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RCRA Facility Investigation Report

Sites 3, 10, and 13
Niagara Falls IAP-ARS
Niagara Falls, New York

Volume 1

June 1995

Prepared for:

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

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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) 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 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 conducted RFIs at three sites at the installation: IRP Sites 3, 10, and 13. This document presents a detailed report on the findings of the three RFIs. The CMSs will be provided in a separate document.

The RFIs were performed in conformance with the work plan (Volumes 1 and 2) submitted to the New York State Department of Environmental Conservation (NYSDEC) and the United States Environmental Protection Agency (EPA) in November 1994 and approved in March 1995. An installation-wide groundwater monitoring project has also been conducted by E & E concurrent with the RFIs. Data collected as part of the groundwater study pertinent to the RFIs have been included in this report.

1.1 Purpose and Objectives

The purpose of this report is to outline the investigative procedures that were used to conduct RFIs at three solid waste management units (SWMUs) at the Niagara Falls IAP-ARS, and to present a summation of the data collected that will be used in the development of corrective measures. In general, the primary objectives of the RFIs were to determine the nature, extent, migration direction, and rate of migration of hazardous wastes by sampling and analyzing various media and to develop a conceptual model of each site to determine the contaminant distribution, migration routes, potential receptors, and concentration of contaminants at receptor locations.

Field activities associated with the RFIs included monitoring well installation; drilling and sampling of subsurface soil borings; collection and analysis of surface water, sediment, soil, and groundwater samples; a survey of sample and well locations; as well as other site-specific requirements. All activities were conducted in accordance with the procedures described in the RFI work plan (E & E 1995).

1.2 Report Organization

This report consists of four major sections. This introductory section briefly discusses the purpose, primary objectives, scope of field activities, and organization of the report. Section 2 provides a summary of background information describing the installation and the surrounding area, reviews the base's history, and presents the current status of the IRP sites with regard to the corrective action requirements of the draft hazardous waste storage permit. Section 3 describes the environmental setting of the installation and its surrounding areas. Section 4 discusses separately each site requiring an RFI, including detailed investigative information, results and conclusions.

Supplemental information is provided in the appendices. Appendix A presents data obtained during the soil gas surveys. Reproductions of historical aerial photographs of Site 3 are provided in Appendix B. Appendix C contains graphical summaries of geophysical data collected for Site 3. Monitoring well construction and soil boring logs are found in Appendix D. Slug test data for all three sites is presented in Appendix E. Laboratory analytical results for RFI field sampling are summarized in Appendix F.

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 southern border of the IAP is adjacent to the northeast corner of the City of Niagara Falls. Access to the ARS is restricted and monitored by base police at three entry points: the main gate on Lockport Road and auxiliary gates on Tuscarora and Walmore Roads.

The IRP-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 United States Air Force Reserve (107th Air Refueling Group) and 914th Airlift Wing. 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.

Thirteen SWMUs have been identified at the Niagara Falls IAP-ARS under the IRP due to their potential for environmental contamination (see Figure 2-2). Based on the results of the previous studies, no further action has been determined for three SWMUs, and additional investigations are required for 10 SWMUs. A list of SWMUs at the installation and their current status is provided in Table 2-1.

2.2 History

Niagara Falls IAP-ARS was established as Niagara Falls Air Force Reserve Facility (AFRF) in November 1942. The federal government leased 468 acres of municipal airport land for use by the Army Air Corps. In 1946, 132.2 acres of the leased land were returned to the City of Niagara Falls. The 136th Fighter Squadron of the New York Air National Guard (NYANG) was established on December 8, 1948, and occupied Old Camp Bell near the Bell Aircraft Plant on the installation. The 76th Air Base Squadron was activated on February 1, 1952, as the installation host unit.

On February 16, 1953, the 518th Air Defense Group replaced the 76th Air Base Squadron as the host unit, and the NYANG 47th Fighter Interceptor Squadron replaced the 136th Fighter Interceptor Squadron. In August 1955, the USAF reactivated the 15th Fighter Group to replace the 518th Air Defense Group. On July 1, 1960, the 15th Fighter Group was deactivated, and the 4621st Support Group began operations as the installation host unit. The 4621st Support Group was redesignated as the 4621st Air Base Group on July 1, 1964.

The North American Defense Command Defense System CIM-10B Boeing Michigan Aeronautical Research Center (BOMARC) missile was deployed in the western portion of the installation in 1959. The 35th Air Defense Missile Squadron and the missiles were deactivated in the late 1960s, and the NYANG 107th Tactical Fighter Group became the tenant organization occupying the western portion of the installation.

The 49th Fighter Interceptor Squadron, 1 Detachment, assumed responsibility for the installation from the 4621st Support Group in March 1970. On January 1, 1971, the installation was transferred from the Aerospace Defense Command to the AFRES Command, and the 914th Tactical Airlift Group became the host unit. The main tenant organization, NYANG 107th Tactical Fighter Group, was redesignated as the 107th Fighter Interceptor Group. In early 1992, the Niagara Falls AFRF was renamed the Niagara Falls IAP-ARS. In late 1993, the 107th Fighter Interceptor Group was redesignated as the 107th Air Refueling Group and the 914th Tactical Airlift Group was redesignated as the 914th Airlift Wing.

The 914th Airlift Wing has the primary installation mission and trains approximately 1,860 reserve officers and airmen for combat ready status for any national emergency. Current activities include airlifting troops and supplies, providing front line troops with personnel and logistical support, and providing medical evacuations.

AFRES is responsible for the implementation of the IRP. The 914th Airlift Wing, as the host unit, is responsible for administering the remediation under the IRP, including contamination resulting from tenant organization activities, specifically NYANG activities.

Contamination may be present in various areas on Niagara Falls IAP-ARS property as a result of the various defense missions or hazardous waste disposal practices, spills, leaks, or other activities carried out since 1942.

2.3 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.

In addition to the closure of Old Site 13, Decision Documents written in 1990 and 1991 approved the closure of Sites 6, 11, and 12 by the USAF with no further action. A June 1992 NYSDEC memorandum agreed that no further action at these sites was warranted. Under the corrective action program, these 13 sites are referred to as SWMUs (see Table 2-1).

Since 1989, additional sampling, limited RI/FSs, remedial design (RD), and long-term groundwater monitoring have been performed for many sites. This includes the following investigations:

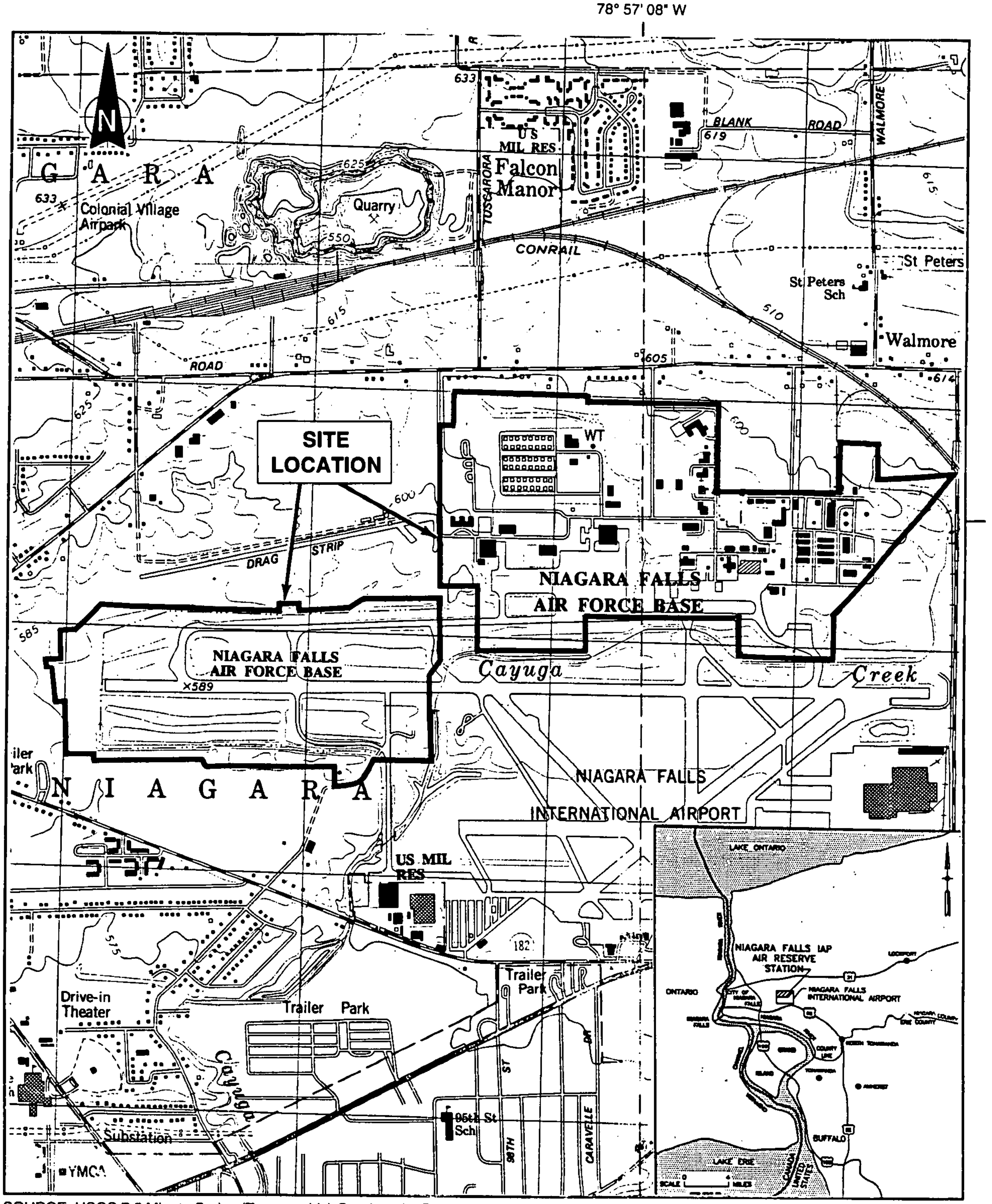
- RD for Sites 8 and 13 (GZA GeoEnvironmental of New York [GZA] 1992a);
- Long-term groundwater monitoring at Site 3 (GZA 1992b, 1993a, 1993b, 1994a, 1994b);
- Limited RI/FS at Site 7 (GZA 1992c);
- Limited RI/FS at Site 10 (Wehran-New York, Inc. and Babinsky-Klein Engineering [Wehran] 1992a, 1992b);
- 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).

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.
MOGAS = Motor gasoline.
NYANG = New York Air National Guard.
POL = Petroleum, oils, and lubricants.
RFI = RCRA Facility Investigation.



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

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

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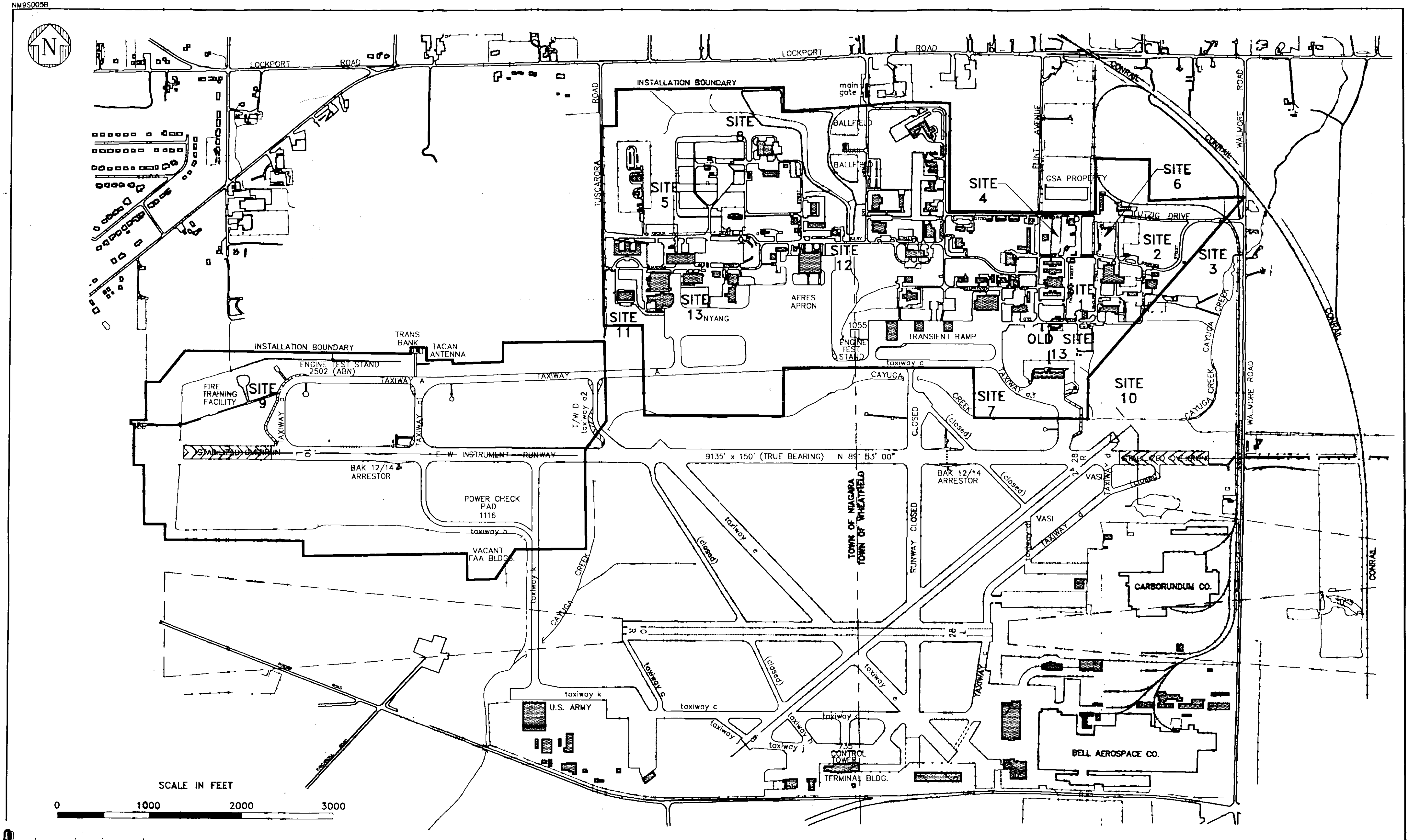

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Figure 2-2 INSTALLATION PLAN
NIAGARA FALLS IAP-ARS

3 Environmental Setting

This section describes the environmental setting at Niagara Falls IAP-ARS including the geology and hydrogeology of the IAP-ARS and surrounding areas. This information was prepared from a review of previous investigations, documented in several reports prepared for AFRES, including the IRP Phase I Record Search (Engineering-Science 1983), the IRP Phase II Confirmation/Quantification Stage I Report (SAIC 1986), IRP RI/FS Report (SAIC 1991), January 1994 Management Action Plan prepared by AFRES, as well as several other studies.

3.1 Regional Geology/Soils/Hydrogeology

3.1.1 Geology

Niagara Falls IAP-ARS is located within the Huron Plain of the Central Lowland physiographic province. This plain is extensive in western New York and extends into Ontario, Canada. It is bounded by the Niagara Escarpment (Lockport dolomite exposure) to the north and by the Onondaga Escarpment (Onondaga limestone exposure) to the south. The Huron Plain is characterized by glacial till and lacustrine soils deposited during the Wisconsin Glacial Stage. Therefore, the dominant landforms of the area have resulted primarily from these deposits as well as from subsequent stream erosion. Elevations in the vicinity of the base range from about 585 to 600 feet above mean sea level, with very little relief (USGS 1980). The escarpments that bound the Huron Plain represent the most pronounced breaks.

Two geologic units in the Niagara Falls IAP-ARS area are important to the present IRP studies. These units are the unconsolidated deposits (overburden) and underlying uppermost bedrock unit. The unconsolidated deposits consist of three types of materials:

- Glacial till, which was deposited directly by glacial ice, consisting of a mixture of unsorted, compacted boulders, gravel, sand, and clay;
- Lacustrine deposits, which were laid in glacial lakes that formed along the margins of the ice sheets, consisting predominantly of clay, with lenses of silt, and fine sand; and

- Fluvial deposits from a complex network of streams, which were active following the last ice retreat, consisting of thin, disconnected lenses of sand and gravel.

The till is present at the base of the unconsolidated deposits and generally less than 10 feet thick. It is overlain by lacustrine deposits throughout most of the area. The lacustrine deposits rarely exceed 20 feet in thickness in the region. Fluvial deposits are isolated and are found above the lacustrine deposits. At Niagara Falls IAP-ARS, overburden thickness has been found to range from approximately 3 to 16 feet in thickness; however, regional overburden thickness ranges from less than 1 foot near the Niagara Escarpment to more than 80 feet along Tonawanda Creek (Yager 1993).

The glacial sediments are underlain by 158 feet of Middle Silurian-age dolomite and limestone beds making up the Lockport Dolomite formation of the Lockport group. This group is underlain by 187 feet of shale and limestone of the Clinton group, followed by 105 feet of sandstone and shale of the Medina group (see Figure 3-1). These units are nearly flat-lying representing a homoclinal structure, with an east-west strike and dip to the south reported to be approximately 25 feet per mile by Yager 1993 and 30 feet per mile by Miller and Kappel 1987. All of these units are seen outcropping along the Niagara Escarpment (Yager 1993). The nomenclature for the Lockport group is currently under revision by Brett *et al.* (1990) and Kappel and Tepper (in press). Because the new nomenclature has not yet been accepted by the United States Geological Survey (USGS), Figure 3-1 references the nomenclature as reported in Miller and Kappel 1987.

The Lockport Dolomite, the uppermost bedrock unit, is defined as a coarse crystalline, thin-to-massive, bedded dolomite, limestone, and shaly dolomite, with vugs containing primarily gypsum and calcite. Other minerals disseminated throughout the formation are sphalerite, pyrite, and galena (Tesmer 1981).

The Lockport can be divided into two zones, based on its water transmitting properties. In general, the upper 10 to 25 feet of rock is moderately permeable due to the presence of abundant horizontal bedding plane fractures that are connected by high-angle (vertical) fractures. The fractures in this zone show signs of weathering through widening by chemical dissolution. Bedding plane fractures become less significant with depth due to the increased pressure of the overlying rock, and vertical fractures become less abundant further away from the Niagara Gorge. Most of the vertical fractures, as seen at the Niagara Gorge are stress relief fractures caused by unloading forces as the gorge was formed; however, they are also a regional feature caused by orogenies that occurred during continental collisions. Regional fracture (joint) orientations trend northeast-southwest as a result of the Taconic

Orogeny, and northwest-southeast as a result of the Acadian Orogeny. These orientations are manifested in the scarp face of the Niagara Escarpment between the cities of Niagara Falls and Lockport. The northeast-southwest fractures are more prominent features, as seen in the Escarpment face, and the northeast trend of the Niagara River Gorge north of the whirlpool (Kappel 1995). A more detailed description of the hydraulic properties of the Lockport Dolomite is provided in Section 3.1.3 of this report.

3.1.2 Soils

According to the United States Department of Agriculture (USDA) Soil Conservation Service (SCS) (Higgins *et al.* 1972), the Niagara Falls IAP-ARS and surrounding areas lie on Odessa-Lakemont-Ovid association soils. These soils are generally poorly to very poorly drained with a fine- to moderately fine-textured subsoil that is mostly reddish in color. This association is the largest in Niagara County (i.e., 21% of the county), consisting of nearly level soils on lake plains. It is composed of Odessa soils (24%), Lakemont soils (14%), Ovid soils (11%), and minor soil types (51%). The Niagara Falls IAP-ARS is underlain by half Odessa soils, and half Lakemont soils, with a minor percentage of cut-and-fill land.

Odessa soils typically are slightly acidic with a dark grayish brown, silty clay loam, surface layer; a firm, brown, silty clay subsoil; and a slightly acidic, firm, brown and light reddish-brown clay and silt underlying material. These soils were formed as lacustrine deposits where calcareous clay is dominant. Odessa soils are found beneath the northern developed area and western portion of the airfield. These soils are classified as Odessa silty clay loam with 0% to 2% slopes. Permeability ranges with depth from 2.0 to less than 0.2 inch per hour. This soil is well suited to hay, grain, pasture, and trees; however, drainage is needed for good crop growth. It is poorly suited for fruits and vegetables because of texture and surface wetness.

Lakemont soils are generally similar to Odessa soils, but have a darker surface layer and show more indications of wetness. The surface layer is typically black, neutral silty clay loam; followed by an upper subsoil that is firm, neutral, gray-to-light-gray silty clay with some reddish-yellow mottles, and a lower subsoil that is firm, neutral, pinkish gray, silty clay with some reddish-yellow mottles; and a substratum that is a firm, reddish gray and reddish brown, calcareous, silty clay loam. Lakemont soils are found beneath the central and eastern portion of the IAP-ARS. These soils are classified as Lakemont silty clay loam. It is a nearly level soil occupying broad flats in basins of former glacial lakes. Undrained areas of this soil are better suited to pasture, woods, or wetland wildlife rather than crops. Runoff is generally slow and the soil is poorly drained, with a permeability of less than 0.20 inch per hour.

Ovid soils are nearly level to gently undulating and are on till landscapes at slightly higher elevations above the lake plain. They are deep and poorly drained with permeabilities ranging in depth from 2 to less than 0.2 inches per hour. Ovid soils typically have a neutral, dark grayish brown, silt loam, surface layer; a neutral, friable, pale-brown, distinctly mottled, silt loam subsoil; and an underlying material of firm, calcareous, reddish brown heavy loam (glacial till).

The minor soils are Churchville, Cayuga, Cazenovia, Fonda, and Hilton series, as well as some areas of shallow muck. The moderately well-drained Hilton and Cazenovia soils occupy the higher parts of the knolls and till ridges that are scattered throughout the association. The poorly drained Churchville and moderately drained Cayuga soils are generally found along the fringes of those areas. The poorly drained Fonda soils and the shallow muck occupy some of the deeper depressions in the lake plain.

The cut-and-fill land located in the northeast corner of the IAP-ARS is designated by the SCS as areas that have had the original soil stripped and removed or covered with soil materials to a depth of at least 3 feet. These areas are mainly a mixture of soil materials that have had little or no profile development. An area on the ARS with this designation is the Site 3 landfill.

3.1.2.1 Land Use

The Niagara Falls IAP-ARS and surrounding areas have a wide variety of land uses. The northern portion of the site has numerous buildings occupied by the 914th Airlift Wing and the 107th Air Refueling Group. The southern and western portions of the site consist of airfield runways and taxiways.

The area immediately adjacent to the northern border of the IAP-ARS along Lockport Road and farther to the north is primarily rural/agricultural, with some small businesses. The area to the east along Walmore Road consists of commercial properties and light industry, followed by agricultural and residential farther to the east. The area immediately adjacent to the south is industrial, commercial, and residential along Niagara Falls Boulevard. The southeast corner to the IAP borders the City of Niagara Falls. A small section of agricultural land exists to the southeast, south of Niagara Falls Boulevard. The area to the west immediately adjacent to the IAP-ARS site is agricultural; however, farther to the west it becomes commercial and urban (USGS 1980; USAF 1994).

3.1.3 Hydrogeology

Numerous studies have been performed on the regional geology and hydrology of the bedrock underlying the Niagara Falls area. Some of the more recent hydrological studies by USGS provide detailed information directly applicable to this project. The following information is a summary of the results compiled by USGS from a 2-year study of the hydrogeology of the Niagara Falls area (Miller and Kappel 1987) and a 5-year model of groundwater flow in the Lockport Group (Yager 1993). Additional information was also obtained for this report through a recent presentation of the results of the 5-year study on the hydrology of the Niagara Falls area (Kappel 1995).

The hydraulic properties of the Lockport Group are principally governed by secondary porosity caused by fractures and vugs (dissolution cavities) widened by chemical dissolution. There is virtually no transmission of groundwater through primary porosity (i.e., through the rock matrix). The principal water-bearing zones in the Lockport Dolomite are weathered bedrock and horizontal fractures near stratigraphic contacts. The weathered bedrock zone is located in the upper 10 to 25 feet of the Lockport Dolomite. This zone contains many closely spaced horizontal fractures interconnected with high-angle (vertical) fractures. Nine horizontal fracture zones have been identified throughout the formation, of which two are believed to be in the upper weathered zone. Each horizontal fracture zone is represented by a series of fractures that range in thickness from a few inches to approximately 2 feet in some areas. The horizontal fractures are the result of unloading from isostatic rebound through erosional unloading and deglaciation. Transmissivity decreases with depth due to the weight of the overlying rock preventing widening of fractures along horizontal contacts, and a decrease in interconnection caused by the diminished presence of vertical fractures.

Aquifer tests performed in these horizontal fracture zones indicated hydraulic conductivities of 0.2 to 200 feet per day (ft/day), with a median conductivity of 40 ft/day. Higher conductivities (i.e., up to 100 ft/day) occur near the Niagara River Gorge due to the presence of stress relief fractures. Typical well yields are on the order of 5 to 50 gallon per minute (gpm). However, yields of more than 300 gpm were encountered in areas near stress relief fractures and in an area that is believed to be a major northeast trending lineament. This lineament runs from Ontario, Canada, under the CECOS landfill, and farther to the northeast.

Vertical fractures are most common where joints have formed during the Taconic and Acadian Orogenies, or have been enlarged through stress relief along the Niagara Gorge and open rock excavations (e.g., quarries and buried power authority water conduits leading from the Niagara River to the forebay canal between the Lewiston and Robert Moses Power Plants). In general, the vertical fractures in most of the formation are not significant water-bearing openings, except in the upper 10 to 25 feet of the weathered zone, within 200 feet of the Niagara River Gorge, within 100 feet of the power authority conduits, or along the northeast trending lineament. The vertical fractures become narrower and less connected with depth.

Solution cavities also serve as conduits for groundwater flow. These cavities are the result of dissolution of gypsum pockets and stringers up to 5 inches in diameter. Most of these cavities are within the upper 10 to 15 feet of rock; however, larger cavities up to several feet in diameter have been reported to be deeper in the formation.

Regional groundwater flow in the Lockport dolomite is from topographic highs near the Niagara Escarpment, north toward the Escarpment, and south and west toward low-lying areas near the Niagara River and outcrop areas along the Niagara River Gorge. Preferred pathways occur in incised beds in the bedrock surface, which generally trend to the south and west. Groundwater flow is generally horizontal along the plane of gently dipping (25 to 30 feet per mile to the south) horizontal fracture zones (stratigraphic beds). These zones are considered artesian aquifers; however, the rock matrix between these zones acts as semi-confining layers because of leakage through vertical fractures. Vertical gradients are downward in recharge areas and discharge areas near bedrock exposures along the Niagara River Gorge. Vertical gradients are upward in discharge areas along the Niagara River upstream of the falls and beneath tributaries to the river. The presence of sodium chloride and low levels of tritium in the lower Lockport formation indicates that the present-day circulation of groundwater is largely restricted to the shallow flow system. Downward flow is also inhibited by the presence of natural gas in the underlying Clinton group. The pressure of the gas reservoir is 5 to 100 pounds per square inch (psi) greater than the hydrostatic pressure in the horizontal fracture zones.

Recharge enters weathered bedrock as infiltration of precipitation from overlying glacial sediments into the horizontal fracture zones and vertical fractures where they intersect the bedrock surface. Recharge also enters as infiltration from the Niagara River, New York Power Authority Reservoir, and unlined city storm sewers. This was observed by the difference in infiltration of 5 to 6 inches per year in urban areas versus 0.5 inches per year in rural areas. Total precipitation across the region is approximately 30 inches per year.

The ultimate discharge point for most of the groundwater in the Niagara Falls area is the Niagara River. Discharge from weathered bedrock to the river and tributaries is generally upward through the overlying glacial sediments, directly to the river and tributaries where the rock is exposed, or onto land along the Niagara River Gorge and Niagara Escarpment. Groundwater also discharges to man-made features such as quarries, the buried Falls Street tunnel (an unlined storm sewer which empties into the Niagara River), and the exterior drain system surrounding the buried twin Power Authority water conduits. The effects of the Falls Street tunnel and water conduits do not influence groundwater flow patterns in the immediate vicinity of the site; however, Cayuga Creek, which flows to the southwest across the central portion of the site, is a local discharge point for groundwater beneath the site.

3.1.3.1 Groundwater Use

Most homes and businesses in the vicinity of the site utilize water from the local central water system installed in the 1950s or 1960s; however, isolated use of domestic water wells may still exist. According to a door-to-door survey performed between 1988 and 1990 on 252 properties as part of an investigation for Bell Aerospace Textron, which is located adjacent to the southeast corner of the IAP, all of the properties were connected to Town of Wheatfield water supply except for a property located south of Jagow Road, approximately 1.2 miles south of the IAP. A total of 112 domestic wells were identified in this survey, of which, seven were identified as active, and one was used for drinking water (the well south of Jagow Road). The seven wells were tested for volatile organic compounds (VOCs); however, only one well tested positive. This well was located on the west side of Walmore Road south of Bergholtz Creek. Bell Aerospace requested the permission of property owners to decommission all wells in the study area. As of 1991, 21 wells were decommissioned, including the one well used as a drinking water source and the one contaminated well (Golder Associates 1991).

In general, most of the domestic water wells were completed at the overburden/ bedrock interface, ranging in depth from 15 to 20 feet below ground surface (BGS). Domestic wells that were drilled into the Lockport Dolomite were generally completed within the upper section of the formation; however, their depths range from 30 to 100 feet BGS. The average yield of wells in the upper section of bedrock was 31 gpm; wells in the lower bedrock produced 7 gpm (SAIC 1991).

There are not many industrial wells tapping the Lockport Dolomite in the immediate vicinity of the site. There is one known well located at the nearby Carborundum facility northwest of the site that uses groundwater for cooling purposes. Other industrial users are located along the Niagara River in the City of Niagara Falls. Wells near the Niagara River reportedly yield as much as 2,000 gpm due to infiltration of water from the river (SAIC 1991).

3.1.3.2 Surface Water Use

The nearest surface water body is Cayuga Creek, which crosses the central portion of the IAP-ARS. The creek originates in Lewiston and flows south to the Niagara River. Cayuga Creek and its tributaries are classified as Class C surface waters (NYCRR Part 837). This class is best used for fishing. The waters are suitable for fish propagation and survival, and the water quality is suitable for primary and secondary contact recreation (NYCRR Part 701). The next nearest significant surface water body is the Niagara River, 1.8 miles to the south of the site. The Niagara River is classified as Class A-Special surface waters (NYCRR Part 837). This class is best used as a source of drinking water; for culinary or food processing purposes; primary and secondary contact recreation; and fishing. The water is also suitable for fish propagation and survival. This classification is also given to international boundary waters that, if subjected to approved treatment, equal coagulation, sedimentation, filtration, and disinfection to reduce naturally occurring impurities, will meet New York State Department of Health (NYSDOH) drinking water standards and, therefore, will be considered safe for drinking water purposes (NYCRR Part 701).

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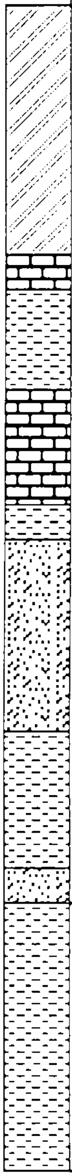

System and series		Group	Formation	Thickness (feet)	Description
Silurian	Middle	Lockport	Lockport Dolomite	158	Dark-gray to brown, massive to thin-bedded dolomite locally containing algal reefs and small, irregularly shaped masses of gypsum. Near the base are light-gray coarse-grained limestone (Gasport Limestone Member) and dark-gray shaley dolomite.
		Clinton	Rochester Shale	60	Dark-gray calcareous shale weathering light-gray to olive.
			Irondequoit Limestone	12	Light-gray to pinkish-white coarse-grained limestone.
			Reynales Limestone	10	White to yellowish-gray shaley limestone and dolomite.
			Neahga Shale	5	Greenish-gray soft fissile shale.
	Lower	Medina	Thorold Sandstone	8	Greenish-gray shaly sandstone.
			Grimsby Sandstone	45	Reddish-brown to greenish-gray cross-bedded sandstone interbedded with red to greenish-gray shale.
			Power Glen Shale	40	Gray to greenish-gray shale interbedded with light-gray sandstone.
			Whirlpool Sandstone	20	White, quartzitic sandstone
Ordovician	Upper	Richmond	Queenston Shale	1,200	Brick-red sandy to argillaceous shale.

SOURCE: Miller and Kappel 1987, modified from Fisher, 1959.

Figure 3-1 STRATIGRAPHY OF THE NIAGARA FALLS AREA

4 RFI Activities, Results, Site Model, Conclusions and Recommendations

This section presents the site characterization activities, analytical results, conceptual models, conclusions, and recommendations for the RFIs conducted by E & E at three SWMUs: IRP Sites 3, 10, and 13. Discussions for each site investigation have been provided in separate subsections. Information presented in each subsection includes the RFI site-specific objectives, a site description, background details, previous investigations, and geologic and hydrogeologic data. Deviations from the work plan (E & E 1995) are discussed within each IRP site subsection. Details pertaining to general sample collection procedures, well drilling methodologies, decontamination procedures, and data review requirements are provided in the work plan.

4.1 IRP Site 3

The specific objectives of the RFI at Site 3 were to:

- Determine the horizontal and vertical extent of the landfill;
- Determine the horizontal and vertical extent of contaminants in the groundwater and surface water;
- Determine the impacts to environmental quality attributable to the site; and
- Develop a conceptual model of the site to identify the contaminant distribution, migration routes, potential receptors, and concentration of contaminants at receptor sites.

All RFI activities were designed to fill data gaps and to satisfy the IRP program and data quality objectives described in the work plan.

4.1.1 Site Description, Background, and Previous Investigations

IRP Site 3 is located on the east side of the installation between Kinross Street, Walmore Road, Cayuga Creek, and the northern boundary of the Niagara Falls IAP-ARS (see Figure 4-1). The inactive landfill consists primarily of gently sloping terrain, which is currently covered with grass and some young trees. The eastern boundary of the landfill extends onto the property of the Niagara Frontier Transportation Authority (NFTA).

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 and some potentially hazardous wastes that were sporadically burned. Burning ceased in 1966 and subsequent waste deposits were buried in trenches along the southern edge of the landfill. Wastes disposed of in this landfill include garbage, ash from coal stores, waste oil, shop wastes, batteries, scrap electrical parts from Bell Aerospace Textron, car parts, trash from the Navy station (formerly located across the runway), and wastes from Army Nike missile sites and other sources (USAF 1994).

During road construction at the Walmore Road entrance gate, car parts, construction debris, and a flowing black material were discovered. The black material was reported to be either charred waste mixed with soil or waste grit from the Carborundum Company industrial facility (USAF 1994).

Site 3 was originally identified during a 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 down-gradient 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 groundwater, 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 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 4-1.

During the development of the corrective action requirements under the hazardous waste storage permit renewal, Site 3 was initially chosen for an interim measure addressing groundwater. However, it was later determined that there was insufficient data to implement a full interim program (see Section 4.1.3.1).

4.1.2 Site Geology and Hydrogeology

4.1.2.1 Site Geology

The geology of Site 3 can be summarized as having a relatively thin, overburden cover consisting of fill material, lacustrine sediments, and glacial till on top of a fractured dolostone bedrock. The overburden rests on a relatively flat bedrock surface with the land surface sloping gently to the east-southeast; the overburden thickness decreases correspondingly in the same direction. The overburden ranges in thickness from approximately 3 feet in the south and southeast portion of the site near Cayuga Creek to 14 feet in the northwest corner of the site (see Figure 4-2). The bedrock surface can be seen in the bed of Cayuga Creek.

Based on the results of site surveys, the landfill is believed to cover an area approximately 10 acres in size with fill thicknesses ranging to over 8 feet. The fill material is primarily made up of disturbed soils, often stained black, with minor amounts of debris such as black slag, burned wood, graphite, carbon slag, and graphite ash. The overburden at the site consists of two distinct natural layers, except for areas that were replaced by fill material. The upper layer consists of stratified lacustrine sediments of clay with silt, sand, and gravel and are a mottled brown, yellow, gray and red in color. Beneath the lacustrine sediments and deposited directly on the underlying bedrock surface is a glacial till layer consisting of an unstratified mixture of clay to cobble-sized particles. This till layer ranges in thickness from 0 to 4 feet and averaged 1.75 feet at the site. The till layer is gravelly clay, red-to-reddish brown and gray in color with sand and subrounded gravel, saturated and soft.

The two groundwater monitoring wells (MW3-1E and MW3-6D) installed under the RFI and the three background (MW3-8, MW3-8D, and MW3-8E) and four replacement (MW3-1DA, MW3-2DA, MW3-4DA, and MW3-5AA) wells installed under the groundwater investigation provide a more complete picture of Site 3. Of the 16 monitoring wells at the site, five (MW3-1, MW3-2, MW3-6A, MW3-7, and MW3-8) are screened entirely in the overburden. Seven of the wells (MW3-1DA, MW3-2DA, MW3-3, MW3-4, MW3-4DA, MW3-6D, and MW3-8D) are completed in the upper 5 to 10 feet of bedrock and two

(MW3-1E and MW3-8E) in the deeper 25 to 35 feet of bedrock. Well MW3-5AA is screened in the top 15 feet of bedrock and was used for a pump test, and well MW3-3D is screened across multiple water-producing zones.

Examination of the rock cores for these wells revealed the bedrock beneath the site is the Lockport dolostone formation. At Site 3, the bedrock surface was found to be rather flat and the upper portion highly fractured to a depth of approximately 10 feet below the bedrock surface.

4.1.2.2 Site Hydrogeology

Groundwater was encountered in the overburden, shallow bedrock, and deep bedrock wells at Site 3. Groundwater flows preferentially in the overburden through the gravel till at the base of the overburden unit. This zone is in direct geologic contact with the most highly conductive zone of the bedrock, the upper 10 to 15 feet of weathered dolostone. The geology as well as the lack of a significant vertical gradient in the bedrock and overburden wells suggest these groundwater zones are hydraulically connected.

Overburden

The overburden at Site 3 is saturated at its base, primarily within the basal till layer that lies directly on the bedrock. The overburden is not a locally usable aquifer because of its typically low hydraulic conductivity and seasonal fluctuations in water level, which sometimes results in its being completely dry. Recharge of the overburden groundwater is primarily from rainfall and snowmelt infiltrating through fractures or micropores in the overlying lacustrine deposits. During the dry seasons, some recharge from the nearby Cayuga Creek may occur. Slug tests were performed on the wells at Site 3. Some of the wells have since been replaced under the groundwater investigation. The new wells will also be slug tested at the end of the drilling program. Results of slug tests performed in four wells (MW3-1, MW3-2, MW3-6A, and MW3-7) completed in the overburden at Site 3 show an average hydraulic conductivity of 5×10^{-4} centimeters per second (cm/s).

With the inclusion of newly installed wells (MW3-6A and MW3-8) and three surface water/sediment sample points, the water table contours presented in Figure 4-4 show a general flow to the southeast toward Cayuga Creek at a gradient of approximately 2.4 feet per 100 feet. A local water table high exists at the north end of the site at Well MW3-1 causing a flow component to the west at this portion of the site. This groundwater contour map shows the overburden groundwater discharges primarily into Cayuga Creek. Cayuga Creek probably sits on top of bedrock and receives groundwater from the shallow bedrock interval.

Comparison of groundwater elevations at overburden wells and bedrock wells in the same well nest shows that some of the water in the overburden discharges downward to the underlying fractured bedrock.

Bedrock

The Lockport dolostone formation is historically known to be a producing aquifer in the Niagara Falls area, able to produce water to wells at sufficient volumes for both residential and commercial use. With little to virtually no primary porosity in the dolostone rock matrix itself, groundwater flow in the Lockport is directly related to the number, size, and interconnection of fractures in the rock. These fractures are caused by weathering and glacial unloading. Most of the fractures occur in the uppermost 10 to 15 feet of bedrock. The majority of the fractures are sub-horizontal, bedding plane fractures with limited additional vertical fractures. During the drilling of the deepest well at Site 3 (MW3-1E), similar sub-horizontal fractures as those in the upper 10 to 15 feet were found at depth but fewer in number. No major aquiclude (water barrier) was encountered between the upper and deeper bedrock indicating hydraulic connection between at least the first 35 feet of bedrock at Site 3.

Slug tests were performed in all of the bedrock wells at Site 3 to quantify the hydraulic conductivity of the bedrock within the vicinity of the well bore. Three of the Site 3 bedrock wells were screened in the upper 10 feet of bedrock (MW3-3, MW3-4, and MW3-6D) were slug tested. Slug test data from these wells resulted in an average hydraulic conductivity of 1 x 10^{-3} cm/s. Data from these wells is considered the most representative of the shallow bedrock interval.

Five wells at Site 3 were screened across both the bedrock and the overburden (MW3-1D, MW3-2D, MW3-3D, MW3-4D, and MW3-5A). Slug test data from these wells provided an average hydraulic conductivity across the entire interval. Calculations on these data suggest the average conductivity across this interval ranges from 10^{-2} to 10^{-4}. (These data are not included in Table 4-2 since they are not representative of any unique water zone).

One of the deep bedrock wells (MW3-1E) was drilled at Site 3 to a depth of 42.1 feet (BGS) or 37.4 feet into bedrock. There is an upward vertical gradient between this well and the clustered well MW3-4 in the shallow bedrock. (The water elevation in the deep well is 588.1 feet above mean sea level (MSL) and 586.63 feet above MSL in the shallow bedrock well). Elsewhere on the site, the gradient is generally downward from shallow to deep bedrock. This observed anomaly may be due to the proximity of these wells to Cayuga Creek (less than 20 feet away).

A slug test was also conducted on this deep bedrock well. The rising head permeability was found to be 6 x 10^{-3} cm/s.

The shallow bedrock groundwater contour map was prepared using six monitoring wells all screened in the upper 5 to 15 feet of bedrock. Most of the wells are recent replacements of old wells that were screened across two or more water-producing zones..

The shallow bedrock groundwater contours show a flow pattern nearly identical to that of the overburden groundwater contour map. The shallow bedrock groundwater primarily flows to the south/southeast toward Cayuga Creek. A local groundwater high exists at the north end of the site in the area of well MW3-1 causing a westerly flow component. The gradient of the potentiometric surface is approximately 4.7 feet per 100 feet.

Comparison of water elevations in the overburden, shallow bedrock, deep bedrock, and Cayuga Creek revealed that at the time the June 9, 1995 measurements were collected, the overburden discharged to Cayuga Creek and the shallow bedrock. At well MW3-7, however, Cayuga Creek is a loosing stream which discharges surface water into the overburden.

Groundwater in the shallow bedrock discharges downward to deeper bedrock in the north part of this site (MW3-8D and MW3-8E) and upward near Cayuga Creek (MW3-4DA and MW3-1E).

4.1.3 RFI Field Activities

This section describes the field activities performed by E & E in support of the RFI at Site 3. Field activities began at Site 3 in December 1994. Activities included a soil gas survey; a geophysical survey; test pit excavation; monitoring well installation and development; sampling of subsurface soil, groundwater, surface water, and sediment; aquifer testing; and surveying. These activities were completed in March 1995. All field activities were performed in accordance with E & E's March 1995 Work Plan with minor exceptions as described in the appropriate sections below.

All fieldwork was conducted by E & E and its subcontractors. With the exception of soil gas and dioxin/furan analyses, all samples were delivered to and analyzed by E & E's Analytical Services Center (ASC). The soil gas samples were shipped to a subcontractor, Northeast Research Institute, LLC (NERI), for analysis by thermal desorption/mass spectrometry (TD/MS) and TD-MS/gas chromatography (GC). Dioxin/furan analysis was performed by Triangle Laboratories of RTP, Inc., in Durham, North Carolina.

4.1.3.1 Evaluation of Existing Data

Prior to the initiation of RFI field activities, E & E conducted a thorough background review of all pertinent Site 3 data to determine the number and location of new monitoring wells needed to completely define the extent of contaminants in the groundwater. Based on the results of this evaluation, E & E recommended the installation of two additional monitoring wells to provide hydrogeologic and analytical data from locations and depths previously not investigated (see Section 4.1.3.4). In addition, three surface water and sediment samples were recommended to be collected to assess the potential impact posed by the site on Cayuga Creek (see Section 4.1.3.7).

E & E's evaluation also concluded the need to decommission and replace three existing wells that were determined to be constructed improperly and the need for installation of a nest of three background wells in the extreme northwest corner of the site.

Contracting issues resulted in the installation of the replacement and background wells being performed as part of the installation-wide groundwater monitoring project. Data collected from the groundwater study pertinent to the Site 3 RFI will be incorporated into this document when available.

4.1.3.2 Soil Gas Survey

E & E conducted a soil gas survey at Site 3 as part of the Installation-Wide Groundwater Monitoring Project. The Petrex passive soil gas technology was chosen to identify occurrences of VOCs and semivolatile organic compounds (semivolatiles) in soil gas and provide reconnaissance screening of soil and groundwater at this site. Petrex soil gas sample tubes were provided and analyzed by NERI. A summary report including methodologies, quality control (QC) procedures, and results was prepared by NERI. The specific objectives of the soil gas survey were to:

- Identify VOCs and semivolatiles in soil gas;
- Determine the areal extent of potential chemical migration and identify migration pathways; and
- Assist in selecting the optimum locations for groundwater monitoring wells, soil borings, and test pits.

In November 1994, E & E conducted a pilot study to determine the effectiveness of the Petrex soil gas method at the base. Subsequent analysis by NERI indicated that the Petrex method was suitable for the purposes intended.

Methodology

Petrex soil gas sample tubes were installed by E & E at Site 3 on December 7 and 8, 1994, and retrieved on January 17, 1995. A description of the sample tube and installation procedures are discussed in the Work Plan. The optimum exposure time for the survey sample tubes was determined by conducting time calibration tests. It was determined that a minimum exposure time of 4 weeks would be required due to cold temperatures and slow VOC flux rates through the saturated clay-rich soil. Two additional sample tubes were installed at each of four locations across the landfill. The first set of time test tubes was retrieved and analyzed after 12 days, and the second set was retrieved after 21 days. Based on these results, a 6-week exposure time was selected for the survey samples.

A 100- by 100-foot grid was established over the landfill extending beyond its suspected boundaries. A sample tube was installed at each node on this grid except over the landfill itself, where the spacing was increased to 200 feet (see Plate 1 in Appendix A). Seventy-five soil gas samples were proposed in the work plan for Site 3. However, due to difficulty penetrating the ground in front of Building 614, this location (Sample No. 58) was eliminated, resulting in a total of 74 samples. All 74 tubes were installed in areas of exposed soil at the site. At the time of installation, standing water was present in five holes at Site 3. Upon retrieval, water was present in 54 holes.

For quality control (QC) purposes, an ambient air sample was collected by exposing an opened tube to ambient conditions for approximately the same amount of time that the survey samplers were exposed during installation and retrieval. Additionally, sealed tubes were shipped to and from the laboratory with the survey tubes serving as travel or trip blanks. Following retrieval, all samples were shipped by Federal Express to NERI's laboratory in Lakewood, Colorado.

Results

The sample collection elements were analyzed by NERI using TD/MS to determine the relative abundance of the contaminants accumulated in each sample. TCE, PCE, and a complex petroleum hydrocarbon mixture were the most prominent compounds detected in the soil gas at Site 3. The petroleum mixture was identified by the TD/MS analysis as being comprised of benzene, toluene, ethylbenzene, and xylenes (BTEX) and C_4 through C_{11} aliphatic hydrocarbons. For QA/QC purposes, 5% of the total number of samples collected installation-wide and analyzed by TD/MS were also analyzed by TD-GC/MS. This analysis confirmed the presence of the compounds detected by TD/MS analysis. Analytical results of the ambient air blank and travel blanks indicated that the survey samplers were not influenced by ambient conditions or shipment and storage.

Relative responses for TCE, PCE, BTEX, and total petroleum hydrocarbons (TPH) were mapped and contoured for Site 3. The results are presented in Plates 2 through 5 in Appendix A. Most of the response levels were considered low and are representative of background concentrations. Therefore, elevated response levels in the soil gas may not represent significant or detectable contamination of soil or groundwater, but define potential areas of contaminant migration.

Low levels and limited distributions of TCE and PCE were detected in soil gas at the site (see Plates 2 and 3, Appendix A). A single sample (Sample No. 32) exhibiting a high relative response level for TCE was identified southeast of the landfill across Cayuga Creek near the railroad bridge. Trichloroethane (TCA) was also detected at this location but is not shown on the maps. Discrete elevated soil gas response levels for PCE were detected south and southwest of the landfill. Most of the responses for these compounds were low and may not represent detectable concentrations in soil or groundwater. The elevated responses were isolated and do not appear to be directly related to landfilling operations.

High soil gas response level for BTEX and TPH were isolated, occurring northwest of MW3-1 and southeast of Building 618 adjacent to the soil storage shed (see Plates 4 and 5, Appendix A). An additional area of high TPH response was detected southwest of the Cayuga Creek pond. Low response values for BTEX and TPH were detected over a significant portion of the survey area, but these values are considered low and may not represent detectable concentrations in soil or groundwater.

Based on the soil gas results for Site 3, it was determined that the proposed locations for the two new monitoring wells as described in the work plan were suitable for the purposes intended. The results were also used to aid in locating test pits and soil borings at the site.

4.1.3.3 Site Surveys

E & E performed several tasks in order to determine the extent of landfilled materials at Site 3. These efforts described below included a historical aerial photograph review, geophysical tests consisting of an electromagnetic conductivity and total earth magnetic survey, and test pit excavations.

Aerial Photo Review

Four aerial photos dating from 1951, 1958, 1966, and 1982 were obtained from the Niagara County Department of Transportation in Lockport, New York. All photos were examined to identify potential fill areas (observations of scarred surfaces) at Site 3. The soil gas and geophysical survey grids were then established in such a manner as to include all of the potential fill areas. A copy of each of these photos is provided in Appendix B.

The 1951 aerial photo shows random scarring over an approximately 9½-acre area, and farmland surrounding this area and the railroad tracks near what is now the Utzig Drive gate. A road leads to the scarred area from near what is now Building 722. The start of base construction is evident, but no structures can be seen.

The 1958 photo shows that major construction has occurred since 1951. Utzig Drive does not yet exist, but the road to the landfill basically follows what is now Kinross Street. The scarred area covers approximately 3½ acres. South of this area are six large (approximately 50- by 150-foot) rectangular structures, each with eight round structures on top. These rectangular structures reportedly are the sand filters for a past wastewater treatment system. They extend from Langley Street to the east beyond the curve in Kinross Street.

The 1966 aerial photo shows four of the filtering structures have been abandoned, but that two are still present. Scarring in the landfill area is bordered by Kinross Street, the railroad tracks, and Cayuga Creek, but extends southward as far as Otis Drive, if it were extended to the east. The scarred surface area covers approximately 10½ acres with an additional 2 acres northwest of this main area, on the west side of Kinross and straddling what is now Utzig Drive. An area just north of the current location of Building 413 is not scarred, and the four rectangular structures are present.

The 1982 photo shows that Utzig Drive and the east gate have been constructed and that only an approximately 1½ acre area north and east of the curve on Kinross Street exhibits scarring. This scarring appears to be the result of grading activities.

Geophysical Survey

Electromagnetic terrain conductivity and total earth field magnetic surveys were performed at the landfill using a model EM31 conductivity meter and model G856 proton precession magnetometer, respectively. The geophysical investigation was designed to accomplish the following objectives:

- To verify the suspected boundaries of the landfill or aid in redefining these boundaries, if necessary;
- To locate and delineate subsurface ferrous objects of concern; and
- To assist in the location of test pits, soil borings, and monitoring wells.

A 725- by 1,200-foot grid was established at the site and data were collected every 25 feet within this grid (see Figure 4-6). A total of 1,230 data station measurements were collected. At each station, one magnetic and two types of conductivity measurements were recorded. Each conductivity measurement was recorded in four orientations, totaling eight conductivity readings per station. The two types of conductivity measurements recorded were the quadrature phase of the ground conductivity in millimhos per meter (mmhos/m) and the in-phase component in parts per thousand (ppt). The four instrument orientations were denoted vertical-1, horizontal-1, vertical-2, and horizontal-2, with 1 corresponding to a north-south alignment of the instrument and 2 corresponding to an east-west orientation. The vertical mode is the instrument's normal operating mode where the dipole of the induced magnetic field is perpendicular to the ground surface. The depth of penetration in the vertical mode is approximately 15 to 18 feet. The horizontal mode indicates that the dipole of the induced field is parallel to the ground surface and the depth of penetration is about 3 to 6 feet.

The EM31 and magnetometer were calibrated at the same location off the grid each day. Magnetometer background readings were also collected at the same location periodically during the survey in order to account for natural fluctuations in the earth's magnetic field known as diurnal drift.

Geophysical data were contoured using *Surfer* for Windows by Golden Software, Inc. Contour maps were generated for total earth field magnetics as well as for each orientation of the EM31 for both the quadrature and in-phase components. These maps are presented in Appendix C. Also provided is a map showing the locations of the data collection stations. Each of these contour maps was produced at the same scale as the site maps included in this report for ease of comparison.

Linear magnetic anomalies were detected in the northern and northeastern areas of the survey grid associated with the chain-link fences and railroad tracks. A north-south linear magnetic anomaly of lower magnitude was detected west of Kinross Street. This anomaly is likely associated with the overhead power lines in this area; however, the overhead power lines along Utzig Drive did not create a similar linear anomaly suggesting that those along Kinross may in part be due to the presence of underground utilities. Two areas exhibiting large magnetic anomalies of unknown source are present. One of these areas is in the north-central portion of the landfill, south of Utzig Drive. The other is near the center of the landfill, southwest of the landscaped mound and display aircraft (RF-101 Vodoo). These two anomalies suggest that massive ferrous objects are buried in these locations.

Both orientations of the vertical dipole mode of the terrain conductivity showed nearly identical formations with only some variations in magnitude suggesting the presence of linear structures. Like the magnetic survey results, the chain-link fences and railroad tracks are clearly evident. A somewhat linear anomaly is also present west of Kinross; however, it begins further south than that shown by the magnetometer and is likely the result of the concrete vault and buried lines of the Imhoff system. Two areas of high conductivity were detected in similar locations as the unknown anomalies on the magnetic contour maps. The anomaly south of Utzig exhibited the highest conductivity values detected within the survey area. The other anomaly was not as strong and was located approximately 250 feet south of the display aircraft. This is located slightly to the south and east of the magnetic anomaly detected in that area. Another anomalous zone detected with the EM31 is a plateau-like feature in the northwest corner of the grid straddling Utzig Drive. This anomaly covers a relatively large area and is of similar magnitude to the one south of display aircraft.

The horizontal dipole plots depict very similar features to those detected in the vertical dipole mode. This indicates that fill in the areas of anomalous conductivity readings is shallow, since the maximum depth of penetration in the horizontal mode is 6 feet. Each of the in-phase conductivity plots were similar to one another as well as to the quadrature phase plots. The only anomaly shown on these maps which is not as evident on the quadrature phase maps is a small circular area at approximately 400,300 on the geophysical grid. The source of this low-magnitude anomaly is unknown.

The geophysical survey indicates that background terrain conductivity in undisturbed areas is less than 10 mmhos/m. The soil/fill encountered at the site generally has a conductivity of 10 to 25 mmhos/m, with some areas exhibiting higher conductivities to approximately 50 mmhos/m. The variation in conductivity is a function of the clay and water content of the soil, the degree of compaction, and the amount of debris or ash mixed with the soil. The only areas that appear to contain fill other than soil are the three areas of high conductivity: the northwest corner of the survey grid; the north-central portion of the landfill south of Utzig Drive; and the east-central portion of the grid, south of the display aircraft. These areas also exhibited high magnetic values, especially the two latter areas, indicating that a portion of the fill consists of ferrous metal.

Test Pits

Test pits were excavated at Site 3 in order to verify the suspected landfill boundaries or aid in the determining these boundaries, where necessary. Test pit locations were based on the following:

- The previously suspected landfill boundaries provided by AFRES;

- The geophysical survey results; and
- The aerial photographs.

A total of 15 test pits were excavated on March 15 and 20, 1995 with a backhoe by E & E's subcontractor SJB Services, Inc. The locations of the test pits are shown on Figure 4-7. Test pits were excavated to depths between 1 and 4 feet and the presence of fill and/or undisturbed soil was noted. A description of the material encountered in each pit is provided in Table 4-4. The fill encountered in test pits consisted primarily of disturbed soil with occasional fragments of wood, ceramic drain tile, nails, etc. This soil/fill appeared to be construction spoils spread in this area after being excavated from other areas of the base. Upon completion, the pits were backfilled with the excavated material.

In order to redefine the landfill boundary, data from the following sources was used:

- Aerial photos;
- Geophysical survey;
- Test pits;
- Soil borings; and
- Existing and new monitoring well borings.

The approximate boundary derived from the above information is shown on Figure 4-8. The new boundary includes an additional area northwest of the previously suspected landfill boundary around MW3-1. This area exhibited high conductivity readings and two test pits west of MW3-1 showed the presence of soil/fill. On the south side, the boundary was moved further north based on the lack of fill in test pit TP-7 and soil boring SB3-4. Additionally, the fill boundary was moved within the abandoned railroad tracks along Utzig Drive and Walmore Road. Aerial photo, test pit, and geophysical data showed that no fill exists in the previously suspected area north and east of these tracks. The formerly suspected landfill boundaries encompassed an area of approximately 10.1 acres. The newly defined landfill covers 9.4 acres. Of this, approximately 7.5 to 8 acres appear to consist of soil/fill, i.e., disturbed or regraded soil containing small amounts of debris.

4.1.3.4 Monitoring Well Installation, Construction, and Development

Two groundwater monitoring wells (MW3-6D and MW3-1E) were installed under the RFI for IRP Site 3. Both of these wells were completed in the bedrock: MW3-6D in the upper bedrock and MW3-1E in the deeper bedrock water-producing zone. The installation of these two new wells increased the number of monitoring wells at this site to 13. Of the 13 wells at Site 3, four (MW3-1, MW3-2, MW3-6A and MW3-7) are completed in the overburden, eight (MW3-1D, MW3-2D, MW3-3, MW3-3D, MW3-4, MW3-4D, MW3-5A, MW3-6D) in the upper bedrock, and one (MW3-1E) in the deep bedrock water-producing zones.

Both new wells were drilled through the overburden using continuous-flight, hollow-stem augers and 2-foot-long, split-spoon samplers to obtain samples of the subsurface soil during drilling. The bedrock was drilled using a HQ-size, diamond rock coring bit to provide rock core samples and a tri-cone roller bit to ream the core hole to the desired diameter.

Both new wells were constructed using 4-inch, and, where appropriate, 6-inch carbon steel casing to seal off the overburden and/or shallow bedrock water-producing zones. Two-inch inner diameter (ID), polyvinyl chloride (PVC) casing and 0.01-inch slot well screen was placed in the wells at the desired depth of water production. Both of the new wells were furnished with a concrete drainage pad, a steel locking protective casing, and bollards. Table 4-5 provides details of the well completion and Appendix D contains geotechnical logs of the two new wells.

At least 24 hours after well completion, the new monitoring wells were developed to restore the natural hydrologic conditions in the immediate vicinity of the well. The development was performed using a precleaned stainless steel bailer to surge and the same bailer and/or a PVC hand pump to evacuate groundwater from the well until field chemistry parameters (i.e., temperature, pH, conductivity and turbidity) stabilized. Table 4-6 provides a summary of the development records for both new wells at IRP Site 3.

4.1.3.5 Subsurface Soil Sampling

Twelve subsurface soil and two duplicate samples were collected at Site 3 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. A list of these samples, the depths at which they were collected, and other pertinent information is presented in Table 4-7.

One soil sample was also collected from each of the monitoring well borings installed at the site. Well boring MW3-6D was sampled on February 15, 1995, and MW3-1E was sampled on February 16, 1995. On February 21, 1995, two borings (SB3-1 and SB3-2) were installed within the landfill downgradient of areas of large conductivity and magnetic anomalies detected during the geophysical survey. Eight borings (SB3-3 through SB3-10) were installed near the suspected boundaries of the landfill on March 20 and 21, 1995.

Subsurface boring logs for SB3-1 through SB3-10, MW3-6D, and MW3-1E and are provided in Appendix D. These logs contain a description of the soil encountered in each boring. The locations of the 10 borings and two wells are shown on Figure 4-7.

During split-spoon sampling, the soil from each boring was screened for organic vapors with a flame-ionization detector. Organic vapors were detected at only two locations, SB3-7 and SB3-10, and soil from those intervals was retained for analysis (see Table 4-7). At SB3-1, a sewage-like odor was noted near the base of the boring from which the sample was collected. At SB3-2, an oil-like odor was noted near the base of the boring. In this case, additional soil/fill from near the top of the boring was composited into the sample in order to obtain enough volume for the required analyses. No organic vapors or physical observations of contamination were detected in the other borings; therefore, samples were retained for analysis from the overburden/bedrock interface (see Table 4-7). Samples were collected from the split spoons using dedicated, precleaned, stainless steel spoons and transferred into appropriate sample containers which were stored on ice. Analytical results are discussed in Section 4.1.5.3.

4.1.3.6 Groundwater Sampling

On March 23 and 24, 1995, E & E collected groundwater samples from 10 wells at Site 3 including eight existing wells and the two newly installed wells. The three existing wells scheduled for replacement, MW3-1D, MW3-2D, and MW3-4D, were not sampled. A summary of the samples collected and the analyses performed is provided in Table 4-8. At the time of sample collection, readings of pH, temperature, specific conductance, and turbidity were recorded. These values are summarized in Table 4-9.

Groundwater sampling was conducted in accordance with the procedures outlined in the work plan. All wells were purged of three standing volumes of water or until dry prior to sampling using a stainless steel bailer and a PVC hand pump. Groundwater samples were then collected using a stainless steel bailer. The organic portion of the sample was collected by gently lowering the bailer into the water and carefully pouring the water into appropriate containers in order to minimize volatilization. If the pre-sample turbidity was greater than 50 nephelometric turbidity units (NTUs), the inorganic sample portion was collected later (within 24 hours) to allow the suspended sediment in the water column to settle. Sample turbidities at wells MW3-1, MW3-2 and MW3-6A were above 50 NTUs.

4.1.3.7 Surface Water and Sediment Sampling

E & E collected three surface water and three sediment samples from Cayuga Creek in the vicinity of Site 3 on March 16, 1995. At the time of collection, field measurements of pH, temperature, specific conductance, and turbidity were also recorded for the surface water samples. A summary of the samples collected, analyses performed, and field measurements is provided in Table 4-10.

Surface water and sediment sampling was conducted in accordance with the procedures discussed in the work plan. The locations of the samples are shown on Figure 4-7. Location SW/SD-1 was in Cayuga Creek at the Conrail railroad bridge approximately 500 feet upstream of where the creek enters the base. This sample was collected as the background location for Site 3 and the installation. SW/SD-2 was collected in Cayuga Creek just after it enters the Base, adjacent to the landfill. This location was selected to determine the level of contaminants entering the installation. SW/SD-3 was collected in Cayuga Creek downstream of the landfill, where a gravel road fords the creek. This location was chosen to determine if the landfill impacted Cayuga Creek.

4.1.3.8 Quality Assurance/Quality Control (QA/QC) Procedures

This section summarizes the QA/QC procedures used for the subsurface soil, groundwater, surface water and sediment samples collected and analyzed for this project. Further description is provided in the Quality Assurance Project Plan (QAPjP) (E & E 1995). All procedures are consistent with United States Environmental Protection Agency (EPA) QA/QC requirements as described in SW-846, Third Edition, revised July 1992.

Field and laboratory QC samples were collected at Site 3 to assist in determining whether project data quality objectives (DQOs) have been met by providing quantitative and qualitative measures of precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters.

Field Quality Control Samples

The purpose of field QC samples is to assess the sampling and transport procedures as possible sources of sample contamination and to document overall sampling and analytical precision. Field QC samples consisted of trip blanks for VOC analysis of all samples, field duplicates, and rinsates for groundwater and subsurface soil samples.

The frequency of field QC samples was as follows:

- One trip blank for every batch of soil and water samples shipped for VOC analysis;
- One rinsate blank for each day for each type of non-dedicated sampling equipment, i.e., groundwater and subsurface soil samplers; and
- One field duplicate for every 20 samples at the same matrix for each analysis.

Due to an oversight, no field duplicate was collected for PCDD/PCDF analysis of the three groundwater samples from Sites 3 and 10. However, the matrix spike/matrix spike duplicate (MS/MSD) sample collected from the Site 3 well was used to assess overall precision in lieu of a field duplicate.

Laboratory Quality Control Samples

The purpose of laboratory QC samples is to assess the accuracy and precision of the analytical methods and to determine any sample contamination from laboratory procedures, such as digestion, extraction, etc. Laboratory QC samples consisted of method blanks, matrix spike/matrix spike duplicates (MS/MSD) for organic analyses, laboratory spikes and duplicates for inorganic analyses, laboratory control samples (LCS) for all applicable methods, and surrogate and internal standards for all organic analyses.

The frequency of laboratory QC samples was as follows:

- One method blank per batch or per 20 samples;
- For organics, one MS/MSD set per batch or per 20 samples, whichever was more frequent;
- For inorganics, one spike/duplicate set per batch or per 20 samples, whichever was more frequent;
- One LCS for each matrix spike/matrix spike duplicate (MS/MSD) set for organics or spike and duplicate combination for inorganics;
- Surrogate standards added to each sample prior to purging or extraction for organics; and
- Internal standards added to each sample prior to instrumental analysis for organics.

No soil matrix LCSs were analyzed for priority pollutant metals because of a misunderstanding with the laboratory. A soil matrix LCS is not required for metals analysis by EPA's SW-846, although the QAPjP does require one for each set of MS/MSD or spike/

duplicate analyses. Future analytical work for this project will include soil matrix LCSs for metals.

4.1.3.9 Aquifer Testing

Following monitoring well installation, development, and sampling, aquifer testing was conducted by E & E at the two new wells (MW3-1E and MW3-6D) on March 29, 1995. The 11 existing wells at Site 3 were tested on November 14 and 15, 1995. The slug test method of aquifer testing was chosen to determine the horizontal hydraulic conductivity and transmissivity of the aquifer immediately adjacent to each well in order to aid in characterizing the groundwater flow regime at the site.

Water level response data were collected for each well according to the methods discussed in the work plan. Both falling- and rising-head tests were performed on new well MW3-6D. At MW3-1E, only a rising head test was performed because the water in the well was too close to the top of the casing to perform a falling-head test. The rising- and falling-head test procedures are discussed in E & E's work plan.

The data collected for all wells was processed using the software package *AQTESOLV* by Geraghty & Miller (1991) utilizing the interpretive methods of Bouwer and Rice (1976), which are applicable to unconfined or leaky confined aquifers. Each of the wells at Site 3 was found to fit this model. For data processing purposes, the height of the water column was used to represent the aquifer thickness. Transmissivity (T) was calculated by multiplying the derived hydraulic conductivity values (K) by the aquifer thickness (b). The slug test results for all of the wells at Site 3 are summarized in Table 4-2 and the graphical representations of the data included in Appendix E.

4.1.3.10 Land Survey

Upon completion of the RFI field activities, a land survey was performed by E & E. The horizontal and, where applicable, vertical positions of pertinent data points were surveyed.

Only newly installed wells, sample points, and key grid points were surveyed. Data points surveyed included:

- Two existing wells MW3-5A and MW3-6A and two new wells MW3-1E and MW3-6D;
- Three surface water and sediment sample locations SW/SED-1, SW/SED-2 and SW/SED-3; and

- Four key transects of the large survey grid established for the site surveys (soil gas, geophysics, test pits and soil borings).

The horizontal locations of the above data points were determined using a combination of Global Positioning System (GPS) and traditional surveying techniques. Three horizontal data points, referenced to the North American Datum 1927, New York State Plane West System were provided by AFRES. These three points were recovered and used to establish the horizontal positions of the wells grid nodes and sample points.

Elevations for all points of interest were obtained using multiple differential leveling loops and referenced to the National Geodetic Vertical Datum 1929 (mean sea level). The loops were tied into the single vertical control point provided by AFRES.

4.1.4 Analytical Results

Analytical results for subsurface soil, groundwater, surface water, and sediment samples collected during Site 3 RFI field activities are summarized in Tables 4-11, 4-12, 4-13, and 4-14. Only results above detection limits for target analytes present in one or more samples are listed in these tables. Field duplicates and other quality control (QC) samples are discussed in Section 4.1.4.4, including any impact on data usability. Laboratory summary data sheets for all sample results are included in Appendix F.

For VOC and BNA analyses, tentatively identified compounds (TICs) were determined by library search for mass spectral matches to non-target compounds with areas comprising at least 10% of the total area of the chromatogram (see Appendix F). Total hydrocarbons (THCs) were determined from the total mass/charge 57 ion over the entire mass spectra for all samples analyzed for VOCs and BNAs (see Appendix F). THCs and TICs and their correlation to total recoverable petroleum (TRPH) levels in subsurface soils are discussed in Section 4.1.4.1. High values for THCs are typically an indication of the presence of jet fuel-related compounds. High values for total unknown hydrocarbon TICs indicate contamination with some type of gasoline and/or diesel fuel.

Metals results for soils were compared to background concentrations in eastern United States soils and other surficial materials (Shacklette and Boerngen 1984) except for cadmium, which was compared to an observed range published by Dragun (1988). The results were compared to the upper limit of the 90th percentile, which represents the statistical concentration below which 90 percent of the study's samples fell (Shacklette and Boerngen 1984). For organics in soils, the guidance values presented by NYSDEC in the Technical and Administrative Guidance Memorandum (TAGM), dated January 24, 1994, were utilized. Sediment results were compared to lowest and severe effect levels in Persaud (1992) and Long and Morgan (1990) as presented in NYSDEC's Technical Guidance for Screening Contaminated Sediments (1993). Sediment results with no applicable guidance value were compared to soil guidance values (NYSDEC 1994). For groundwaters and surface waters, analytical results were compared to the NYSDEC Class GA groundwater and Class C surface water standards, respectively, presented in NYSDEC's Technical and Operational Guidance Series (TOGS) 1.1.1, dated October 1993. The following discussion pertains to samples in which the analytical results exceeded one or more of the guidance values or standards.

All samples were compared to data from previous investigations (SAIC 1991; GZA 1993; GZA 1994). RFI analytical results were found to be consistent with historical data, except where noted.

4.1.4.1 Subsurface Soil

A total of 11 subsurface soil samples, including one field duplicate sample, were collected and submitted for VOC, base/neutral/acid extractable (BNA), priority pollutant metals, and total recoverable petroleum hydrocarbons (TRPH) analyses. In addition, three subsurface soil samples, including one field duplicate sample, were collected and submitted for PCDD/PCDF analyses. Analytical results are listed in Table 4-11. Sample locations and associated analytical results that exceed guidance values are shown on Figure 4-9.

The following metals exceeded the upper limit of the 90th percentile: lead in samples SB3-6, SB3-7, and SB3-10; mercury in SB3-10; selenium in SB3-3, SB3-6 through SB3-8, and SB3-10; and zinc in SB3-3 through SB3-8, SB3-10, MW3-1E and MW3-6D.

TRPHs were detected in four subsurface soil samples: SB3-3, SB3-5, SB3-6, and SB3-10 (see Table 4-11). Although there is no specified regulatory level for TRPHs, it should be noted that TRPH levels in the first three samples were below 100 mg/kg, but sample SB3-10 contained a significantly higher TRPH concentration of 1,200 mg/kg. Comparison of tentatively identified compounds (TICs) detected during the BNA analysis revealed that sample SB3-10 also contained a relatively high unknown hydrocarbon TIC content (a total of 14,000 μg/kg; see Appendix F). THC levels were found to be below 700 μg/kg in all samples, except sample SB3-10 (3,000 μg/kg; see Appendix F). The presence of fuel contamination in sample SB3-10 is substantiated by the high TRPH, TIC, and THC results, as well as the organic vapor screening results obtained during sampling.

VOC analyses indicated elevated concentrations of carbon tetrachloride, trichloroethene, and chloroform were present at concentrations exceeding guidance values in sample SB3-7 and its field duplicate. Trace amounts of other VOCs were detected in these and some other subsurface soil samples, but at levels below the guidance values. Previous RI/FS samples did not contain VOCs at levels exceeding guidance values (SAIC 1991).

Sample SB3-1-SD contained 0.297 μg/kg of OCDD. Based on this result, the total 2,3,7,8-TCDD Toxicity Equivalent was calculated as 0.0003 parts per billion (ppb) or $3x10^{-13}$. The risk-based concentrations for ingestion of OCDD are $4x10^{-6}$ in residential soils and $1.8x10^{-5}$ in industrial or commercial soils. This indicates no apparent health risk as a result of the level of OCDD detected (EPA Region III memorandum, "Risk-Based Concentration Table, January-June 1995," dated March 7, 1995).

The BNA compounds benzo(a)pyrene and dibenzo(a,h)anthracene were detected at concentrations above the guidance values in samples SB3-6 and SB3-10. Samples collected during the RI/FS were not submitted for BNA analyses; therefore, no comparison can be made.

4.1.4.2 Groundwater

Ten groundwater samples were collected and submitted for VOC, BNA, PCB, and priority pollutant metals analyses (see Table 4-8). Two of the samples, MW3-3 and MW3-5A, were also submitted for PCDD/PCDF analyses. These two groundwater samples were resampled for the acid extractable portion of BNA analysis because of analytical problems with the initial samples (see Section 4.1.4.4). Analytical results are listed in Table 4-12. Monitoring well locations and associated analytical results that exceed guidance values are shown on Figure 4-10.

For metals analyses, the NYSDEC Class GA groundwater standards were exceeded for lead in samples MW3-1, MW3-2, MW3-3, and MW3-6A, and for zinc in samples MW3-3 and MW3-6A. Because field parameter data indicated that turbidities for three samples were greater than 50 NTUs, these analytes may be present because the samples were unfiltered and may have contained suspended particulates. Samples with higher turbidities contained higher concentrations of lead and zinc. Data from previous investigations indicate a decrease over time in metals concentrations in all wells, with the exception of MW3-3, which exhibited an increase in lead and zinc concentrations.

Several VOCs were present in sample MW3-3 at levels that met or exceeded the Class GA groundwater standards, including carbon tetrachloride, chloroform, cis-1,2-dichloroethene, methylene chloride, trichloroethene, toluene, and vinyl chloride. TCE was first detected in MW3-3 during the RI sampling in 1989, at a concentration of 55 μg/L (SAIC 1991). Subsequent results have shown a steady increase in TCE concentrations to a level of

920 μg/L during RFI sampling. A similar trend is noted for carbon tetrachloride, which was detected at a concentration of 25 μg/L in 1992, and a 1995 concentration of 2,400 μg/L.

Vinyl chloride was detected in MW3-3 during RI sampling at a concentration of 3.6 μg/L (SAIC 1991); during 1992 sampling activities it was found at a concentration of 2.3 μg/L, but in two subsequent sampling rounds in 1993 it was not detected (GZA 1993). Vinyl chloride was present in MW3-3 during RFI sampling at a concentration of 11 μg/L, which exceeds the Class GA groundwater standard of 2 μg/L. An additional change in MW3-3 groundwater was noted by the decrease in concentrations of trans-1,2-dichloroethene from 170 μg/L in 1992 to 2.0 μg/L in 1995.

Vinyl chloride was also detected in sample MW3-4 at the level of the groundwater standard. Previous data indicates that vinyl chloride has been detected in MW3-4 since 1992, at levels between 1.8 μg/L and 7 μg/L. Low concentrations of other VOCs were detected previously in MW3-4, but these compounds were not detected during RFI sampling.

BNA and PCDD/PCDF compounds were not detected in any of the groundwater samples. PCBs were detected in one sample (MW3-1) at a level of 0.61 μg/L (Aroclor 1254), which exceeds the groundwater standard. PCBs were not detected in the other groundwater samples or samples collected previously from MW3-1.

4.1.4.3 Surface Water and Sediment

Three surface water and three sediment samples were collected and submitted for VOC, BNA, and priority pollutant metals analyses. Additionally, the sediment samples were submitted for percent organic matter analysis. One of the sediment samples, SD3-1, was resampled in duplicate for BNA analysis because of analytical problems with the initial sample (see Section 4.1.4.4). Analytical results are summarized in Tables 4-13 and 4-14 for surface waters and sediments, respectively. Figures 4-9 and 4-10 show the sample locations and associated analytical results found to exceed guidance values.

The only metal detected in the surface water samples at levels exceeding the NYSDEC Class C surface water standard was zinc, which was found in all three samples.

VOCs were not detected in any of the surface water samples. The BNA compound bis(2-ethylhexyl)phthalate was detected above the NYSDEC Class C standard in surface water samples SW3-1 and SW3-3. This compound, at low concentrations, is commonly a result of field and/or laboratory contamination due to the use of rubber gloves that contain phthalate esters. Therefore, it should not be considered site-related contamination.

Metals results for sediments indicated that concentrations exceeded the lowest effect levels for cadmium in samples SD3-1 and SD3-2, and lead in SD3-2. In addition, all three sediment samples exceeded the lowest effect levels for silver and zinc. None of the sediment samples contained analytes at concentrations exceeding the severe effect levels.

No organic compounds exceeded guidance values in any of the sediment samples from the RFI sampling effort or previous efforts. Percent organic matter results obtained for the sediment samples represent typical values.

Sediment sample SD3-1 was selected as the background sample for Site 3. SD3-2 was located upstream of the landfill. The downstream sample location (SD3-3) was selected to determine whether Site 3 has impacted Cayuga Creek. Results indicated that metal and organic concentrations were either essentially the same, not detected, or are lower in the downstream sample, SD3-3, as compared to the upstream samples. Therefore, based on the analytical results, Site 3 has not impacted the sediment in Cayuga Creek.

4.1.4.4 Quality Assurance/Quality Control Results

All analytical data have been reviewed for compliance with precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters. QA/QC concerns that may have an effect on the data usability are summarized below along with the appropriate data qualifiers and discussion of potential impacts. Results flagged "B" are considered undetected because of field or laboratory blank contamination and should be used only as elevated quantitation limits. Results and quantitation limits are considered to be estimated values, when flagged "J" and "UJ", respectively. Any "J" qualifier not explained in the data review memorandum indicates that the level detected is below the method detection limit (MDL) but above the instrument detection limit (IDL). Further explanation is provided in the data review memorandum provided in Appendix F.

Field Quality Control Samples

Field Blanks. Field blank contamination was detected in two split-spoon rinsates associated with two subsurface soil samples, MW3-6D-SM and MW3-IE-SO, sampled on February 15 and 16, 1995, respectively. The contamination consisted of low levels of copper, chromium, nickel, and zinc. Due to an oversight in the field, no split-spoon rinsates were taken on the two other sampling dates, March 20 and 21, 1995, when the remaining nine subsurface soils were sampled for VOC, BNA, priority pollutant metals, and TRPH. Therefore, the results from the two rinsates collected on February 15 and 16, 1995, were applied to all the subsurface soil samples, not just those sampled at that time.

As a result of the contamination found in the two rinsate blanks, extra precautions are being taken during field decontamination procedures. The laboratory has been instructed to provide draft results for rinsates to facilitate any further corrective action, if necessary.

In general, metals were detected at comparable levels in the subsurface soils. Copper ranged from 4.1 to 26 mg/kg, with all results being less than five times the highest rinsate level and, thus, flagged "B" as undetected due to rinsate contamination. This qualification has no effect on data usability because the guidance value for copper is much higher than the copper detected in these samples.

Zinc was detected at concentrations ranging from 84 to 410 mg/kg, all greater than five times the rinsate level and needing no qualification. Therefore, there is no effect on data usability.

Chromium (3.5 to 27 mg/kg) and nickel (5.8 to 29 mg/kg) were detected at greater than five times the blank levels in all samples, except in SB3-4-SO, SB3-5-SO, and MW3-6D-SM. Associated results in these samples were flagged "B" as undetected due to rinsate contamination. These qualifications have no effect on data usability, since the guidance values for chromium and nickel are well above the levels qualified.

Trip blanks indicated no contamination with target VOCs, although THCs were present at levels consistent with those found in the method blanks. The rinsate blanks also indicated THCs at method blank levels (see discussion under laboratory method blanks).

Field Duplicates. Field duplicate analysis indicated poor precision for the following analytes: selenium and trichloroethene (TCE) in SB3-7-S0/SB3-7-SD, OCDD in SB3-1-SO/SB3-1-SD, and BNAs in SD3-1-SO/SD3-1-SD.

These variations are most likely due to the non-homogeneous nature of the soil and sediment samples. Reported results for these analytes are flagged "J" as estimated in the respective field duplicate samples. There is no impact on data usability for selenium and TCE in SB3-7 duplicates and BNAs in SD3-1 duplicates, because the results exceed the respective guidance values by a significant margin.

OCDD was detected in SB3-1-SD at a concentration of 0.297 μg/kg (see Section 4.1.4.1). OCDD was not detected in the original sample from SB3-1 or in any other sample from Site 3. Thus, the estimated value has no effect on data usability.

Laboratory Quality Control Samples

Method Blanks. No contamination was detected in method blanks for the water samples. Acetone, a common laboratory contaminant, was detected in six of the method blanks for soil samples. Acetone results are flagged "B" as undetected in all subsurface soils and sediments except SB3-10-WO, based on ten times the highest blank level detected. These results ranged from 3 to 22 µg/kg; levels well below the acetone guidance value and considered usable as elevated quantitation limits. Acetone in SB3-10-WO at 160 µg/kg or 20% below the guidance value is most likely due to laboratory contamination as well.

Other low-level contamination consisted of the following; methylene chloride and 2-butanone in the VOC methanol extraction blank, 4-methyl-2-pentanone in one sediment method blank, and bis(2-ethylhexyl)phthalate (BEHP) in one subsurface soil blank. The effect on sample results is discussed below.

Methanol extraction was used for dilution analysis of samples SB3-7-SO and SB3-7-SD only. Methylene chloride was present at low levels in the undiluted analysis of these two samples and in one sediment sample; 2-butanone was not detected in any of the samples. No data were qualified, although methylene chloride is considered suspected laboratory contamination. Data usability is not impacted because the guidance value is considerably higher than the levels detected.

Present in two sediments at low levels, 4-methyl-2-pentanone was flagged "B" as undetected. There is no guidance value for this compound in sediments, so data usability is not affected. The qualified results should be considered as elevated quantitation limits.

Bis(2-ethylhexyl)phthalate was found in all subsurface soil samples, except SB3-6D-SM, at levels ranging from 61 to 480 µg/kg. Only one soil result was flagged "B" as undetected, although all other BEHP results should be considered suspect. Phthalate esters, such as BEHP, are common contaminants from the use of plastic gloves in handling samples, both in the field and the laboratory. Data usability is not impacted because the guidance value is 50 times the highest BEHP reported result.

THCs were present at low levels in both laboratory and field blanks because the mass/charge 57 ion is found in the internal standards added to all samples including blanks. The sample results must be blank subtracted to indicate any actual site contamination by THCs (see Section 4.1.4.1).

Laboratory Spikes. The following analytes gave slightly low matrix spike recoveries for the associated samples as noted: antimony for all subsurface soils and sediments, selenium for all groundwaters and sediments, and two subsurface soils, and thallium for all sediments. The presence of these analytes was not detected in any of the associated samples; sample quantitation limits (QLs) were flagged "UJ" as estimated. Although the QLs for selenium, antimony, and thallium should be considered as slightly elevated in these instances, they are still well below the guidance values. Thus, data usability is not affected by the low spike recoveries.

The presence of zinc in nine subsurface soil samples were qualified "J" as estimated, based on a high spike recovery. Zinc results are well above the guidance value, except for sample SB3-9-SO, with a result 20% below the guidance value. For data usability purposes, this sample should be considered as containing zinc above the guidance value.

Laboratory Duplicates. Cadmium, chromium, copper, and zinc had high RPDs in the duplicate analysis, affecting the three sediment samples. Reanalysis gave the same results, indicating the non-homogeneous nature of sediment samples. Results for these analytes were flagged "J" as estimated in the sediments.

Copper was detected at 3.4 to 6.7 mg/kg and chromium was detected at 2.1 to 12 mg/kg, which are well below the lowest effect level. Zinc was detected at 590 to 900 mg/kg, which is well above both the lowest and severe effect levels; thus, data usability is not impacted. Cadmium was detected at 0.82 and 1.6 mg/kg in two of the sediments; these concentrations are between the lowest and severe effect levels, although much closer to the lowest effect. For data usability purposes, these results are considered as exceeding the lowest level only.

Zinc duplicate analysis had a high RPD, which was associated with all subsurface soils, except MW3-IE-SO and MW3-6D-SO. Results for these samples were flagged "J" as estimated based on high spike recovery (see above). Poor duplicate analysis confirmed the problem, most likely a result of the non-homogeneous nature of soil samples. The effect on data usability is the same as stated above.

Surrogate Spikes. Five of the six surrogate compounds gave slightly low recoveries in the BNA analysis of sediment sample SD3-1-SO, collected on March 16, 1995. Reextraction and reanalysis had acceptable recoveries, although reextraction was five days past the seven-day holding time. There were no analytical problems for the resampled SD3-1-SO and its field duplicate SD3-1-SD, collected on May 24, 1995. However, SD3-1-SO contained significantly more BNA contamination than its field duplicate and the other two sediments.

Visual inspection of the sample by the laboratory indicated a much larger amount of black and oily material in SD3-1-SO as compared to the other sediments.

Groundwater samples MW3-3 and MW3-5, collected on March 24 and March 23, 1995, respectively, had very low acid phenol surrogate recoveries. Reextraction and reanalysis was 11 days past the seven-day holding time, although recoveries were acceptable. There were no analytical problems for the resampled groundwaters MW3-3 and MW3-5A, collected on May 24, 1995. The base neutral analyses from the initial sampling in March and the acid phenol analyses from the resampling in May are considered acceptable data with no qualification. BNAs were not present in any of the groundwater samples from Site 3.

Holding Times

Chloroform, carbon tetrachloride, and trichloroethene (TCE) exceeded the calibration range in the VOC analysis of field duplicate samples, SB3-7-S0 and SB3-7-SD. The samples were reanalyzed at a dilution four days past the seven-day holding time. Results for chloroform, carbon tetrachloride, and TCE from the diluted analysis are considered more acceptable, although flagged "J" as estimated because of the holding time problem. The remaining VOC results should be taken from the original analysis. The original and diluted results indicated comparable values for carbon tetrachloride, chloroform, and TCE. Estimated results from the dilution analysis for these three compounds far exceeded their respective guidance values, thus data usability is not affected.

Sample SB3-7-SO and its field duplicate had much higher levels of VOCs than the other subsurface soils. The remaining samples indicated no VOC contamination or very low levels, except for SB3-8-SM and SB3-10-SO. These two samples exhibited contamination with the same VOCs as SB3-7-SO, but at significantly lower levels.

4.1.5 Conceptual Model

In this section, potential contaminant transport from Site 3 is discussed. The present and previous characterizations of the Site 3 groundwater, soils, and soil gas indicate that the groundwater pathway is the most likely discernible exposure pathway for the site. Thus, most of the discussion in this section is about groundwater mediated transport. Emission of volatile contaminants from soil into the atmosphere is also discussed. Subsections consider source characterization, groundwater flow in the vicinity of the site, and groundwater and contaminant travel times. Finally, natural attenuation processes and atmospheric emissions are considered.

Source Characterization

The Site 3 landfill operated during the 1950s and 1960s, and it was used principally for the disposal of construction debris and rubble; but, there is no inventory of the disposed wastes. Additional wastes placed in the landfill included trash, garbage, ash from coal stores, waste oils, shop wastes, electrical and mechanical parts and wastes from Model City and Fort Niagara (SAIC 1991). Disposed wastes were frequently burned in the facility until the middle 1960s when more stringent air pollution regulations were promulgated.

As a potential source term for groundwater contamination, the landfill would appear to be scattered or diffuse, that is, much of the facility is filled with construction rubble with pockets or areas of other disposed materials occurring throughout the facility. The degree to which nonhazardous rubble and waste material are mixed in the facility is unknown. The site survey task discussed in Section 4.1.3.3 showed that the landfill covers approximately 9.4 acres, of which less than 2 acres had terrain conductivities indicative of non-soil fill material.

A number of the materials disposed of in the landfill are potential sources of metal contaminants. Lead, zinc, mercury, and selenium were detected in soil samples at concentrations above the corresponding 90th percentile of the common range for eastern United States soils (Shacklette and Boerngen 1984). However, these metals are elevated regionally, and the detected concentrations may be typical of regional soils.

As noted in the results discussion, both lead and zinc were found to exceed the NYSDEC Class GA groundwater standards in several samples. The concentrations of both metals correlate with the turbidity. Thus, it appears that much of the observed metal concentrations is attributable to the suspended solids in the water. This finding is consistent with earlier work by SAIC (1991). Therefore, there is presently no evidence of significant metal releases from the landfill.

There is evidence, however, of some release of organic contaminants including fuel-related compounds (hydrocarbons), cleaning/degreasing solvents (chloroform, trichloroethene, carbon tetrachloride), and combustion products (polynuclear aromatic hydrocarbons [PAHs]), from the landfill, although the levels observed are not high and the detected areas are scattered (i.e., there is no evidence of extensive contamination in the soils or groundwater at the facility). The observed distributions and levels of contaminant concentrations are consistent with the disposal history of the facility.

Finally, the fill site was originally a depressed marshy area adjacent to Cayuga Creek. It was filled to a depth of 8 to 10 feet. The current investigation indicates disposal down to the upper bedrock in some, but not all, areas. This is below the water levels observed in nearby monitoring wells. Therefore, it is reasonable to assume direct contact between a portion of the wastes and the saturated zone groundwaters at the site.

Groundwater Flow and Contaminant Movement in the Vicinity of Site 3

Contaminants leaching from the Site 3 landfill will move through the overburden and upper bedrock described above. Because this system interacts locally with Cayuga Creek, a local groundwater divide exists in the vertical plane (see Figure 4-11). Water that enters the system on one side of this divide will generally flow to the south-southeast and discharge to Cayuga Creek (flowline A in Figure 4-11). This water moves largely through the overburden and the weathered interface. Water that enters on the other side of the divide will also flow, in general, to the south, but will not discharge to the creek (flowlines B and C). As it moves to the south, this water will also move down from the overburden, through the interface and into the upper bedrock, eventually moving under and beyond the creek. Ultimately, this water, flowline B, will discharge directly into the Niagara River to the south (Yager 1995), or move deeper through vertical fractures in the bedrock, flowline C. This water, too, ultimately discharges into the Niagara River.

This local groundwater divide likely intersects the land surface in the vicinity of the landfill, possibly bisecting the fill area. Therefore, some of the contaminants leached from the fill might be expected to eventually discharge into Cayuga Creek and some of the contaminants may ultimately be discharging directly into the Niagara River via groundwater. Site 3 monitoring wells installed in the overburden are positioned to detect contamination likely to discharge in Cayuga Creek. The deeper bedrock wells are positioned to detect contamination that may flow under the creek, moving eventually to the river.

It is possible that the divide does not intersect the fill area and that the fill lies entirely in the area discharging locally to Cayuga Creek. This may be the case near MW3-3 where the landfill is close to the creek. In addition, the location of the divide at the surface is expected to vary seasonally.

There is an additional factor in groundwater flow and hence contaminant transport from the site. Both the present and the historical observations of the water table elevations at the site suggest that the creek is both a gaining stream, particularly with respect to waters originating at the site, and a losing stream in the vicinity of the site. In the upper reach, immediately east of the landfill, the creek water level is below the water table elevations in nearby wells. In the lower reach, south of and farther away from the landfill, the creek water level was higher than the water table elevations in nearby wells. In addition, a transition zone, where some water originating at the site discharges into the creek and some moves beyond the creek, must exist between these two locations. These interactions between the groundwater and Cayuga Creek are illustrated in the inset to Figure 4-11.

It can be concluded at present that there is a potential for human exposure to Site 3 contaminants via Cayuga Creek and ultimately the Niagara River. In addition, even though there is no evidence that well water is used for drinking in the area, there is a potential for exposure via this pathway. Exposure to any Site 3 contaminants reaching the creek will likely be from recreational uses (i.e., wading, swimming, fishing, boating, etc.). Any relatively small amount of contamination that reaches the Niagara River will be diluted to orders of magnitude below detection by that river's large and turbulent flow. Exposure in the Niagara River due to the site is not likely to be discernible. Because of attenuation by biodegradation and dispersion, drinking water exposures also are not likely to be discernible.

Groundwater and Contaminant Travel Times

Using Darcy's Law (Bear 1987), the linear velocity of the groundwater is:

$$\textit{linear velocity} = (\textit{hydraulic conductivity}) * (\textit{horizontal hydraulic gradient}) / (\textit{effective porosity})$$

The horizontal hydraulic gradient observed in the overburden is approximately 0.024 foot/foot. Hydraulic conductivities determined at the site range from 1×10^{-4} to 8×10^{-3} cm/s with an average value of 2×10^{-3} cm/s. The distance from the southern edge of the fill to Cayuga Creek ranges from 50 feet or less for the nearest point in the vicinity of MW3-3 to 300 feet for the farthest point near MW3-5A.

The effective porosity is that part of the soil's or rock's void space that is interconnected and through which groundwater flow occurs. This parameter must be estimated. The soil types identified in the Site 3 overburden include silt loam, sandy silt, and silty clay (SAIC 1991). Based on these identifications and average soil properties compiled in the literature (e.g., EPA 1988), the total porosity of the overburden materials is expected to vary between 0.4 and 0.5. The ranges of effective porosity would be equal to or less than that of the total porosity; a range of 0.25 to 0.5 is assumed.

Taking these values for the materials comprising the overburden and using Darcy's Law, groundwater travel times in the vicinity of Site 3 can be estimated:

$$travel\ time = \frac{(distance\ to\ creek) * (effective\ porosity)}{(hydraulic\ conductivity) * (horizontal\ hydraulic\ gradient)}$$

For the average hydraulic conductivity, an effective porosity of 0.4 and an intermediate distance of 150 feet, the estimated landfill-to-creek groundwater travel time is 1.2 years. Using the extreme values on the parameter ranges, the travel time may be as little as 23 days from near MW3-3 or as long as 60 years from near MW3-5A. (If the median hydraulic conductivity is used, the travel time from MW3-5A drops to 2.4 years.)

The observed hydraulic conductivity of the shallow bedrock ranges from 5×10^{-4} to 2×10^{-3} cm/s. The average value is 1×10^{-3} cm/s. The horizontal gradient in the shallow bedrock aquifer is approximately 0.047 foot per foot. Some fracture flow is likely occurring in the shallow bedrock zone, and, as a result, the effective porosity is also likely lower. The extent to which the groundwater flows through fractures is not known at the present. Therefore, a broad range, 0.03 to 0.3, is used in the present estimates—the lower bound on the effective porosity being representative of fracture flow and the upper bound being representative of flow through the matrix.

Assuming an intermediate value, 0.095, for the effective porosity and using the average value for the shallow bedrock hydraulic conductivity, the estimated groundwater travel time over the 150 feet from the landfill to the vicinity of the creek is 107 days. Using the parameter extremes the minimum and maximum groundwater travel times through the shallow bedrock to the creek would be 17 days and 1.9 years, respectively.

The contaminants identified in the source characterization do not move with the same velocity as the groundwater, that is, interactions with the soil matrix retard the contaminants' movement. The parameter that characterizes this retardation, the partition coefficient or K_p, is specific to the chemical and the composition of the soils involved.

The expected travel times for organic contaminants at Site 3 can be estimated by considering a very mobile species which has been detected (chloroform) and a moderately mobile species which has been detected (trichloroethene). The retardation is a function of K_p:

$$retardation = R = 1 + \frac{\rho}{e} K_p$$

Where:

ρ = dry bulk density of the soil (g/cc);

e = effective porosity (dimensionless); and

K_p = partition coefficient (mL/g).

The partition coefficient is not constant. It generally increases with the fraction of organic carbon and can be represented by (EPA 1988):

$$K_p = f_{oc}K_{oc}$$

where K_{oc} is called the soil-water partition coefficient (Fetter 1988) and f_{oc} is the dimensionless fraction of organic carbon.

Fetter gives values of 34 mL/g and 152 mL/g for chloroform K_{oc} and trichloroethene K_{oc}, respectively. Estimates for soil f_{oc}'s at the Niagara Falls facility range from 0.0023 to 0.025 (SAIC 1991). Using these values, the estimated K_p for chloroform ranges from 0.078 mL/g to 0.85 mL/g, and the K_p for trichloroethene ranges from 0.35 mL/g to 3.5 mL/g.

The density of a single soil sample taken at Site 3 was 2.67 grams per cubic centimeter (g/cc) with a 27.5% moisture content (SAIC 1991). The dry density would then be 1.94 g/cc.

Using the definition given above and the site parameter values, the retardation of chloroform and trichloroethene can be estimated. In the case of chloroform, the retardation is calculated to be between 1.3 and 4.3 (dimensionless). The trichloroethene estimate ranges from 2.4 to 15. Representative intermediate values for the retardation are 2.8 and 8.7, respectively. Thus, the 1.2-year travel time for groundwater, which was estimated above, translates into 3.4 years and 10.4 years for chloroform and trichloroethene, respectively.

There is no information on organic carbon content or K_p's available for the dolostone. The organic carbon content is expected to be very low, and therefore, it is reasonable (and conservative) to assume little retardation occurs in the shallow bedrock matrix. However, fractures near the interface with the overburden materials may contain some those materials, and contaminants being transported through the fracture would be retarded to a similar degree. If this were the case, the travel times for chloroform and trichloroethene from the landfill—a 150-foot distance—would be 2.3 years and 7.1 years, respectively.

The retardation of any metals released from the facility will depend on a number of factors including redox conditions in the fill and soil or rock and the presence or absence of chelating or complexing agents. Therefore, the retardation of metals can be expected to range from no retardation (in the case of a complexed species) to several hundred or thousands. That is, depending on groundwater chemistry, some metals are extremely mobile, moving with the water, and other metals are essentially immobilized or fixed in place.

Because of the much greater distance involved, the travel times for contaminants from the landfill to the Niagara River are on the order of hundreds to thousands of years. In addition, natural attenuation processes would diminish the total quantity of materials being discharged into the river.

Natural Attenuation Processes

Contaminants in groundwater move along the groundwater flowlines in Figure 4-11, although typically at lower velocities because of retardation effects. In addition, natural processes such as biodegradation and dispersion lead to the attenuation of contaminant concentrations. In samples from well MW3-3 the concentrations of trichloroethene are historically much greater than the concentrations of vinyl chloride—the latter being a biodegradation product of the former. The well is screened in the overburden between the landfill and the creek, which lie in proximity to one another. As noted above, the estimated travel times from the landfill to the well are likely very short, allowing little time for biodegradation of the parent trichloroethene to occur. The predominance of trichloroethene over vinyl chloride at this location is consistent with this short travel time.

The well couple, MW3-4 and MW3-4D is also located near the creek, but further from the landfill. Travel times from the landfill are longer than in the case of MW3-3. Historically, the degradation product vinyl chloride has been observed rather consistently in both wells, though at concentrations very low compared to the trichloroethene concentrations at MW3-3. With the exception of one detection at a very low level in MW3-4 in 1993, trichloroethene has not been detected in either well. These observations suggest that significant biodegradation has occurred in the waters arriving at these wells.

Another process that leads to lower concentrations as a contaminant plume moves away from its source is dispersion—a spreading out of the plume because of molecular diffusion and soil/rock heterogeneities. Unlike biodegradation, dispersion is a conservative process in that the total mass of each contaminant in the aquifer is not reduced as a result of the process—it is merely spread out over a larger volume so the concentration at any one location is lower than in the initial plume.

Both biodegradation and dispersion are important in the conceptual model for Site 3. Biodegradation appears to be a significant factor in reducing contaminant concentrations in much of the groundwater discharging into nearby Cayuga Creek, although discharge in the area of MW3-3 may be an exception. Still, VOCs were not even detected in the surface waters. In addition, the rate of biodegradation implied in the monitoring well data is such that VOC concentrations in groundwaters not discharging to the creek (i.e., waters flowing south to the Niagara River or deeper in the Lockport series) are likely to be attenuated to nondetectable levels before those waters move very far from the site.

Dispersion is probably not as an important factor in contaminant attenuation as biodegradation, at least nearby with discharge to Cayuga Creek. With greater transport of any contaminants, however, dispersion could play a significant role in reducing contaminant concentrations in groundwater far from the site. This would be important for any non-biodegradable contaminants that might be detected in the future.

Atmospheric Emissions

The soil gas survey results presented earlier indicate the presence of a number of volatile emission sources in the vicinity of the Site 3 landfill. Although some contaminants were detected at the landfill, the overall distribution of survey detects does not suggest that the landfill is a major source of emissions of volatiles to the atmosphere. Instead, the sources tend to occur in the vicinities of roadways and buildings, suggesting small, local spills and contamination associated with base operations and not related to the landfill.

Inhalation exposures of on-site personnel and, to a lesser degree, off-site individual could result from the emission of volatiles from the soil and from resuspension of contaminated dust. However, the low occurrences of volatiles observed in the soil gas do not appear to represent a significant source of emissions. Also, because the entire site is covered with vegetation, except for roads, there is little chance for natural resuspension. The most credible dust inhalation scenarios entail intrusion into the landfill.

4.1.6 Summary and Conclusions

The Site 3 landfill is primarily filled with construction rubble with pockets or areas of other disposed materials. Therefore, sources of contamination in the fill material appear to be scattered or diffuse. Because at least a part of the site was originally a depressed marshy area, it can be assumed that some of the wastes are in direct contact with the groundwater in the saturated zone. This, of course, facilitates the leaching of potential contaminants from the disposed materials.

Contamination has been found in both subsurface soils and groundwater in the vicinity of the landfill. Several metals were detected in the soils across Site 3 at concentrations exceeding the corresponding 90th percentile value for the common range of eastern

United States soils. There is also evidence suggesting that this may be because of regionally high values. Hydrocarbons (TRPHs and semivolatiles) were also found at low concentrations in the subsurface soil at four of 11 of the sampling locations scattered across Site 3. Except for one sample from the western edge of the landfill, the detected concentrations were low. The presence of TRPH and semivolatiles as well as the number and locations of the positive samples are consistent with the limited and occasional disposal of waste materials in the landfill. VOCs were also detected in soils at several locations, but with the exception of one location near the northern perimeter of the landfill, were below guidance levels. Again, this is consistent with the history of the landfill.

The results of the soil gas survey over the landfill support the subsurface soil sampling findings; occurrences of VOCs were detected in the soil gas at several locations, but the response levels are considered low and the locations are scattered about Site 3. The highest response levels were near roads or structures.

Some metals and organics were also found in the site groundwater. For metals, lead and zinc were found in most of the groundwater samples, but their concentrations appear to correlate with sample turbidity, again suggesting a natural origin. In addition, the general presence of these metals in waters across Site 3 is distinctly different than the presence of the organics across the site. The latter—clearly materials of anthropogenic origin—are found only at a couple of the locations downgradient from the landfill. Collectively, these findings are consistent with the view that the organics present in the downgradient groundwater are attributable to contamination from the landfill, but the metals occur naturally.

The analyses of sediment samples from upstream and downstream of Site 3 show little difference in the results from the two locations, suggesting that the landfill is not presently impacting the creek sediments. Similar results were obtained for the upstream and downstream surface water samples. Therefore, based on these results, the creek is not presently a concern with respect to Site 3.

The potential for both groundwater and atmospheric contaminant transport at and away from the Site 3 landfill was examined. The only viable exposure pathways appear to be groundwater via Cayuga Creek, Niagara River, and drinking water wells. Even in those cases, the concentrations at receptor locations would likely be very low.

The conceptual model for groundwater flow at the site is complex. This is largely the result of the interaction of the groundwater with Cayuga Creek and the location of the facility with respect to the creek. In the vicinity of Site 3, Cayuga Creek appears to go from being a gaining stream to being a losing stream. It appears that the transition from gaining stream to losing stream occurs within the area delineated by flow from the site. That is, some contaminants will go into the creek and some will not—going instead south to the Niagara River, or deeper into the Lockport series and ultimately to the Niagara River.

An additional factor is the location of the landfill relative to the creek. The eastern boundary or extent of the landfill lies close to the creek. (The creek is gaining at this location.) As a consequence, the groundwater travel times from the facility to the creek are short. There is little time for contaminant concentrations to attenuate. Another concern is that the fill materials are likely to be more permeable than the native soils. This part of the landfill could then be acting as a conduit for contaminated leachate from other parts of the landfill to the creek. In fact, samples from the MW3-3, located in this area, have consistently exhibited contamination at levels above that observed elsewhere on site. Still, no significant concentrations of contaminants have been found in Cayuga Creek water samples.

Unlike the eastern half of the landfill, the western half is located up to several hundred feet from the creek. Here the landfill-to-creek travel times are greater and biodegradation appears to be significantly attenuating contaminant concentrations in the groundwater. Therefore, if groundwater is discharging to the creek, the concentrations are much lower than the concentrations discharging near MW3-3. If, as is possible, some of the groundwater moves beyond the creek, then biodegradation—as discussed above—is likely to rapidly attenuate the contaminant concentration to nondiscernible levels.

Perhaps the most important factor in characterizing the Site 3 landfill is biodegradation. All of the observed data at the site are consistent with the rapid biodegradation of VOCs in the groundwater. In water with short travel times to a sampling location, little biodegradation appears to have occurred. This is evidenced by high trichloroethene concentrations and little or no vinyl chloride. Conversely, in wells farther from the site, vinyl chloride can be found and little or no trichloroethene is found. In addition, the observed vinyl chloride concentrations are low, suggesting they are attenuated.

The arguments for biodegradation are strengthened when the findings of an investigation at the former Carborundum Company facility, located 2,400 feet northwest of the IAP-ARS, are considered (E & E 1990). Apart from a greater surficial thickness of glacial lake sediments and till, the Carborundum facility has an almost identical geological setting. It was the site of spills, leaks, and disposal of large quantities of chlorinated solvents, mainly trichloroethene. Contamination events certainly included the direct infiltration of trichloroethene into the soil and even the aquifer (at least in the overburden) as a separate dense non-aqueous phase liquid. This resulted in serious impacts on groundwater quality.

As a result of a repeated series of expanding field investigations, it was nevertheless found that the trichloroethene under the Carborundum facility and in its vicinity, especially within the aquifer of greatest concern, was being rapidly biotransformed by naturally occurring bacteria. The result is that the trichloroethene concentration declines by four or five orders of magnitude when groundwater samples collected from the most contaminated wells underneath the facility are compared to samples collected not far from the facility boundary.

The biodegradation products of trichloroethene likewise decline sharply in concentration by orders of magnitude within short distances of the facility, including vinyl chloride, a compound that is usually considered moderately persistent and relatively resistant to biotransformation. Concentrations of these chemicals also decrease rapidly with depth in the bedrock beneath the facility, as well as laterally.

As a consequence of the biodegradation, no off-site domestic wells are impacted at levels above drinking water standards by any of the chemicals migrating from the Carborundum site. These conclusions about a facility so close to Site 3, studied in great detail, and of such a similar nature, strongly suggest that the levels of anthropogenically introduced contaminants in the groundwater beneath and downgradient of Site 3 are highly unlikely to represent a threat to off-site receptors.

Table 4-1

SUMMARY OF PREVIOUS ANALYTICAL RESULTS IRP SITE 3 NIAGARA FALLS IRP-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
2-Chloroethylvinylether	ND - 580

Key at end of table.

Table 4-1

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

Parameters of Concern	Observed Range[a]
Chloroform	ND - 1,100
Chloromethane	ND - 57
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 4-2

AQUIFER SLUG TEST RESULTS
IRP SITE 3
NIAGARA FALLS IAP-ARS

Well Number	Average Hydraulic Conductivity (cm/s)	Total Depth (feet BGS)	Depth to Bedrock (feet BGS)	Test Date	Static Water Level (feet BGS)	Screened Interval (feet BGS)	Calculated Hydraulic Conductivity (cm/s)
Overburden Wells							
MW3-1	7×10^{-4}	12.3	12.3	11/30/94	3.98	7.3 - 12.3	8×10^{-4} F
							6×10^{-4} R
MW3-2	6×10^{-4}	9.5	9.5	11/30/94	2.4	5.5 - 9.5	4×10^{-4} F
							7×10^{-4} R
MW3-6A	8×10^{-3}	8	9	11/30/94	2.87	4 - 8	1×10^{-2} F
							7×10^{-3} R
MW3-7	1×10^{-4}	5	6	11/30/94	1.63	3.5 - 5	2×10^{-4} F
							9×10^{-5} R
Shallow Bedrock Wells							
MW3-3	2×10^{-3}	9.4	4.3	11/30/94	1.21	5.4 - 9.4	1×10^{-3} F
							2×10^{-3} R
MW3-4	1×10^{-3}	8.5	4.3	11/30/94	0.76	4.5 - 8.5	2×10^{-3} F
							6×10^{-4} R
MW3-6D	1×10^{-3}	18.3	8	04/06/94	5	13 - 18	1×10^{-3} F
							1×10^{-3} R
MW3-3D	5×10^{-4}	32.4	7.7	11/30/94	-1.69	7.5 - 32.4	5×10^{-4} R
Deep Bedrock Wells							
MW3-1E	7×10^{-3}	42.1	4.7	04/06/95	-0.97	31.5 - 41.5	2×10^{-3} R

Key:

BGS = Below ground surface.
cm/s = Centimeter per second.
F = Falling-head test.
R = Rising-head test.

Table 4-3

MONITORING WELL AND SURFACE WATER ELEVATION DATA
IRP SITE 3
NIAGARA FALLS IAP-ARS

Well Number/ Sample Point	Ground Elevation	TOIC Elevation	Groundwater Elevation on 11/2/94	Groundwater Elevation on 2/28/95	Groundwater Elevation on 5/8/95
MW3-1	601.72	604.42	599.60	598.63	597.67
MW3-1D	591.26	593.46	590.42	589.95	589.45
MW3-1E	588.40	589.69	NA	NA	588.31
MW3-2	596.79	598.95	594.63	594.39	593.72
MW3-2D	596.67	599.98	590.37	589.99	589.48
MW3-3	590.41	593.23	589.95	589.46	589.00
MW3-3D	588.08	590.86	590.41	Frozen	589.53
MW3-4	588.71	590.12	588.32	587.15	586.69
MW3-4D	588.54	590.73	590.41	Frozen	589.51
MW3-5A	592.40	594.57	592.02	Frozen	590.81
MW3-6A	600.10	602.31	597.64	596.06	595.69
MW3-6D	600.80	602.01	NA	NA	595.81
MW3-7	587.93	590.85	587.37	585.52	584.85
SW/SED-1	609.11	NA	590.61	590.21	589.56
SW/SED-2	595.60	NA	588.08	587.20	586.79
SW/SED-3	587.38	NA	586.04	585.04	585.28

Note: All elevations are expressed in feet above mean sea level.

Key:

NA = Not applicable (well not installed at this time).
TOIC = Top of casing.

2

Table 4-4

TEST PIT OBSERVATION SUMMARY
IRP SITE 3
NIAGARA FALLS IAP-ARS

Test Pit No.	Depth (feet)	Description
TP-1	4	Brown loam (topsoil) over native varied lacustrine clay.
TP-2	2	4-inch black carbonaceous material/slag (probable grading material from nearby RR tracks; not landfill) over native clay.
TP-3A	1 - 2	1 foot disturbed soil over black carbonaceous fill/slag.
TP-3B	1 - 2	Disturbed soil with green cuprite fragments.
TP-3C	2	10-inch brown topsoil with ceramic fragment, over 6-inch grey to brown pea gravel, over native clay (out of fill, probable grading material from old railroad crossing).
TP-4A	2	Thin topsoil over native lacustrine clay.
TP-4B	2	Disturbed soil with black carbonaceous material/slag, glass, and unknown red and yellow material mixed throughout.
TP-5A	2	Disturbed soil with black carbonaceous material, wire, nails, and cuprite fragments.
TP-5B	2	Disturbed soil with black carbonaceous material and a bolt.
TP-5C	3 - 4	Disturbed soil with dolostone boulders, no other fill.
TP-5D	1	Disturbed soil with wood and drain tile fragments.
TP-5E	2 - 3	Disturbed soil with wood, copper paint chips, and nails.
TP-6	3 - 4	3-foot sand with drain tile fragments, steel can top, etc. over native lacustrine clay.
TP-7	1	Thin topsoil over native lacustrine clay.
TP-8	1 - 2	1-foot dark brown sandy loam (topsoil) with glass fragment over native sandy clay.

Table 4-5

MONITORING WELL CONSTRUCTION DATA
IRP SITE 3
NIAGARA FALLS IAP-ARS

Well Number	Well Type	Date Completed	Depth to Bedrock	Total Depth Drilled	Total Depth Measured[a]	Screened Interval	Depth of 4-Inch Steel Casing	Depth of 6-Inch Steel Casing	Sand Pack Interval
MW3-1E	Deep bedrock	2-27-95	4.7	42.1	43.39	31.5 - 41.5	23.0	6.7	29.4 - 42.1
MW3-6D	Shallow bedrock	2-17-95	8.0	18.3	19.24	13.0 - 18.0	10.3	NA	11.0 - 18.1

Note: All depth values, except those mentioned below, are expressed in units of feet below ground surface.

[a] This value was measured on 5/8/95 and is expressed in feet below top of inner casing (TOIC).

Key:

NA = Not applicable.

Table 4-6

WELL DEVELOPMENT RECORD
IRP SITE 3
NIAGARA FALLS IAP-ARS

Well Number	Date Developed	Water Volume Removed (gallons)	Final Water Quality Parameters			
			Temp (°F)	Conductivity (mmhos)	pH	Turbidity (NTUs)
MW3-1E	3-13-95	55	55.6	2,510	7.06	96.6
MW3-6D	3-9-95	25	42.7	1,027	7.33	NM

Key:

mmhos = millimhos.
NM = Not measured due to equipment difficulties.
NTU = Nephelometric turbidity units.
°F = Degrees Fahrenheit.

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Table 4-7

SUBSURFACE SOIL SAMPLE SUMMARY
IRP SITE 3
NIAGARA FALLS IAP-ARS

Boring No.	Sample ID No.	Sample Depth (feet BGS)	Depth to Bedrock (feet BGS)	Analyses	Maximum OVA Reading (ppm)	Comments
SB3-1	NM9-SB03-01-SO-022195	4 - 8.3	8.4	PCDD/PCDF	0	Soil fill with sewage-like odor
	NM9-SB03-1-SD-032195	4 - 8.3	8.4	PCDD/PCDF	0	Soil fill with sewage-like odor
SB3-2	NM9-SB03-02-SM-022195	2 - 3 + 6 - 7	7.3	PCDD/PCDF	0	Soil fill with oil-like odor
SB3-3	NM9-SB3-3-SO-032095	2 - 3.5	3.5	VOC, BNA, Priority Pollutant Metals, TRPH	0	Native soil below soil-fill
SB3-4	NM9-SB3-4-SO-032095	2 - 5.8	5.8	VOC, BNA, Priority Pollutant Metals, TRPH	0	Native soil
SB3-5	NM9-SB3-5-SO-032095	4 - 5.8	5.8	VOC, BNA, Priority Pollutant Metals, TRPH	0	Native soil below soil-fill
SB3-6	NM9-SB3-6-SO-032195	0 - 4	7.3	VOC, BNA, Priority Pollutant Metals, TRPH	1	Soil-fill
SB3-7	NM9-SB3-7-SO-032195	6 - 9.5	9.5	VOC, BNA, Priority Pollutant Metals, TRPH	50	Native soil below soil-fill
	NM9-SB3-7-SD-032195	6 - 9.5	9.5	VOC, BNA, Priority Pollutant Metals, TRPH	50	Native soil below soil-fill
SB3-8	NM9-SB3-8-SM-032195	11 - 14	14	VOC, BNA, Priority Pollutant Metals, TRPH	0	Native soil below disturbed soil
SB3-9	NM9-SB3-9-SO-032195	5 - 6.4	6.4	VOC, BNA, Priority Pollutant Metals, TRPH	0	Native soil below soil-fill

Key at end of table.

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Table 4-7

SUBSURFACE SOIL SAMPLE SUMMARY
IRP SITE 3
NIAGARA FALLS IAP-ARS

Boring No.	Sample ID No.	Sample Depth (feet BGS)	Depth to Bedrock (feet BGS)	Analyses	Maximum OVA Reading (ppm)	Comments
SB3-10	NM9-SB3-10-SO-032195	6 - 7	7.0	VOC, BNA, Priority Pollutant Metals, TRPH	7	Soil-fill
MW3-1E	NM9-MW03-1E-SO-021695	2 - 4	4.7	VOC, BNA, Priority Pollutant Metals, TRPH	0	Native soil below soil-fill
MW3-6D	NM9-MW03-6D-SM-021595	6 - 8	8.0	VOC, BNA, Priority Pollutant Metals, TRPH	0	Native soil

Key:

BGS = Below ground surface.
BNA = Method 8270 base/neutral and acid extractables.
OVA = Organic vapor analyzer.
PCDD/PCDF = Method 8280 polychlorinated dibenzo-p-dioxins/polychlorinated dibenzofurans.
TRPH = Total recoverable petroleum hydrocarbons.
VOC = Method 8240 volatile organic compounds.

Table 4-8

GROUNDWATER SAMPLE SUMMARY
IRP SITE 3
NIAGARA FALLS IAP-ARS

Well No.	Sample ID No.	Analyses	Sample Date
MW3-1	NM8-MW3-1-WO-032495	VOC, BNA, PPM, PCB	3-24-95
MW3-1E	NM9-MW3-1E-WO-032495	VOC, BNA, PPM, PCB	3-24-95
MW3-2	NM8-MW3-2-WO-032495	VOC, BNA, PPM, PCB	3-24-95
MW3-3	NM8-MW3-3-WO-032495	VOC, BNA, PPM, PCB, PCDD/PCDF	3-24-95
MW3-3D	NM8-MW3-3D-WO-032395	VOC, BNA, PPM, PCB	3-23-95
MW3-4	NM8-MW3-4-WO-032395	VOC, BNA, PPM, PCB	3-23-95
MW3-5A	NM8-MW3-5A-WM-032395	VOC, BNA, PPM, PCB, PCDD/PCDF	3-23-95
MW3-6A	NM8-MW3-6A-WO-032395	VOC, BNA, PPM, PCB	3-23-95
MW3-6D	NM9-MW3-6D-WO-032395	VOC, BNA, PPM, PCB	3-23-95
MW3-7	NM8-MW3-7-WO-032395	VOC, BNA, PPM, PCB	3-23-95

Note: Three wells at Site 3 (MW3-1D, 3-2D, and 3-4D) are scheduled for replacement and were not sampled.

Key:

BNA = Method 8270 base/neutral and acid extractables.
PCB = Method 8080 polychlorinated biphenyls.
PCDD/PCDF = Method 8280 polychlorinated dibenzo-p-dioxins/polychlorinated dibenzofurans.
PPM = Priority pollutant metals.
VOC = Method 8240 volatile organic compounds.

Table 4-9

GROUNDWATER SAMPLE FIELD PARAMETERS
IRP SITE 3
NIAGARA FALLS IAP-ARS

Well No.	pH	Temperature (°F)	Specific Conductance (mmhos)	Turbidity[a] (NTU)
MW3-1	7.06	42.0	2,140	56.6
MW3-1E	7.13	45.7	2,070	16.9
MW3-2	6.21	43.9	790	142
MW3-3	6.37	40.9	1,160	41
MW3-3D	7.09	47.2	1,500	10.4
MW3-4	6.94	47.6	1,430	35.3
MW3-5A	7.10	48.9	800	26.4
MW3-6A	6.32	45.6	760	967
MW3-6D	7.02	46.6	1,070	35.5
MW3-7	7.15	46.8	990	46.4

[a] The value represents the turbidity of the metals portion of the sample.

Key:

°F = Degrees Fahrenheit.
mmhos = Millimhos.
NTU = Nephelometric turbidity units.

Table 4-10

SURFACE WATER AND SEDIMENT SAMPLE SUMMARY
IRP SITE 3
NIAGARA FALLS IAP-ARS

Sample Location	Sample ID No.	Analyses	pH	Temperature (°F)	Specific Conductance (mmhos)	Turbidity (NTU)
Surface Water Samples						
SW-1	NM9-SW3-1-WO-031695	VOC, BNA, PPM	7.70	51.8	780	13.2
SW-2	NM9-SW3-2-WO-031695	VOC, BNA, PPM	7.83	47.2	740	10.7
SW-3	NM9-SW3-3-WO-031695	VOC, BNA, PPM	7.74	47.5	474	11.2
Sediment Samples						
SED-1	NM9-SD3-1-SO-031695	VOC, BNA, PPM, %OM	NA	NA	NA	NA
SED-2	NM9-SD3-2-SM-031695	VOC, BNA, PPM, %OM	NA	NA	NA	NA
SED-3	NM9-SD3-3-SO-031695	VOC, BNA, PPM, %OM	NA	NA	NA	NA

Key:

BNA = Method 8270 base/neutral and acid extractables.
NA = Not applicable.
NTU = Nephelometric turbidity units.
PPM = Priority Pollutant metals.
VOC = Method 8240 volatile organic compounds.
%OM = Percent organic matter (ASTM D-2974).
°F = Degrees Fahrenheit.
mmhos = Millimhos.

Table 4-11

SOIL SAMPLING ANALYTICAL RESULTS
IRP SITE 3
NIAGARA FALLS IAP-ARS

Analyte — Sample Number: / Sample Depth (feet BGS): / Sample Date:	SB3-1-SO 4-8.3 2/21/95	SB3-1-SD 4-8.3 2/21/95	SB3-2-SM 2-3/6-7 2/21/95	SB3-3-SO 2-3.5 3/20/95	SB3-4-SO 2-5.8 3/20/95
Metals (mg/kg)					
Arsenic	NA	NA	NA	3.9	2.1
Beryllium	NA	NA	NA	0.79	ND
Cadmium	NA	NA	NA	3.8	2.3
Chromium, total	NA	NA	NA	19	8.1 B
Copper	NA	NA	NA	18 B	13 B
Lead	NA	NA	NA	26	11
Mercury	NA	NA	NA	0.21	ND
Nickel	NA	NA	NA	18	8.1 B
Selenium	NA	NA	NA	2.2	ND
Zinc	NA	NA	NA	180 J	230 J
VOCs (µg/kg)					
1,1,1-Trichloroethane	NA	NA	NA	ND	ND
1,1,2,2-Tetrachloroethane	NA	NA	NA	ND	ND
Acetone	NA	NA	NA	13 B	ND
Carbon disulfide	NA	NA	NA	ND	ND
Carbon tetrachloride	NA	NA	NA	ND	ND
Chloroform	NA	NA	NA	ND	ND
cis-1,2-Dichloroethene	NA	NA	NA	ND	ND
Methylene chloride	NA	NA	NA	ND	ND
Tetrachloroethene	NA	NA	NA	ND	ND
Toluene	NA	NA	NA	ND	ND
Trichloroethene	NA	NA	NA	ND	ND
Xylene (total)	NA	NA	NA	ND	ND
BNAs (µg/kg)					
2-Methylnaphthalene	NA	NA	NA	ND	ND
Acenaphthene	NA	NA	NA	ND	ND
Anthracene	NA	NA	NA	ND	ND
Benzo(a)anthracene	NA	NA	NA	ND	ND
Benzo(a)pyrene	NA	NA	NA	ND	ND
Benzo(b)fluoranthene	NA	NA	NA	ND	ND
Benzo(g,h,i)perylene	NA	NA	NA	ND	ND
Benzo(k)fluoranthene	NA	NA	NA	ND	ND
bis(2-Ethylhexyl)phthalate	NA	NA	NA	140 J	61 J
Butylbenzylphthalate	NA	NA	NA	ND	ND
Carbazole	NA	NA	NA	ND	ND
Chrysene	ND	ND	ND	ND	ND
Di-n-butylphthalate	NA	NA	NA	ND	ND
Dibenzo(a,h)anthracene	NA	NA	NA	ND	ND
Diethyl phthalate	NA	NA	NA	ND	ND
Fluoranthene	NA	NA	NA	ND	ND
Fluorene	NA	NA	NA	ND	ND
Indeno(1,2,3-cd)pyrene	NA	NA	NA	ND	ND
Phenanthrene	NA	NA	NA	ND	ND
Pyrene	NA	NA	NA	ND	ND
TRPH (mg/kg)	NA	NA	NA	37	ND
PCDD/PCDF (µg/kg)					
1,2,3,4,6,7,8,9-OCDD	ND	0.297	ND	NA	NA

Key at end of table.

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Table 4-11

SOIL SAMPLING ANALYTICAL RESULTS
IRP SITE 3
NIAGARA FALLS IAP-ARS

Analyte / Sample Number: / Sample Depth (feet BGS): / Sample Date:	SB3-5-SO 4-6 3/20/95	SB3-6-SO 0-4 3/20/95	SB3-7-SO 6-9.5 3/21/95	SB3-7-SD 6-9.5 3/21/95	SB3-8-SM 11-14 3/21/95	SB3-9-SO 5-6.4 3/21/95
Metals (mg/kg)						
Arsenic	1.3	7.1	7.9	8.4	2.8	3.7
Beryllium	ND	ND	0.89	0.74	ND	ND
Cadmium	ND	3.7	5.8	5.4	4.0	2.4
Chromium, total	4.6 B	19	27	21	18	10
Copper	8.4 B	19 B	25 B	26 B	18 B	13 B
Lead	8.8	40	42	21	9.8	4.1
Mercury	ND	0.22	ND	ND	ND	ND
Nickel	5.8 B	14	27	29	19	17
Selenium	0.59	1.4	3.5	1.4	2.8	ND
Zinc	139	160 J	130	120 J	230 J	84 J
VOCs (µg/kg)						
1,1,1-Trichloroethane	ND	ND	98	ND	ND	ND
1,1,2,2-Tetrachloroethane	ND	ND	ND	2 J	ND	ND
Acetone	3 B	22 B	11 B	18 B	9 B	8 B
Carbon disulfide	ND	ND	ND	3 J	ND	ND
Carbon tetrachloride	ND	1 J	21,000 J	26,000 J	78	ND
Chloroform	ND	ND	660 J	630 J	10	ND
cis-1,2-Dichloroethene	ND	ND	ND	1 J	ND	ND
Methylene chloride	ND	ND	6	4 J	ND	1 J
Tetrachloroethene	ND	ND	7	6	ND	ND
Toluene	ND	ND	9	6	ND	ND
Trichloroethene	ND	ND	1,400 J	3,000 J	5 J	ND
Xylene (total)	ND	ND	ND	1 J	ND	ND
BNAs (µg/kg)						
2-Methylnaphthalene	ND	ND	ND	ND	ND	ND
Acenaphthene	ND	ND	ND	ND	ND	ND
Anthracene	ND	ND	ND	ND	ND	ND
Benzo(a)anthracene	ND	140 J	ND	ND	ND	ND
Benzo(a)pyrene	ND	110 J	ND	ND	ND	ND
Benzo(b)fluoranthene	ND	200 J	ND	ND	ND	ND
Benzo(g,h,i)perylene	ND	93 J	ND	ND	ND	ND
Benzo(k)fluoranthene	ND	52 J	ND	ND	ND	ND
bis(2-Ethylhexyl)phthalate	130 J	130 J	170 J	130 J	1,000	340 J
Butylbenzylphthalate	ND	ND	ND	67 J	ND	ND
Carbazole	ND	ND	ND	ND	ND	ND
Chrysene	ND	110 J	ND	ND	ND	ND
Di-n-butylphthalate	ND	ND	ND	ND	ND	ND
Dibenzo(a,h)anthracene	ND	43 J	ND	ND	ND	ND
Diethyl phthalate	ND	ND	ND	ND	ND	ND
Fluoranthene	ND	220 J	ND	ND	ND	ND
Fluorene	ND	ND	ND	ND	ND	ND
Indeno(1,2,3-cd)pyrene	ND	110 J	ND	ND	ND	ND
Phenanthrene	ND	160 J	ND	ND	ND	ND
Pyrene	ND	260 J	ND	ND	ND	ND
TRPH (mg/kg)	29	59	ND	ND	ND	ND
PCDD/PCDF (µg/kg)						
1,2,3,4,6,7,8,9-OCDD	NA	NA	NA	NA	NA	NA

Key at end of table.

Table 4-11

SOIL SAMPLING ANALYTICAL RESULTS
IRP SITE 3
NIAGARA FALLS IAP-ARS

Analyte / Sample Number: / Sample Depth (feet BGS): / Sample Date:	SB3-10-SO 6-7 3/21/95		MW3-1E-SO 2-4 2/16/95		MW3-6D-SM 6-8 2/15/95		MDL	Guidance Value[a]
Metals (mg/kg)								
Arsenic	6.0		1.1		1.8		0.50	16
Beryllium	ND		ND		ND		0.50	1.81
Cadmium	3.6		1.7		1.5		0.50	0.01-7[b]
Chromium, total	19		13		3.5	B	1.0	112
Copper	20	B	4.1	B	10	B	2.0	48.7
Lead	68		13		12		5.0	33
Mercury	0.30		ND		ND		0.10	0.265
Nickel	14		11		5.8	B	2.0	38.2
Selenium	2.1		ND	UJ	ND	UJ	0.50	0.941
Zinc	410	J	220		250		1.0	104
VOCs (µg/kg)								
1,1,1-Trichloroethane	ND		ND		ND		5	800
1,1,2,2-Tetrachloroethane	ND		ND		ND		5	600
Acetone	160		14	B	13	B	10	200
Carbon disulfide	9		ND		ND		5	2,700
Carbon tetrachloride	6	J	ND		ND		5	600
Chloroform	32		ND		ND		5	300
cis-1,2-Dichloroethene	ND		ND		ND		5	NV
Methylene chloride	ND		ND		ND		5	100
Tetrachloroethene	ND		ND		ND		5	1,400
Toluene	ND		ND		ND		5	1,500
Trichloroethene	7	J	ND		ND		5	700
Xylene (total)	ND		ND		ND		5	1,200
BNAs (µg/kg)								
2-Methylnaphthalene	51	J	ND		ND		330	36,400
Acenaphthene	48	J	ND		ND		330	50,000
Anthracene	56	J	ND		ND		330	50,000
Benzo(a)anthracene	180	J	ND		ND		330	MDL
Benzo(a)pyrene	120	J	ND		ND		330	MDL
Benzo(b)fluoranthene	230	J	ND		ND		330	1,100
Benzo(g,h,i)perylene	130	J	ND		ND		330	50,000
Benzo(k)fluoranthene	66	J	ND		ND		330	1,100
bis(2-Ethylhexyl)phthalate	480		240	B	ND		330	50,000
Butylbenzylphthalate	ND		36	J	ND		330	50,000
Carbazole	59	J	ND		ND		330	NV
Chrysene	160	J	ND		ND		330	400
Di-n-butylphthalate	60	J	99	J	27	J	330	8,100
Dibenzo(a,h)anthracene	64	J	ND		ND		330	MDL
Diethyl phthalate	760		3,000		ND		330	7,100
Fluoranthene	380	J	ND		ND		330	50,000
Fluorene	63	J	ND		ND		330	50,000
Indeno(1,2,3-cd)pyrene	140	J	ND		ND		330	3,200
Phenanthrene	330	J	ND		ND		330	50,000
Pyrene	360	J	ND		ND		330	50,000
TRPH (mg/kg)	1,200		ND		ND		20	NV

Key at end of table.

Table 4-11

SOIL SAMPLING ANALYTICAL RESULTS
IRP SITE 3
NIAGARA FALLS IAP-ARS

Analyte / Sample Number: / Sample Depth (feet BGS): / Sample Date:	SB3-10-SO 6-7 3/21/95	MW3-1E-SO 2-4 2/16/95	MW3-6D-SM 6-8 2/15/95	MDL	Guidance Value[a]
PCDD/PCDF (µg/kg)					
1,2,3,4,6,7,8,9-OCDD	NA	NA	NA	0.0544	NV

Note: Shaded values meet or exceed guidance value and/or the 90th percentile of the observed range.

[a] Metal guidance values are based on upper limit of the 90th percentile and the observed range as stated in Shacklette and Boerngen 1984, except as noted. Guidance values for VOCs and BNAs are based on Technical Administrative Guidance Memorandum, NYSDEC 1994.

[b] Observed range for cadmium as stated in Dragun 1988.

Key:

- B = Present in associated method and/or field blank.
- BNA = Base/neutral/acid extractable.
- J = Estimated value; positive result.
- MDL = Method detection limit, based on wet weight, undiluted analysis.
- NA = Not analyzed.
- ND = Not detected.
- NV = No applicable value.
- TRPH = Total recoverable petroleum hydrocarbons.
- UJ = Estimated value's quantitation limit.
- VOC = Volatile organic compound.

Table 4-12

GROUNDWATER SAMPLING ANALYTICAL RESULTS
IRP SITE 3
NIAGARA FALLS IAP-ARS
(µg/L)

Analyte — Sample Number: / Sample Date: / Resample Date:	MW3-1-WO 3/24/95 —	MW3-1E-WO 3/24/95 —	MW3-2-WO 3/24/95 —	MW3-3-WO 3/24/95 5/24/95[a]
Metals				
Arsenic	ND	ND	ND	ND
Chromium, total	ND	ND	ND	ND
Copper	22	ND	ND	ND
Lead	26	10	54	26
Nickel	ND	ND	ND	ND
Zinc	75	15	130	540
VOCs				
Carbon disulfide	ND	ND	ND	110
Carbon tetrachloride	ND	ND	ND	2,400
Chloroform	ND	ND	ND	1,000
cis-1,2-Dichloroethene	ND	ND	ND	36
Methylene chloride	ND	ND	ND	6
Toluene	ND	ND	ND	5
trans-1,2-Dichloroethene	ND	ND	ND	2 J
Trichloroethene	ND	ND	ND	920
Vinyl chloride	ND	ND	ND	11
PCBs				
Aroclor 1254	0.61	ND	ND	ND

Key at end of table.

Table 4-12

GROUNDWATER SAMPLING ANALYTICAL RESULTS
IRP SITE 3
NIAGARA FALLS IAP-ARS
(μg/L)

Analyte	Sample Number: / Sample Date: / Resample Date:	MW3-3D-WO 3/23/95 —	MW3-4-WO 3/23/95 —	MW3-5A-WM 3/23/95 5/24/95[a]	MW3-6A-WO 3/23/95 —
Metals (μg/L)					
Arsenic		ND	ND	ND	17
Chromium, total		ND	ND	ND	23
Copper		ND	ND	ND	33
Lead		12	ND	6.9	100
Nickel		ND	ND	ND	41
Zinc		ND	21	28	1,700
VOCs (μg/L)					
Carbon disulfide		ND	ND	ND	ND
Carbon tetrachloride		ND	ND	ND	ND
Chloroform		ND	ND	ND	ND
cis-1,2-Dichloroethene		ND	ND	ND	ND
Methylene chloride		ND	ND	ND	ND
Toluene		ND	ND	ND	ND
trans-1,2-Dichloroethene		ND	ND	ND	ND
Trichloroethene		ND	ND	ND	ND
Vinyl chloride		ND	2 J	ND	ND
PCBs (μg/L)					
Aroclor 1254		ND	ND	ND	ND

Key at end of table.

Table 4-12

GROUNDWATER SAMPLING ANALYTICAL RESULTS
IRP SITE 3
NIAGARA FALLS IAP-ARS
(μg/L)

Analyte — Sample Number: / Sample Date: / Resample Date:	MW3-6D-WO 3/23/95 —	MW3-7-WO 3/23/95 —	MDL	NYSDEC Class GA Groundwater Standards[b]
Metals (μg/L)				
Arsenic	ND	ND	5.0	25
Chromium, total	ND	ND	10	50
Copper	ND	ND	20	200
Lead	16	9.0	5.0	25
Nickel	ND	ND	20	NV
Zinc	90	88	10	300
VOCs (μg/L)				
Carbon disulfide	ND	ND	5.0	NV
Carbon tetrachloride	ND	ND	5.0	5.0
Chloroform	ND	ND	5.0	7.0
cis-1,2-Dichloroethene	ND	ND	5.0	5.0
Methylene chloride	ND	ND	5.0	5.0
Toluene	ND	ND	5.0	5.0
trans-1,2-Dichloroethene	ND	ND	5.0	5.0
Trichloroethene	ND	ND	5.0	5.0
Vinyl chloride	ND	ND	10	2.0
PCBs (μg/L)				
Aroclor 1254	ND	ND	0.5	0.1

Note: Shaded values meet or exceed the NYSDEC Class GA groundwater standard.

[a] Locations MW3-3 and MW3-5A were resampled for the acid extractable portion of BNA analysis, because of analytical problems with the initial samples.

[b] NYSDEC 1993.

Key:

J = Estimated value; positive result.
MDL = Method detection limit, based on undiluted analysis.
ND = Not detected.
NV = No applicable value.
VOC = Volatile organic compound.

Table 4-13

SURFACE WATER SAMPLING ANALYTICAL RESULTS
IRP SITE 3
NIAGARA FALLS IAP-ARS
(μg/L)

Analyte / Sample Number: / Sample Date:	SW3-1-WO 3/16/95	SW3-2-WO 3/16/95	SW3-3-WO 3/16/95	MDL	NYSDEC Class C Surface Water Standards
Metals					
Zinc	190	190	180	10	30
BNAs					
bis(2-Ethylhexyl)-phthalate	7 J	ND	2 J	10	0.6

Note: Shaded values exceed NYSDEC Class C surface water standards.

[a] NYSDEC 1993.

Key:

BNA = Base/neutral/acid extractable.
J = Estimated value; positive result.
MDL = Method detection limit, based on undiluted analysis.
NA = Not analyzed.
ND = Not detected.

Table 4-14

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

Analyte — Sample Number: / Sample Date: / Resample Date:	SD3-1-SO 3/16/95 5/24/95[a]	SD3-1-SD — 5/24/95[a]	SD3-2-SM 3/16/95 —	SD3-3-SO 3/16/95 —	MDL	Lowest Effect Level[b]	Severe Effect Level[c]
Metals (mg/kg)							
Arsenic	1.9	NA	1.6	1.7	0.50	6.0	33
Cadmium	1.6 J	NA	0.82 J	ND	0.50	0.6	9.0
Chromium, total	4.4 J	NA	12 J	2.1 J	1.0	26	110
Copper	6.1 J	NA	6.7 J	3.4 J	2.0	16	110
Lead	24	NA	34	13	5.0	31	110
Nickel	13	NA	7.7	7.2	2.0	16	50
Silver	4.1	NA	2.3	3.1	1.0	1.0	2.2
Zinc	900 J	NA	680 J	590 J	1.0	120	270
VOCs (μg/kg)							
1,1,1-Trichloroethane	3 J	NA	ND	ND	5	NV[d]	NV[d]
4-Methyl-2-pentanone	11 B	NA	ND	3 B	10	NV[d]	NV[d]
Acetone	ND	NA	5 B	3 B	10	NV[d]	NV[d]
Methylene chloride	1 J	NA	ND	ND	5	NV[d]	NV[d]
BNAs (μg/kg)							
Benzo(a)anthracene	120 J	ND	ND	30 J	330	230	1,600
Benzo(a)pyrene	100 J	ND	ND	40 J	330	400	2,500

Key at end of table.

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Table 4-14

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

Analyte — Sample Number: / Sample Date: / Resample Date:	SD3-1-SO 3/16/95 5/24/95[a]	SD3-1-SD — 5/24/95[a]	SD3-2-SM 3/16/95 —	SD3-3-SO 3/16/95 —	MDL	Lowest Effect Level[b]	Severe Effect Level[c]
Benzo(b)fluoranthene	200 J	ND	ND	32 J	330	NV[d]	NV[d]
Benzo(g,h,i)perylene	62 J	ND	ND	ND	330	NV[d]	NV[d]
Benzo(k)fluoranthene	ND J	ND	ND	ND	330	NV[d]	NV[d]
bis(2-ethylhexyl)phthalate	110 J	ND	ND	ND	330	NV[d]	NV[d]
Chrysene	120 J	ND	ND	31 J	330	400	2,800
Diethylphthalate	2,400 J	ND	ND	ND	330	NV[d]	NV[d]
Fluoranthene	170 J	58 J	43 J	44 J	330	600	3,600
Indeno(1,2,3-cd)pyrene	78 J	ND	ND	ND	330	NV[d]	NV[d]
Phenanthrene	84 J	ND	36 J	ND	330	225	1,380
Pyrene	150 J	ND	36 J	44 J	330	350	2,200
Organic Matter (%)	2.0	NA	1.7	1.8	—	—	—

Notes: Effect levels for organic compounds are based on Long and Morgan (1990) technical memorandum.
Shaded values exceed one or both effect levels.

[a] Location SD3-1 was resampled in duplicate for BNA analysis, because of analytical problems with the initial sample.
[b] Lowest of either Persaud *et al.* (1992) Lowest Effect Level or Long and Morgan (1990) Effect Range - Low.
[c] Lowest of either Persaud *et al.* (1992) Severe Effect Level or Long and Morgan (1990) Effect Range - Moderate.
[d] No sediment levels were available for these compounds; soil guidance values were used for comparison, but sediment results were not found to exceed these values.

Key at end of table.

02:NM9902_D4739-06/15/95-D1

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Table 4-14 (Cont.)

Key:

B	=	Present in associated method and/or field blank.
BNA	=	Base/neutral/acid extractables.
J	=	Estimated value; positive result.
MDL	=	Method detection limit, based on wet weight, undiluted analysis.
NA	=	Not analyzed.
ND	=	Not detected.
NV	=	No applicable value.
VOC	=	Volatile organic compound.

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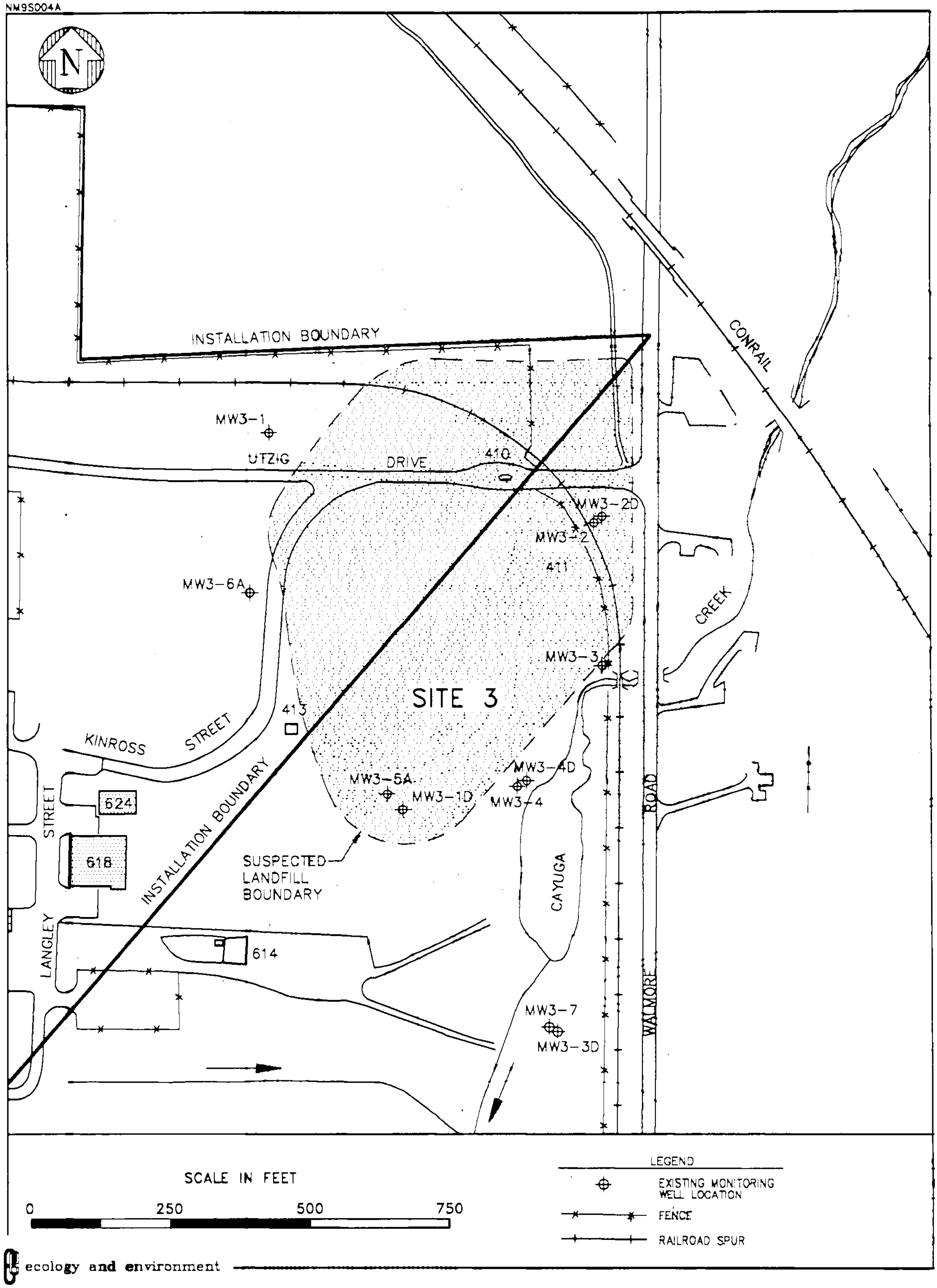

Figure 4-1
SITE MAP
IRP SITE 3
NIAGARA FALLS IAP-ARS

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NM9S006A

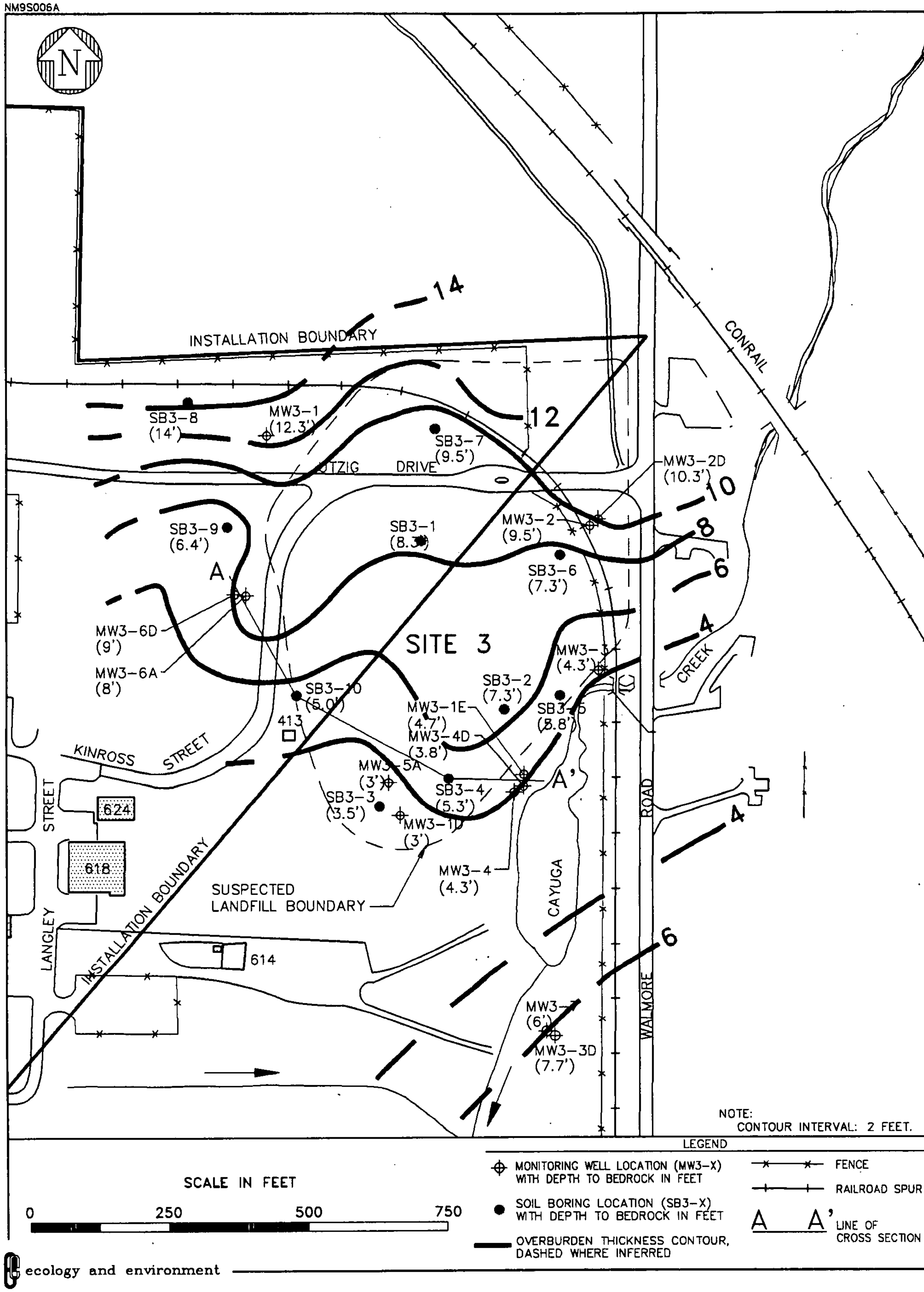

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Figure 4-2
OVERBURDEN THICKNESS
IRP SITE 3
NIAGARA FALLS IAP-ARS

NM9001DB

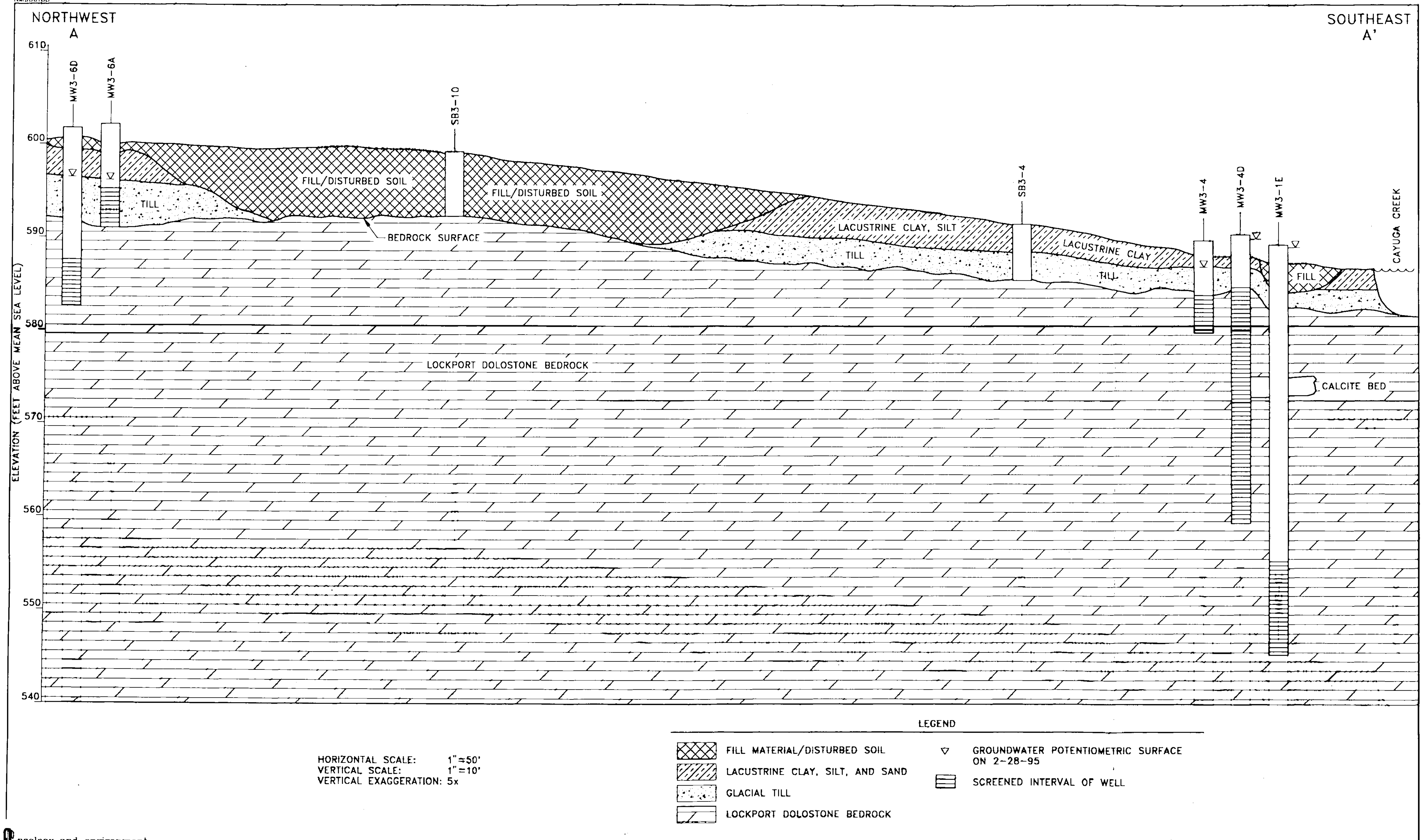

Figure 4-3 GEOLOGIC CROSS-SECTION A-A'
IRP SITE 3
NIAGARA FALLS IAP-ARS

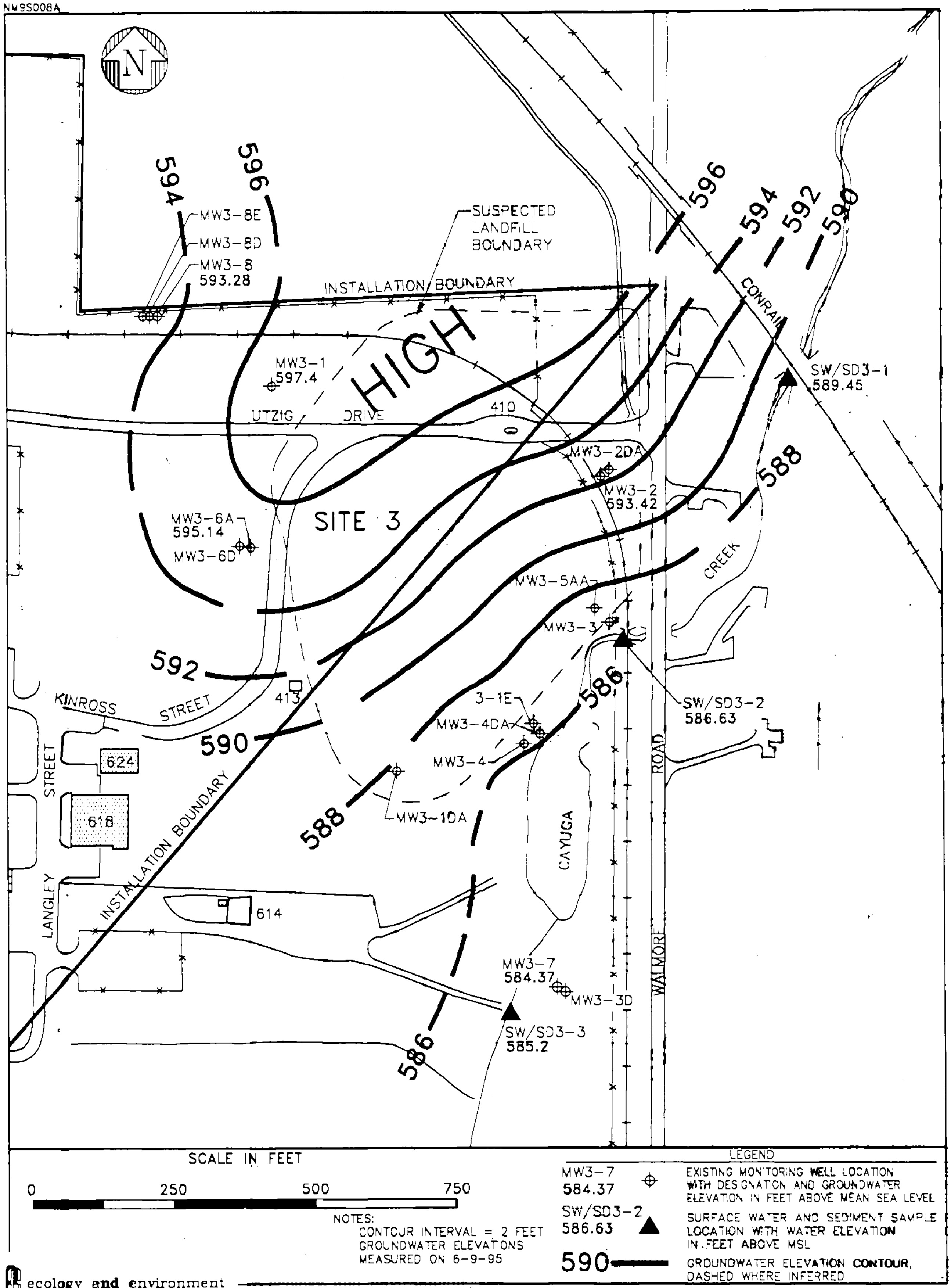

Figure 4-4
OVERBURDEN GROUNDWATER CONTOUR MAP
IRP SITE 3
NIAGARA FALLS IAP-ARS

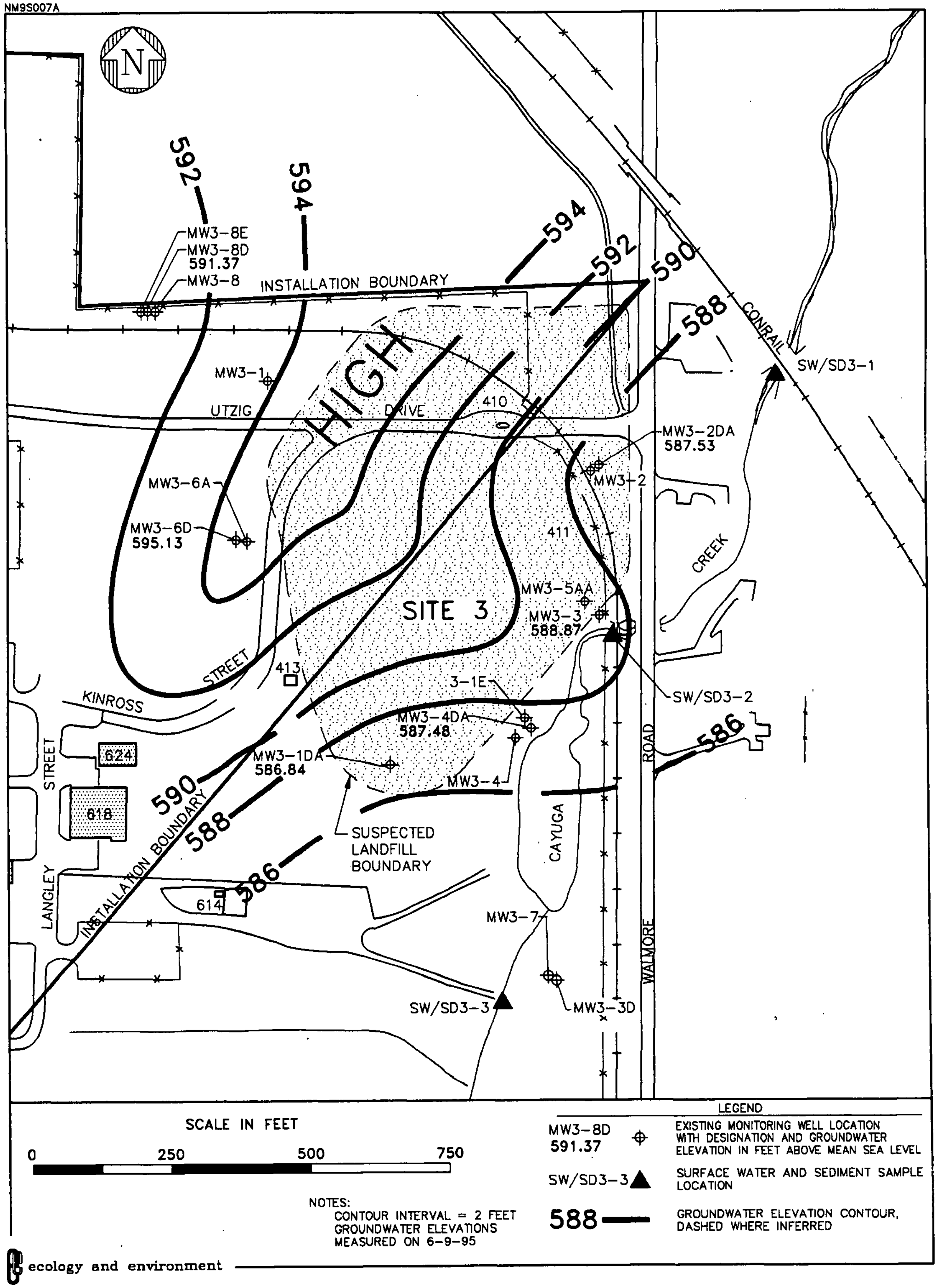

Figure 4-5
BEDROCK GROUNDWATER CONTOUR MAP
IRP SITE 3
NIAGARA FALLS IAP-ARS

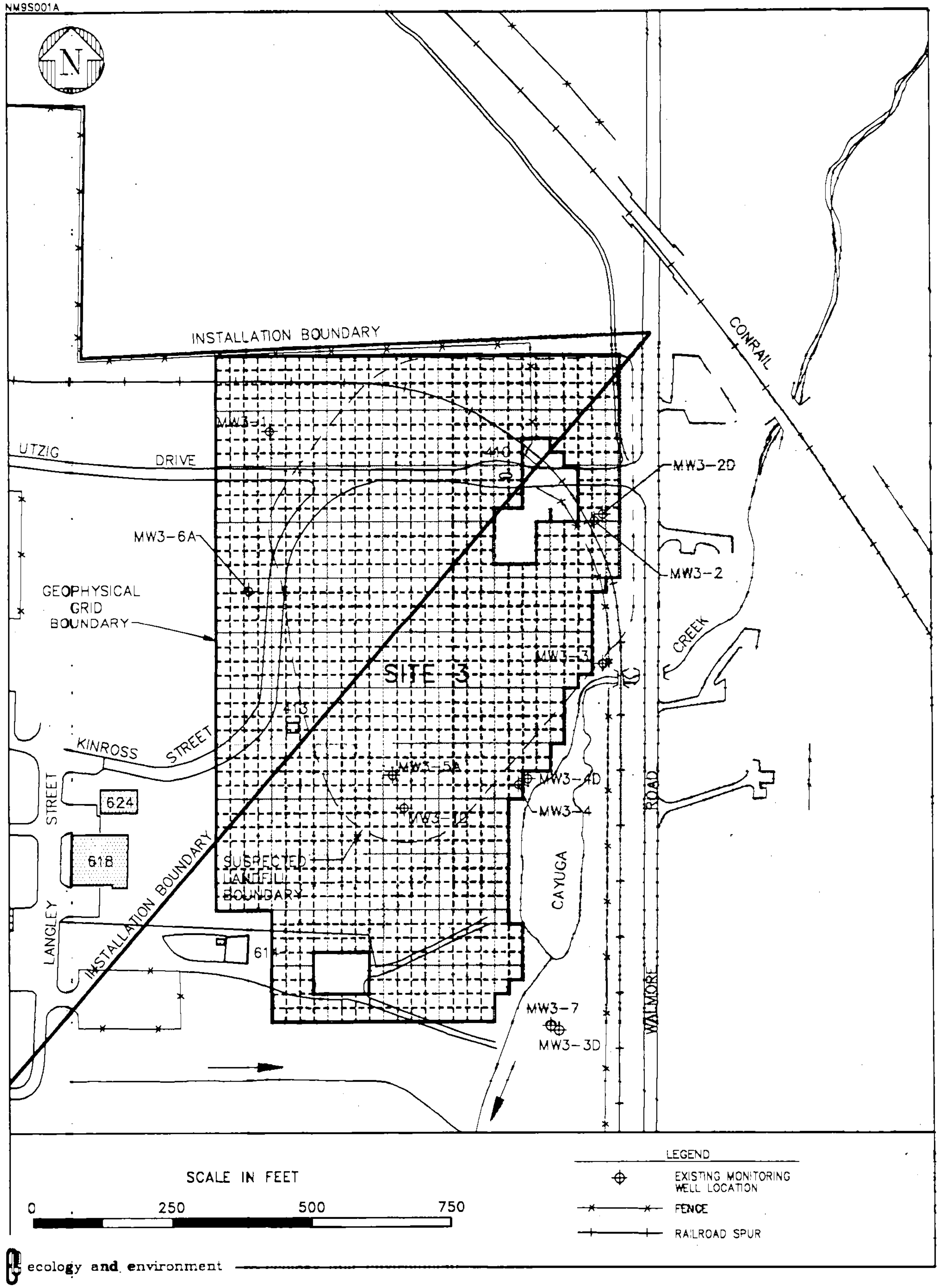

Figure 4-6
GEOPHYSICAL SURVEY GRID LOCATION MAP
IRP SITE 3
NIAGARA FALLS IAP-ARS

NM9S003A

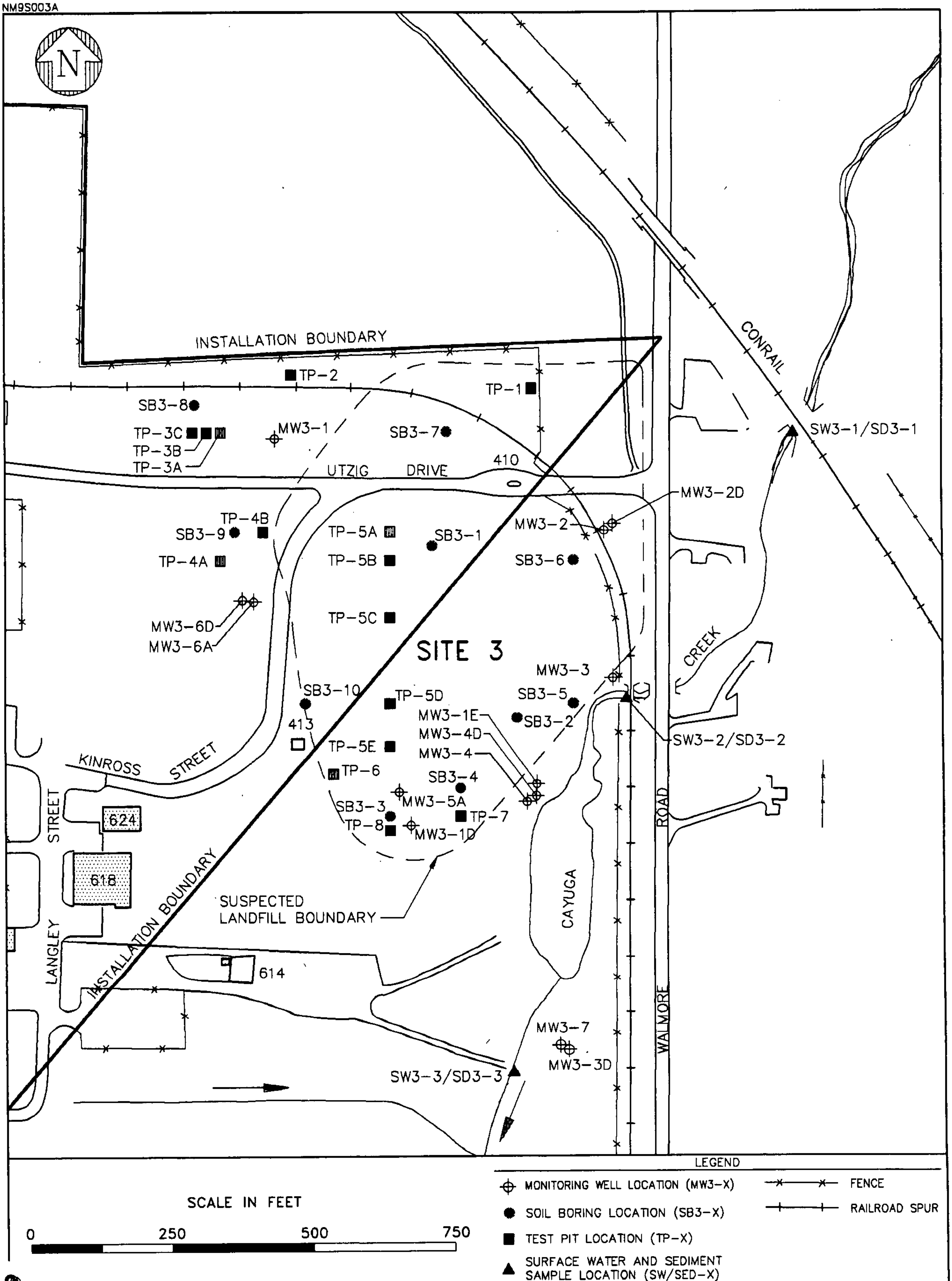

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Figure 4-7
SAMPLE LOCATION MAP
IRP SITE 3
NIAGARA FALLS IAP-ARS

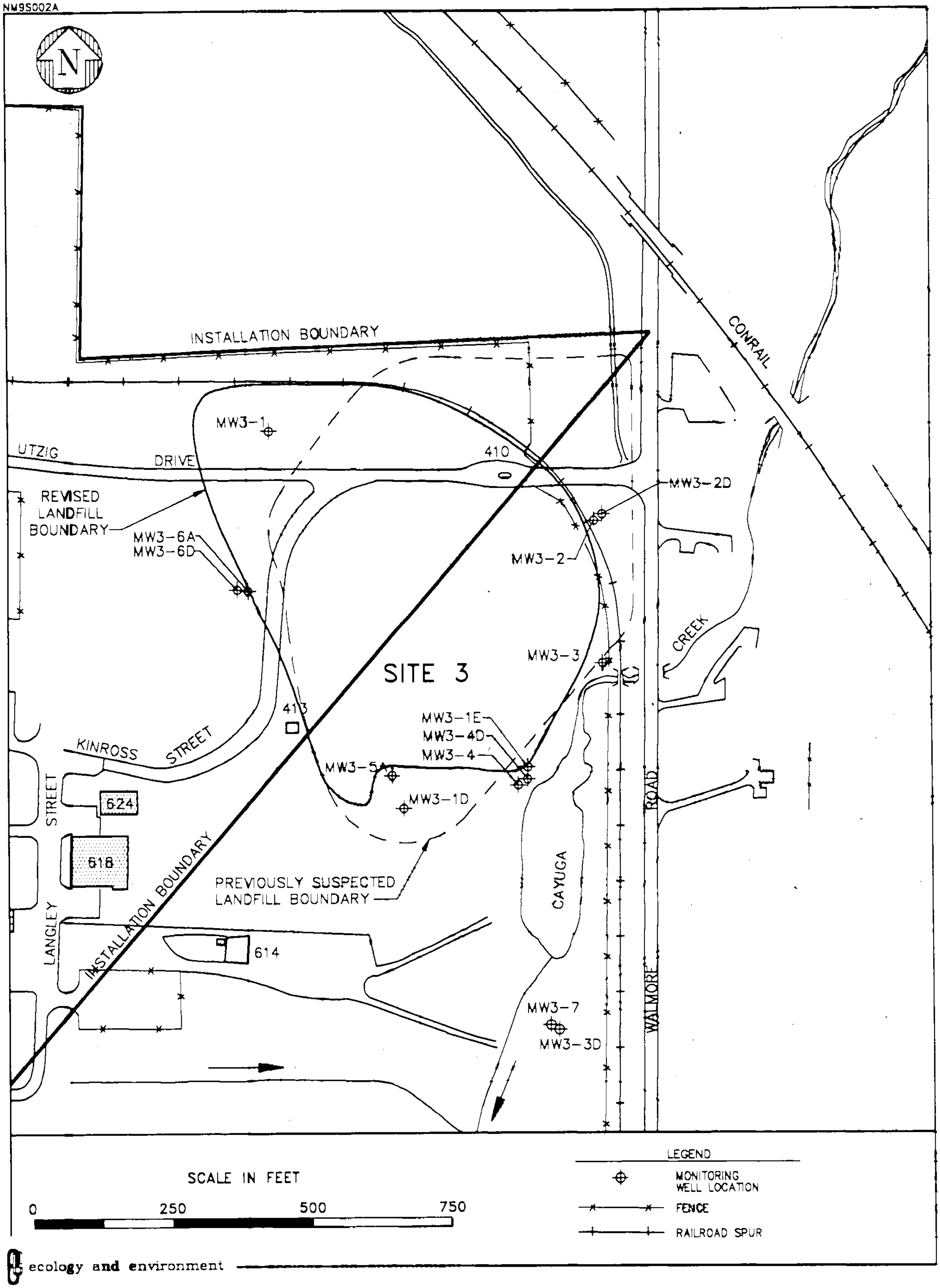

Figure 4-8
REVISED LANDFILL BOUNDARY
IRP SITE 3
NIAGARA FALLS IAP-ARS

NM95011B

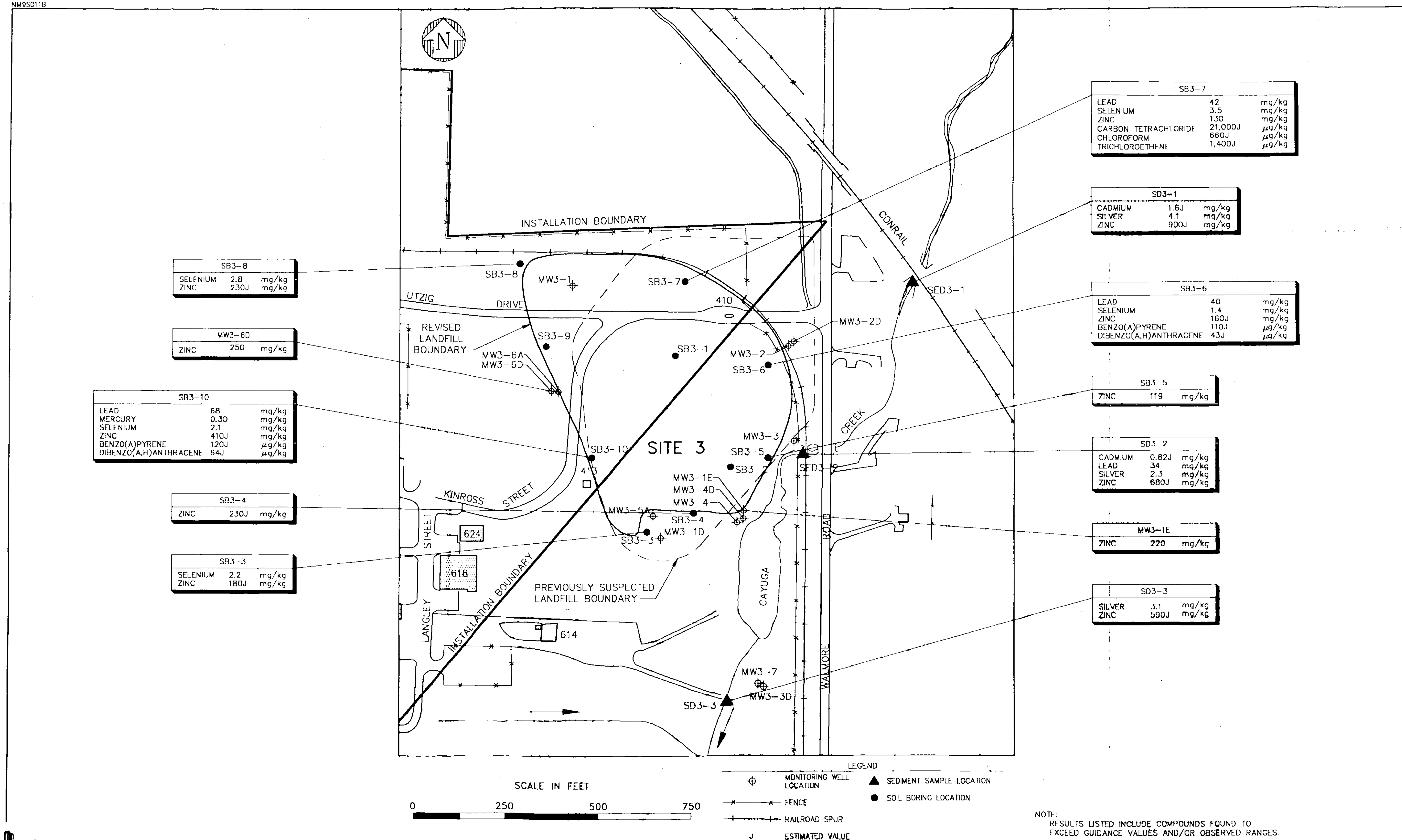

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Figure 4-9 RFI SOIL AND SEDIMENT SAMPLING ANALYTICAL RESULTS IRP SITE 3 NIAGARA FALLS IAP-ARS

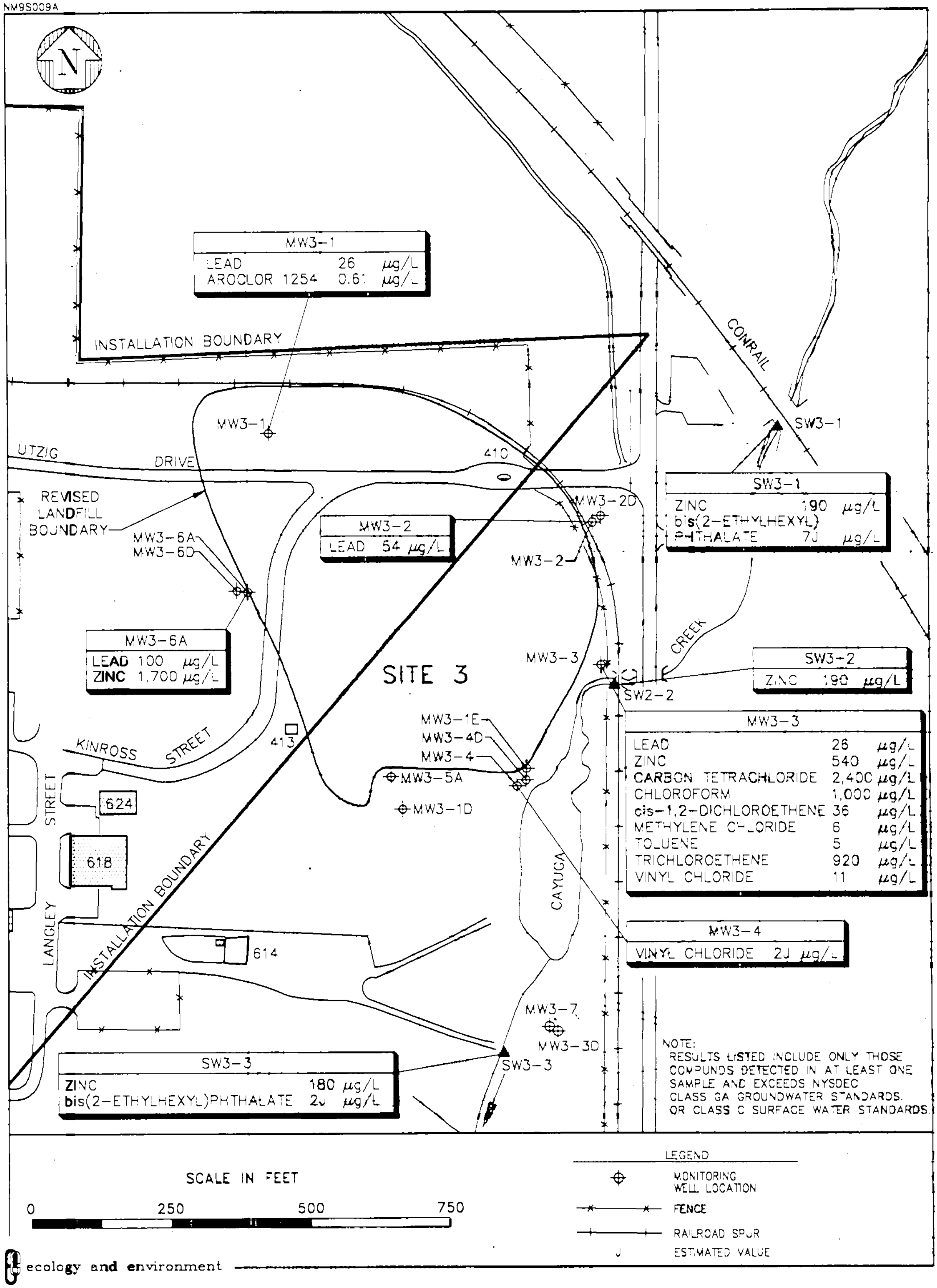

Figure 4-10
GROUNDWATER AND SURFACE WATER SAMPLING ANALYTICAL RESULTS
IRP SITE 3
NIAGARA FALLS IAP-ARS

02: NM99092\NM9_4739.CDR

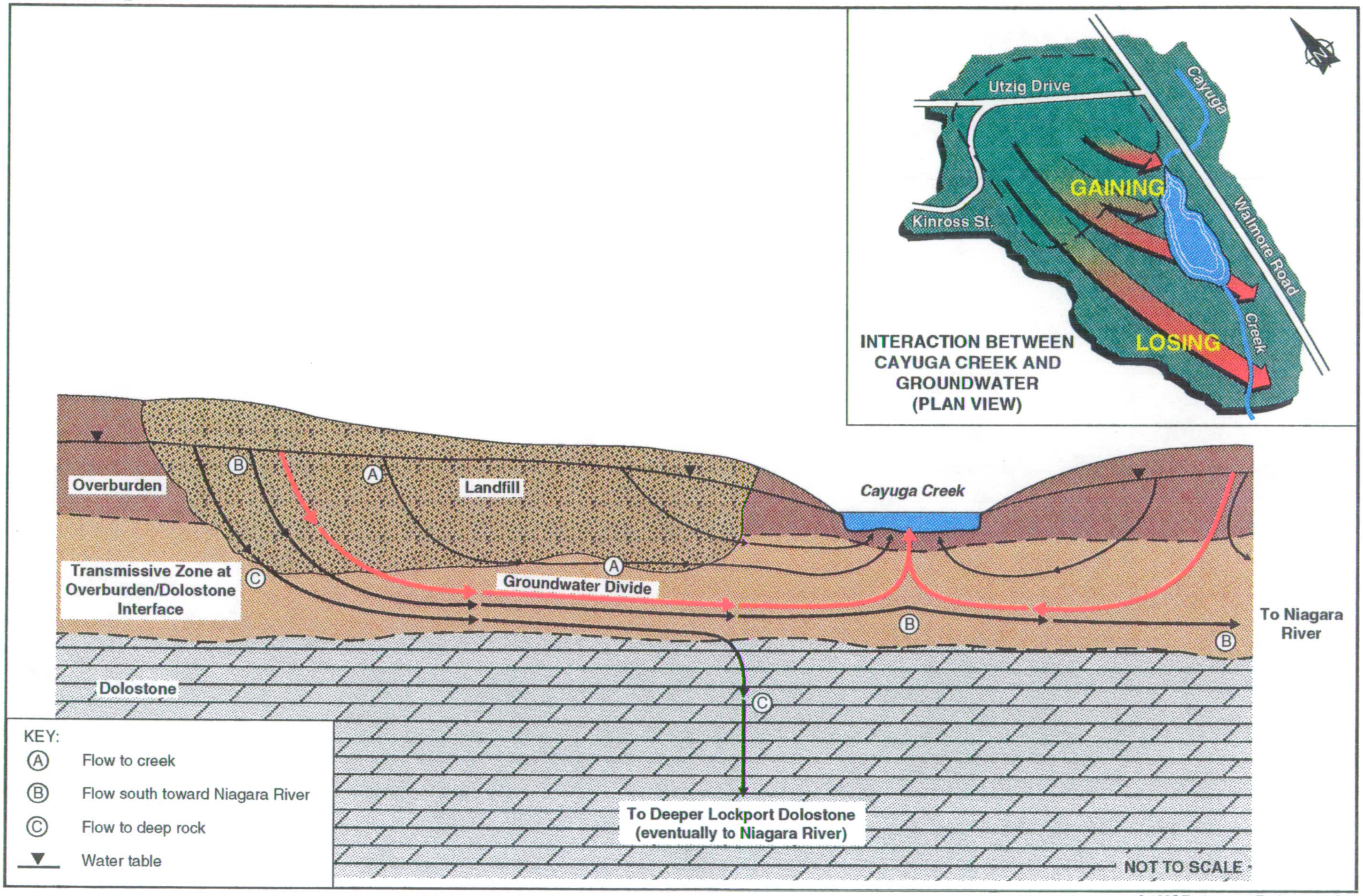

Figure 4-11 SIMPLIFIED CONCEPTUAL MODEL FOR THE SITE 3 LANDFILL

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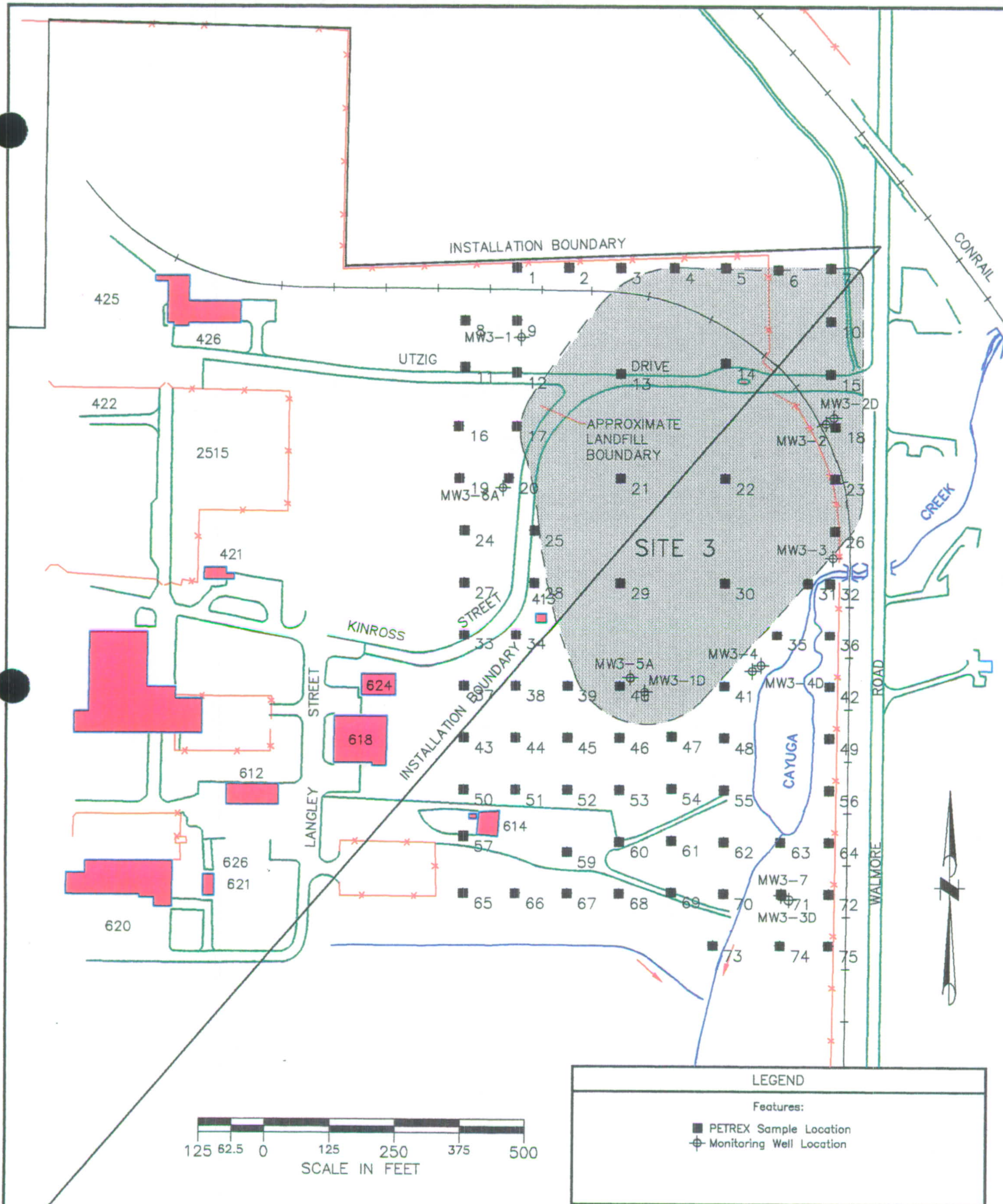
A Soil Gas Results



125 62.5 0 125 250 375 500

SCALE IN FEET

LEGEND

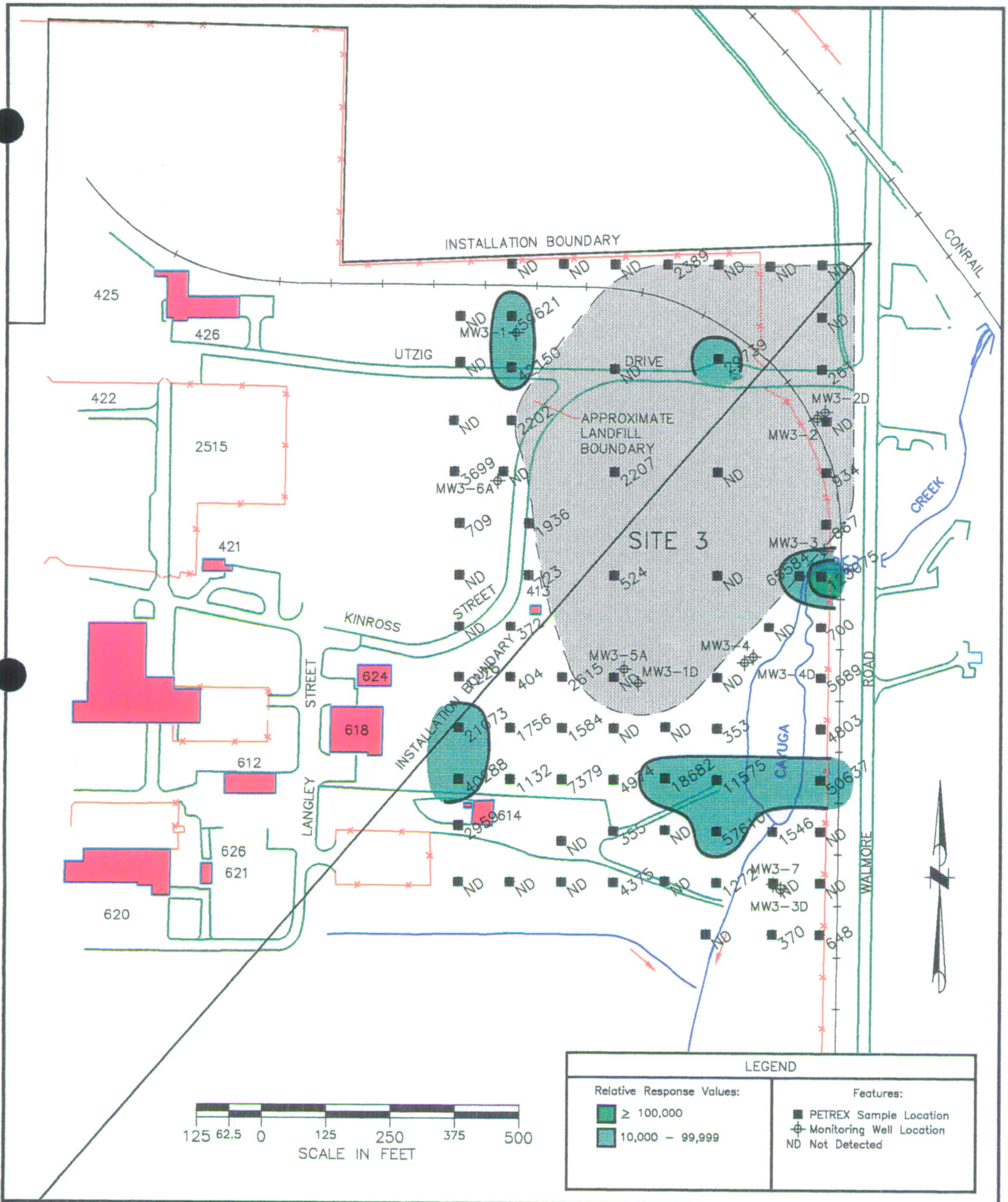
Features:

PETREX Sample Location

Monitoring Well Location

NERI
Northeast Research Institute LLC
605 Parfet Street
Suite 100
Lakewood, Colorado 80215
(303) 238-0090

Drawn By: JCS	Project #: 2219-1E	Ecology and Environment, Inc.	Sample Locations
Checked By:	Date: January 30, 1995	IRP SITE – 3 Niagara Falls IAP – ARS	
Project Manager: JOG	File Name: 2219-1-1.dwg	PETREX FINGERPRINT TECHNOLOGY®	Plate 1



NERI
Northeast Research Institute LLC
605 Parfet Street
Suite 100
Lakewood, Colorado 80215
(303) 238-0090

Drawn By: JCS	Project #: 2219-1E
Checked By:	Date: January 30, 1995
Project Manager: JOG	File Name: 2219-1-2.dwg

Ecology and Environment, Inc.

IRP SITE - 3

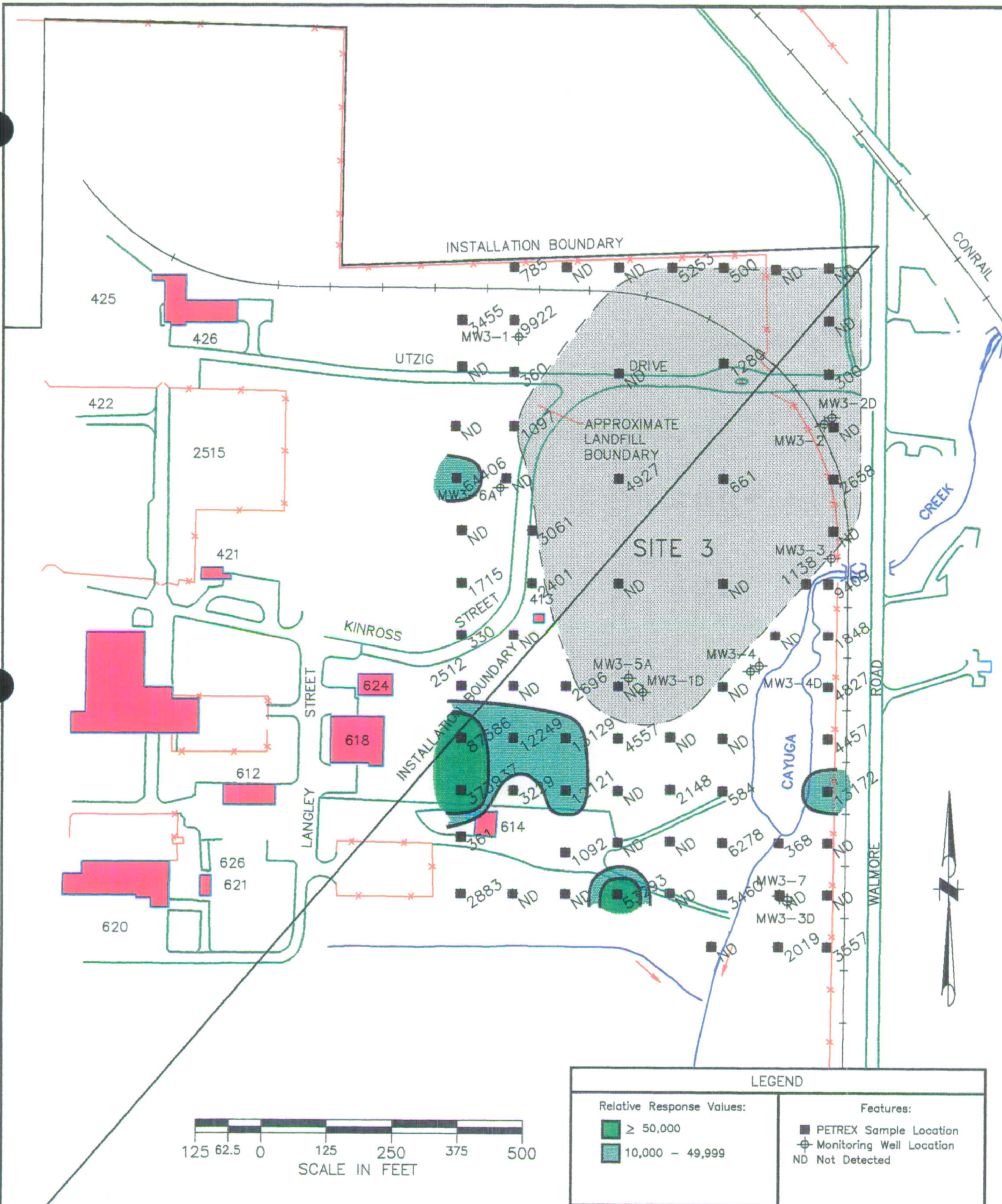
Niagara Falls IAP - ARS

PETREX FINGERPRINT TECHNOLOGY®

Relative Response

Trichloroethene (TCE)

Plate 2



LEGEND

Relative Response Values:

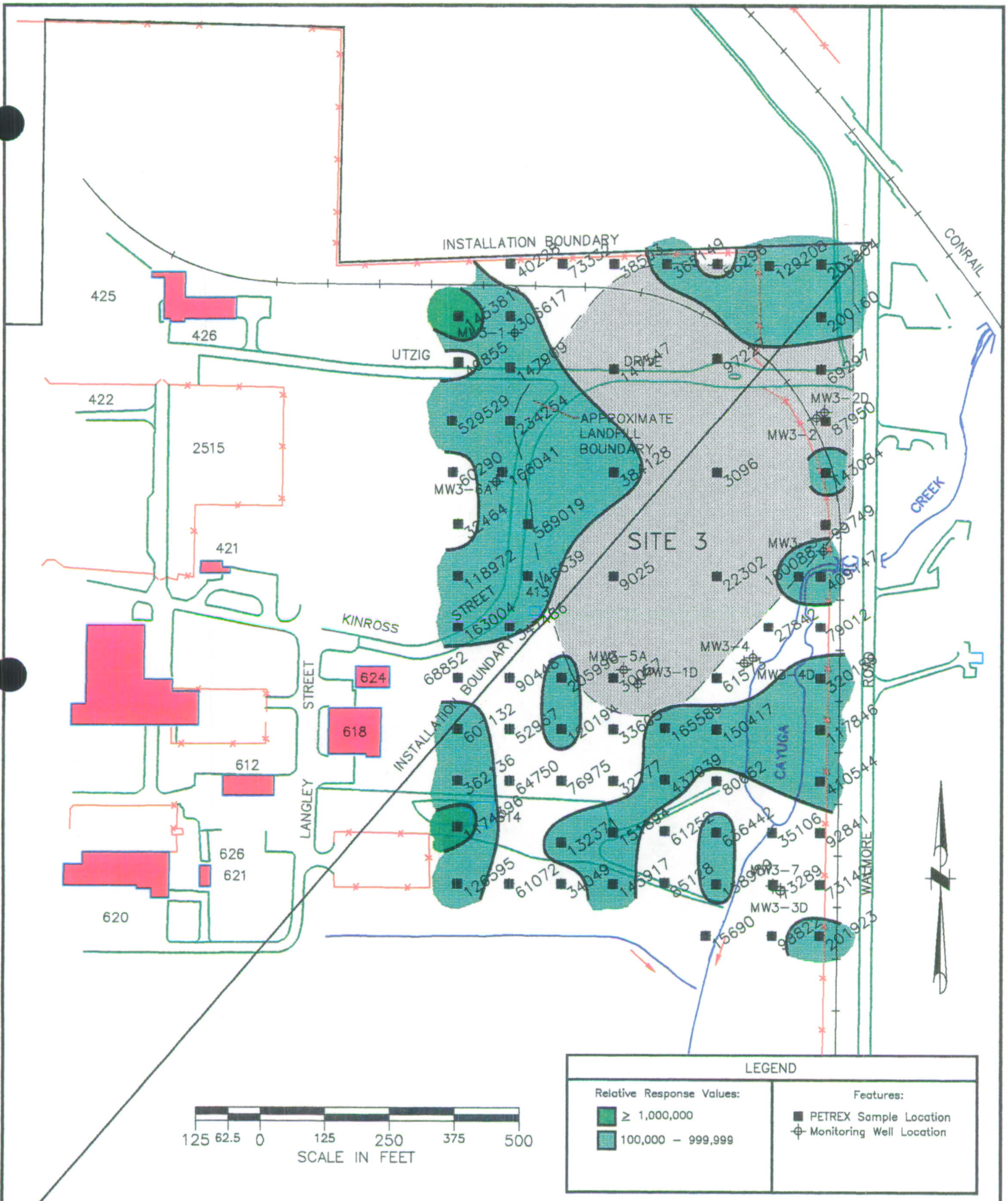
- ≥ 50,000
- 10,000 – 49,999

Features:

- ■ PETREX Sample Location
- ⌖ Monitoring Well Location
- ND Not Detected

NERI Northeast Research Institute LLC
605 Parfet Street
Suite 100
Lakewood, Colorado 80215
(303) 238-0090

Drawn By: JCS	Project #: 2219-1E	Ecology and Environment, Inc.	Relative Response Tetrachloroethene (PCE)
Checked By:	Date: January 30, 1995	IRP SITE – 3 Niagara Falls IAP – ARS	
Project Manager: JOG	File Name: 2219-1-3.dwg	PETREX FINGERPRINT TECHNOLOGY	Plate 3



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605 Parfet Street
Suite 100
Lakewood, Colorado 80215
(303) 238-0090

Drawn By: JCS	Project #: 2219-1E
Checked By:	Date: January 30, 1995
Project Manager: JOG	File Name: 2219-1-4.dwg

Ecology and Environment, Inc.

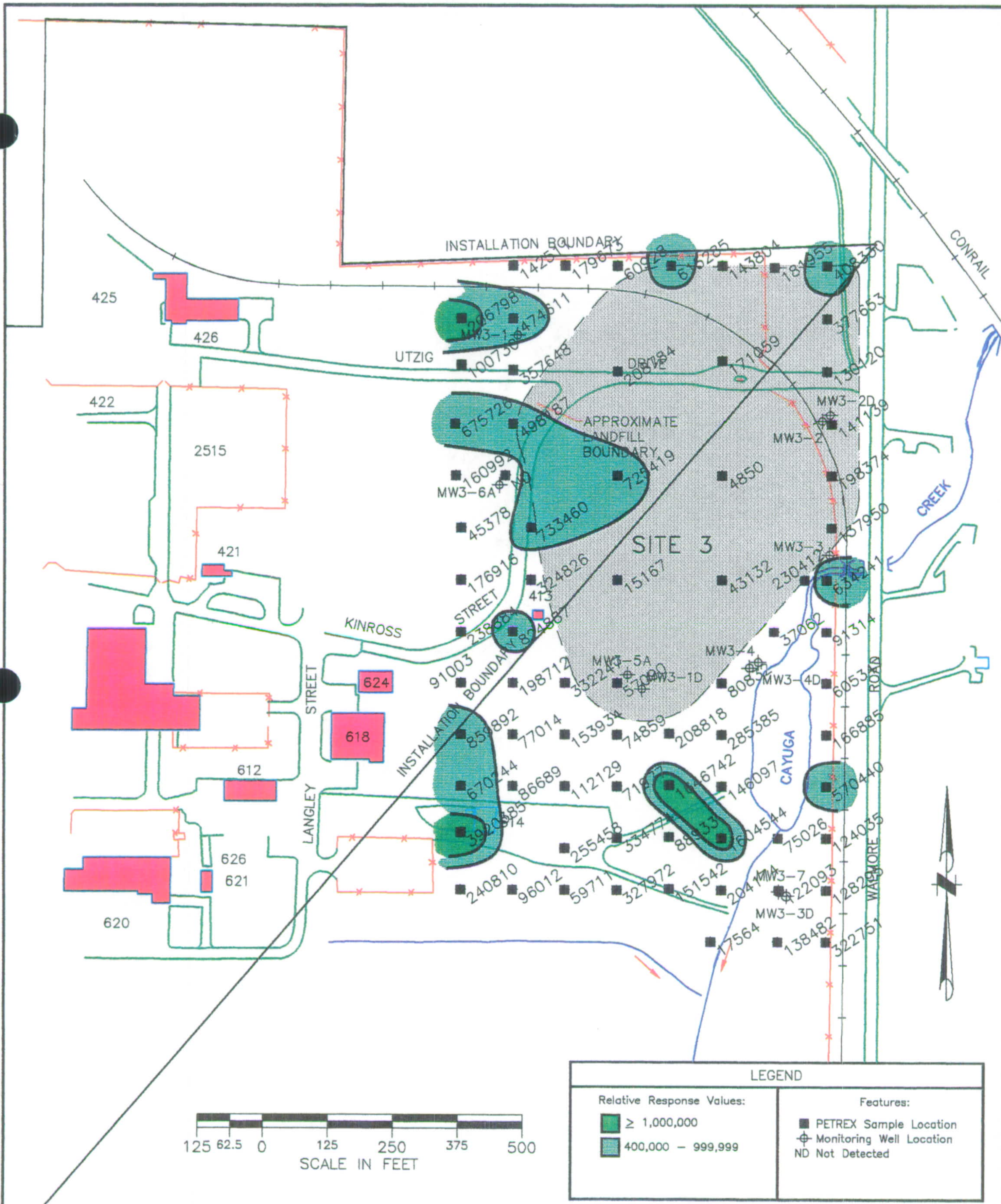
IRP SITE – 3
Niagara Falls IAP – ARS

PETREX FINGERPRINT TECHNOLOGY

Relative Response

Benzene, Toluene, Ethylbenzen, Xylenes (BTEX)

Plate 4



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Suite 100
Lakewood, Colorado 80215
(303) 238-0090

Drawn By: JCS	Project #: 2219-1E
Checked By:	Date: January 30, 1995
Project Manager: JOG	File Name: 2219-1-5.dwg

Ecology and Environment, Inc.

IRP SITE – 3
Niagara Falls IAP – ARS

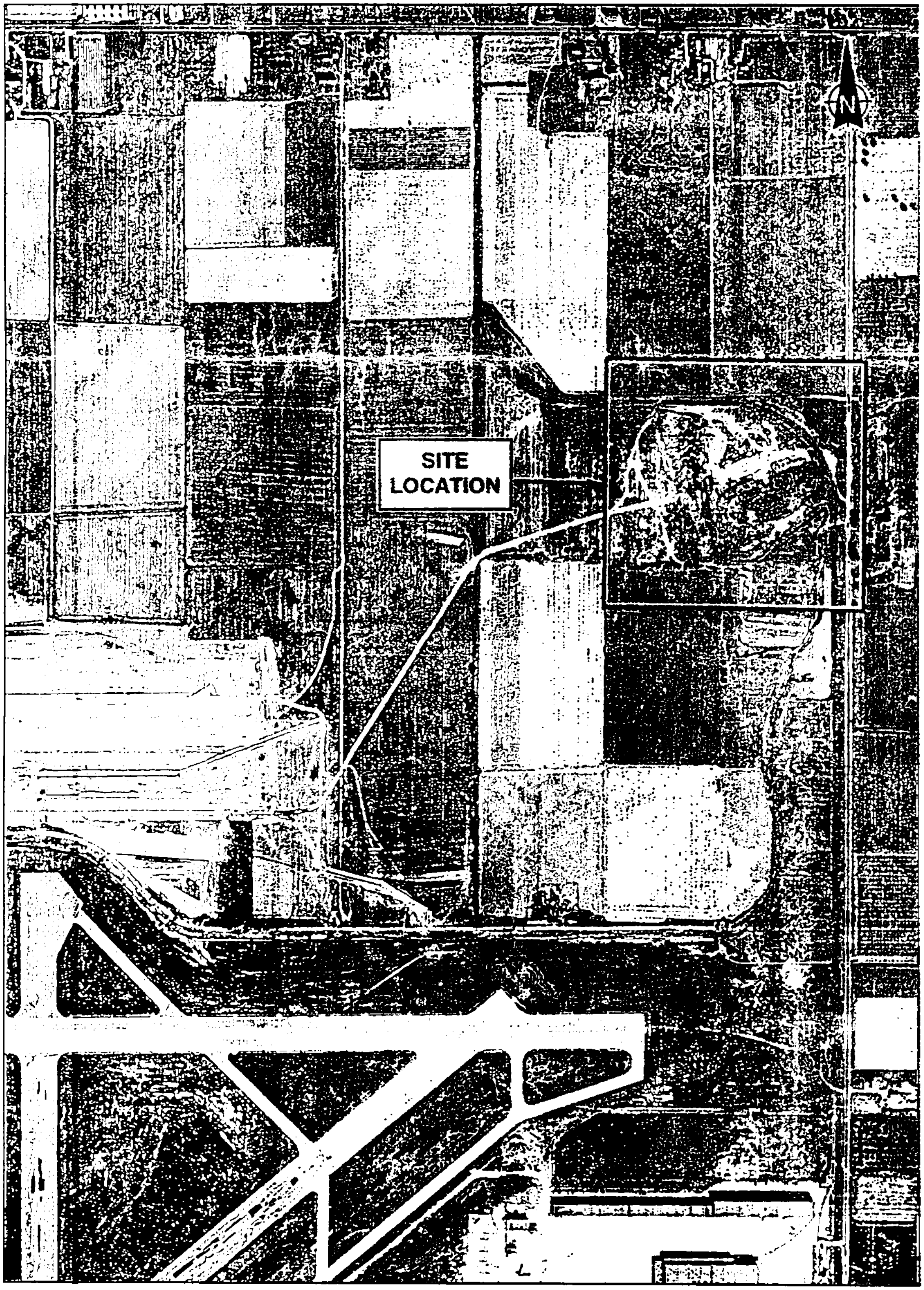
PETREX FINGERPRINT TECHNOLOGY®

Relative Response

Total Petroleum Hydrocarbons (TPH)

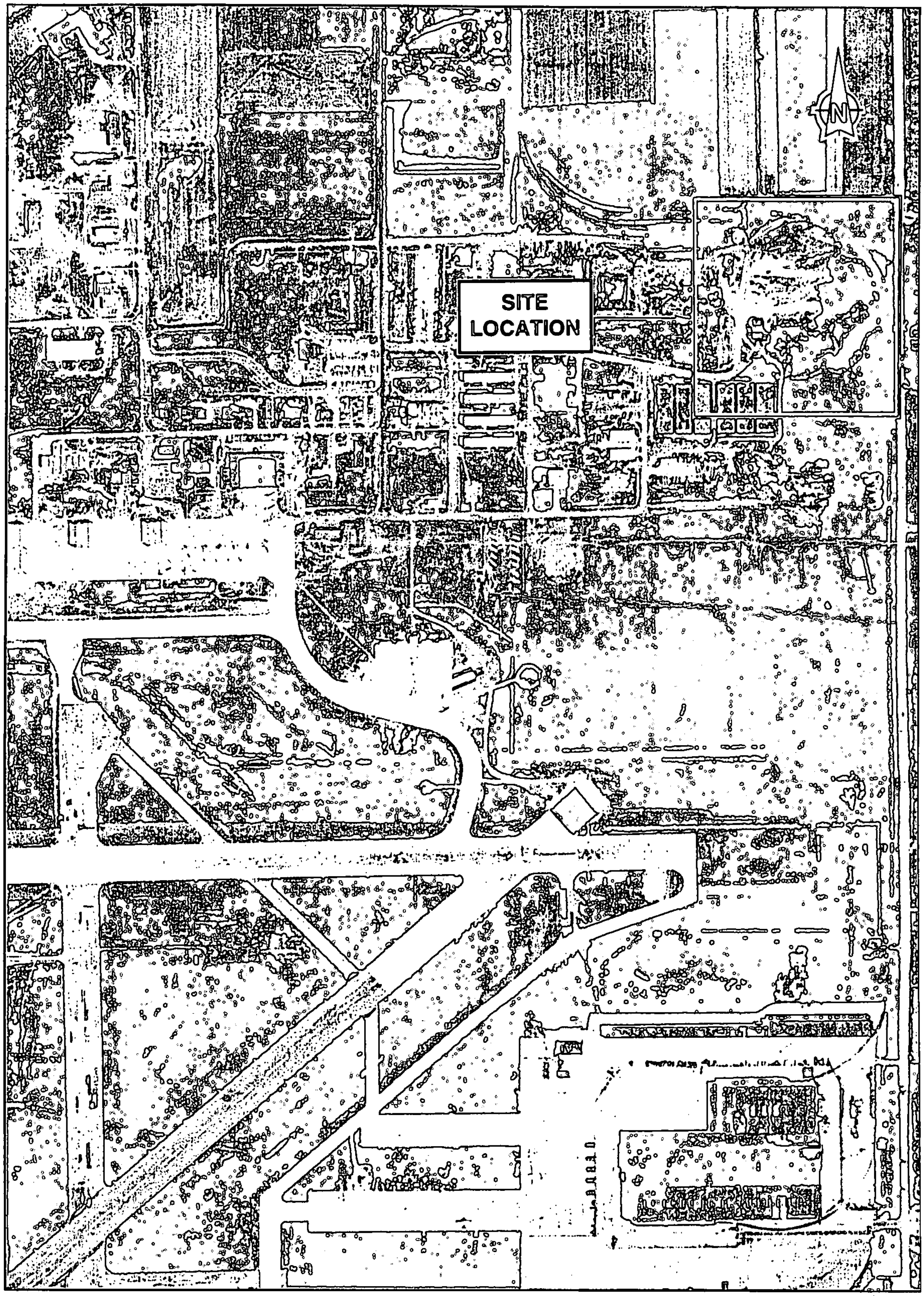
Plate 5

B Aerial Photographs



SOURCE: Niagara County Department of Transportation, Lockport, New York

1951 AERIAL PHOTOGRAPH OF LANDFILL AREA
NIAGARA FALLS IAP-ARS



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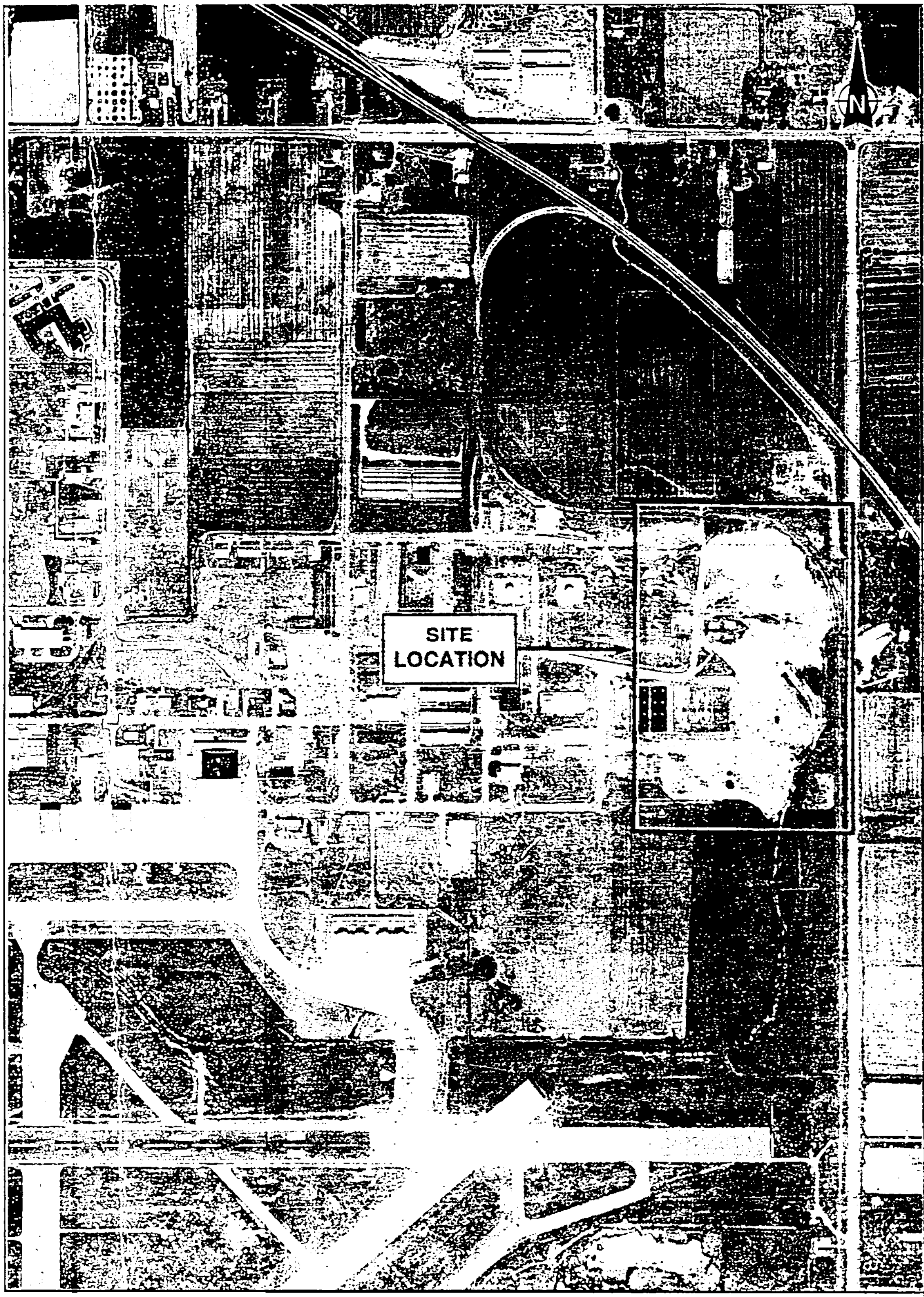
1958 AERIAL PHOTOGRAPH OF LANDFILL AREA
NIAGARA FALLS IAP-ARS



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1966 AERIAL PHOTOGRAPH OF LANDFILL AREA
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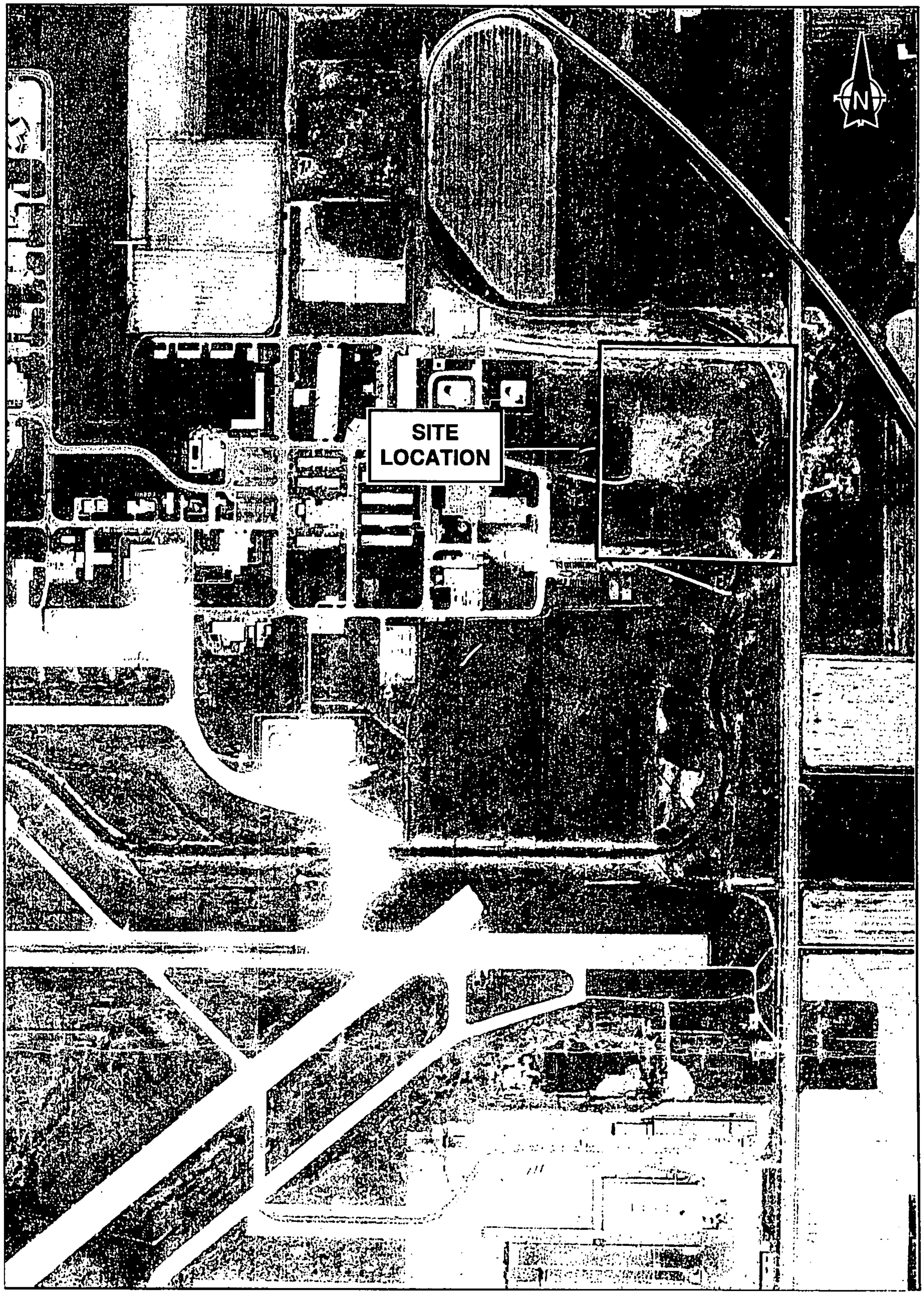


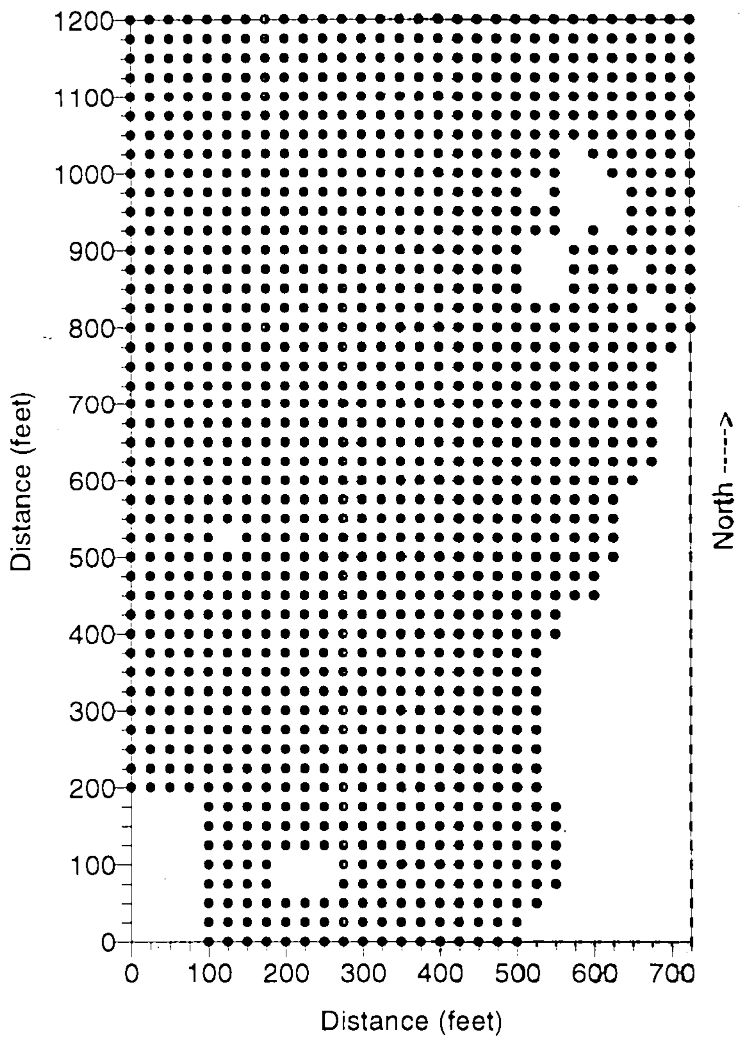
SOURCE: Niagara County Department of Transportation, Lockport, New York

1982 AERIAL PHOTOGRAPH OF LANDFILL AREA
NIAGARA FALLS IAP-ARS

C Geophysical Data

Niagara Falls IAP-ARS
IRP Site 3 (Landfill LF-08)

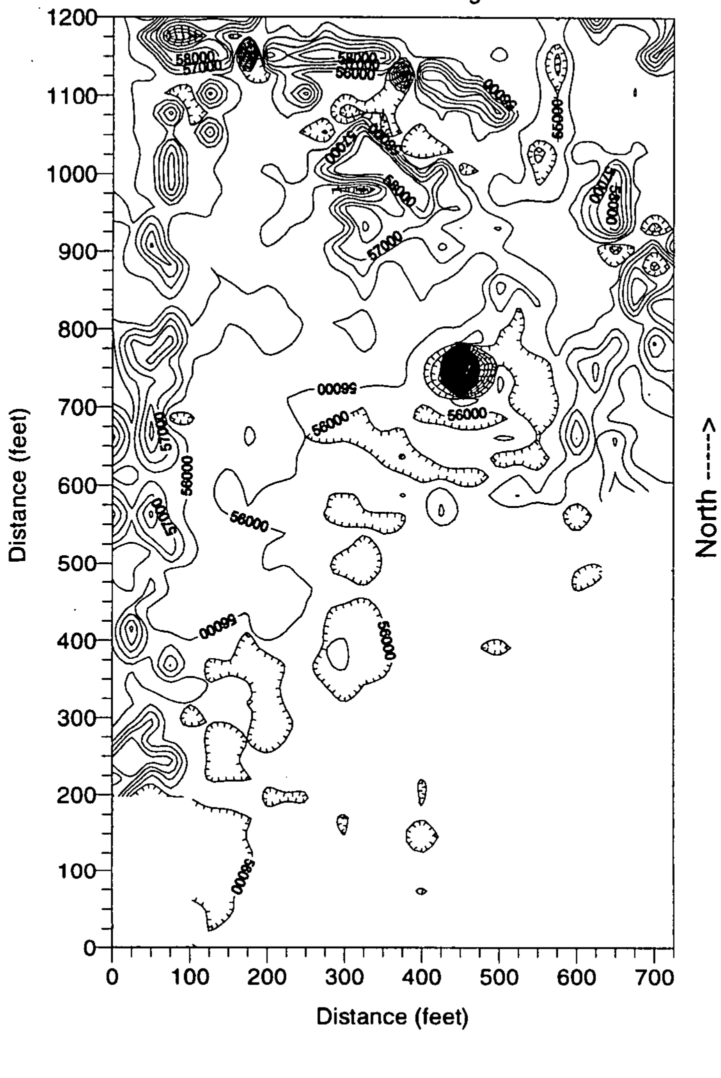
Geophysical Survey Data Collection Stations



Niagara Falls IAP-ARS
IRP Site 3 (Landfill LF-08)

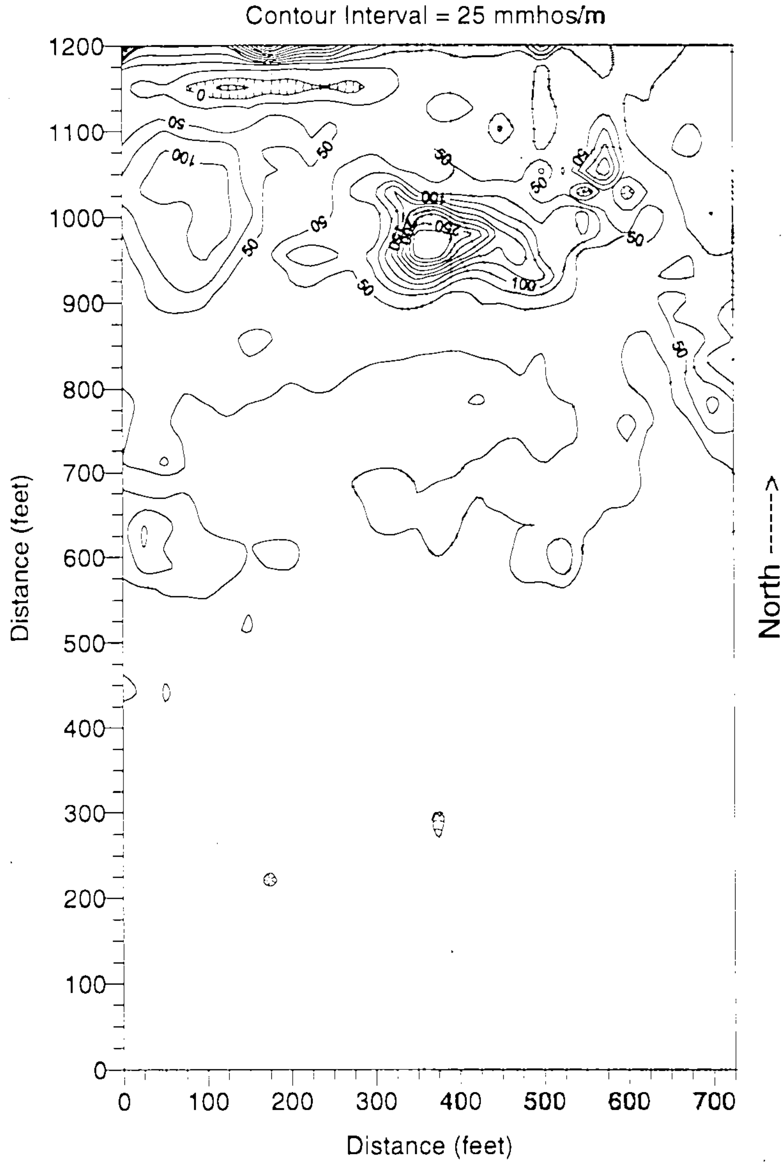
Total Earth Field Magnetics

Contour Interval = 500 gammas



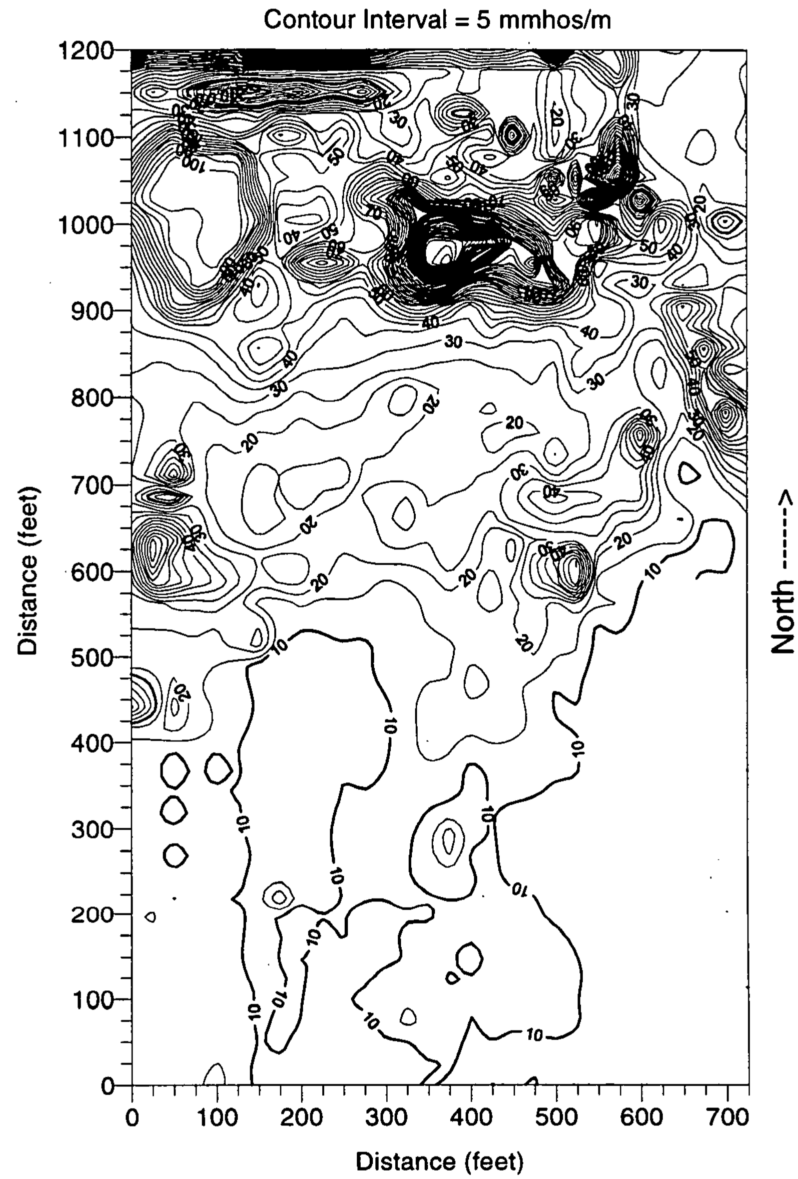
Niagara Falls IAP-ARS
IRP Site 3 (Landfill LF-08)

Quadrature Phase Conductivity
Orientation: Vertical-1



Niagara Falls IAP-ARS
IRP Site 3 (Landfill LF-08)

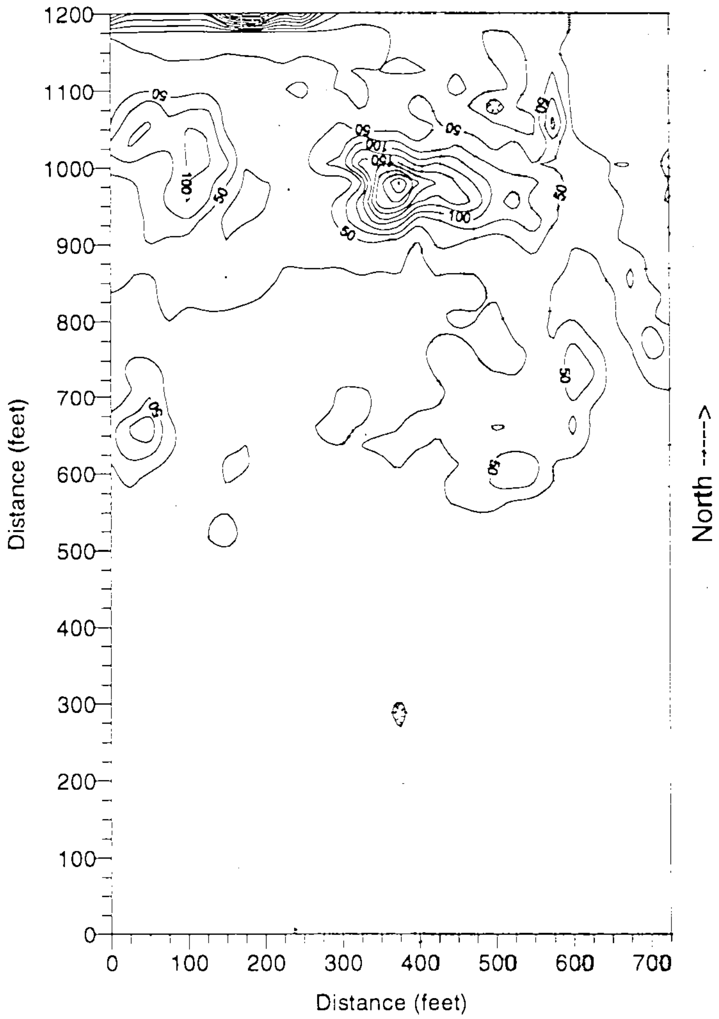
Quadrature Phase Conductivity
Orientation: Vertical-1



Niagara Falls IAP-ARS
IRP Site 3 (Landfill LF-08)

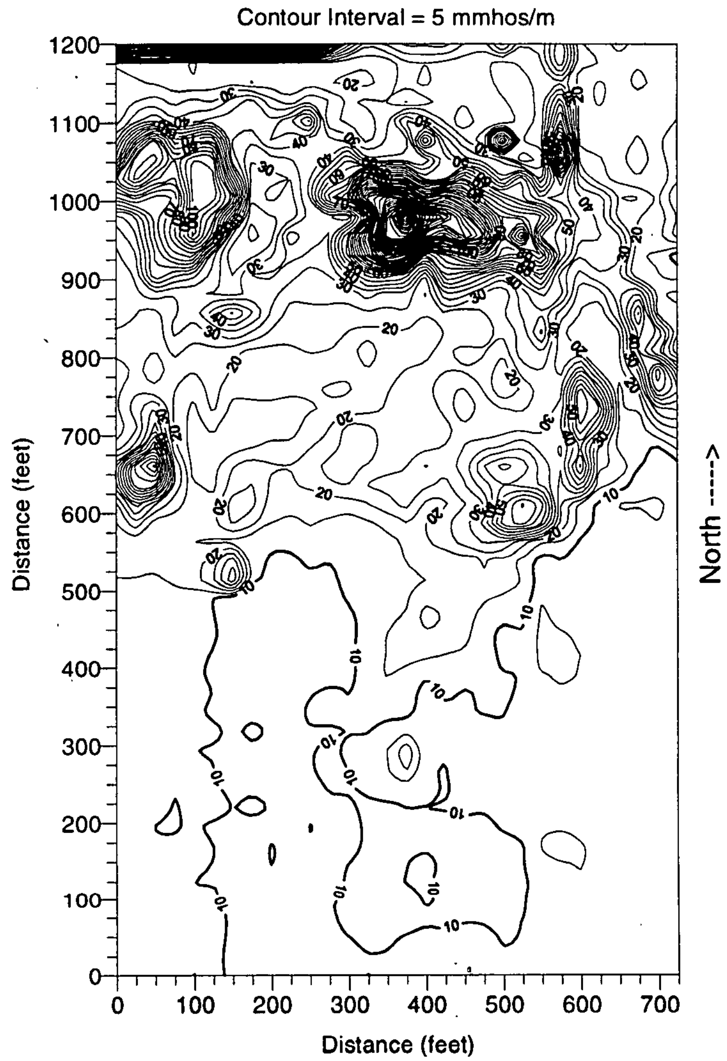
Quadrature Phase Conductivity
Orientation: Horizontal-1

Contour Interval = 25 mmhos/m



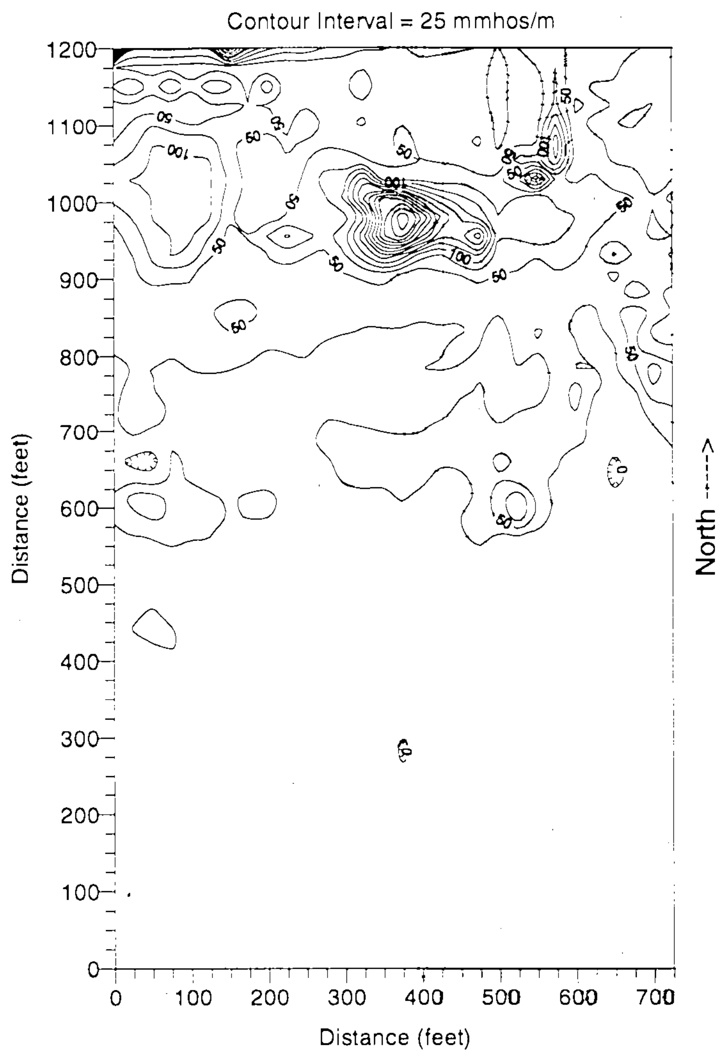
Niagara Falls IAP-ARS
IRP Site 3 (Landfill LF-08)

Quadrature Phase Conductivity
Orientation: Horizontal-1



Niagara Falls IAP-ARS
IRP Site 3 (Landfill LF-08)

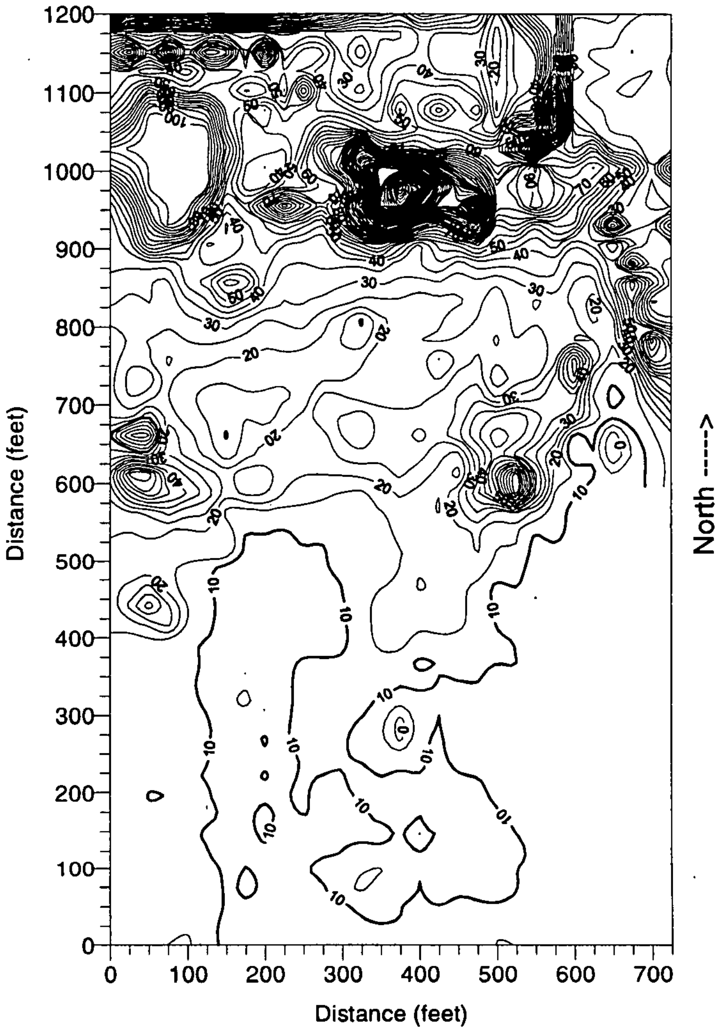
Quadrature Phase Conductivity
Orientation: Vertical-2



Niagara Falls IAP-ARS
IRP Site 3 (Landfill LF-08)

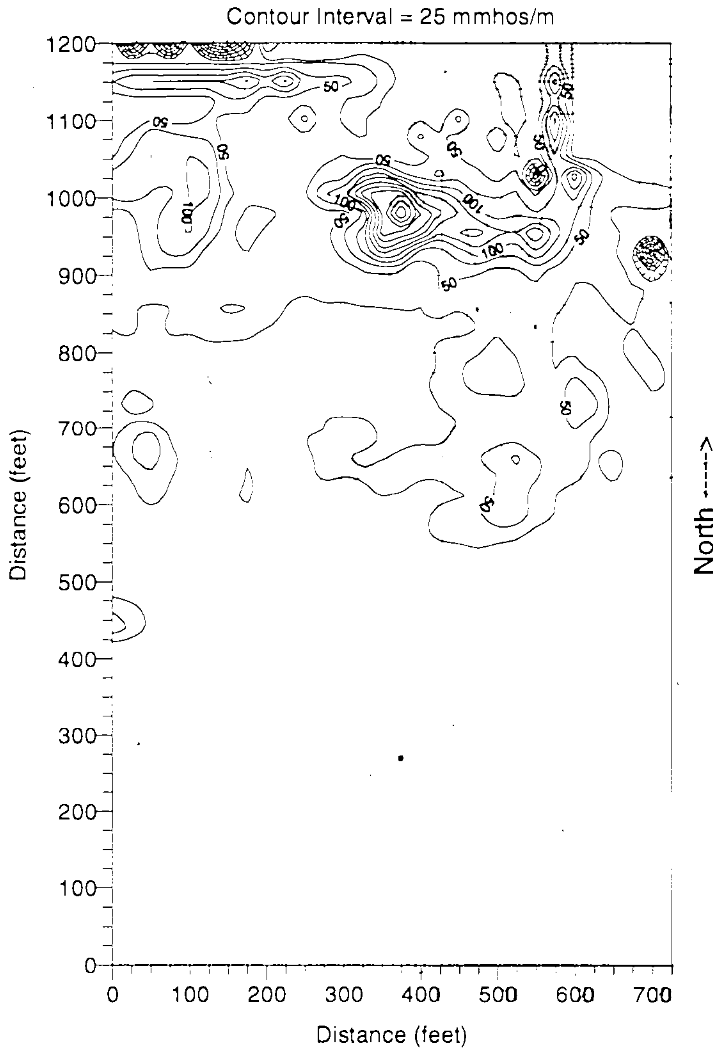
Quadrature Phase Conductivity
Orientation: Vertical-2

Contour Interval = 5 mmhos/m



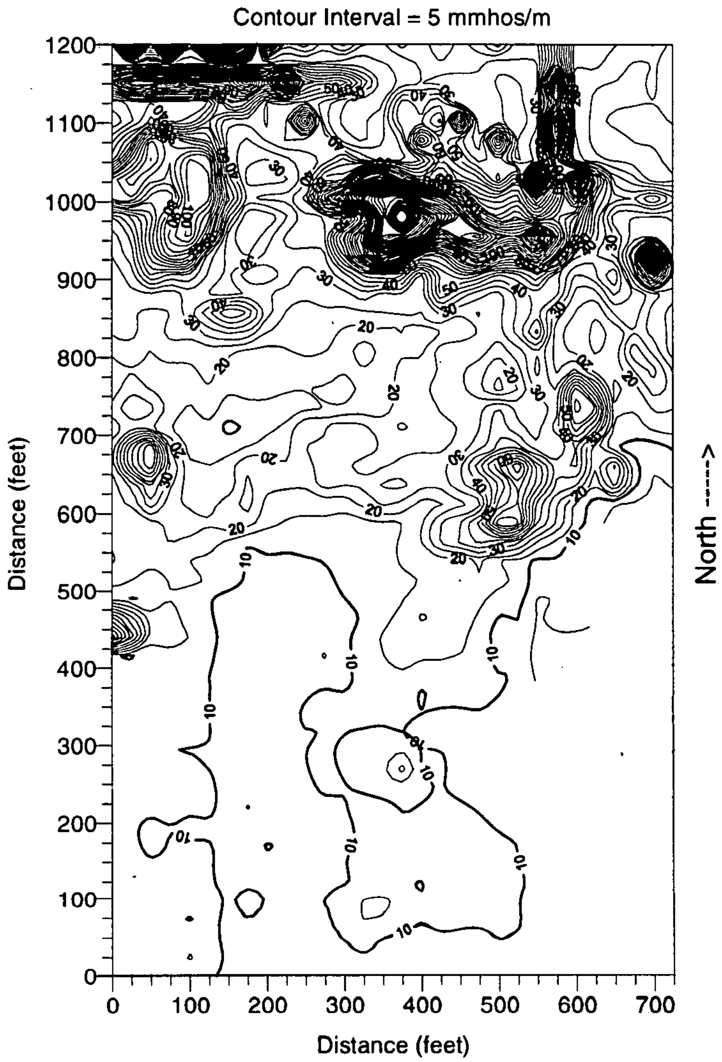
Niagara Falls IAP-ARS
IRP Site 3 (Landfill LF-08)

Quadrature Phase Conductivity
Orientation: Horizontal-2



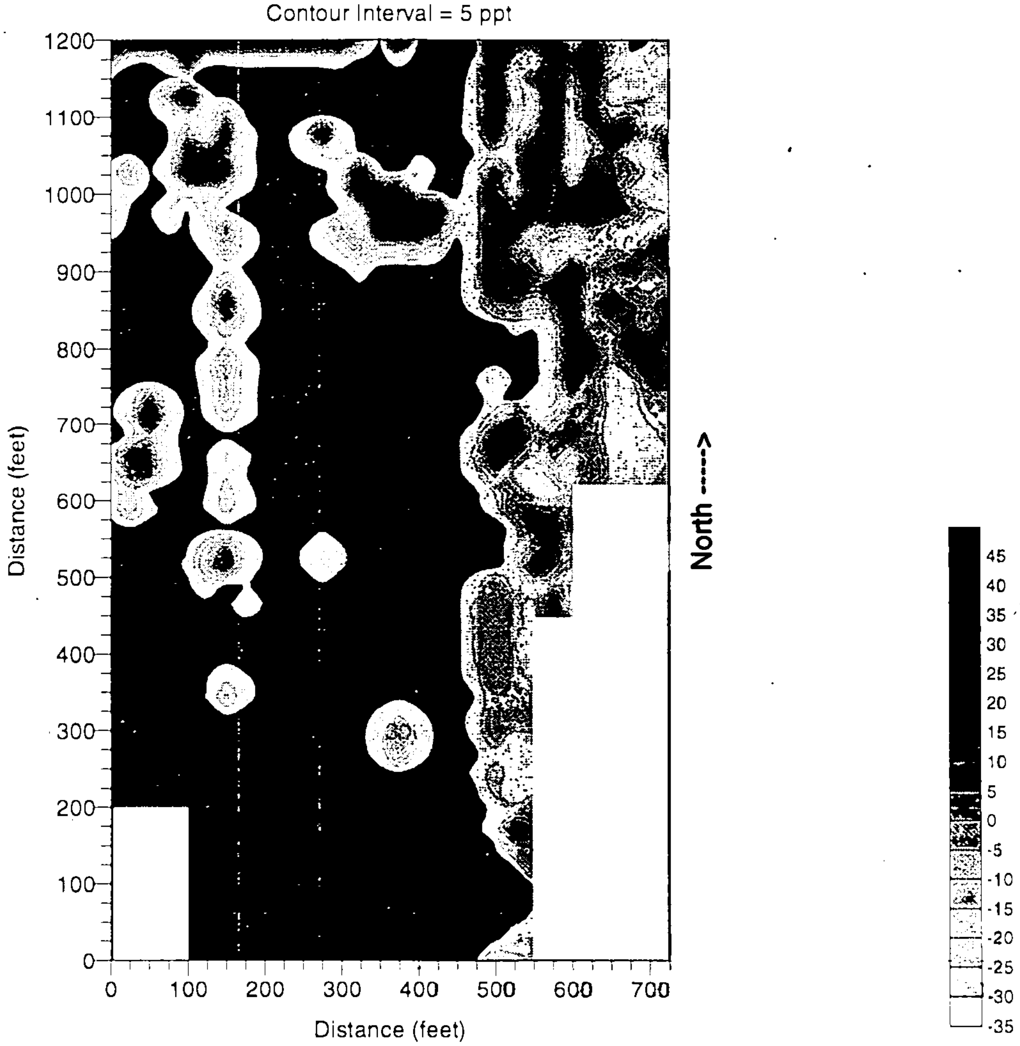
Niagara Falls IAP-ARS
IRP Site 3 (Landfill LF-08)

Quadrature Phase Conductivity
Orientation: Horizontal-2



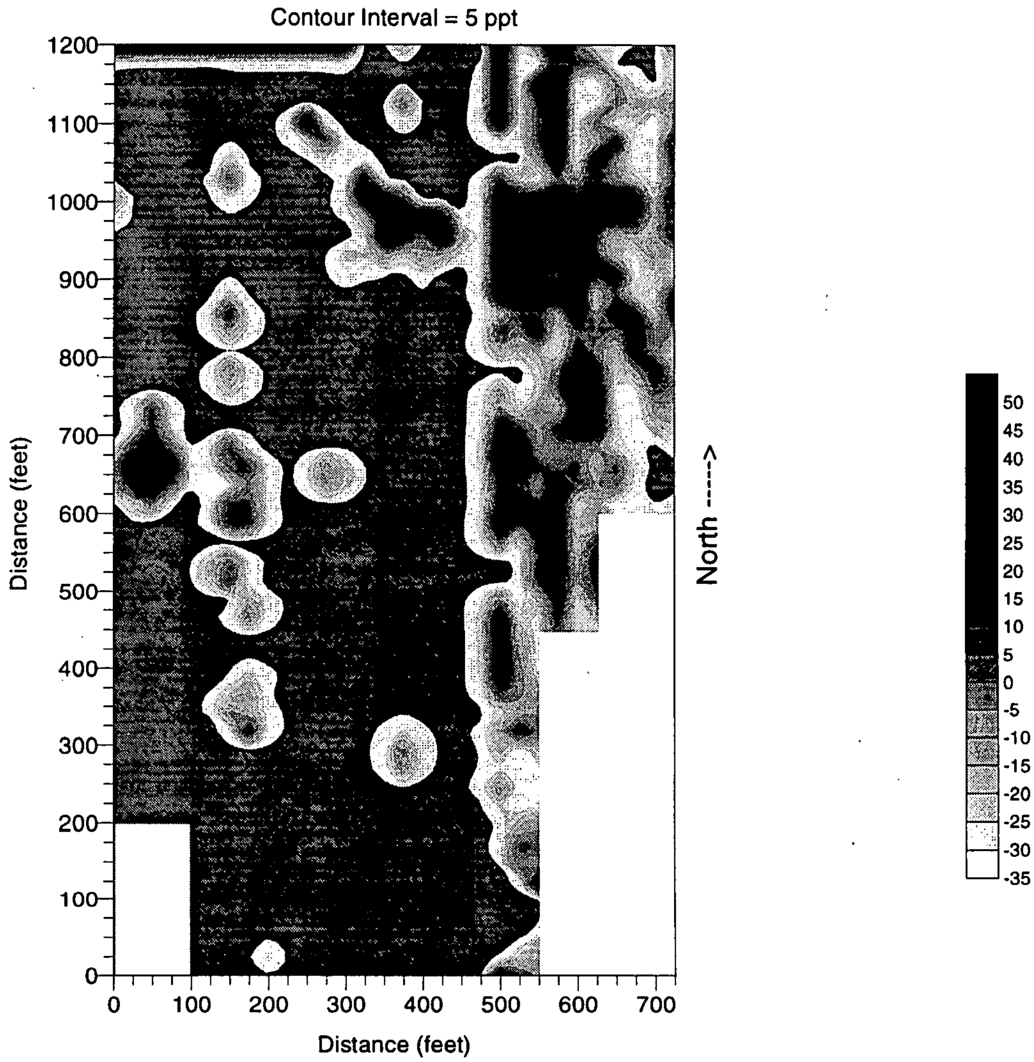
Niagara Falls IAP-ARS
IRP Site 3 (Landfill LF-08)

In-Phase Conductivity
Orientation: Vertical-1



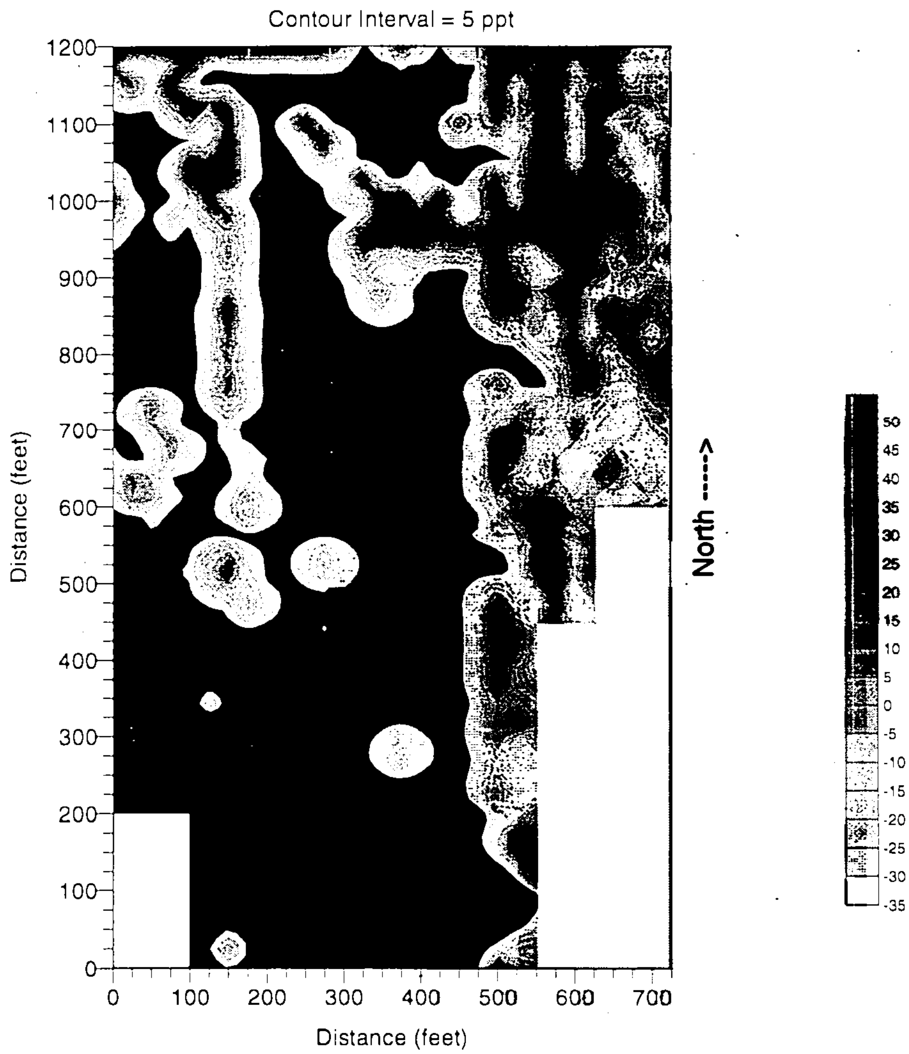
Niagara Falls IAP-ARS
IRP Site 3 (Landfill LF-08)

In-Phase Conductivity
Orientation: Horizontal-1



Niagara Falls IAP-ARS
IRP Site 3 (Landfill LF-08)

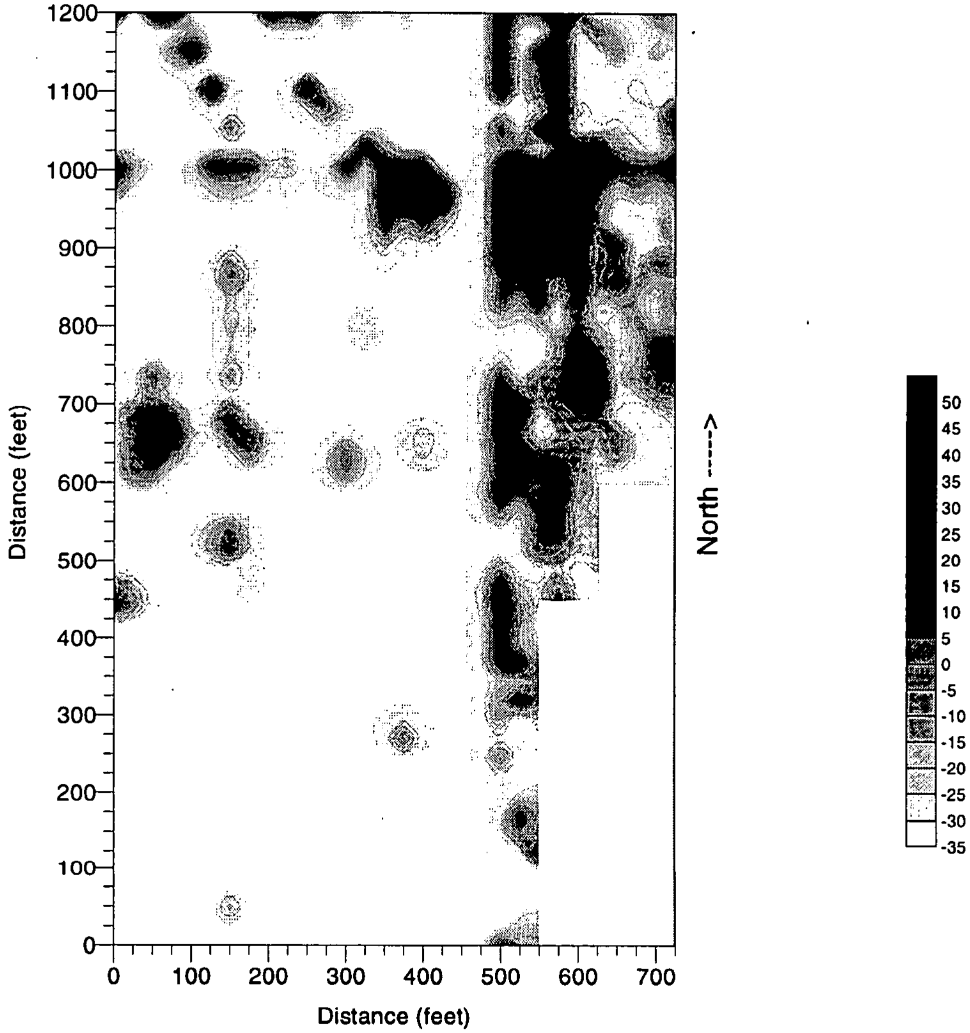
In-Phase Conductivity
Orientation: Vertical-2



Niagara Falls IAP-ARS
IRP Site 3 (Landfill LF-08)

In-Phase Conductivity
Orientation: Horizontal-2

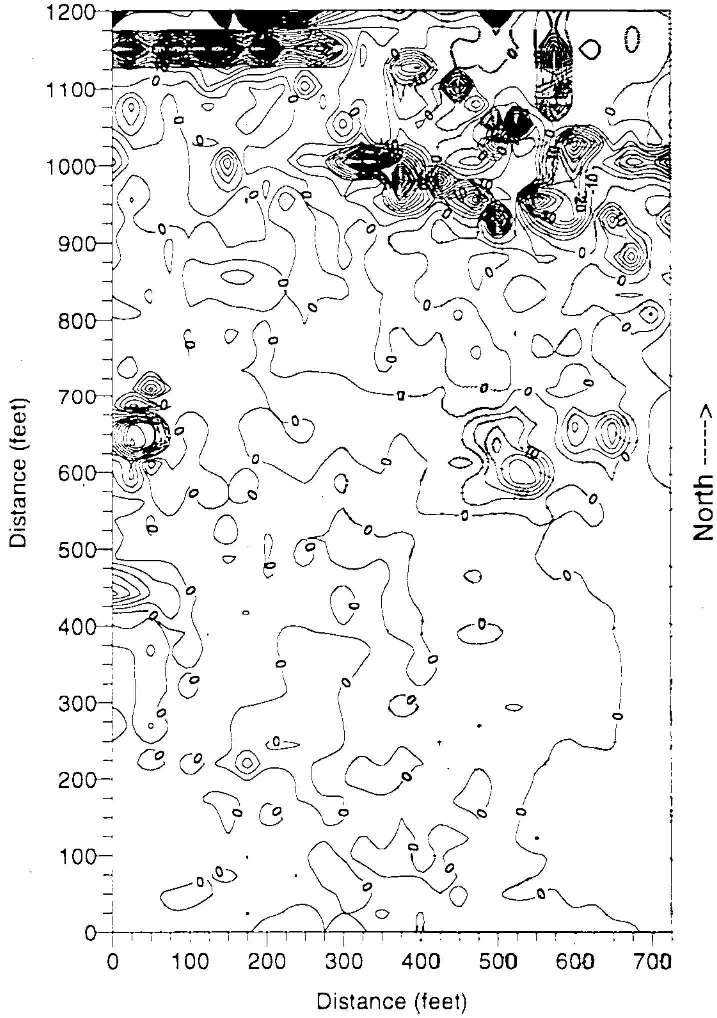
Contour Interval = 5 ppt



Niagara Falls IAP-ARS
IRP Site 3 (Landfill LF-08)

Vertical Dipole Difference

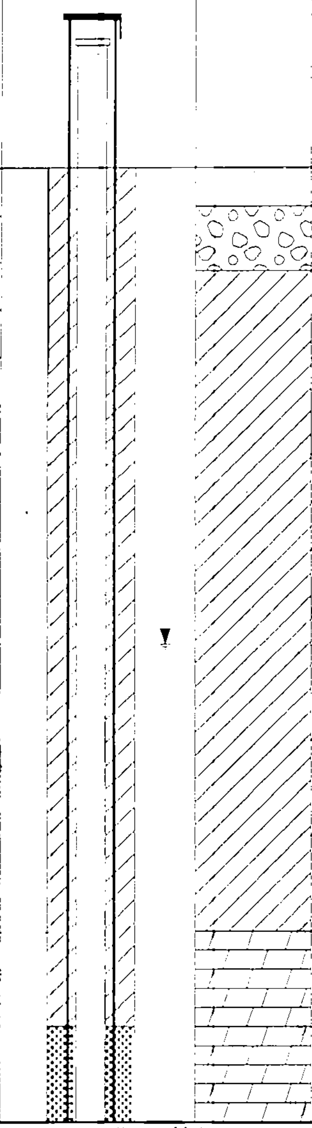
Contour Interval = 5 mmhos/m



D Geotechnical Logs

DRILLING LOG OF WELL NO. MW3-6D

Project:	Niagara Falls IAP - ARS / Site 3	Total Depth of Hole (feet BGS):	18.3
Location:	Niagara Falls, N.Y.	Ground Elevation (feet above MSL):	600.8
Well Coordinates/Reference System:	N 1135503 E 407481	Inner casing Stick-Up (feet above GS):	1.21
Date Started/Finished:	2-15-95 / 2-17-95	G.W. Depth At Completion (feet BGS):	5.0
Drilling Company:	SJB Services Inc.	Lock Number:	Master #140, Key #IG014
Driller/Geologist:	Kenny Swinnich / Rick Watt & Jim Richert		



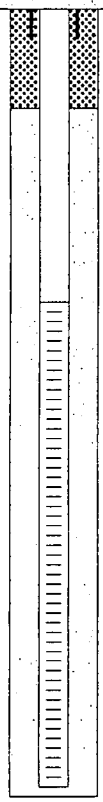
gs elevation - 600.8 ft.

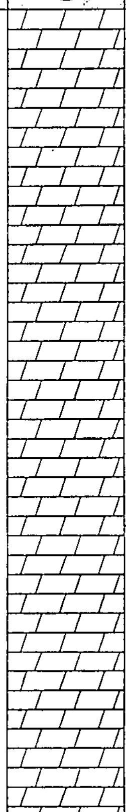
DEPTH	SOIL/ROCK DESCRIPTION	OVA (ppm)	RUN NUMBER	BLOW COUNT	RECOVERY	RQD	PENETRATION TIMES	COMMENTS
0	*ground surface (gs)*							
0–0.4	0-.4' CLAY, Brown, with rootlets. Frozen.	0	SS Run 1	40, 27, 13, 10	1.8'			2-15-95
0.4–1.1	.4'-1.1' Grey crushed stone.							
1.1–1.8	1.1'-1.8' CLAY, Brown, with rootlets and small stringers of yellowish gray. Frozen, very hard.							
2.0–3.5	2.0'-3.5' CLAY, Varved, brown, with yellowish-brown silt.	0	SS Run 2	8, 19, 23, 20	1.5'			
3.5–4.0	3.5'-4.0' CLAY, Reddish-brown with some subrounded gravel and trace sand. Clay becoming softer, probably till.							
4.0–6.0	4.0'-6.0' CLAY TILL, Reddish-brown with silt and very fine to coarse sand. Subround gravel near 6.0', soft.	0	SS Run 3	6, 10, 23, 10	1.3'			
6.0–7.0	6.0'-7.0' CLAY TILL, Reddish-brown, gravelly, wet and soft.	0	SS Run 4	13, 10, 9, 9	1.6'			Composite sample taken from 6-8' for VOC/BNA/metals/TPH analysis. Sample number NM9-MWC3-6D-SM-C2'595
7.0–8.0	7.0'-8.0' CLAY TILL, Reddish-brown with silt and sand. Moist, firm.							
8.0–10.3	8.0'-10.3' Dolostone, Dark gray, fractured and slightly vuggy. Subround gravel near 6.0', soft.	0	Core 1	50	2.3'	55	1445 / 1455	Split-spoon refusal at 8.0'. Installed 4-inch carbon steel casing from 2.0' AGS to 10.3' BGS.

DRILLING LOG OF WELL NO. MW3-6D

Project: Niagara Falls IAP - ARS   Total Depth of Hole (feet BGS): 18.3

Depth scale (feet): 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24





ELEVATION / DEPTH	SOIL/ROCK DESCRIPTION	OVA (ppm)	RUN NUMBER	BLOW COUNT	RECOVERY	RQD	PENETRATION TIMES	COMMENTS
10–10.3		0			2.3'	55		
10.3–15.3	10.3'-15.3' Dolostone, Massive, small vugs and a weathered fracture at 12.3'.	0	Core 2		4.4'	80	0957 1008	2-17-95 Driller said there was a .2' or .3' void at 12.4'
15.3–18.3	15.3'-18.3' Dolostone, Crystal-filled vug at 17.3'.	0	Core 3		3.0'		1026 -	Total depth of the hole is 18.3' BGS. 4" steel casing set to 10.30', 2" PVC, 0.01" slot, well screen set from 13.0' to 18.0' BGS.

DRAFT

DRILLING LOG OF WELL NO. MW3-1E

Project: Niagara Falls IAP - ARS / Site 3

Location: Niagara Falls, N.Y.

Well Coordinates/Reference System: N 1135183 E 407892

Date Started/Finished: 2-16-95 / 2-27-95

Drilling Company: SJB Services Inc.

Driller/Geologist: Kenny Swinnich / Rick Watt & Gene Florentino

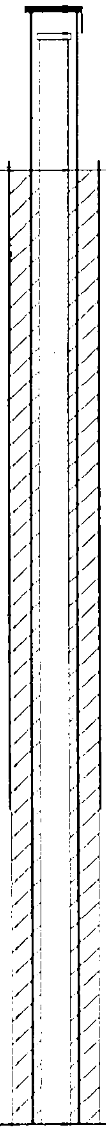
Total Depth of Hole (feet BGS): 42.1

Ground Elevation (feet above MSL): 588.4

Inner casing Stick-Up (feet above GS): 1.29

G.W. Depth At Completion (feet BGS):

Lock Number: Master #140, Key #1G014



ELEVATION	DEPTH	SOIL/ROCK DESCRIPTION	OVA (ppm)	RUN NUMBER	BLOW COUNT	RECOVERY	RQD	PENETRATION TIMES	COMMENTS
gs elevation 588.4 ft		*ground surface (gs)*							
	0–2	0-2.0' TOPSOIL Brown, very fine sandy, gravelly, clayey silt. Brittle to semi-plastic and organic. Top 9" frozen.	0	SS Run 1	6 2 3 3	1.0'			2-16-95
	2–4	2.0'-4.0' SANDY SILT AND CLAY Dark brown, with fine to very fine sand. Orange mottling with some black, ash-like material, semi-plastic and organic.	0	SS Run 2	3 4 4 4	1.0'			Collected soil sample NM9-MW3-1E-SO-021695, from 2' - 4', for VOC, PP metals, and TRPH analysis.
	4–4.7	4.0'-4.7' SAND Medium grained gray, grading to orange-red. Some (<3%) subrounded gravel and silty clay.	0	SS 3	4 100	.7'			Split-spoon refusal at 4.7'.
	4.7–6.7	4.7'-6.7' Dolostone, Gray, few small vugs and minor fracturing.	0	Core 1		1.9'	75		
	6.7–10	6.7'-13.0' Dolostone, Gray, numerous small vugs. Fractures at 7.3', 7.8', 8.4' 9.0', 9.5', 10.1', 10.4', 10.8', and 12.0'. Some remineralization of calcite in vugs and stringers throughout. Thick calcite at 9' and 10.8'. Minor coral throughout.	0	Core 2		6.3'	93		Reamed hole to 7-7/8" diameter and Installed 6-inch I.D. carbon steel casing to 6.7' BGS.

Project: Niagara Falls IAP – ARS

Total Depth of Hole (feet BGS): 42.1

ELEVATION / DEPTH	WELL COMPLETION DIAGRAM	GRAPHIC LOG	SOIL/ROCK DESCRIPTION	OVA (ppm)	RUN NUMBER	BLOW COUNT	RECOVERY	RQD	PENETRATION TIMES	COMMENTS
11–13				0	Core 2		6.3'	93		
13–23			13.0'–23.0' <u>Dolostone</u>, Gray, numerous small vugs throughout. Many open stringers where weathering has occured. Small open-pored corals throughout. some secondary mineralization of calcite and sphalerite throughout. Moderate to heavily fractured from 16.0' – 17.4'. Only 4 sub-horizontal fractures from 17.4'– 23.0'.	0	Core 3		10'	87	1605 1617	
23–24			23.0'–24.0' <u>Dolostone</u>, Gray, fossiliferous (open-pored corals), with several thin shale	0	Core 4		8.8'	91	1045	Reamed hole to 5-7/8" diameter from 6.7' to 23.0' and Installed 4-inch I.D. carbon steel casing from 2.0' AGS to 23.0' BGS.

Project: Niagara Falls IAP - ARS Total Depth of Hole (feet BGS): 42.1

ELEVATION / DEPTH	WELL COMPLETION DIAGRAM	GRAPHIC LOG	SOIL/ROCK DESCRIPTION	OVA (ppm)	RUN NUMBER	BLOW COUNT	RECOVERY	RQD	PENETRATION TIMES	COMMENTS
			stringers.							
25–27			24.0'-32.1' Dolostone, As above without the fossils. Some shale stringers, but very few vugs or open fractures, except for moderate fracturing from 27'-27.8'.							
28				0	Core 4		8.8'	91		
29–31										
32									1058	
			32.1'-42.1' Dolostone, As above, but darker gray. Somewhat more shale stringers. Few horizontal fractures, but moderately fractured from 37'-38'.						1133	
33–34										
35				0	Core 5		NR	NR		
36–38										

Niagara Falls IAP - ARS
Site 3

DRILLING LOG OF WELL NO. MW3-1E

Project: Niagara Falls IAP - ARS   Total Depth of Hole (feet BGS): 42.1

ELEVATION / DEPTH	WELL COMPLETION DIAGRAM	GRAPHIC LOG	SOIL/ROCK DESCRIPTION	OVA (ppm)	RUN NUMBER	BLOW COUNT	RECOVERY	RQD	PENETRATION TIMES	COMMENTS
39										
40				0	Core 5		NR	NR		Total depth of the hole is 42.1' BGS. 6" steel casing set to 6.7' BGS. 4" steel casing set to 23.0' BGS. 2" PVC, 0.01" slot, well screen set from 31.5' to 41.5' BGS.
41										
42									1139	
43										
44										
45										
46										
47										
48										
49										
50										
51										
52										

Niagara Falls IAP - ARS
Site 3

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DRAFT

DRILLING LOG OF BORING NO. SB3-1

Project: Niagara Falls IAP - ARS / Site 3

Total Depth of Hole (feet BGS): 8.4

Location: Niagara Falls, N.Y.

Ground Elevation (feet above MSL): ~600

Date Started/Finished: 2-21-95 / 2-21-95

Driller / Geologist: Kenny Swinnich / Rick Watt

Drilling Company: SJB Services Inc.

DEPTH	GRAPHIC LOG	OVERBURDEN DESCRIPTION	OVA (ppm)	RUN NUMBER	BLOW COUNT	RECOVERY	COMMENTS
0–2		0-1.0' CLAY LOAM Brown, firm, disturbed and frozen to approximately 8" BGS. Gravel (dark gray cobblestone) in shoe blocked the sample.	0	SS Run 1	6 3 4 4	1.0'	Shoe blocked with gravel.
2–4		2.0'-3.0' CLAY Brown, mottled with gray and black. Contains some sand and gravel (fill) and rootlets.	0	SS Run 2	44 30 14 13	1.0'	Shoe blocked with gravel.
4–6		4.0'-5.0' CLAY As above, but soft with some black staining (fill).	0	SS Run 3	4 3 3 4	1.0'	Shoe blocked with gravel. Collected sample NM9-SB03-01-SO022195, and dup cate from 4.0 - 3.3', for PCDD/PCDF.
6–8		6.0'-8.0' CLAY As above, with black staining. Minor greenish-gray slag and what appears to be black, burned wood at 7.5' (fill).	0	SS Run 4	4 3 3 4	.4'	Sewage odor.
8–8.4		8.0'-8.4' GRAVELLY CLAY over wood (fill).	0		100	.3'	Split-spoon refusal at 8.4'.

DRILLING LOG OF BORING NO. SB3-2

Project: Niagara Falls IAP - ARS / Site 3

Total Depth of Hole (feet BGS): 7.3

Location: Niagara Falls, N.Y.

Ground Elevation (feet above MSL): ~593

Date Started/Finished: 2-21-95 / 2-21-95

Driller / Geologist: Kenny Swinnich / Rick Watt

Drilling Company: SJB Services Inc.

DEPTH	GRAPHIC LOG	OVERBURDEN DESCRIPTION	OVA (ppm)	RUN NUMBER	BLOW COUNT	RECOVERY	COMMENTS
0–2		0-2.0' CLAY LOAM Brown, firm, disturbed, sandy, with gravel, silt and rootlets. Ocassionally mottled with black and gray. Also contains several coal-like fragments.	0	SS Run 1	5 5 16 32	1.4'	
2–4		2.0'-3.0' CLAY As above, with glass fragments (fill) and some black staining Becomes gray and soft at 3.0', with some black staining.	0	SS Run 2	4 14 32 18	1.0'	Pushed gravel. Collected sample NM9-SB03-02-SM-022195, From 2' - 3' and 6' - 7', for PCDD/PCDF.
4–6		4.0'-6.0' Poor recovery, pushed gravel.	0	SS Run 3	2 5 8 11	0.2'	Pushed gravel.
6–6.8		6.0'-6.8' CLAY Dark gray, soft, with some black staining.	0	SS Run 4	5 20 100	0.9'	Petroleum odor.
6.8–7.3		6.8'-7.3' GRAVELLY CLAY Reddish-brown.					
7.3–12							Split-spoon refusal at 7.3'.

DRAFT

DRILLING LOG OF BORING NO. SB3-3

Project: Niagara Falls IAP - ARS / Site 3

Total Depth of Hole (feet BGS): 3.5

Location: Niagara Falls, NY

Ground Elevation (feet above MSL): ~592

Date Started/Finished: 3-20-95 / 3-20-95

Driller / Geologist: Don Butler / Rick Watt

Drilling Company: SJB Services, Inc.

DEPTH	GRAPHIC LOG	OVERBURDEN DESCRIPTION	OVA (ppm)	RUN NUMBER	BLOW COUNT	RECOVERY	COMMENTS
0–2		0-1.0' CLAY Brown, sandy, with minor black carbon slag and red, gravelly gravelly sand from 1.0' - 1.0'. A boulder was encountered at 1.5'.	0	SS Run 1	2 3 5 20	1.0'	Boulder encountered at 1.5' BGS. Moved over a few feet to continue sampling.
2–3.5		2.0'-3.5' CLAY Reddish-brown, and sandy.	0	SS Run 2	6 7 8 50	1.5'	Collect sample NM9-SB3-3-SO-032095, from 2.0' - 3.5', for VOC, BNA, metals, and TPH analysis.
3.5							Split-spoon refusal at 3.5'.

Niagara Falls IAP - ARS
Site 3

DRAFT

DRILLING LOG OF BORING NO. SB3-4

Project: Niagara Falls IAP - ARS / Site 3

Total Depth of Hole (feet BGS): 5.8

Location: Niagara Falls, N.Y.

Ground Elevation (feet above MSL): ~592

Date Started/Finished: 3-20-95 / 3-20-95

Driller / Geologist: Don Butler / Rick Watt

Drilling Company: SJB Services Inc.

DEPTH	GRAPHIC LOG	OVERBURDEN DESCRIPTION	OVA (ppm)	RUN NUMBER	BLOW COUNT	RECOVERY	COMMENTS
0–2		0-2.0' CLAY 4" of brown loam overlying brownish-red lacustrine clay.	0	SS Run 1	1 2 3 6	1.5'	
2–3		2.0'-3.0' CLAY Red, varved, lacustrine clay, with thin silt seams.	0	SS Run 2	8 13 16 17	1.0'	Collected sample NM-SB3-4-SO-032095, from 2.0' - 5.8', for VOC, BNA, PP metals and TRPH analysis.
3–4		3.0'-4.0' GRAVELLY SAND TILL Red.					
4–5.8		4.0'-5.8' GRAVELLY SAND TILL Red.	0	SS Run 3	22 25 30 50	0.4'	
5.8–12							Split-spoon refusal at 5.8'.

DRAFT

DRILLING LOG OF BORING NO. SB3-5

Project: Niagara Falls IAP – ARS / Site 3

Total Depth of Hole (feet BGS): 5.8

Location: Niagara Falls, N.Y.

Ground Elevation (feet above MSL): ~592

Date Started/Finished: 3-20-95 / 3-20-95

Driller / Geologist: Don Butler / Rick Watt

Drilling Company: SJB Services Inc.

DEPTH	OVERBURDEN DESCRIPTION	OVA (ppm)	RUN NUMBER	BLOW COUNT	RECOVERY	COMMENTS
0–2	0-2.0' SOIL FILL Brown, with glass and slag.	0	SS Run 1	3 4 4	0.8'	
2–4	2.0'-4.0' SOIL FILL As above.	0	SS Run 2	5 5 9 9	0.4'	
4–4.5	4.0'-4.5' CLAY Red, lacustrine and varved.					Collected sample NM-SB3-5-SO-032095, from 4.0' – 5.8', for VOC, BNA, PP metals and TRPH analysis.
4.5–5.8	4.5'-5.8' GRAVELLY SAND TILL Red.	0	SS Run 3	13 14 19 50	1.2'	
5.8						Split-spoon refusal at 5.8'.

Depth scale: 1 2 3 4 5 6 7 8 9 10 11 12

Niagara Falls IAP – ARS
Site 3

DRAFT

DRILLING LOG OF BORING NO. SB3-6

Project: Niagara Falls IAP - ARS / Site 3

Location: Niagara Falls, N.Y.

Date Started/Finished: 3-21-95 / 3-21-95

Drilling Company: SJB Services Inc.

Total Depth of Hole (feet BGS): 7.3

Ground Elevation (feet above MSL): ~596

Driller / Geologist: Don Butler / Rick Watt

DEPTH	GRAPHIC LOG	OVERBURDEN DESCRIPTION	OVA (ppm)	RUN NUMBER	BLOW COUNT	RECOVERY	COMMENTS
0–2		0-2.0' SANDY LOAM Brown, fill, with black carbon and slag.	0	SS Run 1	1 2 2 3	0.6'	
2–4		2.0'-4.0' SANDY LOAM As above.	1	SS Run 2	3 3 3 3	0.9'	Pushed sample. Collected sample NM-SB3-6-SO-032195, from 0 - 4' for VOC, BNA, PP metals and TRPH analysis.
4–4.5		4.0'-4.5' SANDY LOAM As above.	0	SS Run 3	4 4 5 5	1.5'	Pushed sample.
4.5–6		4.5'-6.0' CLAY Red, lacustrine.					
6–7.3		6.0'-7.3' NO RECOVERY Probably red, gravelly sand till.	NR	SS Run 4	4 4 50	0.0'	Pushed gravel.
7.3–12							Split-spoon refusal at 7.3'.

Niagara Falls IAP - ARS

Site 3

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AFRJ6JR

DRILLING LOG OF BORING NO. SB3-7

Project: Niagara Falls IAP - ARS / Site 3

Total Depth of Hole (feet BGS): 9.5

Location: Niagara Falls, N.Y.

Ground Elevation (feet above MSL): ~600

Date Started/Finished: 3-21-95 / 3-21-95

Driller / Geologist: Don Butler / Rick Watt

Drilling Company: SJB Services Inc.

DEPTH	GRAPHIC LOG	OVERBURDEN DESCRIPTION	OVA (ppm)	RUN NUMBER	BLOW COUNT	RECOVERY	COMMENTS
0–2		0-2.0' SOIL FILL Brown, moist, with black graphite and ash.	0	SS Run 1	3 3 4	0.5'	Pushed sample.
2–4		2.0'-4.0' SOIL FILL Sandy, moist, with slag.	0	SS Run 2	6 2	0.2'	Pushed sample.
4–6		4.0'-6.0' CLAY SOIL FILL Grayish-brown, saturated, with black staining.	4	SS Run 3	1 2	0.9'	
6–8		6.0'-8.0' CLAY Redish-brown, varved, lacustrine and moist.	2	SS Run 4	3 5 7 10	1.7'	Collect sample NM-SB3-7-SO-032195 and duplicate sample NM-SB3-7-SD-032195, from 6.0' - 9.5', for VOC, BNA, metals and TRPH analysis.
8–9.5		8.0'-9.5' CLAY As above with gravelly sand till at base.	50	SS Run 5	6 50	1.1'	
9.5–12							Split-spoon refusal at 9.5'.

Niagara Falls IAP - ARS

Site 3

DRILLING LOG OF BORING NO. SB3-8

Project: Niagara Falls IAP - ARS / Site 3

Location: Niagara Falls, N.Y.

Date Started/Finished: 3-21-95 / 3-21-95

Drilling Company: SJB Services Inc.

Total Depth of Hole (feet BGS): 14.0

Ground Elevation (feet above MSL): ~602

Driller / Geologist: Don Butler / Rick Watt

DEPTH	GRAPHIC LOG	OVERBURDEN DESCRIPTION	OVA (ppm)	RUN NUMBER	BLOW COUNT	RECOVERY	COMMENTS
0–2		0-2.0' SANDY LOAM Brown, moist, disturbed soil. No fill.	0	SS Run 1	3 4 4 4	0.6'	Pushed sample.
2–4		2.0'-4.0' SILTY CLAY Reddish-brown, dry, undisturbed, with rootlets and a 1" fine sand layer at 3.5'.	0	SS Run 2	6 6 8 10	1.0'	
4–6		4.0'-6.0' CLAY Reddish-brown, dry, lacustrine with gray and tan silt varves and mottles.	0	SS Run 3	12 16 20 19	1.8'	
6–8		6.0'-8.0' CLAY As above, moist.	0	SS Run 4	19 24 40 36	2.0'	
8–10		8.0'-10.0' CLAY As above, moist.	0	SS Run 5	32 28 22 21	1.7'	
10–12		10.0'-11.5' CLAY Reddish-brown, sandy, silty, varved, lacustrine. 11.5'-12.0' GRAVELLY SAND TILL Red, moist.	0	SS Run 6	19 9 12 18	2.0'	Collected sample NM-SB3-8-SM-032195, from 11.0' - 14.0', for VOC, BNA, metals and TRPH analysis. A double volume was collected for MS/MSD.

DRAFT

DRILLING LOG OF BORING NO. SB3-8

Project: Niagara Falls IAP - ARS   Total Depth of Hole (feet BGS): 14.0

DEPTH	GRAPHIC LOG	OVERBURDEN DESCRIPTION	OVA (ppm)	RUN NUMBER	BLOW COUNT	RECOVERY	COMMENTS
13		12.0'-14.0' GRAVELLY SAND TILL Red, clayey, saturated.	0	SS Run 7	1-2-2		
14							Split-spoon refusal at 14.0'.
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							

Niagara Falls IAP - ARS
Site 3

DRAFT

DRILLING LOG OF BORING NO. SB3-9

Project: Niagara Falls IAP - ARS / Site 3

Location: Niagara Falls, N.Y.

Date Started/Finished: 3-21-95 / 3-21-95

Drilling Company: SJB Services Inc.

Total Depth of Hole (feet BGS): 6.4

Ground Elevation (feet above MSL): ~601

Driller / Geologist: Don Butler / Rick Watt

DEPTH	GRAPHIC LOG	OVERBURDEN DESCRIPTION	OVA (ppm)	RUN NUMBER	BLOW COUNT	RECOVERY	COMMENTS
0-1		0-1.0' SOIL FILL Brown, loam, with black graphite and slag.	0	SS Run 1	1 4 4 7	1.1'	
1-2		1.0'-2.0' CLAY Reddish-brown, sandy, and silty.					
2-4		2.0'-4.0' CLAY Reddish-brown, moist, sandy, and silty, varved, lacustrine and undisturbed.	0	SS Run 2	8 11 15 11	1.2'	
4-5		4.0'-5.0' CLAY As above.	0	SS Run 3	11 13 16 28	1.2'	Collect sample NM-SB3-9-SO-032195 from 5.0' - 6.4', for VOC, BNA, metals and TRPH analysis.
5-6		5.0'-6.0' SANDY CLAY TILL Red.					
6-6.4		6.0'-6.4' SANDY CLAY TILL Red.	0		50	0.3'	
							Split-spoon refusal at 6.4'.

Depth scale: 1 2 3 4 5 6 7 8 9 10 11 12

Niagara Falls IAP - ARS
Site 3

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AFRIBOR

DRILLING LOG OF BORING NO. SB3-10

Project: Niagara Falls IAP - ARS / Site 3

Total Depth of Hole (feet BGS): 7.0

Location: Niagara Falls, N.Y.

Ground Elevation (feet above MSL): ~599

Date Started/Finished: 3-21-95 / 3-21-95

Driller / Geologist: Don Butler / Rick Watt

Drilling Company: SJB Services Inc.

DEPTH	OVERBURDEN DESCRIPTION	OVA (ppm)	RUN NUMBER	BLOW COUNT	RECOVERY	COMMENTS
0–2	0-2.0' SOIL FILL Brown, loam, with black graphite and ash.	0	SS Run 1	1 4 5 9	1.1'	
2–4	2.0'-4.0' WOOD Burnt, saturated.	0	SS Run 2	5 2 4 3	0.2'	
4–6	4.0'-6.0' SOIL FILL Brown, with black material.	0	SS Run 3	1 3 3 4	0.0'	Moved over and resampled from 4.0' - 7.0', in order to have adequate recovery to sample. First attempt at 4.0' - 6.0' had .2' recovery, with refusal at 5.0'. Blow counts were 2/2/50.
6–7	6.0'-7.0' GRAVELLY CLAY Black / dark gray, with ash.	7	SS Run 4	2 3 50	1.0'	Collect sample NY-SB3-10-SO-032195 from 6.0' - 7.0', for VOC, BNA, PP metals and TRPH analysis.
7						Split-spoon refusal at 7.0'.

Niagara Falls IAP - ARS
Site 3

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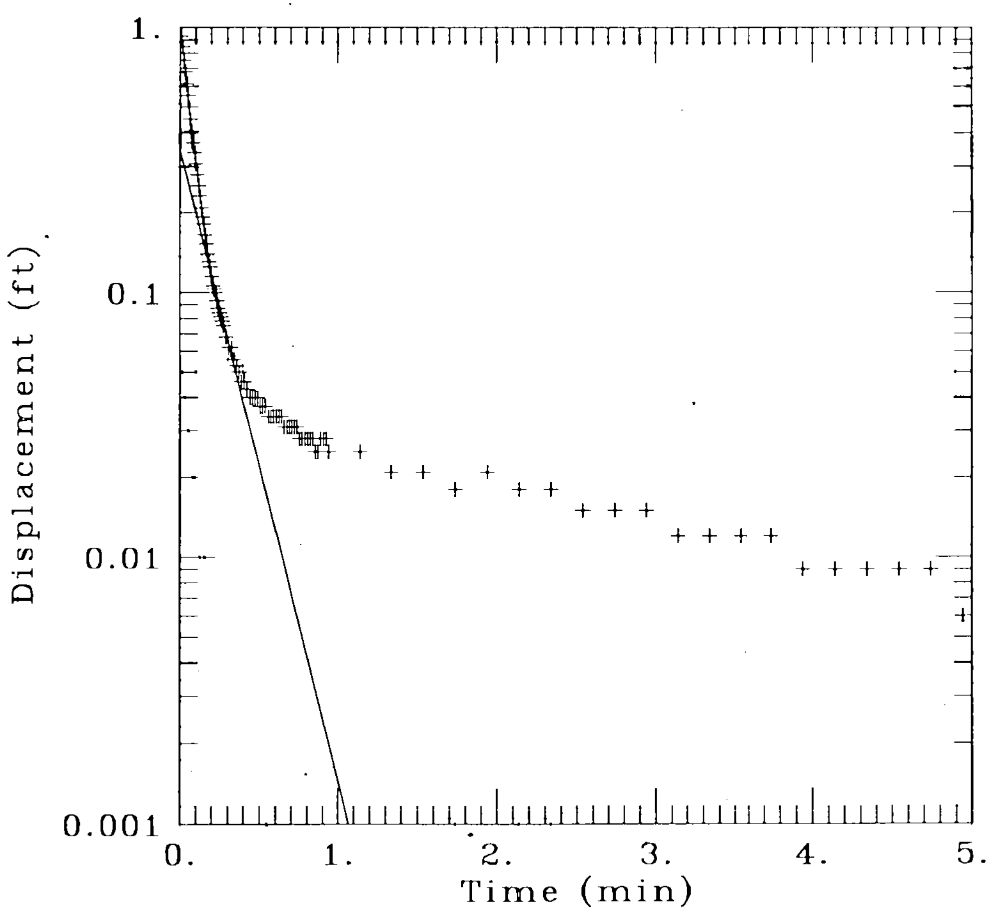
E Slug Test Results

Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM8070	Location: Niagara Falls IAP-ARS Site 3

MW 3-1 (Falling Head)



DATA SET:
3-1f.dat
06/23/95

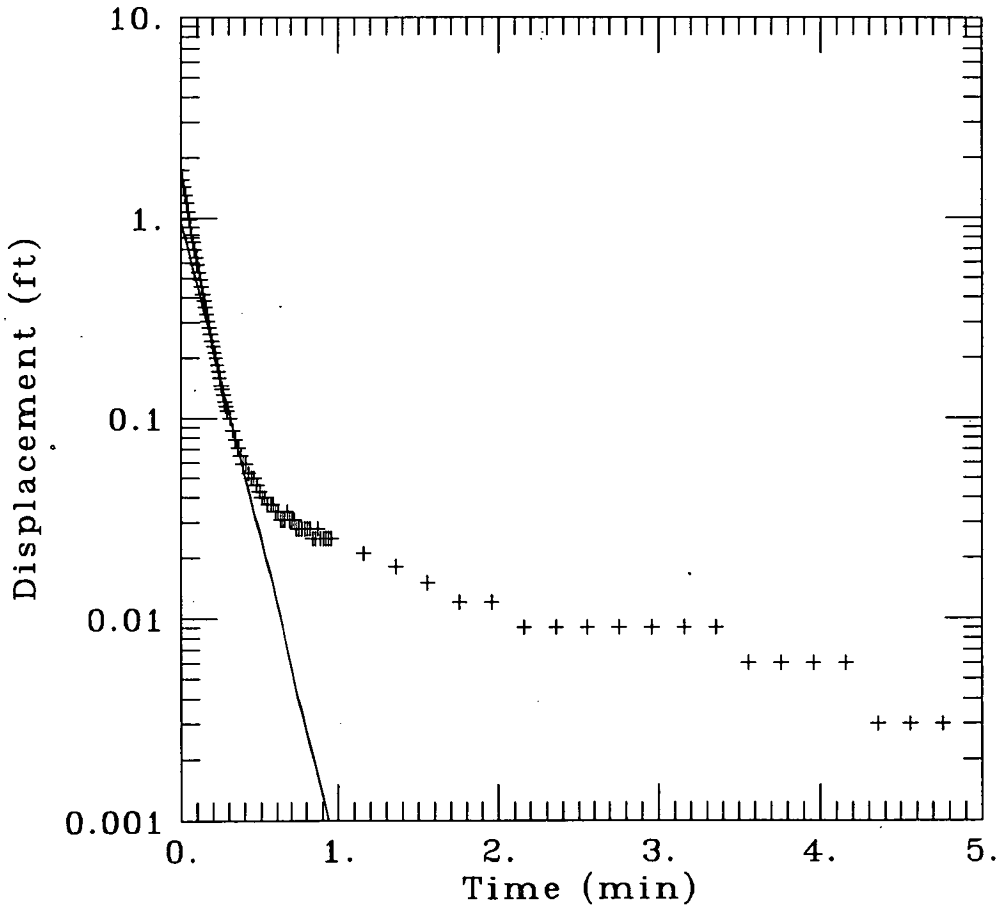
AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice
TEST DATE:
15 NOV 94

ESTIMATED PARAMETERS:
K = 0.006792 ft/min
y0 = 0.3463 ft

TEST DATA:
H0 = 1.153 ft
rc = 0.083 ft
rw = 0.3 ft
L = 7. ft
b = 9.5 ft
H = 9.41 ft

Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM8070	Location: Niagara Falls IAP–ARS Site 3

MW 3-1 (Rising Head)



DATA SET:
3-1r.dat
06/23/95

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
15 NOV 94

ESTIMATED PARAMETERS:
K = 0.009007 ft/min
y0 = 0.9472 ft

TEST DATA:
H0 = 1.744 ft
rc = 0.083 ft
rw = 0.3 ft
L = 7. ft
b = 9.5 ft
H = 9.41 ft

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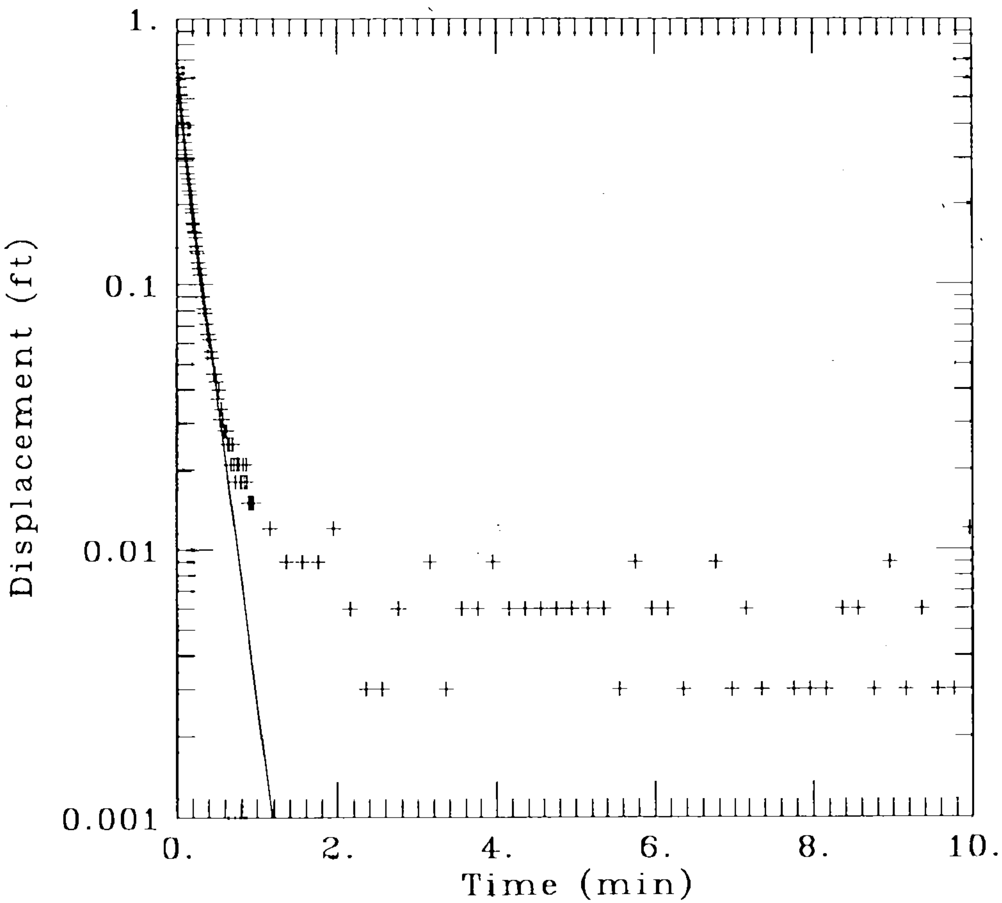
Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM8070	Location: Niagara Falls IAP-ARS Site 3

MW 3-1D (Rising Head)



DATA SET:
3-1DR.DAT
11/30/94

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice
TEST DATE:
14 NOV 94

ESTIMATED PARAMETERS:
K = 0.004804 ft/min
y0 = 0.5591 ft

TEST DATA:
H0 = 0.653 ft
rc = 0.125 ft
rw = 0.25 ft
L = 28. ft
b = 41.55 ft
H = 25.17 ft

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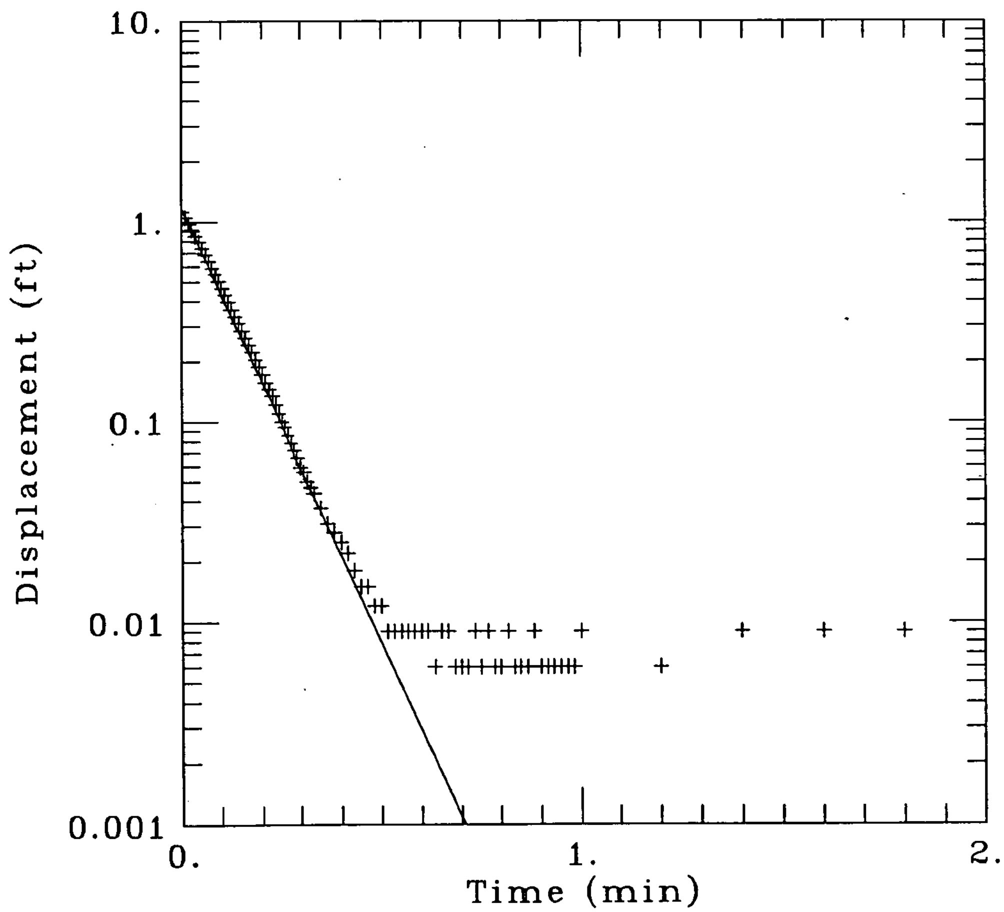
Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM9022	Location: Niagara Falls IAP-ARS Site 3

MW 3-1E (Rising Head)



DATA SET:
3-1er.dat
06/15/95

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice
TEST DATE:
29 MAR 95

ESTIMATED PARAMETERS:
K = 0.01287 ft/min
y0 = 1.157 ft

TEST DATA:
H0 = 1.125 ft
rc = 0.083 ft
rw = 0.167 ft
L = 10. ft
b = 44. ft
H = 43.33 ft

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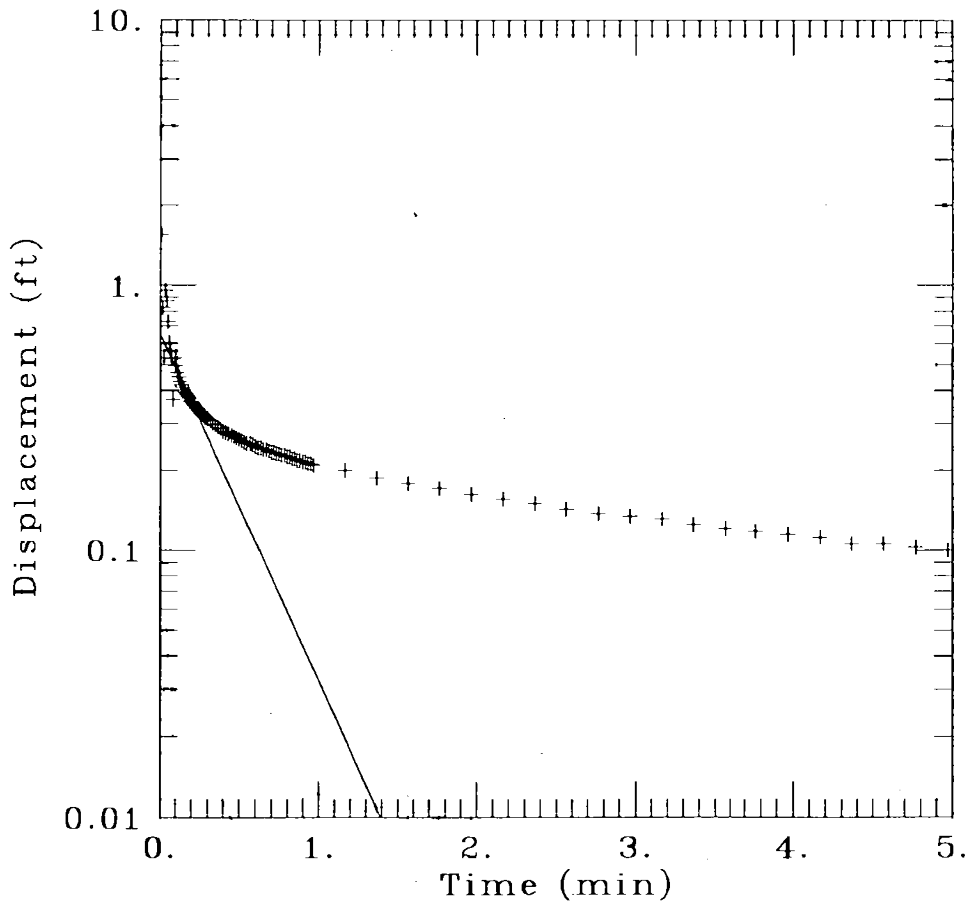
Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM8070	Location: Niagara Falls IAP-ARS Site 3

MW 3-2 (Falling Head)



DATA SET:
3-2f.dat
06/23/95

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
15 NOV 94

ESTIMATED PARAMETERS:
K = 0.003443 ft/min
y0 = 0.655 ft

TEST DATA:
H0 = 2.003 ft
rc = 0.083 ft
rw = 0.3 ft
L = 6.1 ft
b = 7.1 ft
H = 6.05 ft

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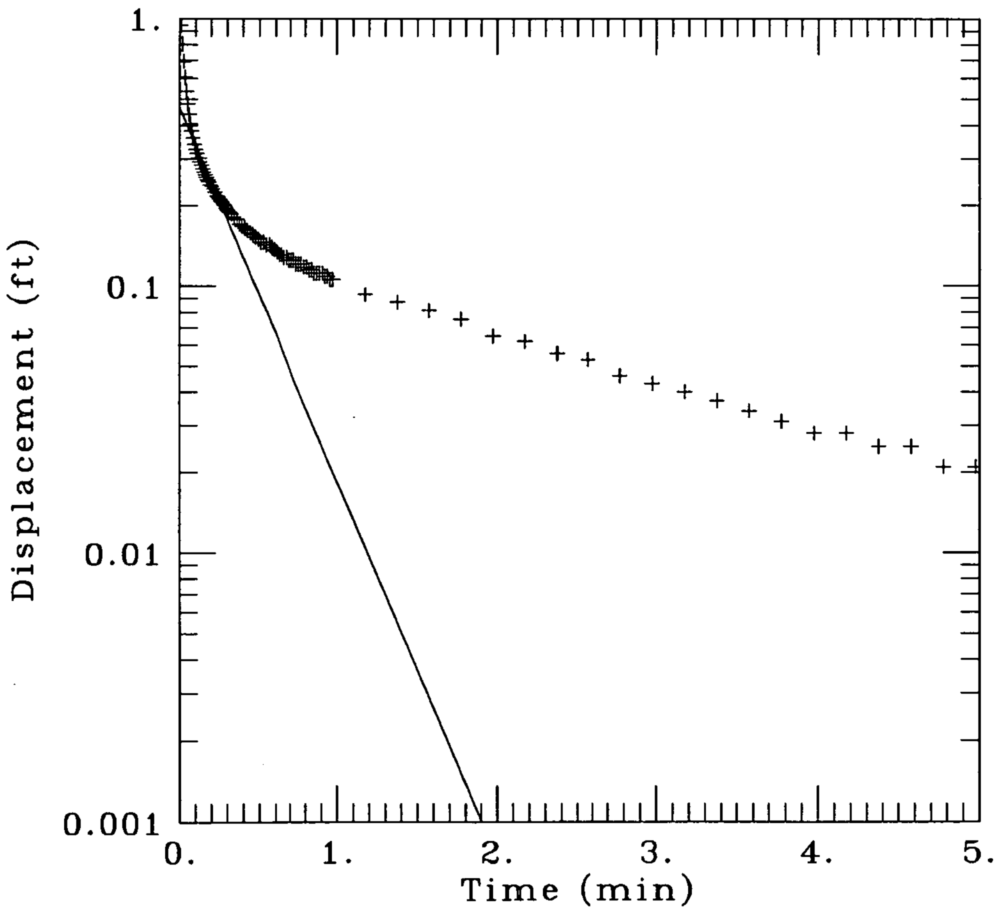
Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM8070	Location: Niagara Falls IAP-ARS Site 3

MW 3-2 (Rising Head)



DATA SET:
3-2r.dat
06/23/95

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice
TEST DATE:
15 NOV 94

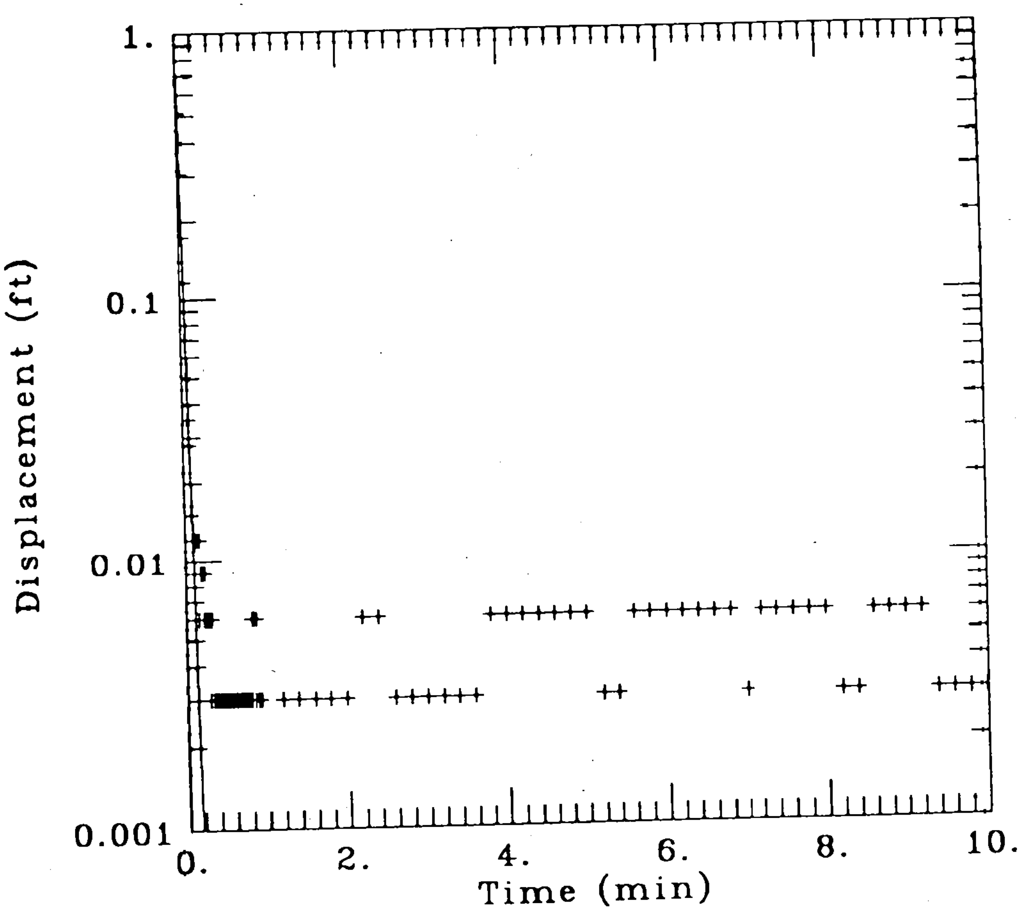
ESTIMATED PARAMETERS:
K = 0.003695 ft/min
y0 = 0.4624 ft

TEST DATA:
H0 = 1.156 ft
rc = 0.083 ft
rw = 0.3 ft
L = 6.1 ft
b = 7.1 ft
H = 6.05 ft

DRAFT

Ecology & Environment, Inc.	Client: **USAFRES 914th Airlift Wing**
Project No.: NM8070	Location: **Niagara Falls IAP-ARS Site 3**

MW 3-2D (Falling Head)



DATA SET:
3-2df.dat
12/01/94

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice
TEST DATE:
15 NOV 94

ESTIMATED PARAMETERS:
K = 0.01785 ft/min
y0 = 0.8268 ft

TEST DATA:
H0 = 0.515 ft
rc = 0.083 ft
rw = 0.25 ft
L = 26.3 ft
b = 43.36 ft
H = 25.02 ft

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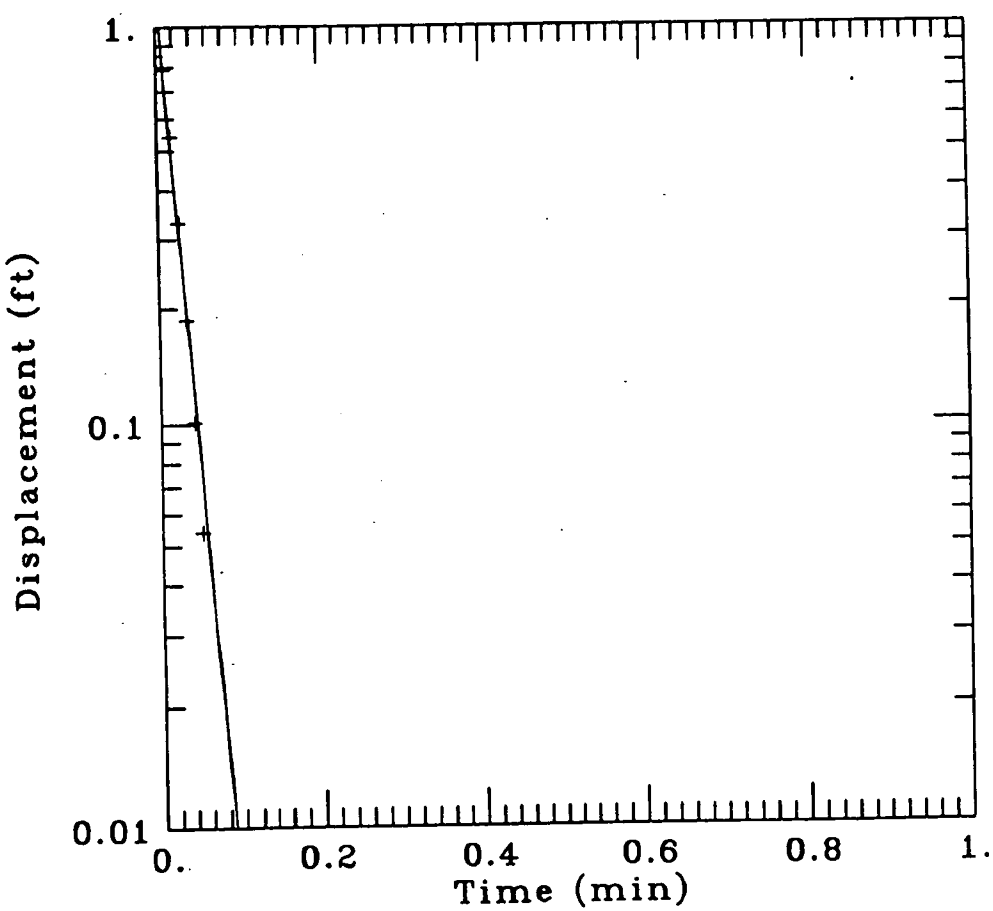
Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM8070	Location: Niagara Falls IAP–ARS Site 3

MW 3–2D (Rising Head)



DATA SET:
3-2dr.dat
12/01/94

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
15 NOV 94

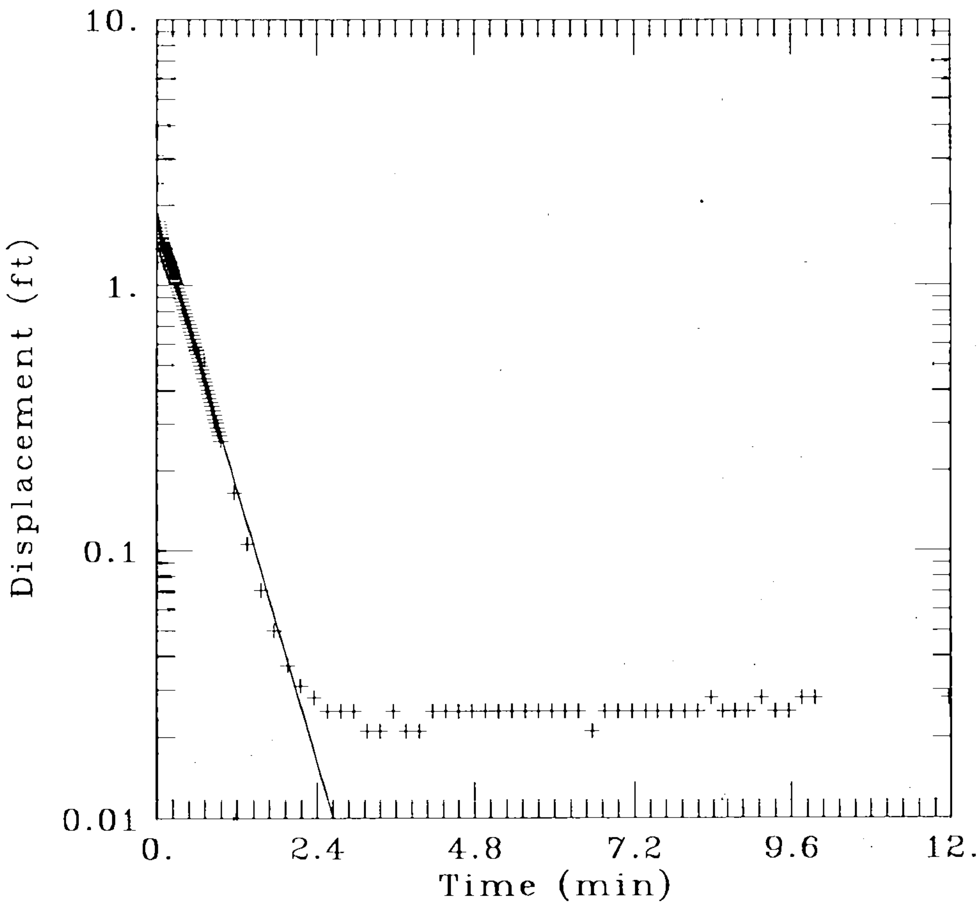
ESTIMATED PARAMETERS:
K = 0.02354 ft/min
y0 = 1.288 ft

TEST DATA:
H0 = 0.85 ft
rc = 0.083 ft
rw = 0.25 ft
L = 26.3 ft
b = 43.36 ft
H = 25.02 ft

DRAFT

Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM8070	Location: Niagara Falls IAP-ARS Site 3

MW 3-3 (Falling Head)



DATA SET:
3-3f.dat
11/30/94

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice
TEST DATE:
15 NOV 94

ESTIMATED PARAMETERS:
K = 0.002805 ft/min
y0 = 1.772 ft

TEST DATA:
H0 = 3.076 ft
rc = 0.083 ft
rw = 0.3 ft
L = 5. ft
b = 9. ft
H = 8.02 ft

E-11

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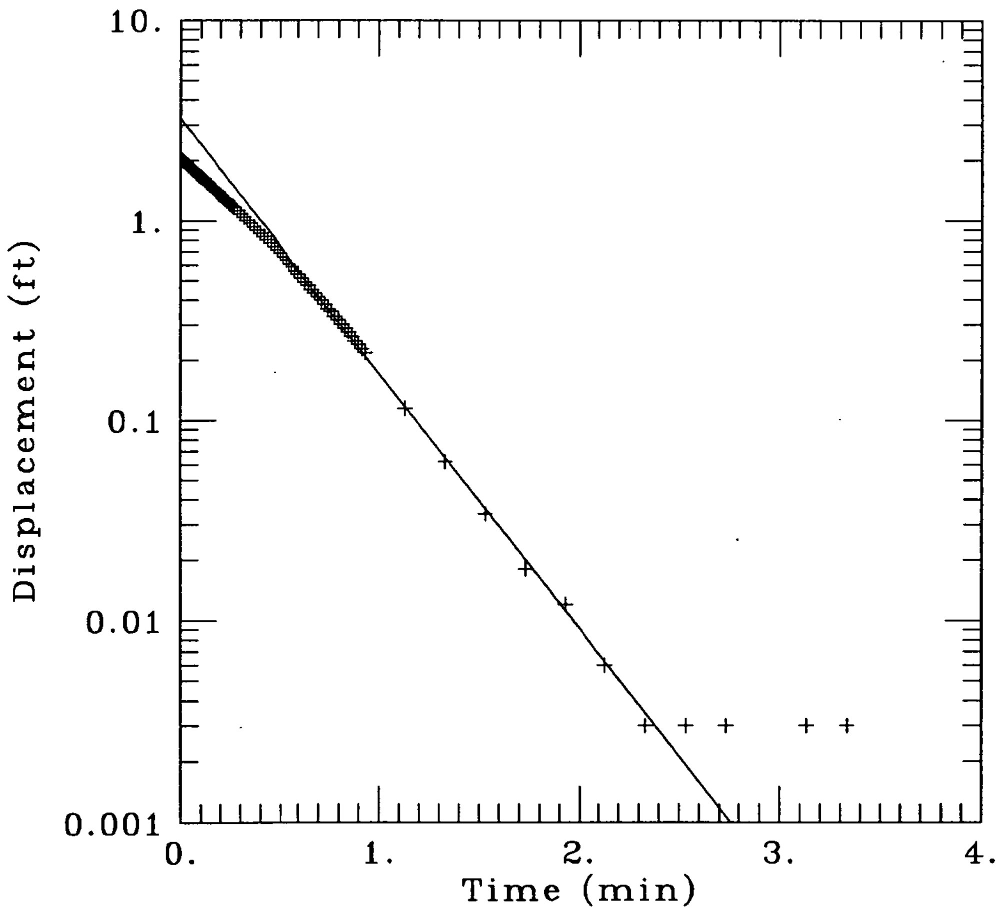
Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM8070	Location: Niagara Falls IAP-ARS Site 3

MW 3-3 (Rising Head)



DATA SET:
3-3r.dat
06/15/95

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice
TEST DATE:
15 NOV 94

ESTIMATED PARAMETERS:
K = 0.004201 ft/min
y0 = 3.235 ft

TEST DATA:
H0 = 2.04 ft
rc = 0.083 ft
rw = 0.3 ft
L = 5. ft
b = 9. ft
H = 8.02 ft

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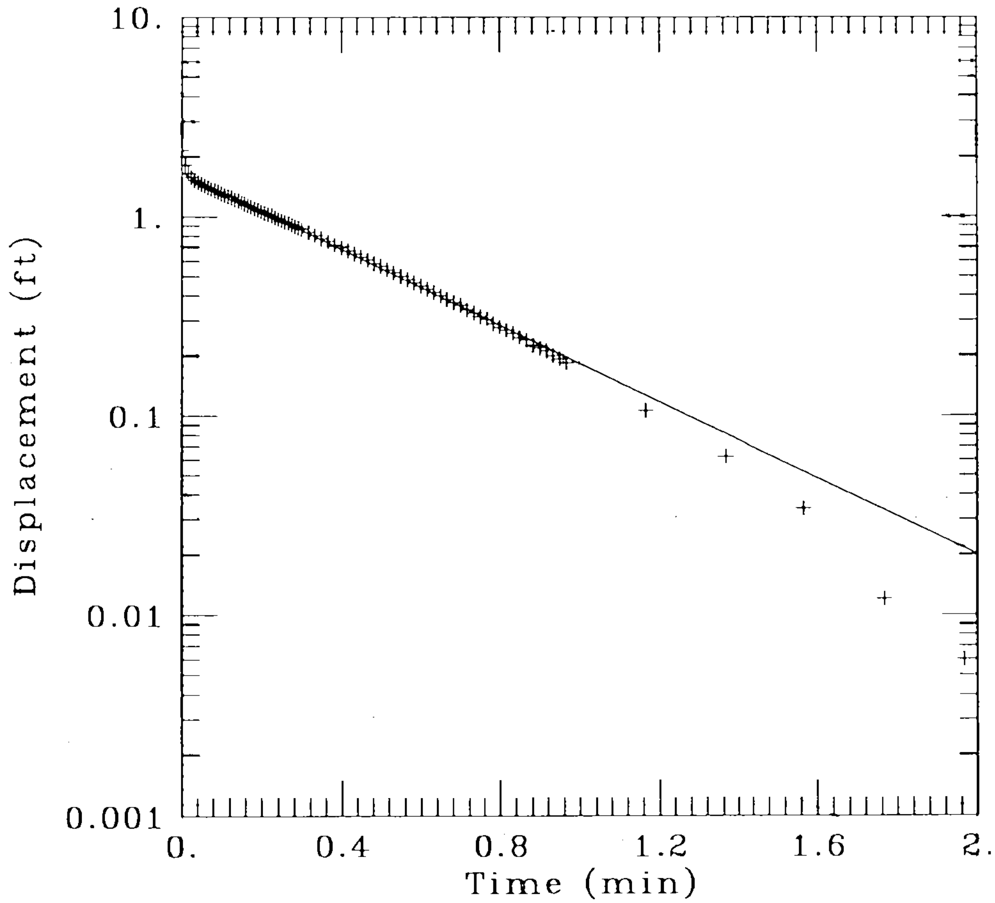
Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM8070	Location: Niagara Falls IAP-ARS Site 3

MW 3-3D (Rising Head)



DATA SET:
3-3dr.dat
11/30/94

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
14 NOV 94

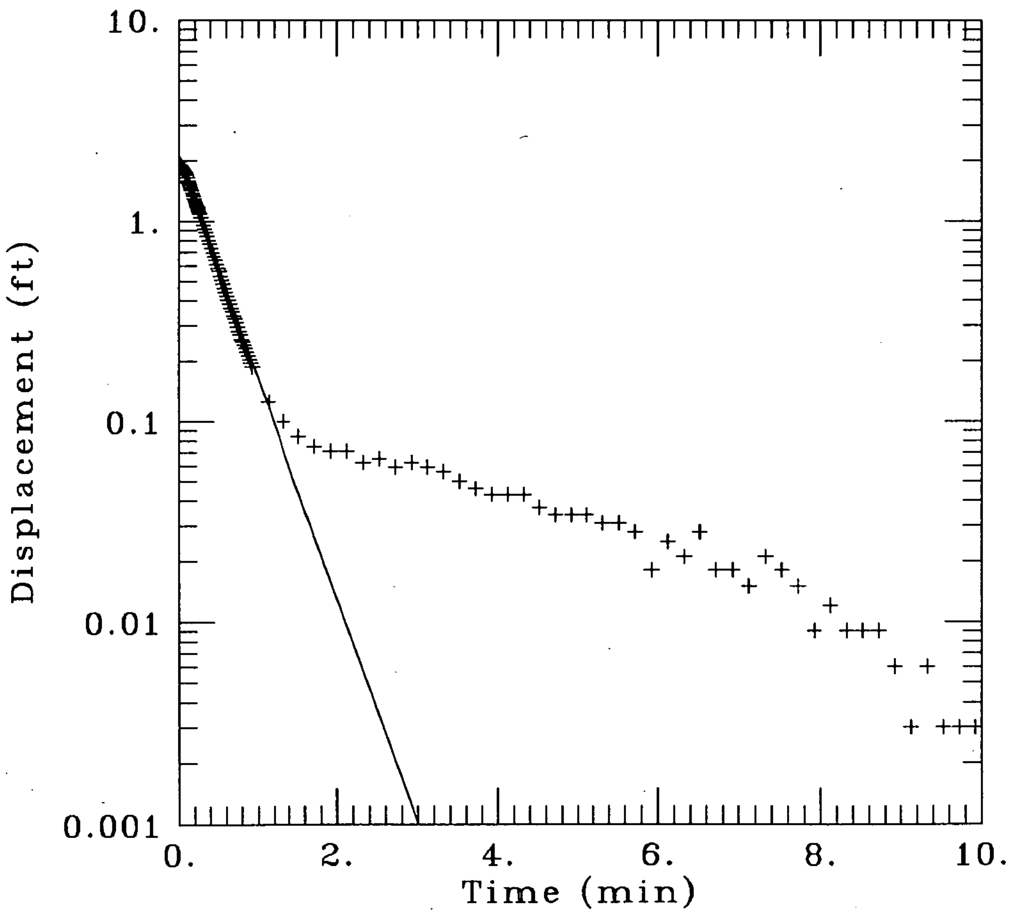
ESTIMATED PARAMETERS:
K = 0.0009888 ft/min
y0 = 1.658 ft

TEST DATA:
H0 = 2.154 ft
rc = 0.083 ft
rw = 0.25 ft
L = 25.9 ft
b = 49.39 ft
H = 33.78 ft

DRAFT

Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM8070	Location: Niagara Falls IAP-ARS Site 3

MW 3-4 (Falling Head)



DATA SET:
3-4f.dat
11/30/94

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice
TEST DATE:
14 NOV 94

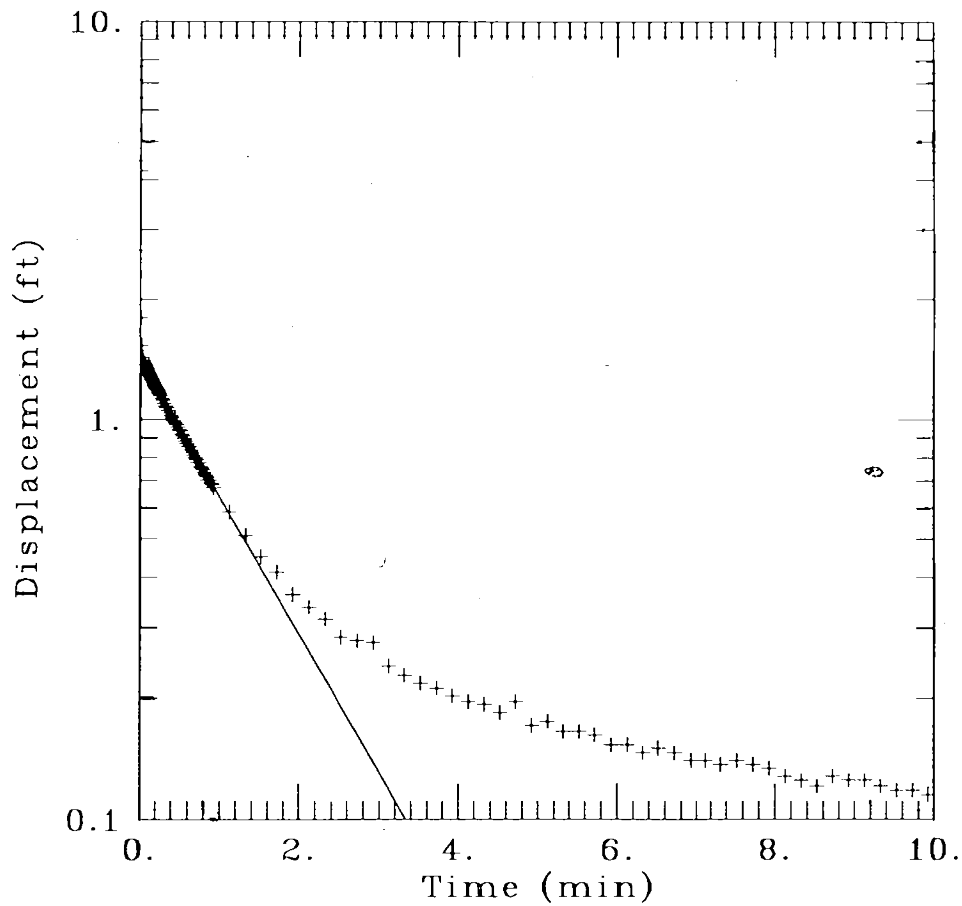
ESTIMATED PARAMETERS:
K = 0.003598 ft/min
y0 = 2.076 ft

TEST DATA:
H0 = 1.978 ft
rc = 0.083 ft
rw = 0.3 ft
L = 5. ft
b = 8. ft
H = 7.25 ft

DRAFT

Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM8070	Location: Niagara Falls IAP-ARS Site 3

MW 3-4 (Rising Head)



DATA SET:
3-4r.dat
11/30/94

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice
TEST DATE:
14 NOV 94

ESTIMATED PARAMETERS:
K = 0.001121 ft/min
y0 = 1.405 ft

TEST DATA:
H0 = 4.209 ft
rc = 0.083 ft
rw = 0.3 ft
L = 5. ft
b = 8. ft
H = 7.25 ft

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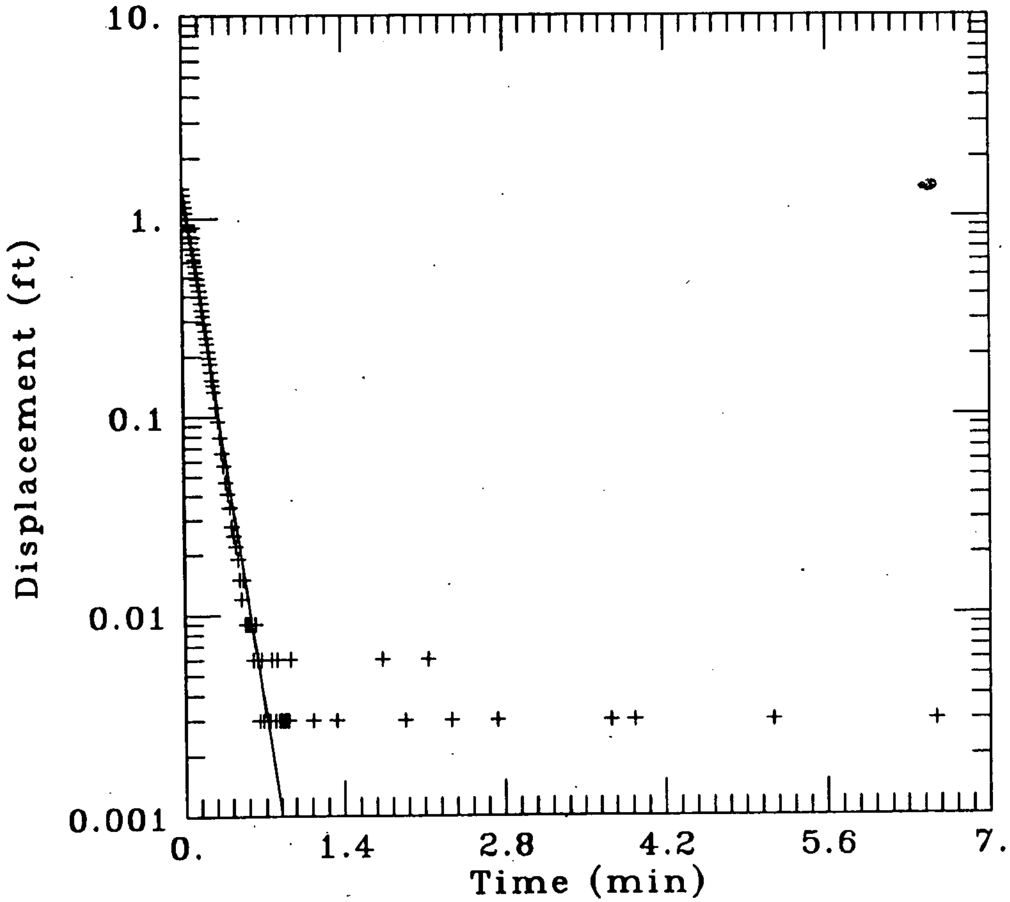
Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM8070	Location: Niagara Falls IAP-ARS Site 3

MW 3-4D (Rising Head)



DATA SET:
3-4dr.dat
12/01/94

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice
TEST DATE:
14 NOV 94

ESTIMATED PARAMETERS:
K = 0.004162 ft/min
y0 = 1.427 ft

TEST DATA:
H0 = 1.408 ft
rc = 0.085 ft
rw = 0.2 ft
L = 26. ft
b = 44.98 ft
H = 29.28 ft

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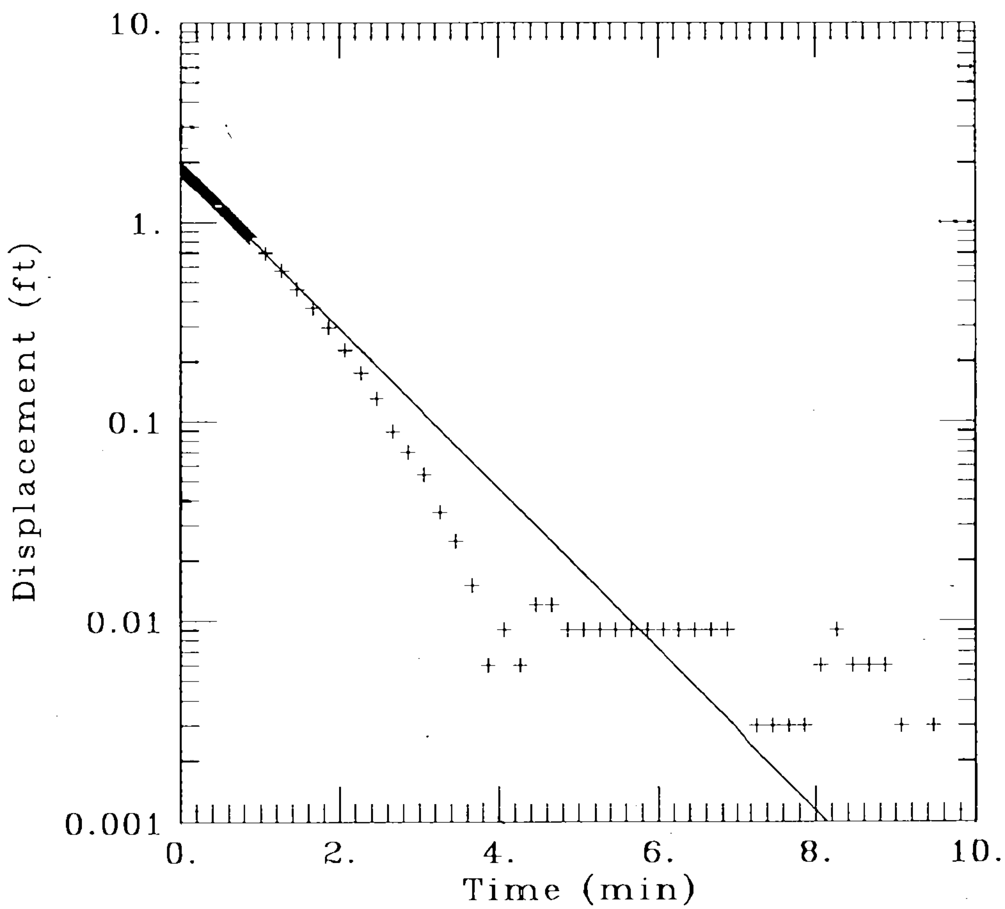
Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM8070	Location: Niagara Falls IAP-ARS Site 3

MW 3-5A (Falling Head)



DATA SET:
3-5af.dat
11/30/94

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice
TEST DATE:
14 NOV 94

ESTIMATED PARAMETERS:
K = 0.001182 ft/min
y0 = 1.859 ft

TEST DATA:
H0 = 2.345 ft
rc = 0.083 ft
rw = 0.4 ft
L = 5. ft
b = 7. ft
H = 6.72 ft

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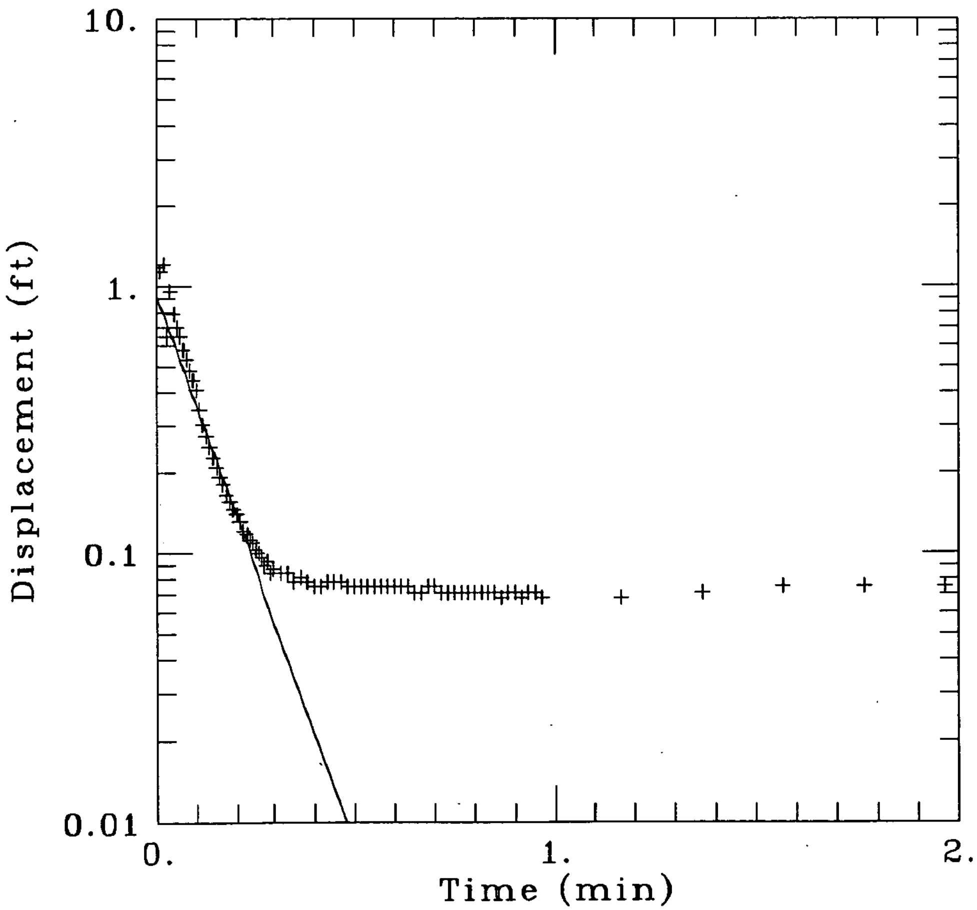
Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM8070	Location: Niagara Falls IAP-ARS Site 3

MW 3-6A (Falling Head)



DATA SET:
3-6af.dat
06/19/95

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice
TEST DATE:
14 NOV 94

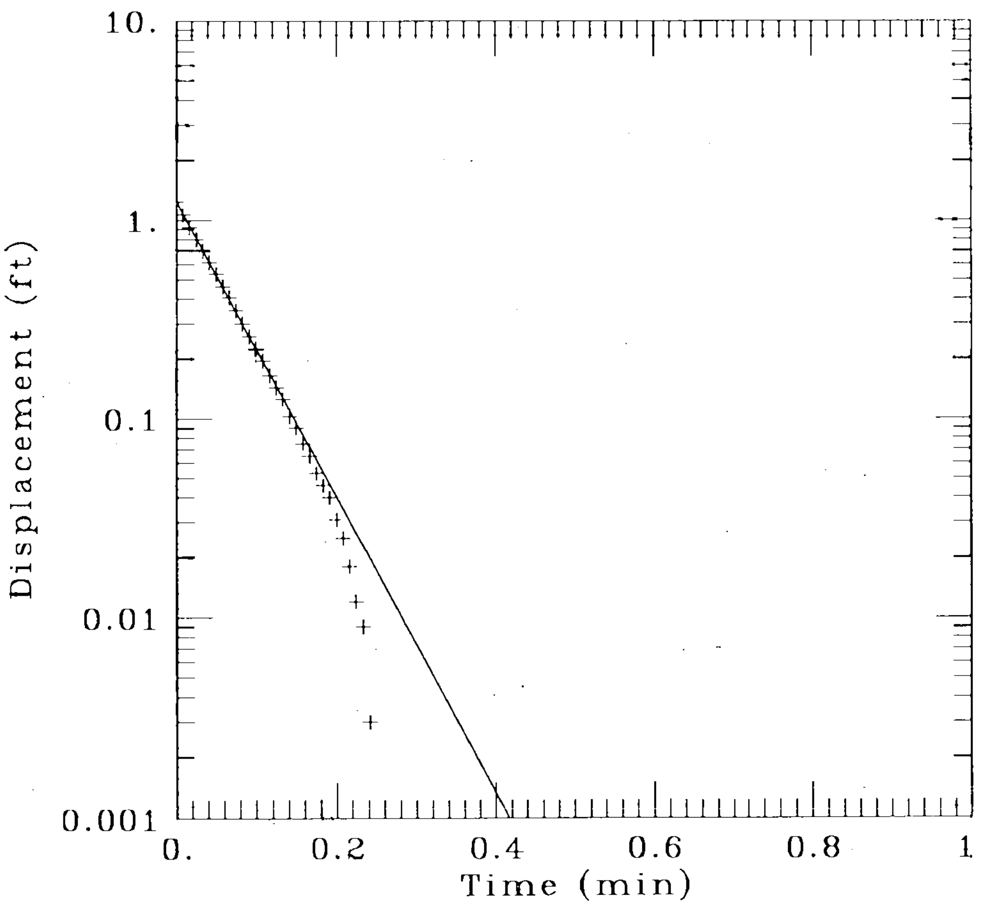
ESTIMATED PARAMETERS:
K = 0.0112 ft/min
y0 = 0.914 ft

TEST DATA:
H0 = 1.181 ft
rc = 0.083 ft
rw = 0.4 ft
L = 5. ft
b = 6.92 ft
H = 6.06 ft

DRAFT

Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM8070	Location: Niagara Falls IAP–ARS Site 3

MW 3–6A (Rising Head)



DATA SET:
3-6ar.dat
11/30/94

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
14 NOV 94

ESTIMATED PARAMETERS:
K = 0.02033 ft/min
y0 = 1.231 ft

TEST DATA:
H0 = 1.24 ft
rc = 0.083 ft
rw = 0.4 ft
L = 5. ft
b = 6.92 ft
H = 6.06 ft

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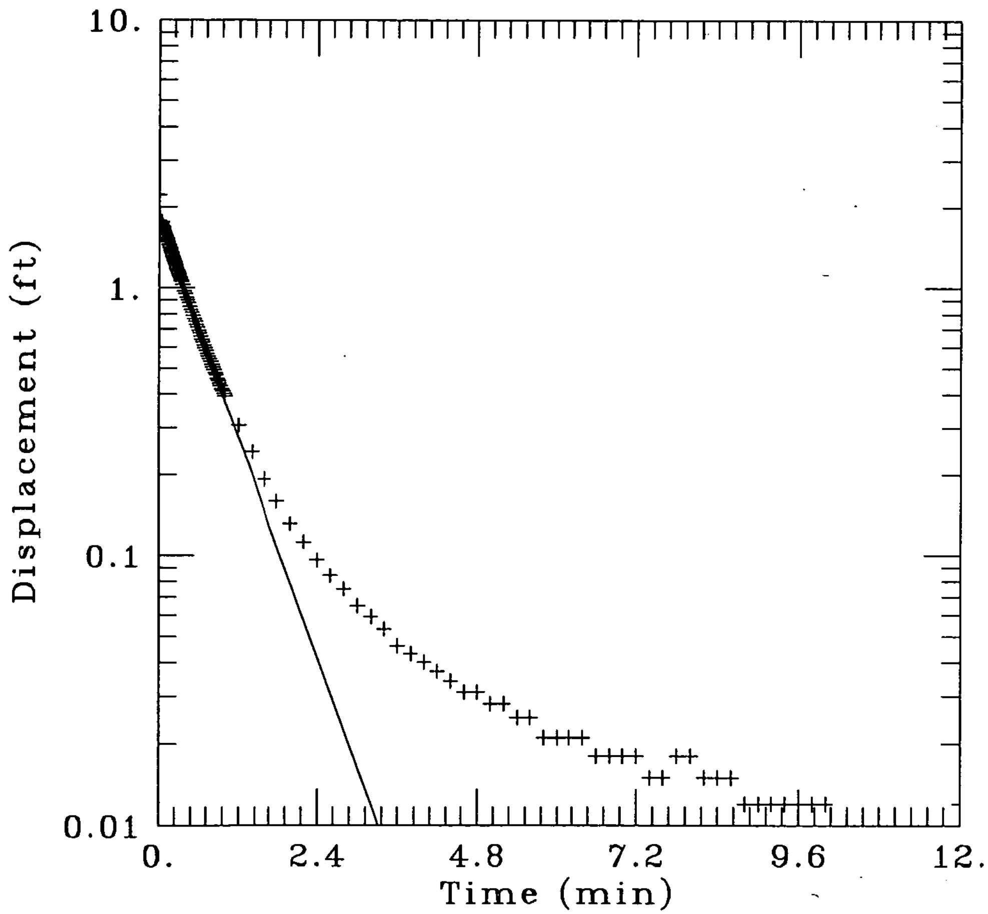
Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM9022	Location: Niagara Falls IAP-ARS Site 3

MW 3-6D (Falling Head)



DATA SET:
3-6DF.DAT
04/06/95

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
29 MAR 95

ESTIMATED PARAMETERS:
K = 0.002325 ft/min
y0 = 1.806 ft

TEST DATA:
H0 = 2.227 ft
rc = 0.083 ft
rw = 0.167 ft
L = 7. ft
b = .15. ft
H = 14.2 ft

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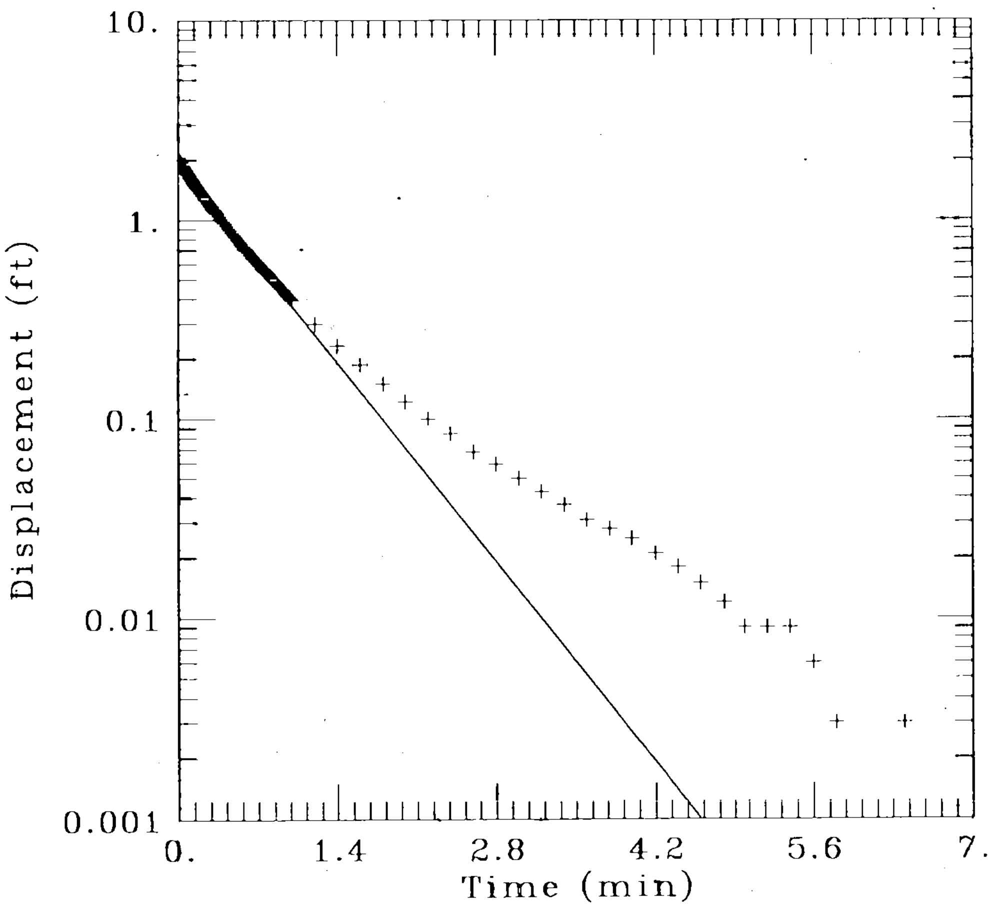
Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM9022	Location: Niagara Falls IAP-ARS Site 3

MW 3-6D (Rising Head)



DATA SET:
3-6DR.DAT
04/06/95

AQUIFER TYPE:
Unconfined
SOLUTION METHOD:
Bouwer-Rice
TEST DATE:
29 MAR 95

ESTIMATED PARAMETERS:
K = 0.002434 ft/min
y0 = 1.897 ft

TEST DATA:
H0 = 2.055 ft
rc = 0.083 ft
rw = 0.167 ft
L = 7. ft
b = 15. ft
H = 14.2 ft

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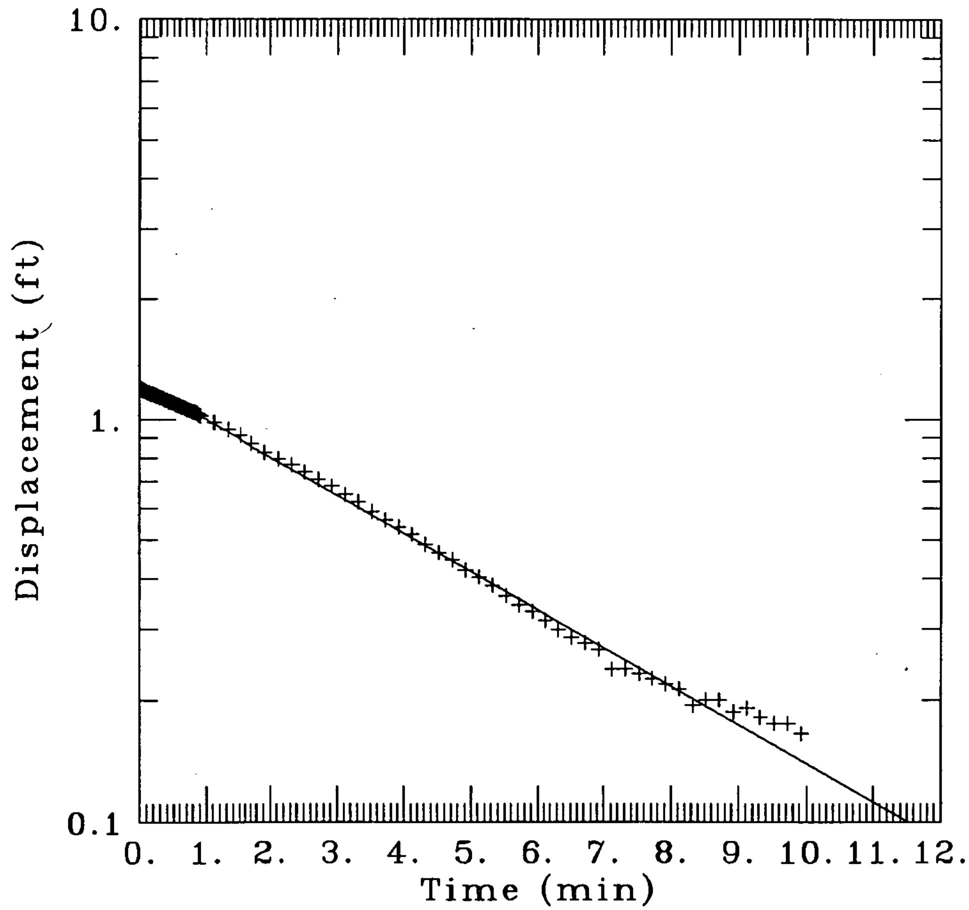
Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM8070	Location: Niagara Falls IAP-ARS Site 3

MW 3-7 (Falling Head)



DATA SET:
3-7f.dat
06/15/95

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

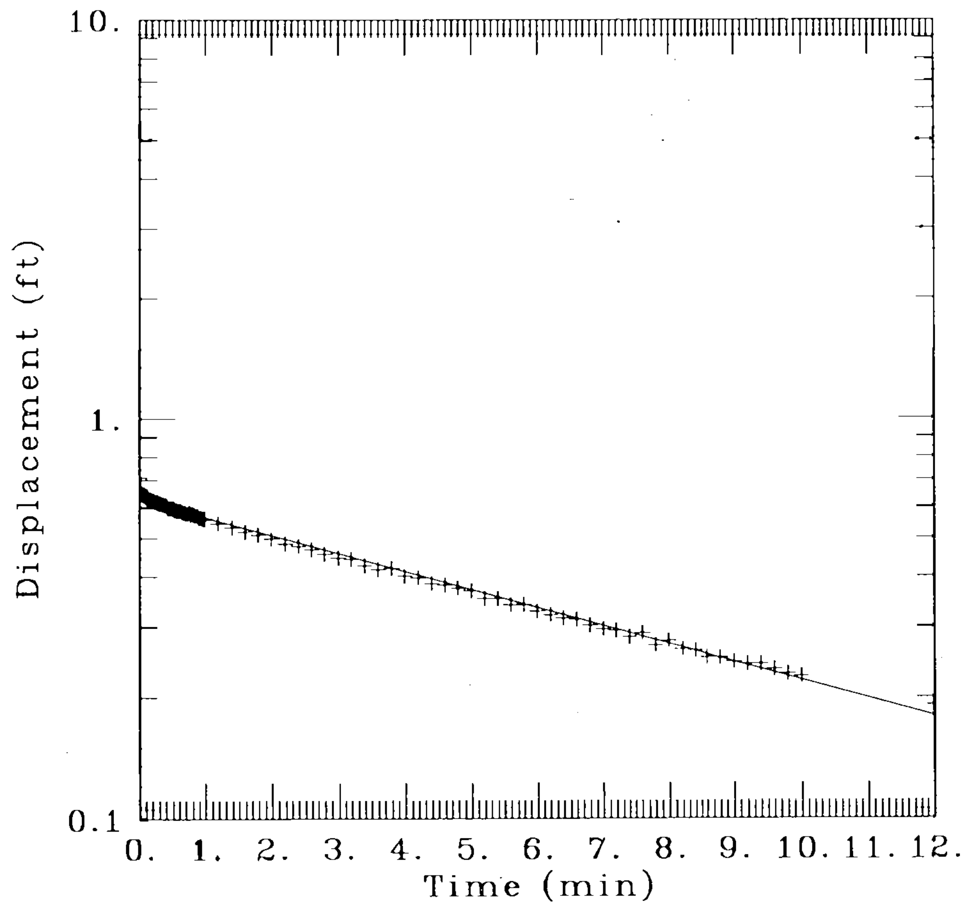
TEST DATE:
14 NOV 94

ESTIMATED PARAMETERS:
K = 0.0003568 ft/min
y0 = 1.246 ft

TEST DATA:
H0 = 1.207 ft
rc = 0.083 ft
rw = 0.4 ft
L = 2.5 ft
b = 4.37 ft
H = 3.3 ft

Ecology & Environment, Inc.	Client: USAFRES 914th Airlift Wing
Project No.: NM8070	Location: Niagara Falls IAP–ARS Site 3

MW 3–7 (Rising Head)



DATA SET:
3-7r.dat
06/15/95

AQUIFER TYPE:
Unconfined

SOLUTION METHOD:
Bouwer-Rice

TEST DATE:
14 NOV 94

ESTIMATED PARAMETERS:
K = 0.0001692 ft/min
y0 = 0.6228 ft

TEST DATA:
H0 = 0.71 ft
rc = 0.083 ft
rw = 0.4 ft
L = 2.5 ft
b = 4.37 ft
H = 3.3 ft