the water table. Saturated soils would not be exposed to SVE. To expose all the soils to SVE, the water table would be lowered where saturated soils are contaminated. For costing purposes, it is assumed that two groundwater wells would be required to create drawdown beneath the cap. The deepest soil contamination above cleanup objectives has been detected to a depth of 8 feet BGS. The top of the bedrock at the former burn pit area is located at 9 feet BGS. Therefore, a drawdown would be created that exposes site soils up to the top of the bedrock.

Because of the tightness of soils and layered formations, the radii of influence for vacuum extraction wells is assumed to be 20 feet. A possible arrangement of four vapor extraction wells and two groundwater extraction wells is shown on Figure 5-10. The SVE system would be housed in a treatment building, probably close to Building 726. The height of the treatment building is expected to be 8 to 9 feet and should not be a concern despite its proximity to the runway.

Downgradient of the pit, one subsurface trench would be used to extract the groundwater plume. The trench would be similar to that adopted for Alternative 3. One shallow trench, approximately 150 feet long and 3 feet wide, would be installed in the vicinity of the well MW3-7. The trench would be installed to the top of bedrock. Existing groundwater contamination between the trench and Cayuga Creek would be allowed to naturally attenuate. It is expected that groundwater cleanup objectives downgradient of the trench would be readily attainable. Because the overburden and the bedrock are hydraulically connected, an upward groundwater flow gradient in the bedrock would be created by extracting groundwater in the overburden. Therefore, bedrock contamination could also be extracted. The zone of influence in the bedrock, however, would depend on the extraction flow rates. As previously discussed, a conservative groundwater extraction flow of 0.25 gpm has been assumed.

For Alternative 4, groundwater treatment would be similar to that described in detail for Alternative 3. On-site treatment would consist of filtration and air stripping. Based on the preliminary design of the air stripper (see Appendix F), no off-gas treatment is anticipated. Treated water would be discharged to the ditch draining to Cayuga Creek. The groundwater treatment system would be housed in the treatment building adjacent to the SVE system.

Technical Concerns

- **Effectiveness.** Because all the contaminants above cleanup goals in soil are VOCs, SVE would be effective in extracting VOCs from site soils. Any residual contamination (i.e., free organic phase, trapped in small pores) remaining in the soils would also be effectively reduced by SVE. SVE alone would not be effective on soils that are below the groundwater table. To make these soils available for SVE, the groundwater table beneath the area to be capped would be lowered by using groundwater dewatering wells. Groundwater removed would be treated on site at the groundwater treatment facility.

  By lowering the water table in the area of known soil contamination, additional plume formation by groundwater contact with soils would be eliminated. To accomplish an effective SVE system, a pilot study would be undertaken before the design of the SVE system at the site. The pilot study would aid in calculating soil permeability, the radius of influence, and vapor flow rate. Soil permeability is the most important parameter to be considered in the successful application of SVE. Other parameters such as water content, organic content, soil heterogeneity in various directions would also be determined in the pilot study. SVE would be implemented until soil-monitoring data shows that VOC contamination has been reduced to the point that it meets and maintains cleanup objectives, or until the limits of this corrective action technology have been reached and the rate of contaminant removal reaches low levels. It is assumed that soil cleanup objectives can be attained within five years after implementation. Following the attainment of soil cleanup goals, the SVE system would be dismantled.

  Technical effectiveness of groundwater extraction by trenches and on-site treatment of extracted groundwater by air-stripping and filtration were discussed in Section 5.2.3.

- **Reliability.** SVE, groundwater extraction by trenches, and treatment by air stripping are reliable technologies. An SVE pilot study would aid in designing a reliable SVE system. Soil conditions are not expected to change. Groundwater treatment and extraction systems are typically designed to handle a wide variety of flow and organic loading conditions, and a similar procedure would be followed in the design phase of the treatment system.

  The O & M requirements include routine maintenance of the SVE and groundwater extraction and treatment system (e.g., air stripper trays, pumps, pipes, and pipe fittings). The basic SVE system consists of blowers to produce vacuum, piping, and valves, which can be easily operated and maintained.

- **Implementability.** This alternative is readily implementable. SVE systems are relatively easy to install, and their use of standard, readily available equipment enables rapid, cost-effective mobilization and implementation. In addition, this in-situ technology can be implemented with only minor disturbances at Site 10. An SVE pilot study is recommended before implementing the SVE design at the site.

Implementability concerns for groundwater extraction and treatment are similar to Alternative 3 and were detailed in Section 5.3.3. The pilot study would determine the performance of SVE system and any vapor phase treatment requirements. Discharge from the system to Cayuga Creek would be frequently monitored. Solids slurry from the sand filter would require off-site disposal on a routine basis. During the design phase, the solids slurry disposal frequency could be adjusted to suit O & M requirements of the system.

It is estimated that approximately 12 months would be required for conducting SVE pilot tests, design, procurement, installation, and start-up of Alternative 4. Procurement of a SPDES permit typically takes two to six months. Based on the extent of soil contamination, it is assumed that Alternative 4 would achieve soil cleanup objectives in five years after start-up. To estimate the time to achieve groundwater cleanup objectives, the following assumptions were made:

- No residual contamination is present in soils;
- The area of groundwater contamination at the site is 200 feet by 150 feet; and
- The subsurface would be purged by one pore volume of groundwater.

Based on these assumptions, the entire contaminated groundwater from the site would be removed in approximately 2.5 years at a groundwater extraction rate of 0.25 gpm. To account for heterogeneities, reduced flow rates, and adsorption of organics to soils, it is recommended that the groundwater extraction and treatment system be operated for five years. Following this, groundwater cleanup goals are likely to be attained at Site 10.

- **Safety.** Implementation of this alternative is not expected to create health risks, threats to the safety of nearby communities, or cause exposure concerns for environmental receptors. Standard design and construction techniques would be adequate for trench installation at the site. Minimal or no dust generation and VOC release are expected during construction of the trench and the treatment system. During construction of trench and routine maintenance of the treatment system, protective clothing and equipment would effectively minimize the potential short-term exposure for on-site workers to VOCs in the groundwater. Maintenance of the treatment system would probably be conducted in Level D personal protective equipment. Disposal of the solids slurry from the filter backwash could be performed in Level D.

Environmental Concerns

Alternative 4 would actively address contamination in soil and groundwater media. Site-related contaminants have been detected above their respective standards and guidance in Cayuga Creek. By extracting soil contaminants, the source of groundwater contamination would be eliminated, thereby minimizing the release of contaminants to Cayuga Creek. In addition, groundwater cleanup objectives would be attained in an accelerated manner. Subsurface trenches would act as a hydraulic boundary to the off-site transport of contaminants from the site into Cayuga Creek. Therefore, long-term exposure of environmental receptors in Cayuga Creek to contaminants would be reduced. The proposed trench would have limited effectiveness in intercepting contamination in the deeper bedrock. In addition, the amount of contaminants that would be extracted from the overburden and anticipated rate of decrease in the level of Cayuga Creek contamination cannot be currently estimated. It would be some time before a decrease in surface water contamination would be observed. Therefore, short-term exposure concerns would not be eliminated. However, no federal- or state-listed threatened or endangered species are reported to exist at the installation, and there are no critical on-site habitats for listed species that might occur (SAIC 1991).

Human Health Concerns

No short- or long-term exposure concerns to site soils exist at the site. No short-term exposure to groundwater contaminants is expected because no drinking water wells currently exist on or in the vicinity of the site. In the long term, this alternative would accelerate the attainment of groundwater cleanup goals by actively extracting and treating site contaminants. By restoring groundwater quality to meet or exceed NYSDEC Class GA standards, human exposure to site contaminants would be eliminated. Based on the assumptions presented earlier, it is estimated that groundwater cleanup objectives can be attained in approximately one year. The proposed trenches would have limited effectiveness in extracting contamination from the bedrock. Contamination in the bedrock would be allowed to naturally attenuate. Institutional actions would be implemented up to the time site cleanup objectives are attained.

Institutional Concerns

NYSDEC Class GA standards would be attained and the threat to human consumption of contaminated groundwater would be eliminated. This alternative would effectively reduce the release of contamination into Cayuga Creek, and surface water cleanup objectives would be attained. Therefore, exposure concerns for environmental receptors in Cayuga Creek would be eliminated. Other institutional concerns related to this alternative would be compliance with a SPDES permit for discharge to the drainage ditch and the release of off-gas from the air stripper to the ambient atmosphere. Preliminary design calculations have shown that effluent from the treatment system would meet or exceed NYSDEC Class C surface water standards. Off-gas from the air stripper would also meet or exceed NYSDEC air quality standards.

Cost

Capital costs of this alternative, consisting of design and installation of the SVE and groundwater extraction and treatment system, is estimated at $327,000 (see Table 5-15). The annual O & M costs consist of SVE, groundwater and treatment system sampling, and routine maintenance of the SVE and groundwater treatment system. The annual O & M costs are estimated at $83,000 (see Table 5-15). Based on the assumed operation period of five years and a 6% discount rate, the total present worth of this alternative is estimated at $0.7 million.

Summary

Alternative 4 calls for in-situ treatment of soil contamination, groundwater extraction and on-site treatment, and discharge of treated groundwater to Cayuga Creek. SVE would be very effective in extracting the VOC contamination present in the site soils. Soils below the water table not otherwise available for SVE treatment would be treated by lowering the water table. It is anticipated that the extracted vapor would not require treatment before discharge to the atmosphere.

Downgradient of the pit area, one subsurface trench would be installed to extract the groundwater plume. The majority of the groundwater contamination has been observed in wells installed in the overburden. Therefore, the trench would be installed to the top of the bedrock. Since the bedrock and overburden are hydraulically connected, groundwater contamination in the bedrock could be extracted via the upward gradient towards the overburden trench.

Groundwater would be treated on site by filtration and air stripping. Preliminary design of the air stripper has shown that non-detect levels can be attained in the effluent. Treated groundwater would be discharged to the ditch connecting to Cayuga Creek under a SPDES permit. No off-gas treatment from the air-stripper is anticipated.

By actively treating soil and groundwater contamination, soil and groundwater cleanup objectives would be attained in an accelerated manner. By minimizing the release of contaminants to Cayuga Creek, surface water standards would be attained. Because no drinking water wells exist on site, no short-term exposure for humans receptors is expected. Currently, contaminant levels in surface waters of Cayuga Creek are above their respective standards (which are set for fish survival and propagation); therefore, short-term exposure concerns for environmental receptors exist. Long-term exposure concerns for human and environmental receptors would be minimized by this alternative.

5.2.5 Alternative 5: Contaminated Soils Excavation and Off-Site Disposal; Groundwater Extraction by Trenches; On-Site Treatment of Extracted Groundwater; and Disposal of Treated Groundwater to Cayuga Creek

Definition/Description

This alternative consists of excavation and off-site disposal of contaminated soils, groundwater plume extraction by trenches, on-site treatment of extracted groundwater, and discharge of extracted groundwater to Cayuga Creek. Alternative 5 is different from Alternative 4 in the soil corrective action technology. However, groundwater corrective measures are similar to Alternatives 3 and 4. As with Alternatives 3 and 4, minimization of further release of site-related contaminants to Cayuga Creek is provided by installing a trench that would intercept off-site contaminants migrating off site toward Cayuga Creek. Until groundwater cleanup objectives are attained, institutional controls could prevent construction of drinking water wells on and in the vicinity of the site. Groundwater and treatment system sampling would be conducted on a routine basis to monitor the efficacy of the alternative and attainment of cleanup objectives.

Based on the soil sampling conducted at the site during the RFI and previous investigations, approximately 2,400 cubic yards of soil contaminated above the site cleanup goals are present at the site (see Figure 5-7). This alternative calls for excavation of soils above the site cleanup goals. Excavation and off-site disposal of these soils would require the following tasks:

- Clearing and grubbing of the area to be excavated;
- Construction of a staging area for dewatering and loading of soils;
- Decommissioning of four monitoring wells;
- Construction of a decontamination pad for excavation and transportation equipment;
- Off-site disposal of site soils. The type of off-site disposal facility chosen would depend on whether the soils are classified as hazardous

under RCRA and New York's Hazardous Waste Regulations. Under RCRA, a solid waste is considered hazardous if it is listed as a hazardous waste or it exhibits the characteristics of toxicity, ignitability, corrosivity, and reactivity as defined in 40 CFR, Subpart C. Based on TAGM 3028 (the "contained in" policy), soils from Site 10 may be transported off the installation as a non-hazardous industrial solid waste to a permitted Part 360 land disposal facility. However, a variance must be obtained from the regulators prior to disposal. No specific testing was done to determine whether site soils exhibit the characteristics of toxicity, ignitability, corrosivity, and reactivity. However, based on the low concentrations of organics, site soils are not expected to exhibit the characteristics of reactivity, corrosivity, and ignitability as defined in 40 CFR. The determination of toxicity characteristics of contaminated soil-like materials, which is determined by the Toxicity Characteristic Leaching Procedure (TCLP) (EPA Method SW-846) can be theoretically determined by assuming that all contaminants in the soils would leach into the extract. Contaminant concentration in the extract would then be 20 times less than the contaminant concentration in the soils (the factor 20 is the mass conversion factor used in the TCLP test to convert contaminant concentrations in soils [in mg/kg] to contaminant concentration in the extract [in mg/L], assuming 100% extraction efficiency, which seldom occurs). The calculated theoretical TCLP extract contaminant concentrations are listed in Table 5-16, calculated from the maximum observed contaminant concentration in site soils. The theoretical TCLP extract concentrations are compared to the regulatory level for the contaminant (40 CFR, Subpart C). Table 5-16 shows that except for TCE, the TCLP extract would meet the TCLP regulatory criteria. The one soil sample that could theoretically fail the TCLP was collected from BH-6 at a depth of 5 to 8 feet BGS (E & E 1994). The theoretical TCLP extract concentration is 0.7 mg/L as compared to the regulatory criteria of 0.5 mg/L. Although TCLP testing is done by the commercial facility before it accepts wastes for disposal, based on the above theoretical determination it is assumed that all of the contaminated site soils would be classified as nonhazardous solid waste and could be disposed off site at a non-hazardous solid waste facility. In addition, because the soils meet the TCLP criteria, no treatment would be required before land disposal of these site soils at the facility;

- Excavated soils would be hauled to the nearest appropriate commercial disposal facility. The primary transport vehicle would be a 20-cubic-yard, lined dump trailer with a paulin cover. Only 12 cubic yards of soil would be transported per trip because of weight restrictions;

- A representative of the installation would have to be available to sign a bill of lading for transportation of the soils to the off-site facility. The manifest would identify the soil contamination and that the installation is the generator of the solid waste;

- Verification sampling of the excavated areas. Verification sampling would have to be done to ensure that all soils contaminated above the soil cleanup objectives have been removed from the site. Soil verification sampling is typically conducted on a 25-foot-square grid;

- Groundwater dewatering and treatment and/or disposal. (Removed groundwater could probably be disposed of at the NCSD.);

- Ambient air monitoring at the site, including dust monitoring; and

- Backfilling, grading, and seeding of the excavated areas. Clean fill from an off-site source would be used for backfilling.

Groundwater corrective measures of Alternative 5 are similar to those for Alternatives 3 and 4. One subsurface trench (150 feet long and 3 feet wide) would be installed in the vicinity of well MW3-7. The trench would extend to the top of the bedrock. Treatment would consist of on-site filtration and air stripping. The treatment building will most likely be located near building 726. Based on the preliminary design, no off-gas treatment is anticipated. Solids slurry from the sand filter would require off-site disposal at a commercial facility as a hazardous waste. Treated water would be discharged to the ditch connecting to Cayuga Creek.

Technical Concerns

Excavation of contaminated soils and off-site disposal is a widely applied corrective measures technology. Groundwater extraction and on-site treatment are often used to remediate contaminated groundwater. The source of groundwater contamination would be removed from the site through excavation and off-site disposal of contaminated soils. By actively extracting the groundwater plume at the site, contamination levels in the groundwater can be decreased and site cleanup objectives can be attained in an accelerated manner. In addition, by extracting groundwater, a hydraulic boundary would be created that would arrest the off-site transport of contaminants toward Cayuga Creek.

- **Effectiveness.** Excavation and off-site disposal of contaminated soil would meet site cleanup objectives. The groundwater contamination source would be removed from the site. Excavated soils from the site would be effectively disposed of off site in a nearby commercial facility as nonhazardous soils.

  Groundwater extraction by trenches and on-site treatment would be effective in groundwater plume interception and treatment. Groundwater extraction by trenches and on-site treatment effectiveness was detailed in the evaluation of Alternative 3. A preliminary design has shown that Class C surface water standards can be easily met for treated groundwater discharged to the ditch connecting to Cayuga Creek.

- **Reliability.** Excavation and off-site disposal of contaminated soils, and groundwater extraction and on-site treatment by air stripping are very reliable technologies. By removing contaminated soils from the site, this alternative would reliably achieve soil cleanup objectives. Alternative 5 retains the high reliability features of groundwater extraction and treatment, similar to Alternatives 3 and 4.

  The O & M requirements include routine maintenance of the groundwater extraction and treatment system (e.g., air stripper, sand-filter, pumps, pipes, and pipe fittings).

- **Implementability.** Because of relatively low levels of soil contamination and the small size of the contaminated areas, few implementability concerns are present for contaminated soil excavation and off-site disposal. Based on low levels of soil contamination, Level D worker safety is anticipated. Air monitoring for VOCs and dust would be required. The extent of the excavation time may be extended due to verification sampling results. Groundwater dewatering would be required at the site to perform excavation. The collected groundwater would require proper disposal. Preferably, disposal of groundwater from dewatering would be at the POTW, subject to NCSD approval.

  Implementability concerns for groundwater extraction and treatment system are similar to Alternative 3 and were detailed in Section 5.3.3. Preliminary design has shown that NYSDEC Class C surface water discharge standards can be easily met at a flow rate of 5 gpm. In addition, no off-gas vapor treatment is expected to be required (see Appendix F for air stripper preliminary design). The discharge from the treatment system to Cayuga Creek would be frequently monitored for its quality. Solids slurry from the sand filter would require off-site disposal on a routine basis. During the design phase, the solids slurry disposal frequency could be adjusted to suit O & M requirements of the system.

  It is estimated that approximately six months would be required for design, procurement, installation, and start-up of Alternative 5. Procurement of a SPDES permit typically takes two to six months. Attainment of soil cleanup objectives would be indicated by verification sampling at the site.

  As presented in Section 5.2.3, groundwater cleanup objectives are expected to be achieved in approximately five years at a groundwater extraction rate of 0.25 gpm.

- **Safety.** Implementation of this alternative is not expected to create health risks or threats to the safety of nearby communities or cause exposure concerns for environmental receptors. Standard design and construction techniques would be adequate for soil excavation and trench installation at the site. Minimal dust generation and VOC release is expected during excavation and construction of the trench and the treatment system. During excavation and construction of the trench and routine maintenance of the treatment system, protective clothing and equipment would effectively minimize potential short-term exposure of on-site workers to VOCs in the groundwater. Maintenance of the treatment system is expected to be conducted in Level D protection. Solids slurry from the treatment system could be disposed of at the POTW.

Environmental Concerns

Site-related contaminants above their respective standards and guidance have been detected in Cayuga Creek. By extracting groundwater contaminants from the site, the release of contaminants to Cayuga Creek would be minimized. By excavating contaminated soils, the source of groundwater contamination from the site would be removed. Subsurface trenches would act as a hydraulic boundary to the off-site transport of contaminants from the site into Cayuga Creek. Therefore, long-term exposure of environmental receptors in Cayuga Creek to site-related contaminants would be reduced. The proposed trench would have limited effectiveness in intercepting contamination in the deeper bedrock. However, the amount of contaminants that would be extracted from the overburden and the anticipated rate of decrease in the level of contaminants in Cayuga Creek currently cannot be estimated. It would be some time before a decrease in surface water contamination would be observed. Therefore, short-term exposure concerns would not be completely eliminated. However, no federal- or state-listed threatened or endangered species are reported to exist at the installation, and no critical on-site habitats exist for listed species that might potentially occur at the base (SAIC 1991).

Human Health Concerns

Because of the low levels of contamination in site soils, no long- or short-term human exposure concerns exist. No short-term exposure to site contaminants is expected, because no drinking water wells currently exist on or in the vicinity of the site. In the long term, this alternative would accelerate the attainment of groundwater cleanup goals by actively extracting and treating site contaminants. By restoring groundwater quality to meet NYSDEC Class GA standards, human exposure to site contaminants would be eliminated. The rate of reduction of contamination or the time when cleanup goals can be attained, however, cannot be estimated. The proposed trenches would also have limited effectiveness in extracting contamination from the bedrock. Contamination in the bedrock would be allowed to naturally attenuate.

Institutional actions preventing the construction of drinking eater wells would be implemented until site cleanup objectives are attained.

Institutional Concerns

NYSDEC Class GA standards would be attained and the threat posed by potential future human consumption of contaminated groundwater would be eliminated. This alternative would effectively reduce the release of contamination into Cayuga Creek, and NYSDEC Class C surface water standards would be attained. Therefore, exposure concerns for environmental receptors in Cayuga Creek would be eliminated. Other institutional concerns related to this alternative would be compliance with all federal and state transportation regulations, SPDES permit for discharge to the drainage ditch, and release of off-gas from the air stripper to the ambient atmosphere. Preliminary design calculation have shown that effluent from the treatment system would meet or exceed NYSDEC Class C surface water standards. Because of low concentrations of VOCs in the stripper off-gas, NYSDEC air quality regulations are expected to be met. Contaminated soils could be disposed of at a nonhazardous waste facility (municipal landfill).

Cost

Capital costs of Alternative 5, which consists of contaminated soil excavation and off-site disposal, and design and installation of the groundwater extraction and treatment system, are estimated at $450,000 (see Table 5-17). As presented earlier, it is assumed that all of the excavated soils would be disposed off site as nonhazardous soils. The annual O & M costs consist of groundwater and treatment system sampling, and routine maintenance of the groundwater treatment system. The annual O & M costs are estimated at $59,000 (see Table 5-17). Based on the assumed 5-year operation period and a 6% discount rate, the total present worth of this alternative is estimated at $0.7 million.

Summary

Alternative 5 calls for excavation and off-site disposal of contaminated soils, extraction and on-site treatment of groundwater, and discharge of treated groundwater to Cayuga Creek. Based on soil sampling, approximately 2,400 cubic yards of soil would require excavation and off-site disposal. Verification sampling would be conducted to confirm attainment of soil cleanup objectives. Similar to Alternatives 3 and 4, one subsurface trench would be installed to extract the groundwater plume. The trench would be installed to the top of the bedrock. Because the bedrock and overburden are hydraulically connected, groundwater contamination in the bedrock could be extracted by the overburden trench. Groundwater would be treated on site by filtration and air stripping. Preliminary design of the air stripper has shown that non-detect levels can be attained in the effluent. Treated groundwater would be discharged under a SPDES permit to the ditch connecting to Cayuga Creek. No off-gas treatment from the air stripper is anticipated.

Alternative 5 consists of effective and reliable technologies. Excavation and off-site disposal of contaminated soils would attain soil cleanup objectives. The subsurface trench would be effective in intercepting the groundwater plume and the transport of contaminants off site and into Cayuga Creek. By minimizing release of contaminants to Cayuga Creek, surface water standards would be attained. Because no drinking water wells exist on the site, no short-term exposure to humans receptors is expected. Currently, contaminant levels in surface waters of Cayuga Creek are above their respective standards (which are protective of fish survival and propagation); therefore, short-term exposure concerns to environmental receptors exist. Long-terms exposure concerns to human and environmental receptors would be minimized by this alternative.

5.2.6 Alternative 6: Excavation and Off-Site Disposal of Contaminated Soils; Groundwater Extraction by Trenches; and Discharge of Extracted Groundwater at POTW

Alternative 6 is similar to Alternative 5 for soils corrective measures. However, for groundwater corrective measures, this alternative uses subsurface trenches (similar to Alternative 4 and 5) and discharge of extracted groundwater to a POTW. Alternative 6 is different from Alternatives 3, 4, and 5 in its groundwater disposal technology. In addition, Alternative 6 involves no groundwater treatment prior to disposal to the POTW. Until groundwater cleanup objectives are attained, institutional controls that would prevent construction and use of wells on and in the vicinity of the site would be required. Groundwater and treatment system sampling would be conducted on a routine basis to monitor the efficacy of the alternative and attainment of cleanup objectives.

Based on soil sampling conducted at the site during the RFI and previous investigations, approximately 2,400 cubic yards of soils contaminated above the site cleanup goals are present at the site (see Figure 5-7). This alternative involves the excavation of soils above site cleanup goals. Contaminated soils excavation and off-site disposal technology was described in detail for Alternative 5. A site program similar to Alternative 5 (see Section

5.2.5) would have to be implemented to perform excavation and off-site disposal of contaminated soil.

Similar to Alternatives 3, 4, and 5, further release of site-related contaminants to Cayuga Creek would be minimized by installing a trench to intercept contaminant transport off site and into Cayuga Creek. For Alternative 5, the subsurface trench for intercepting the groundwater plume would be similar to that proposed for Alternatives 3, 4, and 5.

Groundwater extracted at the site would be disposed of in the manhole nearest the site. A double-walled, flexible PVC hosing would be used for conveying water from the trench to the manhole. The hosing would be embedded beneath the frost line. Figure 5-11 presents a preliminary layout of Alternative 6. NCSD No. 1 presently services the installation and has been contacted regarding the possibility of discharging groundwater to its treatment plant. Specifically, NCSD has been asked for permission to discharge up to 5 gpm of extracted groundwater containing the maximum levels of contaminants observed at the site. The groundwater would be treated by the POTW. NCSD had agreed to accept the extracted groundwater during the pump test conducted at the site. In addition, permission to discharge to the NCSD No. 1 POTW has been conditionally granted (see Appendix E).

Technical Concerns

Excavation and off-site disposal of contaminated soils is a widely applied corrective measures technology. In addition, groundwater extraction and off-site disposal are often used to remediate contaminated groundwater. Excavation and off-site disposal of contaminated soils would remove the source of groundwater contamination from the site. By actively extracting the groundwater plume at the site, contamination levels in the groundwater can be decreased and site cleanup objectives can be attained in an accelerated manner. In addition, by extracting groundwater, a hydraulic boundary can be created that would arrest the transport of contaminants off site and into Cayuga Creek.

- **Effectiveness.** The effectiveness of achieving soil cleanup goals by excavation and off-site disposal of contaminated soils is similar to Alternative 5. Groundwater extraction and discharge to an off-site facility are often used to remediate contaminated groundwater. By actively extracting the groundwater plume at the site, contamination levels in the groundwater can be decreased and site cleanup objectives can be attained in an accelerated manner. In addition, by extracting groundwater, a hydraulic boundary can be created that would arrest the transport of contaminants off site and into Cayuga Creek.

Discharge of extracted groundwater to a POTW would provide effective treatment and disposal. Discharge to a POTW would accomplish two objectives: treatment of extracted groundwater and discharge to surface water (i.e., to the Niagara River via the POTW's effluent). No specific testing has been conducted on the effectiveness of the NCSD plant's treatment of the groundwater from the site. However, NCSD has been treating chlorinated organics-contaminated groundwater from a nearby facility. Chlorinated organics are most likely treated by a combination of physical (volatilization and adsorption) and biological processes, resulting in their removal from the water. Therefore, the POTW would be considered effective for the treatment of groundwater from the site. The effluent from NCSD's POTW is discharged to the Niagara River, thereby providing effective disposal of the treated groundwater.

- **Reliability.** Excavation and off-site disposal of contaminated soils, and extraction and off-site disposal of groundwater are very reliable technologies. By removing contaminated soils from the site, this alternative would reliably achieve soil cleanup objectives. Groundwater extraction by trenches and discharge to a POTW are very reliable technologies. Groundwater extraction by trenches would reliably intercept the groundwater plume. The groundwater extraction and discharge systems are typically designed to handle a wide variety of flow and organic-loading conditions, and a similar procedure would be followed in the design phase of the treatment system. In addition, the system can be connected to an off-site monitoring station through telemetry systems for continuous monitoring. The discharge capacity to the POTW also can be easily augmented.

  The O & M requirements include only routine maintenance of the groundwater extraction system (trench, pumps, and pipes).

- **Implementability.** It is estimated that approximately six months would be required for design, procurement, installation, and start-up of the groundwater extraction and discharge system. Final approval from NCSD will have to be obtained before groundwater can be discharged to the POTW. Alternative 6 does not retain the implementability concerns associated with the design and operation of a groundwater treatment system, nor would disposal of solids slurry be required by this alternative.

  Because of relatively low levels of soil contamination and small areas of soil contamination, few implementability concerns are present for the excavation and off-site disposal of contaminated soil. Based on low levels of soil contamination, Level D protection for worker safety is anticipated. Air monitoring for VOCs and dust would be required. The duration of the excavation time may be extended due to verification sampling requirements. As discussed in Section 5.2.5, groundwater dewatering would be required.

  Attainment of soil cleanup objectives would be indicated by verification sampling at the site. As presented in Section 5.2.4, it is estimated that groundwater cleanup objectives can be attained in five years at a groundwater extraction rate of 0.25 gpm.

- **Safety.** Because of the relatively small volumes of soils to be excavated and the low levels of contamination, implementation of this alternative is not expected to create health risks or threats to the safety of nearby communities or to cause exposure concerns for environmental receptors. Standard design and construction techniques would be adequate for soil excavation and trench installation at the site. Minimal dust generation and VOC release is expected during excavation and construction of the trench and the treatment system. During excavation and construction of the trench and routine maintenance of the treatment system, protective clothing and equipment for on-site workers would effectively minimize the potential short-term exposure to VOCs in the groundwater. Maintenance of the treatment system would have to be conducted in Level D protection because of the presence of VOCs. Off-site disposal of solids slurry from the sand filter backwash would require proper handling and transport as a hazardous waste.

Environmental Concerns

Site-related contaminants above their respective standards and guidance have been detected in Cayuga Creek. By excavating contaminated soils, the source of groundwater contamination at the site would be removed. Alternative 6 would actively extract groundwater contaminants and reduce the transport of contaminants off site and into Cayuga Creek. A trench would create a continuous hydraulic boundary that would also minimize the off-site transport of contaminants. Therefore, long-term exposure of environmental receptors in Cayuga Creek to site-related contaminants would be reduced. The proposed trench would have limited effectiveness in intercepting contamination in the deeper bedrock. In addition, the quantity of contaminants that would be extracted from the overburden and anticipated rate of decrease in the level of Cayuga Creek contamination cannot be currently estimated. It would be some time before a decrease in surface water contamination could be observed. Therefore, short-term exposure concerns would not be completely eliminated. However, no federal- or state-listed threatened or endangered species are reported to exist at the installation, and there are no critical on-site habitats for listed species that might occur (SAIC 1991).

Human Health Concerns

This alternative retains all of the beneficial human health aspects of Alternatives 3, 4, and 5. In addition, exposure concerns associated with a groundwater treatment system O & M are eliminated. No short-term exposure to site contaminants is expected, because no drinking water wells currently exist on or in the vicinity of the site. In the long term, this alternative would accelerate the attainment of site clean-up goals by actively extracting and treating site contaminants. By restoring groundwater quality to meet NYSDEC Class GA standards, human and environmental exposure to site contaminants would be eliminated. The rate of reduction of contamination or the time when cleanup goals can be attained, however, cannot be estimated. The proposed trenches would have limited effectiveness in extracting contamination from the bedrock. Although, some upward flow from the bedrock to the overburden trench would be achieved by groundwater extraction. Contamination remaining in the bedrock would be allowed to naturally attenuate. Institutional actions would be implemented until site cleanup objectives are attained.

Institutional Concerns

This alternative would effectively reduce the release of contamination into Cayuga Creek, and NYSDEC Class C surface water standards would be attained. Therefore, exposure concerns for environmental receptors in Cayuga Creek would be eliminated. NYSDEC Class GA groundwater standards would be attained in an accelerated manner by a combination of source reduction, groundwater extraction, and natural attenuation. Other institutional concerns related to this alternative would be compliance with all federal and state transportation regulations during off-site disposal of contaminated soils. All of the contaminated soils could be disposed of at a nonhazardous waste facility (municipal landfill).

Cost

Capital costs of this alternative, which consists of contaminated soil excavation and disposal, and design and installation of the groundwater extraction and discharge system to a POTW, are estimated at $383,000 (see Table 5-18). The annual O & M costs consist of routine maintenance of the extraction system and groundwater, surface water, and sediment quality monitoring. The annual O & M costs are estimated at $60,000 (see Table 5-18). Based on the assumed five-year operation period and a 6% discount rate, the total present worth of this alternative is estimated at $0.65 million.

Summary

Alternative 6 provides excavation and off-site disposal of contaminated soil, active management of groundwater contamination at the site using trenches, and disposal of extracted groundwater to a POTW. Based on soil sampling, approximately 2,400 cubic yards of soils would require excavation and off-site disposal. Verification sampling would be conducted to confirm attainment of soil cleanup objectives.

Because of the heterogenous geologic conditions at the site, groundwater extraction by a trench would be effective. The trench would be installed to the top of the bedrock. Because the bedrock and overburden are hydraulically connected, groundwater contamination in the bedrock could be extracted by the overburden trench. Until site groundwater cleanup objectives are attained, institutional controls would be implemented to prevent the installation of drinking water wells on and in the vicinity of the site. Groundwater quality and the effluent to the POTW would be routinely sampled to monitor the efficacy of this alternative. By extracting contaminants from the subsurface, site cleanup objectives can be achieved in an accelerated manner. In addition, the release of contaminants to Cayuga Creek would be minimized, thereby attaining surface water standards.

Because no drinking water wells exist on the site, no short-term exposure to humans receptors is expected. Currently, contaminant levels in surface waters of Cayuga Creek are above their respective standards (which are set for fish survival and propagation); therefore, short-term exposure concerns to environmental receptors exist. Long-term exposure concerns for human and environmental receptors would be minimized by this alternative.

5.2.7 Comparative Analyses of Alternatives

In this section, all the alternatives are compared by addressing technical, environmental, human health, and institutional concerns. Capital and O & M costs are also compared for each alternative.

Contamination levels in the groundwater, surface water, and soil exceed the cleanup objectives for the site. No short-term risks are anticipated from the contaminated groundwater at the site. Currently, contaminant levels in surface waters in the vicinity of Site 10 are above the site cleanup goals; therefore, short-term exposure concerns to environmental receptors exist.

Alternatives 1 and 2 utilize natural attenuation processes occurring at Site 10 to attain site cleanup goals. At Site 10, natural attenuation processes do not have enough capacity to diminish contaminant levels at exposure sites. However, natural attenuation would gradually decrease contaminant levels in the groundwater and soils media. Although contamination levels in soil media are too low to cause exposure concerns to human receptors, Alternative 1 does not provide protection to human health from exposure to contaminated groundwater at Site 10 until site cleanup goals are attained. Alternative 1 also does not address exposure concerns to environmental receptors in Cayuga Creek. Further releases of hazardous contaminants from Site 10 to surface waters would increase the exposure concerns. By implementing institutional actions that would prevent the construction of drinking water wells in the vicinity of site 10, Alternative 2 would protect human health. However, institutional actions would not provide protection to environmental receptors in Cayuga Creek from exposure to site-related contaminants.

Alternatives 3, 4, 5, and 6 all provide corrective action by actively addressing contamination in the groundwater and/or soils media. All of these alternatives would afford source control to some extent; and therefore, surface water cleanup objectives could be attained. By extracting contaminated groundwater, Alternatives 3, 4, 5, and 6 would reduce the long-term risks to human receptors. In addition, by reducing release of contaminants to surface waters, surface water cleanup objectives could be attained. Alternatives 3, 4, 5, and 6 provide effective corrective measures to address groundwater contamination. By extracting groundwater contamination from the subsurface, groundwater and surface water cleanup objectives could be attained. Similar to Alternative 2, institutional actions would be implemented until groundwater cleanup objectives are attained.

One 150-foot-long subsurface trench would be installed in the overburden, downgradient of the former pit. Because the bedrock and overburden are hydraulically connected, some groundwater contamination in the bedrock could also be extracted by the overburden trench. The remaining contamination would be allowed to naturally attenuate. Alternatives 3, 4, and 5 include on-site treatment to extracted groundwater. Preliminary design of the on-site treatment shows that non-detect effluent levels for VOCs can be easily achieved, and therefore, all discharge limits would be easily met. However, Alternative 3 does not address soils contamination. Contaminated soils at Site 10 would continue to act as a long-term source of groundwater contamination. Alternative 6 includes disposal of extracted groundwater at a POTW instead of on-site treatment of extracted groundwater and disposal to Cayuga Creek.

Alternative 4, 5, and 6 also provide corrective measures for soil media. By attaining soil cleanup objectives, soils that would continue to act as a long-term source of groundwater contamination would be eliminated. This would help in the timely attainment of groundwater cleanup objectives. Alternative 4 consists of in situ treatment of contaminated soils by SVE technology. A pilot-scale SVE study would be required for effective design of the full-scale SVE system at Site 10. Extracted vapor may require vapor-phase treatment. Alternatives 5 and 6 both utilize excavation and off-site disposal of contaminated soils at a solid waste facility. Because of the relatively small volume (approximately 2,400 cubic yards) of contaminated soils present at Site 10 and relatively low levels of VOCs contamination, excavation and off-site disposal of site soils could be easily implemented.

Capital costs, annual O & M costs, and total present worth of all Alternatives are presented in Figure 5-12.

5.3 Justification and Recommendation of the Corrective Measure

5.3.1 Selection of Recommended CMA

As stated in Section 1, an ICM has been proposed for Site 10 to address contaminated soils. A description of the innovative technology to be conducted is provided in the addendum to this report. Based on the detailed analysis of the Site 10 "groundwater" CMAs presented in Section 5.2, Alternative 6 has been recommended. Table 5-19 summarizes the evaluation of each CMA for suitability at Site 10, and provides the rationale for selection of the recommended CMA. Recommendation and justification criteria is described in detail in Section 4.3. If the ICM does not attain the corrective action objectives (CAOs) specified for contaminated soils, AFRES will implement the "soils" portion to Alternative 6 (i.e., excavation and off-site disposal).

5.3.2 Justification of CMA

Groundwater

Alternatives 1 and 2 do not address groundwater and surface water above the site cleanup goals. Thus, Alternatives 1 and 2 were rejected. Alternatives 3, 4, 5, and 6 would accelerate the attainment of groundwater cleanup goals by extracting groundwater via a subsurface trench. Extraction of contaminants from the subsurface would also effectively minimize future releases of contaminants into surface waters at Site 10, and surface water cleanup goals could be attained at Site 10.

Alternatives 3, 4, and 5 utilize on-site treatment of extracted groundwater and disposal to the ditch draining to Cayuga Creek. Preliminary design of the air-stripping process has shown that non-detect levels of all organics can be attained in the effluent. On-site treatment would require regular O & M. Thus, all anticipated discharge standards can be easily met.

Alternative 6 adopts discharge of extracted groundwater to a POTW. This would provide effective treatment and disposal of extracted groundwater, and eliminate O & M concerns of the on-site treatment system. Thus, Alternatives 3, 4, and 5 were rejected because the O & M requirements are greater than Alternative 6.

Therefore, Alternative 6 is recommended for use in the remediation of groundwater contamination.

Soils (In lieu of the ICM not attaining the CAOs)

Soils contamination levels are too low to cause exposure concerns to human receptors. However, site soils would act as a long-term source of groundwater contamination at Site 10. Alternatives 1 and 2 do not address soils contamination above the site cleanup goals. Thus, Alternatives 1 and 2 were rejected. Alternative 3 was rejected because it does not provide corrective measures for soil media at Site 10. Alternatives 4, 5 and 6 all provide soil corrective measures. By providing soils media corrective measures, Alternatives 4, 5, and 6 would be able to attain soil cleanup goals and eliminate the soils contamination that would act as a long-term source of groundwater contamination. Alternative 4 uses in situ SVE to attain soil cleanup goals. Alternatives 5 and 6 utilize contaminated soils excavation and off-site disposal at a non-hazardous waste facility.

Because the soil contaminants are VOCs, SVE would be effective in extracting contaminants from the soils. Groundwater dewatering would be required to expose contaminated soils that are present below the groundwater table to SVE treatment. Vapor-phase carbon treatment may be required for extracted soil vapor. For an effective full-scale SVE design, Alternative 4 would require an SVE pilot study.

Minimal dust generation and VOC releases are anticipated during the implementation of contaminated soils excavation and off-site disposal. Excavation and off-site disposal of contaminated soils would be as effective as SVE treatment in Alternative 4. In addition, contaminated soils excavation and off-site disposal would be relatively easy to implement. O & M requirements associated with SVE treatment would also be eliminated by adopting contaminated soils excavation and off-site disposal. Therefore, Alternative 4 was rejected.

Alternatives 5 and 6 both involve contaminated soils excavation and off-site disposal in a sanitary waste landfill.

5.4 Performance Monitoring Program

In order to evaluate the effectiveness of the treatment system for the selected CMA, performance goals and preliminary requirements for hydraulic and chemical monitoring have been developed for Site 10. This program will include the following:

- The performance goal for the selected CMA at Site 10 is to attain a 50% or more removal of contamination within 2.5 years from the actual startup of the corrective action system.

- To demonstrate the capture zone of the corrective action system, hydraulic monitoring will be performed on a weekly basis during the first month of the system's operation and monthly thereafter for the following two years; this will be followed by semi-annual monitoring. Hydraulic monitoring will be performed at selected wells at the site.

- For the first year of operation, chemical monitoring will be performed on a monthly basis at the system effluent and on a semi-annual basis at selected wells at the site. Subject to an evaluation of the system's performance and NYSDEC's approval, the system effluent sampling could eventually be cut back to a quarterly and then semi-annual basis.

For Site 10, the Base may petition the agencies for permission to terminate the groundwater extraction system if (1) the groundwater extraction system is functioning as designed and (2) the groundwater contamination levels are above the NYSDEC Class GA standards, but the levels are not decreasing further. This "zero-slope" condition will be determined as follows:

1. The sum of the concentration of hazardous waste constituents resulting from eight consecutive quarterly sampling events will be plotted versus time.

2. If the curve that best fits these data points is linear, a straight line will be fitted to the data through the use of a least squares regression model; the slope of the fitted curve will be computed and designated as the estimated slope.

3. If the data points fit a non-linear form, an exponential curve will be fitted to the data through the use of a least squares regression model. The estimated slope will be the first derivative of the curve at a value of time halfway between the last two sampling points.

4. The estimated slope shall be considered zero if that slope is less than or equal to zero (i.e., the concentration is stable) or the yearly decrease of the total concentration of hazardous waste constituents is less than the average overall precision of the analytical methods used.

In addition, the spatial and temporal distributions of the concentrations of compounds will be assessed to provide additional information regarding trends. If these concentrations are sufficiently low, the Base may petition the agencies for permission to terminate the groundwater extraction system and propose a post-termination monitoring program.

However, the groundwater extraction system would remain in place during the post-termination monitoring period. The purpose of the post-termination monitoring program will be to demonstrate to the agencies that the groundwater contamination levels remain sufficiently low and are in a "zero-slope" condition.

Table 5-1

SUMMARY OF RFI SOIL SAMPLING ANALYTICAL RESULTS
IRP SITE 10
NIAGARA FALLS IAP-ARS

Analyte	Detection Frequency	Concentration Detected	Guidance Value[a]	Exceedance Frequency
Metals (mg/kg)				
Arsenic	1/1	2.5	16	0/1
Cadmium	1/1	0.88	7[b]	0/1
Chromium, Total	1/1	9.3	112	0/1
Copper	1/1	14	48.7	0/1
Lead	1/1	9.6	33	0/1
Nickel	1/1	13	38.2	0/1
Zinc	1/1	150	104	1/1
Semivolatiles (μg/kg)				
bis(2-Ethylhexyl)phthalate	1/1	88	50,000	0/1

a Metals guidance values based on upper limit of 90th percentile as calculated from the data of Shacklette and Boerngen 1984, except as noted. Organics guidance values based on Technical Administrative Guidance Memorandum (TAGM) 4046.
b Dragun 1988.

Table 5-2

SUMMARY OF RFI GROUNDWATER SAMPLING ANALYTICAL RESULTS
IRP SITE 10
NIAGARA FALLS IAP-ARS

Analyte	Detection Frequency	Range of Detected Concentrations		Standard[a]	Exceedance Frequency
		Minimum	Maximum		
Metals (μg/L)					
Arsenic	1/14	5.1	5.3	25	0/14
Lead	8/14	5.4	340	25	4/14
Zinc	14/14	11	620	300	4/14
VOCs (μg/L)					
1,1-Dichloroethane	2/14	11	63	5.0	2/14
1,1,2-Trichloroethene	1/14	4	4	5.0	0/14
1,2-Dichloropropane	1/14	2	2	5.0	0/14
Benzene	2/14	6	130	0.7	2/14
Chloroform	1/14	3	3	7.0	0/14
cis-1,2-Dichloroethene	8/14	13	9,600	5.0	8/14
Toluene	1/14	3	3	5.0	0/14
trans-1,2-Dichloroethene	4/14	1	280	5.0	2/14
Trichloroethene	6/14	1	18,000	5.0	5/14
Vinyl chloride	5/14	2	590	2.0	5/14
Semivolatiles (μg/L)					
bis(2-Ethylhexyl)phthalate	1/14	1	1	50	0/14

[a] NYSDEC 1993, Class GA Groundwater Standards.

Key:

VOCs = Volatile organic compounds.

Table 5-3

SUMMARY OF RFI SURFACE WATER SAMPLING ANALYTICAL RESULTS IRP SITE 10 NIAGARA FALLS IAP-ARS

Analyte	Detection Frequency	Range of Detected Concentrations		Standard	Exceedance Frequency
		Minimum	Maximum		
Metals (μg/L)					
Zinc	4/4	250	600	30[a]	4/4
VOCs (μg/L)					
Carbon tetrachloride	1/4	1	1	0.4[b]	1/4
Chloroform	1/4	2	2	7[b]	0/4
cis-1,2-Dichloroethene	1/4	57	57	5[b]	1/4
Trichloroethene	1/4	40	40	11[a]	1/4
Semivolatiles (μg/L)					
bis(2-Ethylhexyl)phthalate	1/4	1	1	0.6[a]	1/4
Butylbenzylphthalate	1/4	1	1	50[b]	0/4

Note: Class A Surface Water Standards are used when Class C Surface Water Standards are not available.

a NYSDEC 1993 Class C Surface Water Standards.
b NYSDEC 1993 Class A Surface Water Standards.

Key:

VOCs = Volatile organic compounds.

Table 5-4

SUMMARY OF RFI SEDIMENT SAMPLING ANALYTICAL RESULTS IRP SITE 10 NIAGARA FALLS IAF-ARS

Analyte	Detection Frequency	Range of Detected Concentrations		Guidance Value	Exceedance Frequency
		Minimum	Maximum		
Metals (mg/kg)					
Arsenic	4/4	4.4	13	6.0[a]	3/4
Cadmium	1/4	1.0	1.0	0.6[a]	1/4
Chromium, total	4/4	16	21	26[a]	0/4
Copper	4/4	18	32	16[a]	4/4
Lead	4/4	39	95	31[a]	4/4
Mercury	3/4	0.21	0.27	0.2[a]	3/4
Nickel	4/4	17	23	16[a]	4/4
Selenium	1/4	1.0	1.0	NV	0/4
Zinc	4/4	570	1,800	120[a]	4/4
VOCs (μg/kg)					
Acetone	3/4	13	58	200[b]	0/4
cis-1,2-Dichloroethene	2/4	5	21	NV	0/4
Trichloroethene	2/4	7	20	700[b]	0/4
Semivolatiles (μg/kg)					
Acenaphthene	2/4	59	180	150[a]	1/4
Anthracene	3/4	71	260	85[a]	2/4
Benzo(a)anthracene	4/4	240	960	230[a]	4/4
Benzo(a)pyrene	4/4	240	910	400[a]	1/4
Benzo(a)fluoranthene	4/4	340	1,400	1,100[b]	1/4
Benzo(g,h,i)perylene	4/4	140	670	50,000[b]	0/4
Benzo(h)fluoranthene	4/4	130	520	1,100[b]	0/4
bis(2-Ethylhexyl)phthalate	4/4	91	620	50,000[b]	0/4
Butylbenzylphthalate	2/4	90	92	50,000[b]	0/4
Carbazole	1/4	190	190	NV	0/4

Key at end of table.

Table 5-4

SUMMARY OF RFI SEDIMENT SAMPLING ANALYTICAL RESULTS IRP SITE 10 NIAGARA FALLS IAF-ARS

Analyte	Detection Frequency	Range of Detected Concentrations		Guidance Value	Exceedance Frequency
		Minimum	Maximum		
Chrysene	4/4	260	1,000	400[a]	2/4
Dibenz(a,h)anthracene	3/4	100	340	60[a]	3/4
Dibenzofuran	1/4	79	79	6,200[b]	0/4
Fluoranthene	4/4	500	1,900	600[a]	3/4
Fluorene	2/4	61	160	35[a]	2/4
Indeno(1,2,3-cd)pyrene	4/4	180	790	3,200[b]	0/4
Phenanthrene	4/4	290	1,400	225[a]	4/4
Pyrene	4/4	550	2,500	350[a]	4/4

Note: TAGM 4046 values were used when sediment levels were not available.

a Lowest of either Persaud *et al.* 1992 lowest effect level, or Long and Morgan 1990 Effect Range-Low.
b 1994 TAGM NYSDEC.

Key:

NV = No applicable value.
TAGM = Technical Administrative Guidance Memorandum.
VOCs = Volatile organic compounds.

Table 5-5

SOIL CLEANUP OBJECTIVES
IRP SITE 10
NIAGARA FALLS IAP-ARS

Contaminant	TAGM 4046 Recommended Soil Cleanup Objective	EPA Region III RBC[a]	Candidate Cleanup Objective	Maximum Concentration Detected	Site Cleanup Objective
Metals (mg/kg)					
Arsenic	16	310	16	2.5	NA
Beryllium	1.81	0.67	1.81	0.556	NA
Cadmium	7[b]	510	7	1.55	NA
Chromium, total[c]	112	5,100	112	650	112
Copper	48.7	38,000	48.7	37	NA
Lead[c]	33	—	33	56.6	33
Nickel[c]	38.2	20,000	38.2	48	38.2
Zinc[c]	104	310,000	104	640	104
VOCs (μg/kg)					
Acetone	200	200,000,000	200	100	NA
Carbon disulfide	2,700	200,000,000	2,700	17	NA
Chlorobenzene	1,700	41,000,000	1,700	3.0	NA
Ethylbenzene	5,500	200,000,000	5,500	1,100	NA
Methylene chloride	100	760,000	100	34	NA
Toluene	1,500	410,000,000	1,500	16	NA
Total-1,2-Dichloroethene	—	18,000,000	18,000,000	2,100	NA
Trichloroethene	700	520,000	700	14,000	700
Vinyl chloride	200	3,000	200	38	NA
Xylenes, total	1,200	1×10^9	1,200	3,600	1,200
Semivolatiles (μg/kg)					
bis(2-Ethylhexyl)phthalate	50,000	410,000	50,000	220	NA
Di-n-butylphthalate	8,100	200,000,000	8,100	160	NA
Fluorene	50,000	82,000,000	50,000	210	NA
2-Methylnaphthalene	36,400	—	36,400	900	NA
Naphthalene	13,000	82,000,000	13,000	1,000	NA

Key at end of table.

Table 5-5

SOIL CLEANUP OBJECTIVES
IRP SITE 10
NIAGARA FALLS IAP-ARS

Contaminant	TAGM 4046 Recommended Soil Cleanup Objective	EPA Region III RBC[a]	Candidate Cleanup Objective	Maximum Concentration Detected	Site Cleanup Objective
Phenanthrene	50,000	—	50,000	300	NA
Pyrene	50,000	61,000,000	50,000	39	NA

Note: Cleanup objectives for metals are based on the upper limit of the 90th percentile as calculated from the data of Shacklette and Boerngen 1984, except as noted.

[a] EPA Region III RBC dated March 7, 1995.
[b] Upper limit of observed range for cadmium as stated in Dragun 1988.
[c] Does not warrant corrective measure because of the low frequency of detection and/or its presence is believed to be naturally occurring or not attributable to site-related activities.

Key:

— = No value.
NA = Not applicable; maximum concentration detected does not exceed candidate cleanup objective.
RBC = Risk-based criteria.
VOCs = Volatile organic compounds.

Table 5-6

GROUNDWATER CLEANUP OBJECTIVES
IRP SITE 10
NIAGARA FALLS IAP-ARS

Contaminant	NYSDEC Class GA Groundwater Standard	EPA Region III RBC	Candidate Cleanup Objective	Maximum Concentration Detected	Site Cleanup Objective
Metals (μg/L)					
Arsenic	25	11	25	5.3	NA
Chromium, total[a]	50	180	50	51	50
Copper	200	1,400	200	107	NA
Lead[a]	25	—	25	340	25
Nickel	—	730	730	79	NA
Zinc[a]	300	11,000	300	3,750	300
VOCs (μg/L)					
Benzene	0.7	0.36	0.7	360	0.7
Carbon disulfide	—	21	21	3.3	NA
Carbon tetrachloride	5.0	0.16	5.0	9.96	5.0
Chloroform	7.0	0.15	7.0	42.6	7.0
cis-1,2-Dichloroethene	5.0	61	5.0	13,100	5.0
1,2-Dichloroethane	5.0	0.12	5.0	4.4	NA
1,1-Dichloroethene	5.0	0.044	5.0	63	5.0
1,2-Dichloropropane	5.0	0.16	5.0	3.17	NA
Ethylbenzene	5.0	1,300	5.0	3.7	NA
Hexachlorobenzene	0.35	0.0066	0.35	55	0.35
Methylene chloride	5.0	4.1	5.0	4,160	5.0
Tetrachloroethene	5.0	1.1	5.0	1.78	NA
Toluene	5.0	750	5.0	4.7	NA
Total-1,2-Dichloroethene	—	55	55	9,800	55
trans-1,2-Dichloroethene	5.0	120	5.0	280	5.0
1,1,1-Trichloroethane	5.0	1,300	5.0	1.97	NA
1,1,2-Trichloroethane	5.0	0.19	5.0	4.0	NA
Trichloroethene	5.0	1.6	5.0	28,000	5.0

Key at end of table.

Table 5-6

GROUNDWATER CLEANUP OBJECTIVES
IRP SITE 10
NIAGARA FALLS IAP-ARS

Contaminant	NYSDEC Class GA Groundwater Standard	EPA Region III RBC	Candidate Cleanup Objective	Maximum Concentration Detected	Site Cleanup Objective
Vinyl chloride	2.0	0.019	2.0	1,160	2.0
Xylenes, total	5.0	12,000	5.0	2.2	NA
Semivolatiles (μg/L)					
bis(2-Ethylhexyl)phthalate[a]	50	4.8	50	4.7	NA

a Does not warrant corrective measure because of the low frequency of detection and/or its presence is believed to be naturally occurring or not attributable to site-related activities.

Key:

— = No value.
NA = Not applicable; maximum concentration detected does not exceed candidate cleanup objective.
RBC = Risk-based criteria.
VOCs = Volatile organic compounds.

Table 5-7

SURFACE WATER CLEANUP OBJECTIVES
IRP SITE 10
NIAGARA FALLS IAP-ARS

Contaminant	NYSDEC Class C Surface Water Standard	NYSDEC Class A Surface Water Standard	Candidate Cleanup Objective	Maximum Concentration Detected	Site Cleanup Objective
Metals (µg/L)					
Zinc[b]	30	30	30	600	30
VOCs (µg/L)					
Carbon tetrachloride	—	0.4[a]	0.4	1.0	0.4
Chloroform	—	7.0	7.0	2.0	NA
cis-1,2-Dichloroethene	—	5.0[a]	5.0	57	5.0
Trichloroethene	11[a]	11[a]	11	40	11
Semivolatiles (µg/L)					
bis(2-Ethylhexyl)phthalate[b]	0.6	0.6	0.6	1.0	0.6
Butylbenzylphthalate	—	50[a]	50	1.0	NA

a Value listed is guidance value as presented in 6 NYCRR Parts 700-705 (1991).
b Does not warrant corrective measure because of the low frequency of detection and/or its presence is believed to be naturally occurring or not attributable to site-related activities.

Key:

— = No value.
NA = Not applicable; maximum concentration detected does not exceed candidate cleanup objective.
VOCs = Volatile organic compounds.

Table 5-8

SEDIMENT CLEANUP OBJECTIVES
IRP SITE 10
NIAGARA FALLS IAP-ARS

Contaminant	Equilibrium Partitioning-Derived Sediment Criteria[a]	Lowest Effect Level[b]	TAGM 4046 Soil Cleanup Objective[c]	EPA Region III RBC[d]	Candidate Cleanup Objective	Maximum Concentration Detected	Site Cleanup Objective
Metals (mg/kg)							
Arsenic[f]	—	6.0	16	23	6.0	13	6.0
Cadmium[f]	—	0.6	7[e]	39	0.6	1.0	0.6
Chromium, total	—	26	112	78,000	26	21	NA
Copper[f]	—	16	48.7	2,900	16	32	16
Lead[f]	—	31	33	—	31	95	31
Mercury[f]	—	0.15	0.265	23	0.15	0.27	0.15
Nickel[f]	—	16	38.2	1,600	16	23	16
Selenium[f]	—	—	0.941	390	0.941	1.0	0.941
Zinc[f]	—	120	104	23,000	120	1,800	120
VOCs (μg/kg)							
Acetone	—	—	200	7,800	200	58	NA
cis-1,2-Dichloroethene	—	—	—	780	780	21	NA
Trichloroethene	74	—	700	58	74	20	NA
Semivolatiles (μg/kg)							
Acenaphthene	5,180	150	50,000	4,700	5,180	180	NA

Key at end of table.

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Table 5-8

SEDIMENT CLEANUP OBJECTIVES
IRP SITE 10
NIAGARA FALLS IAP-ARS

Contaminant	Equilibrium Partitioning-Derived Sediment Criteria[a]	Lowest Effect Level[b]	TAGM 4046 Soil Cleanup Objective[c]	EPA Region III RBC[d]	Candidate Cleanup Objective	Maximum Concentration Detected	Site Cleanup Objective
Anthracene[f]	—	85	50,000	23,000	85	260	85
Benzo(a)anthracene[f]	48.1	230	224	0.88	48.1	960	48.1
Benzo(a)pyrene[f]	48.1	400	61	0.088	48.1	910	48.1
Benzo(b)fluoranthene[f]	48.1	—	1,100	0.88	48.1	1,400	48.1
Benzo(g,h,i)perylene	—	—	50,000	—	50,000	670	NA
Benzo(k)fluoranthene[f]	48.1	—	1,100	8.8	48.1	520	48.1
bis(2-Ethylhexyl)phthalate	7,382	—	50,000	46	7,382	620	NA
Butylbenzylphthalate	—	—	50,000	16,000	50,000	92	NA
Carbazole[f]	—	—	—	32	32	190	32
Chrysene[f]	48.1	400	400	88	48.1	1,000	48.1
Dibenzo(a,h)anthracene[f]	—	60	14	0.088	60	340	60
Dibenzofuran	—	—	6,200	310	6,200	79	NA
Fluoranthene	37,740	600	50,000	3,100	37,740	1,900	NA
Fluorene[f]	—	35	50,000	3,100	35	160	35
Indeno(1,2,3-cd)pyrene[f]	48.1	—	3,200	0.88	48.1	790	48.1
Phenanthrene	4,440	225	50,000	—	4,440	1,400	NA

Key at end of table.

Table 5-8

SEDIMENT CLEANUP OBJECTIVES
IRP SITE 10
NIAGARA FALLS IAP-ARS

Contaminant	Equilibrium Partitioning-Derived Sediment Criteria[a]	Lowest Effect Level[b]	TAGM 4046 Soil Cleanup Objective[c]	EPA Region III RBC[d]	Candidate Cleanup Objective	Maximum Concentration Detected	Site Cleanup Objective
Pyrene[f]	—	350	50,000	2,300	350	2,500	350

a Lowest of either Persaud *et al.* (1992) Lowest Effect Level or Long and Morgan (1990) Effect Range-Low.
b As calculated from NYSDEC's Technical Guidance for Screening Contaminated Sediments (1993).
c Metals guidance values based on upper limit of the 90th percentile as calculated from the data of Shacklette and Boerngen (1984), except as noted. Organics guidance values based on NYSDEC TAGM (1994).
d From risk-based concentration table as presented by USEPA Region III, Fourth Quarter 1994; values presented are for residential soils.
e Dragun 1988.
f Does not warrant corrective measure because of the low frequency of detection and/or its presence is believed to be naturally occurring or not attributable to site-related activities.

Key:

— = No value.
NA = Not applicable; maximum concentration detected does not exceed candidate cleanup objective.

Table 5-9

PHYSICAL AND CHEMICAL PROPERTIES OF ORGANIC CONTAMINANTS OF CONCERN
IRP SITE 10
NIAGARA FALLS IAP-ARS

Contaminant	Molecular Formula	Molecular Weight	Vapor Pressure (mm Hg)	Water Solubility (mg/L)	Henry's Law Constant (atm-m^3/mol)	Log K_{ow}
Benzene	C_6H_6	78.11	76	1,780	5.43×10^{-3}[a]	2.13
Carbon tetrachloride	CCl_4	153.84	91.3	800	0.02	2.83
Chloroform	$CHCl_3$	119.39	160	8,220	3.75×10^{-3}[a]	1.97
cis-1,2-Dichloroethene	$C_2H_2Cl_2$	96.95	200[a]	3,500	7.5×10^{-3}[a]	1.86
1,1-Dichloroethene	$C_2H_2Cl_2$	96.95	591	2,730	2.10×10^{-2}	2.13
Hexachlorobenzene	C_6Cl_6	284.80	1.9×10^{-5}	0.0062	1.30×10^{-3}	5.31
Methylene chloride	CH_2Cl_2	84.94	350	13,200	2.57×10^{-3}[a]	1.25
trans-1,2-Dichloroethene	$C_2H_2Cl_2$	96.95	265	6,300	6.6×10^{-3}[a]	2.09
Trichloroethene	C_2HCl_3	131.40	58.7	1,000	8.92×10^{-3}[a]	2.42
Vinyl chloride	C_2H_3Cl	62.50	2,300	1,100	0.695	0.60

Notes: Values listed are from EPA 9902.3-1a, Corrective Action Glossary, July 1992. Values are presented at 20°C unless otherwise noted.

a Value is at 25°C.
b Value is at unknown temperature but is assumed to be at 20-25°C.

Table 5-10

PRELIMINARY SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES
IRP SITE 10 SOIL
NIAGARA FALLS IAP-ARS

Corrective Measure Technology (CMT)	Preliminary Screening Criteria			
	Site Characteristics	Waste Characteristics	Technology Limitations	Retain Status? (Y/N)
Capping, surface sealing	Construction of cap would be easily implemented because of relatively small contaminant area.	Volatile organics will escape at edges of cap. DNAPLs will not be contained or reduced.	Well-established technology. Requires continual maintenance.	No
Consolidation	Contaminants are localized. Movement and mixture of soil may produce uncontrolled volatilization of contaminants. Shallow perched aquifer may require dewatering during operations.	Volatile organics may be released during operations.	Well-established technology.	No
Excavation	Localized contaminant source would allow the use of standard construction techniques and equipment.	Volatile organics may be released during operations.	Well-established technology.	Yes
On-site disposal	Future use of site is not consistent with implementation of this technology.	VOCs may not be totally contained. Off-gases may require additional technology/ treatment.	Requires long-term monitoring and O & M. Well-established technology.	No
Off-site disposal	Site is in close proximity to RCRA landfill facility. Contaminants are localized.	Movement of soil may produce uncontrolled volatilization of contaminants.	Well-established technology. Will require special handling and manifesting for transport.	Yes
Thermal destruction	Contaminants are localized.	VOCs are destroyed by this process.	Requires high energy consumption. Well-established technology.	Yes
Thermal desorption	Contaminants are localized.	VOCs are easily transferred from soil to gas.	Relatively new. Will require additional treatment. Requires substantial energy consumption.	No

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Table 5-10

**PRELIMINARY SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES
IRP SITE 10 SOIL
NIAGARA FALLS IAP-ARS**

Corrective Measure Technology (CMT)	Preliminary Screening Criteria			
	Site Characteristics	Waste Characteristics	Technology Limitations	Retain Status? (Y/N)
Ultraviolet/ photolysis (UV)	Low soil permeability may inhibit extraction of contaminants.	VOCs are easily transferred to solution if provided good contact.	Complex technology.	No
Biological treatment	Low soil permeability may inhibit contact of culture with contaminants without extensive working of soil.	Contaminants are not well suited for biological treatment.	Requires pilot testing. Well-developed technology.	No
In-situ soil flushing	Low soil permeability will reduce contact of solution to soil area and greatly increase treatment time. Best suited for highly permeable, granular soil.	Easily transferred to solution with good contact.	Well-developed technology.	No
Solidification/ stabilization (S/S)	Localized contamination.	Limited long-term effectiveness with VOCs.	Requires pilot testing, but has been proven effective at other sites.	No
Soil washing	Clay soil will require much manipulation to achieve adequate contact between washing solution and soil surface area.	Soil contains too high a fraction of fine-grained soil.	Requires additional technology to treat contaminated soil fraction.	No
Solvent extraction	Clay soil will require much manipulation to achieve adequate contact between solvent and soil surface area.	Easily "washed" (soluble).	Requires additional technology to treat contaminated solution.	No
Bioremediation	Low soil permeability may inhibit contact between micro-organisms and contaminants and decrease efficiency of nutrient injection.	Contaminants are not well suited for biological treatment.	Requires pilot testing. Demonstrated technology.	No
Soil vapor extraction (SVE)	Low soil permeability may inhibit stripping process by inhibiting air flow through the contaminated domain.	Volatile organics are amenable to stripping.	Best suited for porous soils. Established technology.	Yes

Table 5-10

**PRELIMINARY SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES
IRP SITE 10 SOIL
NIAGARA FALLS IAP-ARS**

Corrective Measure Technology (CMT)	Preliminary Screening Criteria			Retain Status? (Y/N)
	Site Characteristics	Waste Characteristics	Technology Limitations	
Vitrification (ISV)	Localized, shallow contamination. Requires high-energy source not existing at the site.	Organics can easily be vitrified. Volatilization may occur during vitrification process, requiring additional technology for gas.	Not fully demonstrated.	No
Radio-frequency heating	Localized, shallow contamination.	VOCs require treatment when transferred to gas.	Not fully demonstrated.	No
Steam-enhanced vacuum extraction	Localized, shallow contamination. Low soil permeability will inhibit stripping process. Best suited for more permeable soil types.	VOCs require treatment when transferred to gas.	Established.	No

Table 5-11

PRELIMINARY SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES
IRP SITE 10 GROUNDWATER
NIAGARA FALLS IAP-ARS

Corrective Measure Technology (CMT)	Preliminary Screening Criteria			Retain Status? (Y/N)
	Site Characteristics	Waste Characteristics	Technology Limitations	
Extraction wells	Based on the slug tests done at the site, moderate to low hydraulic conductivities were encountered at Site 10. The pump test conducted at the site recovered negligible amount of water.	Site contaminants are soluble and can be extracted with groundwater.	Groundwater extraction by extraction wells is a well-established technology.	No
Subsurface drains	Complex hydrogeology and presence of preferential pathways of contaminant transport through fractures favors the use of subsurface drains.	Most site contaminants are soluble and could be extracted by collecting groundwater in the drains.	Groundwater extraction by subsurface drains is a well-established technology.	Yes
Horizontal wells	Horizontal wells are usually installed where plumes are large in areal extent and linear in confirmation.	Site contaminants are soluble and can be extracted with groundwater.	Relatively new technology.	No
Subsurface containment (slurry walls, liner panel walls, jet grouting, sheet piling)	For this technology, it is important that vertical containment systems are keyed into a low permeability geologic formation, a condition not present at the site.	Because contamination extends into deeper bedrock, subsurface containment would be ineffective.	Technology cannot be implemented into bedrock aquifers.	No
Biological treatment	Based on the pump test conducted at the site, a maximum flow rate of 0.4 gpm could be achieved on an intermittent basis.	Chlorinated organics have not been well-demonstrated to be treated by this technology.	Biological treatment is a well-established technology. There are more extensive O&M requirements associated with biological treatments than with other technologies under consideration.	No

Table 5-11

PRELIMINARY SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES
IRP SITE 10 GROUNDWATER
NIAGARA FALLS IAP-ARS

Corrective Measure Technology (CMT)	Preliminary Screening Criteria			Retain Status? (Y/N)
	Site Characteristics	Waste Characteristics	Technology Limitations	
Carbon adsorption	Carbon adsorption systems can be operated under a variety of site conditions.	Most site contaminants can be effectively removed by carbon adsorption, with the exception of vinyl chloride. Vinyl chloride and other VOCs can be effectively treated by air stripping technology.	Carbon adsorption is a well-established technology. This technology may require pretreatment such as suspended solids removal.	No
Air stripping	Based on the pump test conducted at the site, a maximum flow rate of 0.4 gpm could be achieved on an intermittent basis.	The majority of site contaminants can be stripped. A polishing stage (i.e., carbon adsorption) may be required to meet discharge criteria.	Air stripping is a well-demonstrated technology.	Yes
UV/Ozonation	Based on the pump test conducted at the site, a maximum flow rate of 0.4 gpm could be achieved on an intermittent basis.	Contaminants with double and triple bonds are not treated effectively.	UV/ozonation is a well-demonstrated technology.	No
Wet air oxidation	Based on the pump test conducted at the site, a maximum flow rate of 0.4 gpm could be achieved on an intermittent basis.	The relatively low concentrations of contaminants and the aqueous matrix promote other simpler, more reliable technologies (i.e., carbon adsorption, air stripping).	This technology requires skilled operator attention and has high O & M requirements.	No
Ion exchange	Ion exchange can be used in unsteady flow and influent concentration conditions.	Ion exchange will not treat organic species at the site.	Relatively simple to operate and maintain. Concentrated waters produced during regeneration will require additional treatment and disposal.	No
Membrane separation	Intermittent operating conditions may render the system difficult to perform efficiently.	Site contaminants can be treated by membrane separation.	Technology is more appropriate for high concentration waste streams.	No

Table 5-11

PRELIMINARY SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES
IRP SITE 10 GROUNDWATER
NIAGARA FALLS IAP-ARS

Corrective Measure Technology (CMT)	Preliminary Screening Criteria			Retain Status? (Y/N)
	Site Characteristics	Waste Characteristics	Technology Limitations	
Filtration	Filtration performs effectively under variable flow conditions expected at site.	Multi-media filtration or bag filtration may be required to effectively separate a wide range of clay, soil, and metals precipitate particle sizes.	Filtration is a well-established technology.	Yes
Sedimentation	Sedimentation does not perform effectively under variable flow conditions.	Fine particle size solids or metals precipitates may also require coagulation/ flocculation.	Sedimentation is a well-established technology.	No
Precipitation/ coagulation/ flocculation	This technology does not perform effectively under variable site conditions.	This technology is not applicable for organics. Expected metals concentrations are much lower than what is typically treated by this method.	Well-established technology.	No
In situ bioremediation	Highly heterogeneous subsurface conditions would make the implementation of this technology difficult.	Chlorinated species present in site groundwater can be biodegraded (natural biodegradation may be occurring currently at the site).	May require addition of cosubstrates that may be restricted by regulations. Cosubstrate addition may be difficult/ineffective due to the heterogenous subsurface conditions.	No
Air sparging	Tightness of site soil and the presence of contaminants in bedrock inhibits this technology.	This technology is applicable for the treatment of VOCs. However, volatilized contaminants in the air extraction well may require treatment prior to venting.	Air sparging is a well-established technology.	No
Passive treatment walls	Relative impermeability of site soil would infeasibly extend the treatment time.	Not all groundwater contaminants amenable to this type of treatment.	Concentrated contaminant levels may be retained in the wall and require additional treatment.	No

Table 5-11

**PRELIMINARY SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES
IRP SITE 10 GROUNDWATER
NIAGARA FALLS IAP-ARS**

Corrective Measure Technology (CMT)	Preliminary Screening Criteria			Retain Status? (Y/N)
	Site Characteristics	Waste Characteristics	Technology Limitations	
Disposal at a TSDF	Based on contaminant species, expected concentrations, and low flow rates, other available disposal options (i.e., discharge to a POTW) would be easier to implement.	Extracted groundwater may be classified as hazardous waste and require manifesting.	Technology is well-developed. A RCRA-permitted TSDF is located very close to the site.	No
Discharge to surface water	A surface water body (Cayuga Creek) is located a short distance from the site.	Organics present in the groundwater require treatment prior to disposal, and may include other limitations (pH, solids concentrations).	Technology is well-developed.	Yes
Reinjection to groundwater	Complex, heterogeneous subsurface site conditions would make this option difficult to implement. Several simpler alternatives exist.	Same as above; it is expected that discharge limits for reinjection are more stringent than discharge limits to a POTW or surface water.	Technology is well-developed.	No
Discharge to POTW	A manhole and drainline would need to be installed at the site for use in the discharge of extracted groundwater.	Similar organic species present in site groundwater have previously been accepted by the Niagara County Sewer District (NCSD)	Technology is well-developed and implemented; prior approval is required from NCSD.	Yes

TABLE 5-12
IRP Site 10
Costs for Alternative 1
No Action and Natural Attenuation

Interest rate	6.0%
Operation and Maintenance (years)	30
Legal, Adminstrative, & Eng. Fees	25.0%
Contigencies	20.0%

Item No.	Description	Quantity	Units	Unit Cost	Cost
CAPITAL COSTS					
	TOTAL CAPITAL COSTS				$0
OPERATION & MAINTENANCE COSTS					
1	Sample collection - groundwater(15 wells)	30	EA	$250	$7,500
2	Sample collection - surf. water/sed.	16	EA	$250	$4,000
3	VOC analysis	52	EA	$275	$14,300
4	Well maintanence	1	LS	$1,500	$1,500
5	Data validation	52	EA	$35	$1,820
6	Report writing	2	EA	$3,000	$6,000
				Subtotal	$35,120
7	Legal, adminstrative, eng. fees	25%			$8,780
				Subtotal	$43,900
8	Contingencies	20%			$8,780
	TOTAL O & M COSTS				**$52,680**
	TOTAL O & M PRESENT WORTH	30 years			**$725,131**
	TOTAL CAPITAL COSTS				**$0**
	GRAND TOTAL COST				**$725,131**

TABLE 5-13
IRP Site 10
Costs for Alternative 2
Institutional Actions and Natural Attenuation

Interest rate	6.0%
Operation and Maintenance (years)	30
Legal Adminstrative, & Eng. Fees	25.0%
Contigencies	20.0%

Item No.	Description	Quantity	Units	Unit Cost	Cost
CAPITAL COSTS					
1	Deed restrictions	1	LS	$6,000	$6,000
				Subtotal	$6,000
2	Legal, adminstrative, eng. fees	25%			$1,500
				Subtotal	$7,500
3	Contingencies	20%			$1,500
	TOTAL CAPITAL COSTS				**$9,000**
OPERATION & MAINTENANCE COSTS					
1	Sample collection - groundwater(15 wells)	30	EA	$250	$7,500
2	Sample collection - surf. water/sed.	16	EA	$250	$4,000
3	VOC analysis	52	EA	$275	$14,300
4	Well maintanence	1	LS	$1,500	$1,500
5	Data validation	52	EA	$35	$1,820
6	Report writing	2	EA	$3,000	$6,000
				Subtotal	$35,120
7	Legal, adminstrative, eng. fees	25%			$8,780
				Subtotal	$43,900
8	Contingencies	20%			$8,780
	TOTAL O & M COSTS				**$52,680**
	TOTAL O & M PRESENT WORTH	30 years			**$725,131**
	TOTAL CAPITAL COSTS				**$9,000**
	GRAND TOTAL COST				**$734,131**

TABLE 5-14
IRP Site 10
Costs for Alternative 3
Groundwater Extraction By Trenches; On-site Treatment of Extracted Groundwater; and Discharge of Treated Groundwater to Cayuga Creek

Interest rate	6.0%
Operation & maintenance period (years)	30
Legal Adminstrative, & Eng. Fees	25.0%
Contigencies	20.0%

Item No.	Description	Quantity	Units	Unit Cost	Cost
CAPITAL COSTS					
1	Mobe/Demobe (4% of capital subtotal)	1	LS	$3,301	$3,301
2	Site services	1	MO	$2,500	$2,500
3	Health & Safety	1	LS	$5,000	$5,000
4	Subsurface drain excavation	150	LF	$9	$1,325
5	Gravel backfill	150	CY	$23	$3,450
6	Perforated PVC pipe	150	LF	$6	$826
7	HDPE membrane	200	SY	$18	$3,600
8	Excavated soils disposal	210	Tons	$32	$6,720
9	Soil backfill	50	CY	$9	$436
10	Treatment building	65	SF	$58	$3,775
11	Sand filter	1	EA	$12,000	$12,000
12	Air Stripper	1	EA	$13,000	$13,000
13	Sump tank	1	EA	$5,000	$5,000
14	Misc. Piping and Equipment	1	LS	$7,500	$7,500
15	Pump enclosures	1	EA	$3,188	$3,188
16	Trench excavation for influent line	200	LF	$4	$844
17	Double wall PVC inlfuent pipe(4")	200	LF	$8	$1,681
18	Backfill trench	200	LF	$0.03	$7
19	4" PVC Schedule 40 effluent pipe	200	LF	$8	$1,681
20	Outfall	1	LS	$1,000	$1,000
21	SPDES Permit	1	LS	$3,000	$3,000
22	Deed restrictions	1	LS	$6,000	$6,000
				Subtotal	$85,834
23	Legal, adminstrative, eng. fees	25%			$21,458
				Subtotal	$107,292
24	Contingencies	20%			$21,458
	TOTAL CAPITAL COSTS				**$128,751**
OPERATION & MAINTENANCE COSTS					
1	Trench maintenance	1	LS	$1,000	$1,000
2	G.W. treatment system maintenance	1	LS	$4,940	$4,940
3	Sample collection - groundwater(19 samples)	38	EA	$250	$9,500
4	Sample collection - surf. water/sed.	16	EA	$250	$4,000
5	VOC analysis	60	EA	$275	$16,500
6	Data validation	60	EA	$35	$2,100
7	Report writing	2	EA	$3,000	$6,000
				Subtotal	$44,040
8	Legal, adminstrative, eng. fees	25%			$11,010
				Subtotal	$55,050
9	Contingencies	20%			$11,010
	TOTAL O & M COSTS				**$66,060**
	TOTAL O & M PRESENT WORTH	30 years			**$909,305**
	TOTAL CAPITAL COSTS				**$128,751**
	GRAND TOTAL COST				**$1,038,055**

TABLE 5-15
IRP Site 10
Costs for Alternative 4
Soil Vapor Extraction; Groundwater Extraction by Trenches; On-site Treatment of Extracted Groundwater; and Discharge of Treated Groundwater to Cayuga Creek

Interest rate	6.0%
Operation & maintenance period (years)	5
Legal Adminstrative, & Eng. Fees	25.0%
Contigencies	20.0%

Item No.	Description	Quantity	Units	Unit Cost	Cost
CAPITAL COSTS					
1	Mobe/Demobe (4% of capital subtotal)	1	LS	$8,393	$8,393
2	Site services	1	MO	$2,500	$2,500
3	Health & Safety	1	LS	$5,000	$5,000
4	Treatability study	1	LS	$50,000	$50,000
5	Vapor extraction wells	28	LF	$100	$2,800
6	Vapor extraction system(15 HP)	1	EA	$20,000	$20,000
7	SVE piping	250	LF	$12	$3,000
8	Electrical panel	1	EA	$7,500	$7,500
9	SVE system startup	10	man-day	$1,200	$12,000
10	System closeout	5	man-day	$1,200	$6,000
11	Subsurface drain excavation	150	LF	$9	$1,350
12	Gravel backfill	150	CY	$23	$3,450
13	Perforated PVC pipe	150	LF	$6	$900
14	HDPE membrane	200	SY	$18	$3,600
15	Excavated soils disposal	210	Tons	$32	$6,720
16	Soil backfill	50	CY	$9	$450
17	Treatment building	150	SF	$58	$8,711
18	Sand filter	1	EA	$12,000	$12,000
19	Air Stripper	1	EA	$13,000	$13,000
20	Sump tank	1	EA	$5,000	$5,000
21	Misc. Piping and Equipment	1	LS	$12,500	$12,500
22	Pump enclosures	6	EA	$3,188	$19,127
23	Trench excavation for influent line	200	LF	$4	$844
24	Double wall PVC inlfuent pipe(4")	200	LF	$8	$1,681
25	4" PVC Schedule 40 effluent pipe	200	LF	$8	$1,681
26	Outfall	1	LS	$1,000	$1,000
27	SPDES Permit	1	LS	$3,000	$3,000
29	Deed restrictions	1	LS	$6,000	$6,000
				Subtotal	$218,206
30	Legal, adminstrative, eng. fees	25%			$54,552
				Subtotal	$272,758
31	Contingencies	20%			$54,552
	TOTAL CAPITAL COSTS				**$327,310**
OPERATION & MAINTENANCE COSTS					
1	Trench maintenance	1	LS	$1,000	$1,000
2	G.W. treatment system maintenance	1	LS	$4,940	$4,940
3	SVE maintenance and power requirements	1	LS	$7,500	$7,500
4	Sample collection - groundwater(21 samples)	42	each	$250	$10,500
5	Sample collection - surf. water/sed.	16	each	$250	$4,000
6	SVE analytical	1	LS	$1,500	$1,500
7	VOC analysis	64	each	$275	$17,600
8	Data validation	64	each	$35	$2,240
9	Report writing	2	each	$3,000	$6,000
				Subtotal	$55,280
10	Legal, adminstrative, eng. fees	25%			$13,820
				Subtotal	$69,100
11	Contingencies	20%			$13,820
	TOTAL O & M COSTS				**$82,920**
	TOTAL 0 & M PRESENT WORTH				**$349,289**
	TOTAL CAPITAL COSTS				**$327,310**
	GRAND TOTAL COST				**$676,599**

Table 5-16

THEORETICAL TCLP EXTRACT CONCENTRATIONS
IRP SITE 10
NIAGARA FALLS IAP-ARS

Contaminant	Extract Regulatory Level[a] (mg/L)	Theoretical Soil Concentration[b] (mg/kg)	Maximum Soil Concentration Detected (mg/kg)
Arsenic	5.0	100	2.5
Barium	100	2,000	290
Benzene	0.5	10	—
Cadmium	1.0	20	1.55
Carbon tetrachloride	0.5	10	—
Chlorobenzene	100	2,000	0.003
Chloroform	6.0	120	—
Chromium	5.0	100	650
1,4-Dichlorobenzene	7.5	150	—
1,2-Dichloroethane	0.5	10	—
1,1-Dichloroethylene	0.7	14	—
Hexachlorobenzenes	0.13	2.6	—
Lead	5.0	100	56.6
Mercury	0.2	4	—
Selenium	1.0	20	—
Silver	5.0	100	—
Tetrachloroethylene	0.7	14	—
Trichloroethylene	0.5	10	14
Vinyl chloride	0.2	4	0.038

Note: Shaded values represent contaminants that theoretically would exceed their regulatory level in the TCLP extract.

[a] Table 1, Subpart C, 40 CFR.
[b] Soil contaminant concentrations that would exceed the extract regulatory level if 100% of the contaminant was transferred to the TCLP leaching fluid.

Key:

— = Not detected.

TABLE 5-17
IRP Site 10
Costs for Alternative 5
Excavation and Off-site Disposal of Contaminated Soils; Groundwater Extraction by Trenches; On-site Treatment of Extracted Groundwater; and Discharge to Cayuga Creek

Interest rate	6.0%
Operation & maintenance period (years)	5
Legal Adminstrative, & Eng. Fees	25.0%
Contigencies	20.0%

Item No.	Description	Quantity	Units	Unit Cost	Cost
CAPITAL COSTS					
1	Mobe/Demobe	1	LS	$11,528	$11,528
2	Site services	1	Month	$2,500	$2,500
3	Health & Safety	1	LS	$10,000	$10,000
4	Decon pad	1	LS	$1,500	$1,500
5	Staging area	1	LS	$2,000	$2,000
6	Excavation of soil/fill	2,400	CY	$3	$7,215
7	Disposal of excavated soil/fill	3,120	Tons	$32	$99,840
8	Dewatering of site	5	Day	$121	$607
9	Verification sampling	22	EA	$250	$5,460
10	Verification analyses	22	EA	$500	$10,920
11	Backfill and compaction	2,400	CY	$24	$57,574
12	Topsoil/seed and mulch	1,256	SY	$11	$13,505
13	Subsurface drain excavation	150	LF	$9	$1,350
14	Gravel backfill	150	CY	$23	$3,450
15	Perforated PVC pipe	150	LF	$6	$900
16	HDPE membrane	200	SY	$18	$3,600
17	Excavated soils disposal	210	Tons	$32	$6,720
18	Soil backfill	50	CY	$9	$450
19	Treatment building	150	SF	$58	$8,711
20	Sand filter	1	EA	$12,000	$12,000
21	Air Stripper	1	EA	$13,000	$13,000
22	Sump tank	1	EA	$5,000	$5,000
23	Misc. Piping and Equipment	1	LS	$7,500	$7,500
24	Pump enclosures	1	EA	$3,188	$3,188
25	Trench excavation for influent line	200	LF	$4	$844
26	Double wall PVC inlfuent pipe(4")	200	LF	$8	$1,681
27	4" PVC Schedule 40 effluent pipe	200	LF	$8	$1,681
28	Outfall	1	LS	$1,000	$1,000
29	SPDES Permit	1	LS	$6,000	$6,000
				Subtotal	$299,724
21	Legal, adminstrative, eng. fees	25%			$74,931
				Subtotal	$374,655
22	Contingencies	20%			$74,931
	TOTAL CAPITAL COSTS				**$449,586**
OPERATION & MAINTENANCE COSTS					
1	Trench maintenance	1	LS	$1,000	$1,000
2	Sample collection - groundwater (19 samples)	38	EA	$250	$9,500
3	Sample collection - surf. water/sed.	16	EA	$250	$4,000
4	VOC analysis	60	EA	$275	$16,500
5	Data validation	60	EA	$35	$2,100
6	Report writing	2	EA	$3,000	$6,000
				Subtotal	$39,100
7	Legal, adminstrative, eng. fees	25%			$9,775
				Subtotal	$48,875
8	Contingencies	20%			$9,775
	TOTAL O & M COSTS				**$58,650**
	TOTAL O & M PRESENT WORTH	5 years			**$247,055**
	TOTAL CAPITAL COSTS				**$449,586**
	GRAND TOTAL COST				**$696,641**

TABLE 5-18
IRP Site 10
Costs for Alternative 6
Excavation and Off-site Disposal of Contaminated Soils; Groundwater Extraction by Trenches; and Discharge to Cayuga Creek

Interest rate	6.0%
Operation & maintenance period (years)	5
Legal Adminstrative, & Eng. Fees	25.0%
Contigencies	20.0%

Item No.	Description	Quantity	Units	Unit Cost	Cost
CAPITAL COSTS					
1	Mobe/Demobe (4% of capital subtotal)	1	LS	$9,812	$9,812
2	Site services	1	Month	$2,500	$2,500
3	Health & Safety	1	LS	$10,000	$10,000
4	Decon pad	1.00	LS	$1,500	$1,500
5	Staging area	1.00	LS	$2,000	$2,000
6	Excavation of soil/fill	2,400	CY	$3	$7,215
7	Disposal of excavated soil/fill	3,120	Tons	$32	$99,840
8	Dewatering of site	5	Day	$121	$607
9	Verification sampling	22	EA	$250	$5,460
10	Verification analyses	22	EA	$500	$10,920
11	Backfill and compaction	2,400	CY	$24	$57,574
12	Topsoil/seed and mulch	1,256	SY	$11	$13,505
13	Subsurface drain excavation	150	LF	$9	$1,350
14	Gravel backfill	150	CY	$23	$3,450
15	Perforated PVC pipe	150	LF	$6	$900
16	HDPE membrane	200	SY	$18	$3,600
17	Excavated soils disposal	210	Tons	$32	$6,720
18	Soil backfill	50	CY	$9	$450
18	Trench excavation for pipe to sewer	200	LF	$4	844.1
19	Discharge pipe to sewer	200	LF	$8	$1,600
20	Trench backfill	200	LF	$0.41	$82
21	Outfall to sewer	1	LS	$1,000	$1,000
22	Pump enclosures	1	LS	$3,188	$3,188
23	Misc. piping and equipment	1	LS	$5,000	$5,000
24	Deed restrictions	1	LS	$6,000	$6,000
				Subtotal	$255,118
25	Legal, adminstrative, eng. fees	25%			$63,779
				Subtotal	$318,897
26	Contingencies	20%			$63,779
	TOTAL CAPITAL COSTS				**$382,677**
OPERATION & MAINTENANCE COSTS					
1	Trench maintenance	1	LS	$1,000	$1,000
2	Disposal at POTW	131	K-GAL	$1.37	$180
3	Sample collection - groundwater (18 samples)	36	EA	$250	$9,000
4	Sample collection - surf. water/sed.	16	EA	$250	$4,000
5	VOC analysis	64	EA	$275.	$17,600
6	Data validation	64	EA	$35	$2,240
7	Report writing	2	EA	$3,000	$6,000
				Subtotal	$40,020
8	Legal, adminstrative, eng. fees	25%			$10,005
				Subtotal	$50,025
9	Contingencies	20%			$10,005
	TOTAL O & M COSTS				**$60,030**
	TOTAL O & M PRESENT WORTH	5 years			**$252,868**
	TOTAL CAPITAL COSTS				**$382,677**
	GRAND TOTAL COST				**$635,545**

Table 5-19

EVALUATION OF CORRECTIVE MEASURE ALTERNATIVES

Criteria/ Definition	Alternative					
	1. No Action and Natural Attenuation	2. Institutional Actions and Natural Attenuation	3. Groundwater Extraction by Trenches; On-site Treatment of Extracted Groundwater; and Disposal of Treated Groundwater to Cayuga Creek	4. Soil Vapor Extraction; Groundwater Extraction by Wells; On-site Treatment of Extracted Groundwater; and Disposal of Extracted Groundwater to Cayuga Creek	5. Contaminated Soil Excavation and Off-site Disposal; Groundwater Extraction by Trench; On-site Treatment of Extracted Groundwater; and Disposal of Extracted Groundwater to Cayuga Creek	6. Contaminated Soil Excavation and Off-site Disposal; Groundwater Extraction by Trench; and Disposal of Extracted Groundwater to a POTW
Definition	Natural attenuation, including dispersion, diffusion, volatilization, biodegradation, and adsorption, would lead to eventual attainment of groundwater, surface water, and soil cleanup goals. Sampling to monitor groundwater, surface water, and sediment quality in Cayuga Creek would continue until site cleanup goals are accomplished.	Similar to Alternative 1, natural attenuation, including dispersion, diffusion, volatilization, biodegradation, and adsorption would lead to eventual attainment of groundwater, surface water, and soil cleanup goals. Institutional actions preventing construction of drinking water wells would be implemented until site groundwater cleanup goals are attained. Sampling to monitor groundwater, surface water, and sediment quality in Cayuga Creek would continue until site cleanup goals are accomplished.	Under this alternative, contaminated groundwater would be extracted by a subsurface trench, treated on site, and discharged to a ditch draining to Cayuga Creek. The trench would be constructed close to the former burn pit and installed to the top of bedrock. No corrective action would be implemented for the soil and surface water media. However, further releases of contaminants to Cayuga Creek would be minimized by extracting contaminated groundwater; thus, surface water cleanup goals would be attained. Institutional actions would be implemented until site groundwater cleanup goals are attained to prevent construction of drinking water wells. Sampling to monitor groundwater, surface water, and sediment quality in Cayuga Creek would continue until site cleanup goals are accomplished.	Under this alternative, corrective action would be implemented for soil and groundwater media. Groundwater corrective measures are similar to Alternative 3. In addition, soil vapor extraction (SVE) would be implemented to attain soils cleanup goals. No corrective action would be implemented for surface water media. However, further release of contaminants in Cayuga Creek would be minimized by extracting contaminated groundwater; thus, surface water cleanup goals would be attained. Institutional actions would be implemented until site groundwater cleanup goals are attained to prevent construction of drinking water wells. Sampling to monitor groundwater, surface water, and sediment quality in Cayuga Creek would continue until site cleanup goals are accomplished.	This alternative is similar to Alternative 4. However, SVE treatment of soils is replaced by contaminated soils excavation and off-site disposal at a commercial facility. Institutional actions would be implemented until site groundwater cleanup goals are attained to prevent construction of drinking water wells. Sampling to monitor groundwater, surface water, and sediment quality in Cayuga Creek would continue until site cleanup goals are accomplished.	Alternative 6 is similar to Alternative 5. However, on-site treatment of extracted groundwater is replaced by discharge and disposal of extracted groundwater to a POTW. Institutional actions would be implemented until site cleanup goals are attained. Sampling to monitor groundwater, surface water, and sediment quality in Cayuga Creek would be continued until site cleanup goals are accomplished.

Table 5-19

EVALUATION OF CORRECTIVE MEASURE ALTERNATIVES

Criteria/ Definition	Alternative					
	1. No Action and Natural Attenuation	2. Institutional Actions and Natural Attenuation	3. Groundwater Extraction by Trenches; On-site Treatment of Extracted Groundwater; and Disposal of Treated Groundwater to Cayuga Creek	4. Soil Vapor Extraction; Groundwater Extraction by Wells; On-site Treatment of Extracted Groundwater; and Disposal of Extracted Groundwater to Cayuga Creek	5. Contaminated Soil Excavation and Off-site Disposal; Groundwater Extraction by Trench; On-site Treatment of Extracted Groundwater; and Disposal of Extracted Groundwater to Cayuga Creek	6. Contaminated Soil Excavation and Off-site Disposal; Groundwater Extraction by Trench; and Disposal of Extracted Groundwater to a POTW
Technical	Natural attenuation processes at the site have limited capacity to reduce contaminant concentrations at exposure sites of environmental and human receptors. Only qualitative information is available about the existence of natural attenuation processes at the site; thus, this alternative may be unreliable.	At Site 10, natural attenuation processes have limited capacity to reduce contaminant concentrations at exposure sites of environmental and human receptors. Only qualitative information is available about the existence of natural attenuation processes at the site; thus, this alternative may be unreliable. If institutional controls are implemented correctly, they could be very effective in preventing construction of drinking water wells.	A subsurface trench would be effective in extracting groundwater contaminants in the overburden. In addition, an upward gradient would be created that would also extract groundwater from the bedrock. On-site treatment by filtration and air stripping would be effective for treatment of extracted groundwater. Preliminary design of the air stripper has shown that Class C surface water standards can be easily attained. Contaminated soils at the site would continue to act as a long-term source of groundwater contamination at the site.	Groundwater corrective measures are similar to Alternative 3. SVE would be effective for soils, since the contaminants can be readily vaporized. The groundwater table at the site would be lowered to expose contaminated soils to SVE. A treatability study would be required to undertake the final design of the SVE system at the site. This alternative consists of reliable and safely implementable technologies.	Groundwater corrective measures are similar to Alternative 3. Excavation and off-site disposal of contaminated soils would be effective. At the site, excavation of contaminated soils would require groundwater dewatering. It is anticipated that excavated site soils could be disposed of off-site at a nonhazardous/solid waste facility. Dust and VOC monitoring would be conducted during excavation and off-site disposal of site soils. This alternative consists of reliable and safely implementable technologies.	This alternative is similar to Alternative 3, except that extracted groundwater would be disposed at a POTW. This would afford effective treatment and disposal of extracted groundwater. This alternative consists of reliable and safely implementable technologies.

Table 5-19

EVALUATION OF CORRECTIVE MEASURE ALTERNATIVES

Criteria/ Definition	Alternative					
	1. No Action and Natural Attenuation	**2. Institutional Actions and Natural Attenuation**	**3. Groundwater Extraction by Trenches; On-site Treatment of Extracted Groundwater; and Disposal of Treated Groundwater to Cayuga Creek**	**4. Soil Vapor Extraction; Groundwater Extraction by Wells; On-site Treatment of Extracted Groundwater; and Disposal of Extracted Groundwater to Cayuga Creek**	**5. Contaminated Soil Excavation and Off-site Disposal; Groundwater Extraction by Trench; On-site Treatment of Extracted Groundwater; and Disposal of Extracted Groundwater to Cayuga Creek**	**6. Contaminated Soil Excavation and Off-site Disposal; Groundwater Extraction by Trench; and Disposal of Extracted Groundwater to a POTW**
Human Health	Contamination levels in site groundwater is above NYSDEC Class GA standards. Alternative 1 does not address potential exposure concerns of human consumption of contaminated groundwater. Currently, no groundwater drinking water wells exist at the site or in its vicinity. Soil contamination levels are too low to cause exposure concerns to human receptors. Human exposure to site-related contaminants in Cayuga Creek is remote, since no on-site recreational activities occur at the installation.	Institutional controls could minimize human exposure to groundwater contaminants. Soil contamination levels are too low to cause exposure concerns to human receptors. Human exposure to site-related contaminants in Cayuga Creek is remote, since no on-site recreational activities occur at the installation.	Attainment of groundwater and cleanup goals can be accelerated by this alternative. Until site cleanup goals are attained, institutional control would be implemented to protect human health exposure to site groundwaters. Soil contamination levels are too low to cause exposure concerns to human receptors. Human exposure to site-related contaminants in Cayuga Creek is remote, since no on-site recreational activities occur at the installation. Routine maintenance of the on-site treatment system would be required.	Attainment of groundwater cleanup goals can be accelerated by this alternative. By removing the source of groundwater contamination, attainment of groundwater cleanup would be attained in an estimated five years. Until site cleanup goals are attained, institutional control would be implemented to protect human health exposure to site groundwaters. Routine maintenance of the on-site SVE and groundwater treatment system would be required. Contaminant concentrations in the extracted soil vapor are expected to be low and not be a cause of exposure concerns to human receptors. Level D worker safety is anticipated.	Excavation and off-site disposal of contaminated soils may expose site workers to site contaminants. However, the levels of contamination are too low to cause any exposure concerns. Only a limited impact to vehicular traffic is anticipated due to the relatively small quantity of soils to be disposed off-site. By removing the source of groundwater contamination from site, groundwater cleanup would be attained in an estimated five years. Until site cleanup goals are attained, institutional controls would be implemented to protect human health exposure to site groundwaters. Routine maintenance of the on-site treatment system would be required.	The human health analysis of Alternative 5 is similar to Alternative 4. In addition, routine maintenance of the groundwater treatment system is eliminated by disposal of groundwater to a POTW. Until site cleanup goals are attained, institutional controls would be implemented to protect human health exposure to site groundwater.
Environmental	This alternative does not address current exposure concerns of environmental receptors in Cayuga Creek. Natural attenuation processes at the site do not have sufficient capacity to diminish contaminant levels in Cayuga Creek. Thus, short- and long-term environmental exposure concerns would remain at Site 10.	The environmental analysis of Alternative 2 is similar to Alternative 1. Institutional controls alone would not be effective in minimizing current and potential exposure concerns to environmental receptors in Cayuga Creek.	By extracting contaminants from the subsurface, long-term exposure of environmental receptors in Cayuga Creek to site-related contaminants would be reduced. A trench would be most effective in minimizing the off-site transport of contaminants.	The environmental analysis of Alternative 4 is similar to Alternative 3.	The environmental analysis of Alternative 5 is similar to Alternative 3.	The environmental analysis of Alternative 6 is similar to Alternative 3.

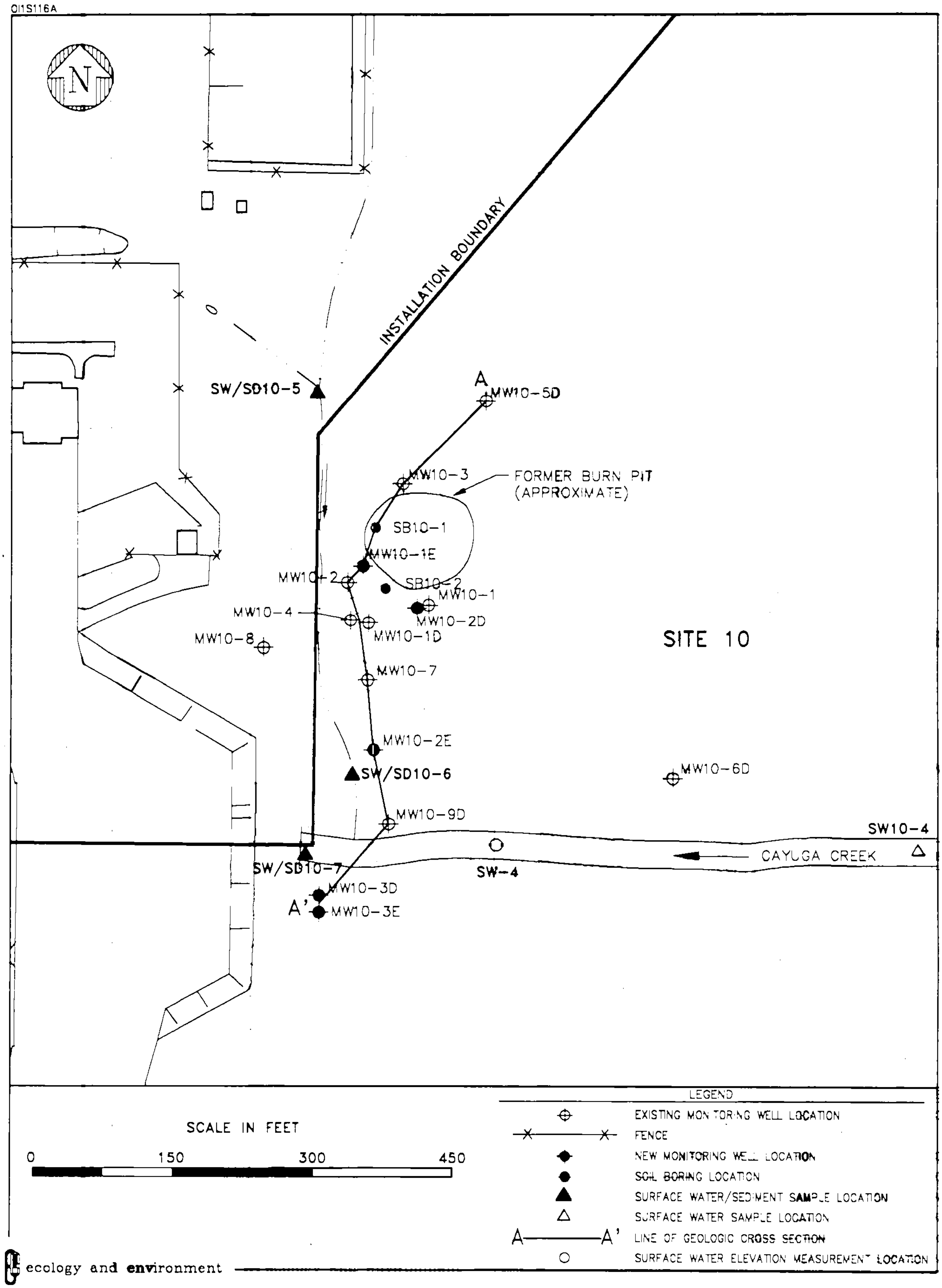
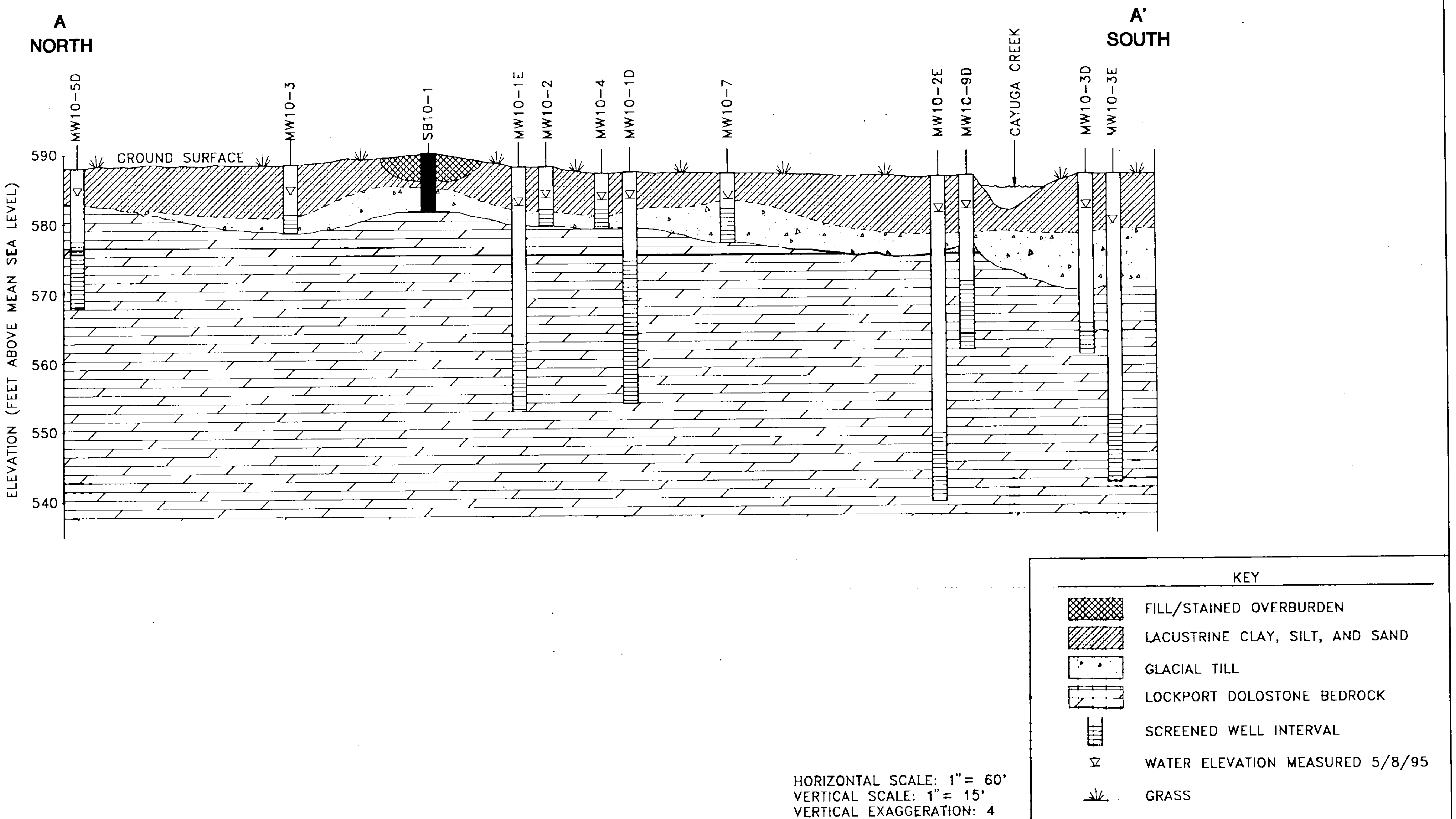


Figure 5-1
IRP SITE 10 - SITE PLAN
RFI SAMPLE LOCATIONS
NIAGARA FALLS IAP-ARS

012X1058



ecology and environment

Figure 5-2 GEOLOGIC CROSS SECTION A-A'
IRP SITE 10
NIAGARA FALLS IAP-ARS

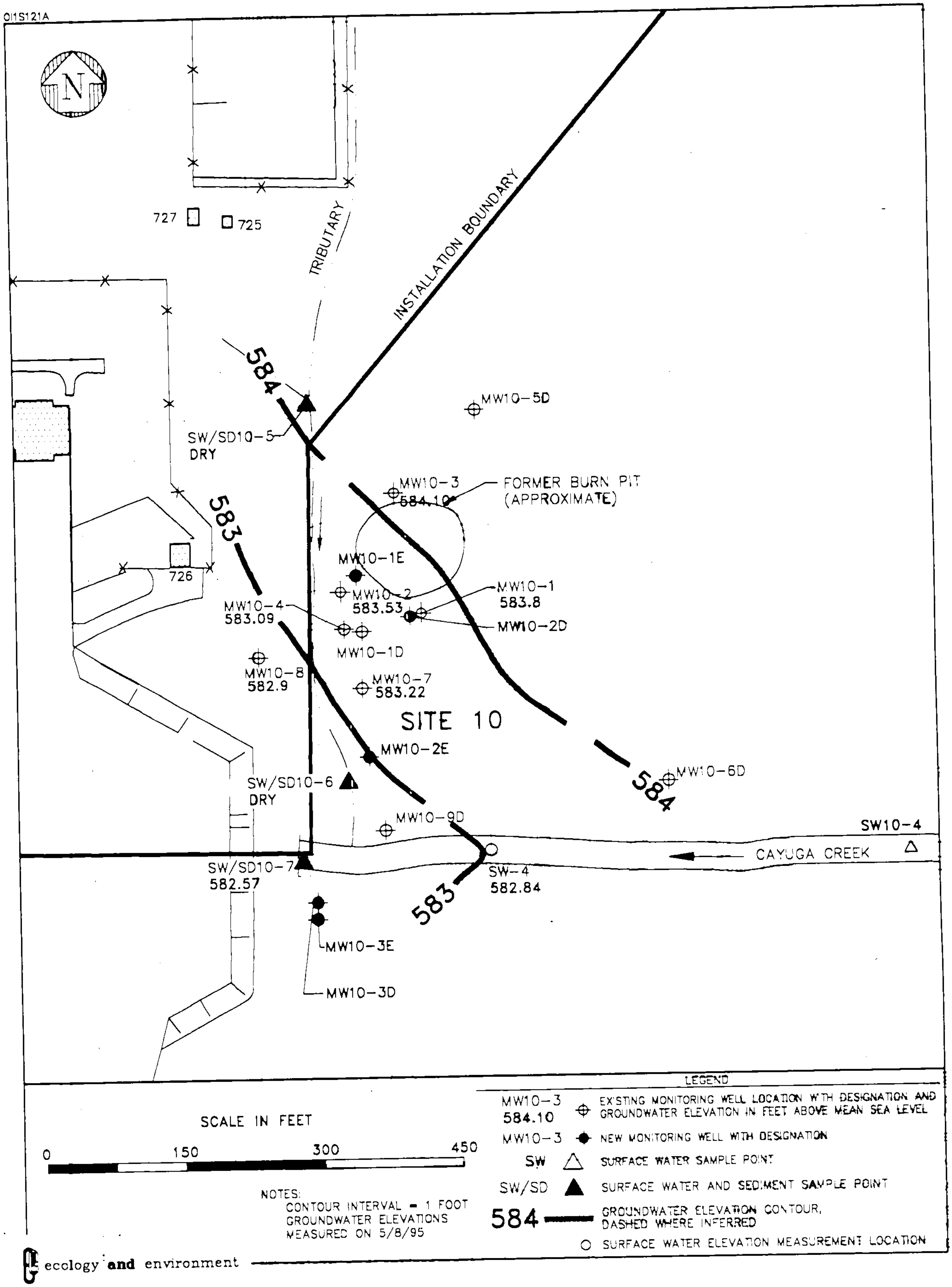


Figure 5-3
OVERBURDEN GROUNDWATER CONTOUR MAP
IRP SITE 10
NIAGARA FALLS IAP-ARS

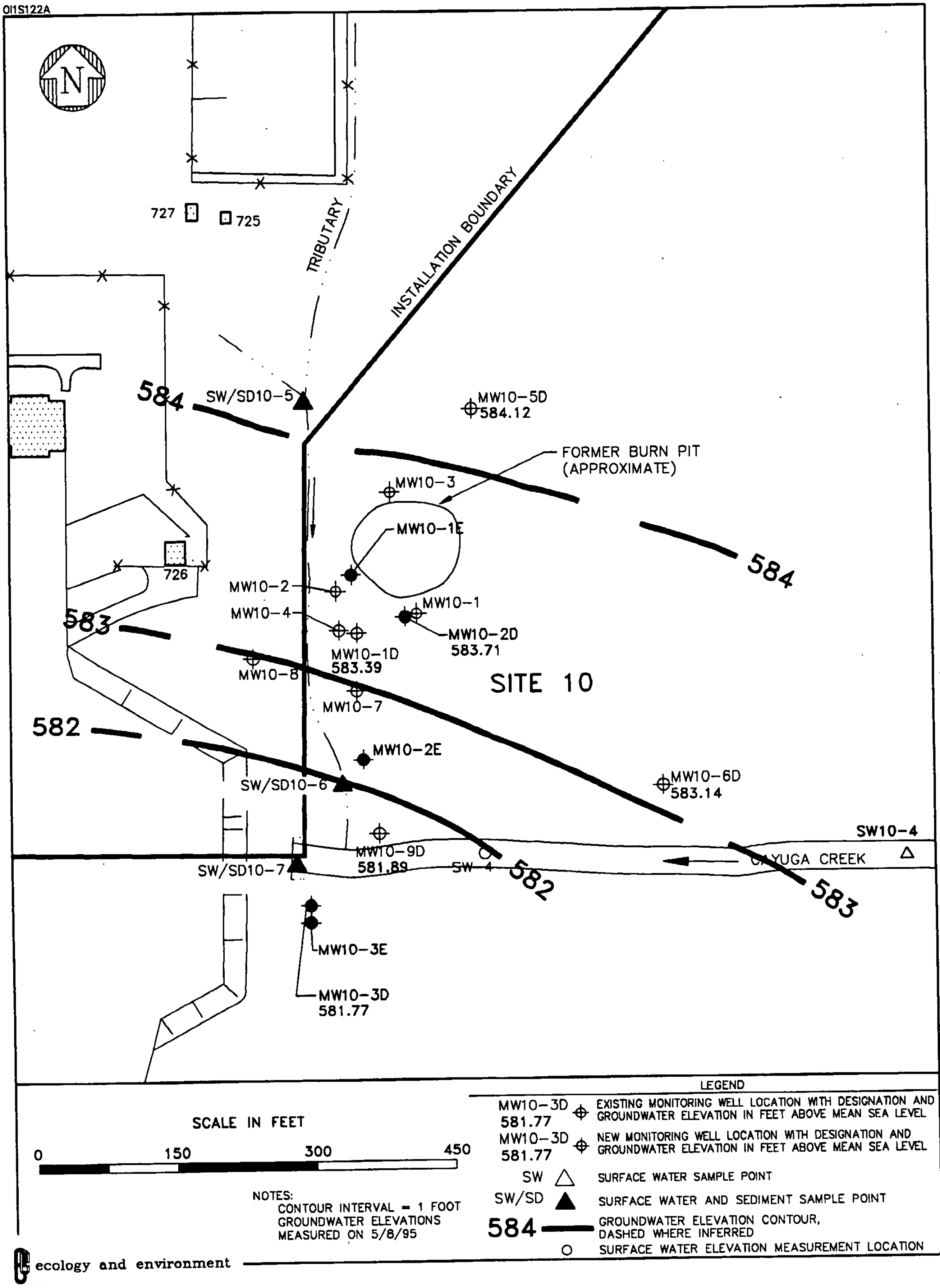


Figure 5-4
SHALLOW BEDROCK GROUNDWATER CONTOUR MAP
IRP SITE 10
NIAGARA FALLS IAP-ARS

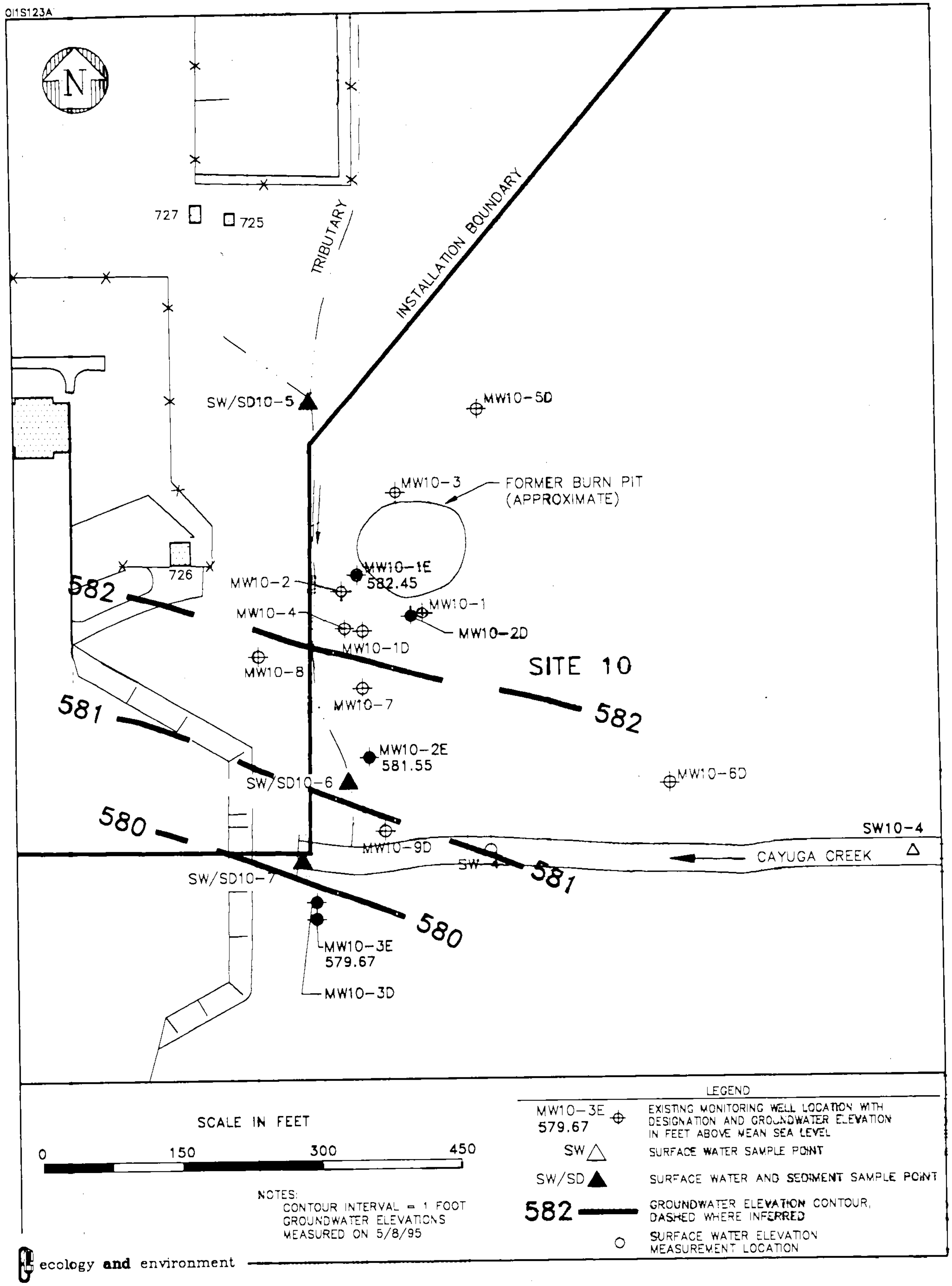


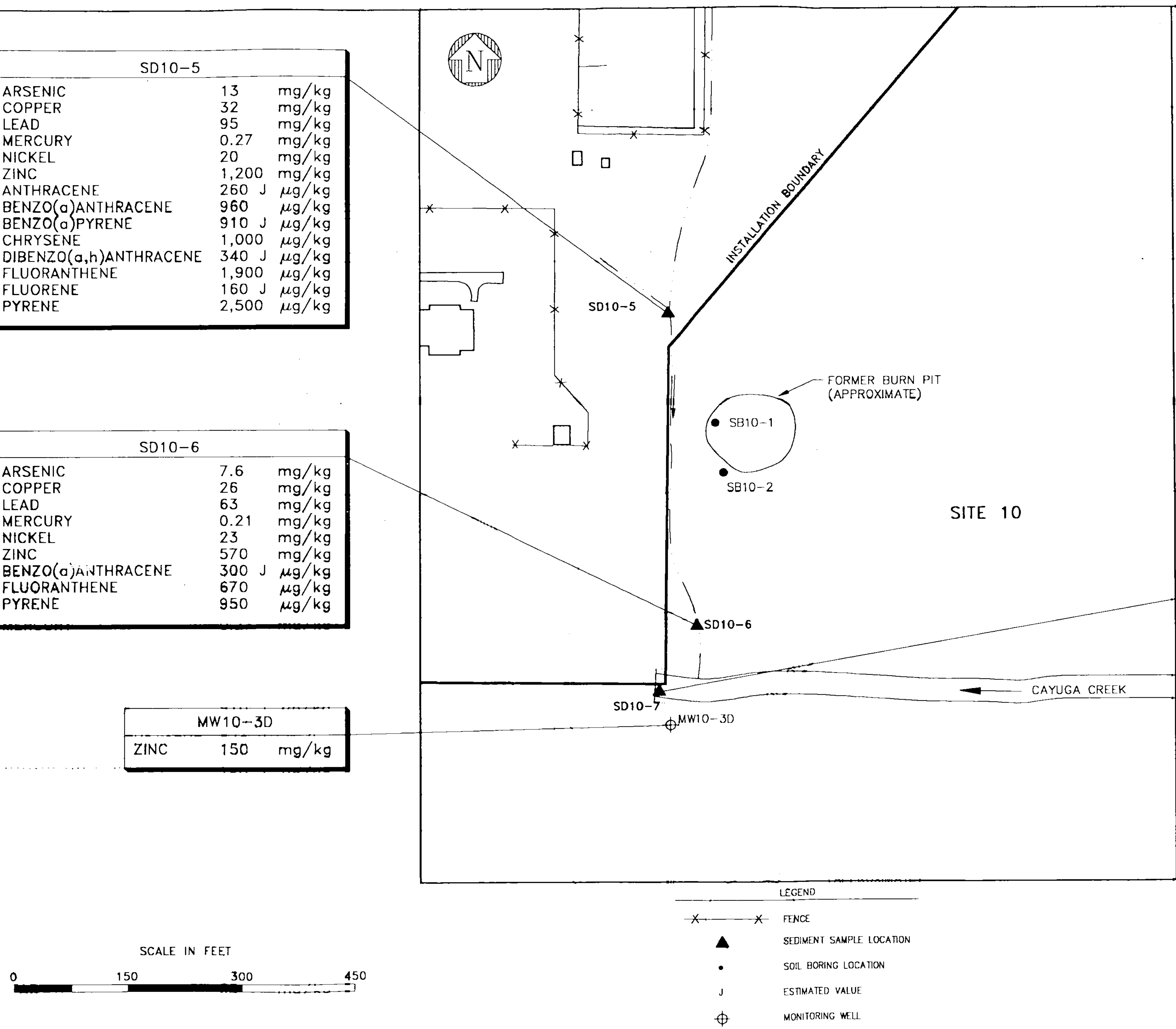
Figure 5-5
DEEP BEDROCK GROUNDWATER CONTOUR MAP
IRP SITE 10
NIAGARA FALLS IAP-ARS

011S120B

SD10-5		
ARSENIC	13	mg/kg
COPPER	32	mg/kg
LEAD	95	mg/kg
MERCURY	0.27	mg/kg
NICKEL	20	mg/kg
ZINC	1,200	mg/kg
ANTHRACENE	260 J	µg/kg
BENZO(a)ANTHRACENE	960	µg/kg
BENZO(a)PYRENE	910 J	µg/kg
CHRYSENE	1,000	µg/kg
DIBENZO(a,h)ANTHRACENE	340 J	µg/kg
FLUORANTHENE	1,900	µg/kg
FLUORENE	160 J	µg/kg
PYRENE	2,500	µg/kg

SD10-6		
ARSENIC	7.6	mg/kg
COPPER	26	mg/kg
LEAD	63	mg/kg
MERCURY	0.21	mg/kg
NICKEL	23	mg/kg
ZINC	570	mg/kg
BENZO(a)ANTHRACENE	300 J	µg/kg
FLUORANTHENE	670	µg/kg
PYRENE	950	µg/kg

MW10-3D		
ZINC	150	mg/kg



SD10-7		
CADMIUM	1.0	mg/kg
COPPER	18	mg/kg
LEAD	39	mg/kg
MERCURY	0.21	mg/kg
NICKEL	17	mg/kg
ZINC	1,800	mg/kg
BENZO(a)ANTHRACENE	240 J	µg/kg
DIBENZO(a,h)ANTHRACENE	110 J	µg/kg
PYRENE	550 J	µg/kg

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Figure 5-6 RFI SOIL AND SEDIMENT SAMPLES ABOVE CLEANUP GOALS
IRP SITE 10
NIAGARA FALLS IAP-ARS

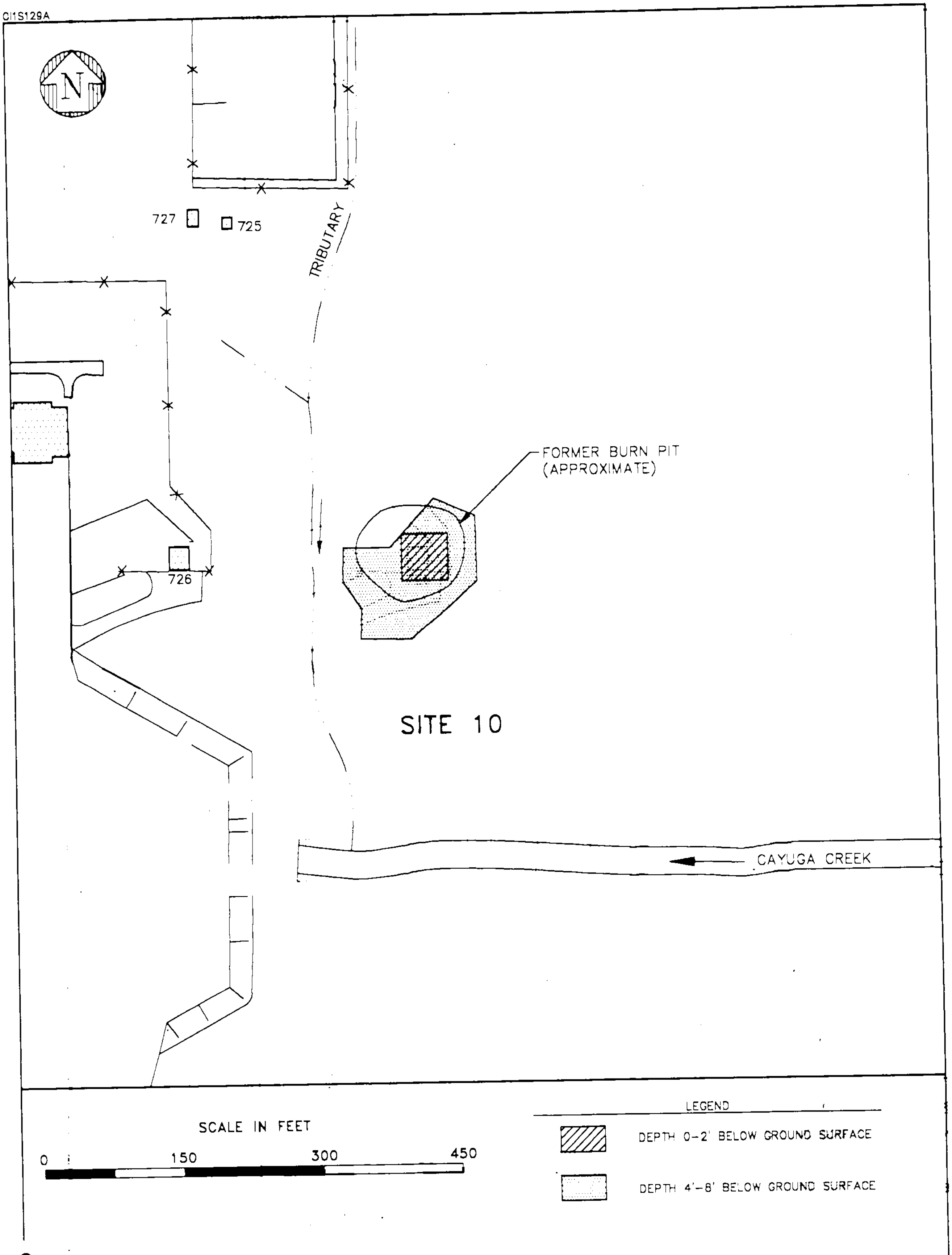

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Figure 5–7
AREAS OF SOIL CONTAMINATION ABOVE ORGANICS CLEANUP GOALS
IRP SITE 10
NIAGARA FALLS IAP–ARS

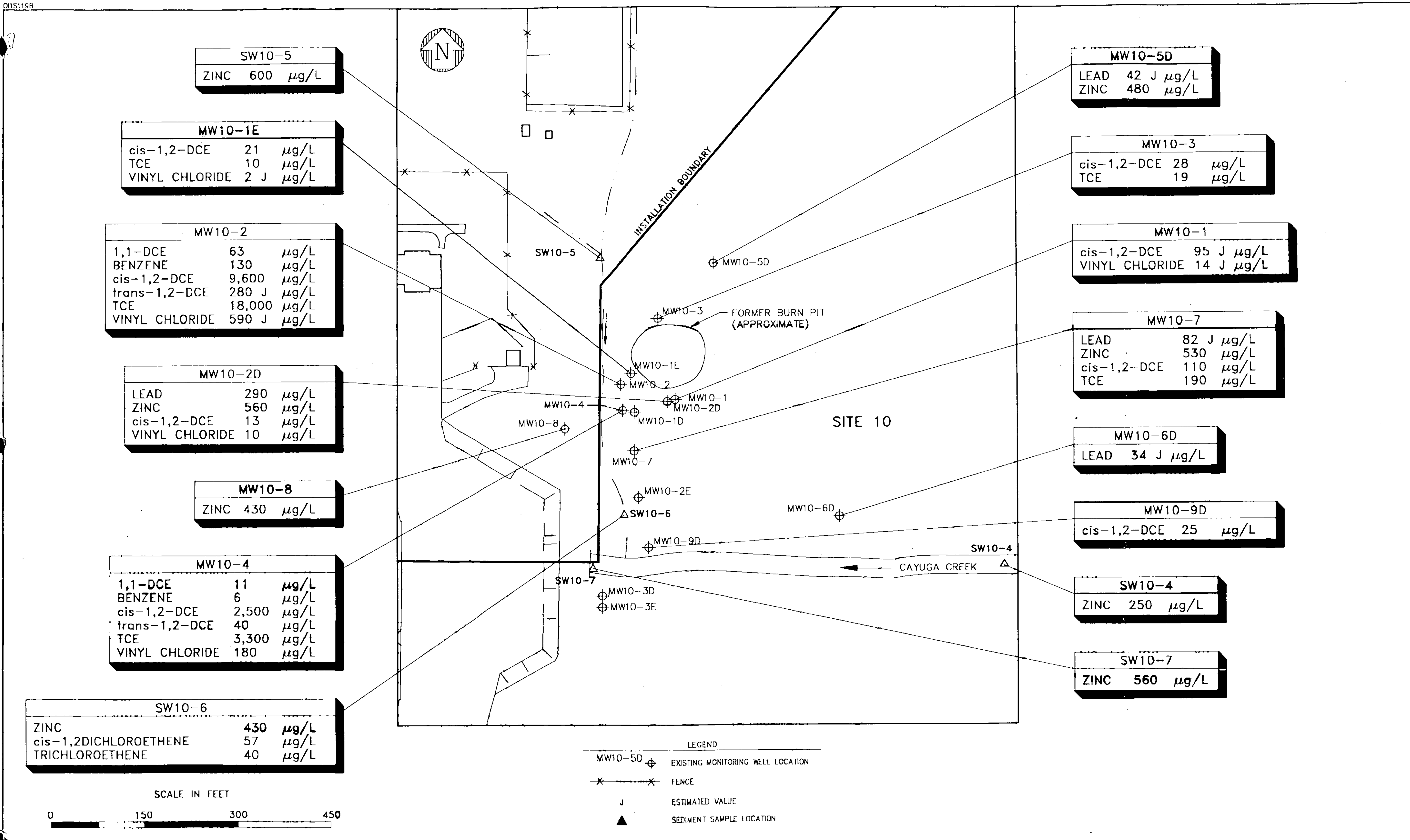
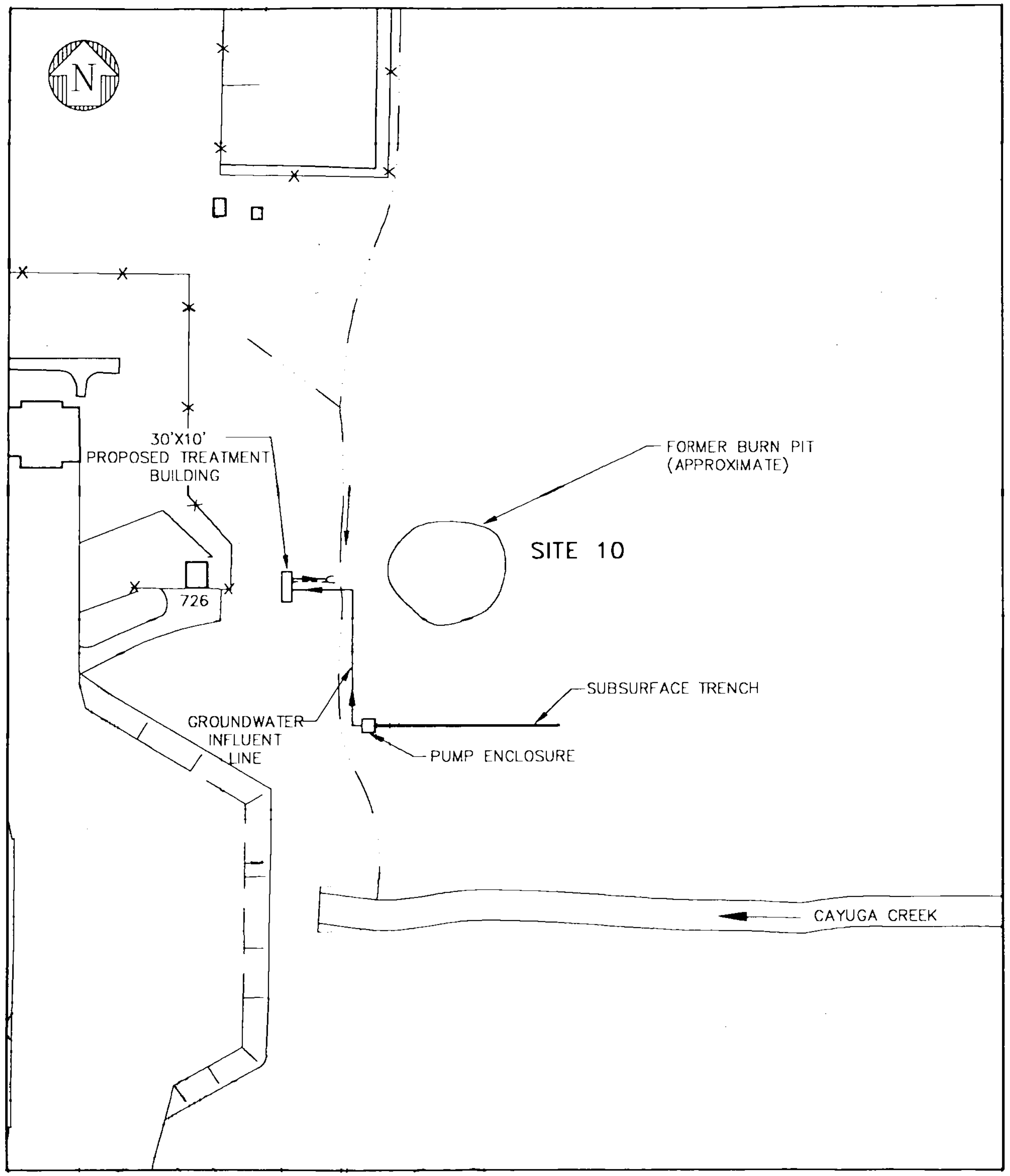
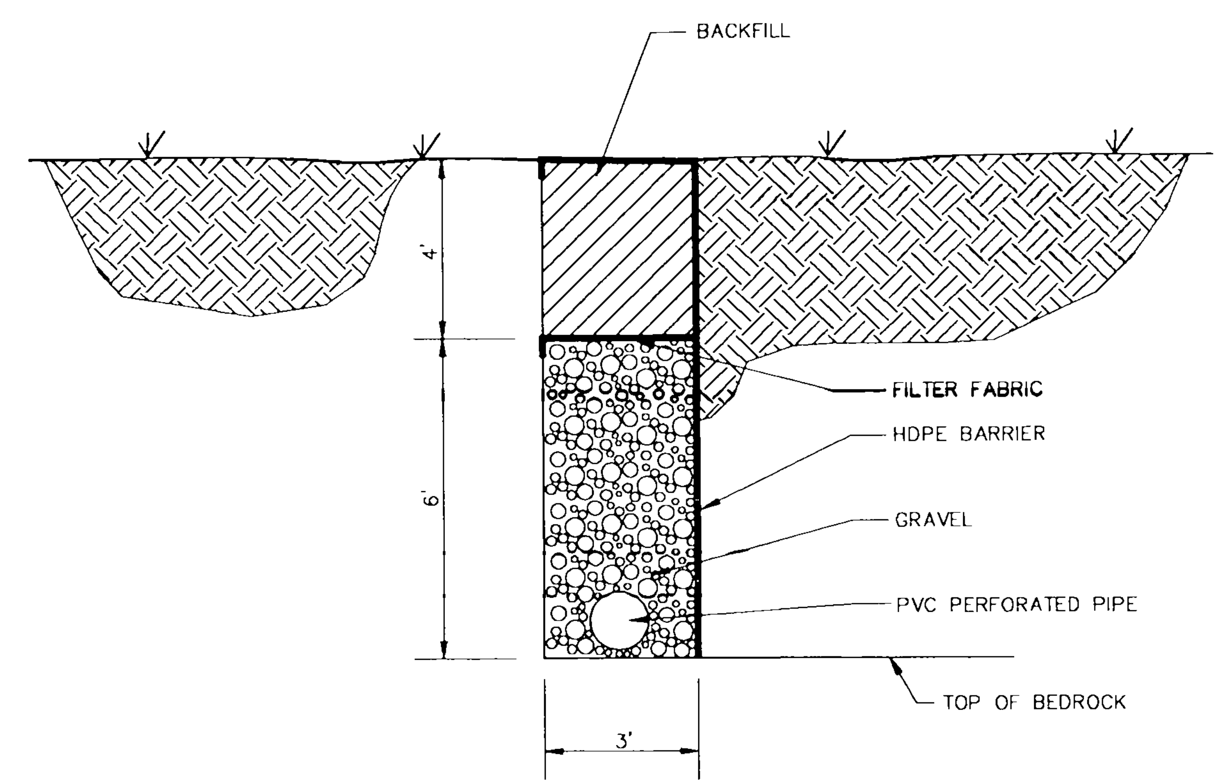


Figure 5-8 RFI WATER SAMPLES ABOVE CLEANUP GOALS
IRP SITE 10
NIAGARA FALLS IAP-ARS

01IS028A





TYPICAL TRENCH CROSS-SECTION
NOT TO SCALE

SCALE IN FEET

0 150 300 450

LEGEND

FENCE

INFLUENT LINE TO TREATMENT BUILDING

EFFLUENT LINE

OUTFALL

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Figure 5-9 ALTERNATIVE 3 LAYOUT
IRP SITE 10
NIAGARA FALLS IAP-ARS

011S027A

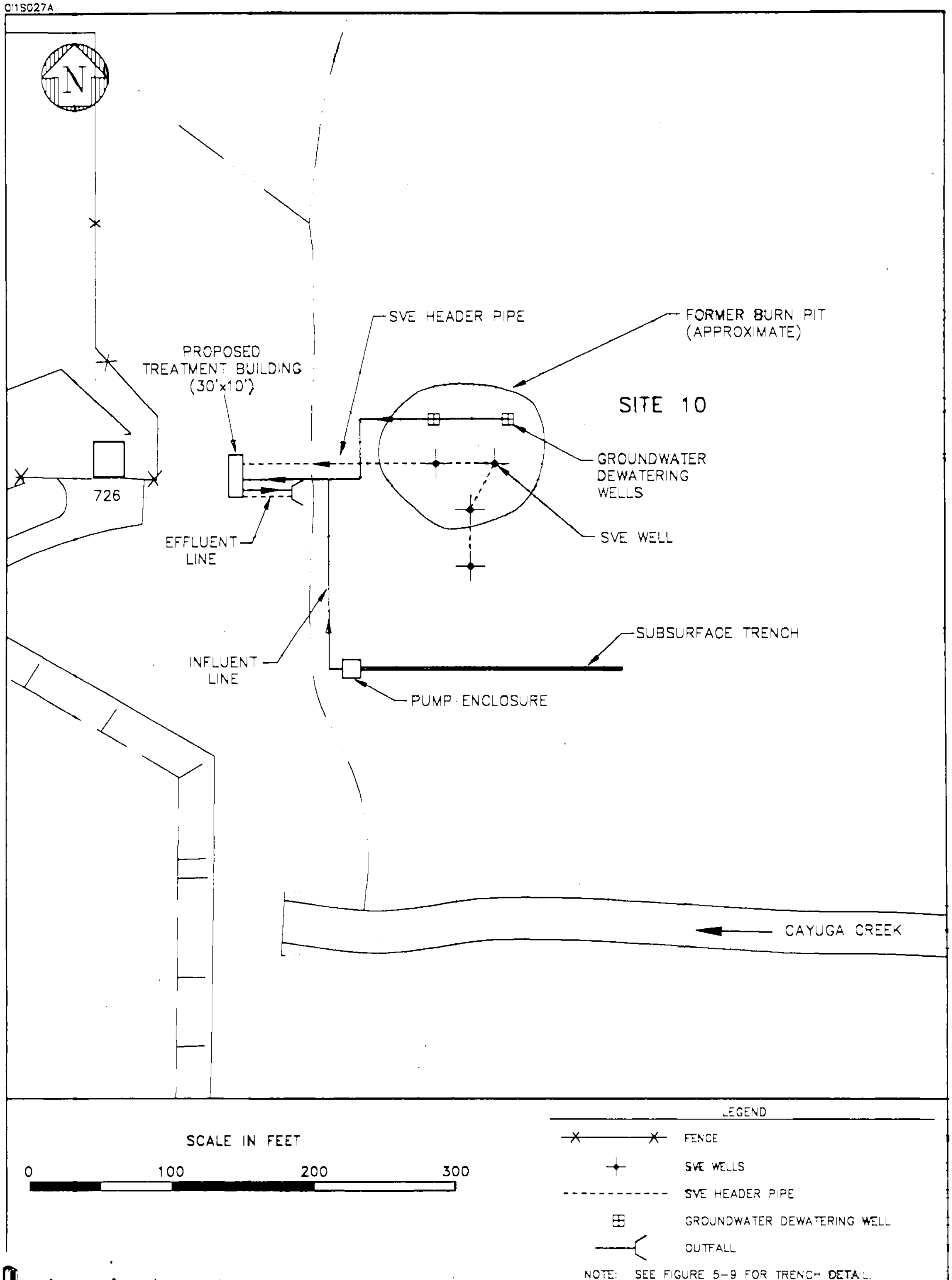

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Figure 5-10
ALTERNATIVE 4 LAYOUT
IRP SITE 10
NIAGARA FALLS IAP-ARS

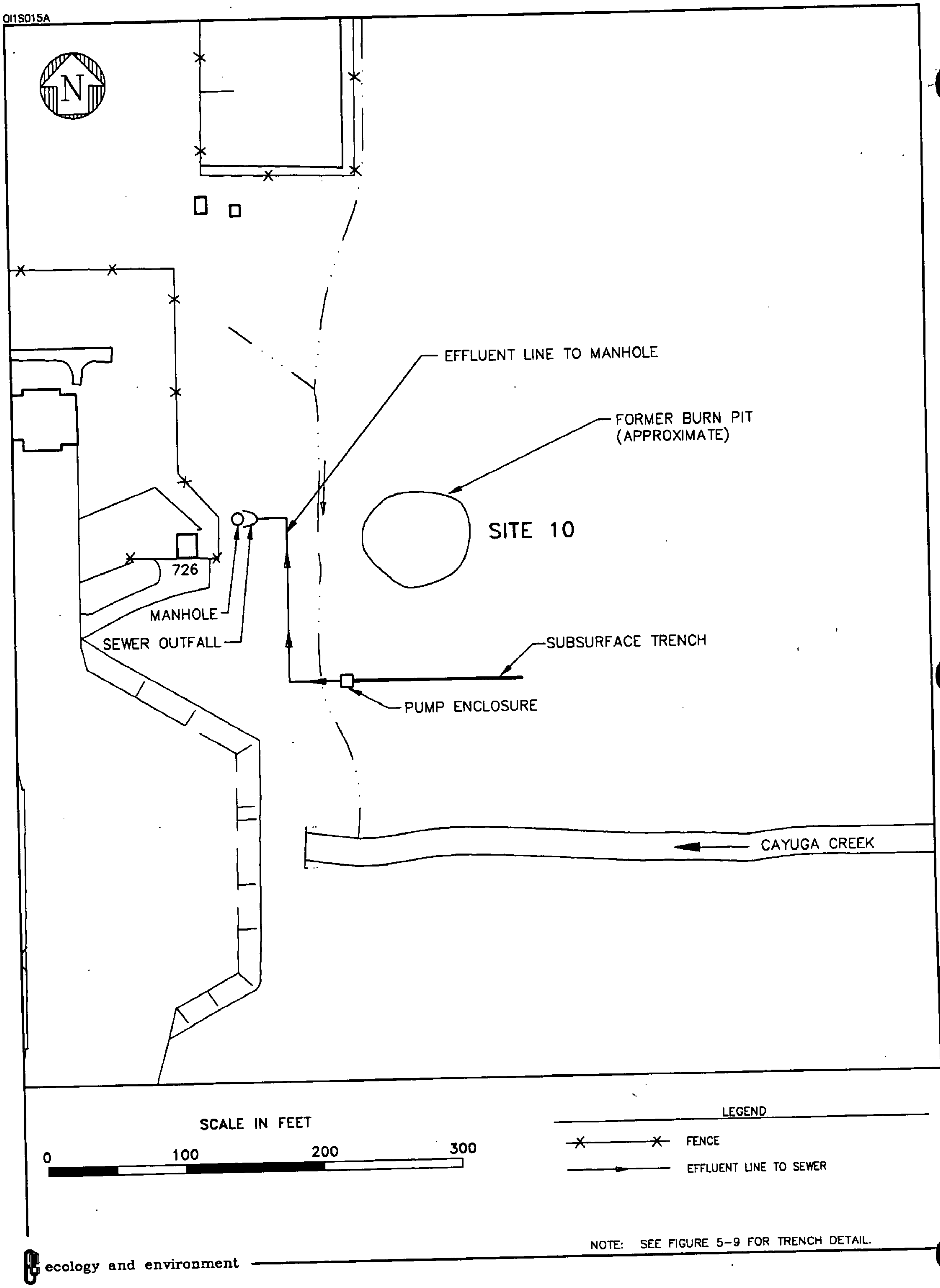


Figure 5-11
ALTERNATIVE 6 LAYOUT
IRP SITE 10
NIAGARA FALLS IAP-ARS

02: OI2000/4769_412.CDR (P3)

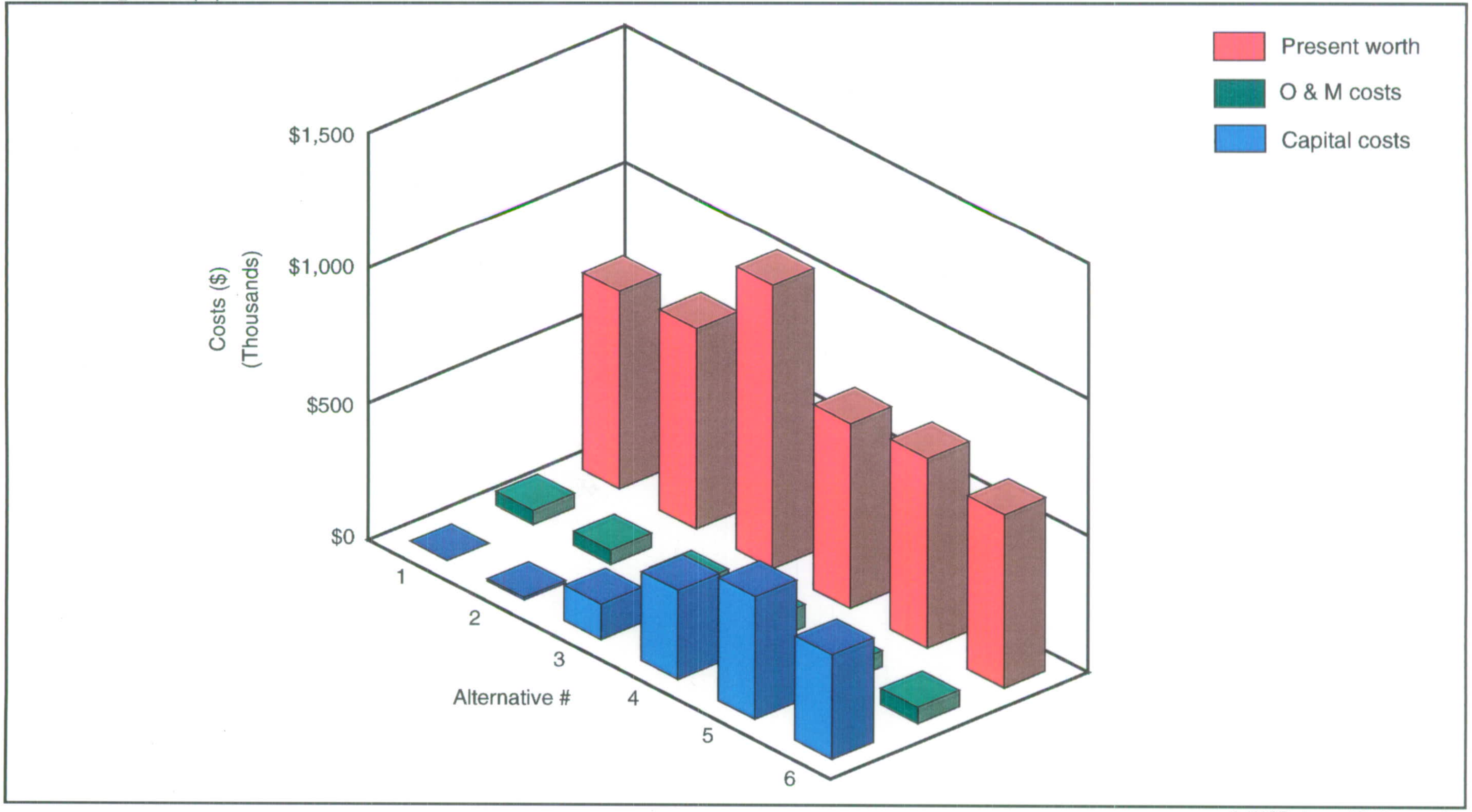


Figure 5-12 CAPITAL, O & M, AND PRESENT WORTH COSTS FOR CMAs
IRP SITE 10
NIAGARA FALLS IAP-ARS

SITE 13

6 Corrective Measures Study - Site 13

6.1 Identification and Development of Corrective Measure Alternatives

The following section details the initial steps required to select an appropriate corrective measure as part of the Niagara Falls IAP-ARS environmental restoration strategy for Site 13. Section 6.1.1 summarizes current site conditions and discusses RFI findings and previous analytical results. The site-specific CAOs are established for all media at this site in Section 6.1.2. Section 6.1.3 provides a comparison of the potential remedial technologies (as listed in Section 3) with the Site 13 CAOs and summarizes the screening process. Section 6.1.4 identifies CMAs found to be potentially feasible at Site 13 and which will be retained for further study.

6.1.1 Description of Current Conditions

6.1.1.1 Site Description

Site 13 is an underground tank pit that initially contained a 4,000-gallon underground storage tank (UST) used to store gasoline for the installation service station. The site is located south of Building 904 and west of Building 905 (see Figure 6-1). After the service station closed in 1971, the tank was used for general shop waste liquids storage. Stored materials included waste oils, solvents, and automotive fluids. In 1986, the tank was emptied, excavated, and removed. The tank pit excavation was backfilled in 1987. The average depth to bedrock at Site 13 is approximately 8.3 feet BGS. Groundwater is present at approximately 6.5 feet BGS and flows toward the northeast (SAIC 1991).

The original source of contamination (the UST) has been removed from the site; however, groundwater monitoring determined that contaminant migration had occurred from the tank pit prior to its removal. Previous analytical data indicates the presence of PCE, TCE, BTEX compounds, vinyl chloride, and various metals in the groundwater at levels exceeding Class GA groundwater standards. Site 13 is listed as a Solid Waste Management Unit (SWMU) in the installation's NYSDEC 373 Draft Storage Permit.

At present, Site 13 is located in a grassy area that is surrounded by asphalt parking lot. Site 13 has been designated for future use as an aircraft operations and maintenance (O & M) area. Potential uses for this area may include control tower support, flight training, aircraft and fuel maintenance, or other aircraft support activities. A portion of Site 13 may also be potentially designated for industrial use, which may involve construction, transportation, and laboratory operations. Land in the immediate vicinity is designated for the same future use as Site 13.

6.1.1.2 Site Geology

The geology of IRP Site 13 is characterized by a relatively thin overburden cover primarily made up of lacustrine sediments on top of a fractured dolostone bedrock. The overburden rests on a bedrock surface that is generally flat. The overburden ranges in thickness from approximately 7 feet at the eastern side to approximately 12 feet at the western side of the site. A generalized geologic cross section of Site 13 is presented in Figure 6-2.

The overburden at Site 13 is made up of three distinct layers as identified in the monitoring wells installed at Site 13 during this and previous investigations. The uppermost layer, where present, is a fill layer up to 4 feet thick consisting of blacktop pavement with natural fill materials such as clay, sand, and gravel. This pavement/fill layer was encountered only at two of the new wells (MW13-3D and MW13-4D).

The next overburden layer encountered is a continuous, 3- to 12-feet-thick layer of stratified lacustrine sediments consisting of primarily clay and silty clay. These sediments were deposited as glacial lake sediments and are described as mottled red and brown in color, cohesive, plastic, firm, and occasionally varved (exhibiting annual sedimentary sequences). Traces of gravel were often noted; lenses of silt and sand were noted less frequently.

Beneath the lacustrine sediments and resting directly on the bedrock at only one well location (MW13-3D) is a glacial till layer 2 feet thick. The till was described as clay similar to that of the overlying lacustrine layer with fine-to-coarse, subangular, dolomitic gravel.

6.1.1.3 Site Hydrogeology

Both the overburden and the bedrock wells produce water at Site 13; no confining layer was encountered between the overburden and the bedrock aquifers and the overburden and bedrock aquifers are hydraulically connected.

The overburden groundwater contour map of Site 13 (see Figure 6-3) shows that the overburden water-bearing zone flows generally to the east with slight northeast and southeasterly components. The gradient of the overburden aquifer potentiometric surface was approximately 1.3 feet per 100 feet.

The shallow bedrock groundwater contour map (see Figure 6-4) shows a general flow to the southeast with minor south and southwest flow components. The gradient of the potentiometric surface is approximately 0.5 foot per 100 feet.

A comparison of the individual groundwater elevation values and contour maps of Site 13 reveals that the overburden water-bearing zone is recharged from infiltration of precipitation and snowmelt; this recharges the shallow bedrock zone, which in turn recharges the deep bedrock.

6.1.1.4 Site-Wide Contamination Distribution

Soil gas, subsurface soil, and groundwater samples were collected from Site 13 as part of RFI field activities. The purpose of this effort was to characterize the nature and extent of contamination that may have resulted from historic practices. Analytical results from Site 13 RFI sampling are summarized in Tables 6-1 and 6-2. These tables also provide a comparison to appropriate guidance values and/or standards. Monitoring well and soil boring locations are shown on Figure 6-1.

Soil Gas

Results of the soil gas survey indicate several VOCs are present in emissions from Site 13. Generally, low levels and limited distributions of TCE, PCE, BTEX, and TRPH compounds were detected at the site. Most of the soil gas response levels were considered low. The presence of PCE and TCE at elevated levels appear to be isolated occurrences, and do not represent significant contamination of soil or groundwater.

High soil gas response levels for BTEX and TRPH compounds were detected throughout the survey grid, with the highest levels present south of Building 904 and to the east of Building 912. The apparent migration of these soil gas plumes to the south and east is consistent with groundwater flow directions in the area (E & E 1995).

Subsurface Soils

A total of four subsurface soil samples were collected as part of RFI activities. These samples were collected from soil borings during the construction of wells MW13-2D, MW13-3D, and MW13-4D. Table 6-1 presents a summary of the RFI analytical results for soil samples. None of the samples contained VOCs above the NYSDEC TAGM 4046 guidance values used as screening benchmarks. Trace amounts of VOCs were detected (such as 1,2-DCE), but at levels well below the guidance values. Previous RI/FS samples did not contain VOCs at levels exceeding guidance values (SAIC 1991; GZA 1994).

The semivolatile compounds bis(2-ethylhexyl)phthalate, butylbenzylphthalate, and di-n-butylphthalate were detected in the soil samples, but at levels well below the guidance values. The presence of these compounds may be a result of field or laboratory contamination (i.e., the use of rubber gloves and tubing).

Zinc was the only metal that was detected above the upper limit of the 90th percentile; it exceeded the 90th percentile in three of the four Site 13 soil samples.

Groundwater

Fourteen unfiltered groundwater samples were collected from 13 monitoring wells at Site 13 during the RFI. RFI groundwater analytical results are summarized in Table 6-2. Several VOC compounds were present in four of the wells at levels that met or exceeded the Class GA groundwater standards, including benzene, cis-1,2-DCE, trans-1,2-DCE, TCE, and vinyl chloride. These compounds were found in samples from MW13-3, MW13-4D, MW13-5, and MW13-5D; RFI results are comparable with previous analytical data. Low concentrations of other VOCs were detected previously in the Site 13 wells; but the only other VOC detected during RFI sampling was toluene, which was present at a low level in MW13-5D.

None of the samples contained semivolatiles above the Class GA groundwater standards.

Lead and zinc were the only metals found to exceed Class GA groundwater standards in the wells; the presence of these analytes may be because the samples were unfiltered and contain suspended particulates, which have been demonstrated to contain elevated concentrations of naturally occurring inorganic materials.

6.1.1.5 Current and Potential Exposure Pathways

The current and potential pathways for contaminant migration to human health receptors, which will be addressed by the CMS, include the following:

- Ingestion/adsorption of soil by installation personnel; and
- Ingestion of groundwater by installation personnel.

Site 13 occupies a relatively small area and is partially paved; therefore, direct contact with site soil by base personnel is unlikely, except during excavation of subsurface soils during future construction activities. The installation currently uses a public drinking water supply, but groundwater at the Niagara Falls IAP-ARS could, theoretically, be used in the future for domestic purposes.

6.1.2 Establishment of Corrective Action Objectives

Contamination at Site 13 is present in soil and groundwater. CAOs were established for each medium through a comparison of observed concentrations to existing standards and guidance values. The site cleanup objectives were then used to identify areas requiring corrective action and to select/evaluate corrective action alternatives.

6.1.2.1 Soils

The soil guidance values presented in NYSDEC TAGM 4046, dated January 24, 1994, were evaluated as potentially applicable for determining soil cleanup objectives for the site soils. TAGM 4046 is a conservative approach to determining soil cleanup objectives; attainment of these generic soil cleanup objectives will, at a minimum, eliminate threats to human health or the environment posed by Site 13. Section 4.1.2.1 discusses the applicability of the TAGM soil cleanup objectives.

For most organic compounds, TAGM 4046 assigns recommended cleanup goals based on a generic model of contaminant migration to groundwater. This generic model may not apply to many sites, but Site 13 soil contaminants have also been detected in the groundwater. This fact, combined with the relatively shallow depth to groundwater, suggests that the TAGM 4046 guidance values would be suitable soil cleanup objectives for this site.

TAGM 4046 does not provide a soil cleanup objective for one contaminant of concern at Site 13: cis-1,2-dichloroethene. In this case, EPA Region III RBCs were used (see Section 4.1.2.1 for further discussion). The area occupied by the site has been classified for aircraft O & M and/or industrial use (USAF 1994). Therefore, the RBCs selected were for industrial soils; relevant RBC calculations are based on adult occupational exposure.

For metals, TAGM 4046 calls for the use of background levels as soil cleanup objectives. The background metals concentrations (except for cadmium) were determined using the upper limit of the 90th percentile of metals concentrations in eastern United States soils and other surficial materials (calculated from the data of Shacklette and Boerngen 1984). Cadmium data was not included in this study. For cadmium, the cleanup objective was determined from the maximum of the range of observed values published by Dragun (1988).

Table 6-3 lists all the contaminants detected during Site 13 soil sampling, the maximum concentration of each contaminant, and the associated soil cleanup objective. A site soil cleanup objective has been established for a contaminant if its maximum observed concentration was found to exceed the selected standard or appropriate guidance value.

The following conclusions have been made regarding Site 13 soil:

- Only one metal (zinc) exceeded the soil cleanup objectives during RFI sampling. Table 6-1 presents the frequency of exceedance for each metal. The bedrock of the base is Lockport dolomite. As discussed previously, the bedrock consists of ores that naturally contain zinc as well as other metals. Groundwater data is consistent with metals concentrations detected in soils. The presence of metals in the soil may be attributed to a naturally occurring source; therefore, corrective action for metals in Site 13 soils will not be addressed in the CMS.

- The semivolatile detections are all phthalates, which are typical laboratory contaminants. Furthermore, none exceeded candidate cleanup objectives. Therefore, they are not addressed in the CMS.

- No VOCs were detected above the soil cleanup objectives in Site 13 soils (E & E 1995). Therefore, soils do not require corrective action due to VOC contamination.

6.1.2.2 Groundwater

NYSDEC Class GA groundwater standards are used as the groundwater cleanup objectives for the Site 13 CMS. Although the groundwater at the installation is not currently used as a water supply source, it is suitable for use as potable water. NYSDEC Class GA standards are not available for nickel or total-1,2-DCE, Site 13 groundwater contaminants of concern. EPA Region III RBCs for tap water were used as groundwater cleanup objectives for these compounds. To calculate these guidance values, EPA Region III has combined the toxicity constants for each chemical with generic exposure scenarios to calculate chemical concentrations corresponding to a hazard quotient of 1 or lifetime cancer risk of 10^{-6}, whichever occurs at a lower level. The use of these groundwater cleanup objectives would eliminate potential threats to human health arising from use of site groundwater as a potable water supply.

Table 6-4 lists all of the contaminants detected, the maximum concentrations, and the groundwater cleanup objectives. A site cleanup objective has been established if a contaminant concentration exceeds the groundwater cleanup objective. Based on Table 6-4, the following conclusions can be made regarding Site 13 groundwater:

- During RFI sampling, only two metals (lead and zinc) exceeded the groundwater cleanup objectives. The frequency of exceedance is presented in Table 6-2. Lead and zinc also exceeded the cleanup objectives at an exceedance frequency of two and five samples, respectively, out of a total of six samples collected during the RI/FS and groundwater monitoring activities conducted at the site (SAIC 1991; GZA 1994). As discussed previously in Sections 4 and 5, lead and zinc are believed to be existing naturally at the installation. Chromium exceeded the site cleanup objections in earlier investigations only. However, metals concentrations in groundwater correlate with turbidity values measured during field sample collection at a 95% confidence level. Similar observations correlating turbidity with metals concentrations were reported during previous investigations. It appears that metals concentrations are attributable to the naturally occurring metals found in the suspended particulate clastic materials rather than site-related contamination. (Appendix B compares groundwater metals data from other sites on the installation and supports this view. Metals concentrations in filtered and unfiltered groundwater samples are also compared.) Thus, metals contamination of groundwater at Site 13 will not be addressed further in the CMS.

- Only one semivolatile compound, bis(2-ethylhexyl)phthalate, was detected in any of the groundwater samples. However, it was present at a concentration well below the Class GA groundwater standard and is a common sampling or laboratory-introduced contaminant. Semivolatiles were not detected previously in Site 13 groundwater. Therefore, no site cleanup objectives have been established for semivolatiles.

- RFI groundwater samples exceeded the NYSDEC Class GA groundwater standards for benzene, cis-1,2-dichloroethene, trans-1,2-dichloroethene, TCE, and vinyl chloride; exceedances were only found in four of the 13 wells. The highest contamination was present in samples from MW13-4D and MW13-5D (shallow bedrock wells), with minor contamination detected in samples from overburden wells MW13-3 and MW13-5. Contaminant concentrations exceeded the standards in nearly every sample where detected. During the RI/FS and groundwater monitoring at Site 13, the following additional VOCs exceeded the Class GA groundwater standards in one out of four samples collected: chlorobenzene, 1,2-dichlorobenzene, 1,4-dichlorobenzene, methylene chloride, toluene, and total xylenes. Site cleanup objectives for VOCs in Site 13 groundwater are listed in Table 6-4. VOCs exceedance at Site 13 will be addressed by appropriate corrective actions.

In some cases, it may not be technically feasible to attain through corrective actions the site groundwater cleanup objectives developed above. A well-designed corrective action system that has been operational for several years would initially achieve a decrease in groundwater contaminant concentrations. After a period of time, however, the concentration of contaminants might not decrease further. This condition, commonly referred to as "zero-slope," is often observed during corrective action implementation. Under such conditions, and if the groundwater contaminant concentrations are sufficiently low, the Base may petition the regulatory agencies for alternate concentration limits and a post-termination monitoring program. These issues are presented in detail in Section 6.4.

Corrective action appropriate for the contaminated groundwater at the site may consist of groundwater extraction, containment, in situ or ex situ treatment, and disposal. The applicable corrective measure technologies are identified and screened in Section 6.1.3.

6.1.3 Screening of Remedial Technologies

Potential remedial technologies were identified and described in Section 3 for the remediation of various media present at the Niagara Falls IAP-ARS. The purpose of this section is to examine each alternative in greater detail and to identify the CMAs that would be applicable to the remediation of Site 13 groundwater.

Each alternative was evaluated based on site, waste, and technology characteristics; this screening is used to eliminate undesirable and inapplicable technologies.

All of the alternatives were screened based on the following site-specific data:

- The majority of the contaminant source (subsurface soils) can be assumed to have been removed. No soil contamination was detected during the most recent sampling activities; therefore, it is assumed that the groundwater contaminant plume will not increase in concentration;
- All proposed technologies must be applicable for treating VOCs;
- A pump test was conducted at Site 13 in June 1995. Results of the pump test are presented in Appendix C.

Various physical and chemical properties of contaminants of concern that will be used during CMA analysis are summarized in Table 6-5 for all chemicals detected in Site 13 groundwater. For each corrective measure technology (CMT), the preliminary screening criteria have been evaluated for feasibility, and the CMTs have been either eliminated or retained for further consideration. Table 6-6 summarizes the screening process.

6.1.4 Selection of Corrective Measure Alternatives

Based on the technologies retained in the preceding section, the following CMAs have been selected for detailed analysis to address Site 13 groundwater contamination:

- **Alternative 1:** No action and natural attenuation;
- **Alternative 2:** Institutional controls and natural attenuation;
- **Alternative 3:** Groundwater collection via extraction wells, on-site treatment, and discharge to storm sewer;
- **Alternative 4:** Groundwater collection via extraction wells, and discharge to POTW; and
- **Alternative 5:** Groundwater extraction via subsurface drains, and discharge to POTW.

Certain treatment technologies retained in the previous section were not used in the development of potential CMAs. Carbon adsorption, which is effective in treating most of the organic contaminants of concern, has limited effectiveness in treating vinyl chloride, the most toxic compound detected at Site 13. Although vinyl chloride is removed by carbon, breakthrough is rapid and high carbon replacement costs are incurred. The observed turbidity of the groundwater would require, at a minimum, a filtering step to remove suspended solids prior to carbon adsorption treatment. Air stripping has been determined to be applicable in treating all VOCs of concern, including vinyl chloride, and can be designed to handle variable flow rates and concentrations. This technology is readily available and is a simpler option than other on- or off-site treatment technologies.

6.2 Evaluation of the CMAs

Five CMAs have been retained for consideration as stated in Section 6.1.4. Each CMA will be evaluated based on technical, environmental, human health, and institutional concerns. This evaluation is summarized in Table 6-13.

6.2.1 Alternative 1: No action and natural attenuation

This alternative provides no remedial action. However, natural attenuation is currently occurring at the site (as provided by degradation products such as cis-1,2-dichloroethene and vinyl chloride), and VOC contamination will be reduced over time. The rate of natural attenuation is unknown. Areas currently impacted by Site 13 contamination would continue to be exposed to the plume.

Technical Concerns

- **Effectiveness.** This alternative does not actively contain, divert, remove, treat, or destroy groundwater contamination which currently exists at Site 13. Natural attenuation processes may reduce contaminant concentrations over time, but it is not known when or if site CAOs would be met. This alternative can be implemented regardless of any future site changes.

- **Reliability.** The no-action alternative does not actively remediate the site. Therefore, contaminant pathways and receptors would continue to be impacted in the same manner unless influenced by a future change in site conditions.

- **Implementability.** No effort is required to implement the no-action alternative. The existing wells are suitable for groundwater monitoring.

- **Safety.** The only safety concerns with regard to the no-action alternative include those relevant to ongoing groundwater contamination (i.e., potential ingestion or personnel exposure during future installation activities).

Environmental Concerns

Because of low soil permeability at the site, the biodegradation processes currently occurring, and distance to the river, it is assumed that there are no long-term environmental impacts from Site 13 on the Niagara River.

Human Health Concerns

The no-action alternative does not provide protection to human health or the environment. Groundwater contamination currently exceeds NYSDEC Class GA groundwater standards; site CAOs would not be achieved in the short term by this alternative. Although groundwater at the installation is not currently used as a drinking water source, groundwater may be used in the future for residential purposes.

Institutional Concerns

The no-action alternative may reduce existing groundwater contamination through natural attenuation, but the estimated time frame is long. Currently, groundwater at Site 13 exceeds the NYSDEC Class GA groundwater standards.

Cost

The only costs associated with this alternative include a periodic groundwater monitoring program. It is assumed that the 13 existing monitoring wells would be sampled semi-annually under this program. There are no capital costs. The estimated present worth cost for Alternative 1 is $0.5 million. Table 6-7 provides a cost breakdown for this alternative.

Summary

The no-action alternative does not require effort to implement, and it will most likely not achieve Site 13 CAOs. This alternative does not provide protection to human health or the environment. This alternative is provided as a baseline for comparison to other CMAs. The impact of performing no action at Site 13 would be assessed through periodic groundwater monitoring.

6.2.2 Alternative 2: Institutional Controls and Natural Attenuation

Natural attenuation is the process by which organic compounds are reduced in toxicity or concentration in groundwater through biological and physical processes. Over time, it is natural attenuation may reduce TCE, vinyl chloride, and other VOCs to levels below Site 13 CAOs. In addition, institutional controls would be implemented at the site in the form of deed restrictions to prohibit the use of site groundwater as a drinking water source. This alternative also includes periodic groundwater monitoring in order to determine the extent to which natural attenuation has occurred and to provide data regarding contaminant plume migration.

Technical Concerns

- Effectiveness. The bedrock permeability in the vicinity of Site 13 is low, a factor which would likely reduce the rate of attenuation because of the decreased pore space. The compound TCE was detected in Site 13 groundwater, along with 1,2-DCE, its biodegradation product. 1,2-DCE is expected to degrade further to vinyl chloride, a significantly more toxic contaminant. Vinyl chloride has a more stringent CAO (2 μg/L) than either 1,2-DCE or TCE (both are 5 μg/L). Vinyl chloride can be expected to degrade further to ethene and chloride, which are not toxic. The estimated time frame to achieve site CAOs is dependent upon the degradation rate of vinyl chloride which appears to be the limiting factor in overall contaminant degradation. However, the effectiveness of the alternative is not expected to decrease with time.

- **Reliability.** This alternative requires minor O & M activities; following the implementation of deed restrictions, the existing semi-annual groundwater monitoring program would be suitable for use at Site 13. The existing monitoring wells are adequate for the initial phase of this task. It is anticipated that additional wells may be required to track the plume migration through the overburden and shallow bedrock aquifers. Although plume migration would be allowed to continue under this alternative, the subsurface soil conditions and the nature of the plume movement (vertical rather than lateral) are not expected to impact the Niagara River (E & E 1995).

- **Implementability.** There are no limiting site conditions that would prevent implementation of this alternative. Labor and materials required for groundwater monitoring are readily available. This alternative can be implemented immediately; natural attenuation can be assumed to be already in progress at Site 13, and historical analytical data (including RFI groundwater data) can be used to establish trends in degradation and dispersion. This information can then be used to assess the extent of the plume and the rate of attenuation.

- **Safety.** Groundwater at the installation and in surrounding areas is not used as a drinking water source; therefore, direct risk to human health is minimal. This alternative would allow the contaminant plume to spread across a larger area, but decrease in concentration. Therefore, in the short term, a larger area would be impacted. This may prove significant if future construction activities are planned at the installation at or near Site 13. Nearby communities that would potentially be impacted by this alternative would be prevented from direct exposure to hazardous substances (i.e., contaminated groundwater) in the future through the establishment of deed restrictions.

Environmental Concerns

Short-term effects of this alternative include the prevention of direct groundwater ingestion. Site 13 groundwater may continue to exceed CAOs for some time, depending upon the rate of attenuation. However, there are no environmentally sensitive areas near Site 13.

Human Health Concerns

The provision of deed restrictions would eliminate the potential for direct source contact throughout operation of this alternative. Based on RFI data, the most significant contaminants of concern include benzene, cis-1,2-DCE, TCE, and vinyl chloride. These are compounds whose maximum detected concentrations were greater than five times the Site 13 CAOs. The overburden well MW13-3 was determined to have contained the highest concentrations of these compounds during previous sampling activities. A comparison made of MW13-3 data over time is presented in Table 6-8.

Based on this data, benzene and TCE in MW13-3 have been reduced to levels below CAOs. The increase in cis-1,2-DCE concentration is likely attributable to contaminant migration and TCE degradation. Vinyl chloride levels have decreased significantly over time, and the threat to human health has also decreased. It is not known whether this alternative will reduce vinyl chloride concentrations to below the CAO of 2 μg/L in a reasonable time frame.

Institutional Concerns

As stated previously, Site 13 groundwater may continue to exceed CAOs in the early life of this alternative. Because the contaminant levels would exceed federal/state standards, deed restrictions need to be enforced until such time that groundwater monitoring consistently indicates that CAOs have been met.

Cost

Costs associated with this alternative include capital and O & M costs for semi-annual groundwater monitoring, as well as the installation of new monitoring wells, if required. The capital cost for the natural attenuation/institutional controls alternative is $9,000. O & M costs total $35,000 per year. It is estimated that the time required to achieve CAOs with this alternative is 30 years.

Therefore, the estimated present worth cost for Alternative 2 is $0.5 million. Table 6-9 provides a cost breakdown for the natural attenuation/institutional controls alternative.

Summary

Alternative 2 involves the process of natural attenuation, whereby organic contaminants are destroyed or degraded through microbiological processes. VOCs may be reduced to concentrations below CAOs over time. Deed restrictions are required to prohibit the use of Site 13 groundwater as a drinking water source. Attenuation rates would be measured during quarterly groundwater monitoring. The treatment time is difficult to estimate due to the low soil permeability and the variable subsurface soil conditions. Direct source contact would be prevented by this alternative. Plume migration may necessitate the installation of additional monitoring wells to track plume migration and concentration.

6.2.3 Alternative 3: Groundwater Collection via Extraction Wells/On-Site Treatment/Discharge to Storm Sewer

This alternative includes the extraction of contaminated groundwater using extraction wells installed in the aquifer impacted by the contaminant plume. One groundwater extraction well in the shallow bedrock would be installed under this alternative. The first groundwater extraction well would be installed at the location at the pump test well (PW13-1).

The pump test conducted at the site confirmed that the superimposing aquifer zones (i.e., overburden and the shallow bedrock) are hydraulically connected (see Appendix C for pump test results). The pump test that lasted for 16.5 hours, and a total drawdown of 0.7 foot was observed in the overburden well MW13-3. Because there is only a slight northeast flow in the overburden, groundwater flow in the overburden as far as well MW 13-5, could be reversed by extracting groundwater at PW13-1. In addition, results from the pump test indicate that the PW13-1 groundwater extraction location would be ideal for contamination extraction from the shallow bedrock in the former UST location. The groundwater extraction flow rate of approximately 0.7 gpm observed during the pump test is the recommended extraction rate.

The second groundwater extraction well location should be located near MW13-4D. VOC contamination detected in well MW13-4D can be attributed to contaminant transport through fractures, a characteristic of the shallow bedrock at the installation. Although, groundwater extraction at well PW13-1 could extract contaminated groundwater near well MW13-4D, it would not be effective in controlling further off-site plume migration. Therefore, by locating a groundwater extraction well near well MW13-4D, off-site contamination transport would also be minimized.

A pump test would have to be conducted to estimate optimum groundwater extraction rates. For the CMS, it is assumed that a groundwater extraction rate of 0.7 gpm (same as achieved in the pump test for well PW13-1) will be used. The locations of the proposed groundwater extraction wells are shown in Figure 6-6.

Following extraction, the groundwater would be treated on site via air stripping and then discharged to the storm sewer. Deed restrictions would also be implemented throughout the life of the project to prevent use of Site 13 groundwater as a drinking water source. Remedial progress of this alternative would be measured via periodic groundwater monitoring.

Technical Concerns

- **Effectiveness.** The use of multiple extraction well locations would provide accurate plume removal, and would optimize groundwater extraction rates. Extraction wells are a well-proven technology for groundwater collection. All of the VOCs present at the site are easily strippable. Site CAOs can be achieved using this technology. Shallow tray-type air strippers are suitable for use at the site, and have low capital/O & M costs. As a pretreatment step, groundwater would be run through a sand filtration system to remove suspended solids, thereby improving the efficiency of the air stripper. For the air stripper design, maximum VOC concentrations were used to provide a conservative estimate (see Appendix G). Site CAOs are the desired effluent concentrations because treated groundwater would be considered "clean" and could then be discharged directly to the storm sewer.

- **Reliability.** Extraction well locations would be determined based on pump test results. Groundwater monitoring would provide data regarding the contaminant plume; additional wells could be installed without interrupting remedial actions. Groundwater treatment via air stripping is a reliable technology; systems are designed to handle a variety of flow and VOC-loading conditions. The system can be designed to include a remote monitoring station to ensure proper operation. Future changes in site conditions can easily be accounted for in both extraction and treatment steps. The O & M requirements for this extraction/treatment system are straightforward, and the necessary equipment is widely available.

- **Implementability.** Extraction wells would need to be checked so as to minimize interference with subsurface utility lines, buildings, etc. Standard construction techniques would be used for well installation. An on-site treatment system, enclosed in a building for weather protection, would need to be installed at Site 13. This can be achieved in a period of a few weeks. This type of setup is easily achieved; power requirements could be satisfied by tapping into existing sources from nearby buildings (i.e., Building 905). Extraction wells could be connected by a main header, which then could be tied into the existing storm sewer lines. Preliminary design calculations indicate that the air stripper would remove VOCs from groundwater to non-detectable levels. Treated groundwater could then be discharged directly to the storm sewer which may require a SPDES permit. The off-gas from the air stripper is anticipated to meet the NYSDEC air quality standards, and therefore, are not expected to require treatment. Periodic groundwater discharge monitoring would be recommended to ensure achievement of CAOs. To estimate the time to achieve groundwater cleanup objectives, the following assumptions were made:

  - No residual contamination is present in soils;

- Based on the shallow groundwater depths observed in overburden wells at Site 13, the majority of the VOC contamination at Site 13 exists in the shallow bedrock extending over an approximately elliptic area of 190 feet by 75 feet. The assumed elliptic area of contamination is bounded by the wells MW13-4D and MW13-5. The depth of the shallow bedrock is assumed to be 15 feet; and

- The shallow bedrock would be purged twice to attain cleanup objectives.

Based on these assumptions, groundwater cleanup objectives can be attained within two years based on an groundwater extraction flow rate of 1.4 gpm. However, attainment of groundwater cleanup objectives may actually take longer due to lower groundwater extraction rates, adsorption of organics to soil materials, and the presence of denser-than-water non-aqueous phase liquids (DNAPLs). In some cases, groundwater contamination re-establishes itself after cleanup objectives have been attained. For costing purposes, it is estimated that groundwater would have to be extracted for a period of five years to attain site cleanup objectives. However, if it appears during the monitoring of the corrective action that contamination exists over a much larger area than is assumed above, additional investigation may be required to delineate the contaminant plume and to determine whether additional extraction wells need to be installed.

- **Safety.** Implementation of this alternative would pose a minimal threat to the area surrounding Site 13. Well construction activities would be conducted with installation notification/approval; health and safety procedures similar to previous well installation programs at the installation would be followed. Routine precautions would be required to be taken by O & M personnel. Sand filtration backwash would consist of solids slurry and require off-site disposal (possibly to the POTW).

Environmental Concerns

The use of extraction wells and air stripping would actively remediate the Site 13 groundwater to levels below CAOs. The treatment system would need to be designed to prevent exposures or releases of VOCs to the environment. There are no environmentally sensitive areas located in the vicinity of Site 13.

Human Health Concerns

Human health would be protected throughout the duration of Site 13 remediation by imposing deed restrictions prohibiting the use of the site groundwater for drinking. The groundwater can be remediated to levels below the NYSDEC Class GA groundwater standards; therefore, the threat to human health would be eliminated.

Institutional Concerns

Site 13 groundwater contamination would be reduced immediately following implementation of this alternative. Groundwater consumption would be restricted throughout remedial activities. Discharge criteria as required by a SPDES permit would need to be met. Off-gas from the air stripper is not expected to require treatment because the off-gas will not exceed NYSDEC air quality standards.

Cost

Capital costs include the design and installation of the groundwater collection/ treatment system and is estimated to be $126,000. The annual O & M costs consist of groundwater monitoring, discharge sampling, and air stripper maintenance. The annual O & M costs total approximately $44,000.

The present worth cost for Alternative 3 is $0.3 million. Table 6-10 provides a cost breakdown for all costs associated with this alternative.

Summary

Alternative 3 consists of contaminated groundwater collection by the use of extraction wells, followed by on-site treatment through air stripping, then discharge to the installation storm sewer. As with the previous alternative, Site 13 groundwater would not be used as a potable water supply until such time that the NYSDEC Class GA groundwater standards are consistently met. The treatment technology can easily achieve site CAOs within approximately 5 years. Health and safety protocol is required due to the O & M tasks associated with the handling of groundwater.

6.2.4 Alternative 4: Groundwater Collection via Extraction Wells/Discharge to POTW

Under this alternative, contaminated groundwater at Site 13 would be withdrawn using a series of shallow wells installed in the aquifer near the contaminant plume. Extraction well locations would be the same as proposed for Alternative 3. Extracted groundwater would then be discharged to the sanitary sewer under conditions specified by the NCSD. Human health concerns would be addressed through the implementation of deed restrictions; this alternative also includes periodic groundwater monitoring to measure the progress of remedial actions until CAOs are met.

Technical Concerns

- **Effectiveness.** Effectiveness of groundwater extraction by wells was discussed in Section 6.2.3. Disposal of extracted groundwater to POTW would afford effective treatment and disposal. NCSD has been accepting groundwater from other facilities contaminated with similar organics as found at Site 13. This alternative would reduce concentrations to levels below CAOs over time; in the interim, Site 13 groundwater would not be used for drinking water.

- **Reliability.** This alternative requires minimal O & M activities. System inspections would be conducted concurrently with groundwater monitoring to ensure that extraction rates are acceptable. Equipment and materials required for this alternative can be easily obtained. It is expected that this alternative would produce noticeable results immediately following implementation. The extraction wells can be used to provide additional data regarding contaminant plume migration over time, including the effects of any future site changes. Additional extraction wells could be installed if needed at minimal additional capital cost.

- **Implementability.** Extraction well locations would need to be selected after taking into account any subsurface utility lines and/or building foundations. Standard construction techniques would be used for well installation. Health and safety design concerns would need to be addressed in order to minimize contaminant exposure and release. All wells could be connected to a main header for ease of operation and connection to sewer lines. All discharge operations would be conducted pending approval by the NCSD. Effluent sampling will be conducted as required by the permit. It is expected that the NCSD would accept untreated groundwater from Site 13 because of the low flow rates and low concentrations. The physical contaminant removal rate achieved through extraction wells is faster than rates of natural attenuation. Groundwater analytical data can be easily obtained from the existing monitoring wells, in addition to the extraction wells. The estimated time to attain groundwater cleanup objectives could be the same as for Alternative 3, that is 5 years.

- **Safety.** This alternative would pose a minimal threat to the area surrounding Site 13. Well construction activities would be conducted with installation notification/approval; health and safety procedures similar to previous well installation programs at the installation would be followed.

Environmental Concerns

The use of extraction wells would actively remove groundwater contamination at Site 13 to levels below CAOs. It would be necessary to implement safety measures to prevent release/exposure of VOCs (especially vinyl chloride) during groundwater collection, pumping, O & M, sampling, or discharge. The use of self-contained pumps and a closed transfer system would prevent adverse environmental effects. There are no environmentally sensitive areas located in the vicinity of Site 13.

Human Health Concerns

Deed restrictions would prevent groundwater ingestion during the life of this alternative. Over time, contaminant concentrations would be reduced to lower levels (below CAOs). Extraction well installation is not expected to impact human health; all remediation personnel would follow proper health and safety procedures.

Institutional Concerns

Site 13 groundwater contamination would continue to exceed CAOs in the early life of this alternative; as mentioned previously, restrictions on groundwater consumption would mitigate exposure to installation personnel and the public. Sampling would be conducted as required by the NCSD to meet discharge criteria. Deed restrictions would not be lifted until such time that Site 13 groundwater contamination is fully remediated.

Cost

Costs associated with this alternative include capital and O & M costs for the installation of an extraction well/collection system, quarterly groundwater monitoring, as well as the installation of new wells, if required. The capital costs for the extraction wells/POTW discharge alternative is $75,000. O & M costs total $43,000 per year.

The present worth cost for Alternative 4 is $0.26 million. Table 6-11 provides a cost breakdown for all costs associated with this alternative.

Summary

Alternative 4 includes the collection of contaminated groundwater by extraction wells, followed by discharge to a POTW in accordance with the installation's SPDES permit. This alternative also includes deed restrictions to limit the use of Site 13 groundwater, and quarterly groundwater monitoring to assess remediation progress. Feasibility of this alternative is dependent upon approval by NCSD to accept Site 13 discharge. It is expected that the site CAOs would be achieved after 5 years. Personnel health and safety protocol would need to be followed to mitigate health threats associated with the handling of groundwater.

6.2.5 Alternative 5: Groundwater Extraction via Subsurface Drains/Discharge to POTW

Under this alternative, subsurface drains would be used to collect contaminated groundwater from Site 13 by gravity flow, after which the groundwater would be discharged to the local POTW for disposal. The purpose of this technique is to physically remove the contaminant plume from the site while minimizing the threat to human health. Deed restrictions would be required to prevent the use of Site 13 groundwater as a drinking water source until CAOs were met.

This alternative also includes periodic groundwater monitoring in order to determine the extent to which contaminant removal has occurred and to provide data regarding plume migration.

Technical Concerns

- **Effectiveness.** Two shallow trenches are proposed (see Figure 6-7): one in the vicinity of the former source area and one in the vicinity of MW13-4. The trenches would be installed into bedrock. The cross section of plume intercepted by a trench is much greater than the zone of influence from an extraction well and is expected to maximize retrievable volumes. Placement of the subsurface drains would allow the site CAOs to be achieved in a shorter period of time. The soil permeability is higher in the area of former UST excavation, which would allow the source area to be remediated first. Existing subsurface conduits may cause the formation of preferential contaminant transport pathways; this could affect the placement of the drain system. This alternative is based on simple technologies and utilizes readily available materials. Proper O & M procedures would minimize the need for replacement of equipment and/or materials during project life. It is anticipated that the CAOs would be met before any damage/degeneration of the drain system.

- **Reliability.** This alternative requires minor O & M activities. After the drain system has been put into operation, periodic inspections would be required to verify proper pump operation and ensure integrity of the sump. Operation of the system would be controlled by float-level alarm switches installed in the sump. In the case of system failure, contaminated groundwater would remain in the vicinity of the trench. Following the implementation of deed restrictions, the semi-annual groundwater monitoring program would be suitable for use at Site 13. The existing monitoring wells are adequate for this task. It is anticipated that additional wells may be required to track the plume migration through the overburden and shallow bedrock aquifers.

- **Implementability.** There are several limiting site conditions that would affect implementation of this alternative. Installation of the subsurface drain system would be accomplished using standard construction techniques. Most of Site 13 is covered with asphalt; the collection system would be designed to minimize pavement removal. All subsurface utilities would need to be located prior to excavation activities. Because the trenches would be installed in areas of known contamination, stringent health and safety precautions would be required to prevent personnel exposure to TCE or vinyl chloride. All activities would require coordination with the installation to acquire appropriate permits. Labor and materials required for the subsurface drain system and groundwater monitoring are readily available. The installation of the drain system can be achieved in a reasonable time frame. Pending approval for discharge to the POTW (Niagara County Sewer District), remedial actions would be initiated immediately following system start-up. A subsurface trench would maximize groundwater retrieval volumes, and theoretically, using a trench would take less time to achieve site cleanup objectives as compared to groundwater extraction wells. However, trenches at the site would be installed in the shallow bedrock which is a fractured bedrock system. The volumes of groundwater that could be extracted would depend on the number of fractures intercepted by the trench along its length. Because no such specific information is available, for costing purposes it is assumed that the time to achieve site cleanup objectives would be same as for groundwater extraction by wells, that is 5 years.

- Safety. Under this alternative, construction activities are planned at Site 13. Appropriate notification to installation management will be required in order to coordinate activities. An exclusion zone would need to be established around the excavation areas to prevent unauthorized entry. All construction personnel would be required to follow health and safety protocol during installation of the system because of its proximity to the contaminant source areas. Scheduling concerns may also include optimizing time periods of limited base activities at or near Site 13, and installing the trench during low-temperature months to reduce volatilization rates. Nearby communities that would potentially be impacted by this alternative would be prevented from direct exposure to hazardous substances (i.e., contaminated groundwater) through the establishment of deed restrictions.

Environmental Concerns

Using this alternative, Site 13 groundwater contamination will be removed over time via a subsurface trench system. Contaminant concentrations will be reduced to below site CAOs. The installation of this system necessitates the excavation of a trench, which would expose subsurface soils to the surface environment. All of the VOCs have high volatility rates; however, due to the relatively small exposed area, and the short duration that the excavation would remain open, the impact on the surrounding area would be minimal.

As groundwater extraction activities progress, the concentrations are expected to decrease, thereby reducing any threat to the vicinity. There are no environmentally sensitive areas near Site 13.

Human Health Concerns

An increased risk to human health would be introduced for the short term during this alternative. The most significant risk would be to remediation personnel; the potential for dermal contact, inhalation, or ingestion of contamination is highest during trench excavation and placement of drainage piping. All personnel will follow established health and safety regulations with regards to personnel protective clothing, work precautions, respiratory protection, and other related matters.

The provision of deed restrictions would eliminate the potential for direct source contact during operation of the drainage system. Monitoring activities will also follow standard health and safety procedures. Site 13 groundwater contamination will decrease over time to levels below CAOs, thereby eliminating threats to human health.

Institutional Concerns

As stated previously, Site 13 groundwater may continue to exceed CAOs in the early stage of this alternative. Of significant concern is the exposure of subsurface soil and groundwater to the atmosphere during installation activities. All activities would be approved and permitted as necessary by the installation. Because the contaminant levels would exceed federal/state standards, deed restrictions need to be enforced until such time that groundwater monitoring consistently indicates that CAOs have been met.

Cost

Costs associated with this alternative include capital and O & M costs for subsurface drain system construction and operation, quarterly groundwater monitoring, as well as the installation of new monitoring wells, if required. The estimated capital costs for the subsurface drains/POTW discharge alternative is $106,000. O & M costs total $44,000 per year. It is estimated that the time required to achieve CAOs with this alternative is 5 years.

The present worth cost for Alternative 5 is $0.3 million. Table 6-8 provides a cost breakdown for all costs associated with this alternative.

Summary

Alternative 5 involves the collection of contamination in the overburden and shallow aquifer by a subsurface drainage system, followed by discharge to a POTW in accordance with the installation's SPDES permit. VOCs would be reduced to concentrations below CAOs. Deed restrictions are required to prohibit the use of Site 13 groundwater as a drinking water source. Groundwater removal rates would be measured during semi-annual groundwater monitoring. Health and safety measures would be required during installation of this alternative. Direct source contact would be prevented by this alternative.

6.3 Recommendations and Justification of Corrective Measures

6.3.1 Selection of Recommended CMA

Based on the detailed analysis of the Site 13 CMAs presented in Section 6.2, Alternative 4 has been recommended for use as a corrective measure for the remediation of contaminated groundwater. Table 6-13 summarizes the evaluation of each CMA for suitability at Site 13, and provides the rationale for selection of the recommended CMA.

6.3.2 Justification of the Selected CMA

The no-action alternative is not feasible because it provides no protection to human health or the environment, and does not achieve site CAOs. Alternative 2 (Natural Attenuation) may provide short-term protection through deed restrictions preventing groundwater usage, but the rate at which Site 13 contaminants may be attenuated is unknown.

The three extraction alternatives (Alternatives 3, 4, and 5) have proven effective in remediating contaminated groundwater. Alternative 3 may require an SPDES permit. Alternatives 4 and 5 are dependent upon approval from the NCSD. Each alternative will achieve Site 13 CAOs over time; however, the installation of subsurface trenches poses a significantly higher risk to human health during excavation than extraction wells. The presence of vinyl chloride and other VOCs necessitates implementation of safety measures to prevent/reduce airborne emissions. Extraction wells require less complex O & M activities than subsurface drains, and can be installed at a lesser cost. Future changes in site conditions may cause changes in the groundwater contaminant plume; design modifications to accommodate these changes are more easily accomplished by extraction wells than by subsurface drains.

Alternatives 3 and 4 both rely on optimal extraction rates, which can be improved by using multiple wells. The O & M activities associated with air stripping (Alternative 3) are more involved than Alternative 4. It is expected that the NCSD would accept untreated groundwater based on similar concentrations and contaminants associated with groundwater accepted from other nearby sites (see Appendix E).

Therefore, Alternative 4 (Groundwater Collection via Extraction/Wells/Discharge to POTW with Monitoring and Institutional Controls) is recommended for use in the restoration of Site 13.

6.4 Performance Monitoring Program

In order to evaluate the effectiveness of the pumping system for the selected CMA, Performance goals and preliminary requirements for hydraulic and chemical monitoring have been developed for Site 13. This program will include the following:

- The performance goal for the selected CMA at Site 13 is to attain a 50% or more removal of contamination within two years from the actual start up of the corrective system.
- To demonstrate the capture zone of the corrective action system, hydraulic monitoring will be conducted on a weekly basis for the first month of the system's operation and monthly thereafter for the following two years, followed by semi-annual monitoring. Hydraulic monitoring will be performed at selected wells at the site.
- For the first year of operation, chemical monitoring will be performed on a monthly basis at the system effluent and on a semi-annual basis at selected wells at the site. Subject to an evaluation of the system's performance and NYSDEC's approval, the system effluent sampling could eventually be cut back to a quarterly and then a semi-annual basis.

For Site 13, the Base may petition the agencies to terminate the groundwater extraction system if (1) the groundwater extraction system is functioning as designed, and (2) the groundwater contamination levels are above the NYSDEC Class GA standards, but the levels are not declining any further. This "zero-slope" condition will be determined as follows:

1. The sum of the concentration of hazardous waste constituents resulting from eight consecutive quarterly sampling events will be plotted versus time.
2. If the curve that best fits these data points is linear, a straight line will be fitted to the data through the use of a least squares regression model; the slope of the fitted curve will be computed and designated as the estimated slope.

3. If the data points fit a non-linear form, an exponential curve will be fitted to the data through the use of a least squares regression model. The estimated slope will be the first derivative of the curve at a value of time halfway between the last two sampling points.

4. The estimated slope shall be considered zero if that slope is less than or equal to zero (i.e., the concentration is stable) or the yearly decrease of the total concentration of hazardous waste constituents is less than the average overall precision of the analytical methods used.

In addition, the spatial and temporal distributions of the concentrations of compounds will be assessed to provide additional information regarding. If these concentrations are sufficiently low, the Base may petition the agencies for permission to terminate the groundwater extraction system and propose a post-termination monitoring program. However, the groundwater extraction system would remain in place during the post-termination monitoring period. The purpose of the post-termination monitoring program will be to demonstrate to the agencies that the groundwater contamination levels remain sufficiently low and are in a "zero-slope" condition.

Table 6-1

SUMMARY OF RFI SOIL SAMPLING ANALYTICAL RESULTS IRP SITE 13 NIAGARA FALLS IAP-ARS

Analyte	Detection Frequency	Range Detected		Guidance Value[a]	Exceedance Frequency
		Minimum	Maximum		
Metals (mg/kg)					
Arsenic	4/4	0.80	3.6	16	0/4
Cadmium	1/4	ND	1.4	7[b]	0/4
Chromium, total	4/4	4.0	18	112	0/4
Copper	4/4	11	24	48.7	0/4
Lead	4/4	7.8	30	33	0/4
Nickel	4/4	6.0	30	38.2	0/4
Zinc	4/4	76	550	104	3/4
VOCs (µg/kg)					
1,1,2,2-Tetrachloroethane	1/4	ND	1.9	600	0/4
Acetone	3/4	14	19	200	0/4
cis-1,2-Dichloroethene	3/4	1.6	88	NV	—
trans-1,2-Dichloroethene	2/4	3.4	5.4	300	0/4
Semivolatiles (µg/kg)					
bis(2-Ethylhexyl)phthalate	4/4	39	150	50,000	0/4
Butylbenzylphthalate	1/4	ND	38	50,000	0/4
Di-n-butylphthalate	1/4	ND	120	8,100	0/4

a Metal guidance values are based on upper limit of the 90th percentile as calculated from the data of Shacklette and Boerngen 1984, except as noted. Guidance values for organics are based on TAGM 4046 (NYSDEC 1994).

b Upper end of cadmium range as stated in Dragun 1988.

Key:

ND = Not detected.
NV = No applicable value.

Table 6-2

SUMMARY OF RFI GROUNDWATER SAMPLING ANALYTICAL RESULTS
IRP SITE 13
NIAGARA FALLS IAP-ARS

Analyte	Detection Frequency	Range Detected (μg/L) Minimum	Range Detected (μg/L) Maximum	NYSDEC Class GA Groundwater Standards[a]	Exceedance Frequency
Metals					
Arsenic	2/14	5.2	11	25	0/14
Chromium, total	3/14	11	41	50	0/14
Copper	2/14	22	31	200	0/14
Lead	8/14	5.7	26	25	1/14
Nickel	3/14	24	51	NV	—
Zinc	13/14	12	1,400	300	5/14
VOCs					
Benzene	1/14	ND	5	0.7	1/14
cis-1,2-Dichloroethene	5/14	3	220	5.0	4/14
Toluene	1/14	ND	2	5.0	0/14
trans-1,2-Dichloroethene	3/14	2	13	5.0	2/14
Trichloroethene	3/14	5	30	5.0	3/14
Vinyl chloride	3/14	26	300	2.0	3/14
Semivolatiles					
bis(2-Ethylhexyl)phthalate	1/14	ND	3	50	0/14

[a] NYSDEC 1993.

Key:

ND = Not detected.
NV = No applicable value.

Table 6-3

SOIL CLEANUP OBJECTIVES
IRP SITE 13
NIAGARA FALLS IAP-ARS

Contaminant	NYSDEC TAGM 4046 Soil Cleanup Objective	EPA Region III RBC[a]	Candidate Cleanup Objective	Maximum Concentration Detected	Site Cleanup Objective
Metals (mg/kg)					
Arsenic	16	610	16	3.6	NA
Cadmium	7[b]	1,000	7	1.4	NA
Chromium, total	112	10,000	112	18.2	NA
Copper	48.7	76,000	48.7	24	NA
Lead	33	—	33	30	NA
Nickel	38.2	41,000	38.2	35.9	NA
Zinc[c]	104	610,000	104	550	104
VOCs (µg/kg)					
Acetone	200	2×10^8	200	60	NA
cis-1-2,-Dichloroethene	—	2×10^7	2×10^7	88	NA
Methylene chloride	100	7.6×10^5	100	20	NA
1,1,2,2-Tetrachloroethane	600	29,000	600	1.9	NA
trans-1,2-Dichloroethene	300	4.1×10^7	300	5.4	NA
Semivolatiles (µg/kg)					
bis(2-Ethylhexyl)phthalate	50,000	4.1×10^5	50,000	400	NA
Butylbenzylphthalate	50,000	4.1×10^8	50,000	38	NA
Di-n-butylphthalate	8,100	—	8,100	120	NA

Note: Cleanup objectives for metals are based the upper limit of the 90th percentile as calculated from the data of Shacklette and Boerngen, except as noted.

[a] EPA Region III RBC dated March 1995.
[b] Upper limit of observed range for cadmium as stated in Dragun 1988.
[c] Does not warrant corrective measure because of the low frequency of detection and/or its presence is believed to be naturally occurring or not attributable to site-related activities.

Key:

NA = Not applicable; maximum concentration detected does not exceed candidate cleanup objective.

Table 6-4

GROUNDWATER CLEANUP OBJECTIVES
IRP SITE 13
NIAGARA FALLS IAP-ARS

Contaminant	NYSDEC Class GA Groundwater Standards	EPA Region III RBC	Candidate Cleanup Objective	Maximum Concentration Detected	Site Cleanup Objective
Metals (μg/L)					
Arsenic	25	11	25	15	NA
Chromium, total[a]	50	180	50	100	50
Copper	200	1,400	200	112	NA
Lead[a]	25	—	25	102	25
Nickel	—	730	730	125	NA
Zinc[a]	300	11,000	300	1,400	300
VOCs (μg/L)					
Benzene	0.7	0.36	0.7	5.0	0.7
Carbon tetrachloride	5.0	0.16	5.0	0.21	NA
Chlorobenzene	5.0	39	5.0	9.1	5.0
Chloroethane	5.0	8,600	5.0	0.34	NA
Chloroform	7.0	0.15	7.0	0.36	NA
cis-1,2-Dichloroethene	5.0	61	5.0	220	5.0
1,2-Dichlorobenzene	4.7[b]	370	4.7	3.6	4.7[b]
1,3-Dichlorobenzene	5.0	540	5.0	1.1	NA
1,4-Dichlorobenzene	4.7[b]	0.44	4.7	9.7	4.7[b]
1,2-Dichloroethane	5.0	0.12	5.0	2.3	NA
Ethylbenzene	5.0	1,300	5.0	3.6	NA
Methylene chloride	5.0	4.1	5.0	160	5.0
Toluene	5.0	750	5.0	15	5.0
total-1,2-Dichloroethene	—	55	55	4.1	NA
trans-1,2-Dichloroethene	5.0	120	5.0	13	5.0
1,1,1-Trichloroethane	5.0	1,300	5.0	0.64	NA
Trichloroethene	5.0	1.6	5.0	30	5.0

Key at end of table.

Table 6-4

GROUNDWATER CLEANUP OBJECTIVES
IRP SITE 13
NIAGARA FALLS IAP-ARS

Contaminant	NYSDEC Class GA Groundwater Standards	EPA Region III RBC	Candidate Cleanup Objective	Maximum Concentration Detected	Site Cleanup Objective
Vinyl chloride	2.0	0.019	2.0	1,600	2.0
Xylenes, total	5.0	12,000	5.0	7.6	5.0
Semivolatiles (µg/L)					
bis(2-Ethylhexyl)phthalate	50	4.8	50	3.0	NA

Note: EPA Region III RBC values are for tap water criteria.

[a] Does not warrant corrective measure because of the low frequency of detection and/or its presence is believed to be naturally occurring or not attributable to site-related activities.
[b] Refers to sum of 1,2-Dichlorobenzene and 1,4-Dichlorobenzene.

Key:

NA = Not applicable; maximum concentration detected does not exceed candidate cleanup objective.
— = Data not available.

Table 6-5

PHYSICAL AND CHEMICAL PROPERTIES OF GROUNDWATER CONTAMINANTS
IRP SITE 13
NIAGARA FALLS IAP-ARS

Compound	Molecular Formula	Molecular Weight	Water Solubility (mg/L)	Vapor Pressure (mm Hg)	Henry's Law Constant (atm-m^3/mol)	Log K_{ow}
Benzene	C_6H_6	78.11	1,780	76	5.43×10^{-3}[a]	2.13
Chlorobenzene	C_6H_5Cl	112.56	490	8.8	3.46×10^{-3}[a]	2.84
cis-1,2-Dichloroethene	CHCl:CHCl	96.95	3,500	200[a]	7.5×10^{-3}[a]	1.86
1,2-Dichlorobenzene	$C_6H_4Cl_2$	147.01	100	0.96	1.88×10^{-3}[a]	3.38
1,4-Dichlorobenzene	$C_6H_4Cl_2$	147.01	80	0.60	1.58×10^{-3}[a]	3.39
Methylene chloride	CH_2Cl_2	84.94	13,200	350	2.57×10^{-3}[a]	1.25
Toluene	$C_6H_5CH_3$	92.13	515	22	6.61×10^{-3}[a]	2.73
trans-1,2-Dichloroethene	CHCl:CHCl	96.95	6,300	265	6.6×10^{-3}[a]	2.09
Trichloroethene	Cl_2C:CHCl	131.40	1,000	58.7	8.92×10^{-3}[a]	2.42
Vinyl chloride	CH_2:CHCl	62.50	1,100	2,300	6.95×10^{-1}	0.60
m-Xylene	$C_6H_4(CH_3)_2$	106.16	200	9	6.91×10^{-3}[a]	3.20
o-Xylene	$C_6H_4(CH_3)_2$	106.16	170	7	4.94×10^{-3}[a]	3.12
P-Xylene	$C_6H_4(CH_3)_2$	106.16	198[a]	9	7.01×10^{-3}[a]	3.15

Notes: Values are presented at 20°C unless otherwise specified. Molecular formulas/weights are from Perry's Chemical Engineers' Handbook, 6th edition.

[a] Value listed is at 25°C.

Source: USEPA 9902.3-1a, Corrective Action Glossary, July 1992.

Table 6-6

PRELIMINARY SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES
IRP SITE 13 GROUNDWATER
NIAGARA FALLS IAP-ARS

Corrective Measure Technology (CMT)	Preliminary Screening Criteria			Retain Status? (Y/N)
	Site Characteristics	Waste Characteristics	Technology Limitations	
Extraction wells	Given that the extent of the contaminant is small and relatively localized, extraction wells would be suitable for the recovery of Site 13 groundwater. A pump test conducted at the site has shown that groundwater yield from the Site 13 wells is low and may not allow efficient recovery without the installation of multiple wells.	Site contaminants are soluble and can be extracted with groundwater.	Groundwater extraction by extraction wells is a well-established technology.	Yes
Subsurface drains	Complex hydrogeology and presence of preferential pathways of contaminant transport through bedrock fractures favors the use of subsurface drains. The presence of contamination in the shallow bedrock aquifer necessitates installation of the trench into bedrock, which may cause additional bedrock fracturing and extend the contaminant plume. Low soil permeabilities at the site may be overcome by the use of drains as opposed to extraction wells.	Site contaminants are soluble and could be extracted by collecting groundwater in the drains.	Groundwater extraction by subsurface drains is a well-established technology. However, because the contaminant plume is located partially in bedrock, trenches would require more time to excavate and may create larger fractures, which would limit effectiveness of the technology.	Yes

Table 6-6

PRELIMINARY SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES
IRP SITE 13 GROUNDWATER
NIAGARA FALLS IAP-ARS

Corrective Measure Technology (CMT)	Preliminary Screening Criteria: Site Characteristics	Preliminary Screening Criteria: Waste Characteristics	Preliminary Screening Criteria: Technology Limitations	Retain Status? (Y/N)
Horizontal wells	Horizontal wells are usually installed where plumes are large in areal extent and linear in confirmation. The site impact area is relatively small, and the proximity of buildings and subsurface utility lines make this infeasible.	Same as for extraction wells and subsurface drains.	Relatively new technology.	No
Subsurface containment (slurry walls, liner panel walls, jet grouting, sheet piling)	For this technology, it is important that vertical containment systems are keyed into a low permeability geologic formation, a condition not present at the site. In addition, the clay-like nature of the soil already limits groundwater movement and would inhibit groundwater extraction.	Because contamination extends into shallow bedrock, subsurface containment would be ineffective.	Technology cannot be implemented into bedrock aquifers.	No
Biological treatment	Based on the pump test conducted at the site, a maximum flow rate of 0.6 gpm could be achieved on an intermittent basis.	Chlorinated organics have not been well-demonstrated to be treated by this technology.	Biological treatment is a well-established technology. There are more extensive O&M requirements associated with biological treatments than with other technologies under consideration.	No
Carbon adsorption	Carbon adsorption systems can be operated under a variety of site conditions.	Most site contaminants can be effectively removed by carbon adsorption, with the exception of vinyl chloride. This technology may require pretreatment such as suspended solids removal.	Carbon adsorption is a well-established technology.	Yes

Table 6-6

PRELIMINARY SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES
IRP SITE 13 GROUNDWATER
NIAGARA FALLS IAP-ARS

Corrective Measure Technology (CMT)	Preliminary Screening Criteria			Retain Status? (Y/N)
	Site Characteristics	Waste Characteristics	Technology Limitations	
Air stripping	Based on the pump test conducted at the site, a maximum flow rate of 0.6 gpm could be achieved on an intermittent basis.	The majority of site contaminants can be stripped. A polishing stage (i.e., carbon adsorption) may be required to meet discharge criteria.	Air stripping is a well-demonstrated technology.	Yes
UV/Ozonation	Based on the pump test conducted at the site, a maximum flow rate of 0.6 gpm could be achieved on an intermittent basis.	All contaminants present except for methylene chloride are amenable to this technology.	UV/ozonation is a well-demonstrated technology. However, other amiable technologies (such as airstripping and carbon adsorption) are equally as effective yet simpler and potentially cheaper.	No
Wet air oxidation	Based on the pump test conducted at the site, a maximum flow rate of 0.6 gpm could be achieved on an intermittent basis.	The relatively low concentrations of contaminants and the aqueous matrix promote other simpler, more reliable technologies (i.e., carbon adsorption, air stripping)	This technology requires skilled operator attention and has high O & M requirements.	No
Ion exchange	Ion exchange can be used in unsteady flow and influent concentration conditions.	Ion exchange will not treat organic species at the site, but it can be used as pretreatment or as a polishing stage to meet treated effluent discharge criteria.	Relatively simple to operate and maintain. Concentrated waters produced during regeneration will require additional treatment and disposal.	Yes
Membrane separation	Intermittent operating conditions may render the system difficult to perform efficiently.	Site contaminants can be treated by membrane separation.	Technology is not well-demonstrated for organics separation at hazardous waste sites, and is more suited to higher concentration waste streams.	No

Table 6-6

**PRELIMINARY SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES
IRP SITE 13 GROUNDWATER
NIAGARA FALLS IAP-ARS**

Corrective Measure Technology (CMT)	Preliminary Screening Criteria			Retain Status? (Y/N)
	Site Characteristics	Waste Characteristics	Technology Limitations	
Filtration	Filtration performs effectively under variable flow conditions expected at site.	Multi-media filtration or bag filtration may be required to effectively separate a wide range of clay, soil, and metals precipitate particle sizes.	Filtration is a well-established technology. Separated solids may be considered to be hazardous waste.	Yes
Sedimentation	Sedimentation does not perform effectively under variable flow conditions.	Fine particle size solids or metals precipitates may also require coagulation/ flocculation.	Sedimentation is a well-established technology.	No
Precipitation/ coagulation/ flocculation	This technology does not perform effectively under variable site conditions.	This technology is not applicable for organics. Expected metals concentrations are much lower than what is typically treated by this method.	Well-established technology.	No
In situ bioremediation	Highly heterogeneous subsurface conditions would make the implementation of this technology difficult.	Chlorinated species present in site groundwater can be biodegraded (natural biodegradation may be occurring currently at the site).	May require addition of cosubstrates that may be restricted by regulations. Cosubstrate addition may be difficult/ineffective due to the heterogenous subsurface conditions.	No
Air sparging	Location of plume in bedrock limits applicable of this technology.	This technology is applicable for the treatment of VOCs. However, volatilized contaminants in the air extraction well may require treatment prior to venting.	Air sparging is a well-established technology.	No
Passive treatment walls	These would be difficult if not impossible to install in bedrock.	High volatility of site contaminants may cause releases during treatment.	Concentrated contaminant levels may be retained in the wall and require additional treatment.	No

Table 6-6

PRELIMINARY SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES
IRP SITE 13 GROUNDWATER
NIAGARA FALLS IAP-ARS

Corrective Measure Technology (CMT)	Preliminary Screening Criteria			Retain Status? (Y/N)
	Site Characteristics	Waste Characteristics	Technology Limitations	
Disposal at a TSDF	Based on contaminant species, expected concentrations, and low flow rates, other available disposal options (i.e., discharge to a POTW) would be easier to implement.	Extracted groundwater may be classified as hazardous waste because of its vinyl chloride concentrations; therefore, manifests may be required. Concentrations of vinyl chloride are expected to decrease over time.	Technology is well-developed. A RCRA permitted TSDF is located close to the site. High O & M requirements are associated with this option.	No
Discharge to surface water	A surface water body (Cayuga Creek) is located a short distance from the site. However, discharge to a POTW would be easier to implement.	Organics present in the groundwater require treatment prior to disposal, and may include other limitations (pH, solids concentrations).	Technology is well-developed and implemented.	No
Reinjection to groundwater	Complex, heterogeneous subsurface site conditions would make this option difficult to implement. Several simple alternatives exist.	Same as above; it is expected that discharge limits for reinjection are more stringent than discharge limits to a POTW.	Technology is well-developed and implemented.	No
Discharge to POTW	A number of manholes exist close to the site that can be used for discharge of extracted groundwater.	Similar organic species present in site groundwater have previously been accepted by the Niagara County Sewer District (NCSD)	Technology is well-developed and implemented; prior approval is required from NCSD.	Yes

TABLE 6-7
IRP Site 13

Costs for Alternative 1
No Action/Natural Attenuation with Monitoring

Interest rate	6.0%
Operation and Maintenance (years)	30
Legal, Administrative, & Eng. Fees	25.0%
Contingencies	20.0%

Item No.	Description	Quantity	Units	Unit Cost	Cost
CAPITAL COSTS					
	TOTAL CAPITAL COSTS				$0
OPERATION & MAINTENANCE COSTS					
1	Groundwater sample collection	26	EA	$250	$6,500
2	VOC analysis	32	EA	$275	$8,800
3	Data validation	32	EA	$35	$1,120
4	Report writing	2	EA	$3,000	$6,000
5	Well maintenance	1	LS	$1,000	$1,000
				Subtotal	$23,420
6	Legal, adminstrative, eng. fees	25%			$5,855
				Subtotal	$29,275
7	Contingencies	20%			$5,855
	TOTAL O & M COSTS				$35,130
	TOTAL O & M PRESENT WORTH	30	years		$483,559
	TOTAL CAPITAL COSTS				$0
	GRAND TOTAL COST				**$483,559**

Table 6-8

COMPARISON OF MW13-3 DATA
SITE 13
NIAGARA FALLS IAP-ARS

Parameter	Results (μg/L)			
	1989	1990	1992	1995
Benzene	2.98	ND	1.8	ND
TCE	ND	14	0.79	ND
cis-1,2-DCE	NA	4.1	NA	52
Vinyl chloride	1,600	450	430	26

Key:

NA = Not analyzed.
ND = Not detected.

TABLE 6 - 9
IRP Site 13

Costs for Alternative 2
Natural Attenuation, Institutional Controls, and Monitoring

Interest rate	6.0%
Operation and Maintenance (years)	30
Legal, Administrative, & Eng. Fees	25.0%
Contingencies	20.0%

Item No.	Description	Quantity	Units	Unit Cost	Cost
CAPITAL COSTS					
1	Deed restrictions	1	LS	$6,000	$6,000
				Subtotal	$6,000
2	Legal, administrative, eng. fees	25%			$1,500
				Subtotal	$7,500
3	Contingencies	20%			$1,500
	TOTAL CAPITAL COSTS				$9,000
OPERATION & MAINTENANCE COSTS					
1	Groundwater sample collection	26	EA	$250	$6,500
2	VOC analysis	32	EA	$275	$8,800
3	Data validation	32	EA	$35	$1,120
4	Report writing	2	EA	$3,000	$6,000
5	Well maintenance	1	LS	$1,000	$1,000
				Subtotal	$23,420
6	Legal, administrative, eng. fees	25%			$5,855
				Subtotal	$29,275
7	Contingencies	20%			$5,855
	TOTAL O & M COSTS				$35,130
	TOTAL O & M PRESENT WORTH	30	years		$483,559
	TOTAL CAPITAL COSTS				$9,000
	GRAND TOTAL COST				**$492,559**

TABLE 6 - 10
IRP Site 13

Costs for Alternative 3
Groundwater Collection via Extraction Wells/On-Site Treatment/Discharge to Storm Sewer with Monitoring and Institutional Controls

Interest rate	6.0%
Operation and maintenance (years)	5
Legal, Administrative, & Eng. Fees	25.0%
Contingencies	20.0%

Item No.	Description	Quantity	Units	Unit Cost	Cost
CAPITAL COSTS					
1	Mobilization/Demobilization (4% of capital subtotal)	1	LS	$3,242	$3,242
2	Site services	1	Month	$2,500	$2,500
3	Health & safety	1	LS	$5,000	$5,000
4	Well drilling - shallow bedrock	2	EA	$7,000	$14,000
5	Pump tests	2	EA	$5,000	$10,000
6	Extraction pump enclosure	2	EA	$3,188	$6,376
7	Treatment Building	65	SF	$58	$3,770
8	Bag Filtration System	1	LS	$12,000	$12,000
9	Air Stripper	1	EA	$12,000	$12,000
10	SPDES Permit	1	EA	$3,000	$3,000
11	Discharge pipe to sewer	50	LF	$8.00	$400
12	Outfall to sewer	1	LS	$1,000	$1,000
13	Miscellaneous (equip., pumps, etc.)	1	LS	$5,000	$5,000
14	Deed restrictions	1	LS	$6,000	$6,000
				Subtotal	$84,288
15	Legal, administrative, eng. fees	25%			$21,072
				Subtotal	$105,360
16	Contingencies	20%			$21,072
	TOTAL CAPITAL COSTS				$126,432
OPERATION & MAINTENANCE COSTS					
1	Well maintenance	1	LS	$1,000	$1,000
2	Groundwater sample collection	36	EA	$250	$9,000
3	VOC analysis	42	EA	$275	$11,550
4	Data validation	42	EA	$35	$1,470
5	Report writing	2	EA	$3,000	$6,000
				Subtotal	$29,020
6	Legal, administrative, eng. fees	25%			$7,255
				Subtotal	$36,275
7	Contingencies	20%			$7,255
	TOTAL O & M COSTS				$43,530
	TOTAL O & M PRESENT WORTH	5 years			$183,364
	TOTAL CAPITAL COSTS				$126,432
	GRAND TOTAL COST				**$309,796**

TABLE 6 - 11
IRP Site 13

Costs for Alternative 4
Groundwater Collection via Extraction Wells/Discharge to POTW with Monitoring and Institutional Controls

Interest rate	6.0%
Operation and maintenance (years)	5
Legal, Administrative, & Eng. Fees	25.0%
Contingencies	20.0%

Item No.	Description	Quantity	Units	Unit Cost	Cost
CAPITAL COSTS					
1	Mobilization/Demobilization (4% of capital subtotal)	1	LS	$1,911	$1,911
2	Site services	1	Month	$2,500	$2,500
3	Health & safety	1	LS	$2,500	$2,500
4	Well drilling - shallow bedrock	2	EA	$7,000	$14,000
5	Pump tests	2	EA	$5,000	$10,000
6	Discharge pipe to sewer	50	LF	$8.00	$400
7	Outfall to sewer	1	LS	$1,000	$1,000
8	Extraction pump enclosure	2	EA	$3,188	$6,376
9	Miscellaneous (equip., pumps, etc.)	1	LS	$5,000	$5,000
10	Deed restrictions	1	LS	$6,000	$6,000
				Subtotal	$49,687
11	Legal, administrative, eng. fees	25%			$12,422
				Subtotal	$62,109
12	Contingencies	20%			$12,422
	TOTAL CAPITAL COSTS				$74,531
OPERATION & MAINTENANCE COSTS					
1	Extraction well maintenance	1	LS	$1,000	$1,000
2	Disposal at POTW	736	KGAL	$1.37	$1,008
3	Groundwater sample collection	34	EA	$250	$8,500
4	VOC analysis	40	EA	$275	$11,000
5	Data validation	40	EA	$35	$1,400
6	Report writing	2	EA	$3,000	$6,000
				Subtotal	$28,908
7	Legal, administrative, eng. fees	25%			$7,227
				Subtotal	$36,135
8	Contingencies	20%			$7,227
	TOTAL O & M COSTS				**$43,362**
	TOTAL O & M PRESENT WORTH	5	years		**$182,657**
	TOTAL CAPITAL COSTS				**$74,531**
	GRAND TOTAL COST				**$257,188**

TABLE 6 - 12
IRP Site 13

Costs for Alternative 5
Groundwater Extraction via Subsurface Drains/Discharge to POTW
with Monitoring and Institutional Controls

Interest rate	6.0%
Operation and Maintenance (years)	5
Legal, Administrative, & Eng. Fees	25.0%
Contingencies	20.0%

Item No.	Description	Quantity	Units	Unit Cost	Cost
CAPITAL COSTS					
1	Mobilization/Demobilization (4% of capital subtotal)	1	LS	$2,674	$2,674
2	Site services	1	MO	$2,500	$2,500
3	Health & safety	1	LS	$10,000	$10,000
4	Additional soil boring installation	2	EA	$520	$1,040
5	Excavation in overburden	361	CY	$2.50	$903
6	Excavation in bedrock	50	CY	$396	$19,800
7	Collection piping	150	LF	$8.00	$1,200
8	Stone backfill	83	CY	$20	$1,660
9	Trench backfill	327	CY	$6.25	$2,044
10	Disposal of excavated soil (non-haz.)	328	CY	$32	$10,496
11	Discharge pipe to sewer	25	LF	$8.00	$200
12	Outfall to sewer	1	LS	$1,000	$1,000
13	Trench pump enclosure	1	LS	$5,000	$5,000
14	Miscellaneous (equip., pumps, etc.)	1	LS	$5,000	$5,000
15	Deed restrictions	1	LS	$6,000	$6,000
				Subtotal	$69,516
16	Legal, administrative, eng. fees	25%			$17,379
				Subtotal	$86,895
17	Contingencies	20%			$17,379
	TOTAL CAPITAL COSTS				$104,274
OPERATION & MAINTENANCE COSTS					
1	Trench maintenance	1	LS	$1,500	$1,500
2	Disposal at POTW	736	KGAL	$1.37	$1,008
3	Groundwater sample collection	34	EA	$250	$8,500
4	VOC analysis	40	EA	$275	$11,000
5	Data validation	40	EA	$35	$1,400
6	Report writing	2	EA	$3,000	$6,000
				Subtotal	$29,408
7	Legal, administrative, eng. fees	25%			$7,352
				Subtotal	$36,760
8	Contingencies	20%			$7,352
	TOTAL O & M COSTS				$44,112
	TOTAL O & M PRESENT WORTH	5 years			$185,816
	TOTAL CAPITAL COSTS				$104,274
	GRAND TOTAL COST				**$290,091**

Table 6-13

**EVALUATION OF CORRECTIVE MEASURE ALTERNATIVES
IRP SITE 13
NIAGARA FALLS IAP-ARS**

Criteria/ Definition	Alternative 1. No Action/Natural Attenuation with Monitoring	2. Natural Attenuation/ Institutional Controls and Monitoring	3. Groundwater Collection via Extraction Wells/ On-Site Treatment/ Discharge to Storm Sewer	4. Groundwater Collection via Extraction Wells/ Discharge to POTW	5. Groundwater Extraction via Subsurface Drains/ Discharge to POTW
Definition	Alternative 1 calls for the use of natural attenuation processes, including dispersion, diffusion, volatilization, biodegradation, and adsorption, to attain cleanup goals. Sampling would be conducted to monitor groundwater quality.	Similar to Alternative 1, this alternative utilizes natural attenuation processes to attain site cleanup goals. Institutional actions preventing construction of drinking water wells at the site and in the vicinity of the site would be implemented until site cleanup goals are accomplished. Groundwater sampling would be continued until site cleanup goals are accomplished.	Groundwater would be extracted by the use of wells and treated on site in an air-stripping and filtration treatment system. Treated groundwater would be discharged to the storm sewer under a SPDES permit. Similar to Alternative 2, institutional actions would be implemented until site cleanup goals are accomplished. Sampling to monitor groundwater quality would be continued until site cleanup goals are accomplished.	Groundwater would be extracted by the use of wells, as in Alternative 3. However, extracted groundwater would be discharged directly to a POTW for treatment and disposal. Institutional actions would be implemented until site cleanup goals are attained. Sampling to monitor groundwater quality would be continued until site cleanup goals are accomplished.	Groundwater would be extracted by the use of trenches. Two subsurface trenches would be constructed bordering the source area and southwest of the former tank location. Extracted groundwater from the trench would be discharged for treatment and disposal to the POTW. Institutional actions would be implemented until site cleanup goals are attained. Sampling to monitor groundwater quality would be continued until site cleanup goals are accomplished.

Table 6-13

EVALUATION OF CORRECTIVE MEASURE ALTERNATIVES
IRP SITE 13
NIAGARA FALLS IAP-ARS

Criteria/ Definition	Alternative				
	1. No Action/Natural Attenuation with Monitoring	**2. Natural Attenuation/ Institutional Controls and Monitoring**	**3. Groundwater Collection via Extraction Wells/ On-Site Treatment/ Discharge to Storm Sewer**	**4. Groundwater Collection via Extraction Wells/ Discharge to POTW**	**5. Groundwater Extraction via Subsurface Drains/ Discharge to POTW**
Technical	Natural attenuation may be technically effective in decreasing contamination levels to site cleanup goals. Natural attenuation processes have limited capacity to reduce contamination levels and do not possess any flexibility to deal with unanticipated releases of contaminants from the site. However, the likelihood of an unexpected release is small.	Natural attenuation may be technically effective in decreasing contamination levels to site cleanup goals. Until site cleanup goals are attained, institutional controls would prevent human exposure to site contaminants. Natural attenuation processes have limited capacity to reduce contamination levels and do not possess any flexibility to deal with unanticipated releases of contaminants from the site. However, the likelihood of an unexpected release is small.	The technical effectiveness of this alternative depends on the location of the extraction wells. Given the heterogeneity at the site, optimal location of wells may pose a problem. An observational approach would have to be adopted to locate the extraction wells. Optimal wells that may effectively extract contaminants from the subsurface may not effectively minimize the off-site transport of contaminants. Preliminary design of the on-site treatment system has shown that effective treatment of the extracted groundwater can be afforded to meet Class C surface water standards. The alternative consists of reliable and safely implementable technologies.	The technical effectiveness of groundwater extraction of this alternative is similar to Alternative 3. Discharge to a POTW for treatment and disposal is an effective technology and is easier to implement than air stripping. The alternative consists of reliable and safely implementable technologies.	Trenches would be most effective for groundwater extraction at the site. Trenches, acting as a continuous line of well points, can intercept many fractures and fissures along their length and depth. The trench would effectively collect groundwater and create a hydrologic boundary to minimize off-site contaminant transport. Discharge of extracted groundwater to a POTW would afford effective treatment and disposal. This alternative consists of reliable technologies. The construction of the trench would require excavation into bedrock and groundwater dewatering, which will increase construction time. The design and construction of the trench may be complicated due to the complex hydrogeology at the site.

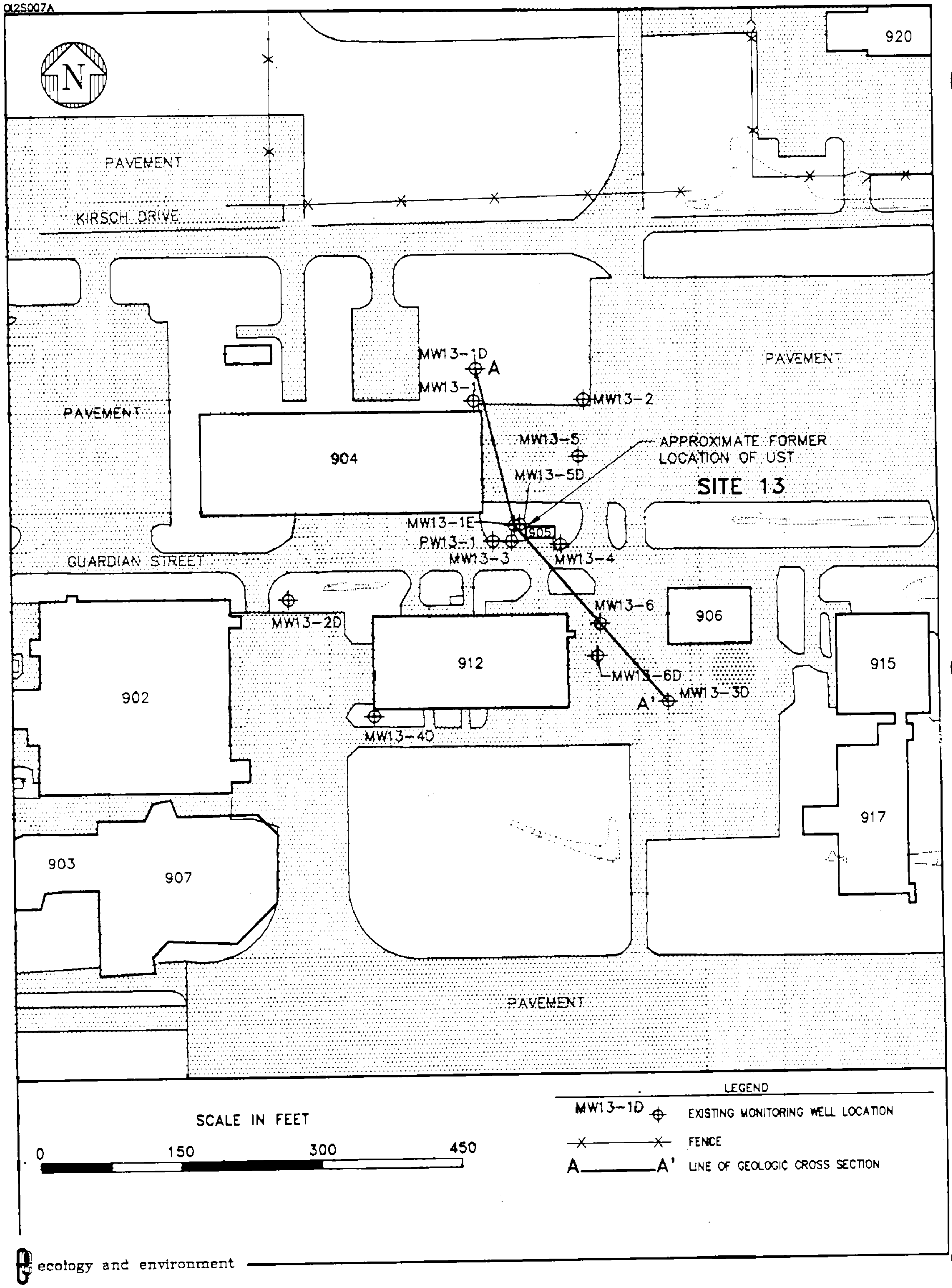


Figure 6-1
IRP SITE 13 - SITE PLAN
RFI SAMPLE LOCATIONS
NIAGARA FALLS IAP-ARS

Table 6-13

EVALUATION OF CORRECTIVE MEASURE ALTERNATIVES
IRP SITE 13
NIAGARA FALLS IAP-ARS

Criteria/ Definition	Alternative				
	1. No Action/Natural Attenuation with Monitoring	2. Natural Attenuation/ Institutional Controls and Monitoring	3. Groundwater Collection via Extraction Wells/ On-Site Treatment/ Discharge to Storm Sewer	4. Groundwater Collection via Extraction Wells/ Discharge to POTW	5. Groundwater Extraction via Subsurface Drains/ Discharge to POTW
Human Health	This alternative provides no long-term beneficial effect for the protection of human health. Groundwater quality standards would continue to be exceeded.	Groundwater quality standards would continue to be exceeded. However, by virtue of institutional controls, minimization of human exposure to site contaminants could be attained.	Attainment of cleanup goals can be accelerated by this alternative. Until site cleanup goals are attained, institutional control would be implemented to protect human health. Routine maintenance of the on-site treatment system would be required.	Attainment of cleanup goals can be accelerated by this alternative. Until site cleanup goals are attained, institutional control would be implemented to protect human health.	Attainment of cleanup goals can be accelerated by this alternative. Until site cleanup goals are attained, institutional control would be implemented to protect human health. There is a significant risk posed to human health during implementation of this alternative.
Environmental	Long-term exposure risks to environmental receptors may not be reduced and cannot be ruled out. Site contaminants will continue to be introduced into the soil and bedrock.	Institutional controls cannot control release of contaminants; thus, site contaminants would continue to migrate away from the site. Long-term exposure risks to environmental receptors may not be reduced and cannot be ruled out.	By extracting contaminants from the subsurface, long-term exposure to environmental receptors would be reduced. Depending on the location of extraction wells, this alternative may be effective in minimizing the off-site transport of contaminants.	The environmental analysis of Alternative 4 is similar to Alternative 3.	By extracting contaminants from the subsurface, long-term exposure to environmental receptors would be reduced. A trench would be most effective in minimizing the off-site transport of contaminants.

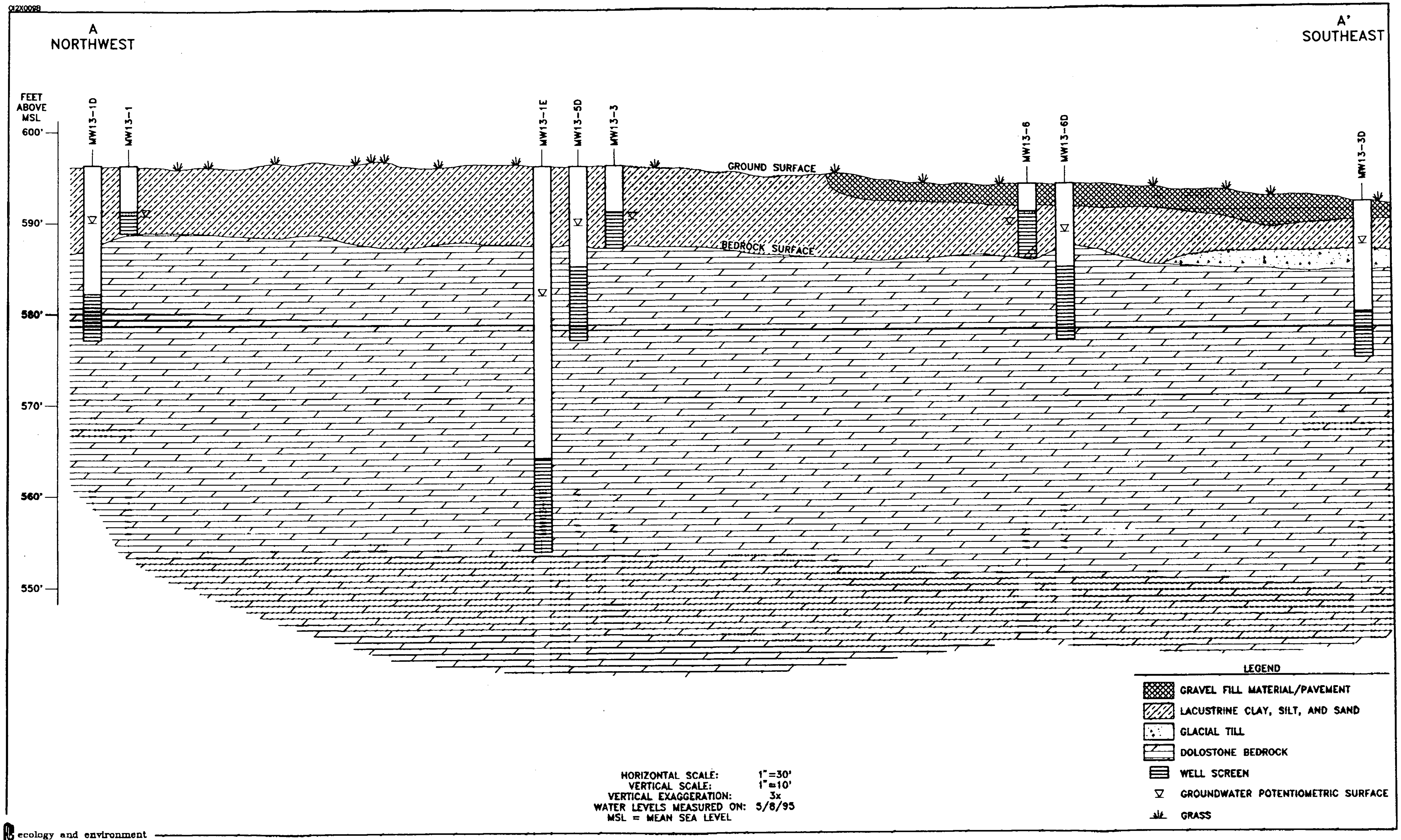


Figure 6-2 GEOLOGIC CROSS SECTION A-A'
IRP SITE 13
NIAGARA FALLS IAP-ARS

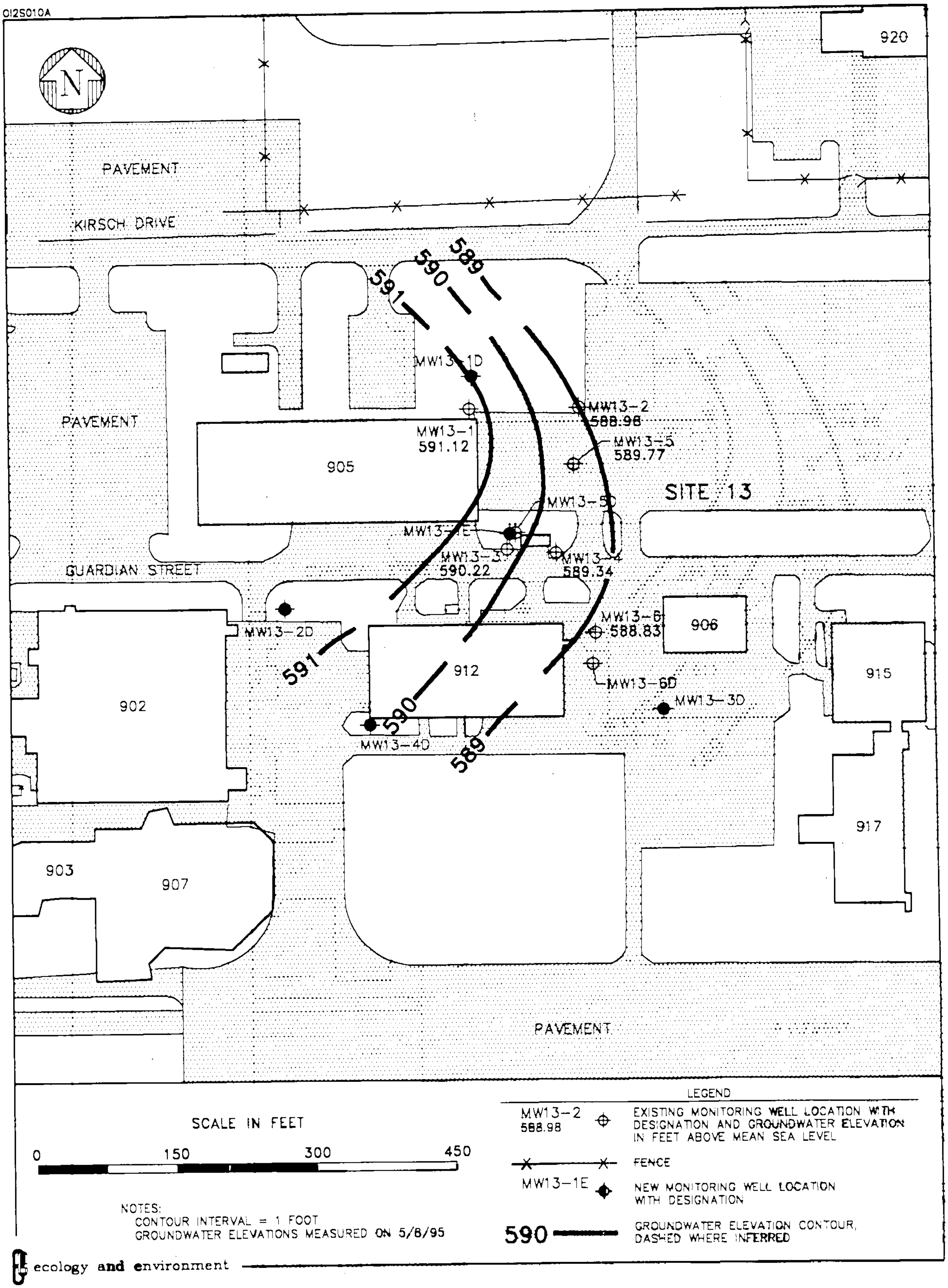


Figure 6-3
OVERBURDEN GROUNDWATER CONTOUR MAP
IRP SITE 13
NIAGARA FALLS IAP-ARS

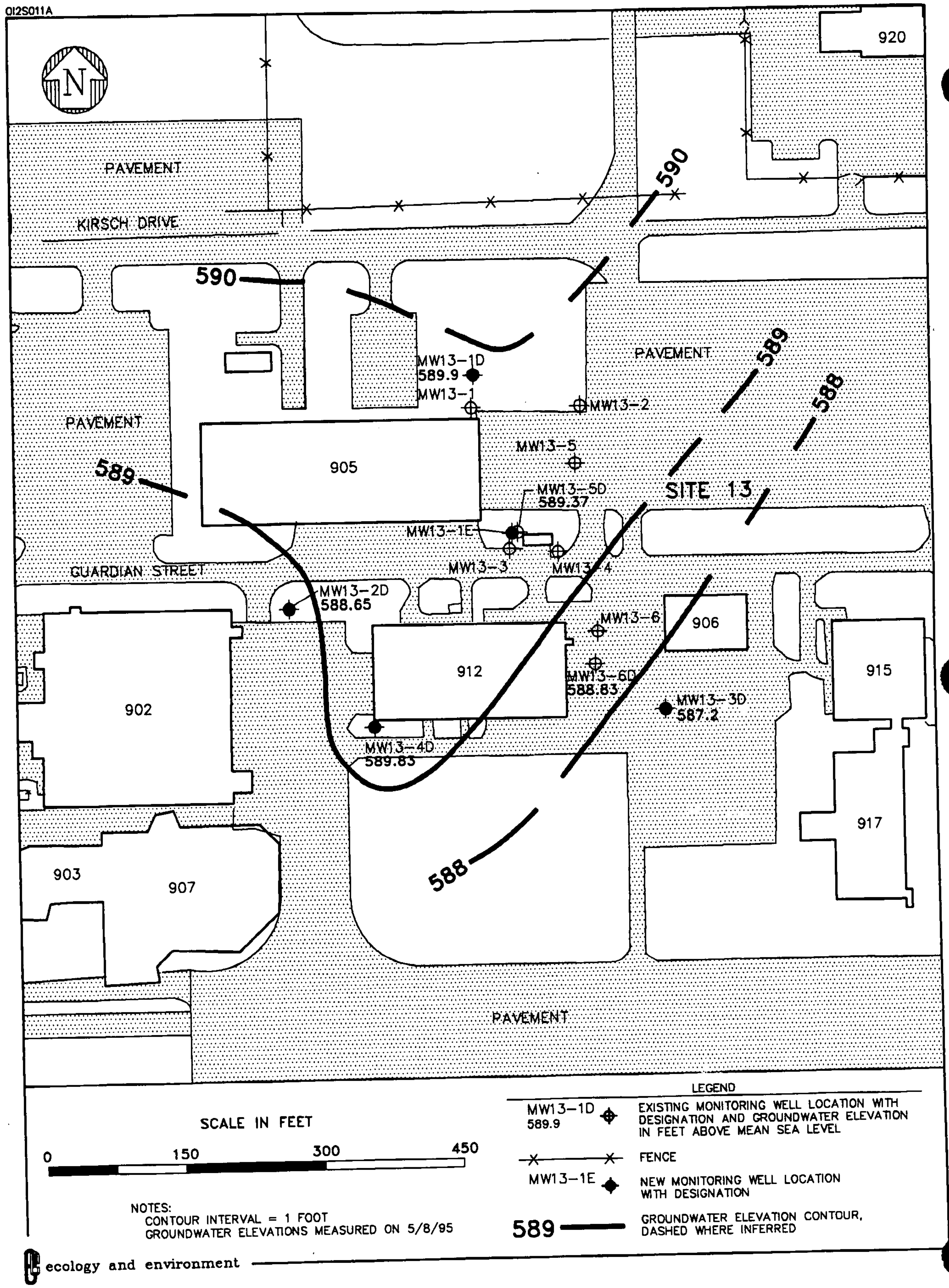


Figure 6-4
SHALLOW BEDROCK GROUNDWATER CONTOUR MAP
IRP SITE 13
NIAGARA FALLS IAP-ARS

01250128

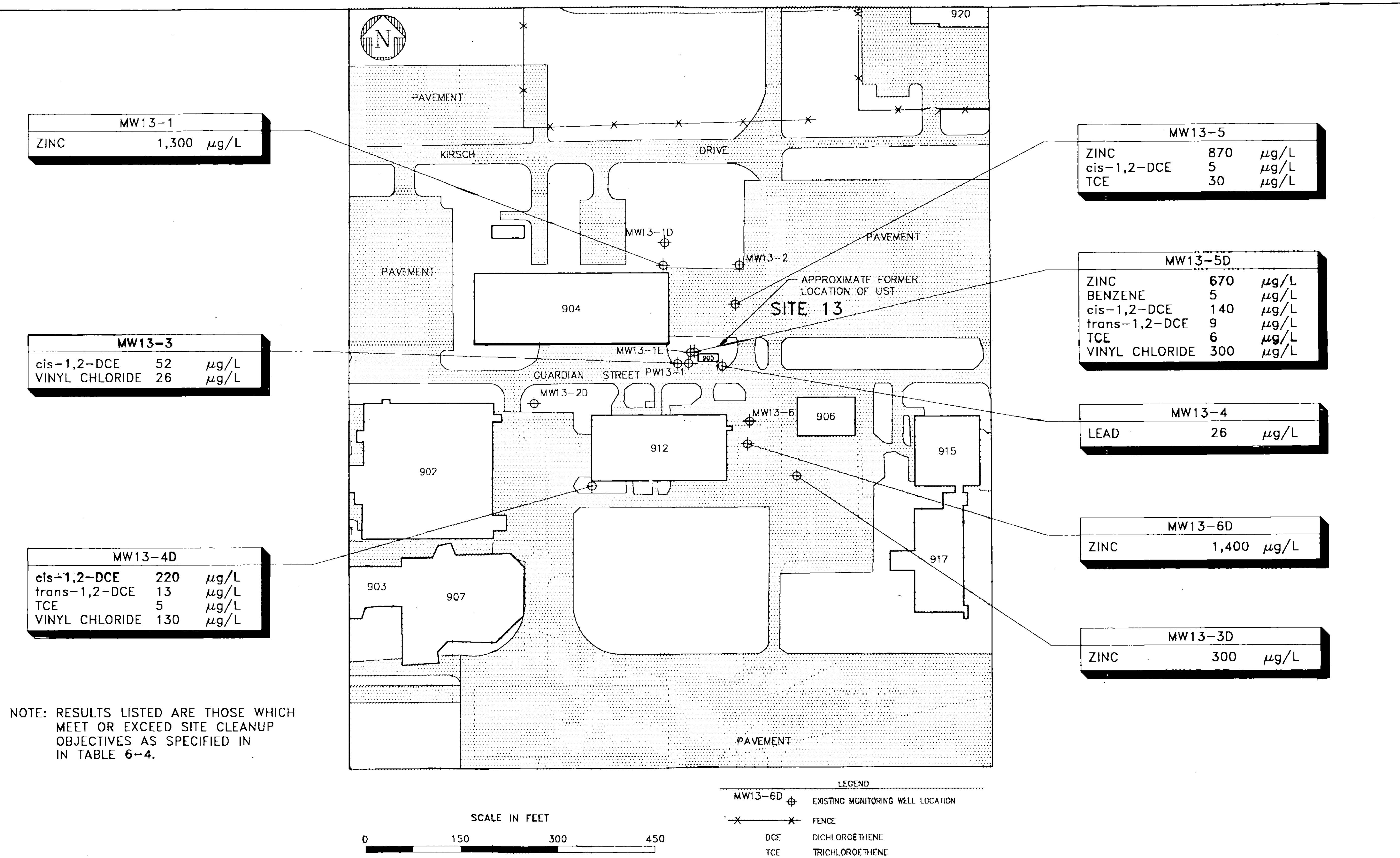


Figure 6-5 RFI GROUNDWATER SAMPLES ABOVE CLEANUP GOALS
IRP SITE 13
NIAGARA FALLS IAP-ARS

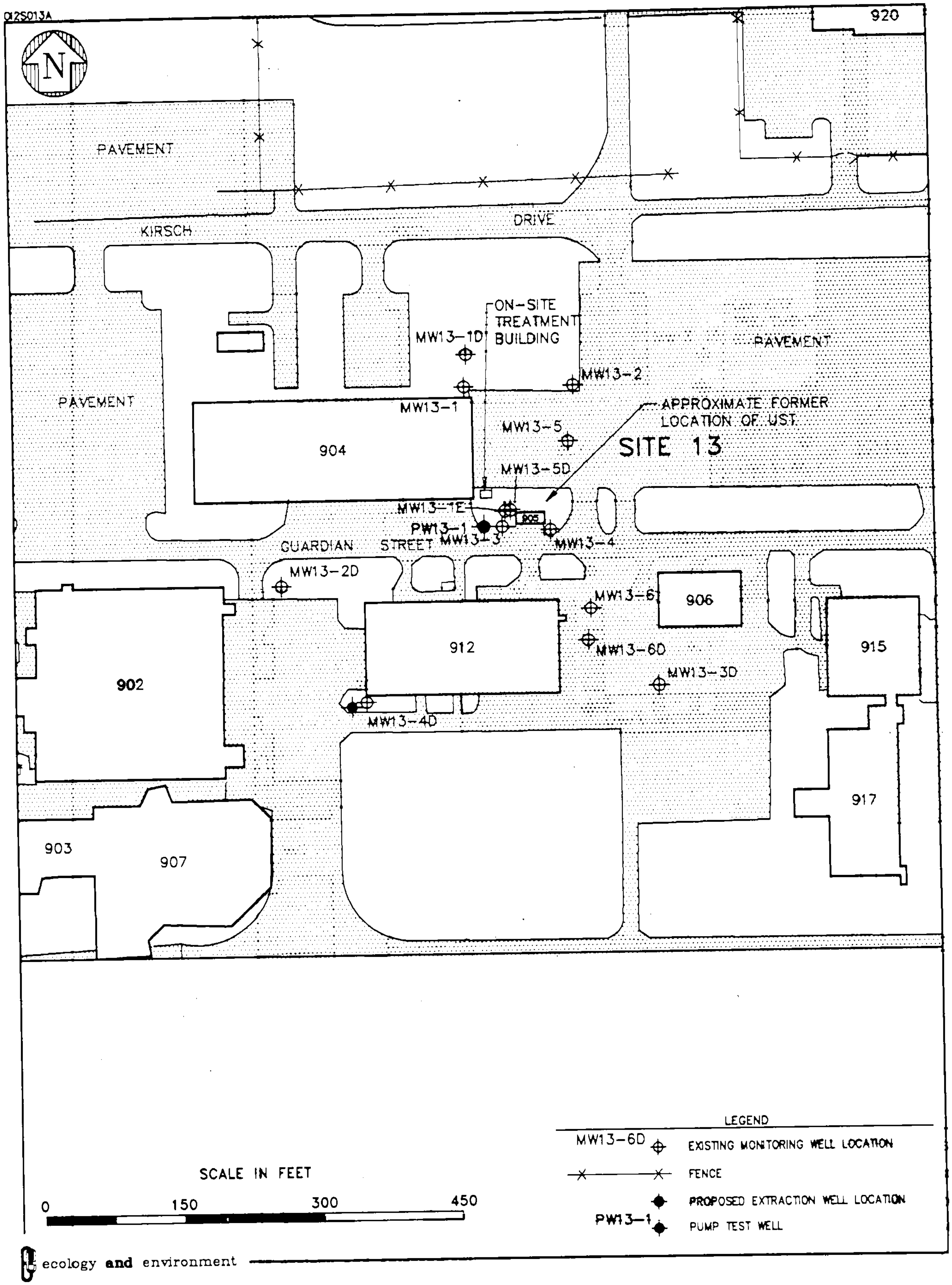
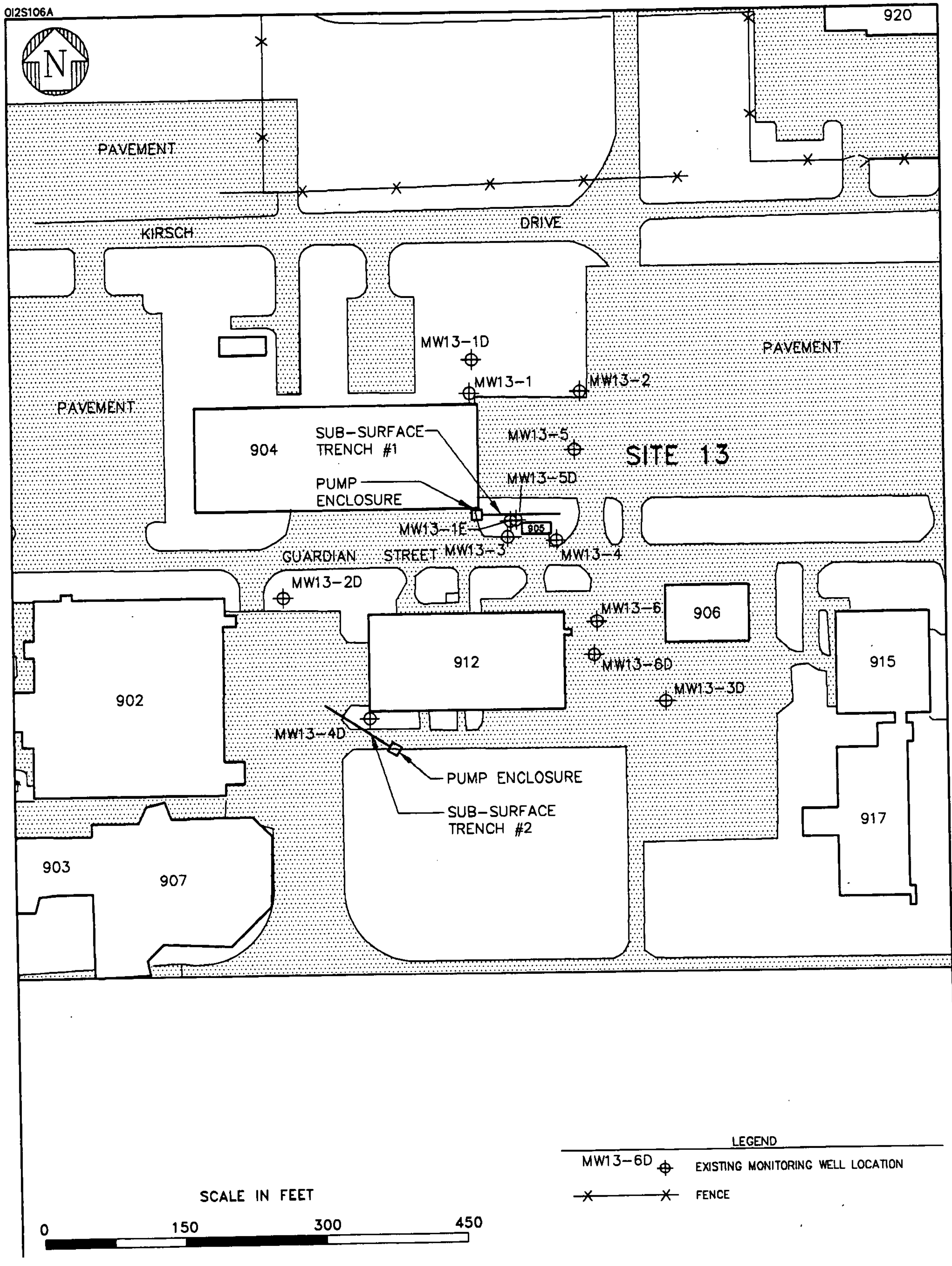


Figure 6-6
ALTERNATIVE 3 LAYOUT
IRP SITE 13
NIAGARA FALLS IAP-ARS



ecology and environment

Figure 6-7
ALTERNATIVE 5 LAYOUT
IRP SITE 13
NIAGARA FALLS IAP-ARS

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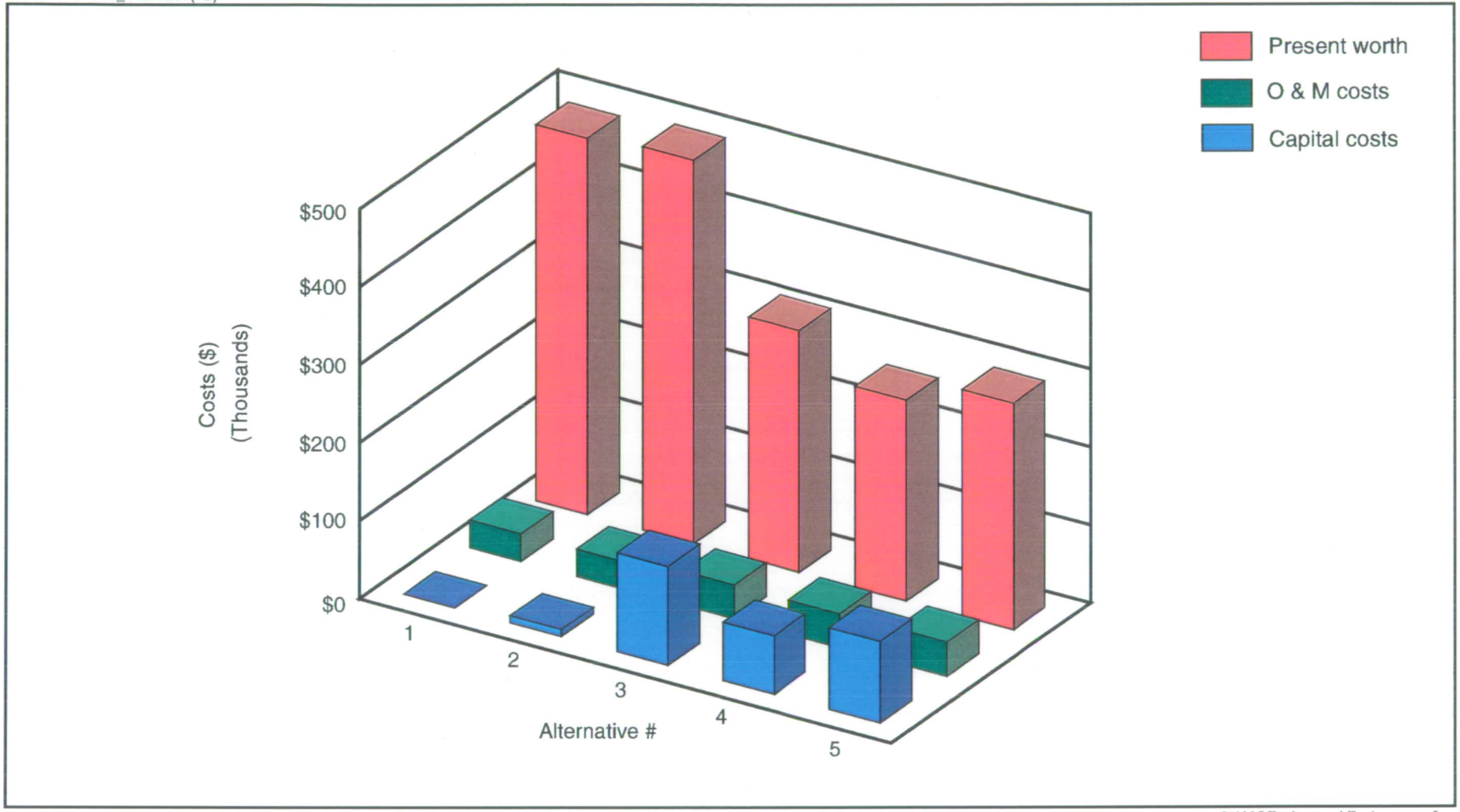

Figure 6-8 CAPITAL, O & M, AND PRESENT WORTH COSTS FOR CMAs
IRP SITE 13
NIAGARA FALLS IAP-ARS

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A Soils Data Comparison

Appendix A

Soils Metals Concentration Comparisons

Figures A-1 and A-2 present the maximum concentrations of metal species detected at IRP Sites 3, 10, and 13. These maximum values are presented in Tables 4-5, 5-5, and 6-3, respectively, and also are tabulated in the table below.

Figure A-1 and A-2 shows that the maximum values of the metals arsenic, beryllium, cadmium, copper, nickel, lead and zinc at each site are comparable to each other. Although, the three sites have very different waste disposal practices associated with them, the observation that the maximum concentrations of the above metals are comparable suggests that the above metals must be naturally existing. The maximum values of chromium at Sites 3 and 13 are also comparable. However, the chromium concentration at Site 10 is abnormally high when compared to the concentrations detected at Sites 3 and 13. As mentioned in Section 5, this maximum value of chromium was detected during the RI sampling in one soil sample and was also abnormally high as compared to other samples collected at the Site 10. Barring this abnormally high concentration, chromium concentrations at Sites 3, 10, and 13 are comparable and further support the view that chromium naturally exists at the Base.

Mercury and selenium were only detected at Site 3. Therefore no comparisons can be made with Site 10 and 13. (As presented in Table 4-5 the maximum concentrations of mercury and selenium are far below the EPA RBC concentrations for industrial soils).

TABLE A-1 COMPARISON OF SOILS METALS CONCENTRATIONS			
Metal	Maximum Concentration Detected (mg/kg)		
	Site 3	Site 10	Site 13
Arsenic	8.4	2.5	3.6
Beryllium	0.89	0.556	0
Cadmium	5.8	1.55	1.4
Chromium	27	650	18.2
Copper	28.8	37	24
Lead	68	56.6	30
Mercury	0.3	0	0
Nickel	29	48	35.9
Selenium	3.5	0	0
Zinc	687	640	550

Figure A-1
Soils Metals Concentrations
IRP Sites 3, 10, & 13

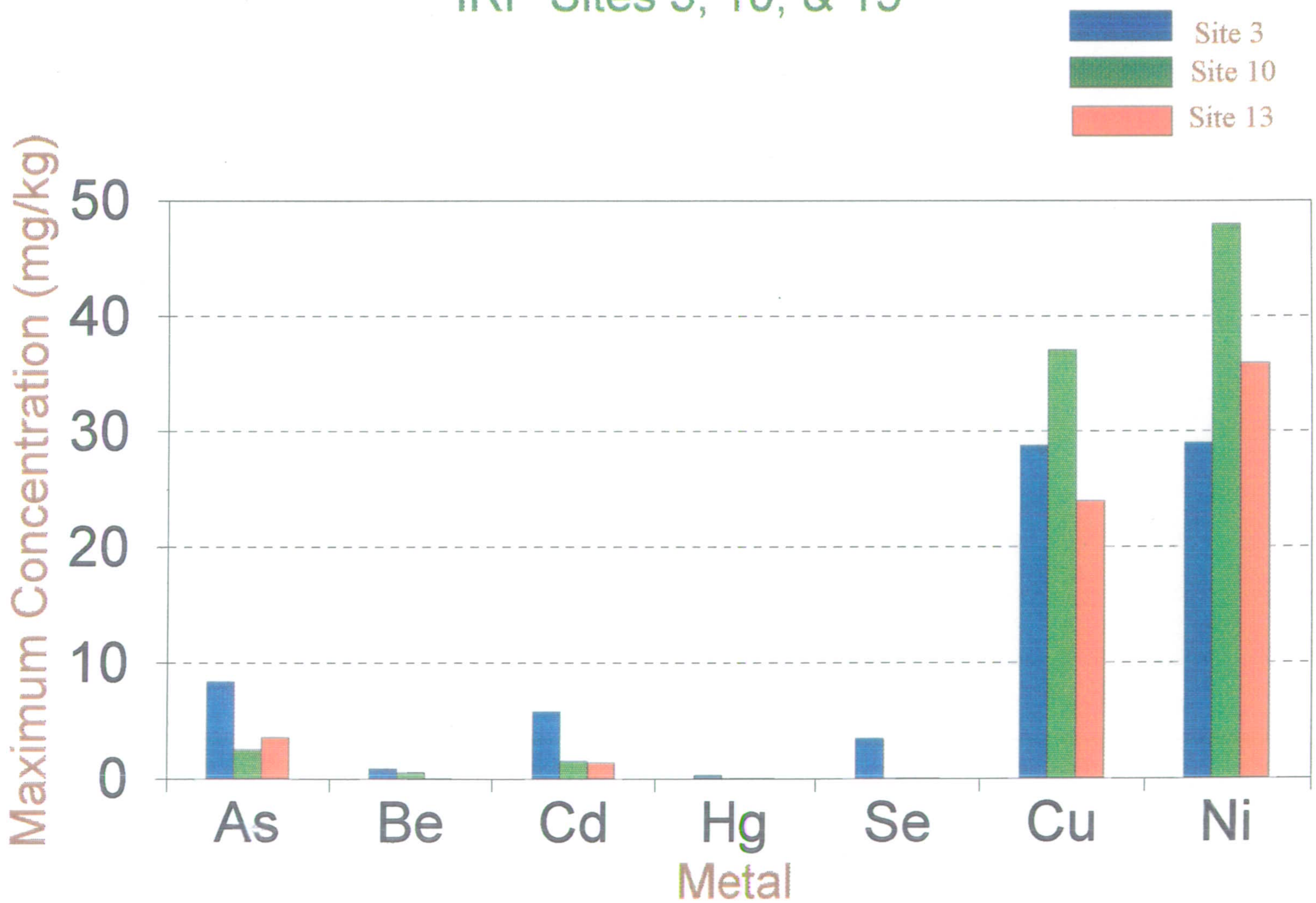
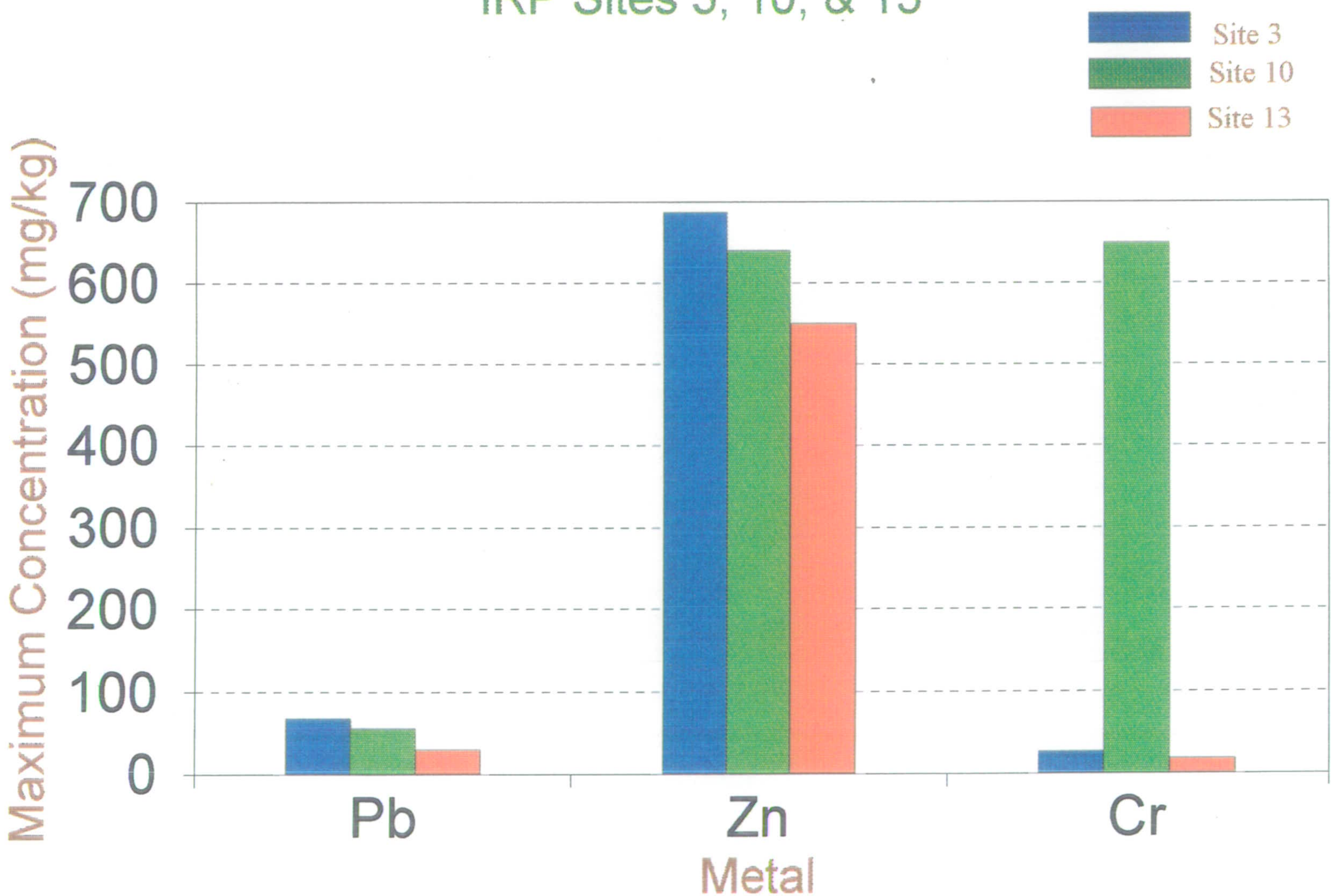


Figure A-2
Soils Metals Concentrations
IRP Sites 3, 10, & 13



B Groundwater Data Comparison

Appendix B

Groundwater Metals Concentration Comparisons

Figures B-1 and B-2 present the maximum concentrations of metal species detected at IRP Sites 3, 10, and 13. These maximum values are presented in Tables 4-6, 5-6, and 6-4, respectively, and also are tabulated in the table below.

Figure B-1 and B-2 shows that the maximum value of the metals arsenic, chromium, lead and zinc at each site are comparable to each other. Although, the three sites have very different waste disposal practices associated with them, the observation that the maximum concentrations of the above metals are comparable suggests that the above metals must be naturally existing. The maximum value of nickel and copper at Sites 10 and 13 are also comparable. However, the maximum value of nickel and copper at Site 3 is not comparable to the maximum values observed at Sites 10 and 13. Mercury and cadmium were only detected at Site 3. Therefore no comparisons can be made with Site 10 and 13 for these metals.

Table B2 and B3 present the results of filtered and unfiltered groundwater samples collected at Sites 3 and 10 by GZA. No soluble metals hits were detected at Site 13, and are thus not presented. As presented in Tables B2 and B3, filtered sample metals concentrations were considerably lower than the unfiltered samples metal concentrations. Since unfiltered groundwater samples contain suspended solids originating from the aquifer matrix, it is likely that detected metals concentrations in groundwater samples is due to suspended particulate.

TABLE B-1 COMPARISON OF G.W METALS CONCENTRATIONS			
Metal	Maximum Concentration Detected (ug/L)		
	Site 3	Site 10	Site 13
Arsenic	20	5.3	15
Cadmium	64	0	0
Chromium	150	51	100
Mercury	0.2	0	0
Nickel	2.33	79	125
Copper	857	107	112
Lead	841	340	102
Zinc	2770	3750	1400

TABLE B-2
FILTERED AND UNFILTERED GROUNDWATER SAMPLES
METALS CONCENTRATIONS
IRP SITE 3

Metal (ug/L)	Cleanup Goals	Unfiltered Sample	Filtered Sample	Unfiltered Sample	Filtered Sample	Unfiltered Sample	Filtered Sample	Unfiltered Sample	Filtered Sample
		July 1992		Jan 1993		July 1993		Jan 1994	
	MW 3-3								
Cadmium	10	ND	ND	ND	ND	ND	ND	ND	ND
Chromium	50	ND	ND	ND	ND	ND	ND	ND	ND
Copper	200	ND	8	ND	ND	ND	ND	ND	ND
Lead	25	ND	ND	4	ND	3	ND	ND	ND
Zinc	300	ND	ND	91	ND	100	ND	150	57
	MW 3-4								
Cadmium	10	ND	ND	ND	ND	ND	ND	14	ND
Chromium	50	12	ND	10	ND	20	ND	11	ND
Copper	200	ND	52	ND	ND	ND	5	69	24
Lead	25	ND	ND	69	21	150	ND	61	ND
Zinc	300	ND	ND	290	100	690	ND	2700	ND
	MW3-5								
Cadmium	10	ND	8	ND	ND	ND	ND	ND	ND
Chromium	50	ND	ND	ND	ND	ND	ND	ND	ND
Copper	200	36	10	ND	ND	ND	ND	16	ND
Lead	25	50	29	5	ND	60	ND	3	ND
Zinc	300	ND	36	ND	27	200	ND	20	ND

Source: GZA, May1994

TABLE B-3
FILTERED AND UNFILTERED GROUNDWATER SAMPLES
METALS CONCENTRATIONS
IRP SITE 10

Metal (ug/L)	Cleanup Goals	Unfiltered Sample	Filtered Sample	Unfiltered Sample	Filtered Sample	Unfiltered Sample	Filtered Sample	Unfiltered Sample	Filtered Sample	Unfiltered Sample	Filtered Sample
		Dec 1991		Dec 1991		Dec 1991		Dec 1991		Dec 1991	
		MW10-05D		MW10-06D		MW10-07		MW10-08		MW10-09D	
Chromium	50	48.4	ND	ND	ND	18.5	ND	18.5	ND	10.8	ND
Lead	25	9.9	ND	ND	28.2	8.6	ND	9.6	ND	7.6	ND
Zinc	300	3750	400	ND	175	180	ND	412	147	188	2770

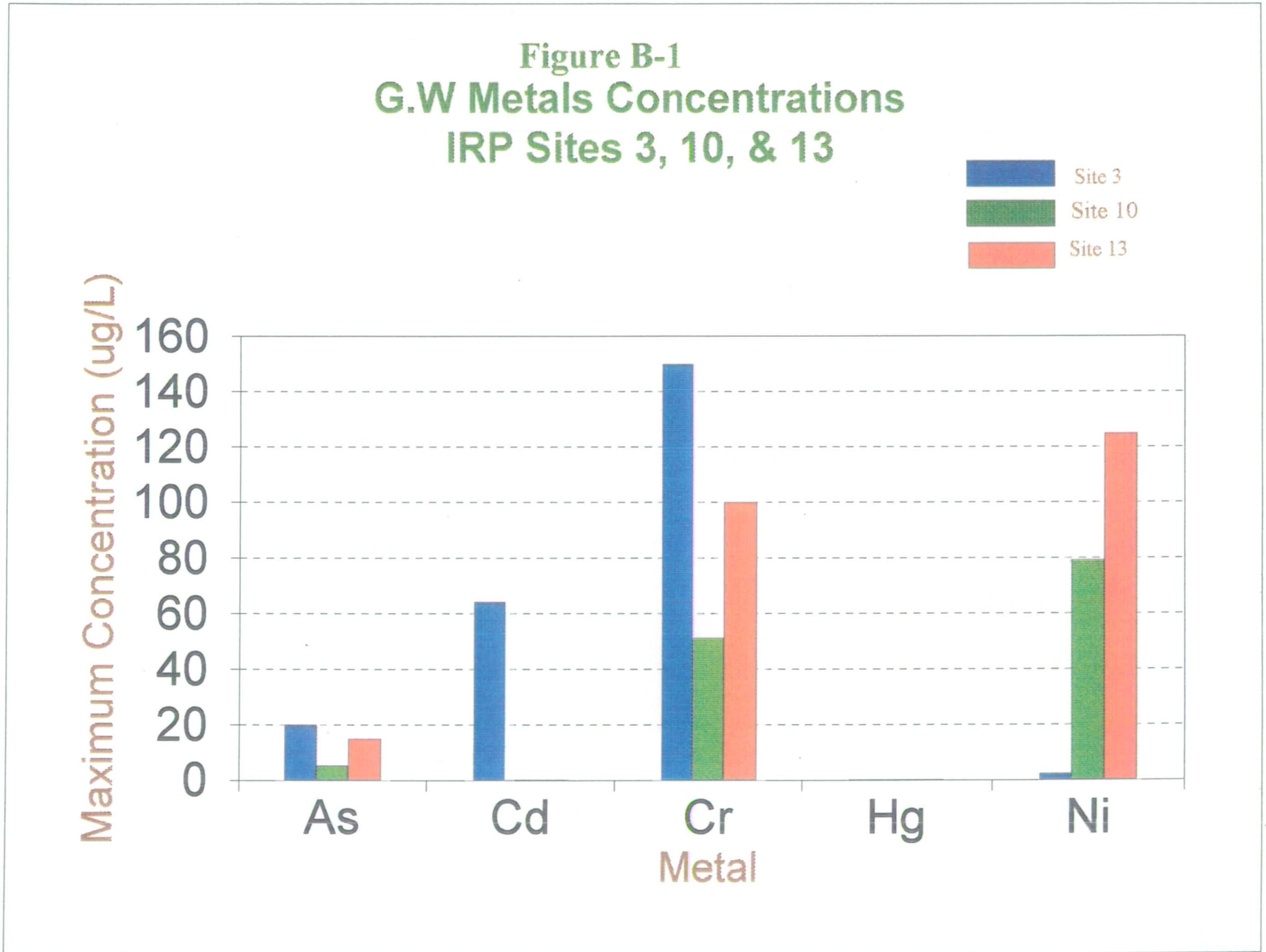
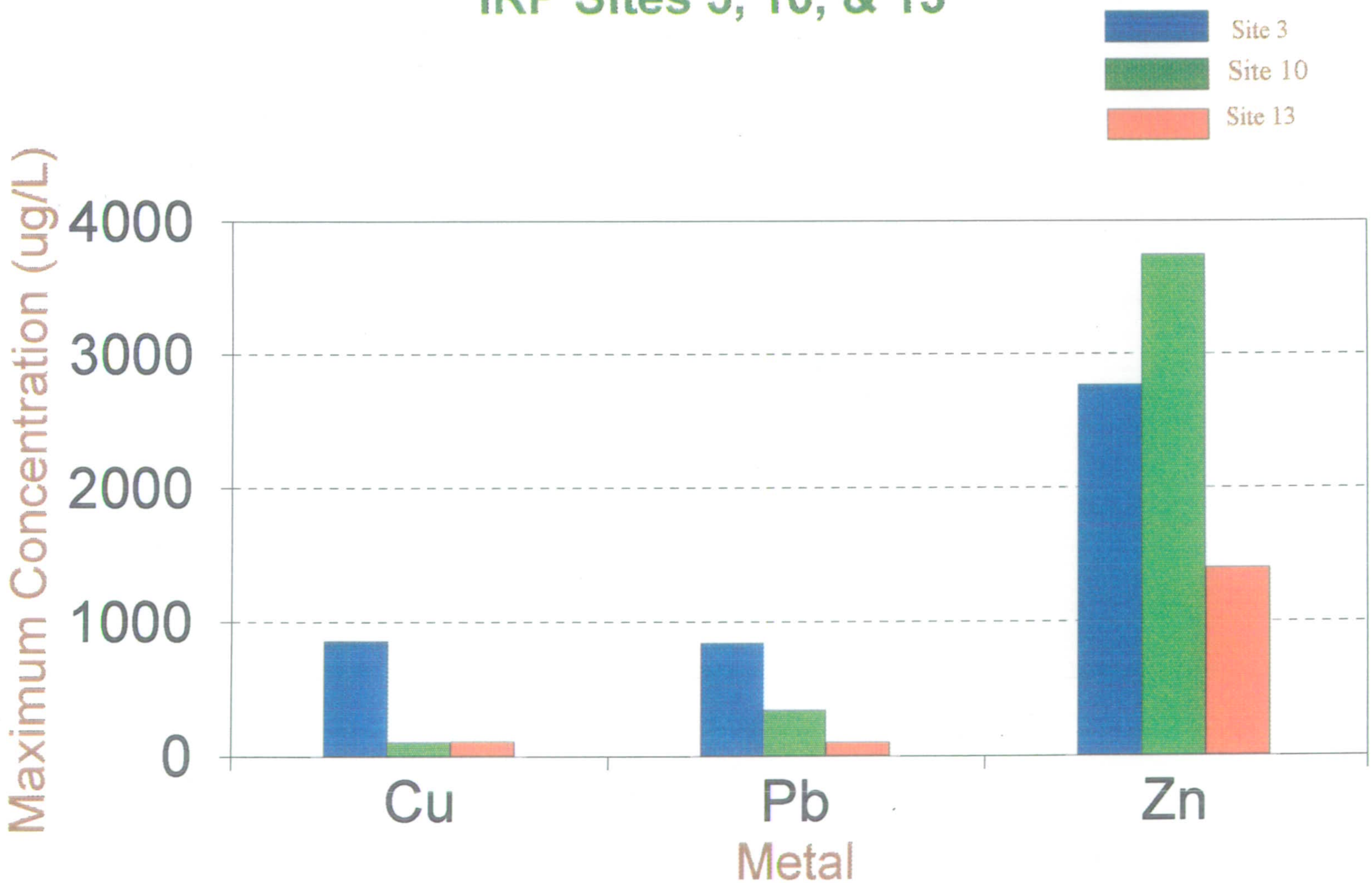


Figure B-1
G.W Metals Concentrations
IRP Sites 3, 10, & 13
Site 3
Site 10
Site 13
Maximum Concentration (ug/L)
160
140
120
100
80
60
40
20
0
As
Cd
Cr
Hg
Ni
Metal

Figure B-2
G.W Metals Concentrations
IRP Sites 3, 10, & 13



C Pump Test Results

MEMORANDUM

TO: **Mark Schmitt**

FROM: **Scott Thorsell**

DATE: **July 13, 1995**

SUBJECT: **NF-ARS/AFB, Sites 3 & 13; Trip Report and Results Summary for Aquifer Testing.**

CC: **J. Bastedo, M. Grant, T. Ferraro, A. Stiener**

Between the dates of June 18 and 27, 1995, the large diameter (6- and 10-inch) pumping wells at sites 3 and 13, respectively, were tested to determine the hydraulic properties and/or the nature of the hydrogeologic aquifer system in the vicinity of these two sites. The field methods used, as well as the results of these tests are discussed in the sections below. All graphical and tabular results for these studies are attached to the end of this memorandum.

Site 3:

□**Static Monitoring Test.** Aquifer testing began at Site 3 on June 19 with a 22-hour static conditions, water level monitoring test. Monitoring for this test was performed using pressure transducers and an electronic data logger which recorded water levels every 20 minutes. Those monitoring wells used for this test included MW3-1E, MW3-2, MW3-2DA, MW3-3, MW3-4, MW3-4DA and MW3-5AA (pumping well). The water level in the nearby creek was also monitored. Estimates of stream flow were made on 6/19 for 2 reaches of the nearby stream. These measurements show an average flow rate of 1.06 ft/sec and discharge of 11.3 gpm (gallons per minute).

All water level data collected for this test are graphically presented in Figures 1 and 2. These data show that water levels displayed a slight cyclical fluctuation, although no significant trends of increasing or decreasing water levels appeared to be present which would influence the interpretation of the pumping test drawdown data.

□**Pumping Test No.1.** On June 20, at 10:50-hours the first of 2 pumping tests was begun. An initial discharge rate of approximately 2.5 gpm was used on the recommendation of field geologists familiar with the low yield, bedrock aquifer. Water levels in the above listed wells were again monitored both electronically and manually. Electronic water level data were recorded at a logarithmic rate interval with a maximum interval of 20 minutes. Manually collected data were taken every 1 to 2 hours. At 12:45-hours, **sample OI2-MW3-5AA-WP1-062095** was collected for the analyses of VOCs, BNAs and PP Metals. Water quality readings taken at the time of sample collection were as follows:

Temp. = 72.9 deg. F;	**Sp. Cond. = 2140 us/cm;**
pH = 6.99;	**Turbidity = 5.54 ntu.**

By approximately the fourth hour of the test the water level in the extraction well (MW3-5AA) had stabilized with only 2 feet of drawdown. Because the sustainable well yield appeared to be much higher, the pumping rate was increased to 3.2 gpm. At this discharge rate, drawdown in well MW-5AA increased to approximately 3.7 feet at 5.5 hours into the test. Given that a drawdown of 12 to 15 feet was more desirable in order to fully stress the aquifer, the pump rate was again increased to 6.1gpm at the direction of T. Ferraro. For this stepped increase in pumping rate, the data logger test was also "stepped" to begin a new record of drawdown data. At this higher rate, however, the capacity of the well was exceeded and the well was pumped dry in 15 minutes.

Due to the excessive drawdown, at 16:53 hours the pump was shut off and the data logger test was stepped a second time to begin water level recovery monitoring. This monitoring continued for only 2 hours because the water level in the extraction well recovered very quickly (90% within 15 min.).

Observations/Results: All water level data recorded electronically for these tests are represented in Figures 3 and 4. It is apparent from these figures that, even though the extraction well sustained a total drawdown of >19 feet, no significant changes in water levels were observed for the surrounding observation wells. A water level decline of 0.2-feet was observed for well MW3-2, however, this does not appear to be related to the pumping due to the low pumping rate and great distance (approx. 240 feet) of this well from the pumping well. Furthermore, the water level fluctuation in well MW3-2, which displayed the greatest variability during the static monitoring test (approx. 0.1 feet show in Figure 2), continued to decline during the recovery period of this test.

The rapid recovery of the water level in the pumping well (<15 min.) is indicative of a low storage, fractured bedrock aquifer system. The low yield of the well indicates that the fracture system is not widely connected and that the matrix of the bedrock itself must be fairly tight and unyielding of ratained groundwater (higher storage in the matrix). Additionally, fracture recharge from the nearby creek is also very likely given that bedrock is exposed at the stream bed in many areas.

□**Pumping Test No.2.** Immediately following the recovery of the water in the extraction well a second pump test was begun at 19:00 hours (7pm) on 6/20. An initial extraction rate of 3.5 gpm was used to begin this test. As given in the table below, pumping rates were again increased throughout this second test in order to observe any changes in the short-term sustainable yield of the extraction well. A final rate of 5 gpm and drawdown of 15.3-feet, was achieved for this 38.2-hour test.

Date	Start Time	Step Time	Length	Rate	Drawdown
6/20	1900	--			
6/21	--	0945	14.75 hr	3.5 gpm	7.0 feet
6/21	0945	1540	5.9	3.9	10.0
6/21	1540	2327	7.8	4.2	11.1
6/21	2327	--			
6/22	--	0733	8.1	4.5	12.3
6/22	0733	0911	1.6	5.0	15.3
6/22	0911	0945	0.6	- -	recovery

The second pumping test was completed at 09:11 hours and recovery monitoring was begun. Recovery of the static water level for the extraction well, again, was very quick. Recovery monitoring was therefore, terminated after 0.6 hours of recovery. Prior to the end of pumping, at 07:55 hours the groundwater **sample OI2-MW3-5AA-WP2-062295** was collected. The following water quality parameters were recorded at the time of sample collection.

Temp. = 55 deg. F; **Sp. Cond. = >10,000 us/cm;**
pH = 6.83; **Turbidity = 22.7 ntu.**

Observations/Results: Those water level data recorded electronically during this second pumping test are presented graphically in Figures 5 and 6. From these data it is apparent that water levels in nearby observation wells were still unaffected by the pumping at well MW3-5AA. The absence of drawdown in these observation wells is either explained by the greater distance of some wells to the extraction well, or by the limited connectedness of the bedrock aquifer fracture system. Well MW3-3, for example, was unaffected by pumping even though it was installed within the same aquifer zone as the extraction well and is only 36 feet away. Fracture recharge from the nearby creek appears to be a major contributor to the water level stability at wells MW3-3 and MW3-5AA, and most probably explains the very rapid recovery of the static water level in the extraction well after pumping.

On 6/21 flow and discharge rates were again estimated for the nearby creek. These estimates indicate that the creek had an average flow velocity of 0.98 ft/sec, and an equivalent discharge of 8.6 gpm. Relative to the estimated average discharge of 11.3 gpm on 6/19, it appears that flow in the creek was declining at this time. Such a condition is very likely given that this area was under serious drought conditions at the time of these tests.

Analysis of Aquifer Properties: Those data collected from the extraction well (MW3-5AA) during Test No.2 described above, were used to perform a "type-curve" match analysis typically used for constant rate pumping tests. Although this type of test is better suited to homogeneous, isotropic aquifers that are not potentially affected by recharge boundaries (i.e. the creek), the results produced by these analyses seem reasonable. Figures 7 and 8 show the results of the type curve analyses. The Neuman (1975) method for unconfined aquifers was used for these analyses.

For each analysis, a saturated aquifer thickness of approximately 20 feet, and an average pumping rate of 3.95 gpm were used. The pumping rate was determined by the total gallons pumped (9055 gal) over the length of the test (2291 minutes). By reducing the results of transmissivity (T) for aquifer thickness (dividing by "b"-aquifer thickness), hydraulic conductivity (K) can be determined. The **average K** for the aquifer in the vicinity of **well MW3-5AA** was determined by this test to be **2.5 x10^{-4}cm/sec.** It must be said that these results are probably not representative of the aquifer as a whole, but probably represent the transmissivity of the bedrock fractures present near the well, and of the fracture(s) which may connect this well to the surface water. The results for storativity (S) and specific yield (Sy) cannot be adequately determined by these analyses due to the lack of significant drawdown in the nearby observation wells.

Site 13:

Field Procedures & Results: For this study, 2 separate pumping tests were conducted on pumping well PW13-1 at Site 13. The first test, conducted on June 22, attempted to perform a low flow, constant rate pumping test. As a result of the very low yield of this well and the excessive drawdown sustained, the results of the test could not be interpreted as initially intended. A second test, therefore, was conducted on June 27 with the intention of providing information about the vertical component of hydrogeologic flow in the vicinity of the pumping well (PW13-1) and the nearby observation wells. During both tests, water levels were regularly monitored in the pumping well and the following observation wells: MW13-3 (overburden), MW13-5D (shallow bedrock), and MW13-1E (deep bedrock). At the time of the test, the pumping well itself was constructed as an open hole, bedrock, well. The overburden was cased off from ground surface to a depth of approximately 10 ft bgs, and the total depth of the well was approximately 27 feet bgs (open 10 to 27 ft. bgs).

During the **first test**, at a discharge rate of approximately 1.8 gpm, the pumping well produced approximately 130 gallons prior to going dry within one hour of pumping. Given that the standing well volume for this 10-inch diameter well was approximately 90 gallons, the actual yield of the well was about 40 gallons per hour, or 0.67 gpm. During this test only well MW13-5D experienced some drawdown as a result of the pumping.

As indicated above, the **second test** was intended to provide hydrogeologic information relative to vertical leakage between the overburden aquifer (MW13-3) and the shallow bedrock aquifer. This test was conducted simply by running the pump as necessary to maintain a depressed water level within the pumping well. By doing this, and monitoring the responses of water levels in the nearby observation wells, the hydraulic connection between the vertically separated aquifer zones could be evaluated. This test was conducted over a period of 16.5 hours and a total of 680 gallons of water was extracted. The results of the water level monitoring during the test are provided in Table 1 and graphed in Figure 9.

Similar to the first test, the results of the second test show that the shallow bedrock observation well, MW13-5D, responded again to the pumping with a total drawdown of 4.22 feet for the 16.5 hour test. During this longer test, it was also observed that the overburden well, MW13-3, responded with a total drawdown of 0.7 feet. Drawdown in this, now, pearched aquifer zone confirms that the two superimposed aquifer zones are hydraulically connected despite their different structure and hydrogeologic character. Water levels for the deep bedrock well MW13-1E, as expected, did not change as a result of pumping. The water level in this well indicates it is vertically downward gradient (below) of the shallower aquifer zones (see table below).

□**Analysis of Vertical Gradients:** Assuming a common ground elevation of 100 feet for the four study wells at site 13, vertical gradients were determined for several pairs of wells, and therefore, for the hydrogeologic zones they represent. The following table presents the results of these calculations:

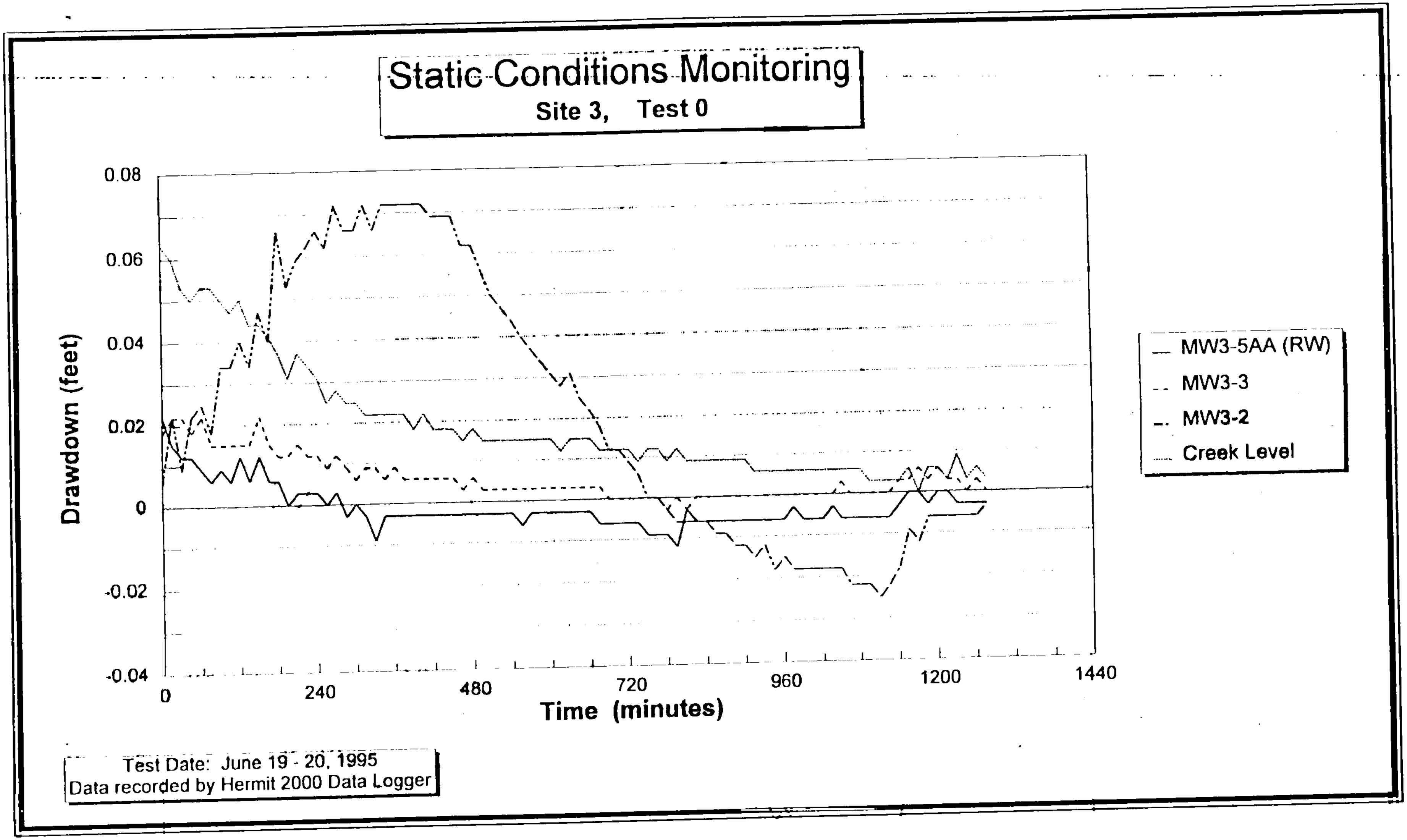
From Well	To Well	Gradient (ft/ft)	Direction
Static conditions:			
MW13-3	**PW13-1**	**0.07**	**very slight downward**
MW13-5D	**PW13-1**	**0.10**	**very slight downward**
PW13-1	**MW13-1E**	**0.43**	**moderately strong downward**
MW13-3	**MW13-5D**	**0.06**	**very slight downward**
Induced gradient at the pumping well:			
MW13-3	**PW13-1**	**1.00**	**very strong downward (perched in overburden)**

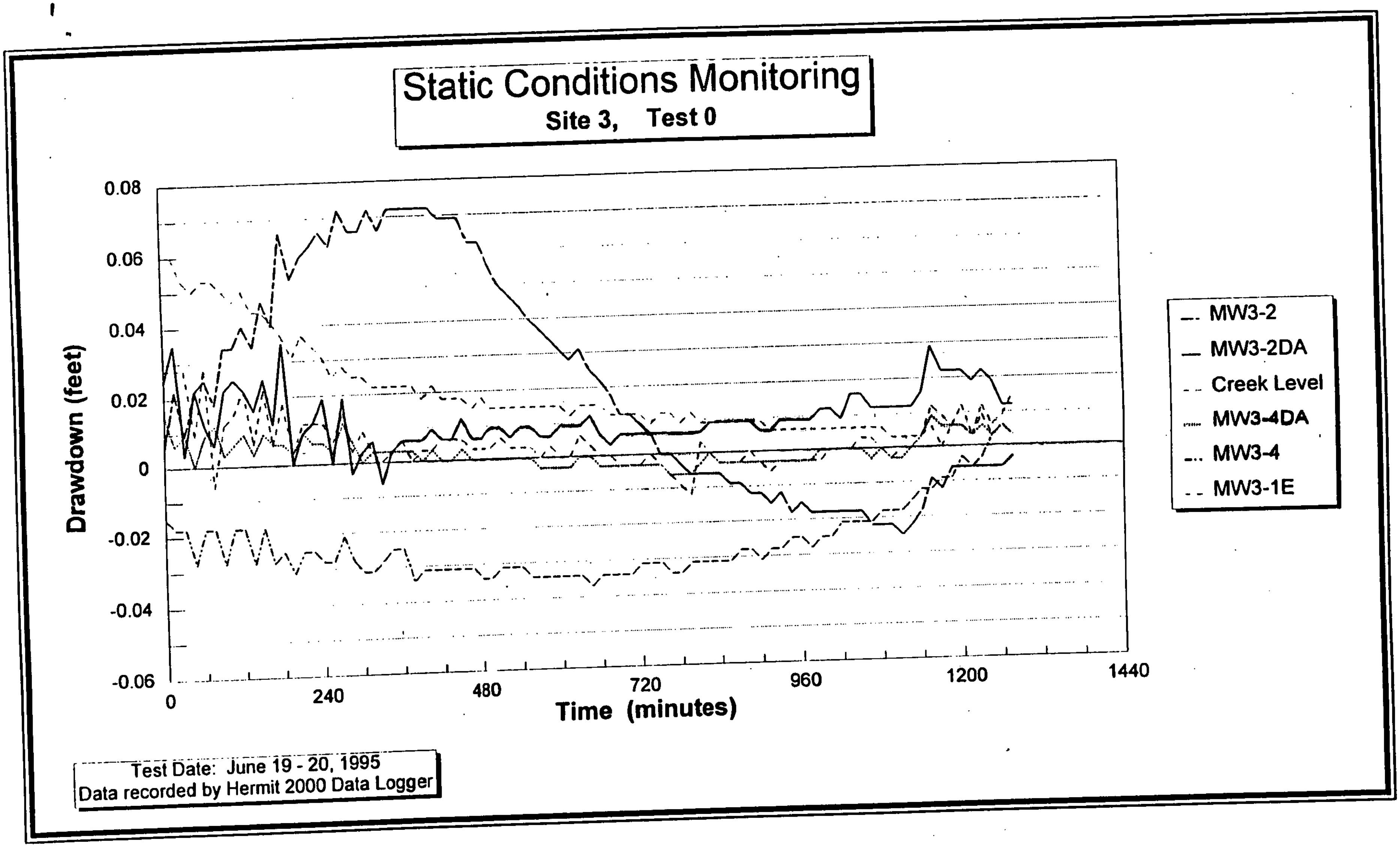
□**Analysis of Hydraulic Properties:** Given that the production rate of the pumping well was discontinuous, a total discharge volume of 680 gallons were removed from the well over a period of 16.5 hours. This is, therefore, the equivalent of 0.69 gpm for the test period. Using the steady water level decline data observed for observation wells MW13-3 and MW13-5D, a type curve analysis of these drawdown data was possible. The results of these analyses are presented in Figures -10, -11, and -12. Both the Neuman (1975) and the Cooper-Jacob (1946) methods for unconfined aquifers were used for these analyses.

The results of these type curve analyses indicate that the hydraulic conductivities of both the overburden and the shallow bedrock aquifer appear to be similar not only to each other, but to that of the shallow bedrock aquifer tested at site 3. Here, an average K of 1.15×10^{-4} cm/sec was determined for the shallow bedrock aquifer, and a K of 4.28×10^{-4} cm/sec for the overburden aquifer. While K values may be similar, the storativity (S), and therefore possibly the yield, of these two zones appear to be quite different as would be expected given the nature of each medium. The overburden, having generally a fine matrix including silts and clays, shows a relatively high storativity of 1.3×10^{-3}. The bedrock zone, which produces water through rock fractures, typically should show a very low storativity. An average S of 4.2×10^{-5} was determined by these analyses.

□**Analyses of Drainage Rates and volume:** Using the formula $V = (K/n)(dh/dl)$, the velocity (V) of groundwater flow can be approximated. Given previously, the gradient between the overburden and the shallow bedrock, K for the bedrock aquifer zone, and then assuming a typical porosity (n) of 25% or 0.25, the velocity of the vertical flow from the overburden to the bedrock is approximately a very low 0.092 feet/day under static conditions. Under the induced gradient the velocity increases dramatically to approximately 2.0 feet/day. This induced gradient, however, is a very transient situation while the overburden water level is dropping.

An additional way to view drainage can be given by considering a cylinder of unit, 1 foot, diameter (area of 0.785 sq. ft), extending through the saturated thickness of just the overburden. Assuming again, a porosity of 0.25 and total change in water level of 0.7 feet as observed at well MW13-3, the estimated volumetric yield of the aquifer is 0.137 cubic feet. This volume extended over the test period of 16.5 hours equates to 1.38×10^{-4} ft^3/minute, 1.03×10^{-3} gpm, or 1.32×10^{-4} gpm/ ft^2.

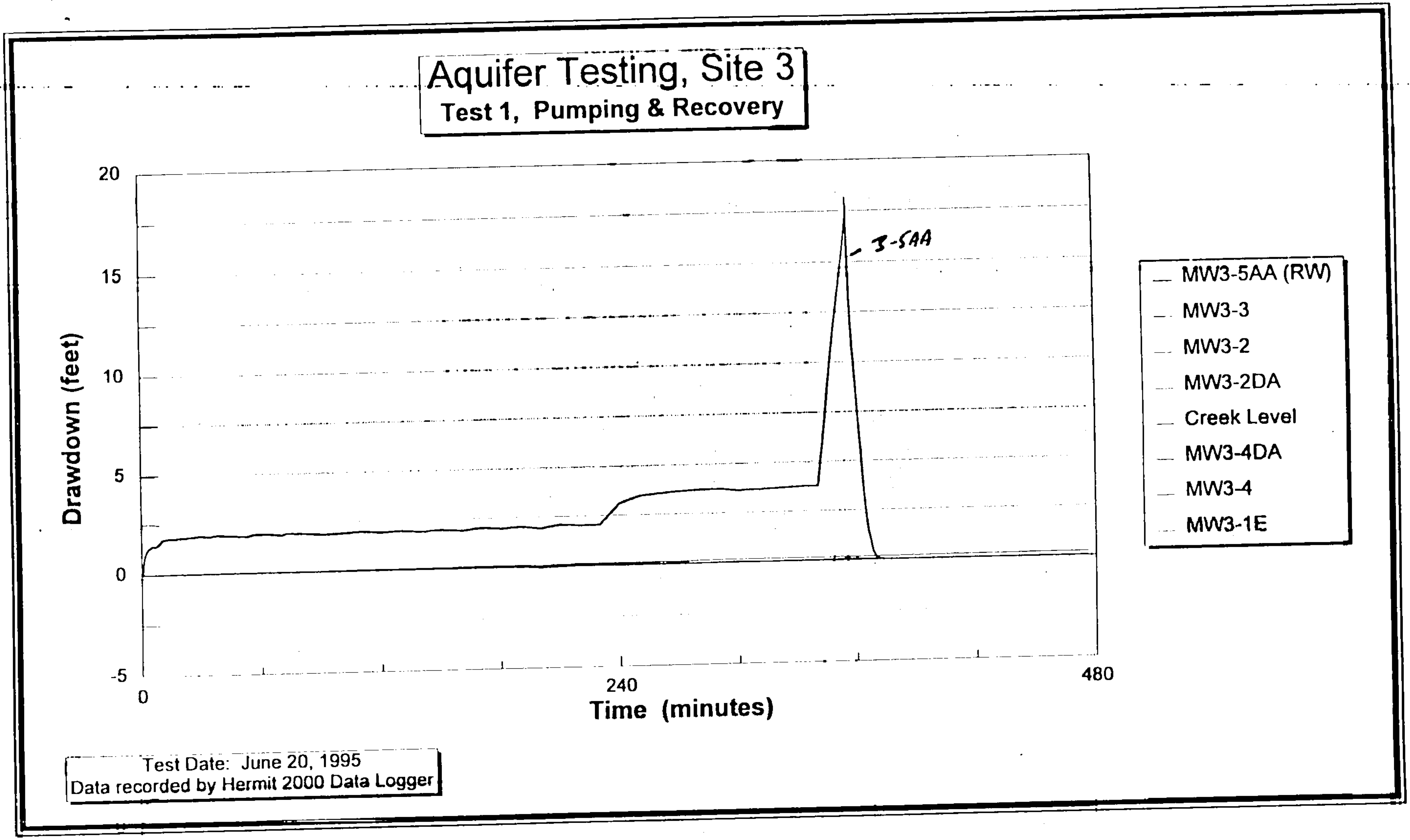

Static Conditions Monitoring
Site 3, Test 0
0.08
0.06
0.04
0.02
0
-0.02
-0.04
Drawdown (feet)
0
240
480
720
960
1200
1440
Time (minutes)
MW3-5AA (RW)
MW3-3
MW3-2
Creek Level
Test Date: June 19 - 20, 1995
Data recorded by Hermit 2000 Data Logger


Static Conditions Monitoring
Site 3, Test 0
Drawdown (feet)
0.08
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
0
240
480
720
960
1200
1440
Time (minutes)
MW3-2
MW3-2DA
Creek Level
MW3-4DA
MW3-4
MW3-1E
Test Date: June 19 - 20, 1995
Data recorded by Hermit 2000 Data Logger

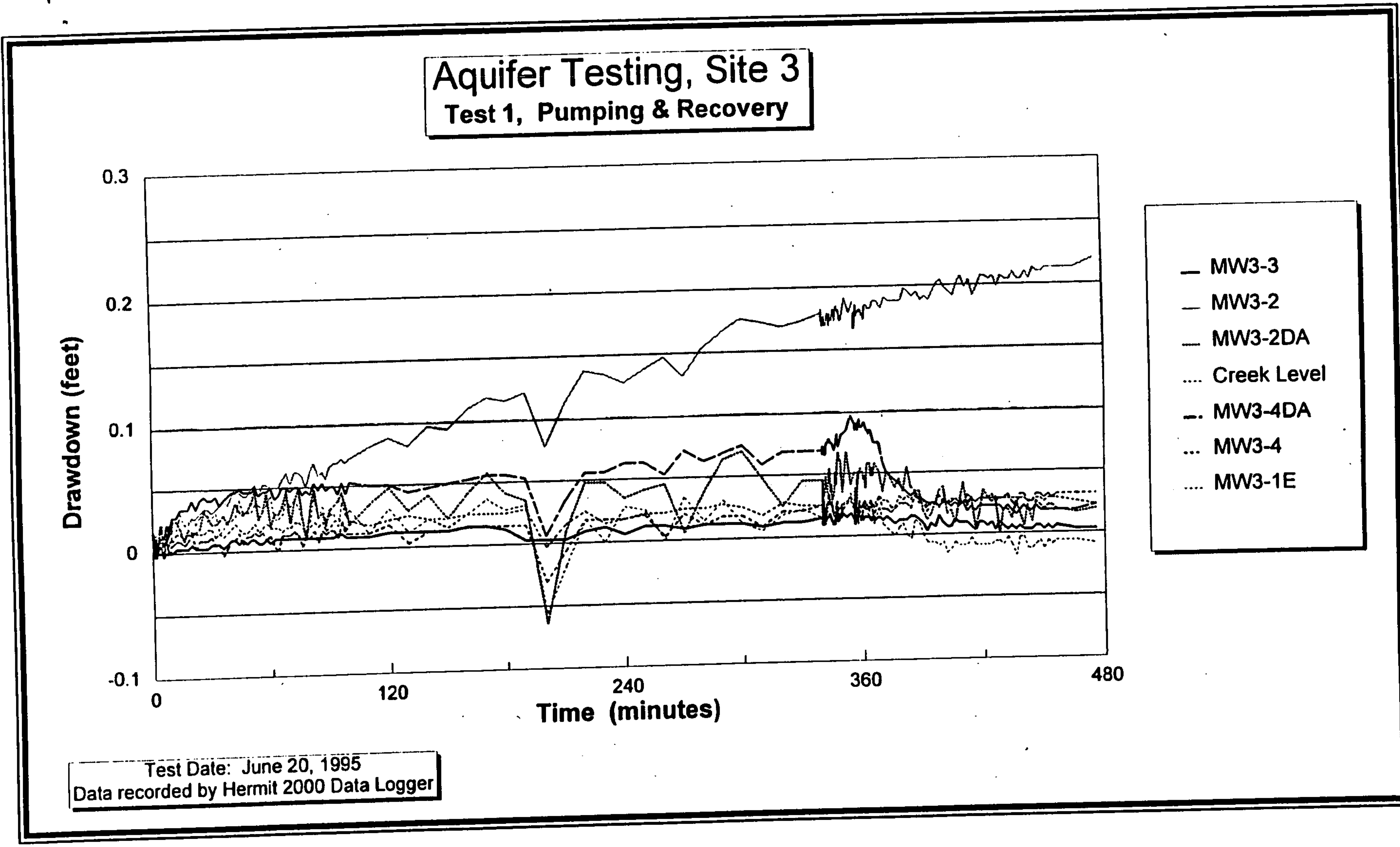
07/13/95 11:17 AM

Figure-3

3-PUMP.WK4



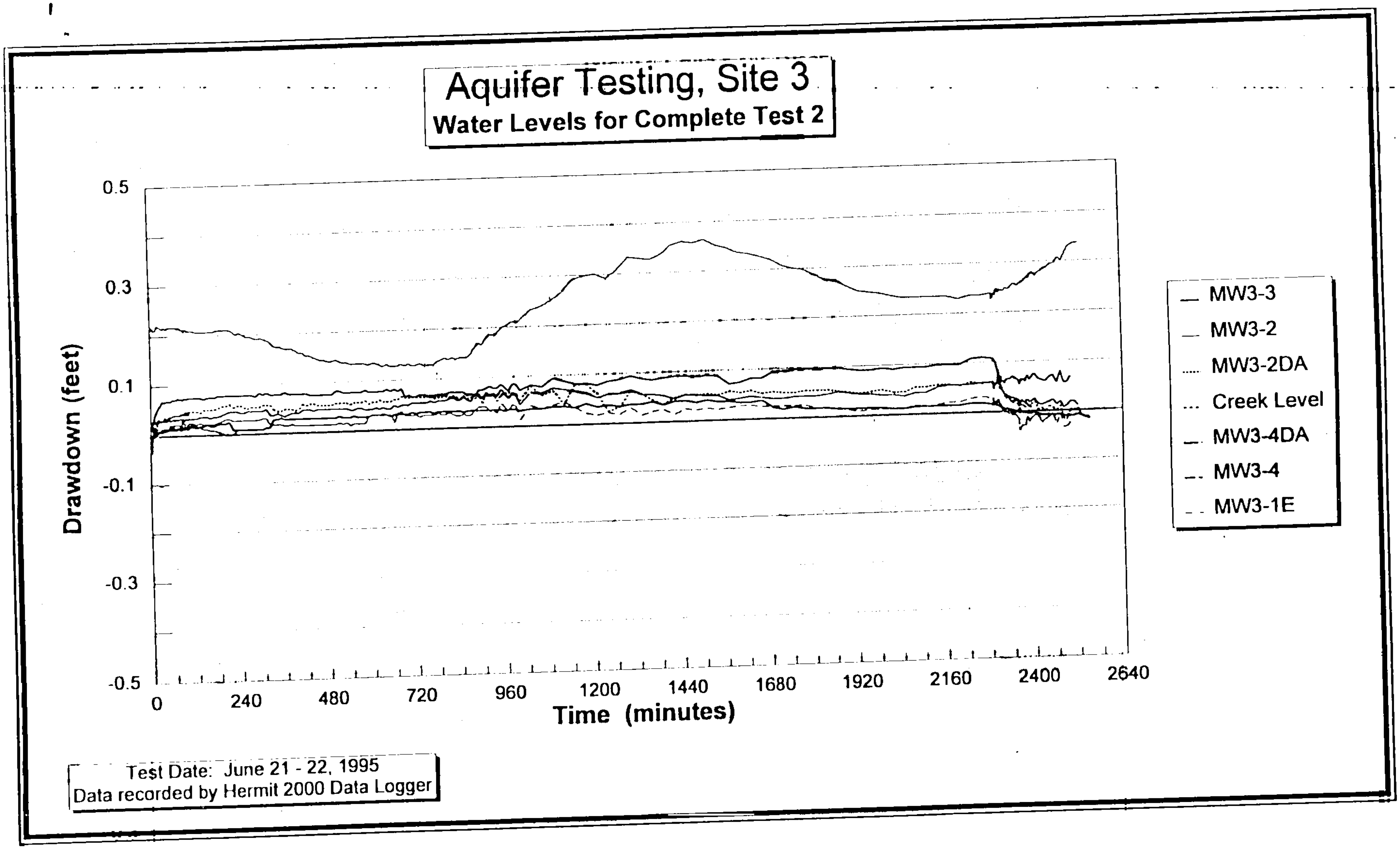
C-9


Aquifer Testing, Site 3
Test 1, Pumping & Recovery
Drawdown (feet)
0.3
0.2
0.1
0
-0.1
0
120
240
360
480
Time (minutes)
MW3-3
MW3-2
MW3-2DA
Creek Level
MW3-4DA
MW3-4
MW3-1E
Test Date: June 20, 1995
Data recorded by Hermit 2000 Data Logger

07/13/95 11:30 AM

Figure -6

3-PUMP.WK4



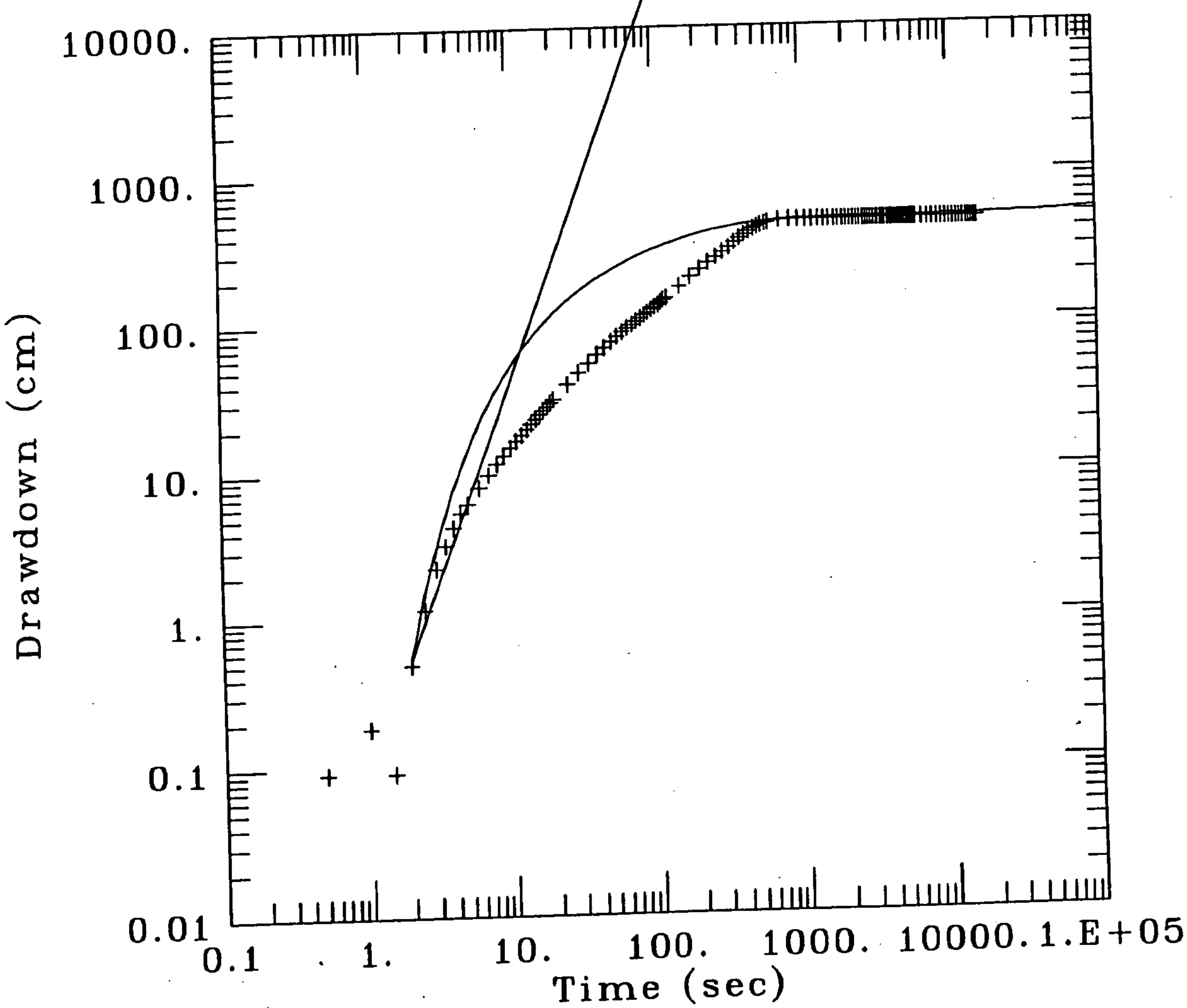
C-11

Niagra Falls - Air Reserve Station

Figure-7

Ecology & Environment, Inc.	Client: NF-ARS
Project No.: Recovery Well 3-5AA	Location: Niagra Falls, NY

Recovery Test: Site 3



DATA SET:
3ec-rec.aqt
07/13/95

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Neuman

TEST DATE:
June, 1995

TEST WELL:
MW3-5AA

OBS. WELL:
MW3-5AA

ESTIMATED PARAMETERS:
T = 0.1024 cm^2/sec
~~S = 0.02329~~
~~Sy = 36.39~~
β = 0.03

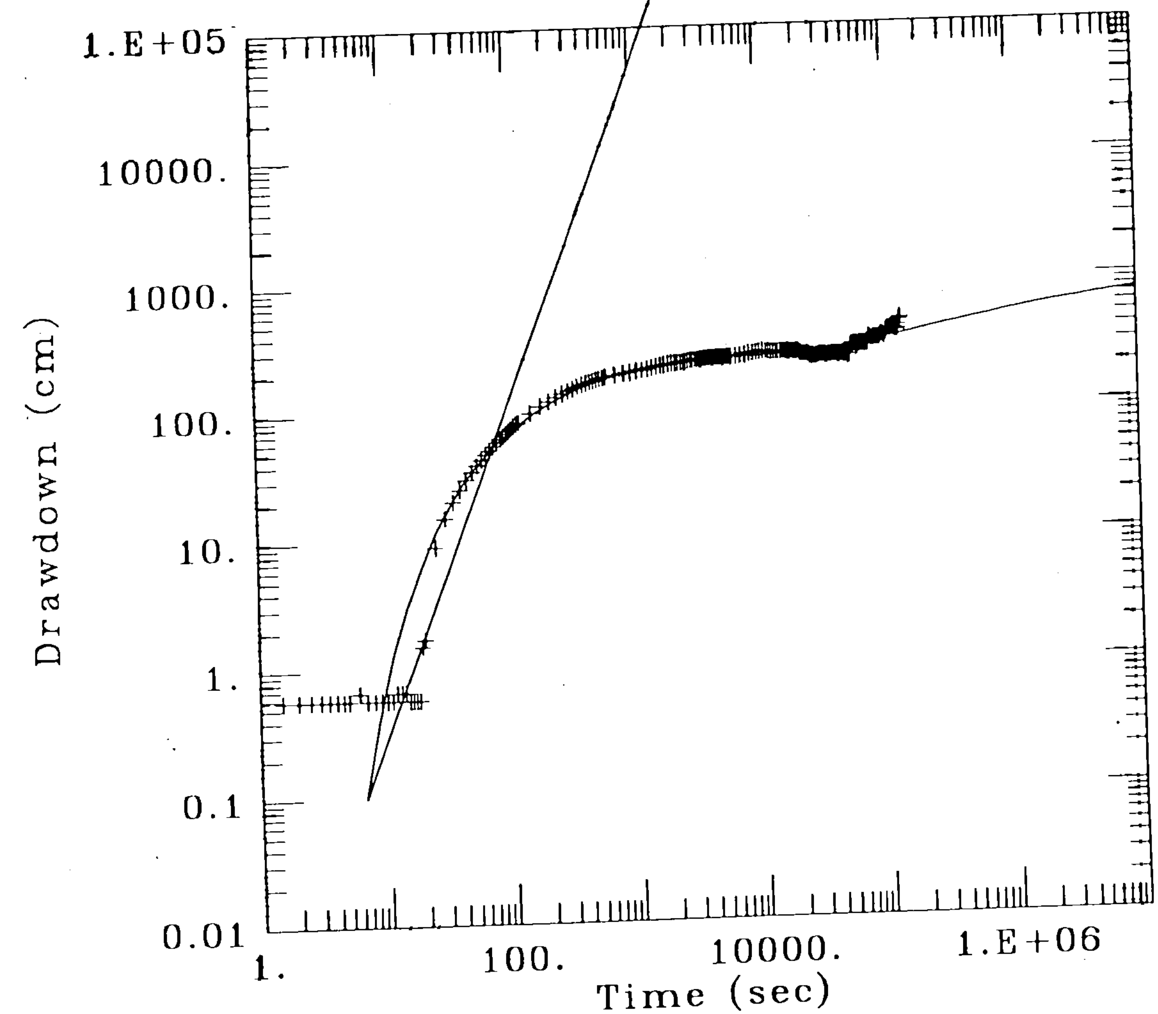
TEST DATA:
Q = 249.2 cm^3/sec
r = 12.19 cm
b = 609.6 cm

$K = \frac{T}{b} = 1.68 \times 10^{-4}$ cm/sec

Figure-8

Ecology & Environment, Inc.	Client: NF-ARS
Project No.: Recovery Well 3-5AA	Location: Niagra Falls, NY

Pumping Test: Site 3



DATA SET:
3ec-pmp.aqt
07/06/95

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Neuman

TEST DATE:
June, 1995

TEST WELL:
MW3-5AA

OBS. WELL:
MW3-5AA

ESTIMATED PARAMETERS:
T = 0.2069 cm^2/sec
~~S = 0.1841~~ e
~~Sy = 13.11~~ e
β = 0.03

TEST DATA:
Q = 249.2 cm^3/sec
r = 12.19 cm
b = 609.6 cm

$K = \frac{T}{b} = 3.39 \times 10^{-4}$ cm/sec.

C-13

Aquifer Drawdown Test, Site 13

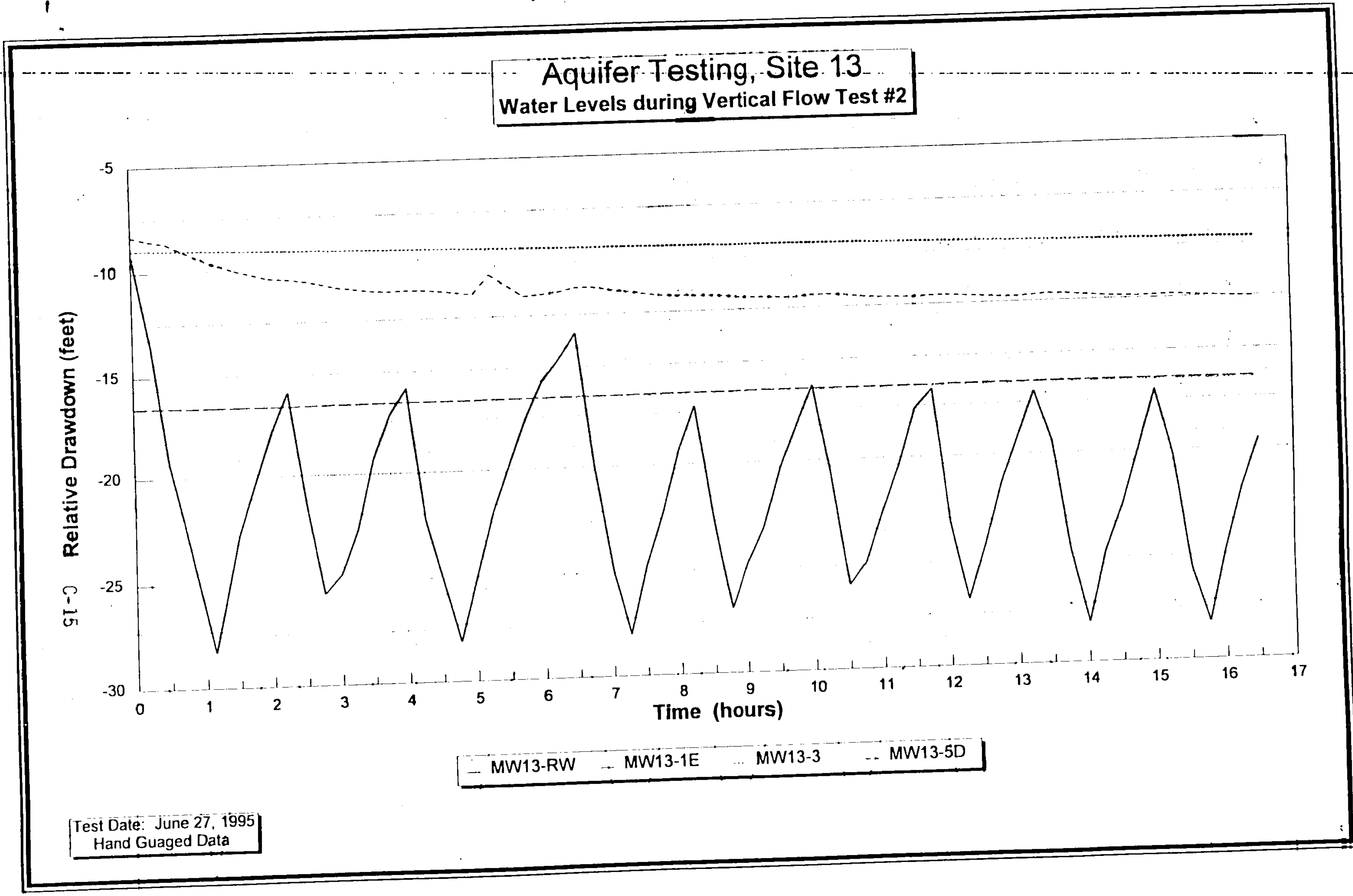
Date: June 27, 1995

Time (Hr)	Time (min)	Cumulative Hours	Pump Totalizer (gal)	Gal Pumped per step	Ave. Pump Rate (gpm)	MW13-RW WL	MW13-RW DD	MW13-1E WL	MW13-1E DD	MW13-3 WL	MW13-3 DD	MW13-5D WL	MW13-5D DD
7	45	0.00	33,214	0	0	9.21	0	16.61	0	8.96	0	8.3	0
8	0	0.25	33,237	23	1.53	13.45	4.24	16.61	0	8.96	0	8.5	0.2
8	15	0.50	33,267	30	1.77	19.3	10.09	16.61	0	8.98	0.02	8.65	0.35
8	30	0.75	33,294	27	1.78	22.8	13.59	16.63	0.02	9	0.04	9.05	0.75
8	45	1.00	33,328	34	1.90	26.45	17.24	16.64	0.03	9.01	0.05	9.39	1.09
8	53	1.13	33,330	2	1.71	28.3	19.09	16.63	0.02	9.02	0.06	9.59	1.29
9	15	1.50	33,330	0	1.29	22.7	13.49	16.63	0.02	9.06	0.1	9.97	1.67
9	45	2.00	33,330	0	0.97	17.9	8.69	16.63	0.02	9.08	0.12	10.38	2.08
10	0	2.25	33,330	0	0.86	15.95	6.74	16.63	0.02	9.09	0.13	10.44	2.14
10	15	2.50	33,359	29	0.97	21.3	12.09	16.62	0.01	9.11	0.15	10.54	2.24
10	30	2.75	33,387	28	1.05	25.6	16.39	16.61	0	9.11	0.15	10.69	2.39
10	45	3.00	33,398	11	1.02	24.7	15.49	16.6	-0.01	9.14	0.18	10.89	2.59
11	0	3.25	33,398	0	0.94	22.6	13.39	16.6	-0.01	9.15	0.19	10.99	2.69
11	15	3.50	33,398	0	0.88	19.3	10.09	16.59	-0.02	9.16	0.2	11.1	2.8
11	30	3.75	33,398	0	0.82	17.2	7.99	16.59	-0.02	9.18	0.22	11.14	2.84
11	45	4.00	33,398	0	0.77	15.9	6.69	16.58	-0.03	9.19	0.23	11.12	2.82
12	0	4.25	33,436	38	0.87	22.2	12.99	16.58	-0.03	9.2	0.24	11.13	2.83
12	15	4.50	33,453	17	0.89	25.1	15.89	16.58	-0.03	9.21	0.25	11.2	2.9
12	30	4.75	33,475	22	0.92	28.1	18.89	16.58	-0.03	9.22	0.26	11.3	3
12	45	5.00	33,475	0	0.87	24.95	15.74	16.58	-0.03	9.24	0.28	11.4	3.1
13	0	5.25	33,475	0	0.83	21.95	12.74	16.57	-0.04	9.26	0.3	10.48	2.18
13	30	5.75	33,475	0	0.76	17.5	8.29	16.56	-0.05	9.27	0.31	11.56	3.26
13	45	6.00	33,475	0	0.73	15.7	6.49	16.56	-0.05	9.28	0.32	11.5	3.2
14	0	6.25	33,475	0	0.70	14.6	5.39	16.55	-0.06	9.3	0.34	11.4	3.1
14	15	6.50	33,475	0	0.67	13.4	4.19	16.55	-0.06	9.31	0.35	11.22	2.92
14	30	6.75	33,518	43	0.75	20.06	10.85	16.54	-0.07	9.32	0.36	11.21	2.91
14	45	7.00	33,540	22	0.78	24.9	15.69	16.54	-0.07	9.32	0.36	11.34	3.04
15	0	7.25	33,562	22	0.80	28	18.79	16.54	-0.07	9.33	0.37	11.44	3.14
15	15	7.50	33,562	0	0.77	24.7	15.49	16.53	-0.08	9.34	0.38	11.58	3.28
15	30	7.75	33,562	0	0.75	22.25	13.04	16.52	-0.09	9.36	0.4	11.68	3.38
15	45	8.00	33,562	0	0.73	19.31	10.1	16.52	-0.09	9.36	0.4	11.73	3.43
16	0	8.25	33,562	0	0.70	17.2	7.99	16.51	-0.1	9.38	0.42	11.74	3.44
16	15	8.50	33,594	32	0.75	22.61	13.4	16.51	-0.1	9.38	0.42	11.77	3.47
16	30	8.75	33,620	26	0.77	26.9	17.69	16.51	-0.1	9.4	0.44	11.83	3.53
16	45	9.00	33,620	0	0.75	24.8	15.59	16.5	-0.11	9.4	0.44	11.91	3.61
17	0	9.25	33,620	0	0.73	23.04	13.83	16.48	-0.13	9.4	0.44	11.94	3.64
17	15	9.50	33,620	0	0.71	20.34	11.13	16.48	-0.13	9.4	0.44	11.96	3.66
17	30	9.75	33,620	0	0.69	18.31	9.1	16.48	-0.13	9.4	0.44	11.98	3.68
17	45	10.00	33,620	0	0.68	16.35	7.14	16.48	-0.13	9.42	0.46	11.9	3.6
18	0	10.25	33,656	36	0.72	20.8	11.59	16.48	-0.13	9.43	0.47	11.88	3.58
18	15	10.50	33,684	28	0.75	25.95	16.74	16.48	-0.13	9.44	0.48	11.94	3.64
18	30	10.75	33,684	0	0.73	24.87	15.66	16.48	-0.13	9.44	0.48	12.02	3.72
18	45	11.00	33,684	0	0.71	22.46	13.25	16.48	-0.13	9.48	0.52	12.08	3.78
19	0	11.25	33,684	0	0.70	20.35	11.14	16.48	-0.13	9.48	0.52	12.1	3.8
19	15	11.50	33,684	0	0.68	17.65	8.44	16.48	-0.13	9.49	0.53	12.12	3.82
19	30	11.75	33,684	0	0.67	16.7	7.49	16.48	-0.13	9.5	0.54	12.08	3.78
19	45	12.00	33,738	54	0.73	23.1	13.89	16.46	-0.15	9.5	0.54	12.07	3.77
20	0	12.25	33,754	16	0.73	26.8	17.59	16.46	-0.15	9.52	0.56	12.12	3.82
20	15	12.50	33,756	2	0.72	24.22	15.01	16.46	-0.15	9.52	0.56	12.17	3.87
20	30	12.75	33,756	0	0.71	21.33	12.12	16.46	-0.15	9.53	0.57	12.22	3.92
20	45	13.00	33,756	0	0.69	19.2	9.99	16.46	-0.15	9.55	0.59	12.24	3.94
21	0	13.25	33,756	0	0.68	16.95	7.74	16.46	-0.15	9.55	0.59	12.2	3.9
21	15	13.50	33,773	17	0.69	19.4	10.19	16.46	-0.15	9.56	0.6	12.14	3.84
21	30	13.75	33,804	31	0.72	24.65	15.44	16.46	-0.15	9.57	0.61	12.18	3.88
21	45	14.00	33,826	22	0.73	28.1	18.89	16.46	-0.15	9.58	0.62	12.24	3.94
22	0	14.25	33,826	0	0.72	24.7	15.49	16.46	-0.15	9.59	0.63	12.3	4
22	15	14.50	33,826	0	0.70	22.55	13.34	16.46	-0.15	9.6	0.64	12.34	4.04
22	30	14.75	33,826	0	0.69	19.9	10.69	16.46	-0.15	9.6	0.64	12.38	4.08
22	45	15.00	33,826	0	0.68	17.05	7.84	16.46	-0.15	9.62	0.66	12.36	4.06
23	0	15.25	33,845	19	0.69	20.3	11.09	16.46	-0.15	9.62	0.66	12.33	4.03
23	15	15.50	33,876	31	0.71	25.58	16.37	16.46	-0.15	9.63	0.67	12.38	4.08
23	30	15.75	33,894	18	0.72	28.22	19.01	16.46	-0.15	9.63	0.67	12.42	4.12
23	45	16.00	33,894	0	0.71	24.8	15.59	16.46	-0.15	9.64	0.68	12.46	4.16
24	0	16.25	33,894	0	0.70	21.8	12.59	16.46	-0.15	9.66	0.7	12.5	4.2
24	15	16.50	33,894	0	0.69	19.5	10.29	16.46	-0.15	9.66	0.7	12.52	4.22
			Total this test: 680 gal		Ave pump rate 0.69 gpm								

07/13/95 11:36 AM

Figure - 9

13-VTEST.WK4

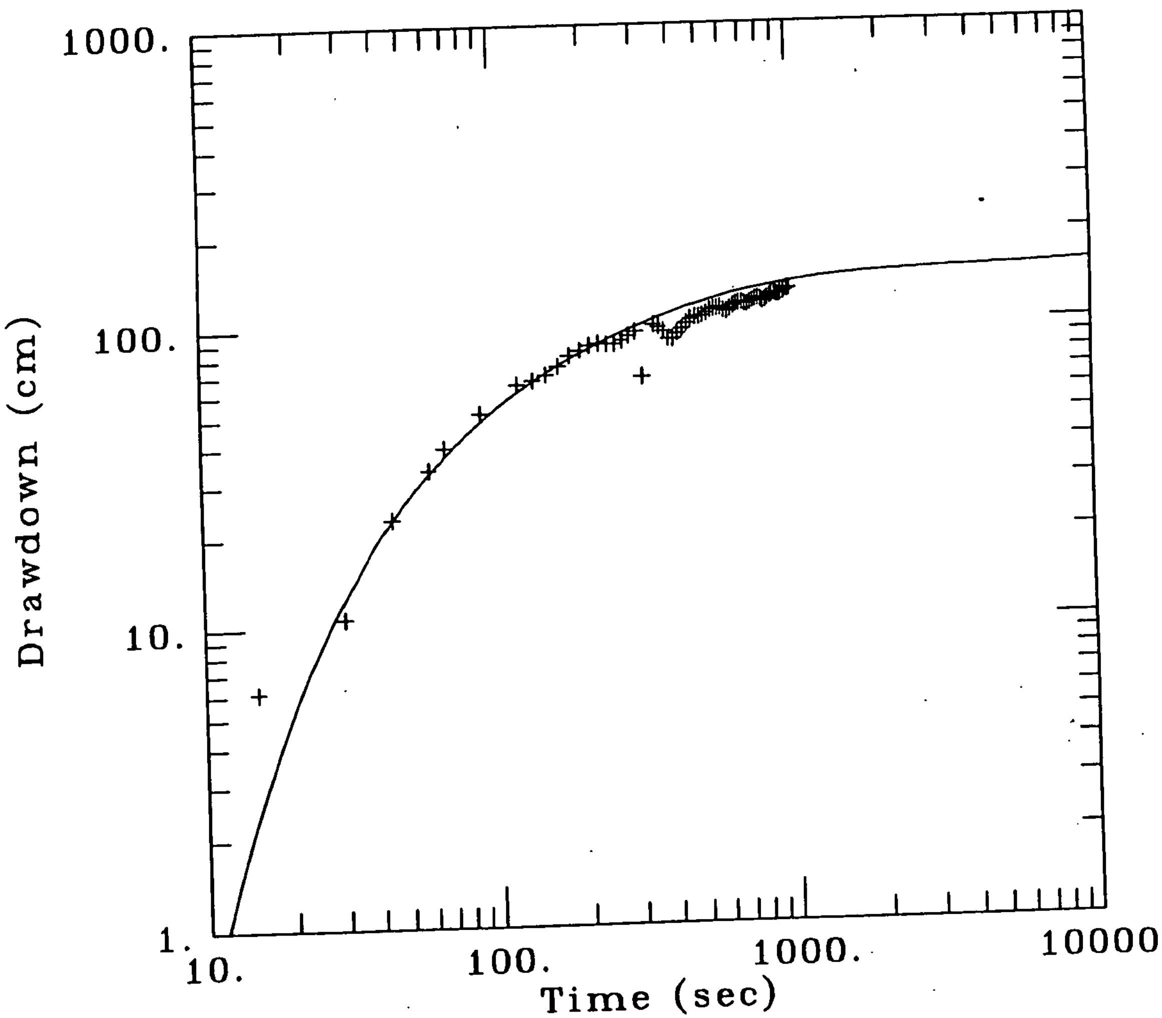


Niagra Falls - Air Reserve Station

Figure - 10

Ecology & Environment, Inc.	Client: NF-ARS
Project No.: Observation Well 13-5D	Location: Niagra Falls, NY

Pumping Test: Site 13



DATA SET:
13-5pc.aqt
07/07/95

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Neuman

TEST DATE:
June, 1995

TEST WELL:
MW13-RW

OBS. WELL:
MW13-5D

ESTIMATED PARAMETERS:
T = 0.04552 cm^2/sec
S = 4.5434E-05
Sy = 0.005794
β = 0.06

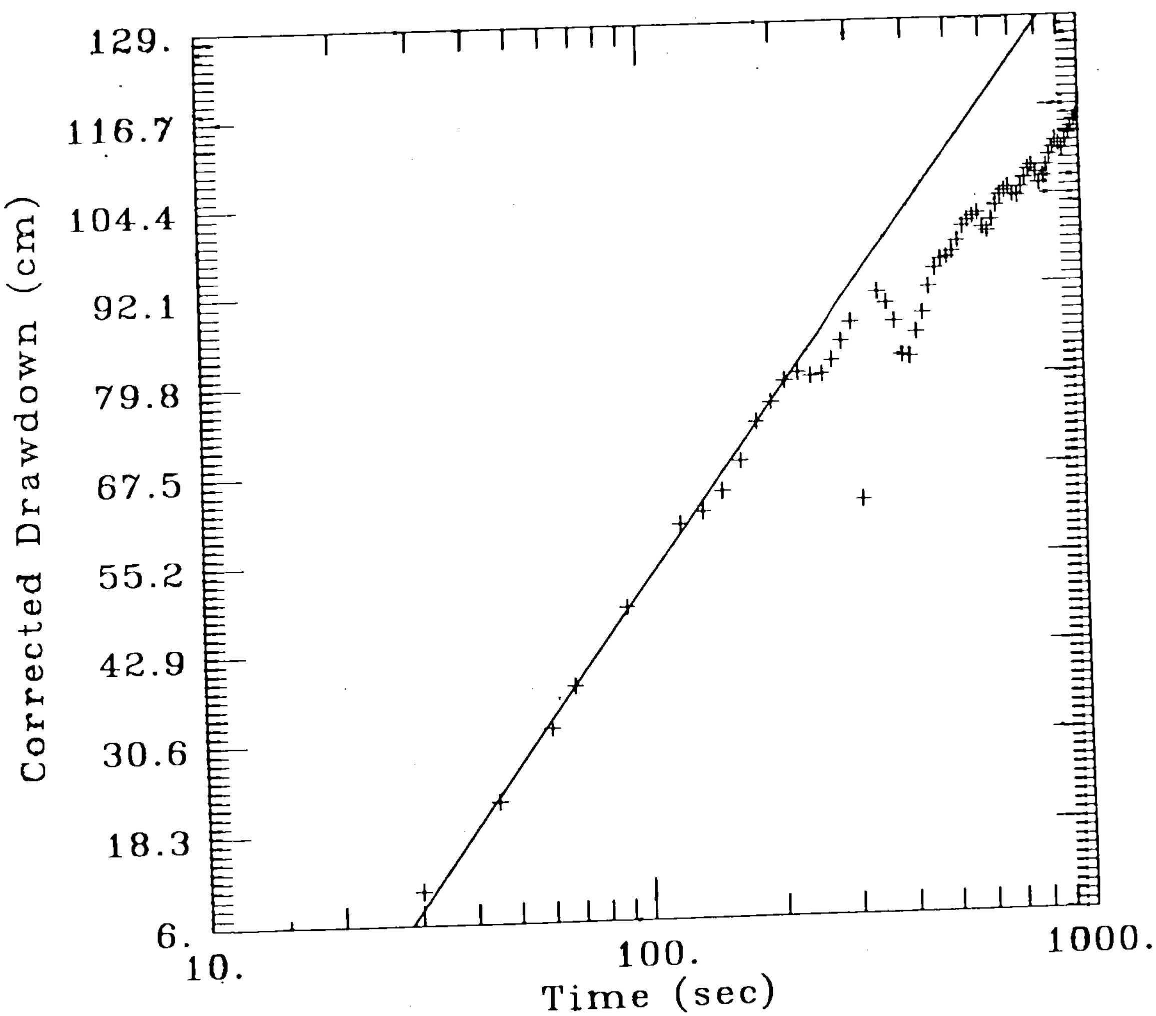
TEST DATA:
Q = 43.32 cm^3/sec
r = 365.8 cm
b = 609.6 cm

$K = \frac{T}{b} = 7.47 \times 10^{-5}$

Figure - 11

Ecology & Environment, Inc.	Client: NF-ARS
Project No.: Observation Well 13-5D	Location: Niagra Falls, NY

Pumping Test: Site 13



DATA SET:
13-5pc.aqt
07/06/95

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Cooper-Jacob
TEST DATE:
June, 1995
TEST WELL:
MW13-RW
OBS. WELL:
MW13-5D

ESTIMATED PARAMETERS:
T = 0.0943 cm^2/sec
S = 3.7963E-05

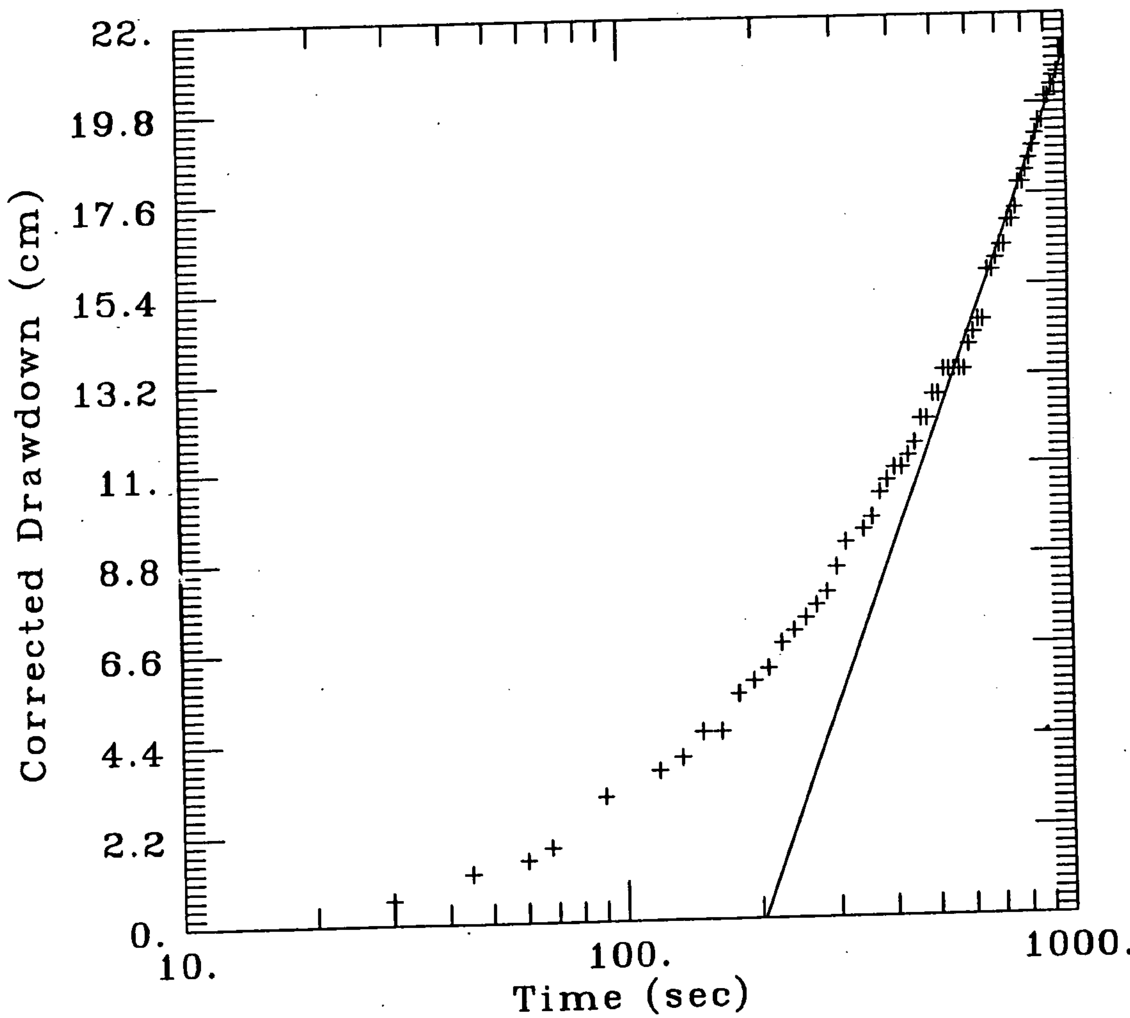
TEST DATA:
Q = 43.32 cm^3/sec
r = 365.8 cm
b = 609.6 cm

$K = \frac{T}{b} = 1.55 \times 10^{-4}$

Figure-12

Ecology & Environment, Inc.	Client: NF-ARS
Project No.: Observation Well 13-3	Location: Niagra Falls, NY

Pumping Test: Site 13



DATA SET:
13-3pc.aqt
07/07/95

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Cooper-Jacob

TEST DATE:
June, 1995

TEST WELL:
MW13-RW

OBS. WELL:
MW13-3

ESTIMATED PARAMETERS:
T = 0.2609 cm^2/sec
S = 0.001279

TEST DATA:
Q = 43.32 cm^3/sec
r = 304.8 cm
b = 1219.2 cm

$K = \frac{T}{b} = 2.14 \times 10^{-4}$

D Preliminary Design of Air Stripper for Site 3

North East Environmental Products, Inc.
17 Technology Drive West Lebanon NH 03784
(603) 298-7061 Fax (603) 298-7063

Wednesday, August 30, 1995

Sandeep Sisodia
Ecology & Environment Incorporated
368 Pleasant View Drive
Lancaster, New York

RE: Proposal #895918
Site ID: NFAFB Site #3, NY

Dear Sandeep,

To follow-up your request, North East Environmental Products is pleased to submit the following proposal for our ShallowTray® air stripper to remove Chlorinated VOCs from the groundwater remediation stream on your NFAFB Site #3 project in New York.

Performance:

To provide the required stripping performance at a design flowrate of 15 gpm and a minimum influent water temperature of 59°F, we offer our four-tray polyethylene **Model 1341-P** ShallowTray low profile air stripper (hydraulic flow range 0.5-15 gpm, fresh air inlet flowrate 150 cfm). Removal efficiencies will follow the attached System Performance Estimate.

It is important that foam causing surfactants (soaps, detergents, oils, and greases) be prevented from entering the influent stream since they can inhibit the stripping operation if not properly treated. Additionally, high levels of iron, manganese, calcium, and magnesium may affect the long term operation of the stripper and therefore require sequestration or maintenance consideration.

Pricing: The selling price for the ShallowTray **Model 1341-P** air stripper with options follows:

Basic System Model 1341-P	
Sump tank, Cover & 1 Tray, LLDPE (rotationally molded Linear Low Density Polyethylene) Sump & Cover, Tray Ring, Trays, & Baffles	
3 Additional tray(s), LLDPE	
Forced Draft Blower, 4 tray, 3 hp, 150 cfm @ 18wc, 1 Ø, 230V, 60Hz, TEFC	
Inlet screen & damper, 304L SS mist eliminator, spray nozzle, sight tube, gaskets, SS latches, & Schedule 80 PVC piping.	
Basic System Price Model 1341-P	$5,573

Options		
Skid Mounting: Fabricated Frame with Control & Instrument Stanchion	1	$575
Gravity discharge piping with vacuum relief valve	1	$65
Air pressure gauge, pneumatic	1	$74
Standard NEMA 3R Control Panel, w/main disconnect switch, alarm interlocks, motor starter, & panel light, UL listed	1	$2,072
Panel Option: Intermittent operation circuitry	1	$336
Panel Option: Strobe alarm light, w/Blue, Red, or Amber lens	0	$0
Low Air pressure alarm/shutdown switch, pneumatic, EXP	1	$171
High water level alarm/shutdown float switch	1	$70
Pump level control float switch(es)	0	$0
Digital Water Flow Indicator/Totalizer	0	$0
Air flow meter, insertion pitot tube w/pressure gauge, pneumatic	0	$0
Line sampling ports, inlet and/or discharge	2	$53
Air blower silencer, fan inlet	0	$0
Options Cost		$3,415
Total Model 1341-P System Price, Including Options, US$ Each:		**$8,988**

Design Details: Each **Model 1341-P** ShallowTray air stripper system is 6'10" high, 5'10" long, 2'4" wide, and weighs approximately 400 pounds dry. Additional design and dimension information is included in the attached **Model 1341-P** drawing.

The blower selected for the stripper above was sized to provide sufficient pressure drop for the air stripper requirements only. If additional pressure drop is required for upstream or downstream losses for ductwork, vapor treatment, etc., North East Environmental Products can meet those needs with a single upgraded blower, providing additional energy and cost efficiency. If such an arrangement might prove beneficial to this project, please let me know what additional pressure drop is needed.

Electrical Requirements: Please note that the ShallowTray system quoted above requires the supply of 230 volt, single phase, 60 Hertz, three wire plus ground electrical power. If your onsite electrical provisions are different, please contact North East Environmental Products. Please confirm this vital electrical information in writing on your formal purchase order.

Terms & Shipment:

Each **ShallowTray** system is shipped pre-assembled and factory tested. An O&M manual and system start-up video are included with each unit. Normal shipment is approximately 4 weeks after receipt of order.

Payment terms are 30% with order, 70% net 30 days after shipment. Prices are quoted in US$, F.O.B. West Lebanon, New Hampshire, excluding freight, duty, taxes, and brokerage, and are valid for 90 days.

I invite you to phone or fax me immediately if I can answer any additional questions, comments, or concerns you may have. I look forward to working with you on this project as it develops, and to providing you and your client the most cost effective stripper available. Once again, thank you for your interest in our products.

Sincerely,

D. Shearouse

Don Shearouse, P.E.
Customer Service

File: Ecology & Environment

ShallowTray™
low profile air strippers

System Performance Estimate

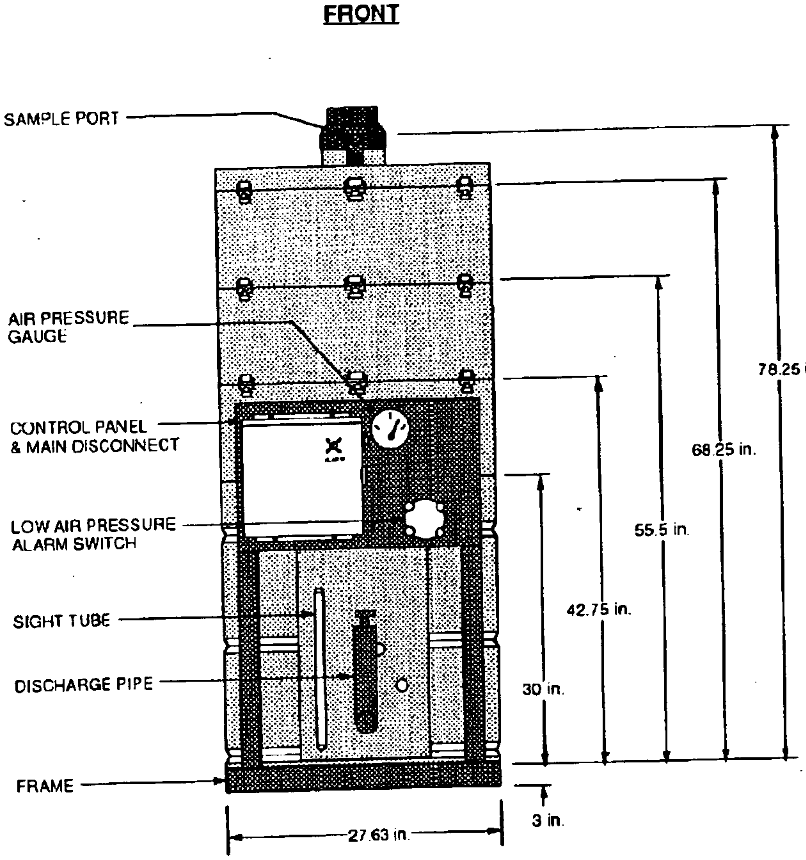
Client & Proposal Information:

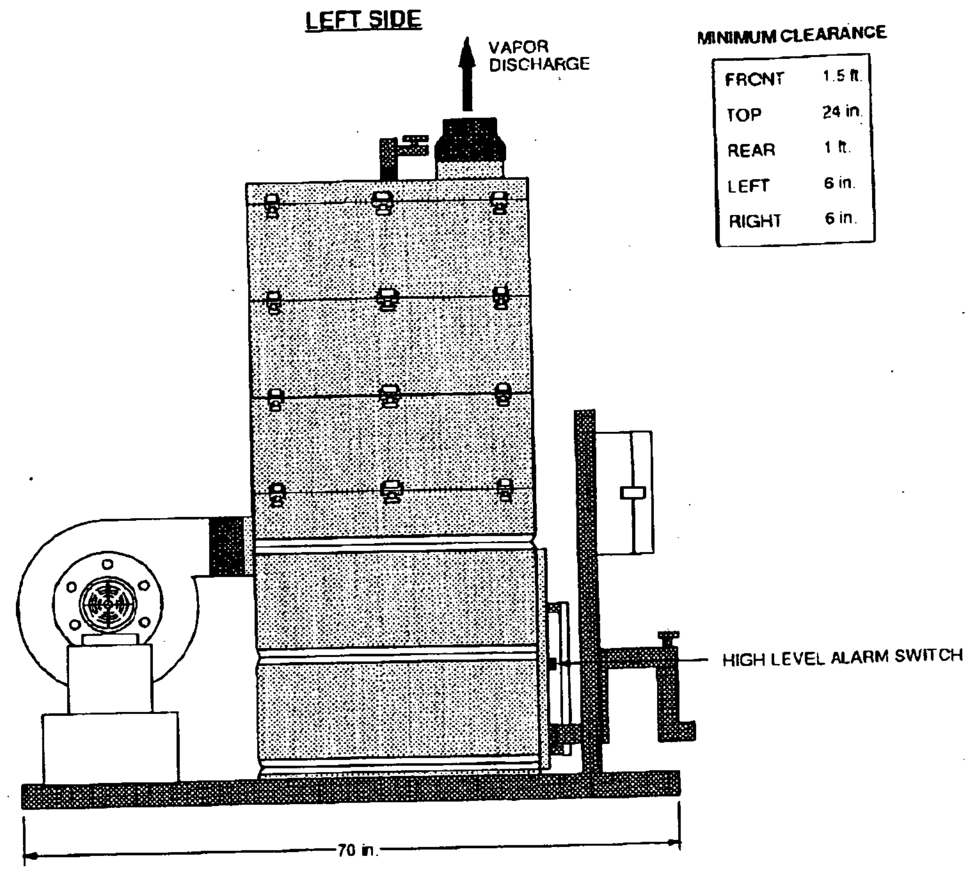
Ecology & Environment: Sandeep Sisodia
Niagara Falls AFB: Site #3
#895918

Model chosen: 1300
Water Flow Rate: 15.0 gpm
Air Flow Rate: 150 cfm
Water Temp: 59.0 °F
Air temp: 40.0 °F
A/W Ratio: 74.8
Safety Factor 25%

Contaminant	Untreated Influent / Effluent Target	Model 1311 Effluent Water / Air(lbs/hr) / % removal	Model 1321 Effluent Water / Air(lbs/hr) / % removal	Model 1331 Effluent Water / Air(lbs/hr) / % removal	Model 1341 Effluent Water / Air(lbs/hr) / % removal
Benzene	2 ppb 1 ppb	1 ppb 0.000008 81.9455%	<1 ppb 0.000015 96.7403%	<1 ppb 0.000015 99.4115%	<1 ppb 0.000015 99.8937%
1,2-Dichloroethylene	36 ppb 5 ppb	7 ppb 0.000218 83.1630%	2 ppb 0.000255 97.1652%	<1 ppb 0.000269 99.5227%	<1 ppb 0.000270 99.9196%
Carbon Tetrachloride	2400 ppb 5 ppb	184 ppb 0.016627 92.3465%	15 ppb 0.017895 99.4142%	2 ppb 0.017993 99.9552%	<1 ppb 0.018007 99.9966%
Chloroform	1100 ppb 7 ppb	222 ppb 0.006588 79.8464%	45 ppb 0.007916 95.9383%	10 ppb 0.008179 99.1814%	2 ppb 0.008239 99.8350%
Methylene Chloride	6 ppb 5 ppb	3 ppb 0.000023 65.6581%	1 ppb 0.000038 88.2063%	<1 ppb 0.000043 95.9498%	<1 ppb 0.000044 98.6091%
1,2-Dichloroethylene	170 ppb 5 ppb	26 ppb 0.001080 85.1012%	4 ppb 0.001246 97.7803%	1 ppb 0.001268 99.6693%	<1 ppb 0.001275 99.9507%
Trichloroethylene	920 ppb 5 ppb	116 ppb 0.006033 87.4955%	15 ppb 0.006790 98.4364%	2 ppb 0.006888 99.8045%	<1 ppb 0.006901 99.9755%
Vinyl Chloride	55 ppb 2 ppb	3 ppb 0.000390 95.9391%	<1 ppb 0.000412 99.8351%	<1 ppb 0.000413 99.9933%	<1 ppb 0.000413 99.9997%

This report has been generated by ShallowTray Modeler software version 2.0.4. This software is designed to assist a skilled operator in predicting the performance of a ShallowTray air stripping system. North East Environmental Products, Inc. is not responsible for incidental or consequential damages resulting from the improper operation of either the software or the air stripping equipment. Report generated: 8/30/95





MINIMUM CLEARANCE

FRONT	1.5 ft.
TOP	24 in.
REAR	1 ft.
LEFT	6 in.
RIGHT	6 in.

D-6

BASIC SYSTEM

- ✓ SUMP TANK
- ✓ STRIPPER TRAYS
- ✓ BLOWER
- ✓ MIST ELIMINATOR
- ✓ PIPING
- ✓ SPRAY NOZZLE
- ✓ WATER LEVEL SIGHT TUBE
- ✓ GASKETS
- ✓ LATCHES

OPTIONAL ITEMS

- ✓ FRAME
- ✓ DISCHARGE PIPING
- __ DISCHARGE PUMP
- __ FEED PUMP
- __ ADDITIONAL BLOWER
- __ EXPLOSION-PROOF MOTOR(S)
- __ BLOWER START/STOP PANEL
- ✓ CONTROL PANEL
- ✓ MAIN DISCONNECT SWITCH
- __ I.S. COMPONENTS/REMOTE MOUNT
- ✓ INTERMITTENT OPERATION
- __ POWER LAPSE INDICATOR
- __ STROBE LIGHT
- __ ALARM HORN
- ✓ AIR PRESSURE GAUGE
- ✓ LOW AIR PRESSURE ALARM SWITCH
- ✓ HIGH WATER LEVEL ALARM SWITCH
- __ DISCHARGE PUMP LEVEL SWITCH
- __ WATER PRESSURE GAUGE(S)
- __ DIGITAL WATER FLOW INDICATOR
- __ AIR FLOWMETER
- __ TEMPERATURE GAUGE(S)
- ✓ LINE SAMPLING PORTS
- __ AIR BLOWER SILENCER
- __ WASHER WAND
- __ AUTO DIALER

NOTES:

1. DRAWING REPRESENTS A UNIT TYPICAL OF THE SPECIFICATIONS YOU REQUESTED. MINOR CHANGES MAY RESULT DURING THE MANUFACTURING PROCESS.
2. OPTIONAL ITEMS ARE SHIPPED 'LOOSE' EXCEPT WHEN A FRAME IS SUPPLIED BY N.E.E.P.

CONNECTION INFORMATION

ITEM	SIZE
GRAVITY DISCHARGE	2 in. Ø SOCKET, PVC80
DISCHARGE PUMP	1-1/4 in. Ø FNPT
WATER INLET	1-1/4 in. Ø FNPT
AIR EXHAUST NOZZLE	8 in. Ø STUB W/8x6 CPLG

POWER: 1Ø, 230 volts, 3 WIRE + GROUND

*CONSULT N.E.E.P. FOR AMPACITIES AND OTHER VOLTAGE OPTIONS

NORTH EAST ENVIRONMENTAL PRODUCTS, INC.
17 TECHNOLOGY DRIVE
WEST LEBANON, NEW HAMPSHIRE 03784
PHONE: 603-298-7061 FAX: 603-298-7063

TOLERANCES UNLESS OTHERWISE SPECIFIED: ± 1 INCH

DRAWING NAME: ShallowTray® Model 1341-P

DRAWING #: Proposal #895918

DRAWN: DCS

CUSTOMER: Ecology & Environment: NFAFB #3

DATE: 8/30/95

SCALE: NTS

SIZE: A

E

NCSD Correspondence

NIAGARA COUNTY SEWER DISTRICT NO. 1
WATER POLLUTION CONTROL CENTER

7346 Liberty Drive
Niagara Falls, NY 14304-3762
Phone 716-693-0001
FAX 716-693-8759

FLOYD D. SNYDER
Chairman

WRIGHT H. ELLIS
Vice-Chairman

FRANK A. NERONE
Chief Operator

August 22, 1995

Ecology and Environment, Inc.
Buffalo Corporate Center
368 Pleasant View Dr.
Lancaster, NY 14086

Attention: Sandeep Sisodia

Re: Discharge of contaminated groundwater From Air Base

Gentlemen:

We have reviewed your submittal regarding contaminated groundwater at the Niagara Falls Air Base. Our understanding is that you are looking into several possible alternatives for the disposal of this groundwater, and would like our comments regarding accepting it into the NCSD #1 sewer system.

Your fax of August 21, 1995 showed that all the analyzed organic compounds were not detected with the possible exception of acetone. Assuming that an analysis for metals in this wastestream would yield similar results, this discharge could most likely be incorporated into the Air Base's upcoming discharge permit, without the need for pretreatment.

Of course there will be monitoring and reporting requirements in this permit. If you choose to include this contaminated groundwater in the overall facility discharge, the monitoring requirements would include organics as well as metals.

Permit limits which we impose on other users for organic compounds vary from about 0.02#/D to 6.8#/D. Current permit limits for other users for metals are in the range of about 0.05#/D to 0.44#/D.

Whether the Air Base permit would contain specific limits or "surveillance only" status for these compounds would depend on what levels were detected in additional tests.

If you do choose to pursue this route of disposal, please let us know and we will decide what additional preliminary data we need in order to establish monitoring requirements and limits.

If there are comments and/or questions on the above, please contact Mr. Daniel Kummer of this office.

Very truly yours,

NIAGARA COUNTY SEWER DISTRICT #1

Frank A. Nerone, P.E.
Chief Operator

LD4/LEEABG1/2

F Preliminary Design of Air Stripper for Site 10

North East
Environmental Products, Inc.
17 Technology Drive West Lebanon NH 03784
(603) 298-7061 Fax (603) 298-7063

Wednesday, August 30, 1995

Sandeep Sisodia
Ecology & Environment Incorporated
368 Pleasant View Drive
Lancaster, New York

RE: Proposal #895919
Site ID: NFAFB Site #10, NY

Dear Sandeep,

To follow-up your request, North East Environmental Products is pleased to submit the following proposal for **our** ShallowTray® air stripper to remove Chlorinated VOCs from the groundwater remediation stream on your NFAFB Site #10 project in New York.

Performance:

To provide the required stripping performance at a design flowrate of 15 gpm and a minimum influent water temperature of 59°F, we offer our four-tray polyethylene **Model 2341-P** ShallowTray low profile air stripper (hydraulic flow range 1-50 gpm, fresh air inlet flowrate 300 cfm). Removal efficiencies will follow the attached System Performance Estimate.

It is important that foam causing surfactants (soaps, detergents, oils, and greases) be prevented from entering the influent stream since they can inhibit the stripping operation if not properly treated. Additionally, high levels of iron, manganese, calcium, and magnesium may affect the long term operation of the stripper and therefore require sequestration or maintenance consideration.

Pricing: The selling price for the ShallowTray **Model 2341-P** air stripper with options follows:

Basic System Model 2341-P Sump tank, Cover & 1 Tray, LLDPE (rotationally molded Linear Low Density Polyethylene) Sump & Cover, and HDPE (High Density Polyethylene) Perforated Trays & Baffles 3 Additional tray(s), HDPE Forced Draft Blower, 4 tray, 5 hp, 300 cfm @ 18wc, 1 Ø, 230V, 60Hz, TEFC Inlet screen & damper, 304L SS mist eliminator, spray nozzle, sight tube, gaskets, SS latches, & Schedule 80 PVC piping.	
Basic System Price **Model 2341-P**	$9,226

Options		
Skid Mounting: Fabricated Frame with Control & Instrument Stanchion	1	$975
Gravity discharge piping with vacuum relief valve	1	$112
Air pressure gauge, pneumatic	1	$74
Standard NEMA 3R Control Panel, w/main disconnect switch, alarm interlocks, motor starter, & panel light, UL listed	1	$2,072
Panel Option: Intermittent operation circuitry	1	$336
Panel Option: Strobe alarm light, w/Blue, Red, or Amber lens	0	$0
Low Air pressure alarm/shutdown switch, pneumatic, EXP	1	$171
High water level alarm/shutdown float switch	1	$70
Pump level control float switch(es)	0	$0
Digital Water Flow Indicator/Totalizer	0	$0
Air flow meter, insertion pitot tube w/pressure gauge, pneumatic	0	$0
Line sampling ports, inlet and/or discharge	2	$53
Air blower silencer, fan inlet	0	$0
Options Cost		$3,862
Total Model 2341-P System Price, Including Options, US$ Each:		**$13,088**

Design Details: Each **Model 2341-P** ShallowTray air stripper system is 6'9" high, 8'0" long, 4'0" wide, and weighs approximately 700 pounds dry. Additional design and dimension information is included in the attached **Model 2341-P** drawing.

The blower selected for the stripper above was sized to provide sufficient pressure drop for the air stripper requirements only. If additional pressure drop is required for upstream or downstream losses for ductwork, vapor treatment, etc., North East Environmental Products can meet those needs with a single upgraded blower, providing additional energy and cost efficiency. If such an arrangement might prove beneficial to this project, please let me know what additional pressure drop is needed.

Electrical Requirements: Please note that the ShallowTray system quoted above requires the supply of 230 volt, three phase, 60 Hertz, four wire plus ground electrical power. If your onsite electrical provisions are different, please contact North East Environmental Products. Please confirm this vital electrical information in writing on your formal purchase order.

Terms & Shipment:

Each **ShallowTray** system is shipped pre-assembled and factory tested. An O&M manual and system start-up video are included with each unit. Normal shipment is approximately 4 weeks after receipt of order.

Payment terms are 30% with order, 70% net 30 days after shipment. Prices are quoted in US$, F.O.B. West Lebanon, New Hampshire, excluding freight, duty, taxes, and brokerage, and are valid for 90 days.

I invite you to phone or fax me immediately if I can answer any additional questions, comments, or concerns you may have. I look forward to working with you on this project as it develops, and to providing you and your client the most cost effective stripper available. Once again, thank you for your interest in our products.

Sincerely,

D. Shearouse

Don Shearouse, P.E.
Customer Service

File: Ecology & Environment

ShallowTray

low profile air strippers

System Performance Estimate

Client & Proposal Information:

Ecology & Environment: Sandeep Sisodia
Niagara Falls AFB: Site #10
#895919

Model chosen:	2300
Water Flow Rate:	15.0 gpm
Air Flow Rate:	300 cfm
Water Temp:	59.0 °F
Air temp:	40.0 °F
A/W Ratio:	149.6
Safety Factor	25%

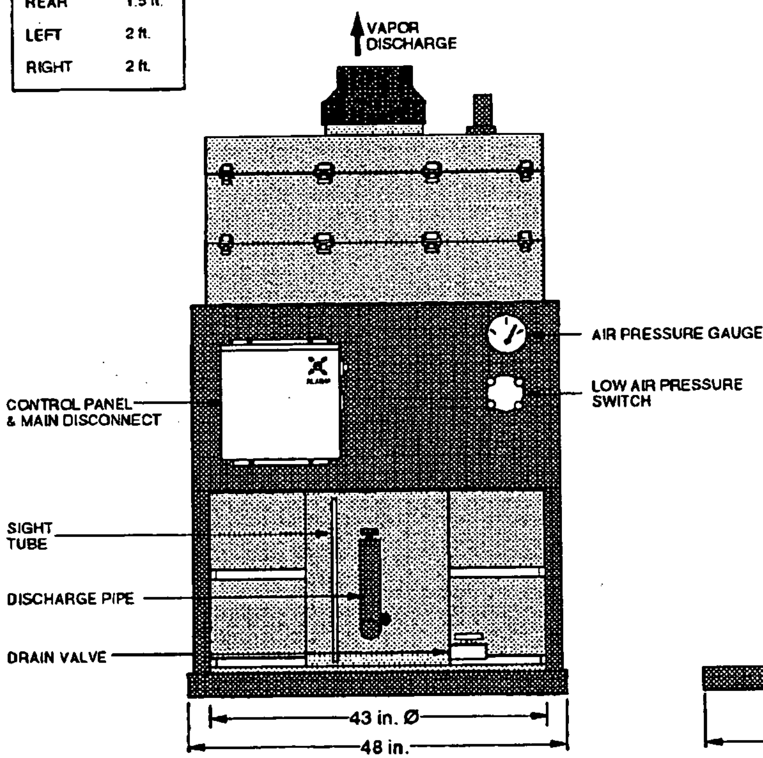
Contaminant	Untreated Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	Model 2331 Effluent Water Air(lbs/hr) % removal	Model 2341 Effluent Water Air(lbs/hr) % removal
1,1-Dichloroethylene	**63 ppb** 5 ppb	**1 ppb** 0.000465 98.7033%	**<1 ppb** 0.000473 99.9832%	**<1 ppb** 0.000473 99.9998%	**<1 ppb** 0.000473 100.0000%
Benzene	**360 ppb** 1 ppb	**21 ppb** 0.002544 94.4209%	**2 ppb** 0.002686 99.6887%	**<1 ppb** 0.002701 99.9826%	**<1 ppb** 0.002701 99.9990%
c-1,2-Dichloroethylene	**13100 ppb** 5 ppb	**313 ppb** 0.095945 97.6108%	**8 ppb** 0.098233 99.9429%	**<1 ppb** 0.098292 99.9986%	**<1 ppb** 0.098293 100.0000%
Carbon Tetrachloride	**10 ppb** 5 ppb	**<1 ppb** 0.000074 99.5008%	**<1 ppb** 0.000075 99.9975%	**<1 ppb** 0.000075 100.0000%	**<1 ppb** 0.000075 100.0000%
Chloroform	**43 ppb** 7 ppb	**2 ppb** 0.000305 96.5903%	**<1 ppb** 0.000319 99.8837%	**<1 ppb** 0.000320 99.9960%	**<1 ppb** 0.000320 99.9999%
Methylene Chloride	**4160 ppb** 5 ppb	**414 ppb** 0.028107 90.0506%	**42 ppb** 0.030899 99.0101%	**5 ppb** 0.031176 99.9015%	**1 ppb** 0.031206 99.9902%
t-1,2-Dichloroethylene	**280 ppb** 5 ppb	**6 ppb** 0.002056 98.1260%	**<1 ppb** 0.002100 99.9649%	**<1 ppb** 0.002101 99.9993%	**<1 ppb** 0.002101 100.0000%
Trichloroethylene	**28000 ppb** 5 ppb	**371 ppb** 0.207309 98.6766%	**5 ppb** 0.210055 99.9825%	**<1 ppb** 0.210092 99.9998%	**<1 ppb** 0.210093 100.0000%
Vinyl Chloride	**1160 ppb** 2 ppb	**2 ppb** 0.008689 99.8582%	**<1 ppb** 0.008704 99.9998%	**<1 ppb** 0.008704 100.0000%	**<1 ppb** 0.008704 100.0000%

This report has been generated by ShallowTray Modeler software version 2.0.4. This software is designed to assist a skilled operator in predicting the performance of a ShallowTray air stripping system. North East Environmental Products, Inc. is not responsible for incidental or consequential damages resulting from the improper operation of either the software or the air stripping equipment. Report generated: 8/30/95

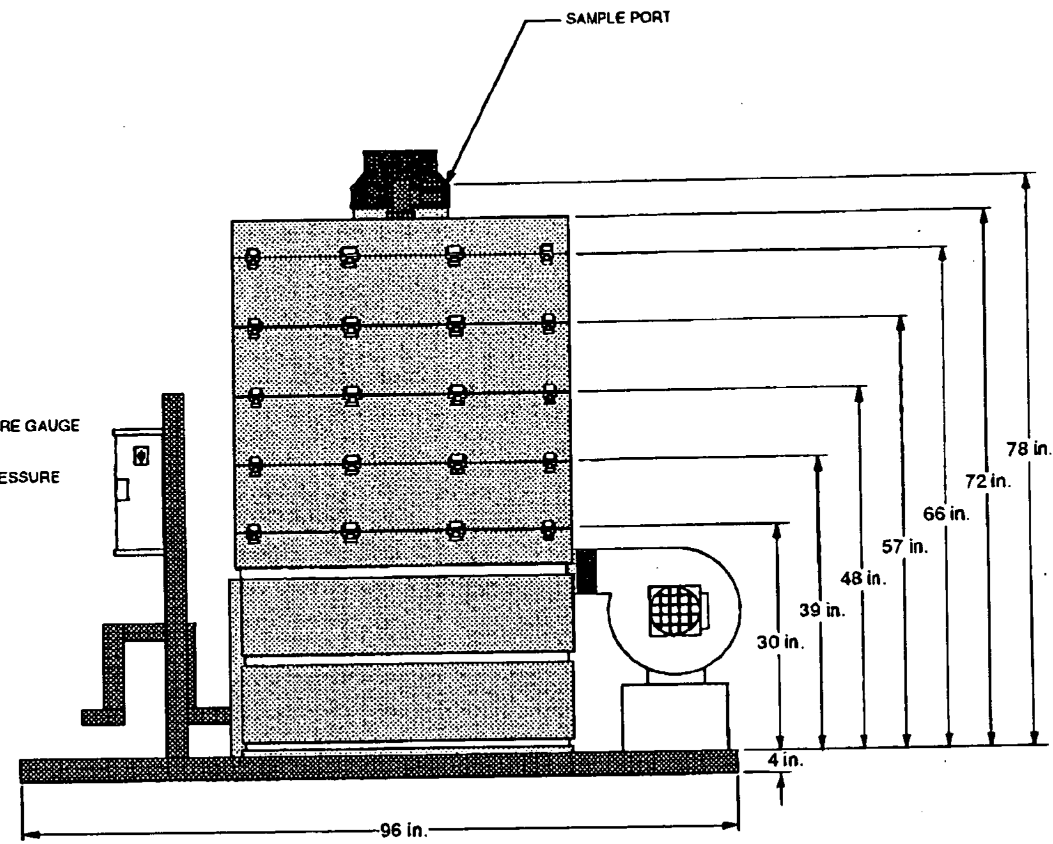
MINIMUM CLEARANCE

FRONT	1.5 ft.
TOP	12 in.
REAR	1.5 ft.
LEFT	2 ft.
RIGHT	2 ft.

FRONT



RIGHT SIDE



BASIC SYSTEM

- ✓ SUMP TANK
- ✓ STRIPPER TRAYS
- ✓ BLOWER
- ✓ MIST ELIMINATOR
- ✓ PIPING
- ✓ SPRAY NOZZLE
- ✓ WATER LEVEL SIGHT TUBE
- ✓ GASKETS
- ✓ LATCHES

OPTIONAL ITEMS

- ✓ FRAME
- ✓ AIR PRESSURE GAUGE
- ✓ DISCHARGE PIPING
- __ DISCHARGE PUMP
- __ FEED PUMP
- __ ADDITIONAL BLOWER
- __ EXPLOSION-PROOF MOTOR(S)
- __ BLOWER START/STOP PANEL
- ✓ CONTROL PANEL
- ✓ MAIN DISCONNECT SWITCH
- __ I.S. COMPONENTS/REMOTE MOUNT
- ✓ INTERMITTENT OPERATION
- __ STROBE LIGHT
- __ ALARM HORN
- __ POWER LAPSE INDICATOR
- ✓ LOW AIR PRESSURE ALARM SWITCH
- ✓ HIGH WATER LEVEL ALARM SWITCH
- __ DISCHARGE PUMP LEVEL SWITCH
- __ WATER PRESSURE GAUGE(S)
- __ DIGITAL WATER FLOW INDICATOR
- __ AIR FLOW METER
- __ TEMPERATURE GAUGE(S)
- ✓ LINE SAMPLING PORTS
- __ AIR BLOWER SILENCER
- __ WASHER WAND
- __ AUTO DIALER

NOTE:

1. DRAWING REPRESENTS A UNIT TYPICAL OF THE SPECIFICATION YOU REQUESTED. MINOR CHANGES MAY RESULT IN THE MANUFACTURING PROCESS

POWER: 1Ø, 230 Volts, 3 WIRE + GROUND

*CONSULT N.E.E.P. FOR AMPACITIES AND OTHER VOLTAGE OPTIONS

CONNECTION INFORMATION

ITEM	SIZE
GRAVITY DISCHARGE	2 in Ø SOCKET, PVC80
DISCHARGE PUMP	3/4 in. Ø FNPT
WATER INLET	1-1/4 in Ø FNPT
AIR EXHAUST NOZZLE	8 in Ø STUB W/8x6 CPLG

NORTH EAST ENVIRONMENTAL PRODUCTS, INC.
17 TECHNOLOGY DRIVE
WEST LEBANON, NEW HAMPSHIRE 03784
PHONE: 603-298-7061 FAX: 603-298-7063

TOLERANCES UNLESS OTHERWISE SPECIFIED ± 1 INCH	DRAWING NAME: ShallowTray® Model 2341-P
	DRAWING #: Proposal #895919
DRAWN: DCS	CUSTOMER: Ecology & Environment: NFAFB #10
DATE: 8/30/95	SCALE: NTS · SIZE: A · SHEET: 1 OF: 1

G Preliminary Design of Air Stripper for Site 13

North East Environmental Products, Inc.
17 Technology Drive West Lebanon NH 03784
(603) 298-7061 Fax (603) 298-7063

Monday, July 31, 1995

Jennifer Barth
Ecology & Environment Incorporated
368 Pleasantview Drive
Lancaster, New York 14086

RE: Proposal #795929
Site ID: Niagara Falls AFB, NY

Dear Jennifer,

To follow-up your request, North East Environmental Products is pleased to submit the following proposal for our ShallowTray® air stripper to remove VOCs from the groundwater treatment stream on your project for Niagara Falls Air Force Base in New York.

Performance:

To provide the required stripping performance at a design flowrate of 20 gpm and a minimum influent water temperature of 59°F, we offer our three-tray polyethylene **Model 2331-P** ShallowTray low profile air stripper (hydraulic flow range 1-50 gpm, fresh air inlet flowrate 300 cfm). Removal efficiencies will follow the attached System Performance Estimate.

It is important that foam causing surfactants (soaps, detergents, oils, and greases) be prevented from entering the influent stream since they can inhibit the stripping operation if not properly treated. Additionally, high levels of iron, manganese, calcium, and magnesium may affect the long term operation of the stripper and therefore require sequestration or maintenance consideration.

For this low flow groundwater application, you may want to consider the economic benefits of North East Environmental Products' new EconoPump™ system. The EconoPump system offers continuous groundwater drawdown from multiple wells with a single pump, without the use of downwell valves, pumps, electrical connections, compressed air, or moving parts. While maintaining a constant drawdown level (±0.1 ft) in each well, the individual water operated venturis provide vacuum to each well and remain unaffected by other wells when they break suction. In addition to such simplicity of operation, the EconoPump offers significant capital, operating, and maintenance cost advantages over other multi-well pumping alternatives. Please let me know if this project will benefit from the use of the EconoPump.

Pricing: The selling price for the ShallowTray **Model 2331-P** air stripper with options follows:

Basic System Model 2331-P	
Sump tank, Cover & 1 Tray, LLDPE (rotationally molded Linear Low Density Polyethylene) Sump & Cover, and HDPE (High Density Polyethylene) Perforated Trays & Baffles	
2 Additional tray(s), HDPE	
Blower, 3 tray, 3 hp, 300 cfm @ 14wc, 3 Ø, 230V, 60Hz, TEFC	
Inlet screen & damper, 304L SS mist eliminator, spray nozzle, sight tube, gaskets, SS latches, & Schedule 80 PVC piping.	
Basic System Price Model 2331-P	**$7,991**

Options		
Skid Mounting: Fabricated Frame with Control & Instrument Stanchion	1	$975
Gravity discharge piping with vacuum relief valve	0	$0
Air pressure gauge, pneumatic	1	$74
Discharge pump, 30 gpm, 50 tdh, 1.5 hp, 3 Ø, 230V, TEFC	1	$481
NEMA 3R Control Panel, w/pump level controls, main disconnect switch, alarm interlocks, motor starter, & panel light, UL listed	1	$2,324
Panel Option: Intermittent operation circuitry	1	$336
Panel Option: Strobe alarm light, w/Blue, Red, or Amber lens	0	$0
Low Air pressure alarm/shutdown switch, pneumatic, EXP	1	$171
High water level alarm/shutdown float switch	1	$70
Discharge Pump level control float switch(es)	1	$70
Digital Water Flow Indicator/Totalizer	0	$0
Air flow meter, insertion pitot tube w/pressure gauge, pneumatic	1	$144
Line sampling ports, inlet and/or discharge	2	$53
Air blower silencer, fan inlet	0	$0
Options Cost		$4,697
Total Model 2331-P System Price, Including Options, US$ Each:		**$12,688**

Design Details: Each **Model 2331-P** ShallowTray air stripper system is 6'0" high, 8'0" long, 4'0" wide, and weighs approximately 600 pounds dry. Additional design and dimension information is included in the attached **Model 2331-P** drawing.

The blower selected for the stripper above was sized to provide sufficient pressure drop for the air stripper requirements only. If additional pressure drop is required for upstream or downstream losses for ductwork, vapor treatment, etc., North East Environmental Products can meet those needs with a single upgraded blower, providing additional energy and cost efficiency. If such an arrangement might prove beneficial to this project, please let me know what additional pressure drop is needed.

Electrical Requirements: Please note that the ShallowTray system quoted above requires the supply of 230 volt, three phase, 60 Hertz, four wire plus ground electrical power. If your onsite electrical provisions are different, please contact North East Environmental Products. Please confirm this vital electrical information in writing on your formal purchase order.

Terms & Shipment:

Each ShallowTray system is shipped pre-assembled and factory tested, and an O&M manual and system start-up video are included with each unit. Normal shipment is 4 weeks after receipt of authorized purchase order.

Purchase terms are 30% with order, 70% net 30 days after shipment, with approved credit. Prices are quoted in US$, F.O.B. West Lebanon, New Hampshire, exclusive of freight, duty, taxes, handling, and brokerage, and are valid for 90 days. Low monthly financing is available.

I invite you to phone or fax me immediately if I can answer any additional questions, comments, or concerns you may have. I look forward to working with you on this project as it develops, and to providing you and your client the most cost effective stripper available. Once again, thank you for your interest in our products.

Sincerely,

D. Shearouse

Don Shearouse, P.E.
Customer Service

File: Ecology & Environment

ShallowTray™
low profile air strippers

System Performance Estimate

Client & Proposal Information:

Ecology & Environment: Jennifer Barth
Niagara Falls AFB: #13, New York
#795929

Model chosen:	2300
Water Flow Rate:	20.0 gpm
Air Flow Rate:	300 cfm
Water Temp:	59.0 °F
Air temp:	40.0 °F
A/W Ratio:	112.2
Safety Factor	10%

Contaminant	Untreated Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	Model 2331 Effluent Water Air(lbs/hr) % removal	Model 2341 Effluent Water Air(lbs/hr) % removal
1,1,1-Trichloroethane	**1 ppb** 5 ppb	**<1 ppb** 0.000010 95.8146%	**<1 ppb** 0.000010 99.8248%	**<1 ppb** 0.000010 99.9927%	**<1 ppb** 0.000010 99.9997%
1,2- Dichloroethane	**2 ppb** 5 ppb	**1 ppb** 0.000010 54.5418%	**1 ppb** 0.000010 79.3355%	**<1 ppb** 0.000018 90.6063%	**<1 ppb** 0.000019 95.7298%
Benzene	**5 ppb** 1 ppb	**1 ppb** 0.000040 90.4290%	**<1 ppb** 0.000050 99.0840%	**<1 ppb** 0.000050 99.9123%	**<1 ppb** 0.000050 99.9916%
c-1,2-Dichloroethylene	**220 ppb** 5 ppb	**11 ppb** 0.002091 95.2083%	**1 ppb** 0.002191 99.7704%	**<1 ppb** 0.002201 99.9890%	**<1 ppb** 0.002201 99.9995%
Carbon Tetrachloride	**0 ppb** 5 ppb	**<1 ppb** <.000001 NAN(004)%	**<1 ppb** <.000001 NAN(004)%	**<1 ppb** <.000001 NAN(004)%	**<1 ppb** <.000001 NAN(004)%
Chloroform	**0 ppb** 7 ppb	**<1 ppb** <.000001 NAN(004)%	**<1 ppb** <.000001 NAN(004)%	**<1 ppb** <.000001 NAN(004)%	**<1 ppb** <.000001 NAN(004)%

Ethyl Benzene	**4 ppb** 5 ppb	**1 ppb** 0.000030 91.3328%	**<1 ppb** 0.000040 99.2488%	**<1 ppb** 0.000040 99.9349%	**<1 ppb** 0.000040 99.9944%
Methylene Chloride	**160 ppb** 5 ppb	**32 ppb** 0.001281 80.0132%	**7 ppb** 0.001531 96.0053%	**2 ppb** 0.001581 99.2016%	**1 ppb** 0.001591 99.8404%
p-Xylene	**8 ppb** 5 ppb	**1 ppb** 0.000070 90.6778%	**<1 ppb** 0.000079 99.1310%	**<1 ppb** 0.000080 99.9190%	**<1 ppb** 0.000080 99.9924%
t-1,2-Dichloroethylene	**13 ppb** 5 ppb	**1 ppb** 0.000120 96.0443%	**<1 ppb** 0.000130 99.8435%	**<1 ppb** 0.000130 99.9938%	**<1 ppb** 0.000130 99.9998%
Toluene	**15 ppb** 5 ppb	**2 ppb** 0.000130 89.2267%	**<1 ppb** 0.000148 98.8394%	**<1 ppb** 0.000150 99.8750%	**<1 ppb** 0.000150 99.9865%
Trichloroethylene	**30 ppb** 5 ppb	**1 ppb** 0.000290 96.9944%	**<1 ppb** 0.000300 99.9097%	**<1 ppb** 0.000300 99.9973%	**<1 ppb** 0.000300 99.9999%
Vinyl Chloride	**1600 ppb** 2 ppb	**9 ppb** 0.015917 99.4846%	**<1 ppb** 0.016007 99.9973%	**<1 ppb** 0.016007 100.0000%	**<1 ppb** 0.016007 100.0000%

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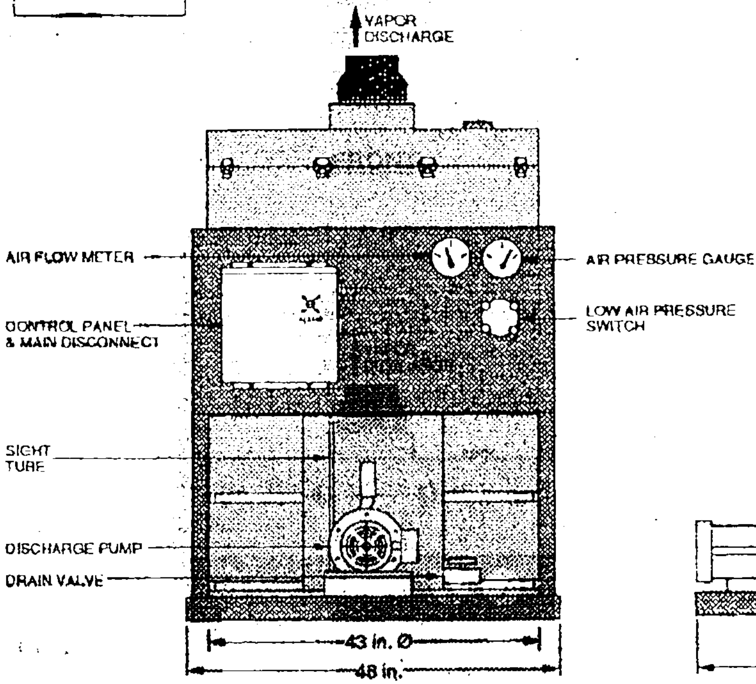
This report has been generated by ShallowTray Modeler software version 2.0.4. This software is designed to assist a skilled operator in predicting the performance of a ShallowTray air stripping system. North East Environmental Products, Inc. is not responsible for incidental or consequential damages resulting from the improper operation of either the software or the air stripping equipment. Report generated: 7/31/95

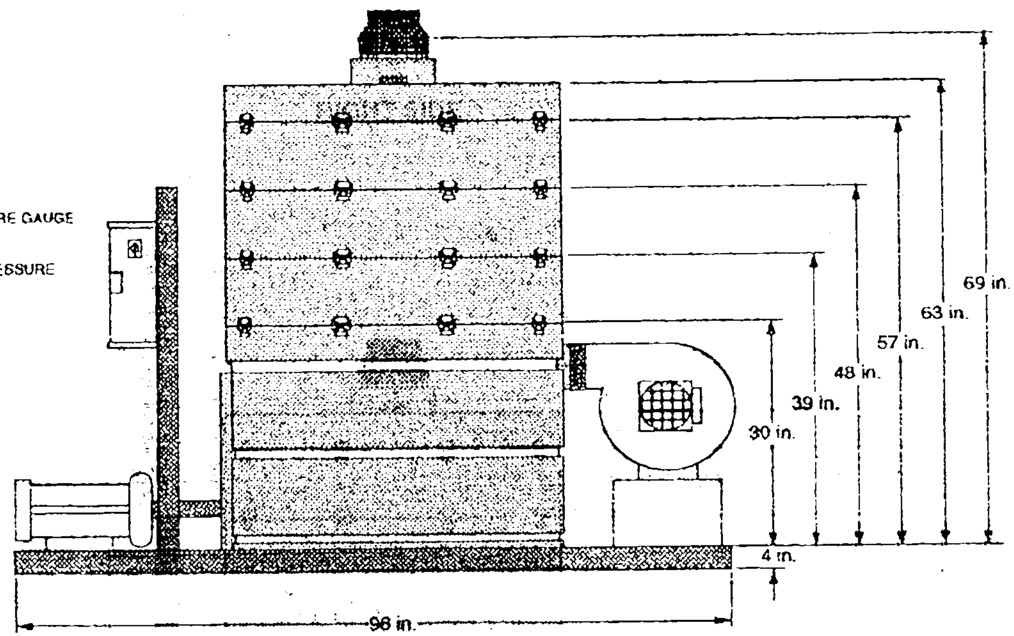
MINIMUM CLEARANCE

FRONT	1.5 ft
TOP	12 in
REAR	1.5 ft
LEFT	2 ft
RIGHT	2 ft

FRONT



RIGHT SIDE



BASIC SYSTEM

- ✓ SUMP TANK
- ✓ STRIPPER TRAYS
- ✓ BLOWER
- ✓ MIST ELIMINATOR
- ✓ PIPING
- ✓ SPRAY NOZZLE
- ✓ WATER LEVEL SIGHT TUBE
- ✓ GASKETS
- ✓ LATCHES

OPTIONAL ITEMS

- ✓ FRAME
- ✓ AIR PRESSURE GAUGE
- __ DISCHARGE PIPING
- ✓ DISCHARGE PUMP
- __ FEED PUMP
- __ ADDITIONAL BLOWER
- __ EXPLOSION-PROOF MOTOR(S)
- __ BLOWER START/STOP PANEL
- ✓ CONTROL PANEL
- ✓ MAIN DISCONNECT SWITCH
- __ I.S. COMPONENTS/REMOTE MOUNT
- ✓ INTERMITTENT OPERATION
- __ STROBE LIGHT
- __ ALARM HORN
- __ POWER LAPSE INDICATOR
- ✓ LOW AIR PRESSURE ALARM SWITCH
- ✓ HIGH WATER LEVEL ALARM SWITCH
- ✓ DISCHARGE PUMP LEVEL SWITCH
- __ WATER PRESSURE GAUGE(S)
- __ DIGITAL WATER FLOW INDICATOR
- ✓ AIR FLOW METER
- __ TEMPERATURE GAUGE(S)
- __ LINE SAMPLING PORTS
- __ AIR BLOWER SILENCER
- __ WASHER WAND
- __ AUTO DIALER

NOTE:

1. DRAWING REPRESENTS A UNIT TYPICAL OF THE SPECIFICATION YOU REQUESTED. MINOR CHANGES MAY RESULT IN THE MANUFACTURING PROCESS

POWER: 3Ø 230 Volts, 4 WIRE + GROUND

*CONSULT N.E.E.P. FOR AMPACITIES AND OTHER VOLTAGE OPTIONS

CONNECTION INFORMATION

ITEM	SIZE
GRAVITY DISCHARGE	2 in. Ø SOCKET, PVC80
DISCHARGE PUMP	3/4 in. Ø FNPT
WATER INLET	1-1/4 in. Ø FNPT
AIR EXHAUST NOZZLE	6 in. Ø STUB W/8x6 CPLG

NORTH EAST ENVIRONMENTAL PRODUCTS, INC.
17 TECHNOLOGY DRIVE
WEST LEBANON, NEW HAMPSHIRE 03784
PHONE: 603-298-7061 FAX: 603-298-7063

TOLERANCES UNLESS OTHERWISE SPECIFIED ± 1 INCH	DRAWING NAME: ShallowTray® Model 2331-P
	DRAWING #: Proposal #795929
DRAWN: DCS	CUSTOMER: Ecology & Environment: Niagara Falls ARB, NY
DATE: 7/31/95	SCALE: NTS · SIZE: A · SHEET: 1 OF: 1