

REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

at the

GRATWICK-RIVERSIDE PARK SITE

NIAGARA COUNTY, NEW YORK

PART I REMEDIAL INVESTIGATION

SITE # 932060



Prepared for :

NEW YORK STATE
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

50 Wolf Road, Albany, New York 12233

Thomas C. Jorling — Commissioner

DIVISION OF HAZARDOUS WASTE REMEDIATION

Michael J. O'Toole, Jr., P.E. — Acting Director

URS Consultants, Inc.

570 Delaware Avenue
Buffalo, New York 14202

MARCH 1991

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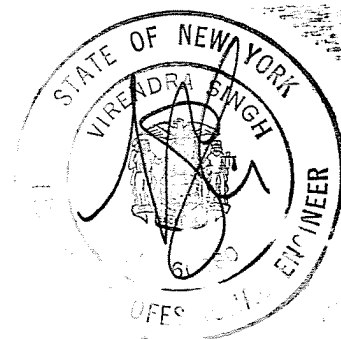
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PART I

REMEDIAL INVESTIGATION
FOR
GRATWICK-RIVERSIDE PARK

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Appendix G has been appended to the Feasibility Study volume.

EXECUTIVE SUMMARY

PART I - REMEDIAL INVESTIGATION

The Gratwick-Riverside Park site is a 53-acre parcel of land located between the Niagara River and River Road in the City of North Tonawanda, Niagara County, New York. The site is leased by the City of North Tonawanda from Niagara Mohawk Corporation, owner of the property since the 1950's. The site consists of mixed fill which was dumped into and adjacent to the Niagara River and includes municipal and industrial wastes, incinerator ash, road construction debris, molding sand, and metal and fiber drums. The landfill was closed in 1968 and subsequently graded, covered and grassed. In 1969 the site was reopened by the City as a park.

The site is located in an area zoned as general industrial. A sewage treatment plant lies to the south of the site, an automobile wreckers yard to the east and the Niagara County Refuse Disposal - Wheatfield Hazardous Waste Site (National Priorities List) to the northwest. The Niagara River bounds the site on its western edge.

Wastes suspected to have been deposited at the site include metallurgical sludge, municipal waste, phenolic resins, phenolic molding compounds, oil and grease, incinerator ash, chlorinated organic pesticides, and slag. As a consequence of waste deposition, the site is known or suspected to be contaminated with polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds, heavy metals, phenols and PCBs.

The primary purpose of the Remedial Investigation was to define the existing geologic and hydrologic conditions at the site, identify the extent of contamination and modes of contaminant transport, and evaluate the potential impact of the site upon public health given its use as a

public park, and the environment in particular the Niagara River. Accomplishment of these objectives involved completion of the following:

- o review and evaluation of existing data and information concerning the site from previous investigations
- o development of Health/Safety and Work/Quality Assurance Plans prior to the initiation of onsite activities
- o development of a topographic base map of the site, and field survey to determine the locations and elevations of all data points
- o performance of detailed geophysical studies of the site using the techniques of seismic refraction and magnetic surveys
- o excavation of backhoe test pits to evaluate the possibility of buried metallic objects
- o installation of soil borings and groundwater monitoring wells
- o performance of slug tests in the monitoring wells to determine hydraulic conductivities
- o performance of organic vapor screening tests on soil samples obtained during boring operations to determine the vertical extent of soil contamination
- o collection of soil samples from the borings for detailed laboratory analyses on physical properties

- o collection of water level measurements in monitoring wells and stream water to determine horizontal flow directions and vertical hydraulic gradients in the overburden
- o performance of two 24-hour monitoring level events in order to assess the presence of a flow reversal between the Niagara River and the site
- o collection of groundwater samples from monitoring wells during two rounds, for field measurements and detailed laboratory chemical analyses
- o collection of surface water samples both on and offsite during two rounds, for detailed laboratory chemical analyses
- o collection of soil samples onsite from the test pits, surficial soil, subsurface soil, and shoreline soil for detailed laboratory chemical analyses.

Several distinct stratigraphic units were identified as being present at the site: a 9-20 foot thick fill layer; discontinuous lacustrine silty sand and silt and clay layers; a 20 foot thick till layer; and bedrock. The upper aquifer is comprised of the fill and lacustrine silty sand units which are hydraulically connected. The saturated thickness of this aquifer is approximately 10 feet; measured hydraulic conductivity values for the aquifer averaged (arithmetic average) greater than 2.3×10^{-3} cm/sec. The confining unit consists of the till and lacustrine silt and clay units. Measured hydraulic conductivities for the confining unit averaged 4.8×10^{-7} cm/sec. Measurements of hydraulic conductivity were taken in the upper 10 feet of the bedrock. Measurements averaged 7.4×10^{-3} cm/sec and are indicative of the fractured zone of bedrock.

Groundwater elevation data indicates that flow in the upper aquifer is primarily towards the Niagara River. However, high water levels in the river during night-time hours result in flow reversal near the shoreline. A small, intermittent stream and drainage ditches near the site are the only other surface water systems in the vicinity. Downward gradients prevail across the site indicating that there is slow but steady flow to the underlying confining unit. The permeability of the confining unit is such that there is little, if any, flow through it to the bedrock.

Soil at the site is primarily contaminated in the fill with semi-volatile organic compounds (SVOCs), mainly PAHs, approximately 10 to 15 feet below the surface. Shoreline soil was found to contain lower levels of SVOCs than surficial soil. However, the contamination of the shoreline soil appears to be concentrated in areas where drum removal has occurred.

Surface water on the site does not appear to contain contaminant levels that would cause concern.

There appears to be an increase in the number and concentration of organics in the upper aquifer as it passes below the site. Organic compounds are present at much lower concentrations and frequency in the bedrock aquifer than in the upper aquifer. The presence of contamination in the bedrock aquifer needs to be assessed with continued monitoring. It also appears that groundwater contamination is primarily located in the central portion of the site, specifically in wells GW-7S and GW-9S. The number and concentration of organics in the monitoring wells located on the perimeter of the site are much lower than in these two wells.

A baseline health risk assessment was performed to determine the impact of the site contaminants in the absence of remedial measures. In terms of noncarcinogenic effects, the site is unlikely to pose a long-term health risk to exposed populations. When representative concentrations are utilized, the carcinogenic risk is $64.9\text{E-}06$ or over an order of magnitude

greater than the commonly used benchmark of $1.0\text{E}-06$ (i.e. one excess cancer death per one million population). When worst-case concentrations are used, the carcinogenic risk is $713\text{E}-06$ or over two orders of magnitude greater than the commonly used benchmark of $1.0\text{E}-06$. Under both representative and worst-case conditions, 100 percent of the carcinogenic risk results from direct exposure (soil ingestion or dermal contact) to surficial soil during recreational activities.

The primary potential environmental impact of the site is upon the Niagara River. Contaminants from the site are discharged to the river via groundwater and erosion of shoreline and onsite surficial soil. It is estimated that approximately 2.6 pounds/day of TCL organic compounds and 2.0 pounds/day of metals are discharged to the Niagara River by groundwater passing below the site. These values are comparable to the estimate of toxics loading to the Niagara River (1.3 lb/day) from the Gratwick Riverside Park by the USEPA and NYSDEC (Report on Reduction of Toxic Loadings to the Niagara River from Hazardous Waste Sites in the United States, USEPA and NYSDEC, November 1989). Additional contaminant loading to the Niagara River may be caused by erosion of shoreline soils. Erosion of surficial and shoreline soil is of concern due to the presence of PAHs and PCBs in the soil.

PART II FEASIBILITY STUDY

Based upon the results of the Remedial Investigation, the following remedial objectives were established for the Gratwick site:

- (1) Prevent direct human contact with on-site surface soils thereby reducing the total incremental health risk;
- (2) Prevent erosion of contaminated on-site surficial and shoreline soil from the Gratwick site into the Niagara River;
- (3) Limit the migration of contaminated groundwater from the site into the Niagara River based on the findings of the "Reduction of Toxic Loadings to the Niagara River from Hazardous Waste Sites in the United States" Report; and
- (4) Reduce contaminant levels in the groundwater in order to achieve groundwater standards.

The extent of contamination to which remedial measures should be applied was determined to be the entire 53 acres of the site extending the depth of the fill layer, an average of 15 feet.

Remedial technologies and process options applicable to the site were identified, screened, and combined into a number of remedial alternatives for evaluation. The remedial alternatives span a range of general response actions including no action, institutional action, containment, physical controls, excavation/removal, collection and treatment.

In order to facilitate an evaluation of alternatives, two separate three-dimensional groundwater flow models of the Gratwick site and vicinity were developed. The models utilized infiltration rates, calculated independently using a water balance analysis, to evaluate groundwater flow

relationships under both existing and modified conditions associated with the implementation of potential remedial alternatives.

From the numerous alternatives studied, the following were selected for detailed evaluation and cost analysis:

Alternative 1 - No Action

Alternative 2 - Institutional Action

Alternative 3 - Sheetpile breakwater, multi-layered cap with synthetic geomembrane (MSG), withdrawal wells, groundwater pretreatment.

Alternative 4 - Sheetpile breakwater, slurry wall, MSG cap, withdrawal wells, groundwater pretreatment.

Alternative 5 - Sheetpile breakwater, slurry wall, soil cap, withdrawal wells, groundwater pretreatment.

Alternative 6 - Sheetpile breakwater, soil cap, withdrawal wells, groundwater pretreatment.

The above alternatives were evaluated in detail using the NYSDEC scoring system (TAGM HWR-89-40305, NYSDEC, 1989) utilizing the following criteria:

- (1) Short-term impacts and effectiveness
- (2) Long-term effectiveness and permanence
- (3) Reduction in toxicity, mobility and volume of hazardous waste
- (4) Implementability
- (5) Compliance with New York State Standards, Criteria and Guidance
- (6) Overall protection of human health and the environment
- (7) Cost

Based on the evaluation of alternatives, the selected remedial approach for the Gratwick site is Alternative 6 - Sheetpile breakwater, soil cap, withdrawal wells, and groundwater pretreatment. With respect to cost, Alternative 6 at \$18,110,000 had the lowest cost when compared to Alternatives 3, 4, and 5 which ranged from \$19,980,000 to \$22,160,000. Alternatives 1 and 2 were determined to be ineffective and therefore not considered in the final analysis.

A conceptual design and preliminary site layout are presented in the final section of the Feasibility Study, along with a listing of additional investigations which will be necessary during the design phase.

1.0 INTRODUCTION

1.1 Site Background

1.1.1 General Description

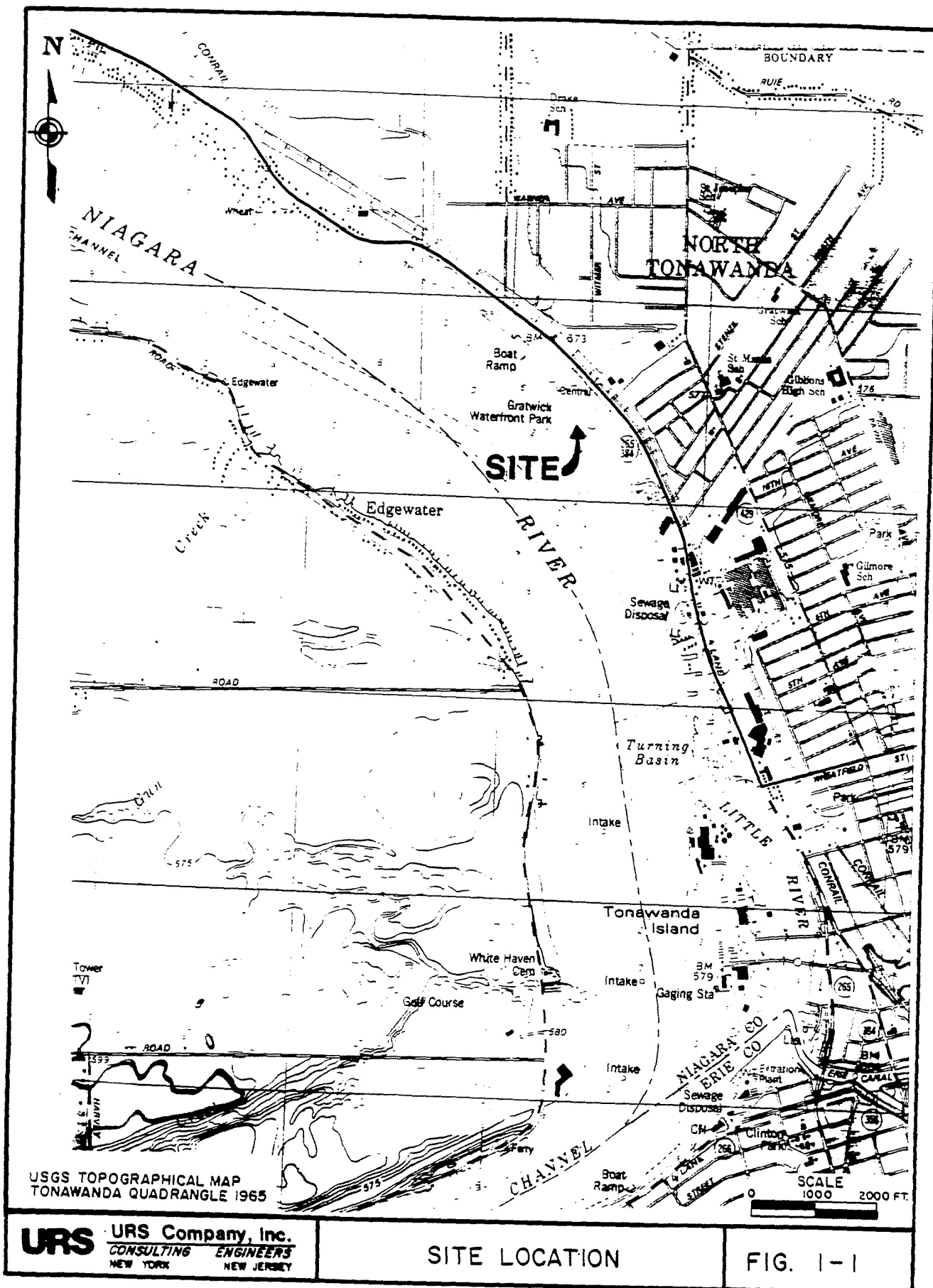
Gratwick-Riverside Park is a 53-acre parcel of land located between the Niagara River and River Road in the City of North Tonawanda, Niagara County, New York at latitude 43° 03' longitude 78° 54' (Figure 1-1). As stated in the deed, the property includes parts of Lot Nos. 69, 70, 71, and 72, Mile Reservation. This location is about 3 miles south of the City of Niagara Falls and 7 miles north of Buffalo. The site is leased by the City of North Tonawanda from Niagara Mohawk Power Corporation, owner of the property since the late 1950s, and is currently used as a public park.

The site is basically "made land", consisting of mixed fill that was dumped into and adjacent to the Niagara River. The mixed fill includes municipal and industrial wastes, incinerator ash, road construction debris and molding sand.

Relief is low, being generally confined to small, irregularly distributed mounds of construction debris (3 to 4 feet high) in the southeastern portion of the site, shallow depressions and "potholes" (1 to 2 feet deep) attributed to settlement in the site's central portion, and the river bank (5 to 10 feet above water level) along the south edge.

1.1.2 Site History

The following site history is based upon a review of information provided by the New York State Department of Environmental Conservation (NYSDEC), and the results of a limited property title search.



A-2589

Available information respecting site ownership history is summarized in Table 1-1.

Very little information is available on use of the site prior to about 1957. Early aerial photographs of the property dated 1938, 1951, 1966, 1968, 1969, and 1975, were examined to determine the sequence of land development/expansion as a result of waste disposal activities. Based on aerial photographs the bulk of landfilling appears to have occurred between 1938 and 1968, the shoreline configuration having changed most notably during these years.

Based on available boring logs, most of the site is underlain by a slag-like material. Although the source of this slag is not currently known, one possible source is the Tonawanda Iron Corporation, which was located about one-half mile south of the site until it went out of business in the 1960s. The site was used by the City of North Tonawanda for municipal waste disposal in the early 1960s. Waste types were reported to have included municipal incineration residue, garbage and general refuse; wastes were covered biweekly with incinerator ash, road construction debris or molding sand. Open burning of refuse was reportedly frequent.

According to the Report of the Interagency Task Force (ITF) on Hazardous Waste (1979) the site was also used for industrial waste disposal and may have received wastes from the Durez Division of Hooker Chemical, Bell Aerospace, Rapid Disposal Services, Inc. (refuse collector), and other industries located in North Tonawanda during the 1960s. It is estimated in the ITF Report that Durez disposed of the following wastes at the site between 1962 and 1968:

- o 25,000 tons of phenolic molding compounds;
- o 25,000 tons of phenolic resin; and
- o 50 tons of oil and grease.

TABLE 1-1

HISTORY OF PROPERTY OWNERSHIP

Tax Map S.B.L. No.	Liber Page (Niagara Co. Deed Records)	Ownership	Dates	Remarks
P/O175.19-1-28	1322/1	Niagara Mohawk Power Corp.	6/30/59 to Present	Southerly portion of Parkland
	--	American Radiator and Standard Sanitary Corp.	Pre 1959	
P/O175.19-1-28	1281/237	Niagara Mohawk Power Corp.	12/31/57 to Present	Northerly portion of Parkland
	--	City of North Tonawanda	Pre 1957	
181.08-2-1	767/451	City of North Tonawanda	11/20/44 to Present	Marina Site
	--	Niagara Franklin Corp.	Pre 1944	

The landfill site was closed in 1968 and was subsequently graded, covered and grassed. The site was reopened by the City as a park in 1969 and currently features a boat launch ramp and dock, sheltered picnic and cooking areas, open space, and a "dog walking" area. The southern portion of the park is largely undeveloped and still contains mounds of construction debris.

1.1.3 Previous Investigations

The earliest reported investigations at the site were conducted by the New York State Department of Health (NYSDOH) in 1964 and 1965. These investigations involved site inspections and documentation of waste disposal activities. At this early date, an inspector noted the possibility that material from the site may leach to the Niagara River. A March 1969 report by NYSDOH noted that 75 percent of the site was graded and that the remainder contained piles of brush, dirt, rock, wood, drums and other metal items.

A summary of previous environmental sampling activities at the park is presented in Table 1-2; detailed information is provided in Section 5.0.

In 1979 the City of North Tonawanda retained Recra Research, Inc., to install and sample five (5) groundwater monitoring wells at the site (one upgradient and four onsite). The wells are identified as MW-10 through MW-14 in Figure 1-2 and the borehole logs are presented in Appendix B-4. The groundwater collected from the onsite wells contained phenol concentrations as high as 63.1 mg/l and total halogenated organics (THO) concentrations as high as 1,100 ug/l. The analytical results for the upgradient well indicated that phenol and THO concentrations were below detection and below 0.05 ug/l, respectively. The results of subsequent analyses of samples from two of the wells showed the presence of a number of organic compounds. Recra Research, Inc., concluded that

TABLE 1-2
SUMMARY OF PREVIOUS ENVIRONMENTAL SAMPLING ACTIVITIES

Sampling Date	Sampling Program	Environmental Matrix	Chemical Analysis
June 11, 1979	Recra Research, Inc. (for City of N. Tonawanda)	Groundwater (4 wells)	Phenols, total halogenated organic scan, GC/MS characterization of organic constituents
Nov. 29, 1979	Recra Research, Inc. (for City of N. Tonawanda)	Groundwater (2 wells)	Conductivity, total organic carbon, chloride, pH, total phenol, total halogenated organic scan, GC/MS characterization of organic constituents, chlorinated organic scan
Dec. 26, 1979	Recra Research, Inc. (for City of N. Tonawanda)	Groundwater (1 well)	Conductivity, chloride, total halogenated organic scan, GC/MS characterization of organic constituents
Jan. 10, 1980	Recra Research, Inc. (for City of N. Tonawanda)	Groundwater (1 well)	Recoverable phenols, halogenated and chlorinated organic scans
July 16, 1981	Niagara County Health Dept.	Groundwater (4 wells)	Metals (5), total halogenated organic scan
Aug. 12, 1981	Niagara County Health Dept.	Groundwater (3 wells)	Phenols
July 28, 1982	United States Geological Survey (USGS)	Groundwater (5 wells)	Full analysis of inorganic and organic parameters
Nov. 13, 1982	USGS for Environmental Protection Agency (EPA)	Groundwater (1 well)	Full analysis of inorganic and organic parameters

TABLE 1-2 (Continued)

Sampling Date	Sampling Program	Environmental		Chemical Analysis
		Matrix		
July 22, 1983	Roy F. Weston, Inc. for EPA	Groundwater (2 wells) Shoreline soil/ split spoon (8 samples) Residue (1 sample)	Full analysis of inorganic and organic parameters	
June 29-30, 1984	Wehran Engineering, P.C. for NYSDEC	Air (HNU pedestrian survey & quantitative sampling)	Volatile organics	
Sept. 1984	Pittsburgh Testing Lab. for private party	Soil from boreholes (2 comp. samples)	Full analysis of inorganic and organic parameters	
Oct. 29, 1986	Recreational Environmental, Inc. for Niagara Mohawk Power Corporation	Soil (20 samples)	Analysis of Hazardous Substance List parameters (inorganic and organic)	
Oct. 29, 1986	Niagara County Health Dept.	Soil (20 samples)	Analysis of Hazardous Substance List parameters (inorganic and organic)	

A-2606

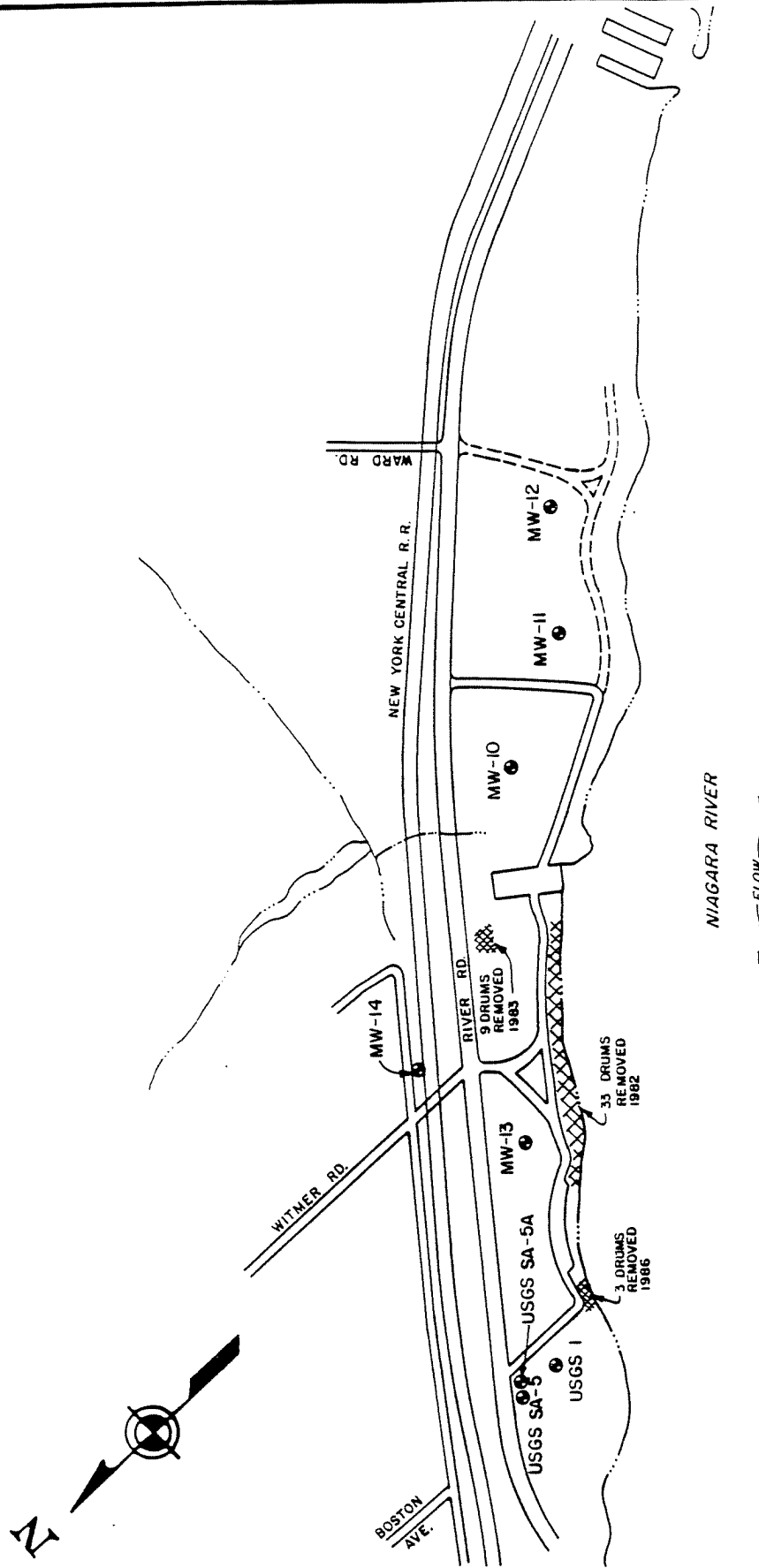


FIGURE 1-2

PREVIOUS INVESTIGATIONS
DRUM & MONITORING WELL SAMPLING LOCATIONS

URS
CONSULTING ENGINEERS
NEW YORK NEW JERSEY

URS Company, Inc.

the groundwater below the site was contaminated and that the hydraulic gradient was towards the Niagara River.

The Niagara County Health Department (NCHD) conducted site investigations, involving a site inspection and well sampling, in 1981. Groundwater samples were analyzed for five metals, THO scan and phenol. The metal concentrations were very low (generally below detection); THO concentrations reached 35 ug/l and phenol, 17 mg/l. As a result of the site inspection, 33 drums exposed by erosion along the shoreline and containing fully cured phenolic resin were removed in 1982 by Niagara Mohawk. The locations are shown in Figure 1-2.

A monitoring well (identified as USGS-1, Figure 1-2) was installed onsite in early 1982 by the U.S. Geological Survey (USGS) as part of a joint NYSDEC, U.S. Environmental Protection Agency (USEPA), and USGS study of waste disposal sites along the Niagara River. The borehole log is presented in Appendix B.4. As part of this study the new well and four of the Recra wells were sampled in July 1982, and the samples analyzed for inorganic and organic constituents. Several inorganic/organic constituents (including iron, lead, mercury, phenol and tetrachloroethylene) in the groundwater obtained from onsite wells exceeded USEPA limits for drinking water and/or New York State standards for maximum permissible concentrations in groundwater.

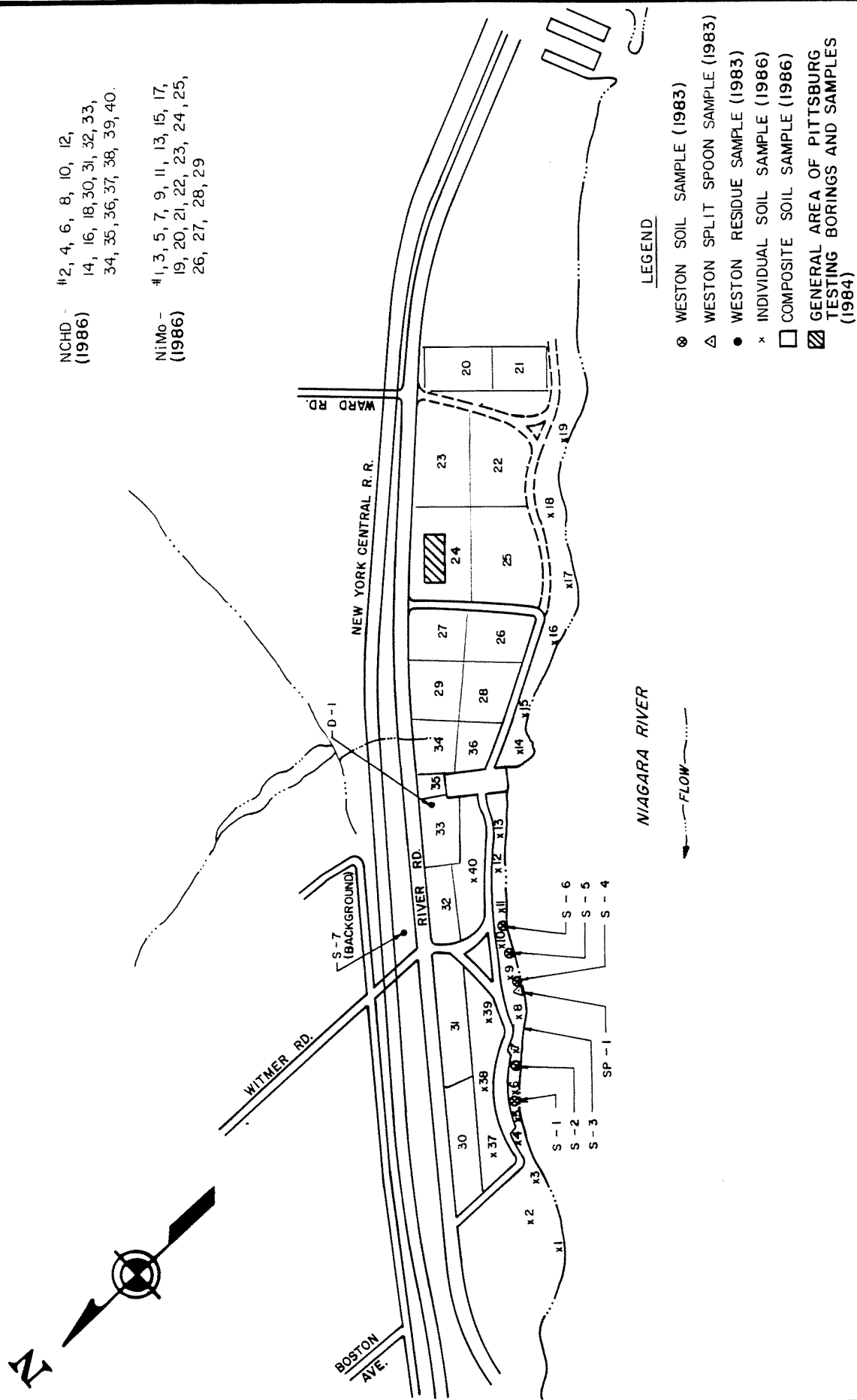
The USGS installed two additional wells (identified as USGS-SA-5 and SA-5A in Figure 1-2) in November 1982 to characterize the regional geology/hydrogeology/ground-water chemistry. The borehole log for USGS-SA-5A is presented in Appendix B.4. A single groundwater sample was collected from USGS-SA-5 on November 13, 1982. Parameters which exceeded USEPA limits for drinking water or New York State limits for groundwater, as referenced in USEPA, 1985, included arsenic (2 ug/l), cadmium (20 ug/l), lead (220 ug/l), and alpha-chlordane (1.08 ug/l).

Other organic priority pollutants which were detected included methylene chloride (110 ug/l), toluene (170 ug/l), and dibutylphthalate (11 ug/l).

In July 1983, Roy F. Weston, Inc., performed a shoreline assessment for USEPA which included analysis of soil samples taken from along the river (Figure 1-3), and limited well sampling. High Total Organic Carbon (TOC) readings (to 80,000 ppm) at MW-14 (upgradient of site) led investigators to believe that most of the organic carbon contamination was coming from offsite. MW-13, however, showed onsite contamination both from volatiles and semi-volatiles, some of which were absent at MW-14. Soil samples were collected by Weston personnel at seven points along the river, at one point near River Road (considered as background), and one residue sample at an exposed drum area. The shoreline samples, however, were collected in an area partially excavated in 1982 during the drum removal operations where clean backfill was added. These samples contained phenols (to 1.2 mg/kg) and no detectable PCBs. Levels of metals, with the exception of copper and lead, were measurable but generally low. (Lead was measured at a maximum concentration of 4,910 mg/kg and copper at 6,440 mg/kg each about an order of magnitude above the background level in S-7). Pesticide levels were less than 1 ppm with the exception of endosulfan at 1.24 mg/kg. Polynuclear aromatic hydrocarbon (PAH) concentrations to 1.24 mg/kg were found (fluoranthene). The Weston report concluded that the environmental impact of contaminants at the Gratwick-Riverside site upon the Niagara River "would be insignificant" (Weston, 1983).

Late in 1983, nine drums containing solid phenolic resin were discovered by NCHD near River Road, having "floated" to the surface. The drums were subsequently removed in 1983.

In September 1984, three borings were completed near River Road, just north of the Ward Road entrance, for a private party (by Pittsburgh Testing Laboratory). Analysis by Ecology and Environment,



PREVIOUS INVESTIGATIONS SOIL SAMPLING LOCATIONS

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Inc., showed no volatiles, semi-volatiles, pesticides or PCBs in the two soil samples analyzed from the three borings. A number of HSL metals were detected, however, with lead levels being measured at 461 mg/kg.

In 1986 three freshly exposed drums were removed from the shoreline by Niagara Mohawk at the direction of NCHD. Analysis by Recra of the drummed material showed it to be fully cured phenolic resin, non-hazardous by RCRA definition.

In October 1986, twenty soil samples were taken by the NCHD (analysis by New York State Department of Health), and twenty by Niagara Mohawk (analysis by Recra Environmental). Niagara Mohawk (NiMo) obtained 10 individual samples along the shoreline, and 10 composite samples in zones at the south end of the park; NCHD obtained 13 individual samples just back from the shoreline, and 7 composite samples in zones in the middle and northern end of the park (Figure 1-3). Detailed results are presented in Section 5.0.

Few volatiles were found in the soil samples. A large number of semi-volatiles were found to be present across the site in the ppb and ppm range; however, many of the organic parameter results from NCHD are listed as "not confirmed" and possibly erroneous. Pesticides and PCBs were found in almost all samples (again, some NCHD samples are listed as "not confirmed"). Areas of highest concentrations (ppm range) are along the shoreline at locations 1 (endosulfan sulfate) and 13 (PCB-1242, PCB-1254) and in zone 32 (chlordanes, PCB-1260). Metals appear to be present across the site ranging in concentration from not detected to 14,700 ppm (copper at shoreline location 11).

1.1.4 Regulatory Status

Gratwick-Riverside Park, Site #932060 on the New York State inactive hazardous waste disposal site registry, is presently listed as a

classification 2 - significant threat to the public health or environment, with action required. The site is a New York State, but not a federal, Superfund site.

In June 1983, a Phase I Engineering Investigation was completed at this site by Engineering-Science and Assoc., and in October 1985, a Phase II Investigation by Wehran Engineering. The present RI/FS contract was signed in June of 1987.

The history of this site has been one of cooperation among all concerned parties: New York State (Departments of Health, and Environmental Conservation); Niagara County; the City of North Tonawanda; and Niagara Mohawk.

Initial Hazard Ranking System (HRS) scoring of this site was as follows:

$$S_M = 5.82 \text{ (} S_{gw} = 6.12, S_{sw} = 8.00, S_a = 0 \text{)}$$

$$S_{FE} = 0$$

$$S_{DC} = 25.00$$

In final HRS scoring, S_{DC} was increased to 37.50.

1.2 Nature and Extent of Problem

Abundant evidence exists that hazardous wastes were in fact deposited at this site. A number of analyses have shown soils and groundwater to be contaminated with one or more of the following substances: metals, phenols, PAHs, and other semi-volatiles and volatiles. Since the site still receives heavy usage as a city park, the question has arisen whether and to what extent the public might be exposed to the effects of waste materials deposited here. Potential pathways for human exposure include inhalation from vapors at or near ground level,

dermal contact from persons with the ground or surface water, and possible ingestion of soil.

1.3 Remedial Investigation Approach

The purpose of the Remedial Investigation (RI) at the Gratwick-Riverside Park site was to develop sufficient data to characterize the site, identify contaminant transport modes, assess the extent of contamination, and evaluate the site's impact upon public health and the environment. Field investigations at the site commenced in July, 1987 and were substantially completed in August, 1988 with the second round of sampling. In addition, there was a one week test pit program performed in May 1989. The major portion of the field investigations, however, was conducted in the Fall of 1987. Field activities employed during the RI are briefly summarized in this section. Subsequent sections of the report address the methods of investigation utilized in performing these activities as well as the results. Additional details concerning field investigation activities and methods may be found in the following two documents which were prepared at the outset of the project:

1. Health and Safety Plan for the Remedial Investigation and Feasibility Study at the Gratwick-Riverside Park Site, Niagara County, New York (URS Company, Inc., 1987a);
2. Work/QA Project Plan for the Remedial Investigation and Feasibility Study at the Gratwick-Riverside Park Site, Niagara County, New York (URS Company, Inc., 1987b).

Major elements of the Remedial Investigation Program are described and summarized below:

- o Surveying and Mapping - Surveying at the site commenced in July 1987. Field surveys were performed to establish a

baseline (approximately 5,000 feet in length) across the site and to determine the exact locations and elevations of all field data points (such as borings/wells). Standard field surveying methods were practiced to establish a 40-foot grid system and to obtain necessary elevations. Topographic base maps were prepared at a scale of 1 inch = 100 feet and contour intervals of both 1 and 2 feet. All vertical elevations were based on the United States Coastal and Geodetic Survey (USC&GS) mean sea level datum. A topographic base map with contour intervals of 2 feet is presented as Figure 1-4.

- o Surface Geophysical Survey - Surface geophysical studies conducted at the site included both seismic refraction and magnetic surveys. The refraction survey was performed to provide information on the subsurface geology, specifically, the depth to bedrock and overburden stratigraphy. The magnetic survey was conducted to assist in locating possible concentrations of buried ferrous metallic objects, such as drums. Collectively, surface geophysical results were used to establish the final number, location and depths of borings and monitoring wells. Field parameters, equipment and other investigative methods employed during the geophysical surveys are discussed in Section 4.0 of this report. A complete and separate geophysical study report which provides survey results, as well as an interpretation of these results, is included in Appendix B.1.

The initial survey was performed in September 1987. In April 1989 an additional magnetic survey was performed, with a tighter grid, to further define the magnetic anomalies encountered in the area around baseline stations P39+00 through P45+00. This second survey was performed as a portion

of the test pit program, discussed in section 4.1.7 and the resulting report is in Appendix B.1.

- o Soil Gas Survey - Using a Photovac TIP, organic vapor monitoring was performed on air and soil at 1,383 test hole locations across the site. Air was monitored in the breathing zone and soil at a maximum depth of 18 inches below ground surface. Air monitoring was also performed during drilling in the work area and at additional locations around the perimeter of the site to assess general air quality.
- o Test Borings and Monitoring Well Installations - Test borings and monitoring wells were installed at the site in order to evaluate various subsurface conditions, including: overburden and bedrock stratigraphy, soil properties, aquifer parameters, groundwater flow and groundwater quality. A total of 22 test borings were drilled at 12 locations. Locations of all onsite borings/monitoring wells are shown in Figure 1-5 (offsite locations are shown in the cross section location map, Figure 4-3 presented in Section 4.2.3.2). Split-spoon samples were collected and described by the onsite geologist for 17 of the borings. Bedrock coring was conducted at a total of 4 boring locations.

Well instrumentation, including 15 monitoring wells and 6 piezometers, were installed in all but one of the 22 borings. Four of the monitoring wells were completed in bedrock. Each of the monitoring wells was developed by pumping until relatively sediment-free samples were obtainable. Boring and monitoring well locations, as well as further discussion and interpretation of results, are presented in Section 4.0. Data sheets for drilling and well operations are presented in the following appendices: borehole logs (Appendix B.2),

monitoring well/piezometer construction details (Appendix C.1), and well development forms (Appendix C.2).

- o Geotechnical Laboratory Testing - Selected soil samples obtained from the soil borings were analyzed for physical properties, including grain size distribution (12 sieve and hydrometer analyses), moisture content (33 tests) and Atterberg Limits (10 tests). In addition, triaxial permeability tests were performed on 2 Shelby tube samples. Laboratory results are presented in Appendices B.3 and C.3, and are discussed in Section 4.0.
- o Hydraulic Conductivity Testing and Water Level Monitoring - Slug tests were performed on all monitoring wells (15) and piezometers (6) in order to determine the hydraulic conductivity over the screened interval of the various geologic units. Water level readings were measured and recorded for all monitoring wells/piezometers on a regular basis and at one hour intervals for two twenty-four hour periods. Water level measurements were used in evaluating groundwater hydrology of the area. Additional hydraulic conductivity details and all water level measurements are presented in Appendices C.3 and C.4; results for each are discussed in Section 4.0.
- o Organic Vapor Screening - In order to evaluate vertical soil contamination profiles, selected split-spoon samples obtained during boring operations were scanned with either a Photovac TIP or HNu photoionization detector. Selected samples for screening included those samples collected from the deepest boring for each single/pair/cluster location, with the exception of pairs 7S/7I and 8S/8I which had no samples screened. Results are presented and discussed in Section 5.0, and included in the borehole logs found in Appendix B.3.

- o Environmental Sampling Analysis - Environmental sampling was conducted in order to assess the degree and extent of contamination at the site, and included the following:
 - o Groundwater samples were collected on two occasions (December 1987 and August 1988) from all 15 monitoring wells initially, and 14 wells during the second sampling round (well GW-2S was damaged and could not be sampled).
 - o Surface water samples were collected on two occasions. Initially (November, 1987) samples were collected at 7 locations adjacent to the site (along the Niagara River), upstream of the site, and onsite. Four of the locations were resampled in August 1988.
 - o Shoreline soil/waste samples were collected at 8 shoreline locations in October 1987.
 - o Soil samples were collected in November and December, 1987 from borings at various depths (11 samples). In addition, 20 shallow soil samples were collected from suspect areas (elevated organic vapor readings during soil gas survey) and offsite for background quality. Three additional offsite shallow soil samples were collected in August 1988.

Sampling methodologies are discussed in Section 5.0 and complete environmental sampling reports are presented in Appendix E.2.

Chemical analyses performed on environmental samples included the following parameters:

- o Groundwater and surface water samples were analyzed for Hazardous Substance List (HSL) compounds, and with the exception of one surface water sample, also for total cyanide, total phenols, oil and grease, and various field measurements and indicator parameters.
- o Additional groundwater samples were taken and analyzed for volatiles and semi-volatiles in GW-7S and GW-9S at the bottom of the water column prior to purging of these wells. These samples were taken in order to confirm or rule-out the suspected presence of dense, non-aqueous phase liquids near the bottom of the upper aquifer.
- o Shoreline soil/waste, soil boring and selected shallow soil samples were analyzed for HSL compounds, total cyanide, total phenols, pH, various indicator parameters, and selected samples for dioxin/furans.
- o In order to investigate some unique patterns of magnetic anomalies identified from the surface geophysical study, it was decided to add a test pit program to the scope of the investigation. These anomalies were first resurveyed in April 1989 using a tighter grid magnetometer survey. Based upon this information 7 test pits were dug in May 1989. Section 4.1.7 discusses this program in detail.

1.4 Report Overview

Part I of the report (Sections 1.0 through 6.0) presents the Remedial Investigation (RI) phase of the project. Part II (Sections 7.0 through 11.0) which is a separate volume, addresses the Feasibility Study (FS). Appendices are bound separately. The following summarizes the contents of each section:

- o Section 2.0 describes site features. Questions of demography, land use, natural resources, and climate are addressed here.
- o Section 3.0 identifies and discusses the hazardous substances that may be present at the site. It includes a discussion of past waste disposal activities, and characteristics of waste components suspected or known to have been deposited.
- o Section 4.0 presents the results of the detailed geologic and hydrogeologic investigations at the site. It includes a description of field investigative methods, an evaluation of overburden and bedrock geology on a regional and site-specific basis, and an assessment of regional and site-specific hydrology. Both groundwater and surface water hydrology are discussed in this section, the latter including a description of local drainage patterns.
- o Section 5.0 addresses chemical quality of groundwater and surface water, shoreline soil/waste, and overburden soils (or fill). It also includes a subsection on air quality investigations. RI results are compared with results of previous investigations and federal ARARs and NYS SCGs.
- o Section 6.0 presents an assessment of the potential impact of the site upon public health and the environment.
- o Section 7.0 provides a summary of information from the Remedial Investigation necessary for the Feasibility Study.
- o Section 8.0 presents an identification and initial screening of technologies potentially appropriate for the site.

- o Section 9.0 presents the development and screening of remedial alternatives for all media of interest at the site.
- o Section 10.0 provides a detailed evaluation of the remedial alternatives and compares them against the NYSDEC scoring system. Feasibility-level cost estimates are provided.
- o Section 11.0 presents the conceptual design of the selected remedial alternative, a preliminary cost estimate, and recommendations for additional studies to be performed.

2.0 SITE FEATURES

2.1 Demography

Gratwick-Riverside Park is located within the corporate limits of the City of North Tonawanda, Niagara County, New York. North Tonawanda has experienced a slight decline in population according to the U.S. Census Bureau from a population of 36,012 in 1970 to a population of 35,760 in 1980. The population of Niagara County as a whole is 227,101 according to the 1980 census. This is approximately a 4% decrease from the 1970 population of 235,720.

2.2 Land Use

All land off of River Road in the vicinity of and including Gratwick-Riverside Park is currently zoned as General Industrial (M-2). A number of industries are located near the site including a sewage disposal plant to the south, an automobile wreckers yard to the east, and the Niagara County Refuse Disposal - Wheatfield hazardous waste site (National Priorities List) to the northwest. Directly across River Road paralleling the site are Conrail railroad tracks and their right-of-way. A number of utilities have their above- and below-ground lines in this strip of land.

The site is a public park adjacent to the Niagara River operated by the City of North Tonawanda. Recreational water activities on the Niagara River include boating, fishing and swimming from the boat launch ramp and dock located onsite. Other onsite facilities include sheltered picnic and cooking areas, as well as wide-open areas for recreation. The site has been a public park since 1969. Previously, however, it had been used as a landfill for private and municipal waste.

Historical aerial photographs from 1938, 1951, 1966, 1968, 1975, 1978, and 1987 were examined in order to delineate changes in the development, land use, and shoreline of Gratwick Park and the surrounding area. These changes can be summarized as follows:

Shoreline Changes

- 1938-1951 o Extensive advancement of shoreline riverward immediately north of the site (NW of 71+00W)
- 1951-1966 o Fill extended up to 100 feet into the river in the northern portion of the site (60+00W to 66+00W)
- o Continued advancement of shoreline riverward north of the site (NW of 71+00W)
- 1966-1968 o Boathouse, launch, and jetty constructed (52+00W to 54+00W)
- o Marina excavated southeast of site (~20+00W to 23+00W)
- 1975-1978 o Infill of man-made inlets southeast of site and at location of petroleum storage depot

Onsite or Near Site Development

- 1938-1951 o Filling apparent north and south of the intersection of Witmer and River Roads
- o Buildings razed onsite near River Road (~40+00W)
- o Possible excavation at future site of marina
- o Large industrial facility constructed between future marina site and petroleum storage depot
- 1951-1966 o Park roadway system under construction
- o Depressions filled and surface graded
- o River Road widened to four lanes
- o Active landfilling opposite Ward Rd.
- o Automobile wrecker's facility initiates operations off River Road

- 1966-1968
 - o Active filling in south-central portion of park
 - o North-central portion of park largely graded
 - o Stream channel infilled (51+50W)
 - o Spot infilling and grading at east end of park
 - o Active filling north of site
 - o Extensive fill opposite Ward Rd.
 - o Marina constructed
- 1968-1975
 - o Park graded and in use
 - o Boathouse and jetty constructed
 - o Debris piles evident in area of proposed "dog walk" stone wall
 - o Active landfilling at nearby Niagara County Refuse Disposal - Wheatfield
- 1975-1978
 - o Shelter and "dog walk" completed
 - o Additional fill or regrading in area east of stream (~51+00W), northeast of "dog walk", and immediately west of boathouse
 - o Continued landfilling at Niagara County Refuse Disposal - Wheatfield
- 1978-1987
 - o Potholing evident
 - o Shallow mounds of debris evident near "dog walk"
 - o Some additional infilling and/or regrading

Offsite Development

- 1938-1951
 - o Extensive urban expansion to north
 - o Street and residences constructed near stream to north of site
 - o Petroleum storage tank added to existing depot
- 1951-1966
 - o Infill of small tributary of stream due to nearby residential development

- o Greatest period of residential and industrial expansion to northeast and northwest
- o Manufacturing plant constructed on Ward Rd.
- 1968-1975 o New industrial plants off Witmer and Ward Rds.
- 1975-1978 o Large expansion of petroleum tank facility to south (upstream) of site
- 1978-1987 o New manufacturing plant on Ward Rd.
- o Four new buildings on Witmer Rd.
- o Facility expansion southeast of Felton St.

In general, the period of time between 1938-1987 was characterized by an encroachment of urban development, residential and industrial, into areas of previously rural land use primarily to the northwest and northeast of the site and well inland from the Niagara River. The development of shoreline facilities offsite was completed between 1951 and 1978. Activities at Gratwick Park from 1938 - 1975 included filling, grading, and roadway and facilities construction. After 1975, only slight regrading and filling took place onsite.

2.3 Natural Resources

The Niagara River, located adjacent to the site, is classified as Class A - Special (International boundary waters) whose best usage is as a source of water supply for drinking, culinary or food processing purposes, primary contact recreation and any other usages. For both Canada and the United States, the river provides municipal and industrial water supplies and a source of power generation, commerce, recreation and tourism. As a source of municipal drinking water, it serves a combined Canadian/US population of more than 400,000 people (Niagara Toxics Committee, 1984). In return, the river receives the treated waste from this same population in the form of municipal and industrial waste.

2.4 Climate

Climate data was obtained from the National Climatic Data Center (National Oceanic and Atmospheric Administration (NOAA), 1987) for the Buffalo airport, and from the U.S. Air Force Weather Squadron for the Niagara Falls airport. These two airports are located approximately 16 miles apart; the site is about halfway between them. Both sets of climatological data are included and averaged to determine representative climatic conditions at the site.

Precipitation data for a 30-year period of record (1959-87) at the Buffalo airport and a 36-year period of record (1951-87) at the Niagara Falls airport is provided in Table 2-1. The mean annual precipitation considered representative of the site is 35.30 inches. A 24-hour maximum of 5.01 inches of precipitation, occurring during June 1987, is reported for Buffalo. The maximum for Niagara Falls, is reported to be 4.40 inches for September (the year not specified).

Temperature data for the same periods of record are provided in Table 2-2. The mean annual temperature is approximately 48°F. The highest recorded temperature was 99°F in August 1948 for Buffalo and 96°F in September (year not specified) for Niagara Falls; the lowest recorded temperature was -20°F in February 1961 for Buffalo and -17°F in February (year not specified) for Niagara Falls.

The prevailing wind direction is out of the southwest, the mean of which is 12.0 mph for Buffalo and 10.4 mph for Niagara Falls.

TABLE 2-1
PRECIPITATION DATA

Mean Precipitation Values (inches)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Buffalo	3.10	2.67	2.76	2.69	2.89	2.89	2.90	3.24	3.08	3.05	3.32	3.28	35.87
Niagara Falls	2.50	2.34	2.60	2.90	2.90	2.80	2.70	3.70	3.20	2.90	3.20	3.10	34.84
Site	2.80	2.50	2.66	2.78	2.89	2.84	2.80	3.47	3.14	2.97	3.26	3.19	35.30

24-Hour Maximum Precipitation Values (inches)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Buffalo	2.57	2.31	2.14	1.71	3.52	5.01	3.38	3.88	4.94	3.49	2.51	2.16
Niagara Falls	1.40	3.10	2.30	1.60	1.90	2.50	2.00	3.20	4.40	2.40	1.66	1.30

Note the period of record for Buffalo was 1958 - 1987 and for Niagara Falls 1951 - 1987.

TABLE 2-2

TEMPERATURE DATAMean Temperature Values ($^{\circ}$ F)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual
Buffalo	24.7	24.6	32.5	43.6	54.9	64.8	70.4	68.9	62.5	51.6	40.0	29.6	47.4
Niagara Falls	24	26	34	47	57	66	71	70	62	52	41	31	48
Site	24	25	33	45	56	65	70	69	62	52	40	30	48

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Buffalo (min)	-16	-20	10	12	26	35	43	38	32	20	9	-10
Buffalo (max)	72	65	81	88	90	95	94	99	98	87	80	74
N. Falls (min)	-16	-17	-8	12	29	33	46	40	30	23	-2	-8
N. Falls (max)	57	64	79	84	92	93	95	93	96	84	79	71

3.0 HAZARDOUS SUBSTANCES

3.1 Investigative Methodology

Several technical documents were reviewed at the outset of this Remedial Investigation (RI) in order to obtain information concerning suspected and confirmed contamination at the Gratwick-Riverside Park site. Onsite environmental sampling, predominantly involving a groundwater matrix (but also including soil and air monitoring), was performed during previous investigations. Chemical analyses were performed to determine waste components and to assess the extent of contamination at the site. A summary of these sampling activities is presented in Table 1-2 and discussed further in Section 1.1.3.

The information obtained from previous investigations served as a framework for the development of the field investigation program conducted as part of this RI. Field activities were structured to provide a determination of possible sources of contamination as well as identify specific contaminants existing at the site.

Previous reports by the New York State Department of Health (NYSDOH), the Niagara County Health Department (NCHD), and others indicated a history of drum discoveries and subsequent removals. Using the techniques of magnetometry, a surface geophysical survey was conducted across the site during this RI. The magnetic data were used to locate possible concentrations of buried metallic objects which were further investigated with a test pit program.

Test borings and groundwater monitoring wells were installed in order to provide further detail on subsurface conditions. Environmental samples were collected from groundwater, surface water, shoreline soil/waste and soils. Reports of former waste disposal practices at the site and analytical data from previous investigations were utilized in

determining various parameters for chemical analyses of samples. Because of the site's history of industrial waste disposal, in conjunction with the occurrence of volatile and semi-volatile organic compounds in groundwater and soil samples in previous investigations, most environmental samples collected for this RI were analyzed for Hazardous Substance List (HSL) volatile and semi-volatile organics. With the exception of 10 shallow soil samples, all samples were also analyzed for HSL metals because of reports of metallurgical sludge and incinerator ash disposal, as well as relatively high concentrations of various metals in groundwater and soil samples in previous investigations. Similarly, the disposal of phenolic resins and molding compounds were reported and phenol was detected in previous sampling (groundwater and soil). Thus, total phenols were analyzed for in all environmental samples. Pesticides, which were detected in previous soil sampling programs, were also analyzed for in most samples collected during this investigation. Reports of the burning of wastes and the disposal of incinerator ash onsite prompted dioxin analysis for selected soil and shoreline soil/waste samples.

Further information on sampling and chemical analytical results for this RI, as well as for previous investigations conducted by the NYSDOH, NCHD, USGS/USEPA/NYSDEC and others are included in Section 5.0 of this report.

3.2 Waste Disposal Activities

Aerial photographs indicate changes to the shoreline configuration between 1938 and 1968. The shoreline has not been appreciably altered since 1968. Dumping of some sort is evident from the aerial photographs as early as 1938, although it is not known what wastes were disposed of.

Known waste disposal activities occurred from 1962 to 1968, metallurgical sludge being the earliest known waste deposited during

this period. Beginning in 1964, the City of North Tonawanda used the site for disposal of both municipal and industrial wastes. Hooker Durez and Bell Aerospace also disposed of industrial wastes here. (The ITF Report lists only phenolic resins, phenolic molding compounds, oil and grease, and "rubbish" as wastes known to have been deposited.) Burning of wastes onsite was reportedly a common practice during the 1960s. Wastes were covered at intervals with incinerator ash, road construction debris and molding sand.

Waste deposition appears from the record to have been fairly random across the site.

3.3 Waste Component Characteristics

Characteristics of waste components known or suspected to have been deposited or formed at this site are as follows:

- o Phenolic resins - any of several types of synthetic, thermosetting resins obtained by the condensation of phenol or substituted phenols with an aldehyde. Phenol-formaldehyde resins are typical and constitute the chief class of phenolics. These are hard, infusible solids, resistant to solvents, noncombustible and generally nontoxic.
- o Phenolic molding compounds - a mixture, usually in granular or pelleted form, of a plastic base material (e.g., a phenolic resin) together with necessary modifying ingredients, such as fillers, plasticizers or pigments. The resin is generally nontoxic. Fillers are inert mineral powders such as calcium carbonate or silicates. Among the more important plasticizers are nonvolatile organic liquids and low-melting solids, such as phthalate, glycols and

others. Some of these substances are toxic. Most pigments are insoluble in organic solvents or water, and therefore present only a limited environmental threat.

- o Oil and grease - limited toxicity. Oil and grease are not HSL substances; however, a number of their constituents are.
- o Molding sand - sand mixed with suitable binders for use in making molds for casting metals. The binders include resins of various types. Toxicity of molding sand depends on binder used.
- o Incinerator ash - the mineral content of a material remaining after complete combustion. Metal content may be high, depending on what was incinerated.
- o Metals - any metal in high concentration is toxic, and may be quite mobile, depending on matrix pH. Some are more toxic than others.
- o Polynuclear aromatic hydrocarbons - a class of compounds including anthracene, benzo (a) anthracene, fluoranthene, phenanthrene, pyrene, benzo (a) pyrene, naphthalene and other compounds which have been found onsite. PAHs are products of incomplete combustion of solid fuel. They are produced by various industrial processes, space heating, vehicle exhaust, lighted cigarettes and even barbecues. Some of the industrial operations producing PAHs are pyrolysis of wood, coke production, gas production from petroleum, and oil-refining operations. PAHs are all fairly nonvolatile (included among semi-volatiles), high-melting solids, crystalline in form. They are chemically inert. A

background level is present in most soils, the result of removal from the air and sedimentation processes.

Many PAHs are moderately toxic and persistent. Some are known carcinogens and/or mutagens.

- o Phenol - a class of aromatic organic compounds including phenol itself, the cresols, xylenol, resorcinol and naphthols. Phenol itself is a white crystalline mass which liquifies on contact with moist air. It is combustible. Phenol is toxic by ingestion, inhalation and skin absorption. It is a strong irritant to tissue. It is used, among other things, in the production of phenolic resins.
- o Volatile organic compounds - those found onsite are moderately toxic and moderately persistent. They generally have relatively higher vapor pressure, readily volatilizing in air or water. They are highly mobile in groundwater.
- o Chlorinated organic pesticides - many of these, such as alpha chlordane and DDT and its degradation products, found onsite, are highly toxic and persistent in the environment.
- o Slag - the fused agglomerate which separates in metal smelting and floats on the surface of the molten metal. It contains many of the impurities separated from the metal, and can produce an acidic or basic leachate, depending upon constituents. Other toxic substances may also be present in slag.
- o Dioxin - any of a family of chemical compounds consisting of two oxygen atoms joining a pair of benzene rings. Chlorinated dioxins, especially 2,3,7,8-tetrachlorodibenzo-

p-dioxin (TCDD), are of special interest, being highly toxic to test animals, and presumably dangerous to humans. TCDD is extremely heat stable. Dioxins have been shown to form in incinerators at temperatures as high as 400°C, and perhaps higher (Duckett, 1981). TCDD will decompose completely if exposed to temperatures of 800°C for 21 seconds (Hay, 1982). At 700°C, the same exposure will yield only 50% decomposition.

4.0 GEOLOGY/PHYSICAL HYDROGEOLOGY/SURFACE WATER HYDROLOGY

4.1 Investigative Methodology

Various sources of information were utilized to develop a geologic/hydrogeologic interpretation of the area and include regional and local geologic and topographic maps, previous studies and investigations conducted in the area, as well as field and laboratory information collected as part of this Remedial Investigation. Field and laboratory activities for this investigation include a surface geophysical survey (seismic refraction and magnetometry) that lead to a test pit program which included 7 test pits, a test boring program which included 22 borings (4 of which penetrated bedrock), installation of 21 monitoring wells and piezometers, insitu hydraulic conductivity testing, water level monitoring, and laboratory analyses performed on soil samples to determine physical properties.

4.1.1 Review of Existing Information

Several subsurface geologic investigations were conducted at the site prior to this Remedial Investigation. Borings were drilled to obtain information on subsurface geology, hydrogeology and/or for environmental sampling. Borehole locations for previous studies are shown in Figures 1-2 and 1-3.

The earliest known subsurface investigation at the site was conducted by Recra Research, Inc. for the City of North Tonawanda in June, 1979. Earth Dimensions, Inc. (EDI) drilled a total of five borings (four onsite and one offsite) as part of the Recra study. Onsite borings, all of which were completed in the overburden, ranged in depth from 14 to 21 feet.

In 1982, as part of the Niagara River Study, the U.S. Geological Survey (USGS), in conjunction with the NYSDEC and USEPA, drilled three additional onsite borings. Two of the borings encountered bedrock; the third was completed in the till unit.

Pittsburgh Testing Laboratory completed three onsite test borings for a private party in September 1984. Each boring was completed in the unconsolidated sediments at a depth of 12 feet.

Borehole logs from previous investigations are presented in Appendix B.4. Results are further discussed in Section 4.2.3 on Site Geology.

4.1.2 Surface Geophysical Survey

Surface geophysical studies were conducted at the site by Hager-Richter Geoscience, Inc. of Windham, New Hampshire from September 9-17, 1987 and again in April of 1989. Geophysical surveys performed include a seismic refraction survey and two magnetic surveys.

The seismic refraction survey was conducted in order to determine depth to bedrock and overburden stratigraphy. Seismic data were recorded using an EG & G Model ES1225 multiple channel signal enhancement seismograph which allowed for 12-channel recording. The energy sources consisted of either a "Betsy" seisgun or a 60-pound weight drop, dependent upon the particular location. Field parameters included a 240-foot spread length, 20-foot geophone spacing and an 80-foot shotpoint interval. The refraction survey covered approximately 5,520 linear feet which largely consisted of five profiles across the site. The remainder were two short spreads shot in the southern portion of the site which resulted in unusable data due to the nature of the subsurface material. A north-south trending profile (approximately 3,600 linear feet) traversed a large portion of the length of the site

along the pre-established baseline. Four shorter profiles, ranging in length from 240 to 480 feet, were oriented perpendicular to the baseline and spaced across the site.

The magnetic surveys were performed in order to assist in determining the presence and location of possible concentrations of buried, ferrous metallic objects (such as drums). In addition, magnetic data were collected to determine the locations of subsurface metal outfall pipes. An EG & G Model G856 proton precession portable magnetometer was used to perform the survey. Magnetic data were collected at 4,788 stations over a predominantly 20-foot grid. A larger-spaced grid (20 feet by 40 feet) was used in the area to the south due to the irregular terrain and overgrown vegetation.

In order to locate the subsurface outfalls, two sets of parallel traverses (totalling 12 magnetic profiles) were surveyed. Individual profiles ranged from 60 to 80 feet in length and measurements were taken at 10-foot intervals.

A complete report of the surface geophysical surveys, including further discussion of the investigative methods as well as a presentation and interpretation of the results, is presented in Appendix B.1. The geophysical results were consulted in establishing final drilling and test pit locations, and depths, and provided stratigraphic control between boreholes. Areas of anomalously high magnetic readings were avoided during drilling.

4.1.3 Test Borings and Monitoring Well Installations

A total of 22 test borings were completed during the Remedial Investigation. The locations of the borings are shown in Figure 1-5. Soil samples were collected from 17 of the test borings with either a Shelby-tube, split-spoon sampler or, in the case of GW-5D, drill

cuttings. The unsampled borings were shallow counterparts of either well pairs or well clusters. Select soil samples were submitted for geotechnical and/or chemical analysis. Table 4-1 summarizes soil sampling methods and interval sampled.

During boring operations, air monitoring, using a TIP photoionizer or an OVA, was conducted at each location. No readings above background were obtained.

Bedrock cores were obtained with a NX size core barrel at two offsite (GW-1D and GW-2D) and two onsite (GW-5D and GW-6D) boring locations. Rock coring was conducted in order to "prove out" and identify the bedrock unit, to establish the extent of fracturing, and to create an opening for installation of bedrock monitoring wells. A description of the bedrock cores is provided in Section 4.2.3.4.

Samples were described in the field by the onsite geologist, placed in suitable containers and taken to a heated storage facility. Detailed borehole logs were prepared based on the field descriptions, geotechnical test results and on subsequent re-examination of the samples in storage. The borehole logs are presented in Appendix B.2 and the geotechnical laboratory test results are provided in Appendix B.3.

Fifteen (15) of the test borings drilled during the Remedial Investigation were completed as monitoring wells, 6 as piezometers and 1 boring was not instrumented. Well/piezometer construction details are presented in Appendix C.1. The 21 wells/piezometers, were arranged as follows:

- o 2 well clusters consisting of a shallow and a deep monitoring well, and an intermediate piezometer (onsite locations GW-5 and GW-6);

TABLE 4-1
SUMMARY OF SOIL SAMPLING PROCEDURES

Borehole Location No. (Well No.) ⁽¹⁾	Drill Cuttings Sample Interval (ft.)	Split-Spoon Sampling Sample Interval (ft.)	Shelby-Tube Sampling Sample Interval (ft.)
GW-1 (S)			
GW-1 (D)		0.0-38.4	
GW-2 (S)		0.0-10.0	
GW-2 (D)		0.0-36.0	
GW-3 (S)			
GW-3 (I)		0.0-18.0	
GW-4 (S)		8.0-14.0	
GW-4 (I)		0.0-16.0, 20.0-22.0	16.0-18.0, 18.0-20.0
GW-5 (S)			
GW-5 (I)		12.0-26.0	
GW-5 (D)	7.0 - 9.0 ⁽²⁾	(2)	
GW-6 (S)			
GW-6 (I)		10.0-17.0, 19.0-21.0	25.0-25.5, 26.0-26.9
GW-6 (D)		0.0-36.0	
GW-7 (S)			
GW-7 (I)		0.0-20.0	
GW-8 (S)		8.0-16.0	
GW-8 (I)		0.0-20.0, 22-26	20.0-22.0
GW-9(S)		0.0-18.0	
GW-10(S)		0.0-13.0	
GW-11(S)		0.0-10.0	
TB-1		15.0-22.0	

NOTES:

- (1) (S) Shallow Monitoring Well
- (I) Intermediate Piezometer
- (D) Deep Monitoring Well
- (2) Poor recovery; not able to collect split-spoon sample.

- o 2 well pairs consisting of a shallow and deep monitoring well (offsite locations GW-1 and GW-2);
- o 4 well/piezometer pairs consisting of a shallow monitoring well and an intermediate piezometer (onsite locations GW-3, GW-4, GW-7 and GW-8); and
- o 3 single shallow monitoring wells (onsite locations GW-9, GW-10 and GW-11).

The screened portions of the piezometers were completed in the confining unit (lacustrine silt and clay and till) which underlies the site. Because the low permeability of this unit precludes proper well development, a requirement of representative sampling, the piezometers were used exclusively for hydraulic conductivity testing and water level monitoring. The monitoring wells were completed in more permeable units and consequently have been used for hydraulic conductivity testing, water level measuring, and for sampling of the groundwater.

4.1.4 Geotechnical Laboratory Testing

Selected soil samples obtained from the soil borings were analyzed for various physical properties. Laboratory tests include grain size distribution, moisture content, Atterberg Limits and constant head triaxial permeability. A total of 12 grain size distribution analyses (including sieve and hydrometer), 33 moisture content tests, and 10 Atterberg Limit tests were each performed on samples from 6 different borings. Two constant head triaxial permeability tests were conducted on Shelby tube samples from 2 different borings. Laboratory analyses were performed by Empire Soils Investigations, Inc. in Hamburg, New York in accordance with A.S.T.M. specifications, including D-422 (mechanical analyses), D-2216 (moisture content), and D-4318 (Atterberg Limits). Constant head triaxial permeability tests were performed by Huntington

Analytical Services in Middleport, New York. A deviation from the Work/QA Project Plan which outlines use of the modified M.I.T. specifications for classification of soil textures was done in order to use the #200 sieve in defining the amount of fines present. (A #200 sieve has openings 0.075 millimeters instead of those specified in the M.I.T. specifications which are 0.06 millimeters.) It should be noted that classification of grain sizes differ for the A.S.T.M. and M.I.T. specifications. Geotechnical laboratory results are discussed in Section 4.2.3.3 on Overburden Geology and are presented in Appendix B.3.

4.1.5 Monitoring Well Development

Following monitoring well completion, each well was developed to improve the hydraulic properties of the sand pack and to remove any sediment within the well and adjacent to the screen/sand pack. Development was accomplished by pumping with either a battery powered ISCO Portable Peristaltic Pump or a gasoline powered Fuji Robins Centrifugal Pump. In each well, dedicated, new, polyethylene tubing was used to avoid cross-contamination of wells. The tubing was left in each well until development was completed.

Development continued until the discharged water was relatively sediment free. The effectiveness of the development measures was closely monitored in order to keep the volume of discharged waters to a minimum and still obtain sediment-free samples. A Model DRT-15B portable turbidimeter (HF Scientific, Inc.) was used to monitor development effectiveness. A turbidity reading of 100 NTU was used as a guide for discontinuing well development. Development procedures and individual "Well Development/ Purging Report" forms are provided in Appendix C.2.

All discharged water from onsite wells was collected in 55 gallon drums for disposal offsite at a licensed facility.

4.1.6 Hydraulic Conductivity Testing and Water Level Monitoring

The hydraulic conductivity of the various geologic units was assessed by analyzing the water level response in the monitoring well/piezometer following an instantaneous change in water level (slug test). Water level response was monitored by using either an electronic data logger and transducer which automatically recorded changes in water level pressure or a manually operated water level meter. A 2- or 5-foot stainless steel slug was used to displace the water level.

Hydraulic conductivity values were calculated using both the variable head and basic time lag formulas developed by Hvorslev (1951) as referenced in Lambe and Whitman (1969). Additional details are presented in Appendix C.3.

Hydraulic heads were established by water level measurements in the monitoring wells and piezometers. Water levels were measured frequently (almost daily) during active field investigations and at least monthly thereafter (December 1987 to March 1988) until all wells/piezometers had fully recovered. Hydraulic head values used in depicting groundwater flow and the calculation of flow velocities (Section 4.3.3) represent fully recovered water levels. Two 24-hour water level monitoring events were conducted on selected wells near the north end of the park, in June 1988 and May 1989, to establish the correlation between groundwater levels and the Niagara River water level. A discussion of this correlation is presented in Section 4.3.3.3. Appendix C.4 presents all water level measurements, both during and after the drilling program.

4.1.7 Test Pit Program

Plate 1 of the September 1987 Surface Geophysical Survey report (Appendix B.1) shows the site's magnetic field based on a 20-foot

grid magnetometer survey. Parallel linear groupings of anomalies can be seen both right and left of baseline stations P39+00 through P45+00. There was concern that these anomalies might indicate groupings of buried drums. To investigate this possibility it was decided to add a test pit program to the scope of the Remedial Investigation.

The first step of this program was to have Hager-Richter Geoscience, Inc. perform a refined magnetometer survey reducing the grid to 10-foot spacings. This was done in April 1989 and the resulting report is in Appendix B.1. This information was used to locate the test pits, which were dug on May 9, 10, 11 & 12, 1989 by URS's subcontractor CECOS International Inc. Seven (7) pits were dug and their locations are shown in Figure 1-5.

Pits TP-A, B, C, D, F & G were dug in areas of high magnetic anomalies while TP-E was dug away from magnetic highs to be used as a control. No drums or major metallic objects were found in TP-E. Of the 6 remaining pits, 5 (TP-A, B, C, F, G) had remnants of either fiber or metal drums. Three metal drums were found and the number of fiber drums was between 7 and 9 but uncertain due to their deteriorated condition. TP-D had no drums. The findings for individual pits are listed in the Test Pit Logs in Appendix B-5.

No drums were found intact. Fiber drums were identified from fiber remnants, metal strapping and the drum shaped solids they once contained. The metal drums were rusted through in several places. The contents of all drums were a yellow to reddish orange solid resin-like substance. Two samples were taken at TP-B and the results are discussed in the next section.

Other debris found in the pits included general municipal garbage such as tires, paper, plastic, bottles and cans, and non-municipal wastes such as black foundry sand, a white rubbery compound

and a bright blue/green solid (sampled at TP-B). Metal debris included steel cable, auto parts, scrap metal and other metal objects. A bluish white slag-like layer was encountered at the base of the TP-D, E, F & G and may extend over a wide area since it covered the base of each pit where it was found.

The cause of the magnetic anomalies was, therefore, the metal debris and not a concentration of drums. The located drums appear to have been randomly mixed in with the general refuse. As such, there is apparently no way to identify isolated areas where drums may exist.

4.1.7.1 Analytical Results From Test Pit Samples

Two samples were collected during the Test Pit Program in May 1989 from test pit TP-B (samples labeled 5-1 and 5-2) and were sent to Ecology & Environment, Inc. and analyzed for full HSL/TAL parameters plus an anion scan. The analytical results for organic compounds detected above the detection limits are reported in Table 4-2. The analytical results for metals are reported in Table 4-3. As the results indicate, the analyses did not fully identify the compositional components of the samples, especially in the organic analytes. There were many assumptions made in order to calculate the inorganic compounds, such as the physical appearance of the samples, the chemistry involved and the site history. To further identify these samples would require extensive testing and research into the production processes of the companies known to have deposited waste at the site.

Organic Results. Sample 5-1 had a physical appearance of a blue/green powder and was slightly water soluble. The sample has 47.0% organic matter and of this value, 2.16% of the organic compounds were identified (see Table 4-2). The sample contained a small percentage of chlorinated compounds, i.e. methylene chloride and chloroform, which have been found in the groundwater and other soil boring samples

TABLE 4-2

RESULTS ABOVE DETECTION LIMIT FOR ORGANIC COMPOUNDS FOUND IN TEST PIT SAMPLES*

<u>Compound</u>	<u>Sample 5-1</u>	<u>Sample 5-2</u>
Naphthalene	<0.006	0.011
Methylene Chloride	0.0000044	<0.00013
Acetone	0.000029	<0.00026
Chloroform	0.000064	<0.00013
Tetrachloroethene	0.000041	<0.00013
Total Xylenes	<0.0000032	0.00017
Phenol	<0.0064	0.26
Total Phenols	0.0013	0.44
Cyanic acid, phenylester (1)	0.64	---
Unknown "trichloro" compound (1)	1.25	---
1-Phenyl-ethanone (1)	0.27	---
Methenamine (1)	---	0.25
2,2'-methylenebis phenol (1)	---	0.32
Methylphenol isomer (1)	---	0.089
Naphthalenamine-unknown (1)	---	0.12
Total Organic Compounds	2.16	1.48

* All results reported as percent % based on dry weight basis unless otherwise noted.

(1) Tentatively Identified Compounds

TABLE 4-3

ANALYTICAL RESULTS FOR METALS IN TEST PIT SAMPLES*

<u>Element</u>	<u>Sample 5-1</u>	<u>Sample 5-2</u>
Aluminum	24,000	447
Antimony	4,380	<16.0
Arsenic	2.56	4.45
Barium	18.2	14.3
Beryllium	<0.50	<0.50
Cadmium	<1.30	8.30
Calcium	69,300	17,500
Chromium	11.2	7.97
Cobalt	<2.60	<2.60
Copper	9.22	14.5
Iron	1,170	6,010
Lead	4.05	30.6
Magnesium	6,890	2,380
Manganese	98.2	489
Mercury	<0.13	<0.13
Nickel	<3.80	8.06
Potassium	146	<110
Selenium	<1.30	<1.30
Silver	<2.60	<2.60
Sodium	1,350	716
Thallium	<1.30	<1.30
Vanadium	78.1	10.5
Zinc	199	629

* All results are reported in mg/kg, dry weight basis.

throughout the site. The total phenols concentration is low but it is important to note that cyanic acid was found in the sample and the chemistry of this acid will react with phenols and neutralize the compounds.

Sample 5-2 had a physical appearance of a hard crystalline resin structure and was yellow to reddish orange in color. The sample contained 51.0% organic matter with the major identified component as total phenols at 0.44%. The remaining identified organic compounds are typical of those found in phenolic resins.

Inorganic Results. The inorganic compounds presented in Table 4-4 were calculated as carbonates, oxides, and salts based on the physical tests, physical appearance, and the chemical reactivity of the samples. As the test results show, sample 5-1 contained 25.3% of the calculable carbonates, oxides, and salts while sample 5-2 contained only 7.1% of the same compounds. The anions (NO_3 , Cl, SO_4) were not added to the totals as they were used to identify the above compounds.

Physical Parameters. The physical parameters are broken down into three components i.e. Organic Matter, Inorganic Matter and Moisture to Total 100%. These parameters are presented in Table 4-5. The total solids determination was used to calculate results on a dry weight basis and the pH value was used to define corrosivity of the samples.

4.2 Geology

A discussion of the regional and site-specific geology is included in this section commencing with a summary of the previous geologic investigations conducted in the region which are considered pertinent (Section 4.2.1.2). A regional geologic discussion, including a presentation of the physiography, major overburden units and bedrock follows in Section 4.2.2. A discussion of the site geology, including

TABLE 4-4

PERCENTAGE OF INORGANIC COMPOUNDS IN TEST PIT SAMPLES*

<u>Inorganic Compound</u>	<u>Sample 5-1</u>	<u>Sample 5-2</u>
Al as Al_2O_3	4.54	0.085
Sb as Sb_2O_3	0.53	<0.0019
Ba as BaSO_4	0.019	0.413
Ca as CaCO_3	17.3	4.37
Fe as Fe_2O_3	0.17	0.86
Mg as MgCO_3	2.39	0.83
Mn as Mn_3O_4	0.014	0.068
Na as NaCl	0.34	0.39
V as V_2O_5	0.014	0.002
Zn as ZnO	0.025	0.078
Total Inorganic Compounds	25.3	7.1
Nitrate	<0.0055	0.043(1)
Chloride	0.0048	0.24
Sulfate	0.0077	0.17

* All results reported as percent % based on dry weight basis unless otherwise noted.

(1) Natural biodegradation product of amines.

TABLE 4-5

PHYSICAL PARAMETERS

<u>Parameter</u>	<u>Sample 5-1</u>	<u>Sample 5-2</u>
pH Units	8.89	8.23
Organic Matter, %	47.0	51.0
Inorganic Matter, %	31.0	25.0
Moisture %	22.0	24.2
Total Solids, %	78.0	76.0

information on the site topography, a description of the specific geologic units which were encountered underlying the site, and the subsurface characteristics of the site are presented in Section 4.2.3.

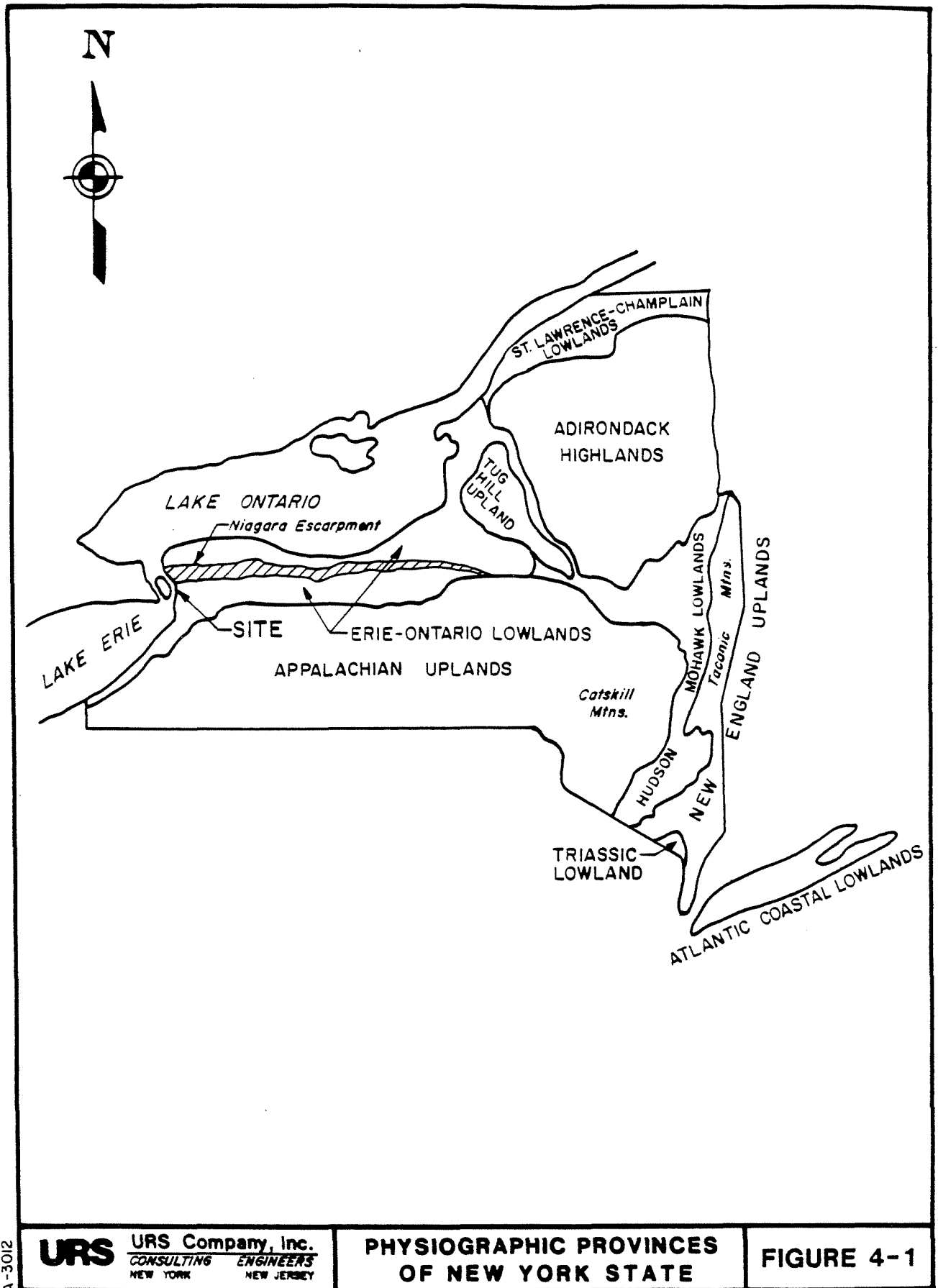
4.2.1 Previous Geologic Investigations

Several regional as well as smaller-scale local geologic studies have been conducted in the area. A brief synopsis of reference materials which have been particularly useful in this investigation is presented below.

LaSala (1968) presents a concise summary of Paleozoic stratigraphy and unconsolidated sediments in the Erie-Niagara Region. Regional bedrock mapping of western New York and the Niagara Peninsula, Canada was compiled by Rickard and Fisher for the New York State Geological Survey in 1970. A Quaternary geologic map of Western New York and a portion of the Niagara Peninsula, produced by Ernest H. Muller for the New York State Geological Survey in 1977 identifies the surficial sediments of the region. The Quaternary geology of the Niagara Peninsula in southern Ontario, Canada was extensively investigated by Feenstra, 1981. A hydrogeologic investigation was conducted by Geologic Testing Consultants Ltd. for the Ontario Ministry of Environment in 1983 in an area just east of the Gratwick-Riverside Park site. This report provided detailed information on the local geology, particularly the unconsolidated sediments. Novakowski and Lapcevic (1987) presents regional information on the Silurian and Ordovician stratigraphy and a brief discussion of the structural geology of the units in the vicinity of Niagara Falls, Canada.

4.2.2 Regional Geology

As illustrated in Figure 4-1, the site is located within the extreme western portion of the New York State physiographic province



A-3012

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**PHYSIOGRAPHIC PROVINCES
OF NEW YORK STATE**

FIGURE 4-1

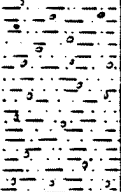
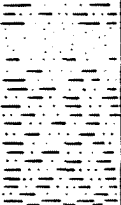
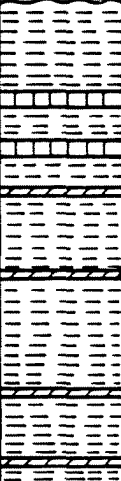
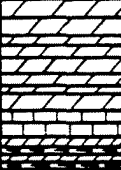
designated as the Erie-Ontario Lowlands (University of the State of New York, 1966). This province forms a band across the western half of New York State, lying east of Lake Erie and largely south of Lake Ontario. The province extends southward to the boundary with the hilly, higher-relief province of the Appalachian Uplands. The Erie-Ontario Lowlands are characterized by relatively flat-lying, low relief topographic features. Surface elevations increase gently eastward and southward from Lake Erie and Lake Ontario and their respective lake levels of 570.5 feet and 244 feet. The major physiographic feature of the area is the east-west trending Niagara Escarpment which extends westward into Ontario, Canada and becomes discontinuous towards Rochester, New York to the east. The Middle Silurian Lockport Dolomite forms the Escarpment's resistant caprock.

Glacial erosion and deposition has significantly modified the topography of the Erie-Ontario Lowlands. In contrast with the Appalachian Uplands to the south, this region has undergone more extensive glaciation, in terms of both duration and frequency. The area has experienced repeated southward advance and northward retreat of the glacial ice margin, resulting in the deposition of a variety of glacial sediments. Regionally, the Erie-Ontario Lowlands are characterized by series of long, parallel, elliptical-shaped hills termed drumlins, as well as recessional moraines and shoreline deposits.

Figure 4-2 illustrates a generalized geologic columnar section of the region. Further discussion is presented in the following sections.

4.2.2.1 Overburden geology

The Quaternary Geology Map of New York (Muller, 1977) indicates that the unconsolidated materials of the region predominantly consist of Pleistocene deposits of glacial origin, although smaller

PERIOD	EPOCH	GROUP	FORMATION	SECTION	THICK- NESS (FT.)	DESCRIPTION
QUATERNARY	HOLOCENE	UNCON- FORMITY	RECENT DEPOSITS		1-21	Lacustrine, Alluvium, Fill Lake, stream, wetland and artificial deposits of variable texture, with local organic inclusions.
			LACUSTRINE CLAY, SILT & FINE SAND		8-24	Predominantly reddish-brown clayey-silt to silty-clay Some reddish-brown to brown to tan fine sand grading finer with depth.
	PLEISTOCENE		TILL		13-39	Reddish-brown gravelly silty-clay to clayey-silt. Some sand, gravel and large shale fragments near base.
UPPER SILURIAN	CAYUGA	SALINA	CAMILLUS SHALES		400	Predominantly gray, some green, thin-bedded shale and massive carbonate mudstone interbedded with dolomite. Gypsum beds, lenses and veins common.
	NIAGARA		LOCKPORT DOLOMITE		150	Light to dark gray, thin-bedded to massive dolomite. Light gray limestone near base. Shaly dolomite at base.

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amounts of Holocene sediments are also represented. The Pleistocene deposits largely include morainal deposits and glacio-lacustrine sediments, as well as a variety of sand and gravel deposits. The Holocene deposits consist primarily of lacustrine sediments. Other post-glacial deposition includes minor amounts of alluvium, beach sand and gravel, wetland deposits (peat and muck) and artificial fill. Excluding areas of artificial fill, the total overburden thickness is generally less than 50 feet in the area (LaSala, 1968).

The major unconsolidated units present in the region are illustrated on the geologic section found in Figure 4-2 and include a lacustrine/glaciolacustrine unit and a glacial till unit.

A description of each major unit follows. The lacustrine/glaciolacustrine unit includes lake sediments deposited in both glacial-ice impounded basins, as well as those which had suitable closure without the glacial-ice margin, and thus continued to exist after deglaciation (Muller, 1977). (Further detail on depositional environments associated with these deposits, and others subsequently discussed, may be obtained in LaSala (1968) and Muller (1977). Collectively, the lacustrine unit consists of fine-grained sediments including clay, silt and fine sand. The unit is described as thin-bedded to massive, and commonly possesses characteristics of cyclic bedding. Subsurface investigations conducted by the U.S. Geological Survey in 1982 also identified clay beds containing discontinuous sand and silt stringers (less than 3 feet thick) in the area (USEPA, 1985).

The glacial till is mapped by Muller and LaSala as a widespread unit deposited predominantly as ground moraine, but with substantial amounts of end moraine as well. The ground moraine is largely lodgment till comprised of clay, silt, sand and larger grain sizes. Lodgment till, which is transported by and deposited beneath the glacial ice, is a typically poorly-sorted, compact and relatively-

impermeable deposit. The end morainal deposits consist of stoney and gravelly ablation and lodgment till of variable thickness. Deposition is the result of melting of the glacial-ice edge. Deposits are poorly sorted and of variable permeability. The till unit generally overlies bedrock in the region.

4.2.2.2 Bedrock geology

The relatively thin veneer of unconsolidated Quaternary deposits are unconformably underlain by Paleozoic sedimentary rocks. A weathered and highly-fractured bedrock surface is common throughout the region and apparently occurs independent of bedrock lithology (Novakowski and Lapcevic, 1987). Regional dip is gently to the south at an average of 30 to 40 feet per mile.

The Geologic Map of New York (Rickard and Fisher, 1970) identifies the Camillus Shale as the youngest formation in the region, and thus the first bedrock unit encountered below the unconsolidated materials. The Camillus Shale is the lower (older) formation of the Salina Group which was deposited during the Upper Silurian Period. The Camillus is a predominantly gray, thin-bedded shale interbedded with massive carbonate mudstone (gray limestone and dolomite). Lenticular beds of gypsum are common and occur up to five feet in thickness and may extend three to four miles laterally. Thin lenses and veins of gypsum are also present in the formation. The estimated total thickness of the Camillus Shale is approximately 400 feet in the region (LaSala, 1968).

The Camillus Shale is underlain by the Upper Silurian Lockport Dolomite. The Lockport is a gray, fine-to coarse-grained, thin-bedded to massive dolomite. Gypsum nodules are commonly present. A light gray limestone (Gasport Limestone Member) and a shaly dolomite (DeCew Limestone Member) occur at the base of the formation. The total thickness of the Lockport is approximately 150 feet.

4.2.3 Site Geology

4.2.3.1 Site topography

The surface topography is generally flat with relief provided by differential settlement and pot holes in the northern developed portion of the site, and scattered piles of debris in the southern undeveloped portion of the site. The surface topography as compiled by aerial photography mapping is presented in Figure 1-4. Surface elevations range from a low of approximately 564 feet (above mean sea level) along the river bank to 587 feet in the southeastern corner of the site. The Niagara River has eroded the shoreline creating a 5-to 10-foot high bank along the western edge of the site.

The northern, developed portion of the site has been graded and seeded and currently consists of groomed lawn with scattered shrubs and trees. The terrain of the southern portion of the site is very irregular, and the area is largely overgrown by vegetation. Hummocky features (3- to 4-foot relief) near the central portion of the site are attributed to localized settlement.

4.2.3.2 Stratigraphic sequence

A total of 3 geologic cross-sections, including one oriented north-south and 2 traversing the width of the site (east-west), were prepared using the boring logs to illustrate the site's subsurface stratigraphy. The locations of the cross-section traverses are presented in Figure 4-3 and the geologic cross-sections are illustrated in Figures 4-4 and 4-5. (These are plates found at the end of the report.)

Several distinct stratigraphic units have been identified within the unconsolidated materials. Extending from ground surface to

bedrock, the stratigraphic sequence is identified as man-made fill, lacustrine sediments, till and bedrock. Table 4-6 summarizes the stratigraphy encountered in the borings drilled during this investigation.

The uppermost unit consists of man-made fill materials which occur throughout the site. The fill is composed of a variety of textures and assorted debris, including paper, plastic, metal, brick and glass fragments, concrete and asphalt rubble and an abundance of slag-like material. A thin layer of topsoil is sometimes present at the top of this unit.

Underlying the man-made fill, a unit consisting of fine-grained sediments is occasionally encountered. These materials comprise the lacustrine unit which consists of sediments that settled out of suspension in lakes persisting after deglaciation. The lake deposits are predominantly clay and silt, with a lesser occurrence of fine-grained sand.

A continuous till unit of glacial origin was encountered below the lacustrine unit (or immediately underlying the fill where the lacustrine unit is absent). This unit is interpreted as a ground morainal deposit of lodgment till which was transported by, and deposited beneath, the glacial ice. The unit typically consists of a variety of textures including some large shale fragments in some deeper portions near the bedrock contact. The till unit apparently overlies bedrock throughout the site.

Surface exposures of bedrock were not observed at, or in the immediate vicinity of, the site. The three borings which penetrate bedrock on site indicate that the depth to bedrock ranges from approximately 36.0 to 57.5 feet. These three boring locations do not, however, provide sufficient data to define the bedrock surface

TABLE 4-6

SUMMARY OF STRATIGRAPHY IN BORINGS

Boring/ Well No.	Ground Elevation	Depth	Elevation	Thickness	Stratigraphic Unit
GW-1S	576.78	0-15.0	----	----	Not sampled
GW-1D	576.79	0-0.4	576.79-576.39	0.4	Topsoil
		0.4-1.7	576.39-575.09	1.3	Fill
		1.7-5.8	575.09-570.99	4.1	Lacustrine Silty Fine Sand
		5.8-25.7	570.99-551.09	19.9	Lacustrine Silt & Clay
		25.7-38.4	551.09-538.39	12.7	Till
		38.4-49.9	538.39-526.89	11.5	Bedrock
GW-2S	575.61	0-1.0	575.61-574.61	1.0	Fill
		1.0-15.0	574.61-560.61	14.0	Lacustrine Silt & Clay
GW-2D	575.37	0-1.7	575.37-573.67	1.7	Fill
		1.7-2.5	573.67-572.87	0.8	Lacustrine Silt & Clay
		2.5-3.8	572.87-571.57	1.3	Lacustrine Silty Fine Sand
		3.8-15.0	571.57-560.37	11.2	Lacustrine Silt & Clay
		15.0-34.5	560.37-540.87	19.5	Till
		34.5-46.0	540.87-529.37	11.5	Bedrock
GW-3S	573.93	0-12.0	----	----	Not Sampled
G-W-3I	573.93	0-0.5	573.93-573.43	0.5	Topsoil
		0.5-12.0	573.43-561.93	11.5	Fill
		12.0-18.0	561.93-555.93	6.0	Till
GW-4S	576.87	0-8.0	----	----	Not Sampled
		8.0-14.0	568.87-562.87	6.0	Fill
GW-4I	576.77	0-1.0	576.77-575.77	1.0	Topsoil
		1.0-14.2	575.77-562.57	13.2	Fill
		14.2-21.8	562.57-554.97	7.6	Lacustrine Silt & Clay
		21.8-22.0	554.97-554.77	0.2	Till
GW-5S	568.55	0-15.0	----	----	Not Sampled
GW-5I	568.69	0-12.0	----	----	Not Sampled
		12.0-20.0	556.69-548.69	8.0	Fill
		20.0-31.0	548.69-537.69	11.0	Till
GW-5D	568.92	0-19.0	568.92-549.92	19.0	Fill
		19.0-57.5	549.92-511.42	38.5	Till
		57.5-68.5	511.42-500.42	11.0	Bedrock
GW-6S	572.56	0-15.0	----	----	Not Sampled

TABLE 4-6 (Continued)

Boring/ Well No.	Ground Elevation	Depth	Elevation	Thickness	Stratigraphic Unit
GW-6I	571.98	0-10.0	----	----	Not Sampled
		10.0-15.5	561.98-556.48	5.5	Fill
		15.5-28.0	556.48-543.98	12.5	Till
GW-6D	571.98	0-0.5	571.98-571.48	0.5	Topsoil
		0.5-16.0	571.48-555.98	15.5	Fill
		16.0-36.0	555.98-535.98	20.0	Till
		36.0-47.0	535.98-524.98	11.0	Bedrock
GW-7S	572.36	0-15.0	----	----	Not Sampled
GW-7I	572.32	0-12.0	572.32-560.32	12.0	Fill
		12.0-20.0	560.32-552.32	8.0	Lacustrine Silt & Clay
GW-8S	574.09	0-8.0	----	----	Not Sampled
		8.0-14.0	566.09-560.09	6.0	Fill
		14.0-16.0	560.09-558.09	2.0	Lacustrine Silty Fine Sand
GW-8I	573.94	0-14.0	573.94-559.94	14.0	Fill
		14.0-18.0	559.94-555.94	4.0	Lacustrine Silty Fine Sand
		18.0-22.0	555.94-551.94	4.0	Lacustrine Silt & Clay
		22.0-26.0	551.94-547.94	4.0	Till
GW-9S	572.51	0-17.0	572.51-555.51	17.0	Fill
		17.0-18.0	555.51-554.51	1.0	Till
GW-10S	572.05	0-0.5	572.05-571.55	0.5	Topsoil
		0.5-11.5	571.55-560.55	11.0	Fill
		11.5-13.0	560.55-559.05	1.5	Lacustrine Silt & Clay
GW-11S	574.32	0-9.3	574.32-565.02	9.3	Fill
		9.3-10.0	565.02-564.32	0.7	Lacustrine Silt & Clay
TB-1	580.85	0-20.5	580.85-560.35	20.5	Fill
		20.5-22.0	560.35-558.85	1.5	Lacustrine Silt & Clay

NOTES:

(1) All measurements are in feet.

throughout the site. Therefore, geophysical methods were employed to further define subsurface conditions.

Seismic refraction data indicated three distinctive layers throughout the site. The high-velocity, deep layer was interpreted as bedrock, overlain by an intermediate layer of variable unconsolidated sediments, and a thin, low velocity layer consisting of topsoil and fill occurring near the surface. Geophysical data indicated depth to bedrock is approximately 26 to 32 feet below ground surface. Disparities between depth to bedrock findings through geophysical means and those derived from actual subsurface drilling are certainly related to specific testing locations finding variations in surface elevation and local irregularities in the bedrock surface.

4.2.3.3 Overburden geology

The various overburden units encountered at the site are described in this section. A summary of the geotechnical laboratory results referred to below is provided in Table 4-7.

Man-Made Fill Unit. This is the uppermost unit encountered at the site. Man-made fill was also encountered at the two offsite locations (GW-1 and GW-2). At location GW-1 about 1.3 feet of granular asphalt-like material was encountered. At GW-2 about 1.7 feet of coarse backfill, material likely used in constructing the nearby railbed, was encountered. Thickness of this unit onsite ranges from 9.3 to 20.5 feet at GW-11S and TB-1, respectively. The thickness of the fill unit onsite was observed to generally increase to the south (Figure 4-4). A thin layer (0.5 to 1.0 feet thick) of topsoil overlies this unit in the northern portion of the site which is the developed area. The topsoil is described as a reddish-brown to dark-brown, organic clayey-silt.

TABLE 4-7
GEOTECHNICAL LABORATORY RESULTS SUMMARY

Boring No.	Unit	Sample No.	Sample Interval	GRAIN SIZE DISTRIBUTION (%)			N Count ⁽¹⁾	Moisture Content(%)	ATTERBERG LIMITS		
				Gravel	Sand	Silt	Clay		Liquid Limit	Plastic Limit	Plasticity Index
GW-1	LSC	S-6	8.0-10.0	0.0	0.2	6.4	93.4	21	27.8	25	26
	LSC	S-7	10.0-12.0					17	30.8		
	LSC	S-8	12.0-14.0					6	40.1		
	LSC	S-9	14.0-16.0					4	40.5		
	LSC	S-12	20.0-22.0	0.1	0.9	20.0	79.0	2	35.1	23	22
	Till	S-16	28.0-30.0					34	7.3		
	Till	S-17	30.0-32.0	56.3	18.9	15.6	9.2	38	5.6		
	Till	S-20	36.0-36.9					50/.4	8.0		
	LSC	S-5	8.0-10.0	2.8	10.8	16.9	69.5	17	25.5		
	LSC	S-9	12.0-14.0					5	33.7		
GW-2	Till	S-11	16.0-16.8					50/.3	6.0		
	Till	S-15	24.0-26.0	14.7	25.7	31.7	27.9	27	8.0	12	8
	Till	S-18	30.0-31.7					52	8.6	11	3
	Till	S-5	22.0-24.0					21	18.6		
	Till	S-6	24.0-26.0	9.1	38.1	35.6	17.2	43	8.9	15	3

TABLE 4-7 - Continued
GEOTECHNICAL LABORATORY RESULTS SUMMARY

Boring No.	Unit	Sample No.	Sample Interval	GRAIN SIZE DISTRIBUTION (%)			N Count (1)	Moisture Content (%)	ATTERBERG LIMITS		
				Gravel	Sand	Silt			Liquid Limit	Plastic Limit	Plasticity Index
GW-5	Till	S-8	28.0-30.0				47	8.2			
	Till	S-10	32.0-34.0				26	10.8			
	Till	S-11	34.0-36.0				28	8.7			
	Till	S-13	38.0-38.4					8.3			
	Till	S-15	42.0-43.9	51.6	31.3	10.7	84	5.4			
	Till	S-16	46.0-46.9				50/.4	5.9			
GW-6	Till	S-17	48.0-49.2				95/.7	8.1	23	15	8
	Till	S-19	54.0-54.8	11.9	54.4	17.6	50/.3	11.9			
	Till	S-14	22.0-24.0	16.3	32.5	36.0	61	8.2	NP	NP	NP
	Till	S-15	24.0-26.0				43	10.4			
	Till	S-17	28.0-30.0				22	18.4	NP	NP	NP
	Till	S-19	32.0-32.9	17.6	35.9	22.0	50/.4	29.7			
GW-7	LSC	S-7	12.0-14.0				2	41.2	45	26	19
	LSC	S-8	14.0-16.0				3	40.4			
	LSC	S-10	18.0-20.0	0.0	0.8	13.1	2	38.7			

TABLE 4-7 - Continued
GEOTECHNICAL LABORATORY RESULTS SUMMARY

Boring No.	Unit	Sample No.	Sample Interval	GRAIN SIZE DISTRIBUTION (%)			N Count (1)	Moisture Content (%)	ATTERBERG LIMITS	
				Gravel	Sand	Silt	Clay		Liquid Limit	Plasticity Index
GW-8	LFS	S-9	16.0-18.0						NP	NP
	LCS	S-10B	18.0-20.0	0.0	2.5	29.3	68.2	37.1		
	Till	S-12	24.0-26.0					9.2		

Notes: (1) Standard penetration blow count 6-18 inches.

(2) NP = non-plastic.

TS = Topsoil

F = Fill

LSC = Lacustrine Silt & Clay

LFS = Lacustrine Silty Fine Sand

T = Till

Sampling of the fill has indicated that the unit is predominantly a reddish-brown to brown to dark-brown clayey-silt with some sand and gravel. Assorted debris was observed in this unit including brick, glass, wood and concrete fragments, as well as a frequent occurrence of slag. Slag was reported in all onsite borings with the exceptions of GW-3 and GW-6. A black to dark blue to purple material of variable texture was reported at several locations across the site.

Results of the geophysical (magnetic) survey indicated several areas of anomalously high readings across the site. Although some of these are likely attributed to surface materials, some are indicators of possible buried, metallic objects within the fill unit. Of particular interest is the area of irregular topography in the southern portion of the site. In this area, magnetic data revealed distinct linear features which were oriented roughly east-west across the site. These features, which average about 250 feet in length, were further investigated as part of a test pit excavation program, whose results are presented in Section 4.1.7.

Lacustrine unit. A unit of fine-grained lake sediments occurs underlying the man-made fill, although it is not present at all boring locations. A total of eight borings (only deepest boring per pair/cluster considered) encountered the lacustrine deposit; however, only four of these completely penetrated the unit. Thickness of the lacustrine sediments at these locations ranged from 7.6 feet at GW-4 to 24.0 feet at GW-1. At GW-8, the only onsite boring other than GW-4 to completely penetrate the unit, the lacustrine sediments measured 8.0 feet in thickness. The lacustrine silt and clay unit was found to be discontinuous within the site area possibly due to erosion of the river shoreline prior to landfilling. This unit was, however, encountered in all offsite borings and found to gradually thicken eastward.

The unit consists of interbedded layers of fine-grained sediments including clay, silt and fine sand. A silty, fine sand was observed at the two offsite locations as well as one of the onsite borings (GW-8). The thickness of the onsite sand lens was approximately 4 feet. A sand layer was also reported in the logs for borings completed in the north-central portion of the site by Earth Dimensions, Inc. (EDI). A 0.5-foot thickness of medium sand was encountered in EDI boring MW-10, a 1-inch thick layer of silty sand in EDI boring MW-11 and a 3.0-foot thick layer of fine sand in EDI boring MW-12. A 1.7-foot thickness of medium silty-sand was also encountered in Pittsburgh Testing Laboratory Boring no. 1 (central portion of site). Boring locations are approximated in Figure 1-2 and the logs are presented in Appendix B.4. A 4.1-foot thick section of the lacustrine fine sand was observed at GW-1. At this location the unit grades finer with depth, grading from a silty, fine sand with some clay, to a higher silt content and decreasing amounts of sand, eventually grading to a silty-clay. A thin lens (1.3-foot thick) of fine sand was also observed at location GW-2. Samples from the fine sand facies of the lacustrine unit are described as reddish-brown to brown to tan in color.

The predominant portion of the lacustrine unit, is a finer grained facies described as a reddish-brown clayey-silt to silty-clay. Sieve and hydrometer analyses were performed on a total of five samples from four different borings which penetrated this unit. As evident in Table 4-3, which presents the geotechnical data summary, the unit is predominantly clay. The average grain size distribution for the five samples analyzed is 0.6% gravel, 3.0% sand, 17.1% silt and 79.2% clay. Eleven samples from this unit (from four different borings) were analyzed for moisture content. Moisture content values ranged from 25.5% to 41.2%, and averaged 35.5%. Atterberg Limits were performed on three samples from two borings. Based on the plasticity indices (PI) and liquid limits reported, the three samples are all classified as clay. However, the shallow sample from GW-1 (8.0 to 10.0 feet) was

identified as a fat clay and the remaining two samples are classified as a lean clay, having both a lower liquid limit and lower PI than the shallow sample.

Two subunits of the lacustrine silt and clay unit were identified based on the geotechnical results. The upper subunit consists of a clayey-silt with a trace of sand and gravel. The sediments are typically reddish-brown in color. Geotechnical tests were performed on three samples from this subunit (depths ranging from 8 to 12 feet) collected from offsite locations. The standard penetration resistance (N count) ranged from 17 to 21. Moisture content results ranged from 25.5 to 30.8% and averaged 28% for samples from this subunit. Grain size analyses were performed on two samples which indicated an average distribution of 1.4% gravel, 5.5% sand, 11.7% silt and 81.5% clay.

The lower subunit was identified as a mottled, brownish-gray, clayey-silt with a trace of sand. Geotechnical data are available for eight samples from this subunit (from four different borings). These samples were collected from depths ranging from 12 to 22 feet. The N count was quite low and significantly less than those values reported for the upper clayey-silt. The N count for the lower clayey-silt ranged from 2 to 6 and averaged 3.3, as compared to an average of 18.3 for the upper subunit. Moisture content results for samples from the lower subunit ranged from 33.7 to 41.2% and averaged 38.4%. These values are considerably higher than those measured for the apparently more desiccated upper clay-silt which averaged 28.0% for moisture content. Grain size distribution for the lower subunit averaged 0.1% gravel, 1.4% sand; 20.8% silt and 77.8% clay, based on analyses performed on three samples from both onsite and offsite boring locations.

The lacustrine silt and clay unit ranges in thickness from 4.0 feet at GW-8 to 19.9 feet at GW-1 (based on borings which completely

penetrate the unit). The unit was also encountered at GW-2, GW-4, as well as four additional onsite borings which were partial penetrations. The silt and clay was also encountered in Earth Dimensions, Inc. borings MW-10 (3.5-foot partial penetration), MW-11 (2.5-foot partial penetration) and MW-12 (1.5-foot partial penetration), and in Pittsburgh Testing Laboratory borehole 1 (1.4-foot partial penetration).

Till unit. The till unit is the lowest, and thus oldest, unit of unconsolidated materials occurring at the site. The till is immediately underlain by bedrock in the area. Boring information indicates that the occurrence of till appears to be widespread representing a continuous unit across the site and vicinity. The four "deep" borings completely penetrated the till unit. Till thickness at these borings ranged from 12.7 to 38.5 feet at GW-1D and GW-5D, respectively, and averaged 22.7 feet. Till was not encountered at boring locations GW-7, GW-10S, GW-11S and TB-1; as these borings were completed in the overlying lacustrine unit.

The till is described predominantly as a reddish-brown, gravelly silty-clay to clayey-silt. Some sand, gray gravel and large shale fragments are reported, particularly in deeper borings which penetrate zones overlying bedrock. The unit is typically hard, dense and compact.

Grain size analyses (sieve and hydrometer) were performed on seven samples from the till unit representing four different borings. (This includes one test performed on the sandy till subunit.) The average grain size distribution for the till is 26.7% gravel, 35.5% sand, 24.5% silt and 15.4% clay. However, Table 4-3 shows the unit is quite variable in texture. Analytical results indicate as much as 56.3% gravel and relatively small amounts of clay (9.2%) in the 30.0- to 32.0-foot sample from boring GW-1 compared to 14.7% gravel and 26.0% clay as measured in boring GW-2 (24.0-to 26.0-foot sample), the till sample

which measured the highest percentage of clay. Grain size analyses performed on one sample from GW-6 (32.0 to 32.9-foot depth) subunit indicated the following distribution: 17.6% gravel, 35.9% sand, 22.0% silt and 24.6% clay. Analyses for moisture content were performed on 21 samples from the till unit, which included five different boring locations. Moisture content results for the unit ranged from 5.4% to 18.6% with an average of 8.7%, excluding those values for the sand subunit. As a function of increased porosity, samples from the sandy till subunit measured a significantly higher percentage for moisture content than those from the main till unit. Moisture content for the two samples from the sandy till, both from GW-6, were 18.4% and 29.7%. The standard penetration resistance (N count) for the till ranged from 21 to 95/.7 indicating that the sediment are compact to very dense. Atterberg Limits were performed on six samples from three different borings. Results for the plasticity indices (PI) and liquid limit indicate that two samples were classified as lean clay (GW-2, S-15 and GW-5, S-17), two were classified as silt (GW-2, S-18 and GW-5, S-6), and the remaining two were classified as non-plastic (GW-6, S-14 and S-17).

4.2.3.4 Bedrock geology and topography

Bedrock was encountered at two offsite (GW-1D and GW-2D) and two onsite (GW-5D and GW-6D) boring locations. Bedrock core data are summarized in Table 4-8. Bedrock at all four locations is a medium-gray shale which is thin bedded and hard. Vuggy deposits and interbeds of gypsum occur within the formation which is interpreted as Camillus Shale. Near the bedrock/till contact, the shale is moderately weathered with broken and crushed zones observed in the cores. The occurrence of fracturing along bedding planes was reported in both onsite cores.

Depths from the ground surface to the top of bedrock are 38.4, 34.5, 57.5 and 36.0 feet for borings GW-1D, GW-2D, GW-5D and GW-6D, respectively. These depths correspond to elevations of 538.39, 540.87,

TABLE 4-8
BEDROCK CORE DATA

	<u>GW-1D</u>	<u>GW-2D</u>	<u>GW-5D</u>	<u>GW-6D</u>
Top of Bedrock Elevation (ft.)	538.39	540.87	511.42	535.98
Lithology	Shale	Shale	Shale	Shale
Interval Cored (ft.)	38.4-49.9	36.0-46.0	57.5-68.5	36.0-47.0
Core Penetration (ft.)	11.6	10.0	11.0	11.0
Recovery (ft.)	4.4	8.5	10.4	7.9
Percent Recovery	38%	85%	95%	72%
Rock-Quality Designation*	0%	9%	54%	0%

* NOTES

Rock - Quality
Designation (RQD)

Description of
Rock Quality

0-25%
25-50%
50-75%
75-90%
90-100%

Very Poor
Poor
Fair
Good
Excellent

511.42 and 535.98 feet above mean sea level for GW-1D, GW-2D, GW-5D and GW-6D, respectively. In general, the boring information indicates that the bedrock surface appears to be relatively flat-lying with a gentle slope towards the Niagara River. Data results from the seismic refraction survey conducted at the site further support this. The anomalously low bedrock elevation reported at GW-5D is interpreted as an erosional channel feature, presumably formed by either a glacial scouring of the bedrock or a preglacial river. The channel is in-filled by glacial till.

4.3 Physical Hydrogeology

This section presents a discussion of both the regional and local (site-specific) hydrostratigraphy and the hydrogeologic properties of the major water-bearing units.

4.3.1 Previous Hydrogeologic Investigations

Various regional and local hydrogeologic studies previously conducted in the area are pertinent to this investigation. Johnston's work in 1964 is a comprehensive study of groundwater occurrence in the Niagara Falls, New York area. A groundwater study of the Erie-Niagara Basin by LaSala (1968) includes a hydrogeologic evaluation of both the unconsolidated sediments and bedrock units in the area. Both of these works are particularly valuable for an understanding of the regional hydrogeology. In 1983, Geologic Testing Consultants Ltd. prepared a hydrogeologic evaluation of a site located just east of Gratwick-Riverside Park. The Niagara River Toxics Committee's (1984) report provides a description of the water-bearing units encountered in the Niagara River Region (including the U.S. and Canada) on an area-by-area basis. A report by Novakowski and Lapcevic (1987) presents an extensive description of the Paleozoic hydrostratigraphic units in the Niagara Falls area.

4.3.2 Regional Hydrogeology

4.3.2.1 Overburden Hydrogeology

In the unconsolidated deposits, groundwater occurs within the intergranular pore spaces. The amount of pore space available varies with lithology.

The lacustrine deposits consist predominantly of low permeability silt and clay. During periods of high precipitation, a seasonal perched water table exists in this unit due to their low permeability. Gradients develop toward topographic lows and the groundwater discharges to nearby surface water bodies. Vertical permeability for this unit is generally low, ranging from 10^{-5} to 10^{-8} cm/sec.

Sand and gravel deposits are present in the area; however, their distribution is limited. A north-south trending, sand- and gravel-filled stream channel which is several hundred feet in width is reported to exist about one mile east of Gratwick Park (Geologic Testing Consultants, Ltd., 1983). This highly-permeable channel has a significant impact on groundwater flow in its vicinity. Well yields for the sand and gravel deposits throughout the region are expected to vary as a function of the permeability and the saturated thickness of the deposits. For example, well yields of up to 1,400 gallons per minute (gpm) are reported in thick glacial outwash deposits in the area south of Batavia, New York (LaSala, 1968). Relatively-permeable sand stringers are also reported in this unit. However, although fairly high initial yields are obtainable from these sands, the yields commonly diminish significantly with time (USEPA, 1985).

The glacial till consists of poorly-sorted material and overlies bedrock in the region. Due to the compact nature of the till,

as well as its characteristically poorly-sorted matrix, this unit typically has a low porosity and movement of groundwater is slow. Wells completed in the till are not likely to be capable of high sustained yields.

4.3.2.2 Bedrock Hydrogeology

The general direction of regional groundwater flow in bedrock is north toward Lake Ontario. Its potential for use as an aquifer, however, is limited. Bedrock in the area consists of sedimentary rock strata in which secondary cementation has greatly reduced the amount of intergranular pore space available to water. Various forms of secondary porosity typically provide the major portion of water-bearing openings in bedrock. These include vertical joints, and more commonly horizontal joints (which largely occur along bedding planes), carbonate solution cavities, and to a lesser extent, faults.

The Camillus Shale, which underlies the unconsolidated sediments in the area, is considered the most productive bedrock aquifer in the region. The Camillus contains large amounts of gypsum, a highly-soluble, calcium-sulfate mineral which plays an important part in the water-bearing properties of this formation. When gypsum is exposed to groundwater, the mineral is dissolved and rock openings are widened. In the Camillus, gypsum largely occurs in thin beds and lenses; thus, the water-bearing zones formed by solution processes are primarily horizontal. Groundwater also occurs within joints and fractures, although to a lesser extent.

A water-bearing weathered zone of fracturing and solution exists at the bedrock/till contact and extends several feet below the bedrock surface. Well yields are reported as high as 1,200 gpm for industrial wells in the area (LaSala, 1968).

The Lockport Dolomite, which underlies the Camillus Shale, is also a significant water-bearing unit in the area. Groundwater occurs primarily along horizontal bedding-plane joints in the Lockport, particularly where thick or massive beds overlie thin beds which are more likely to fracture (Johnston, 1964). Although vertical joints are generally not as significant in water-bearing capabilities, an extensive zone of weathered, highly- fractured rock occurs at the upper surface of the Lockport where it subcrops below the overburden. This weathered zone is an estimated 10 to 15 feet in thickness. (Locally, the Lockport is overlain by the Camillus Shale bedrock.) Joints and fractures in the Lockport are sometimes widened by solution. Groundwater also occurs, although to a lesser extent, within solution voids formed by the dissolving of gypsum nodules in the formation. The nodules commonly occur along bedding planes, particularly in the upper portion of the unit. However, the solution cavities are typically poorly connected. Individual well yields of the Lockport Dolomite generally range from 4 to 90 gpm. Although well yields in excess of 90 gpm are possible, their occurrence is rare.

4.3.3 Site Hydrogeology

4.3.3.1 Hydrostratigraphy and hydraulic properties

The geologic units present at the site were grouped for discussion purposes, according to their hydraulic properties, including hydraulic conductivity and porosity, into three hydrostratigraphic units; Upper Aquifer, Confining Unit and Bedrock Aquifer. The relationship between the geologic and hydrostratigraphic units is shown in Table 4-9. The upper aquifer is comprised of saturated fill materials, and the sand facies of the lacustrine unit where it is in direct contact, or, in the cases of GW-2D, is within a foot, and hydraulically continuous with the fill. The confining unit consists of the silt/clay facies of the lacustrine unit where present, and the till unit which locally

TABLE 4-9

HYDROSTRATIGRAPHY RELATIVE TO GEOLOGIC UNITS

<u>Geologic Units</u>	<u>Hydrostratigraphy</u>
Fill	
Lacustrine Fine Sand	Upper Aquifer
Lacustrine Clay and Silt	
Till	Confining Unit
Camillus Shale Formation (Salina Group)	Bedrock Aquifer

underlies the lacustrine material. The Camillus Shale unit makes up the bedrock aquifer. Hydraulic properties of each of these units are discussed in the following sections.

Upper Aquifer Zone. As discussed in Section 4.2, a 9 to 20 foot thick layer of fill material blankets the site. The fill material is of variable texture and composition, ranging from large fragments of concrete to incinerator ash to a consolidated slag-like material. The lower 2 to 8 feet of fill is saturated, with the water table occurring within the fill at a depth of between 5 and 10 feet.

A saturated silty, fine sand layer was encountered immediately underlying the fill at borehole location GW-8 and was reported to be present in three of the boreholes completed by Earth Dimensions, Inc. This unit was grouped with the fill because it is hydraulically continuous with the fill and is likely to be fairly permeable relative to the finer textured facies of the lacustrine unit and the underlying till.

The hydraulic conductivity values for the fill obtained by slug testing are presented in Table 4-10. These values represent the arithmetic means of the test values. The actual values are presented in Appendix C.3. The hydraulic conductivity values show some variability, ranging from a low of 5.5×10^{-6} cm/s to a high in excess of 1×10^{-2} cm/s (upper limit of the testing equipment). Five out of the nine tests resulted in hydraulic conductivities $> 1 \times 10^{-2}$ cm/s. The geometric mean for the nine tests is $> 2.3 \times 10^{-3}$ cm/s. No boreholes were screened in the lacustrine fine sand and it was therefore not possible to determine its hydraulic conductivity. The hydraulic conductivity is estimated to be about 5×10^{-4} cm/s based on values for similar materials presented in Freeze and Cherry (1979).

TABLE 4-10
SUMMARY OF HYDRAULIC CONDUCTIVITY TESTS

Well No.	Elevation of Test Interval (ft)	Stratigraphic Unit Tested	Hydraulic Conductivity ft./min.	Average Hydraulic Conductivity cm/sec.
GW-1S	561.78 - 568.78	Lac.* Silt & Clay	6.3×10^{-7}	3.2×10^{-7}
GW-1D	532.39 - 539.79	Till/Bedrock	9.0×10^{-3}	5.9×10^{-3}
GW-2S	560.61 - 567.61	Lac. Silt & Clay	8.8×10^{-5}	4.5×10^{-5}
GW-2D	529.37 - 540.87	Till/Bedrock	1.8×10^{-2}	9.2×10^{-3}
GW-3S	561.93 - 568.93	Fill	$> 2 \times 10^{-2}$	$> 1 \times 10^{-2}$
GW-3I	555.93 - 559.43	Till	8.5×10^{-8}	4.3×10^{-8}
GW-4S	562.87 - 569.87	Fill	$> 2 \times 10^{-2}$	$> 1 \times 10^{-2}$
GW-4I	554.77 - 558.77	Lac. Silt & Clay/Till	5.6×10^{-6}	2.9×10^{-6}
GW-5S	553.55 - 563.55	Fill	1.0×10^{-5}	5.5×10^{-6}
GW-5I	537.69 - 546.19	Till	6.3×10^{-7}	3.2×10^{-7}
GW-5D	500.42 - 513.92	Till/Bedrock	8.3×10^{-3}	4.2×10^{-3}
GW-6S	557.56 - 566.56	Fill	6.3×10^{-3}	3.2×10^{-3}
GW-6I	543.98 - 546.98	Till	3.6×10^{-7}	1.8×10^{-7}
GW-6D	524.98 - 537.98	Till/Bedrock	2.5×10^{-2}	1.3×10^{-2}
GW-7S	557.36 - 565.36	Fill/Lac. Silt & Clay	2.7×10^{-4}	1.4×10^{-4}
GW-7I	555.32 - 557.32	Lac. Silt & Clay	3.1×10^{-7}	1.6×10^{-7}
GW-8S	558.09 - 565.59	Fill/Lac. Silt & Clay	$> 2 \times 10^{-2}$	$> 1 \times 10^{-2}$
GW-8I	547.94 - 552.44	Lac. Silt & Clay/Till	2.7×10^{-7}	1.4×10^{-7}
GW-9S	554.51 - 567.01	Fill/Till	$> 2 \times 10^{-2}$	$> 1 \times 10^{-2}$
GW-10S	559.05 - 567.05	Fill/Lac. Silt & Clay	$> 2 \times 10^{-2}$	$> 1 \times 10^{-2}$
GW-11S	564.32 - 571.02	Fill/Lac. Silt & Clay	1.2×10^{-2}	5.9×10^{-3}

* Lac. = Lacustrine

The porosity of the fill unit is expected to be highly variable as a function of the variable material texture. A value of 30% was assumed for both the fill and the lacustrine fine sand.

Confining Unit. The lacustrine silt and clay facies and the till, based on their horizontal continuity across the site and low permeability act as a confining layer, or aquitard, essentially isolating the upper aquifer from the bedrock aquifer. The combined thickness of this confining layer on-site ranges from approximately 20.0 ft. to 38.5 ft., averaging about 29.2 ft.; offsite the confining unit ranges in thickness from 30.7 ft. to 32.6 ft., averaging 31.6 ft.

The hydraulic conductivity values for the silt and clay and till, as determined by slug and recovery test analysis are presented in Table 4-10. The values, apart from GW-2S and GW-4I, are generally on the order of 10^{-7} cm/s or lower. The boring log for GW-2S indicates that the material found at this location is less compact and possibly more permeable. Piezometer GW-4I is completed largely in the lacustrine silt and clay but straddles the interface between the silt and clay and the underlying till. Laboratory testing on Shelby tube samples of the lacustrine silt and clay from GW-4I yielded a value of 3.1×10^{-8} cm/sec, and from GW-8I a value of 4.1×10^{-8} cm/sec. The geometric mean of hydraulic conductivity values for the confining unit (geometric mean was used as opposed to arithmetic mean to remove the bias presented by the high values in GW-2S and GW-4I) is 4.8×10^{-7} cm/s.

Porosity for the silt/clay and till was estimated from the average water content for the material and an assumed specific gravity of 2.67, using equations outlined by Craig (1978, p. 15-16). Based on an average water content of 35.5% for the silt/clay and 8.7% for the till, the porosity for these materials is estimated to be 48.7% and 18.8%, respectively. These values are consistent with representative

porosity ranges for similar unconsolidated materials presented in the literature (Freeze and Cherry, 1979; Driscoll, 1986).

The till near the bedrock interface is slightly coarser in texture with increased sand and gravel content noted in the two deep borings (GW-5D and GW-6D). Although the hydraulic conductivity of the basal till zone was not assessed, as no wells were completed in this zone, it is assumed to be one to two orders of magnitude higher than the geometric mean value for this unit (about 10^{-5} to 10^{-6} cm/s).

Bedrock Aquifer. The Camillus shale bedrock was encountered at depths of 38.4, 34.5, 57.5 and 36.0 ft. in borings GW-1D, GW-2D, GW-5D and GW-D, respectively. Available data indicates that the bedrock surface is relatively flat-lying with a gentle slope towards the Niagara River. The anomalously thick overburden thickness at GW-5D is attributed to the presence of an infilled bedrock erosional channel feature. The bedrock is vuggy, contains thin gypsum beds and is extensively fractured. It is assumed that the fracturing is related to weathering prior to sediment deposition and that the fractures have likely been widened by solution.

The hydraulic conductivity of the bedrock based on water level recovery following pumping ranges from 4.2×10^{-3} cm/s to 1.3×10^{-2} cm/s. The geometric mean is 7.4×10^{-3} cm/s.

The matrix porosity of the shale is expected to vary widely as a function of its composition and stress history. Values of 0-10% are cited in Freeze and Cherry (1979) as representative of matrix porosity for shale. In addition, the presence of fractures imparts a secondary porosity that is usually even more variable depending on the nature of the fracturing. For purposes of estimating groundwater flow (discussed in Section 4.3.3.2), a porosity of 5% was assumed.

4.3.3.2 Site Groundwater Flow

The directions and rates of groundwater flow at Gratwick Riverside Park were determined by combining information on the hydraulic properties of the hydrostratigraphic units (Section 4.3.3.1), with information on the hydraulic gradients that exist within and between the units. Water level measurements used in establishing hydraulic gradients are presented in Appendix C.4.

Table 4-11 summarizes the physical hydraulic properties of the hydrostratigraphic units as determined during this study and groundwater flow characteristics for each unit including principal flow direction, hydraulic gradient and estimate values for specific discharge and average linear velocity.

The significance of the reported values and the role of each of the hydrostratigraphic units in the local ground- water flow system is described in the following sections. Two 24-hour water level monitoring events were conducted on selected wells near the north end of the park, in June 1988 and May 1989, to establish the correlation between groundwater levels and the Niagara River water level. The results of these efforts, along with other water level measurements taken from the monitoring wells, are discussed in the following sections. Full details of all water level measurements are provided in Appendices C.4 (monitoring wells) and D (Niagara River).

Upper Aquifer - The interface between the groundwater flow system and the surface water system occurs within this zone. Groundwater contours for this unit are shown on Figure 4-6. Precipitation falling on the site will percolate downward through the unsaturated portion of the fill to the water table. Water level fluctuations following precipitation events are expected to show low amplitude (slow rise in water level) due to the high hydraulic

TABLE 4-11
SUMMARY OF HYDRAULIC PROPERTIES OF MAJOR HYDROGEOLOGIC UNITS

HYDROSTRATIGRAPHY		Physical Properties			Groundwater Flow Characteristics		
Units	Thickness (ft) (m)	Hydraulic Conductivity(k) (cm/s)	Porosity (n)	Principal Flow Direction	Average Hydraulic Gradient (i) (3/7/88) (m/s)	Specific Discharge (v=ki) (m/s)	Average Linear Velocity (v=v/n) (m/s)
o geologic components							
Upper Aquifer							
o fill	13.4(4.1)	$>2.3 \times 10^{-3}$	0.30(2)	lateral towards Niagara River	.005	1.1×10^{-7}	3.8×10^{-7}
o lacustrine fine sand							
Confining Unit							
o lacustrine silt and clay	31.7 (9.7)	4.8×10^{-7}	0.19 (till) to 0.49 (clay)	inland vertical downward shoreline vertical variable	.38	1.8×10^{-9}	3.6×10^{-9} to 9.4×10^{-9}
o till					.006	2.8×10^{-11}	5.8×10^{-9} to 1.4×10^{-10}
Bedrock Aquifer							
o fractured shale bedrock	10 ⁽¹⁾ (3.0)	7.4×10^{-3}	0.05(3)	lateral primarily towards Niagara River	.0001	7.4×10^{-7}	1.5×10^{-5}

Notes:

- (1) assumed thickness of weathered shale based on regional observations (Johnston, 1964)
- (2) assumed porosity value - considerable textural variability
- (3) assumed fracture porosity value based on values presented in Freeze and Cherry (1979)

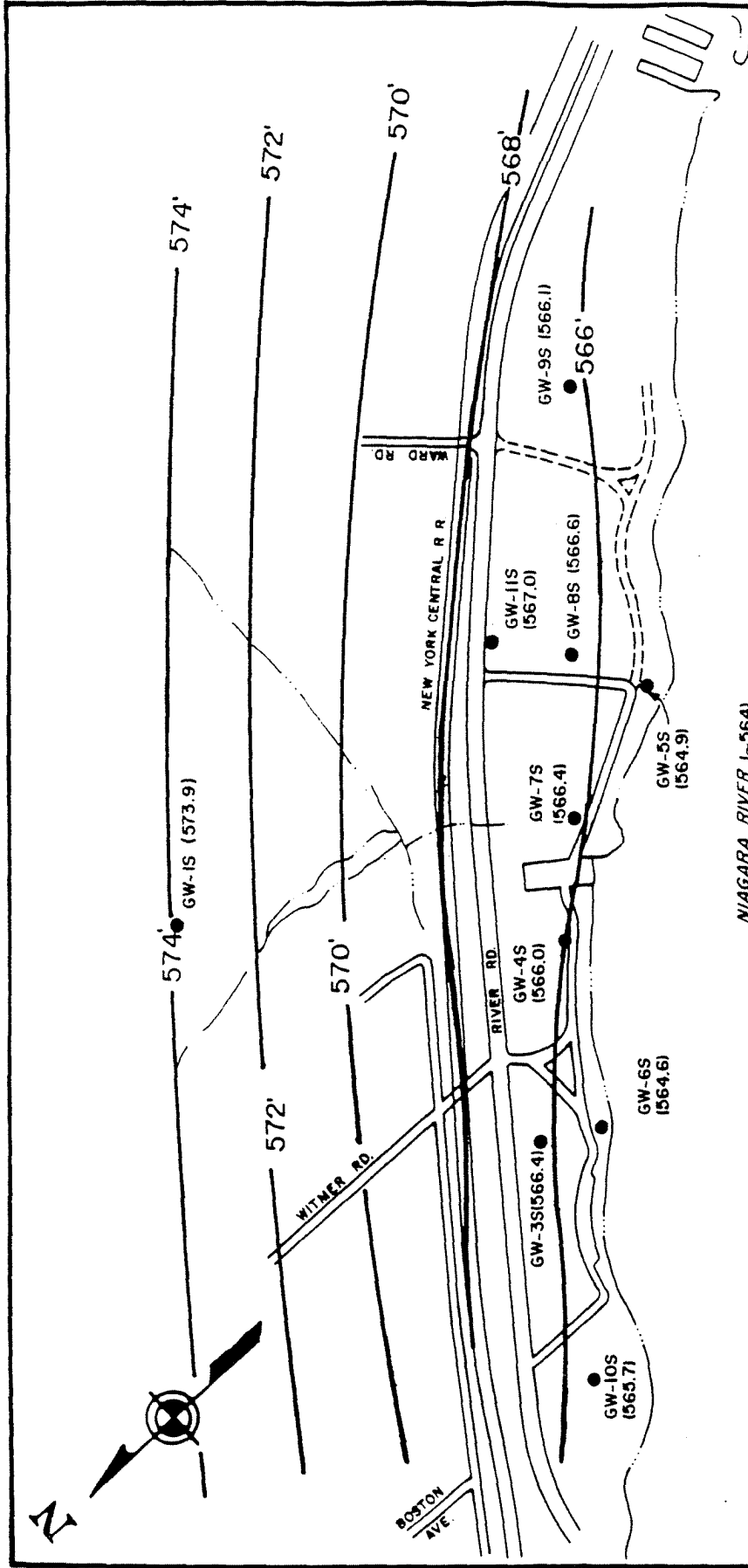
conductivity and large void space (porous openings). From monitoring well measurements, it was determined that it is not uncommon to have a one-foot change in water level in the upper aquifer over the course of a day. A groundwater contour map for the upper aquifer is given in Figure 4-6 showing water levels used to determine the hydraulic gradient presented in Table 4-11.

The greatest portion of precipitation in the form of groundwater moves laterally through this zone towards the Niagara River. Regardless of the position of the water table, downward gradients prevail across most of the site indicating that there is slow but steady flow to depth through the underlying confining unit. Gradients between the upper aquifer and the confining unit along the Niagara River show periodic reversals of gradients, indicating upward flow. This appears to coincide with high water levels in the Niagara River.

A review of water levels taken periodically in the monitoring wells between October 1987 and August 1988 revealed that measurements were taken between 8:00 am and 5:00 pm. Levels in the Niagara River adjacent to the site were calculated during this time period from information obtained from the U.S. Army Corps of Engineers. Water levels onsite were found to be consistently higher than in the River. This data does not support the presence of a flow reversal between the River and the site, at least between the hours of 8:00 am and 5:00 pm.

Groundwater and river elevations were measured across a section of the site for 24 hour periods on June 2, 1988 and May 18, 1989. Data from these events are presented in Appendix C. Results of this monitoring indicate an influence on nearshore groundwater within the upper aquifer associated with fluctuations in river elevations due to withdrawal of water for electrical power generation. Average fluctuation in river level between the two events was 0.60 feet resulting in fluctuation in groundwater level at nearshore well GW-6S an

A - 3021



● — WATER LEVELS IN SHALLOW
MONITORING WELLS MEASURED
ON MARCH 7, 1988

NOTE: GW-2S WAS DAMAGED AND THE
WATER LEVEL COULD NOT BE MEASURED

SCALE: 1" = 600'

URS
CONSULTANTS

**GROUNDWATER CONTOUR MAP
FOR THE UPPER AQUIFER**

average of 0.42 feet. The affects of these fluctuations were found to diminish within the fill unit and showed no apparent influence on groundwater levels at well GW-3S located approximately 250 feet inland of GW-6S.

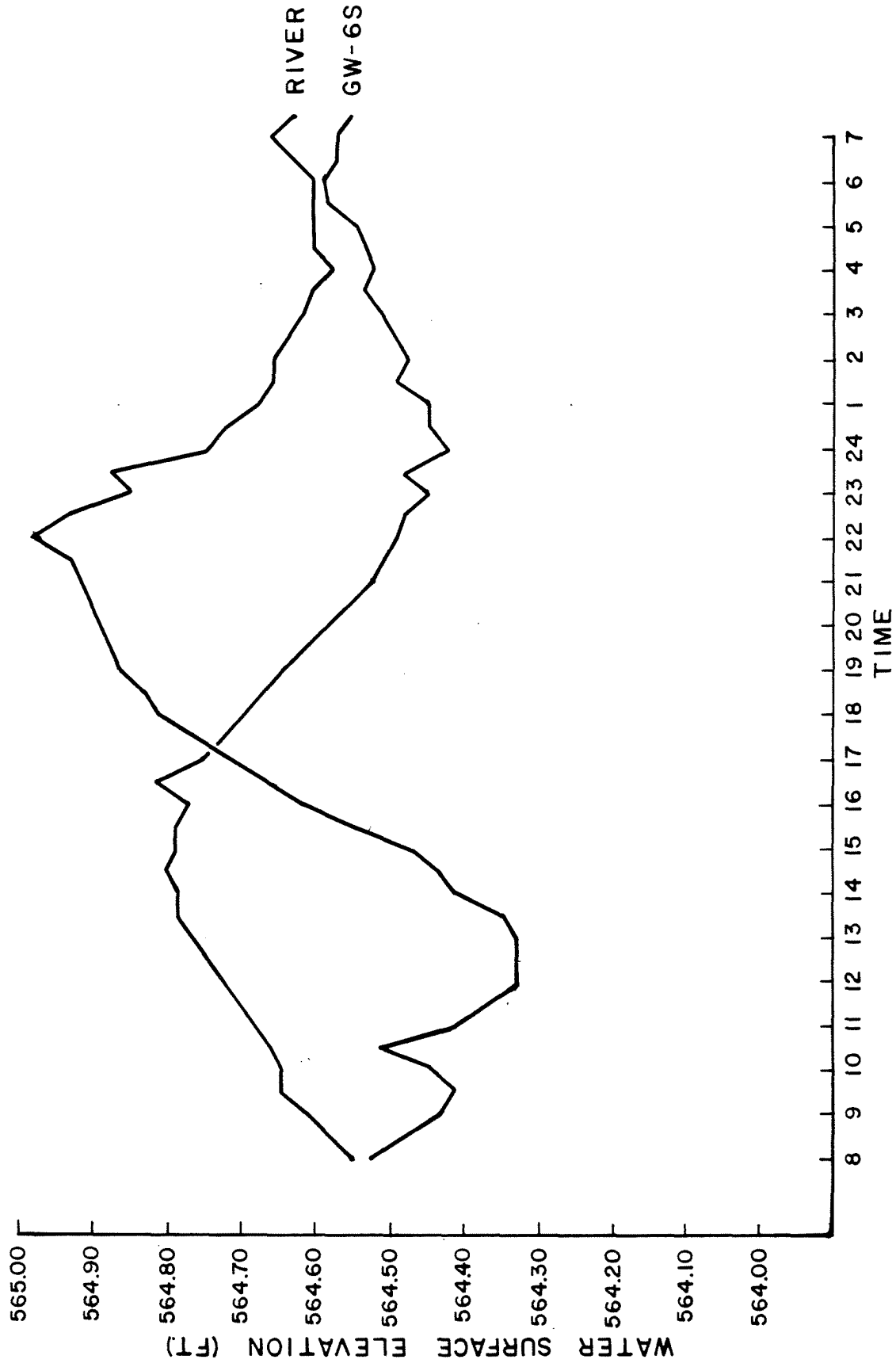
Results of the June 1988 24-hr. monitoring display a lag in time of about 12 hours between the rise in river elevation and the rise in groundwater at well GW-6S (Figure 4-7). This was found to cause a reversal in hydraulic gradient and recharge to nearshore shallow groundwater between the hours of 5:00 pm and 8:00 am. Similarly, a fall in river elevation is followed by a fall in groundwater elevation again reversing the hydraulic gradient and effecting a discharge of shallow groundwater. These conclusions indicate a periodic flushing of the nearshore upper aquifer due to reversals of groundwater flow direction (Figure 4-7).

Results of the May 1989 24-hr. monitoring were found to differ significantly from the 1988 findings. The 1989 data indicates that fluctuations in river level are followed almost immediately by similar fluctuations in shallow groundwater at GW-6S and does not create reversals of the hydraulic gradient between GW-6 and the river (Figure 4-8).

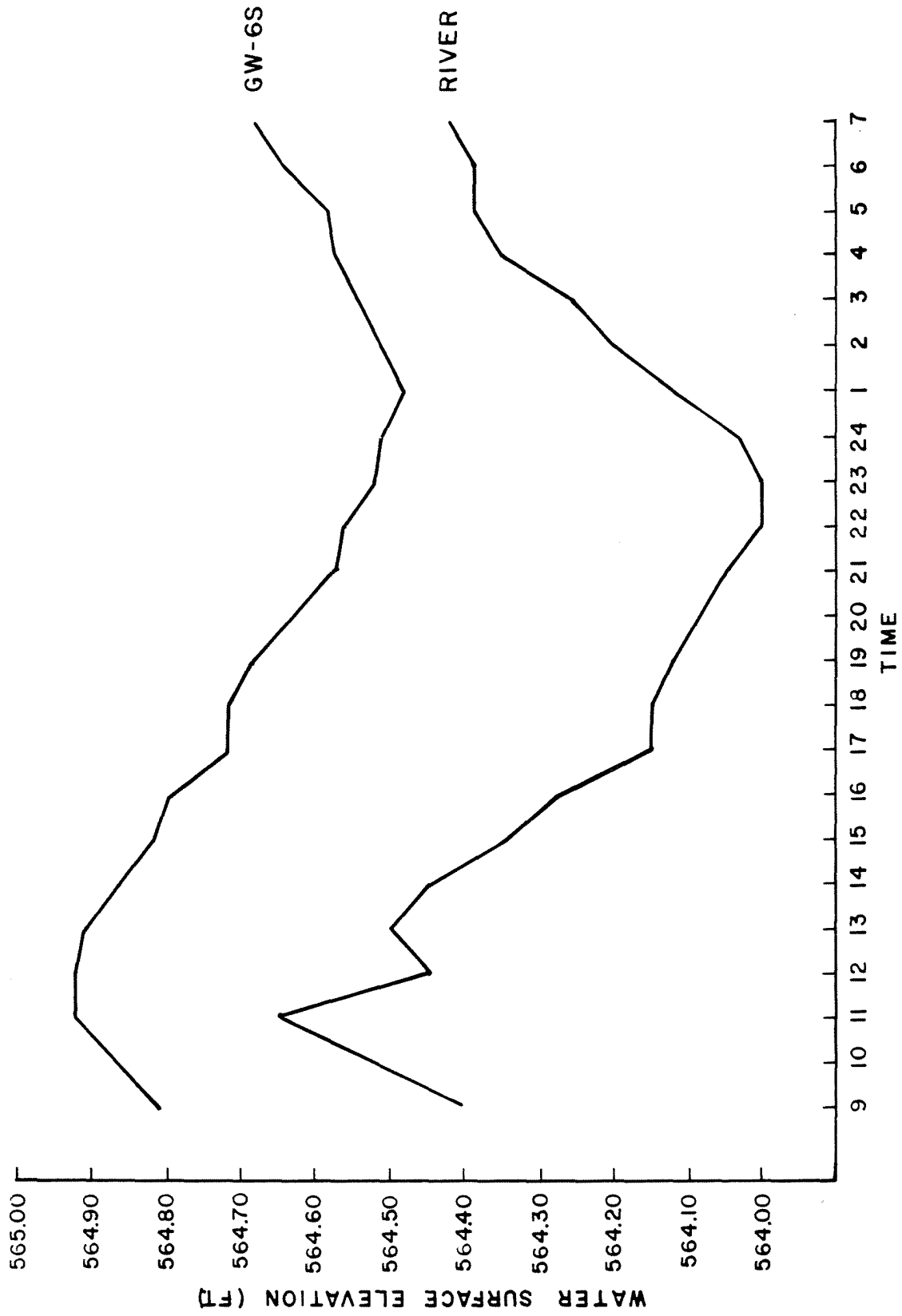
A hand calculation was attempted in order to calculate the site's groundwater discharge to the Niagara River; results are presented below. The assumptions were simplistic for steady-state conditions and not calibrated to the groundwater flow regime at and in the vicinity of the site. A detailed groundwater flow model will be developed and calibrated during the FS phase of the project which more accurately defines site conditions.

The lateral gradient in the upper aquifer across the site averages about 0.005. The specific discharge to the Niagara River is

A-3101



A-3100



24 HOUR WATER LEVEL MONITORING 5/18/89

FIGURE 4-8

calculated to be about 1.1×10^{-7} m/s resulting in approximately 4.4×10^{-4} m³/s (5.6 gpm) discharging to the Niagara River from the site. The average linear groundwater velocity is calculated to be about 3.8×10^{-7} m/s.

Confining Unit - Groundwater movement through the lacustrine silt/clay and till over the site is primarily downward. In the vicinity of the Niagara River, the hydraulic gradients in the upper portion of the unit appear to reverse on a regular basis as a function of river level fluctuation (upward gradients dominate during rising stages of river levels and downward gradients during water level decline).

The vertical hydraulic gradient as measured at well locations GW-1 and GW-2 (both off site) average about 0.38. Adjacent to the River, the vertical gradient is extremely small, averaging only 0.006.

The specific discharge (in the vertical direction) offsite and over the eastern portion of the site, is calculated to be about 1.8×10^{-9} m/s. Adjacent to the Niagara River, the specific discharge decreases to about 2.8×10^{-11} m/s as a function of the small vertical gradient. The average downward linear velocity away from the River is calculated to be between 3.6×10^{-9} m/s, and 9.4×10^{-9} m/s, and adjacent to the River between 5.8×10^{-9} m/s and 1.4×10^{-10} m/s. Discharge from this unit to the Niagara River is estimated to be between 1.7×10^{-4} m³/s (0.3 gpm) and 2.6×10^{-7} m³/s (4×10^{-4} gpm).

Bedrock Aquifer - Groundwater flow through the upper weathered portion of the bedrock is primarily lateral towards the Niagara River. Observations of water levels over two 24-hour periods indicates that the hydraulic gradients in the weathered bedrock reverse on a regular basis with flow moving inland away from the River. This reversal in flow coincides with high water levels in the River, and based on the field

observations, is of short duration. The effects of flow reversal are noticed as far inland as well GW-1D.

The horizontal hydraulic gradient is 0.0001. The specific discharge is calculated to be about 7.4×10^{-7} m/s and the average linear velocity is about 1.5×10^{-5} m/s resulting in an estimated discharge to the Niagara River of 2.2×10^{-3} m³/s (3.7 gpm).

4.4 Surface Water Hydrology

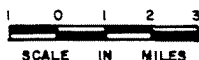
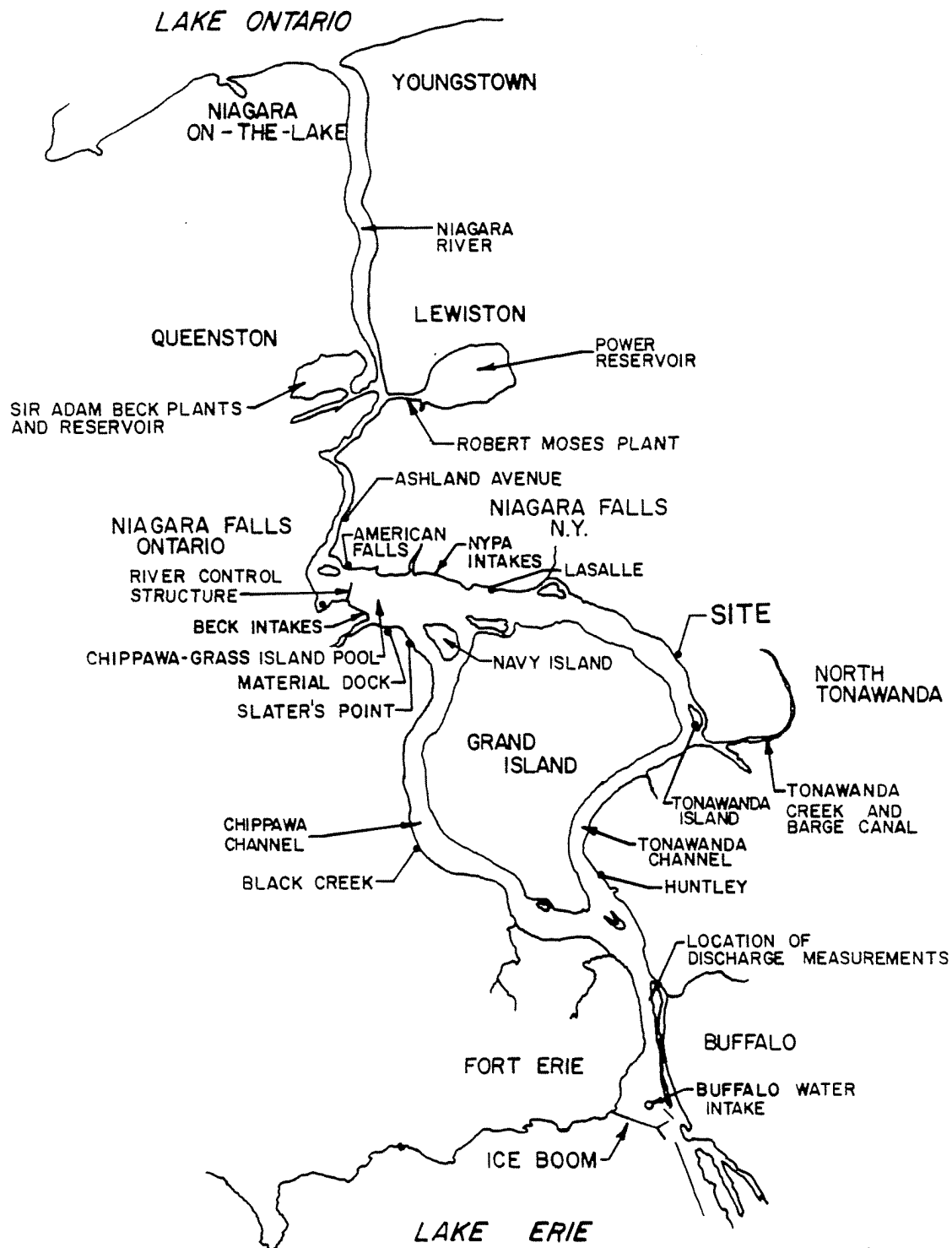
4.4.1 Introduction

4.4.2 Niagara River

The Niagara River, with an average flow of 200,000 cubic feet per second (cfs), forms the western boundary of the site. The river drains an area of about 88,000 square miles and is approximately 37 miles long. Between Lake Erie and Lake Ontario, the river drops about 328 feet with about one-half of the drop occurring at Niagara Falls.

At Grand Island, the river divides into two channels, the Chippawa Channel and the Tonawanda Channel, located west and east of Grand Island, respectively, as shown in Figure 4-9. The Tonawanda Channel which passes the site, is approximately 15 miles long, and carries about 43 percent of the total river flow (86,000 cfs). During the navigation season (April/May through November/December), the New York State Barge Canal, located upstream from the site, withdraws an average of 1,100 cfs from the Tonawanda Channel.

The confluence of the Chippawa and Tonawanda Channels occurs at the north end of Grand Island to form the Chippawa-Grass Island Pool. The Niagara River level drops about 3 feet between the southern end of Grand Island and the Pool. At the present time, the Niagara River



LEGEND: • RECORDING GAUGE

A - 2604

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NEW YORK NEW JERSEY

MAP OF THE NIAGARA RIVER

FIGURE 4-9

Treaty, as signed into effect in 1950 by the U.S. and Canada, mandates that the water level in the Pool be maintained as nearly as may be practicable to its long-term average elevation of 561 feet. This level is maintained with the aid of a control structure at the northern end of the Pool. The structure consists of eighteen gates and extends from the Canadian shore part way across the river. It is operated by the New York Power Authority and Ontario Hydro, under the direction of the International Joint Commission's International Niagara Board of Control.

The operation of the control structure and maintenance of water levels at about 561 ft. stabilizes water levels in the Tonawanda Channel adjacent to the site (approximately 6.5 miles upstream from the gates). River levels are recorded by the Army Corps of Engineers at several locations. The location closest to the site is a gage on the west side of Tonawanda Island approximately 1.5 miles upstream from the site's southern end. Whereas River water levels could possibly be up to a foot less near the site than those recorded at the Tonawanda gaging station, hourly/daily/monthly fluctuations should generally be similar. Hourly river measurements for the months of October 1987 - 1988 by the Corps, are presented in Appendix D.1.

A comparison of river levels with water levels measured in monitoring wells installed at Gratwick was undertaken on two separate occasions (June 2, 1988 and May 18, 1989) to establish a correlation between fluctuations in river and the monitoring well water levels. Groundwater level and river level fluctuations as measured on June 2, 1988 show good correlation, with a 0.60 ft. change in river level corresponding to about a 0.42 ft. change in groundwater level at GW-6D (at river's edge) and a 0.38 ft. change at GW-2D (about 600 ft. inland from the river's edge).

A similar correlation was found on May 18, 1989 with a 0.56 ft. change in River level corresponding to a 0.60 ft. change in

groundwater level at GW-6D and a 0.41 ft. change at GW-2D. On both occasions, the highest water levels occurred from 9:00 am to noon, and the lowest water levels at 10:00 pm.

4.4.3 Local Surface Drainage

Excluding the Niagara River, which was discussed in the previous section, the only local surface water mapped on the USGS topographic quadrangle (Tonawanda West, NY, 1980) is a small, intermittent stream located northeast of the site. This unnamed stream drains a topographic low area which lies just east of Witmer Road. The stream apparently discharges to a storm drain on the north side of the railroad tracks which crosses the site in the vicinities of the boat launch.

Although they do not appear on the USGS topographic quadrangle, additional surface water systems were identified during this Remedial Investigation. Two, small, intermittent drainage ditches lie east of the site, paralleling River Road for nearly the entire site length. One ditch lies on the eastern side of River Road, between the road and railroad tracks; the other lies between the double set of tracks and the single track. Both drainage ditches are discontinuous due to the roadways which intersect River Road. These roadways are topographically higher than the drainage areas they intersect; therefore, surface water flow directions change at these road intersections. A culvert is located approximately 1,000 feet south of Witmer Road and extends underneath the railroad tracks and across the site with eventual discharge to the Niagara River.

Because of the high permeability of the fill materials and the hummocky terrain, much of the precipitation which falls on the site is expected to infiltrate with only minimal overland flow on the paved areas. Therefore, a low runoff coefficient was used in the infiltration analysis for the site. A quantitative analysis of infiltration (I) was

performed using "The Water Balance Method" by Thornthwaite and Mather (1955). This method is based upon the relationship between precipitation, evapotranspiration, surface runoff, soil moisture storage, and infiltration. It was applied to the Gratwick site using procedures outlined in the following document: Use of the Water Balance Method for Predicting Leachate Generation From Solid Waste Disposal Sites (Fenn, et al., 1975). In applying this method, climatic data discussed in Section 2.0 for Buffalo and Niagara Falls, New York was used. The results of the analysis are presented in Appendix G and summarized in Table 4-12.

The results presented in Table 4-12 indicate that, out of the average annual precipitation of 35.30 inches, approximately 10 percent (3.53 inches) leaves the site as surface runoff, approximately 54 percent (19.13 inches) is evapotranspired, and approximately 36 percent (12.63 inches) enters the water table as infiltration. This average annual infiltration rate ($I = 12.63 \text{ inches/year} = 0.00288 \text{ feet/day}$) will be used in the design of remedial alternatives.

TABLE 4-12

INFILTRATION ANALYSIS BY WATER BALANCE METHOD

<u>Month</u>	Precipitation (in.)	Runoff (in.)	Evapotranspiration (in.)	Infiltration (in.)
January	2.80	0.28	0	2.52
February	2.50	0.25	0	2.25
March	2.66	0.27	0	2.39
April	2.78	0.28	1.34	1.16
May	2.89	0.29	3.01	0
June	2.84	0.28	3.61	0
July	2.80	0.28	2.95	0
August	3.47	0.35	3.18	0
September	3.14	0.31	2.84	0
October	2.97	0.30	1.71	1.00
November	3.26	0.33	0.49	0.44
December	<u>3.19</u>	<u>0.32</u>	<u>0</u>	<u>2.87</u>
ANNUAL	35.30	3.53	19.13	12.63

5.0 ENVIRONMENTAL QUALITY

This section presents data from previous site investigations and the recently completed field work for the Remedial Investigation performed at Gratwick Riverside Park. This data, including analytical results, historical data, and field reports, is used to describe the nature and extent of contamination at the site in soil, shoreline soil/waste, surface water, and groundwater, and potential sources of contamination. This section also presents New York State Standards, Criteria and Guidance (SCGs) for groundwater and surface water for compounds detected in any matrix during sampling and analysis.

5.1 Surficial and Subsurface Soil

5.1.1 Previous Investigations of Soil Contamination

Onsite subsurface soil was sampled in September 1984. Two samples were collected near River Road, north of the Ward Road entrance (Figure 1-3), and were analyzed for volatiles, semi-volatiles, pesticides/PCBs, and hazardous substance list (HSL) metals by Ecology & Environment, Inc. The results show no organic constituents present in the soil. A number of HSL metals were present with total lead being measured at 461 mg/kg. Results are presented in Table 5-1.

The most recent soil samples collected prior to the remedial investigation were collected by Niagara Mohawk and the Niagara County Health Department in October 1986; sample locations are shown in Figure 1-3. Shallow soil samples were collected for Niagara Mohawk from areas at the south end of the park and composited into ten samples. Samples were analyzed for priority pollutant volatiles, semi-volatiles, pesticides/PCBs, and total metals by Recra Environmental, Inc. Results above detection limits for these 10 composited soil samples are presented in Table 5-2. The Niagara County Health Department (NCHD) collected 7

TABLE 5-1

1984 SUBSURFACE SOIL ANALYTICAL RESULTS

Composite Samples
(Results in mg/kg)

VOLATILE ORGANIC COMPOUNDS

Compound	Sample I.D.	
	B-2	B-3
acrolein	<1	<1
acrylonitrile	<1	<1
benzene	<0.1	△0.1
carbon tetrachloride	<0.1	△0.1
chlorobenzene	<0.1	△0.1
1,2-dichloroethane	<0.1	△0.1
1,1,1-trichloroethane	<0.1	△0.1
1,1-dichloroethane	<0.1	△0.1
1,1,2-trichloroethane	<0.1	△0.1
1,1,2,2-tetrachloroethane	<0.1	△0.1
chloroethane	<0.1	△0.1
2-chloroethylvinyl ether	<0.1	△0.1
chloroform	<0.1	△0.1
1,1-dichloroethene	<0.1	△0.1
trans-1,2-dichloroethene	<0.1	△0.1
1,2-dichloropropane	<0.1	△0.1
trans-1,3-dichloropropene	<0.1	△0.1
cis-1,3-dichloropropene	<0.1	△0.1
ethylbenzene	<0.1	△0.1
methylene chloride	<0.1	△0.1
chloromethane	<0.1	△0.1
bromomethane	<0.1	△0.1
bromoform	<0.1	△0.1
bromodichloromethane	<0.1	△0.1
fluorotrichloromethane	<0.1	△0.1
dichlorodifluoromethane	<0.1	△0.1
chlorodibromomethane	<0.1	△0.1
tetrachloroethene	<0.1	△0.1
toluene	<0.1	△0.1
trichloroethene	<0.1	△0.1
vinyl chloride	<0.1	△0.1

TABLE 5-1 - Continued
1984 SUBSURFACE SOIL ANALYTICAL RESULTS
Composite Samples
(Results in mg/kg)

BASE/NEUTRAL COMPOUNDS

Compound	Sample I.D.	
	B-2	B-3
acenaphthene	<0.5	<0.5
benzidine	<1	<1
1,2,4-trichlorobenzene	<0.5	<0.5
hexachlorobenzene	<0.5	<0.5
hexachloroethane	<0.5	<0.5
bis(2-chloroethyl)ether	<0.5	<0.5
2-chloronaphthalene	<0.5	<0.5
1,2-dichlorobenzene	<0.5	<0.5
1,3-dichlorobenzene	<0.5	<0.5
1,4-dichlorobenzene	<0.5	<0.5
3,3'-dichlorobenzidine	<1	<1
2,4-dinitrotoluene	<0.5	<0.5
2,6-dinitrotoluene	<0.5	<0.5
1,2-diphenylhydrazine	<0.5	<0.5
fluoranthene	<0.5	<0.5
4-chlorophenyl phenyl ether	<0.5	<0.5
4-bromophenyl phenyl ether	<0.5	<0.5
bis(2-chloroisopropyl)ether	<0.5	<0.5
bis(2-chloroethoxy)methane	<0.5	<0.5
hexachlorobutadiene	<0.5	<0.5
hexachlorocyclopentadiene	<0.5	<0.5
isophorone	<0.5	<0.5
naphthalene	<0.5	<0.5
nitrobenzene	<0.5	<0.5
N-nitrosodiphenylamine	<0.5	<0.5
N-nitrosodipropylamine	<0.5	<0.5
bis(2-ethylhexyl)phthalate	<0.5	<0.5
benzyl butyl phthalate	<0.5	<0.5
di-n-butyl phthalate	<0.5	<0.5
di-n-octyl phthalate	<0.5	<0.5
diethyl phthalate	<0.5	<0.5
dimethyl phthalate	<0.5	<0.5
benzo(a)anthracene	<0.5	<0.5
benzo(a)pyrene	<0.5	<0.5
benzo(b)fluoranthene	<0.5	<0.5
benzo(k)fluoranthene	<0.5	<0.5
chrysene	<0.5	<0.5
acenaphthylene	<0.5	<0.5
anthracene	<0.5	<0.5
benzo(ghi)perylene	<1	<1
fluorene	<0.5	<0.5
phenanthrene	<0.5	<0.5
dibenzo(a,h)anthracene	<1	<1
indeno(1,2,3-cd)pyrene	<1	<1
pyrene	<0.5	<0.5

TABLE 5-1 - continued

1984 SUBSURFACE SOIL ANALYTICAL RESULTS

Composite Samples
(Results in mg/kg)

PESTICIDES AND POLYCHLORINATED BIPHENYLS

<u>Compound</u>	<u>Sample I.D.</u>	
	<u>B-2</u>	<u>B-3</u>
Aldrin	<0.01	<0.01
a-BHC	<0.01	<0.01
b-BHC	<0.01	<0.01
g-BHC	<0.01	<0.01
d-BHC	<0.025	<0.025
Chlordane	<0.035	<0.035
4,4'-DDD	<0.03	<0.03
4,4'-DDE	<0.03	<0.03
4,4'-DDT	<0.03	<0.03
Dieldrin	<0.01	<0.01
Endosulfan I	<0.035	<0.035
Endosulfan II	<0.01	<0.01
Endosulfan sulfate	<0.15	<0.15
Endrin	<0.02	<0.02
Endrin aldehyde	<0.07	<0.07
Heptachlor	<0.01	<0.01
Heptachlor epoxide	<0.10	<0.10
PCB - 1016	<0.25	<0.25
PCB - 1221	<0.25	<0.25
PCB - 1232	<0.25	<0.25
PCB - 1242	<0.25	<0.25
PCB - 1248	<0.25	<0.25
PCB - 1254	<0.25	<0.25
PCB - 1260	<0.25	<0.25

TABLE 5-1 - Continued
1984 SUBSURFACE SOIL ANALYTICAL RESULTS

Composite Samples
(Results in mg/kg)

TOTAL METALS AND CYANIDE

<u>Compound</u>	<u>Sample I.D.</u>	
	<u>B-2</u>	<u>B-3</u>
Antimony	<0.50	<0.50
Arsenic	0.95	0.37
Beryllium	6.3	7.0
Cadmium	0.21	<0.10
Chromium	17.4	13.6
Copper	27.6	7.3
Lead	461	1.8
Mercury	<0.2	<0.2
Nickel	4.2	<2.5
Selenium	<0.20	<0.20
Silver	5.2	5.2
Thallium	<0.50	<0.50
Zinc	76.2	15.4
Phenol	<0.25	<0.25
Cyanide*	8	9

* The presence of sulfide interference in the sample matrix reduced the obtainable accuracy of the method.

TABLE 5-1 - Continued

1984 SUBSURFACE SOIL ANALYTICAL RESULTS

Composite Samples
(Results in mg/kg)

ACID COMPOUNDS

<u>Compound</u>	<u>Sample I.D.</u>	
	<u>B-2</u>	<u>B-3</u>
2,4,6-trichlorophenol	<1	<1
p-chloro-m-cresol	<1	<1
2-chlorophenol	<0.5	<0.5
2,4-dichlorophenol	<0.5	<0.5
2,4-dimethylphenol	<0.5	<0.5
2-nitrophenol	<0.5	<0.5
4-nitrophenol	<1	<1
2,4-dinitrophenol	<0.5	<0.5
4,6-dinitro-2-methylphenol	<1	<1
pentachlorophenol	<1	<1
phenol	<0.5	<0.5

TABLE 5-2

HIGHEST LEVEL OF CONTAMINANTS DETECTED BY
 NIAGARA MOHAWK (1986) IN TEN COMPOSITED SURFACE SOIL SAMPLES

SEMI-VOLATILES

<u>Compound</u>	<u>Sample ID(s)</u>	<u>Concentration (ug/g=ppm)</u>
acenaphthene	20,21,22,24	<0.33
acenaphthylene	21,29	<0.33
anthracene	21	4.5
benzo(a)anthracene*	29	3.2
benzo(a)pyrene	21	4.3
benzo(b)fluoranthene**	21	2.7
di-n-butylphthalate	20	3.3
fluoranthene	21	6.0
naphthalene	21	0.43
phenanthrene	21	9.6
pyrene	21	3.0
1,2,4-trichlorobenzene	22	<0.33
bis(2-ethylhexyl)phthalate	28	1.1
diethylphthalate	25,26,27,28,29	<0.33
benzo(g,h,i)perylene	29	0.84
dibenz(a,h)anthracene	29	<0.33
indeno(1,2,3-cd)perylene	29	1.1

Note: No volatile organic compounds were detected.

* Chromatographically, benzo(a)anthracene and chrysene coelute, the reported value is therefore an "and/or" value.

** Chromatographically, benzo(b)fluoranthene and benzo(k)fluoranthene coelute, the reported value is therefore an "and/or" value.

TABLE 5-2 - Continued

HIGHEST LEVEL OF CONTAMINANTS DETECTED BY
 NIAGARA MOHAWK (1986) IN TEN COMPOSITED SURFACE SOIL SAMPLES

PESTICIDES AND POLYCHLORINATED BIPHENYLS

<u>Compound</u>	<u>Sample ID(s)</u>	<u>Concentration (ug/g=ppm)</u>
Delta-BHC	20	0.020
4,4'-DDD****	20	0.11
4,4'-DDE	20	0.24
4,4'-DDT	20	0.94
aldrin	28	0.014
endosulfan sulfate	29	0.28
endrin ketone	29	0.059
endosulfan I	27	0.061
heptachlor epoxide	24	0.053
beta-BHC	24	0.0087
endrin aldehyde	26	0.064
heptachlor	27	0.037
aroclor-1260	27	0.45

**** Chromatographically, 4,4'-DDD and endosulfan II coelute.
 The reported value is therefore an "and/or" value.

TOTAL METALS

total arsenic	27	28
total beryllium	27	1.86
total chromium	23	75
total copper	20	51
total lead	21	368
total mercury	22	0.781
total nickel	21	18
total zinc	22	254
total cadmium	29	3.24

MISCELLANEOUS

Total recoverable phenolics	20	1.1
total cyanide	23,26	1.3

composited shallow soil samples from areas in the middle and northern end of the park, as shown in Figure 1-3. Samples were analyzed for priority pollutant volatiles, semi-volatiles, pesticides/PCBs, and total metals by the New York State Department of Health, Wadsworth Center for Laboratories and Research. The highest level of contaminants detected in the soil samples are reported in Table 5-3.

The data presented in Tables 5-1 through 5-3 can be used to describe the nature and extent of contamination present at Gratwick Riverside Park; however, it should be noted that the results from all nineteen samples were not validated, therefore the scientific usefulness of this data is limited. The analytical data reported in Table 5-3 especially, has been labeled "final but suspicious" by the Niagara County Health Department. The organic parameter results, especially the acid extractable series are listed as "Not Confirmed".

As shown in Table 5-2, 12 semi-volatile compounds, 12 pesticides, one PCB (Aroclor-1260), 9 metals, phenol and cyanide were detected in surface soil samples collected by Niagara Mohawk. Eleven of the twelve semi-volatiles detected were PAHs. The maximum concentrations of these compounds ranged from 0.43 to 9.6 ppm. Pesticides were detected at lower maximum concentrations ranging from 0.0087 to 0.94 ppm. The highest level of metal contamination detected was lead at 368 ppm.

As shown in Table 5-3, 2 volatile compounds, 27 semi-volatile compounds, 5 pesticide, one PCB (Aroclor-1260), and 9 metals were detected in surficial soil samples collected by NCHD. The semi-volatiles are the most prevalent organic species, and are generally detected in the highest concentrations. Maximum concentrations range from 0.53 to 23 ppm. These results, however, were labeled as suspicious by the NCHD. Twelve of the 27 semi-volatile detected in NCHD samples were PAHs. Maximum concentrations of volatile compounds ranged from 0.04 to 0.05 ppm; pesti-

TABLE 5-3

HIGHEST LEVEL OF CONTAMINANTS DETECTED BY
 NIAGARA COUNTY HEALTH DEPARTMENT (1986) IN SEVEN COMPOSITED SURFACE
 SOIL SAMPLES

VOLATILES

<u>Compound</u>	<u>Sample ID(s)</u>	<u>Concentration (ug/g=ppm)</u>
methylene chloride	32	0.05
1,1,1-trichloroethane	32	0.04

SEMI-VOLATILES

phenol	38	23
2-chlorophenol	32	13
2,4-dinitrophenol	32	1.1
4-nitrophenol	32	0.64
pentachlorophenol	40	2.3
n-nitrodiphenylamine	40	0.55
1,2-diphenylhydrazine	40	0.55
hexachlorobenzene	40	0.93
phenanthrene	40	2.4
anthracene	40	0.62
di-n-butylphthalate	32	1.7
fluoranthene	40	7.1
pyrene	40	8.4
benzidine	40	17
butylbenzylphthalate	32	3.1
benzo(a)anthracene	40	10
chrysene	40	11
bis(2-ethylhexyl)phthalate	32	6.0
di-n-octylphthalate	32,36	1.8
benzo(b)fluoranthene	32	0.86
benzo(k)fluoranthene	40	17
indeno(1,2,3-cd)pyrene	32	2.2
dibenzo(a,h)anthracene	32	1.3
benzo(g,h,i)perylene	32	0.95
bis(2-chloroethoxy)methane	32	0.64
diethylphthalate	40	1.2
fluorene	40	0.53

PESTICIDES AND POLYCHLORINATED BIPHENYLS

delta-BHC	38	0.52
chlordane	32	3.5
4,4'-DDD	32	0.25
4,4'-DDE	32	0.15
4,4'-DDT	32	0.6
PCB-1260	32	2.5

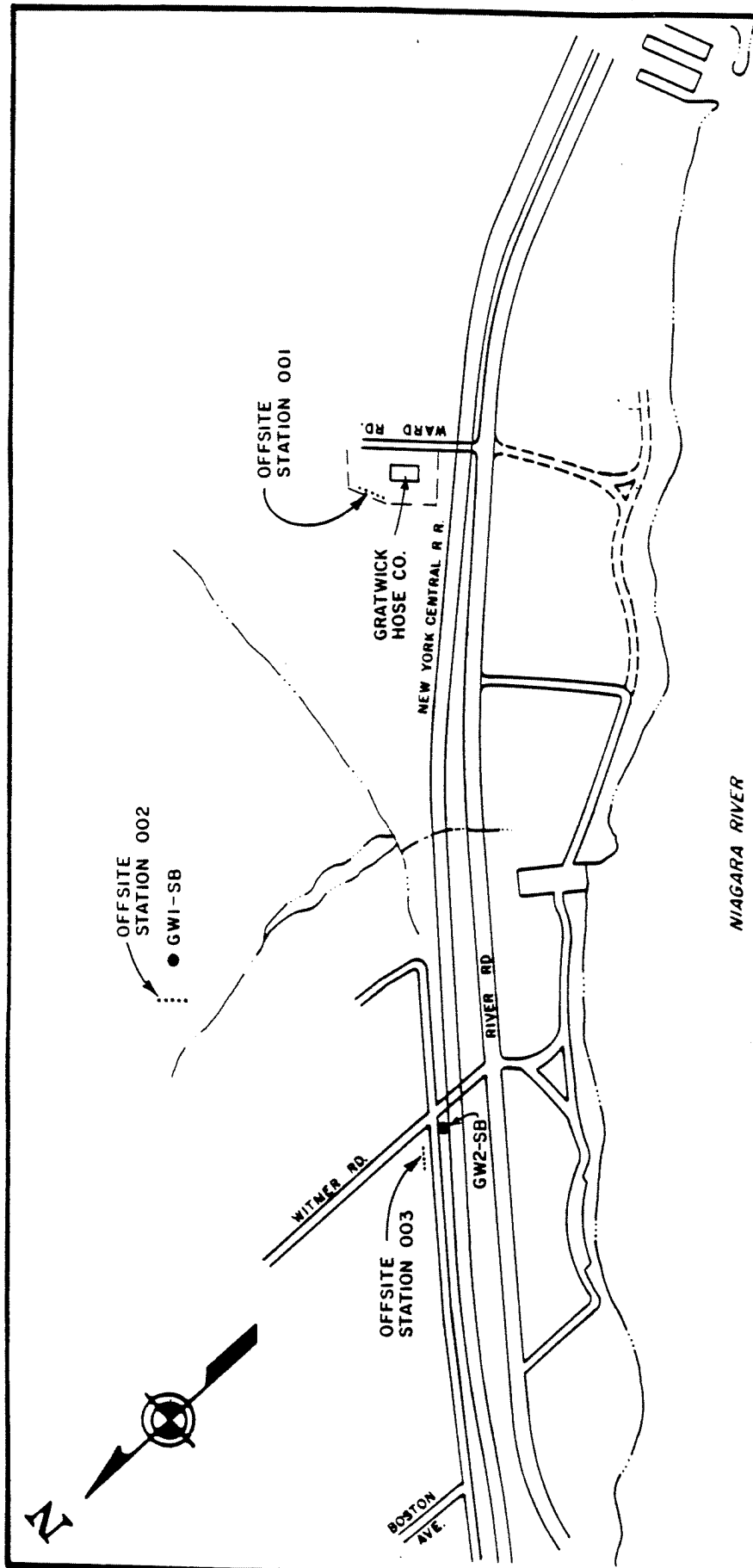
TABLE 5-3 - Continued

HIGHEST LEVEL OF CONTAMINANTS DETECTED BY
NIAGARA COUNTY HEALTH (1986) DEPARTMENT IN SEVEN COMPOSITED
SURFACE SOIL SAMPLES

TOTAL METALS

<u>Compound</u>	<u>Sample ID(s)</u>	<u>Concentration</u> <u>(ug/g=ppm)</u>
total cadmium	32,35	7.8
total chromium	32	101
total copper	32	560
total lead	32	500
total mercury	32	1.5
total nickel	32	60
total selenium	31,35	1.3
total silver	32	6
total zinc	32	700

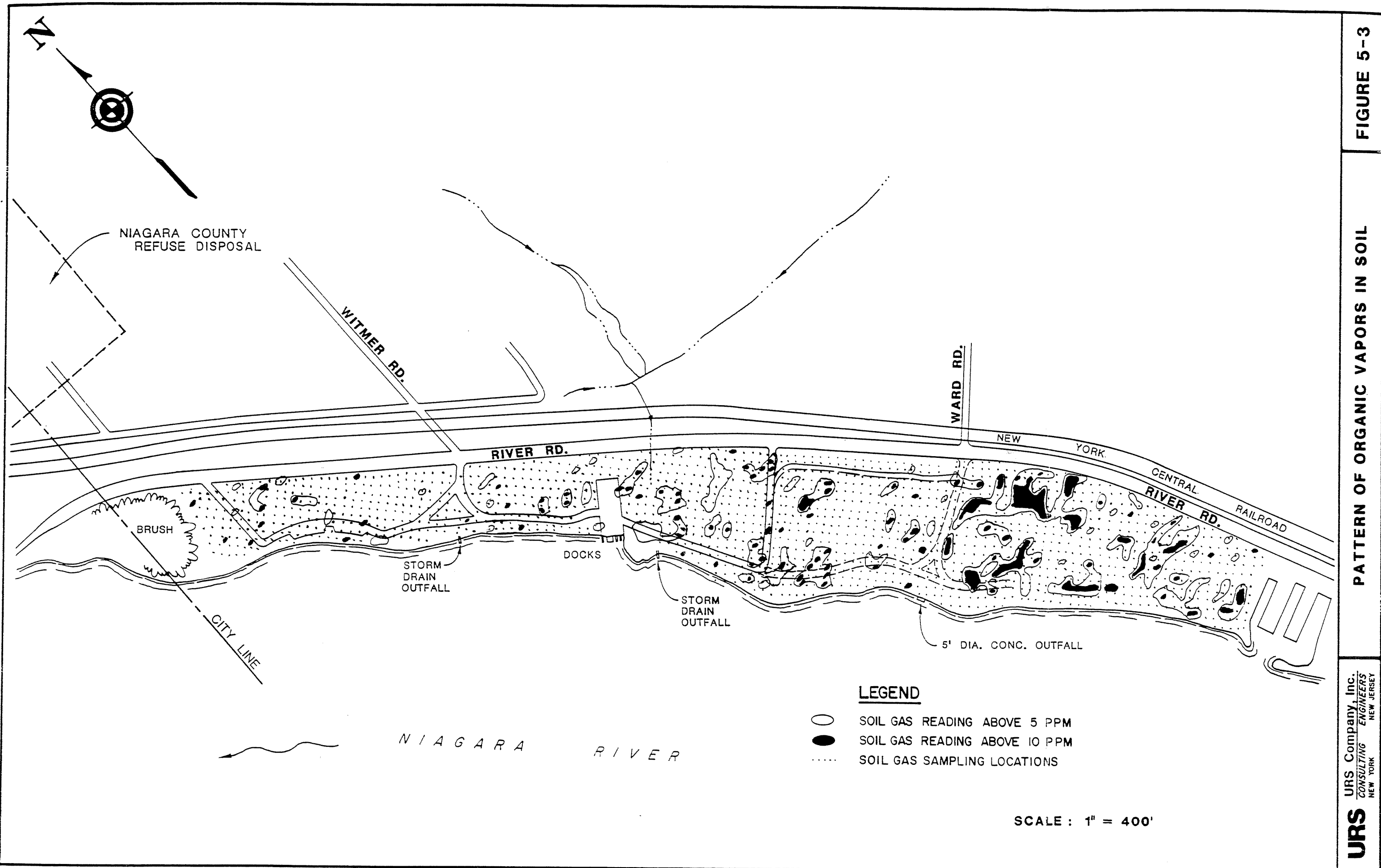
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URS
CONSULTANTS

LOCATION PLAN
OFFSITE ENVIRONMENTAL SAMPLES

FIGURE 5-2



and/or suspected areas of contamination within the park (e.g., the areas where drums were previously exposed at the surface). Ten of the 20 surficial samples were analyzed for volatile organics and total phenols as determined by the field geologist, using visual observation, odors, or PID screening results. All remaining surficial and subsurface samples were chemically tested for hazardous substance list (HSL) volatiles, semi-volatiles, pesticides/PCBs, metals, cyanide, total phenols, dioxin, and miscellaneous inorganic parameters. All surface and subsurface soil was collected and analyzed in accordance with the procedures defined in the Work/QA Project Plan (URS, 1987), Health and Safety Plan (URS, 1987), and USEPA CLP protocols (Organic SOW 9/84; Inorganic SOW 784).

5.1.2.1 Soil Gas Survey and Soil Sample Screening

A photoionization detector (PID) was used in the Remedial Investigation (RI) activities to screen for volatiles content in the shallow in-situ soil (approximately 24 inches in depth) and soil samples. Although this screening method is not quantitative it can yield general qualitative data on the total volatile and some semi-volatile content of soil. It is, moreover, a quick and relatively non-intrusive method of obtaining data.

The soil gas survey was conducted prior to intrusive activities. It was conducted on a 40- by 40-foot grid with a probed depth of approximately 24 inches. Methodologies and detailed results are found in Appendix E.1. This survey was used to select sampling sites and to aid in overall interpretation of the extent and nature of contamination prior to obtaining chemical analytical data.

The results of the soil gas survey were used to identify a number of anomalous areas (Figure 5-3). In general, surficial soil samples were collected in areas where the PID readings were the highest.

TABLE 5-4

ELEMENT CONCENTRATIONS IN EASTERN U.S. SOIL*

<u>Element</u>	<u>Eastern United States Observed Range (ppm)</u>
aluminum	7,000 - 100,000
antimony	<1 - 8.8
arsenic	<0.1 - 73
barium	10 - 1,500
beryllium	<1.0 - 7
cadmium	
calcium	100 - 28,000
cobalt	<0.3 - 70
chromium	1.0 - 1,000
copper	<1.0 - 700
iron	100 - 100,000
lead	<10 - 300
magnesium	50 - 50,000
manganese	<2 - 7,000
mercury	0.01 - 3.4
nickel	<5 - 700
potassium	50 - 37,000
selenium	0.1 - 3.9
silver	0.1 - 73
sodium	500 - 50,000
thallium	2.2 - 23
vanadium	<7 - 300
zinc	<5 - 2,900

* H.T. Shacklette and J.G. Boerngen "Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States", U.S. Geological Survey, Professional Paper 1270, pg. 6, 1984.

PID readings were also taken on each split-spoon sample from every boring. These readings were one of the criteria used in selecting which split-spoon samples were to be subjected to chemical analysis. The split-spoon samples with PID readings greater than ambient (i.e., greater than 1 ppm) are listed in Table 5-5.

5.1.2.2 Data Validation and Determination of Useability of Analytical and QA/QC Samples

All environmental samples collected during the first round of the RI were audited by an independent firm, Versar, Inc. The second round of samples collected were audited by URS' QA/QC Officer and environmental chemist. The data validation, reduction, and determination of useability, was performed in accordance with USEPA SOP No. HW-3 CLP Organic Data Review. The inorganic data validation processes were performed in accordance with Contract Compliance Screening Evaluation Listing for RAS Inorganic - SOW 784. As a result of the data audits, Versar and URS identified several sample fractions which were non-compliant with CLP criteria and/or CLP holding time requirements. The following samples and fractions were rejected.

First Round:

<u>Sample Rejected</u>	<u>Fraction</u>
SP1-SW	Pesticide/PCB
SP2-SW	Pesticide/PCB
SP4-SW	Pesticide/PCB
GW-11S	Semivolatile
GW-SB-Rinse Blank	Semivolatile
GW1-SB-01'	Semivolatile
GW2-SB-01'	Semivolatile
GW3-SB-4-12'	Semivolatile
GW3-SB-14-18'	Semivolatile

TABLE 5-5

SUMMARY OF ORGANIC VAPOR SCREENING OF SOIL BORINGS
(Results Above Background)

Boring No.	Sample No.	Depth (ft)	PID Reading (ppm)
GW-4I	8	14-16	2.0
GW-5D	4	20-22	3.0
	6	24-26	1.6
GW-6D	2	1.5-3.0	11.0
	3	3.0-4.5	5.0
	4	4.5-6.0	5.0
	5	6.0-7.5	2.0
	6	7.5-9.0	2.0
	7	9.0-10.5	4.0
	8	10.5-12.0	5.0
	9	12.0-13.5	4.0
	10	13.5-15.0	2.0
GW-9S	5	8-10	1.7
	7	12-14	1.3

Second Round:

<u>Sample Rejected</u>	<u>Fraction</u>
GW3-S	Total Organic Carbon
GW6-S	Total Organic Carbon
GW6-D	Total Organic Carbon
St 001	Arsenic, Cyanide
St 002	Arsenic, Cyanide
St 003	Arsenic, Cyanide

The remaining analytical samples collected during the first and second round sampling events were compliant with CLP requirements and the data is useable. The data audit results of both the first and second round samples collected at Gratwick Riverside Park are summarized in the "Analytical Data Assessment" reports sent to the NYSDEC Division of Hazardous Waste Remediation. The pesticide/PCB surface water samples which were rejected during the first round were resampled during the second round with the exception of SP1-SW. Sample SP1-SW was not scheduled to be collected during the second round sampling event and since no pesticide/PCB were detected in the first round analysis, the sample was not recollected during the second round. Samples GW-11S and GW-SB-Rinse Blank for semivolatiles were resampled during the second round sampling event. Subsurface semivolatile soil background samples, GW1-SB-0-1' and GW2-SB-01', were not resampled during the second round because additional background samples were collected during the second round sampling which were thought to be more representative of background offsite soil conditions. Subsurface samples GW3-SB-4-12' and GW3-SB-14-18' for semivolatiles were not resampled during the second round because of the added cost of remobilizing a drill team and rig and also because it was concluded that there was adequate semivolatile data to characterize the site. The second round groundwater samples, GW3-S, GW6-S, and GW6-D, were not resampled for total organic carbon because there was sufficient information gathered during the first round concerning this parameter.

Samples St.001, St.002 and St.003 were resampled and reanalyzed for arsenic and cyanide and the results are included in this report.

Field Quality Control/Quality Assurance Samples - Approximately four field (rinse) blanks and twelve trip blanks were collected during the first and second sampling events at Gratwick Riverside Park. All field and trip blanks were audited in the same manner as the analytical samples. The only compounds detected in the field and/or trip blanks were methylene chloride, acetone, 2-butanone, toluene and phthalate esters, all of which are defined by the USEPA as common laboratory contaminants. The concentrations of these compounds were taken into account while validating the sample compound concentration. The USEPA data validation procedures states that for volatiles and semivolatiles, no positive results are reported unless the concentration of the compound in the sample exceeds 10 times the amount in any field or method blank for common laboratory contaminants. The analytical results presented in this chapter reflect this criteria.

5.1.2.3 Background Soil Samples

Two offsite subsurface samples, identified as GW1-SB and GW2-SB, were collected at a one foot depth. The locations of these offsite samples are shown in Figure 5-2. All analytical results for samples collected in December 1987 were validated by Versar, Inc. As a result of the data audit, Versar identified the semi-volatile fraction for the offsite subsurface samples as not compliant with USEPA CLP analytical holding time requirements. The data for both offsite samples are therefore rejected for the semi-volatile fraction only. The analytical results are presented in Table 5-6. Since GW-2 is located near the railroad tracks, previous fill activities or chemical spills or leaks may have contributed to contamination in the area, and therefore, only GW-1 was considered to represent background conditions for subsurface soil. It should be noted that GW-1 was utilized to represent background subsurface conditions even though the interval of sampling was only 0-1 foot since

cides from 0.15 to 3.5 ppm and Aroclor-1260 was detected at 2.5 ppm. The maximum concentration of detected metals was zinc at 700 ppm.

The results of previous soil investigations at the Gratwick site may be summarized as follows:

- no organic compounds were detected in subsurface soil samples;
- the primary contaminants detected in surficial soil are semi-volatiles. The major portion is PAHs;
- all metals except total lead are within the observed range of metals in the Eastern United States shown in Table 5-4 (Shacklette and Boerngen, 1984) for both surficial and subsurface soil samples. (Lead was present in sample 21 at 368 ppm; in sample 32 at 500 ppm; in sample B-2 at 461 ppm.)

5.1.2 Soil Sample Results from the Remedial Investigation

Surficial and subsurface soil was sampled in December 1987 as part of the remedial investigation at Gratwick Riverside Park. Eleven subsurface samples were collected using continuous split-spoon sampling methods. The locations of the boreholes are presented in Figure 5-1 (offsite locations are shown in Figure 5-2). The URS field geologist determined which boring depths would be chemically tested based upon organic vapor readings, physical appearance, and knowledge of previous investigations performed at the site.

A total of 20 surficial soil samples were collected using dedicated, pre-cleaned, stainless steel hand (bucket type) augers. The locations of these samples, presented in Figures 5-1 and 5-2, were based upon the results of previous sampling programs, soil vapor readings,

TABLE 5-6

RI Offsite and Onsite Subsurface Soil Sample Results

BORING I.D. SOIL DEPTH INTERVAL (FT.)														
DATE COLLECTED		GW1-SB 0-1	GW2-SB 0-1	GW3-SB 4-12	GW3-SB 14-18	GW4-SB 8-12	GW4-SB 20-22	GW5-SB 12-18	GW5-SB 20-24	GW5-SB 24-26	GW6-SB 10-15	GW6-SB 15-16	GW6-SB 19-20	GW8-SB 9-16
Parameter	Class	10/29/87	10/29/87	12/01/87	12/01/87	11/30/87	11/30/87	11/17/87	11/17/87	11/17/87	11/15/87	11/15/87	11/15/87	11/23/87
Chloromethane	VOC													
Bromomethane	VOC													
Vinyl Chloride	VOC													
Chloroethane	VOC													
Methylene Chloride	VOC	14.0	14.0	8.00	6.00	7.00	6.00	22.0	11.0	14.0	11.0	10.0	9.00	
Acetone	VOC	20.0	66.0	190	310	46.0	210	100	25.0	31.0	18.0	18.0	270	
Carbon Disulfide	VOC			26.0		20.0	9.00		4.00				19.0	
1,1-Dichloroethane	VOC													
1,1-Dichloroethane	VOC													
trans-1,2-Dichloroethene	VOC													
Chloroform	VOC	1.00	1.00	1.00	1.00				1.00	2.00				
1,2-Dichloroethane	VOC													
2-Butanone (or MEK)	VOC	30.0	84.0	32.0	25.0									
1,1,1-Trichloroethane	VOC													
Carbon Tetrachloride	VOC													
Vinyl Acetate	VOC													
Bromodichloromethane	VOC													
1,2-Dichloropropane	VOC													
trans-1,3-Dichloropropene	VOC													
Trichloroethene	VOC		1.00	1.00	1.00									
Dibromochloromethane	VOC													
1,1,2-Trichloroethane	VOC													
Benzene	VOC			1.00	1.00						4.00			
cis-1,3-Dichloropropene	VOC													
2-Chloroethyl Vinyl Ether	VOC													
Bromoform	VOC													
4-Methyl-2-pentanone	VOC													
2-Hexanone	VOC													
Tetrachloroethene	VOC									3.00				
1,1,2,2-Tetrachloroethane	VOC													
Toluene	VOC			2.00	3.00						10.0			
Chlorobenzene	VOC													
Ethyl Benzene	VOC				1.00						9.00			
Styrene	VOC													
Total Xylenes	VOC			1.00	3.00				1.00		22.0	3.00		

ALL RESULTS REPORTED IN ug/Kg
ONLY RESULTS ABOVE DETECTION LIMITS REPORTED

TABLE 5-6 (continued)

BORING I.D.
SOIL DEPTH INTERVAL (FT.)

Parameter	DATE COLLECTED	Class	GW1-SB 0-1	GW2-SB 0-1	GW3-SB 4-12	GW3-SB 14-18	GW4-SB 8-12	GW4-SB 20-22	GW5-SB 12-18	GW5-SB 20-24	GW5-SB 24-26	GW6-SB 10-15	GW6-SB 15-16	GW6-SB 19-20	GW8-SB 9-16
Phenol	10/29/87	SEMI	*												
bis(2-Chloroethyl) ether		SEMI	*		*	*									
2-Chlorophenol		SEMI	*		*	*									
1,3-Dichlorobenzene		SEMI	*		*	*									
1,4-Dichlorobenzene		SEMI	*		*	*									
Benzyl Alcohol		SEMI	*		*	*									
1,2-Dichlorobenzene		SEMI	*		*	*									
2-Methylphenol		SEMI	*		*	*									
bis(2-Chloroisopropyl) ether		SEMI	*		*	*									
4-Methylphenol		SEMI	*		*	*									
N-Nitroso-Dipropylamine		SEMI	*		*	*									
Hexachloroethane		SEMI	*		*	*									
Nitrobenzene		SEMI	*		*	*									
Isophorone		SEMI	*		*	*									
2-Nitrophenol		SEMI	*		*	*									
2,4-Dimethylphenol		SEMI	*		*	*									
Benzoic Acid		SEMI	*		*	*									
bis(2-Chloroethoxy) methane		SEMI	*		*	*									
2,4-Dichlorophenol		SEMI	*		*	*									
1,2,4-Trichlorobenzene		SEMI	*		*	*							410		
Naphthalene		SEMI	*		*	*									
4-Chloroaniline		SEMI	*		*	*									
Hexachlorobutadiene		SEMI	*		*	*									
4-Chloro-3-methylphenol		SEMI	*		*	*									
2-Methylnaphthalene		SEMI	*		*	*									
Hexachlorocyclopentadiene		SEMI	*		*	*									
2,6-Dichlorophenol		SEMI	*		*	*									
2,4,6-Trichlorophenol		SEMI	*		*	*									
2-Chloronaphthalene		SEMI	*		*	*									
2-Nitroaniline		SEMI	*		*	*									
Dimethyl Phthalate		SEMI	*		*	*									84.0
Acenaphthylene		SEMI	*		*	*						840			
3-Nitroaniline		SEMI	*		*	*									
Acenaphthene		SEMI	*		*	*						3600			
2,4-Dinitrophenol		SEMI	*		*	*									
4-Nitrophenol		SEMI	*		*	*					4500				
Dibenzofuran		SEMI	*		*	*									
2,4-Dinitrotoluene		SEMI	*		*	*									
2,6-Dinitrotoluene		SEMI	*		*	*									
Diethylphthalate		SEMI	*		*	*									
4-Chlorophenyl Phenyl Ether		SEMI	*		*	*			140						

ALL RESULTS REPORTED IN ug/kg
ONLY RESULTS ABOVE DETECTION LIMITS REPORTED
* DATA REJECTED - EXCEEDED HOLDING TIMES

BORING I.D.
SOIL DEPTH INTERVAL (FT.)

Parameter	Class	DATE COLLECTED	10/29/87	10/29/87	12/01/87	12/01/87	12/01/87	11/30/87	11/30/87	11/17/87	11/15/87	11/15/87	11/23/87
Fluorene	SEMI	*	*	*	*	*	*						
4-Nitroaniline	SEMI	*	*	*	*	*	*				7700		
4,6-Dinitro-2-methylphenol	SEMI	*	*	*	*	*	*						
N-nitrosodiphenylamine	SEMI	*	*	*	*	*	*						
4-Bromophenyl Phenyl Ether	SEMI	*	*	*	*	*	*						
Hexachlorobenzene	SEMI	*	*	*	*	*	*						
Pentachlorophenol	SEMI	*	*	*	*	*	*						
Phenanthrene	SEMI	*	*	*	*	*	*	87.0			67.0		
Anthracene	SEMI	*	*	*	*	*	*	34.0	270	300		63.0	540
Di-n-butylphthalate	SEMI	*	*	*	*	*	*	230					
Fluoranthene	SEMI	*	*	*	*	*	*						
Pyrene	SEMI	*	*	*	*	*	*	160			29000		
Butyl Benzyl Phthalate	SEMI	*	*	*	*	*	*						
3,3'-Dichlorobenzidine	SEMI	*	*	*	*	*	*	120			19000		
Benzo(a)anthracene	SEMI	*	*	*	*	*	*	1200	840	180			
bis(2-ethyl hexyl)phthalate	SEMI	*	*	*	*	*	*	200			18000		430
Chrysene	SEMI	*	*	*	*	*	*	55.0	100				
Di-n-octyl Phthalate	SEMI	*	*	*	*	*	*	310			32000		
Benzo(b)fluoranthene	SEMI	*	*	*	*	*	*						
Benzo(k)fluoranthene	SEMI	*	*	*	*	*	*	55.0			19000		
Benzo(a)pyrene	SEMI	*	*	*	*	*	*	71.0			11000		
Li-cno(1,2,3-cd)pyrene	SEMI	*	*	*	*	*	*				3200		
D: -cnz(a,h)anthracene	SEMI	*	*	*	*	*	*				7600		
Benzo(g,h,i)perylene	SEMI	*	*	*	*	*	*	84.0					

ALL RESULTS REPORTED IN ug/Kg
ONLY RESULTS ABOVE DETECTION LIMITS REPORTED
* DATA REJECTED - EXCEEDED HOLDING TIMES

TABLE 5-6 (continued)

BORING I.D. SOIL DEPTH INTERVAL (FT.)		GW1-SB 0-1	GW2-SB 0-1	GW3-SB 4-12	GW3-SB 14-18	GW4-SB 8-12	GW4-SB 20-22	GW5-SB 12-18	GW5-SB 20-24	GW5-SB 24-26	GW6-SB 10-15	GW6-SB 15-16	GW6-SB 19-20	GW8-SB 9-16
DATE COLLECTED DATE EXTRACTED DATE ANALYZED	Parameter	10/29/87	10/29/87	12/01/87	12/01/87	11/30/87	11/30/87	11/17/87	11/17/87	11/17/87	11/15/87	11/15/87	11/15/87	11/23/87
	Class													
	alpha-BHC													
	beta-BHC													
	delta-BHC													
	gamma-BHC (Lindane)													
	Heptachlor													
	Aldrin													
	Heptachlor Epoxide													
	Endosulfan I													
	Dieldrin													
	4,4'-DDE													
	Endrin													
	Endosulfan II													
	4,4'-DDD													
	Endosulfan Sulfate													
	4,4'-DDT													
	Methoxychlor													
	Endrin ketone													
	Chlordane													
	Toxaphene													
	Aroclor-1016													
	Aroclor-1221													
	Aroclor-1232													
	Aroclor-1242													
	Aroclor-1248													
	Aroclor-1254													
	Aroclor-1260													

ALL RESULTS REPORTED IN ug/kg
ONLY RESULTS ABOVE DETECTION LIMITS REPORTED

TABLE 5-6 (continued)

BORING I.D.
SOIL DEPTH INTERVAL (FT.)

Parameter	DATE COLLECTED	Class	GW1-SB 0-1	GW2-SB 0-1	GW3-SB 4-12	GW3-SB 14-18	GW4-SB 8-12	GW4-SB 20-22	GW5-SB 12-18	GW5-SB 20-24	GW5-SB 24-26	GW6-SB 10-15	GW6-SB 15-16	GW6-SB 19-20	GW8-SB 9-16
Aluminum	10/29/87	MCP	12900	9800	39400	7260	45900	26700	69100	11030	8920	26600	9920	7510	43400
Antimony		MCP													
Arsenic		MCP	3.80	153	4.40	2.00	1.85	4.68		2.50			1.69	2.32	
Barium		MCP	46.0	65.0	349	39.8	3060	139	2820	182	94.7	808	92.4	80.6	234
Beryllium		MCP			3.20		4.34	1.00	13.20		0.52	3.94			6.38
Cadmium		MCP	2100	8380	189000	164000	189000	68200	278000	111000	81300	123000	119000	132000	292000
Calcium		MCP	12.0	14.0	9.19	6.19	14.0	27.8	6.20	10.0	10.6	13.0	11.5	10.7	3.86
Chromium		MCP	4.50	4.10	3.40	2.79	4.35	13.7		4.35	4.10	3.34	5.82	4.51	
Cobalt		MCP	9.70	49.0	17.4	9.2	7.62	28.0	10.3	15.5	13.0	111	22.2	15.2	3.86
Copper		MCP	12600	15400	34000	9130	11500	39100	5370	14100	12400	25300	15400	11500	3130
Iron		MCP													
Lead		MCP	23.0	72.0	18.7	10.0	7.03	11.5	6.00	14.1	9.49	106	34.0	151	9.35
Magnesium		MCP	1680	2290	10400	79400	14700	24500	19800	34500	26400	8450	34500	32500	8520
Manganese		MCP	128	177	1660	619	31400	633	3740	794	584	1450	658	602	3340
Mercury		MCP			0.33		0.33								
Nickel		MCP	17.0	19.0	7.08	4.38	33.3	33.3		11.8	11.6	9.59	12.3	9.09	
Potassium		MCP	867	506	2190	1190	1420	5250	3070	2130	2340	1280	2800	2060	2840
Selenium		MCP													
Silver		MCP					5.13	330	1120	286	258	563	352	278	1790
Sodium		MCP	37.0	214	1480	226	875								
Thallium		MCP						39.8	9.59	14.8	15.0	10.0	18.7	14.2	5.69
Vanadium		MCP	22.0	12.0	12.4	10.0									
Zinc		MCP	79.0	148	109	79.9	89.9	85.6	48.1	103	86.8	285	98.0	119	12.7
Cyanide		MCP			4.30		8.70		18.0	2.20		1.72			
Phenols, Total		MCP													
pH		MCP	5.84	7.21	10.2	9.34	11.2	9.02	11.0	10.2	9.87	10.0	8.82	8.90	8.10
Specific Conductance		MCP													11.5
Temperature		MCP													
TH3-N		MISC													
TKN			78.0	70.0	58.0	10.0	12.0	16.0	100	30.0	20.0	45.0	27.0	31.0	9.7
LOC			1300	1600	680	87.9	620	460	110	34.0	22.0	57.0	30.0	35.0	470
MOISTURE			71.0	74.0	65.0		59.0		26.0	18.0	25.0	89.0	27.0		74.0
DIOXIN			27.0	50.0	22.0		34.0	30.0	50.0	12.0	12.0	32.0	7.00	7.00	41.0
TCDD															
PeCDD															
HxCDD															
HpCDD															
OCDD															
TCDF															
PeCDF															
HxCDF															
HpCDF															
OCDF															

ONLY RESULTS ABOVE DETECTION LIMIT REPORTED, DIOXIN REPORTED IN ug/Kg, MCP and MISC REPORTED IN mg/Kg

TABLE 5-7

RI Offsite Surficial Soil Sample Results

SAMPLE I.D.			
001	002	003	
DATE COLLECTED	8/18/88	8/18/88	8/18/88
Parameter	CLASS		
Chloromethane	VOC		
Bromomethane	VOC		
Vinyl Chloride	VOC		
Chloroethane	VOC		
Methylene Chloride	VOC		
Acetone	VOC		
Carbon Disulfide	VOC		
1,1-Dichloroethene	VOC		
1,1-Dichloroethane	VOC		
trans-1,2-Dichloroethene	VOC		
Chloroform	VOC		
1,2-Dichloroethane	VOC		
2-Butanone (or MEK)	VOC		
1,1,1-Trichloroethane	VOC		
Carbon Tetrachloride	VOC		
Vinyl Acetate	VOC		
Bromodichloromethane	VOC		
1,2-Dichloropropane	VOC		
trans-1,3-Dichloropropene	VOC		
Trichloroethene	VOC		
Dibromochloromethane	VOC		
1,1,2-Trichloroethane	VOC		
Benzene	VOC		
cis-1,3-Dichloropropene	VOC		
2-Chloroethyl Vinyl Ether	VOC		
Bromoform	VOC		
4-Methyl-2-pentanone	VOC		
2-Hexanone	VOC		
Tetrachloroethene	VOC		
1,1,2,2-Tetrachloroethane	VOC		
Toluene	VOC		
Chlorobenzene	VOC		
Ethyl Benzene	VOC		
Styrene	VOC		
Total Xylenes	VOC		

ONLY DETECTED RESULTS ARE REPORTED, ALL RESULTS REPORTED IN ug/kg
 J - Indicates an estimated value

TABLE 5-7 (continued)

SAMPLE I.D.		001	002	003
DATE COLLECTED	Parameter	8/18/88	8/18/88	8/18/88
class				
SEMI	Phenol	43 J		
SEMI	bis(2-Chloroethyl)ether			
SEMI	2-Chlorophenol			
SEMI	1,3-Dichlorobenzene			
SEMI	1,4-Dichlorobenzene			
SEMI	Benzyl Alcohol			
SEMI	1,2-Dichlorobenzene			
SEMI	2-Methylphenol			
SEMI	bis(2-Chloroisopropyl) eth			
SEMI	4-Methylphenol			
SEMI	N-Nitroso-Dipropylamine			
SEMI	Hexachloroethane			
SEMI	Nitrobenzene			
SEMI	Isophorone			
SEMI	2-Nitrophenol			
SEMI	2,4-Dimethylphenol			
SEMI	Benzoic Acid			
SEMI	bis(2-Chloroethoxyl) metha			
SEMI	2,4-Dichlorophenol			
SEMI	1,2,4-Trichlorobenzene			
SEMI	Naphthalene			
SEMI	4-Chloroaniline			
SEMI	Hexachlorobutadiene			
SEMI	4-Chloro-3-methylphenol			
SEMI	2-Methylnaphthalene			
SEMI	Hexachlorocyclopentadiene			
SEMI	2,4,6-Trichlorophenol			
SEMI	2,4,5-Trichlorophenol			
SEMI	2-Chloronaphthalene			
SEMI	2-Nitroaniline			
SEMI	Dimethyl Phthalate			
SEMI	Acenaphthylene			
SEMI	3-Nitroaniline			
SEMI	Acenaphthene			
SEMI	2,4-Dinitrophenol			
SEMI	4-Nitrophenol			
SEMI	Dibenzofuran			
SEMI	2,4-Dinitrotoluene			
SEMI	2,6-Dinitrotoluene			
SEMI	Diethylphthalate			
SEMI	4-Chlorophenyl Phenyl Eth			

ONLY DETECTED RESULTS ARE REPORTED, ALL RESULTS REPORTED IN ug/kg
J - Indicates an estimated value

TABLE 5-7 (continued)

SAMPLE I.D.			001	002	003
Parameter	DATE COLLECTED	Class	8/18/88	8/18/88	8/18/88
Aluminum		MCP	11200	12800	11800
Antimony		MCP			
Arsenic		MCP	2.6 N	3.7 N	3.4 N
Barium		MCP	130 *	83.1 *	128 *
Beryllium		MCP	0.496		
Cadmium		MCP			
Calcium		MCP	56100	2450	65900
Chromium		MCP	12.8	13.3	14.8
Cobalt		MCP			4.51
Copper		MCP	673.0	4.84	24.0
Iron		MCP	15700	13300	22000
Lead		MCP	213 *	11.1 *	42.5 *
Magnesium		MCP	20600 *	2630 *	15400 *
Manganese		MCP	685.0	168.0	657.0
Mercury		MCP			
Nickel		MCP	9.66	7.6	16.6
Potassium		MCP	717	766	2040
Selenium		MCP			
Silver		MCP			
Sodium		MCP	119	33.3	709
Thallium		MCP			
Vanadium		MCP	9.26	11.1	15.6
Zinc		MCP	134.0	50.2	88.5
Cyanide		MCP	4.7		
Total Organic Carbon		MISC	>4%	>4%	>4%
Nitrate-Nitrogen		MISC	140.0	180.0	290.0
Ammonia-Nitrogen		MISC	31.0	450.0	16.0
Total Kjeldahl Nitrogen		MISC	230.0	660.0	240.0

ONLY DETECTED RESULTS ARE REPORTED, ALL PARAMETERS REPORTED IN mg/kg

N - Indicates spike sample recovery is not within control limits

* - Indicates duplicate analysis is not within control limits

TABLE 5-7 (continued)

SAMPLE I.D.			001	002	003
DATE COLLECTED			8/18/88	8/18/88	8/18/88
Parameter	Class				
alpha-BHC	PST				
beta-BHC	PST				
delta-BHC	PST				
gamma-BHC (Lindane)	PST				
Heptachlor	PST				
Aldrin	PST				
Heptachlor Epoxide	PST				
Endosulfan I	PST				
Dieldrin	PST		88.0		1.7 J
4,4'-DDE	PST				
Endrin	PST				
Endosulfan II	PST		26 J		
4,4'-DDD	PST				
Endosulfan Sulfate	PST		140.0		5.1 J
4,4'-DDT	PST				
Methoxychlor	PST				
Endrin Ketone	PST				
Chlordane	PST				
Toxaphene	PST				
Aroclor-1016	PCB				
Aroclor-1221	PCB				
Aroclor-1232	PCB				
Aroclor-1242	PCB				
Aroclor-1248	PCB				
Aroclor-1254	PCB				
Aroclor-1260	PCB				

ONLY DETECTED RESULTS ARE REPORTED, ALL RESULTS REPORTED IN ug/kg

J - Indicates an estimated value

TABLE 5-7 (continued)

SAMPLE I.D.		001	002	003
DATE COLLECTED	Parameter	8/18/88	8/18/88	8/18/88
class				
SEMI	Fluorene			
SEMI	4-Nitroaniline			
SEMI	4,6-Dinitro-2-methylphenol			
SEMI	N-nitrosodiphenylamine			
SEMI	4-Bromophenyl Phenyl Ether			
SEMI	Hexachlorobenzene			
SEMI	Pentachlorophenol			
SEMI	Phenanthrene	310 J		230 J
SEMI	Anthracene	52 J		60 J
SEMI	Di-n-butylphthalate			
SEMI	Fluoranthene	740.0		250 J
SEMI	Pyrene	650.0		210 J
SEMI	Butyl Benzyl Phthalate			
SEMI	3,3'-Dichlorobenzidine			
SEMI	Benzo(a)anthracene	400.0		140 J
SEMI	bis(2-ethyl hexyl)phthalat			
SEMI	Chrysene	550.0		160 J
SEMI	Di-n-octyl Phthalate			
SEMI	Benzo(b)fluoranthene	930.0		220 J
SEMI	Benzo(k)fluoranthene			
SEMI	Benzo(a)pyrene	570.0		130 J
SEMI	Indeno(1,2,3-cd)Pyrene	540.0		74 J
SEMI	Dibenz(a,h)anthracene	160 J		
SEMI	Benzo(g,h,i)perylene	610.0		69 J

ONLY DETECTED RESULTS ARE REPORTED, ALL RESULTS REPORTED IN ug/kg
J - Indicates an estimated value

data concerning subsurface background conditions at greater depths was not obtained during the RI.

Three offsite surficial soil samples (001, 002, 003) were collected in August 1988, the locations are shown in Figure 5-2. All three samples were collected using pre-cleaned, dedicated, stainless steel hand bucket augers. Five samples from each location were collected and composited into one for submittal to the laboratory for analysis. The analytical results for these samples are reported in Table 5-7. The results for two of the three samples, i.e., 001 and 003, are considered anomalous since many organic contaminants were detected. Sample 003 was collected approximately 10 feet northwest of Witmer Road next to the Conrail railroad tracks which runs parallel to the park. The soil was reported to consist of topsoil, stones, clay, and road debris. Sample contamination may have resulted from construction activities (using fill for railroad bed) or leaks and spills from the railroad operation. Sample 001 was collected west of the parking lot, along the northern portion of the fence line behind Gratwick Hose Company. The sample consisted of topsoil and stones with some clay. The field report suggests that the sample may be fill rather than natural soil. A review of aerial photographs indicates disturbance in the area of Sample 001 at the same time as activities were occurring at the Gratwick site. Sample 002 was collected in the fields northwest of well pair GW-1S and GW-1D. The sample consisted of topsoil for approximately 10 inches; the remaining sample consisted of clay. No evidence of disturbances in the area of sample 002 was detected in aerial photographs. No organic compounds were detected in this sample. Many metals were detected, but are within the ranges of values for the Eastern U.S. presented in Table 5-4. Evidence of disturbance and the physical characteristics of the soil in the area of sample 001 and the proximity to railroad tracks and the physical soil characteristics in the area of sample 003 suggest that these samples may represent localized contamination from unknown sources and therefore, may not represent background conditions in the vicinity of the site. Conse-

quently only sample 002 was utilized for comparison with onsite surficial soil samples.

5.1.2.4 Subsurface Soil Samples

The analytical results of eleven subsurface soil samples are reported in Table 5-6. Also reported in this table are the results for the two offsite subsurface soil samples collected and identified as GW1-SB and GW2-SB. All analytical data was validated by Versar, Inc. Two of the eleven subsurface samples (i.e., GW3-SB collected at two depths) exceeded USEPA CLP analytical holding times for semi-volatiles; therefore, no data is reported for these sample fractions. No pesticides/PCBs, dioxin compounds, or total phenols were detected in any of the subsurface soil samples.

Thirty-four organic compounds (12 volatile organic compounds (VOCs) and 22 semi-volatile organic compounds (SVOCs) were detected in the subsurface soil samples. The frequency of occurrence and maximum concentration of detected compounds is presented in Table 5-8. On an individual basis, sample GW6-SB-15-16' contained the highest total volatile organic concentration at 45 ppb. The next highest concentration is found in sample GW3-SB-4-12' at 34 ppb. These values do not include the concentrations of acetone, methylene chloride, and 2-butanone because they were also present in the offsite samples at approximately the same concentrations. These three compounds are known as common laboratory contaminants as defined by the USEPA. The most commonly detected compounds, excluding methylene chloride, acetone, 2-butanone, and di-n-butylphthalate (another common laboratory contaminant), are total xylenes and carbon disulfide (each detected in 5 of the 11 samples). The sample which contained the highest total concentration of semi-volatiles is GW6-SB-10-15' with 277,520 ppb, followed by GW4-SB-8-12' with 2,912 ppb. Both of these samples consist primarily of polynuclear aromatic hydrocarbons (PAHs). The most commonly detected semi-volatile is phenanthrene in 3 out of 9 samples.

FREQUENCY AND MAXIMUM CONCENTRATIONS
OF COMPOUNDS DETECTED IN SUBSURFACE
SOIL SAMPLES

TABLE 5-8

COMPOUNDS DETECTED IN MORE THAN ONE SUBSURFACE SOIL SAMPLE
(11 samples)

<u>Compound</u>	<u>No. of Detections (Max. 11)</u>	<u>Maximum Concentration (ppb)</u>
Methylene Chloride*	11	22
Acetone*	11	310
Carbon Disulfide	5	26
Trans-1,2-dichloroethene	2	2.0
Chloroform	2	1.0
2-Butanone*	2	84
Trichloroethene	2	1.0
Benzene	3	4.0
Toluene*	3	10
Ethylbenzene	2	9.0
Total Xylenes	5	22
Naphthalene	2	4,000
2-Methylnaphthalene	2	1,700
Diethylphthalate*	2	140
Phenanthrene	3	49,000
Di-n-butylphthalate*	7	540
Fluoranthene	2	54,000
Pyrene	2	29,000
Benzo(a)anthracene	2	19,000
Bis(2-ethylhexyl)phthalate*	4	1,200
Chrysene	2	18,000
Di-n-octylphthalate*	2	100
Benzo(b)fluoranthene	2	32,000
Benzo(a)pyrene	2	19,000
Indeno(1,2,3-cd)pyrene	2	11,000
Benzo(g,h,i)perylene	2	7,600

* Common laboratory contaminant

TABLE 5-8 - Continued

COMPOUNDS DETECTED IN ONLY ONE SUBSURFACE SOIL SAMPLE

<u>Compound</u>	<u>Sample I.D.</u>	<u>No. of Detections</u>	<u>Maximum Concentration (ppb)</u>
Tetrachloroethene	GW6-SB-10-15'	1	3.0
Dimethylphthalate*	GW8-SB-9-16'	1	84
Acenaphthylene	GW6-SB-10-15'	1	840
Acenaphthene	GW6-SB-10-15'	1	3,600
Dibenzofuran	GW6-SB-10-15'	1	4,500
Fluorene	GW6-SB-10-15'	1	7,700
Anthracene	GW6-SB-10-15'	1	13,000
Dibenz(a,h)anthracene	GW6-SB-10-15'	1	3,200

A comparison was made between the mean concentrations of metals in subsurface soil samples to New Jersey Department of Environmental Protection (NJDEP) guidelines and is presented in Table 5-9. The guidelines are used by NJDEP on a case by case basis in evaluating possible cleanup requirements. All metals are within NJDEP guidelines except for barium and beryllium.

In order to assess the contamination in subsurface soil, a contaminant considered attributable to the site is defined as a contaminant that is present in a significant percentage of samples and is attributable to the site rather than background sources. These identified compounds/metals will be utilized in Section 6.0 when compiling a list of indicator chemicals for the purpose of the health risk assessment. The criteria used to establish the contaminants attributable to the site in subsurface soil are as follows:

- a) Contaminants had to be found in more than one sample;
- b) Mean concentration of organic compounds had to be an order of magnitude above the mean concentration of the background samples GW1-SB and 002;
- c) The mean metal concentrations had to be an order of magnitude above the mean back-ground concentration and/or above the normal range of values for soil in the Eastern United States, presented in Table 5-4, as reported by the United States Geological Survey (Shacklette and Boerngen, 1984);
- d) Other inorganic compounds had to be an order of magnitude above background samples GW1-SB and 002.
- e) Any compound or element which was detected in only one sample from the remedial investigation would be considered a contaminant attributable to the site if it

TABLE 5-9

COMPARISON OF MEAN CONCENTRATIONS OF SUBSURFACE,
SURFACE, AND SHORELINE SOIL SAMPLES TO NJDEP GUIDELINES

Element	Mean Concentration (ppm) of Element in Subsurface Soil Samples	Mean Concentration (ppm) of Element in Surface Soil Samples	Mean Concentration (ppm) in Shoreline Soil Samples	NJDEP Guidelines* in ppm
Aluminum	26,885	13,545	18,824	NL
Antimony	ND	ND	18.8	NL
Arsenic	2.13	4.85	8.8	20
Barium	718	215	224	400
Beryllium	3.1	0.58	ND	1.0
Cadmium	ND	3.72	6.5	3.0
Calcium	158,773	37,353	55,088	NL
Chromium	11.2	22.2	55	100
Cobalt	5.12	7.24	4.4	NL
Copper	23	60.9	674	170
Iron	16,448	36,210	61,088	NL
Lead	34.3	158	1185	250-1,000
Magnesium	26,697	9.85	15,952	NL
Manganese	4134	711	1327	NL
Mercury	0.07	0.12	0.30	1.0
Nickel	10.1	22.4	67	100
Potassium	2415	1634	901	NL
Silver	1.4	1.9	2.3	5.0
Sodium	687	270	464	NL
Vanadium	14.1	22.5	32	NL
Zinc	102	284	850	350
Cyanide	4.8	2.8	6.9	12

Note: * - New Jersey Department of Environmental Protection Guidelines
which are used on a case by case basis by the State in
evaluating possible cleanup requirements.

ND - Not Detected

NL - Not Listed in NJDEP Guidelines

was detected in at least two samples from the previous investigations performed at Gratwick Riverside Park.

Based upon the criteria established above contaminants considered attributable to the site in subsurface soil samples have been identified and are presented in Table 5-10. Calcium fulfills the established criteria, however, it is not a toxic metal and would not be utilized in Section 6.0 for the purpose of the health risk assessment. For this reason calcium is not included in Table 5-10.

5.1.2.5 Surficial Soil Samples

The analytical results for onsite surficial soil and offsite surficial soil are presented in Tables 5-11 and 5-7, respectively. All onsite surficial soil analytical data were validated by Versar, Inc. Table 5-12 summarizes the frequency of occurrence and maximum concentration of detected compounds. Eight volatiles, 21 semi-volatiles, and 3 pesticides/PCB's were detected on the surface of Gratwick Riverside Park. Of the 32 organic compounds detected, 24 were detected in two or more samples and 17 compounds were detected in half of the surficial soil samples collected. The most frequently detected volatiles were methylene chloride, acetone, chloroform, and 2-butanone. Methylene chloride, acetone, 2-butanone, and toluene are common laboratory contaminants. The volatile found in the highest concentration, excluding the common laboratory contaminants, was tetrachlorethane at 96 ppb detected in sample SPS-17. The semi-volatiles detected included phthalate esters, which are common laboratory contaminants, and polynuclear aromatic hydrocarbons (PAHs). The semi-volatile detected at the highest concentration was benzo(b)fluoranthene at 18,000 ppb in sample SPS-9. This sample also contained the highest total concentration of PAHs. Although the PAH concentrations are greater in sample SPS-9, they appear to be present in proportional concentrations in samples collected throughout the site, except for samples SPS-1 and SPS-10. Pesticides were not detected in more than one sample. For the purposes of this investigation, the individual

TABLE 5-10

CONTAMINANTS ATTRIBUTABLE TO THE SITE IN SUBSURFACE SOIL SAMPLES

ORGANIC COMPOUNDS

Carbon Disulfide	Benzo(b)fluoranthene
Trans-1,2-dichloroethene	Benzo(a)pyrene
Trichloroethene	Indeno(1,2,3-cd)pyrene
Benzene	Benzo(g,h,i)perylene
Ethylbenzene	Naphthalene
Toluene	2-Methylnaphthalene
Total Xylenes	Fluoranthene
Phenanthrene	Benzo(a)anthracene
Pyrene	Diethylphthalate
Chrysene	Di-n-butylphthalate
	Bis(2-ethylhexyl)phthalate
	Di-n-octyl phthalate

INORGANIC COMPOUNDS

Cyanide

TABLE 5-11

RI Onsite Surficial Soil Sample Results

SHALLOW SOIL SAMPLE I.D.	SPS-1	SPS-2	SPS-3	SPS-4	SPS-5	SPS-6	SPS-7	SPS-8	SPS-9	SPS-10
Parameter	DATE COLLECTED	10/29/87	10/29/87	10/28/87	10/28/87	10/28/87	10/28/87	10/29/87	10/29/87	10/29/87
Class										
Chloromethane	VOC									
Bromomethane	VOC									
Vinyl Chloride	VOC									
Chloroethane	VOC									
Methylene Chloride	VOC	22	7	18	19	17	11	11	10	11
Acetone	VOC	150	29	30	28	21	34	26	22	27
Carbon Disulfide	VOC									
1,1-Dichloroethene	VOC									
1,1-Dichloroethane	VOC									
trans-1,2-Dichloroethene	VOC									
Chloroform	VOC	1	1	1	1	1	1	2	1	1
1,2-Dichloroethane	VOC									
2-Butanone (or MEK)	VOC									
1,1,1-Trichloroethane	VOC	93	40	36	37	35	41	40	33	36
Carbon Tetrachloride	VOC									
Vinyl Acetate	VOC									
Bromodichloromethane	VOC									
1,2-Dichloropropane	VOC									
trans-1,3-Dichloropropene	VOC									
Trichloroethene	VOC				2		1			
Dibromochloromethane	VOC									
1,1,2-Trichloroethane	VOC									
Benzene	VOC									
cis-1,3-Dichloropropene	VOC									
2-Chloroethyl Vinyl Ether	VOC									
Bromoform	VOC									
4-Methyl-2-pentanone	VOC									
2-Hexanone	VOC									
Tetrachloroethene	VOC									
1,1,2,2-Tetrachloroethane	VOC				5		8			1
Toluene	VOC			1						1
Chlorobenzene	VOC									
Ethyl Benzene	VOC									
Styrene	VOC									
Total Xylenes	VOC									

ALL RESULTS REPORTED IN ug/KG
ONLY RESULTS ABOVE DETECTION LIMIT REPORTED

TABLE 5-11 (continued)

SHALLOW SOIL SAMPLE I.D.		SPS-11	SPS-12	SPS-12R	SPS-13	SPS-14	SPS-15	SPS-16	SPS-17	SPS-18	SPS-19	SPS-20
Parameter	DATE COLLECTED	10/30/88	10/30/88	10/30/88	10/30/88	10/30/88	10/30/88	10/30/88	10/30/88	10/30/88	10/30/88	10/30/88
Class												
Chloromethane	VOC											
Bromomethane	VOC											
Vinyl Chloride	VOC											
Chloroethane	VOC											
Methylene Chloride	VOC	12	10	11	13	13	12	14	15	16	17	11
Acetone	VOC	55		12	17							68
Carbon Disulfide	VOC											
1,1-Dichloroethene	VOC											
1,1-Dichloroethane	VOC											
trans-1,2-Dichloroethene	VOC											
Chloroform	VOC	1										
1,2-Dichloroethane	VOC											
2-Butanone (or MEK)	VOC	33	45	28	38	34	54	51	45	53	41	90
1,1,1-Trichloroethane	VOC											
Carbon Tetrachloride	VOC											
Vinyl Acetate	VOC											
Bromodichloromethane	VOC											
1,2-Dichloropropane	VOC											
trans-1,3-Dichloropropene	VOC					13				5		
Trichloroethene	VOC											
Dibromochloromethane	VOC											
1,1,2-Trichloroethane	VOC											
Benzene	VOC											
cis-1,3-Dichloropropene	VOC											
2-Chloroethyl Vinyl Ether	VOC											
Bromoform	VOC											
4-Methyl-2-pentanone	VOC											
2-Hexanone	VOC											
Tetrachloroethene	VOC							9	96	53		1
1,1,2,2-Tetrachloroethane	VOC											
Toluene	VOC											
Chlorobenzene	VOC											
Ethyl Benzene	VOC											
Styrene	VOC											
Total Xylenes	VOC											
Phenols, Total	VOC									5		
MISC												

ALL RESULTS REPORTED IN ug/KG
ONLY RESULTS ABOVE DETECTION LIMITS REPORTED

TABLE 5-11 (continued)

SHALLOW SOIL SAMPLE I.D.	SPS-1	SPS-2	SPS-3	SPS-4	SPS-5	SPS-6	SPS-7	SPS-8	SPS-9	SPS-10
DATE COLLECTED	10/29/87	10/29/87	10/28/87	10/28/87	10/28/87	10/28/87	10/29/87	10/29/87	10/29/87	10/29/87
Parameter										
Class										
Phenol	SEMI									
bis(2-Chloroethyl) ether	SEMI									
2-Chlorophenol	SEMI									
1,3-Dichlorobenzene	SEMI									
1,4-Dichlorobenzene	SEMI									
Benzyl Alcohol	SEMI									
1,2-Dichlorobenzene	SEMI									
2-Methylphenol	SEMI									
bis(2-Chloroisopropyl) ether	SEMI									
4-Methylphenol	SEMI									
N-Nitroso-Dipropylamine	SEMI									
Hexachloroethane	SEMI									
Nitrobenzene	SEMI									
Isophorone	SEMI									
2-Nitrophenol	SEMI									
2,4-Dimethylphenol	SEMI									
Benzoic Acid	SEMI									
bis(2-Chloroethoxy) methane	SEMI									
2,4-Dichlorophenol	SEMI									
1,2,4-Trichlorobenzene	SEMI		90	150	58		50	100	260	
Naphthalene	SEMI									
4-Chloroaniline	SEMI									
Hexachlorobutadiene	SEMI									
4-Chloro-3-methylphenol	SEMI									
2-Methylnaphthalene	SEMI		99	200	71			120	130	
Hexachlorocyclopentadiene	SEMI									
2,4,6-Trichlorophenol	SEMI									
2,4,5-Trichlorophenol	SEMI									
2-Chloronaphthalene	SEMI									
2-Nitroaniline	SEMI									
Dimethyl Phthalate	SEMI									
Acenaphthylene	SEMI								170	
3-Nitroaniline	SEMI								210	
Acenaphthene	SEMI									
2,4-Dinitrophenol	SEMI									
4-Nitrophenol	SEMI									
Dibenzofuran	SEMI									
2,4-Dinitrotoluene	SEMI	100		70				50	240	
2,6-Dinitrotoluene	SEMI									
Diethylphthalate	SEMI									
4-Chlorophenyl Phenyl Ether	SEMI									

ONLY RESULTS ABOVE DETECTION LIMITS REPORTED, ALL RESULTS REPORTED IN ug/kg

TABLE 5-11 (continued)

SHALLOW SOIL SAMPLE I.D.		SPS-1	SPS-2	SPS-3	SPS-4	SPS-5	SPS-6	SPS-7	SPS-8	SPS-9	SPS-10
DATE COLLECTED		10/29/87	10/29/87	10/28/87	10/28/87	10/28/87	10/28/87	10/29/87	10/29/87	10/29/87	10/29/87
Parameter	Class										
Fluorene	SEMI										
4-Nitroaniline	SEMI									450	
4,6-Dinitro-2-methylphenol	SEMI										
N-nitrosodiphenylamine	SEMI										
4-Bromophenyl Phenyl Ether	SEMI										
Hexachlorobenzene	SEMI										
Pentachlorophenol	SEMI										
Phenanthrene	SEMI		670	350	460	180	71	130	240	4500	50
Anthracene	SEMI		120	51	68					1300	
Di-n-butylphthalate	SEMI	370	94	470	220	340	460	140	120	200	710
Fluoranthene	SEMI		1200	550	680	320	140	180	310	8700	50
Pyrene	SEMI										
Butyl Benzyl Phthalate	SEMI		1100	530	600	230	110	180	540	13000	
3,3'-Dichlorobenzidine	SEMI				190						
Benzo(a)anthracene	SEMI	160	590	470	460	200	620	130	370	8800	360
bis(2-ethyl hexyl)phthalate	SEMI		230	450	800	240		140	160	370	
Chrysene	SEMI		650	580	590	250	93	190	450	7900	
Di-n-octyl Phthalate	SEMI			460		120		230	230		
Benzo(b)fluoranthene	SEMI		1100	1300	1100	400	140	230	1400	18000	
Benzo(k)fluoranthene	SEMI										
Benzo(a)pyrene	SEMI		660	640	630	220	76	140	600	9500	
Indeno(1,2,3-cd)Pyrene	SEMI		440	520	520	190	66	100	470	9900	
Dibenz(a,h)anthracene	SEMI		96	160	140					2800	
Benzo(g,h,i)perylene	SEMI		380	420	700	180	61	110	350	8300	

ONLY RESULTS ABOVE DETECTION LIMITS REPORTED, ALL RESULTS REPORTED IN ug/Kg

TABLE 5-11 (continued)

SHALLOW SOIL SAMPLE I.D.		SPS-1	SPS-2	SPS-3	SPS-4	SPS-5	SPS-6	SPS-7	SPS-8	SPS-9	SPS-10
DATE COLLECTED		10/29/87	10/29/87	10/28/87	10/28/87	10/28/87	10/28/87	10/29/87	10/29/87	10/29/87	10/29/87
Parameter	Class										
Aluminum	MCP	38600	17600	6580	8550	13000	7320	9290	8310	14800	11400
Antimony	MCP										
Arsenic	MCP	173	2.5	3.2	6	4.8	3.9	5.8	3.5	4.8	13
Barium	MCP		78	50	133	100	72	57	47	591	851
Beryllium	MCP		1.3								
Cadmium	MCP	17		1.1	2.8	2.6			1.9	8	2.3
Calcium	MCP	90000	59000	12300	22000	22200	49200	39700	8230	43600	27300
Chromium	MCP	42	12	14	23	21	11	10	17	45	27
Cobalt	MCP	19	5		4.1	6.5	2.7	4	3	16	7.1
Copper	MCP	38	19	59	68	40	26	25	96	151	87
Iron	MCP	53600	16000	20500	30000	38400	17100	21400	36500	101000	27600
Lead	MCP	15	60	20	104	47	27	22	24	514	747
Magnesium	MCP	29000	18800	1800	2980	5610	11900	12300	1080	8020	7030
Manganese	MCP	893	457	568	1500	662	557	490	590	946	449
Mercury	MCP				0.27					0.43	0.23
Nickel	MCP	49	14	15	17	24	11	15	22	35	22
Potassium	MCP	7530	1270	568	757	1480	766	1170	565	1130	1100
Selenium	MCP										
Silver	MCP						2.3	588	125	8.6	341
Sodium	MCP	422	210	108	222	141	208			335	
Thallium	MCP										
Vanadium	MCP	66	19	13	20	28	12	15	16	10	26
Zinc	MCP	127	119	70	130	173	149	175	106	1070	720
Cyanide	MCP						1.3			3.9	3.1
Phenols, Total	MCP										
pH	MCP										
Specific Conductance	MCP										
Temperature	MCP										
NH3-N	MISC										
TKN	MISC	340	36	47	350	100	200	7.9	46	40	14
LOC	MISC	22	600	32	33	120	20	210	320	1000	350
MOISTURE	MISC	45	16	9	12	22	14	24	100	44	410
DIOXIN,S	MISC							11	11	18	19
TCDD	MISC										
PeCDD	MISC										
HxCDD	MISC										
HpCDD	MISC										
OCDD	MISC										
TCDF	MISC										
PeCDF	MISC										
HxCDF	MISC										
HpCDF	MISC										
OCDF	MISC										

ONLY RESULTS ABOVE DETECTION LIMITS REPORTED, DIXON REPORTED IN ug/Kg, MCP and MISC REPORTED IN mg/Kg

FREQUENCY AND MAXIMUM CONCENTRATIONS OF
COMPOUNDS DETECTED IN SURFICIAL SOIL SAMPLES

TABLE 5-12

COMPOUNDS DETECTED IN MORE THAN ONE SURFICIAL SOIL SAMPLE

<u>Compound</u>	<u>No. of Detections (Max. 10)**</u>	<u>Maximum Concentration (ppb)</u>
Methylene Chloride*	20	22
Acetone*	14	150
Chloroform	10	2.0
2-Butanone*	19	93
Trichloroethene	4	13
Tetrachloroethene	6	96
Toluene*	3	1.0
Naphthalene	6	260
2-Methylnaphthalene	5	200
Dibenzofuran	4	240
Phenanthrene	9	4,500
Anthracene	4	1,300
Di-n-butylphthalate*	10	710
Fluoranthene	9	8,700
Pyrene	8	13,000
Benzo(a)anthracene	6	8,800
Bis(2-ethylhexyl)phthalate*	10	800
Chrysene	8	7,900
Di-n-octylphthalate*	4	460
Benzo(b)fluoranthene	8	18,000
Benzo(a)pyrene	8	9,500
Indeno(1,2,3-cd)pyrene	8	9,900
Dibenz(a,h)anthracene	4	2,800
Benzo(g,h,i)perylene	8	8,300

COMPOUNDS DETECTED IN ONLY ONE SURFICIAL SOIL SAMPLE

<u>Compound</u>	<u>Sample I.D.</u>	<u>No. of Detections</u>	<u>Maximum Concentration (ppb)</u>
Total Xylenes	SPS-18	1	5
Acenaphthylene	SPS-9	1	170
Acenaphthene	SPS-9	1	210
Fluorene	SPS-9	1	450
Butylbenzylphthalate*	SPS-4	1	190
4,4'-DDT	SPS-10	1	270
Aroclor-1242	SPS-4	1	1,700
Aroclor-1260	SPS-7	1	7,200

* Common laboratory contaminant.

** Ten surficial soil samples were collected. All additional 10 samples were collected for volatile and total phenols analyses only.

Aroclors (i.e. Aroclor-1248, Aroclor-1254, etc.) will be considered as one compound, therefore, PCBs were detected in two different samples, SPS-4 and SPS-7.

A comparison was made between the mean concentrations of metals in surface soil samples to NJDEP guidelines and is presented in Table 5-9. The guidelines are used by NJDEP on a case by case basis in evaluating possible cleanup requirements. All metals are within NJDEP guidelines except for cadmium.

The contaminants attributable to the site in surficial soil are presented in Table 5-13. These identified contaminants will be utilized for selecting indicator chemicals for the purpose of the health risk assessment presented in Section 6.0. The following criteria was used to identify the contaminants attributable to the site in surficial soil:

- a) Contaminants had to be detected in more than one sample;
- b) Mean of organic compounds had to be an order of magnitude above the concentration of background samples 002 and GW1-SB;
- c) The mean concentration of inorganic contaminants (elements/compounds) had to be an order of magnitude above the concentration of the background sample; and/or
- d) The geometric mean of metals had to be above the normal range of values for soil in the Eastern United States, as presented in Table 5-4, reported in United States Geological Survey.
- e) Any compound or element which was detected in only one sample from the remedial investigation would be considered a contaminant attributable to the site if it was detected in at least two samples from the previous investigations performed at Gratwick Riverside Park.

TABLE 5-13

CONTAMINANTS ATTRIBUTABLE TO THE SITE IN SURFICIAL SOIL SAMPLES

ORGANIC COMPOUNDS

4,4'-DDT	Phenanthrene
PCB	Anthracene
Acenaphthene	Fluoranthene
Acenaphthylene	Pyrene
Trichloroethene	Benzo(a)anthracene
Tetrachloroethene	Chrysene
Toluene	Benzo(b)fluoranthene
Naphthalene	Benzo(g,h,i)perylene
2-Methylnaphthalene	Benzo(a)pyrene
Dibenzofuran	Di-n-butylphthalate
Indeno(1,2,3-cd)pyrene	Bis(2-ethylhexyl)phthalate
Dibenz(a,h)anthracene	Di-n-octyl phthalate

INORGANIC ELEMENTS AND COMPOUNDS

Cadmium
Cyanide
Beryllium

Based upon the criteria established above contaminants considered attributable to the site in surface soil samples have been identified and are presented in Table 5-13. Calcium fulfills the established criteria, however, it is not a toxic metal and would not be utilized in Section 6.0 for the purpose of the health risk assessment. For this reason calcium is not included in Table 5-13. Butylbenzylphthalate also fulfills the established criteria, but it is a common laboratory contaminant and its presence in the samples collected during the remedial investigation as well as the results of previous investigations do not indicate it is persistent enough to warrant it being considered a contaminant attributable to the site.

5.1.2.6 Summary of Analytical Results of Surficial and Subsurface Soil Samples

Based on data from previous investigations and results of the Remedial Investigation, the nature and extent of contamination in the surficial and subsurface soil at Gratwick Riverside Park may be summarized as follows:

- o The analytical results of both the RI and previous investigations appear to display a similar degree of organic contamination with similar ranges of chemicals in the surficial soil samples collected. These soils do not indicate any obvious distribution pattern.

- o Volatiles contamination in surficial and subsurface soil, although above background levels for some contaminants, does not appear to be at high concentrations or frequencies, which concurs with the results of the limited number of samples collected during previous investigations.

- o Semi-volatiles were detected in subsurface soil during the RI but not in previous investigations. The primary contaminants are PAHs which were most highly concentrated in fill approximately ten to fifteen feet below the surface. The higher concentrations were detected in areas of previous drum removal.
- o Pesticides/PCBs were not detected in either previous investigations or during the RI in subsurface soil.
- o Many metals occur naturally in soil and the majority of metals detected in the surficial and subsurface soil are within the typical range of values of soil in the Eastern United States.

5.2 Shoreline Soil/Waste

5.2.1 Previous Investigations of Shoreline Soil/Waste Contamination

Shoreline soil/waste samples, located in Figure 1-3, were collected by Roy F. Weston in July, 1983. Seven samples were obtained along the shoreline and one near River Road which was considered offsite (background). One residue sample was also collected from an exposed drum. Samples were analyzed for priority pollutant volatiles, semi-volatiles, pesticides/PCBs, metals, and phenols. The highest concentration of contaminants detected in these samples is reported in Table 5-14. It should be noted that the shoreline samples collected were obtained from an area that had been partially excavated in 1982 to remove 33 drums that became exposed. The area was subsequently backfilled with clean fill.

In October 1986, Niagara Mohawk collected 10 shoreline samples. In addition, the NCHD collected 13 soil samples immediately

TABLE 5-14

HIGHEST LEVEL OF CONTAMINANTS DETECTED
IN 1983 SHORELINE SOIL SAMPLES

VOLATILES

<u>Compound</u>	<u>Sample ID(s)</u>	<u>Concentration (mg/kg=ppm)</u>	<u>Concentration In Background Sample (mg/kg=ppm)</u>
Chloroform	S-2,S-4,S-5	0.01	0
Methylene Chloride	S-4	0.06	0.03

SEMI-VOLATILES

Anthracene	S-3	0.57	0.54
Benzo(b)fluoranthene	S-4	0.25	0
Chrysene	S-3	0.67	0.41
Fluoranthene	S-3	1.24	1.24
Pyrene	S-3	1.21	1.07

PESTICIDES/PCB

Aldrin	S-4	0.818	0
4,4'-DDT	S-3	0.122	0
4,4'-DDE	S-6	0.578	0
Endosulfan	S-2	1.24	0.62
Endrin	S-4	0.064	0
Endrin Aldehyde	S-1	0.806	0
Heptachlor	S-1	0.590	0
Heptachlor Epoxide	S-2	0.166	0

TOTAL METALS:

Total Antimony	S-6	42.2	<1.0
Total Arsenic	S-1	9.06	6.67
Total Beryllium	S-5	5.38	4.10
Total Cadmium	S-3	0.772	0.015
Total Chromium	S-1	233	29.9
Total Copper	S-3	6,440	61.9
Total Lead	S-1	4,910	298
Total Mercury	S-3	1.24	1.02
Total Nickel	S-1	92.4	17.6
Total Silver	SP-1	1.42	0.134
Total Zinc	S-3	23.8	2.42

TABLE 5-14 - Continued
HIGHEST LEVEL OF CONTAMINANTS DETECTED
IN 1983 SHORELINE SOIL SAMPLES

MISCELLANEOUS

<u>Compound</u>	<u>Sample ID(s)</u>	<u>Concentration (mg/kg=ppm)</u>	<u>Concentration In Background Sample (mg/kg=ppm)</u>
Phenols	S-3	1.2	0.45

north of the shoreline. All sample locations are presented in Figure 1-3. These samples were analyzed for priority pollutant volatiles, semi-volatiles, pesticides/PCBs, and metals. The highest concentrations of each contaminant measured above detection limits in these 23 samples are reported in Table 5-15.

In general, volatiles were detected in very few of the shoreline samples. Chlorinated compounds (methylene chloride, chloroform, and 1,1,1-trichloroethane) were detected only in the area where drums had been previously excavated. There were many semi-volatiles detected with phenol reported at the highest concentration in sample 16 at 25 ug/g. Many polynuclear aromatic compounds were detected, with benzo(k)fluoranthene having the highest concentration at 3.4 ug/g. Sample #1 contained the greatest number and concentration of pesticides. Relatively high concentrations of PCBs were reported for samples #1 and #13. Metals were detected in most samples, with arsenic, copper, zinc, and lead having the highest concentrations in the shoreline soil. It should be noted that the shoreline samples analyzed in 1983 were above the background levels. It should also be noted that analytical results were not validated; however, the data is reported to serve as a basis for comparison with RI results. The results of the inorganic and organic analyses from previous investigations indicate that contamination is present along the shoreline. The nature and extent of the contamination is delineated further during the first round of RI sampling.

5.2.2 Shoreline Soil/Waste Sample Results from the Remedial Investigation

Eight shoreline soil samples were obtained during the RI using dedicated, pre-cleaned, stainless steel hand trowels. The samples were chemically tested for hazardous substance list (HSL) volatiles, semi-volatiles, pesticides/PCBs, metals, dioxin, total phenols, cyanide, and miscellaneous inorganic parameters and the results are presented in Table 5-16. All samples were collected and analyzed in accordance with the procedures defined in the Work/QA Project Plan (URS, 1987), Health and

TABLE 5-15
HIGHEST LEVEL OF CONTAMINANTS DETECTED IN
1986 SHORELINE SOIL SAMPLES

VOLATILES

<u>Compound</u>	<u>Sample ID(s)</u>	<u>Concentration (ug/g=ppm)</u>
1,1,1-Trichloroethane	9	7.4
Chloroform	11	≤1.6

SEMI-VOLATILES

Anthracene	11	0.67
Benzo(a)anthracene*	15	1.7
Benzo(a)pyrene	15	2.3
Benzo(b)fluoranthene	6	2.8
Benzo(g,h,i)perylene	13	≤1.00
Bis(2-ethylhexyl)phthalate	8	4.3
Diethylphthalate	5	0.35
Di-n-butylphthalate	3	1.2
Fluoranthene	14	2.2
Indeno(1,2,3-cd)pyrene	3,13	≤0.33
Naphthalene	1,3,5,7,9,13,15,17,19	≤0.33
Phenanthrene	9	2.2
Pyrene	14	1.7
Isophorone	1	0.90
Nitrobenzene	3	≤0.33
Acenaphthene	7,9,15,17	≤0.33
1,2,4-Trichlorobenzene	9,13,15,17	≤0.33
Dibenzo(a,h)anthracene	13	≤1.00
Acenaphthylene	15	≤0.33
Phenol	16	25
2-Chlorophenol	18	1.3

Note:

Odd numbered samples were collected by Niagara Mohawk and analyzed by Recra Environmental, Inc. Even numbered samples were collected by NCHD and analyzed by Ecology & Environment, Inc.

- * Chromatographically, benzo(a)anthracene and chrysene coelute, the reported value is therefore an "and/or" value.

TABLE 5-15 - Continued
HIGHEST LEVEL OF CONTAMINANTS DETECTED IN
1986 SHORELINE SOIL SAMPLES

SEMI-VOLATILES (Continued)

<u>Compound</u>	<u>Sample ID(s)</u>	<u>Concentration (ug/g=ppm)</u>
2,4-Dinitrophenol	8	2.7
4-Nitrophenol	14	0.51
Pentachlorophenol	14	1.5
Benzidine	14	3.4
Butylbenzylphthalate	6	0.57
Chrysene	14	2.2
Di-n-octylphthalate	18	1.1
Benzo(k)fluoranthene	14	3.4
Bis(2-chloroethyl)ether	16	77

PESTICIDES/PCBs

Beta-BHC	18	0.03
Delta-BHC	9	0.011
4,4'-DDD**	1	0.29
4,4'-DDE	1	0.33
4,4'-DDT	1	1.1
Aldrin	7	0.043
Heptachlor	9	0.015
Endosulfan I	1	0.058
Endosulfan Sulfate	1	2.9
Heptachlor Epoxide	1	0.056
Endrin Ketone	1	0.67
PCB-1242	13	43
PCB-1248	6	0.08
PCB-1254	13	66
PCB-1260	6	1.2

TOTAL METALS:

Total Antimony	11	8.67
Total Arsenic	11	240
Total Beryllium	9	1.6
Total Cadmium	1	12
Total Chromium	7	78

** Chromatographically, 4,4'-DDD and Endosulfan II coelute. The reported value is therefore an "and/or" value.

TABLE 5-15 - Continued
HIGHEST LEVEL OF CONTAMINANTS DETECTED IN
1986 SHORELINE SOIL SAMPLES

TOTAL METALS: Continued

<u>Compound</u>	<u>Sample ID(s)</u>	<u>Concentration (ug/g=ppm)</u>
Total Copper	11	14,700
Total Lead	3	11,100
Total Mercury	6	1.5
Total Nickel	11	194
Total Selenium	12	1.2
Total Silver	1	2.9
Total Zinc	11	2,960

TABLE 5-16

RI Shoreline Sample Results

SOIL SAMPLE I.D.		SP1-SS	SP2-SS	SP3-SS	SP4-SS	SP5-SS	SP6-SS	SP7-SS	SP8-SS
Parameter	DATE COLLECTED	10/27/87	10/27/87	10/27/87	10/27/87	10/27/87	10/27/87	10/27/87	10/27/87
Class									
Chloromethane	VOC								
Bromomethane	VOC								
Vinyl Chloride	VOC								
Chloroethane	VOC								
Methylene Chloride	VOC	7	13	8	7	40	6	11	8
Acetone	VOC	42	29	37	33	54	33	53	32
Carbon Disulfide	VOC								
1,1-Dichloroethene	VOC								
1,1-Dichloroethane	VOC								
trans-1,2-Dichloroethene	VOC								
Chloroform	VOC	49	5	4	5	4	1	3	2
1,2-Dichloroethane	VOC								
2-Butanone (or MEK)	VOC	55	51	29	37	47	35	35	31
1,1,1-Trichloroethane	VOC	10	7						
Carbon Tetrachloride	VOC								
Vinyl Acetate	VOC								
Bromodichloromethane	VOC								
1,2-Dichloropropane	VOC								
trans-1,3-Dichloropropene	VOC							1	
Trichloroethene	VOC								
Dibromochloromethane	VOC								
1,1,2-Trichloroethane	VOC								
Benzene	VOC								
cis-1,3-Dichloropropene	VOC								
2-Chloroethyl Vinyl Ether	VOC								
Bromoform	VOC								
4-Methyl-2-pentanone	VOC								
2-Hexanone	VOC								
Tetrachloroethene	VOC								
1,1,2,2-Tetrachloroethane	VOC								
Toluene	VOC	2	1	1	1				
Chlorobenzene	VOC	2							
Ethyl Benzene	VOC								
Styrene	VOC								
Total Xylenes	VOC		3						

ONLY RESULTS ABOVE DETECTION LIMITS REPORTED, ALL RESULTS REPORTED IN ug/Kg

TABLE 5-16 (continued)

SOIL SAMPLE I.D.		SP1-SS	SP2-SS	SP3-SS	SP4-SS	SP5-SS	SP6-SS	SP7-SS	SP8-SS
DATE COLLECTED		10/27/87	10/27/87	10/27/87	10/27/87	10/27/87	10/27/87	10/27/87	10/27/87
Parameter	Class								
Aluminum	MCP	11100	7890	6000	17400	10900	83700	5760	7840
Antimony	MCP				94		20		
Arsenic	MCP	3.8	9.2	6.6	6.4	22	6.1	11	5.5
Barium	MCP	108	96	113	125	849	202	225	75
Beryllium	MCP								
Cadmium	MCP	1.2	5.6	1.4	1.8	23	5	13	1.8
Calcium	MCP	89800	44600	43500	132000	31900	34400	26900	37600
Chromium	MCP	13	17	12	21	46	264	54	16
Cobalt	MCP	2.8	2.5		3	2.4	8.2	7.6	3.3
Copper	MCP	75	112	46	360	363	4290	116	32
Iron	MCP	17000	70900	18300	35200	73500	90000	165000	18800
Lead	MCP	120	33	83	6410	1790	766	125	153
Magnesium	MCP	25700	4210	8970	57300	5240	6880	5820	13500
Manganese	MCP	565	1280	677	949	654	2010	3620	856
Mercury	MCP				0.14	1.3	0.61		0.18
Nickel	MCP	13	17	9.4	60	81	301	45	11
Potassium	MCP	1250	649	590	1200	1440	647	515	920
Selenium	MCP								
Silver	MCP					2.4	10		
Sodium	MCP	273	318	583	1430	376	315	232	186
Thallium	MCP								
Vanadium	MCP	14	24	8.9	13	124	35	24	12
Zinc	MCP	139	249	213	492	2530	2720	313	142
Cyanide	MCP	1.6		2.8		29		1.5	
Phenols, Total	MCP		0.47		0.47		0.73		0.64
pH	MCP	7.89	8.38	8.02	7.93	7.82	7.87	8.75	8.5
Specific Conductance	MCP								
Temperature	MCP								
NH3-N	MISC								
TKN	MISC	470	190	620	370	580	441	91	
LOC	MISC	10	10	17	18	81	1300	310	830
DIOXIN'S	MISC						38	12	110
TCDD	MISC								
PeCDD	MISC								
HxCDD	MISC						3.82		
HpCDD	MISC						3.78		
OCDD	MISC					3.22			
TCDF	MISC								
PeCDF	MISC								
HxCDF	MISC				1.32		6.48		
HpCDF	MISC				2.8		20.7		
OCDF	MISC				3.16		26.7		
MOISTURE	MISC	12	19	22	28	22	21	21	9

ONLY RESULTS ABOVE DETECTION LIMITS REPORTED, DIOXIN REPORTED IN ug/Kg, MCP and MISC REPORTED IN mg/Kg

TABLE 5-16 (Continued)

SOIL SAMPLE I.D.		SP1-SS	SP2-SS	SP3-SS	SP4-SS	SP5-SS	SP6-SS	SP7-SS	SP8-SS
Parameter	DATE COLLECTED	10/27/87	10/27/87	10/27/87	10/27/87	10/27/87	10/27/87	10/27/87	10/27/87
	Class								
alpha-BHC	PST								
beta-BHC	PST								
delta-BHC	PST								
gamma-BHC (Lindane)	PST								
Heptachlor	PST								
Aldrin	PST								
Heptachlor Epoxide	PST								
Endosulfan I	PST								
Dieldrin	PST								
4,4'-DDE	PST								38
Endrin	PST								
Endosulfan II	PST								
4,4'-DDD	PST								
Endosulfan Sulfate	PST								
4,4'-DDT	PST					19000			190
Methoxychlor	PST								
Endrin Ketone	PST								
Chlordane	PST								
Toxaphene	PST								
Aroclor-1016	PCB								
Aroclor-1221	PCB								
Aroclor-1232	PCB								
Aroclor-1242	PCB								
Aroclor-1248	PCB								
Aroclor-1254	PCB								
Aroclor-1260	PCB								

ONLY RESULTS ABOVE DETECTION LIMITS REPORTED, ALL RESULTS REPORTED IN ug/Kg

TABLE 5-16 (continued)

SOIL SAMPLE I.D.		SP1-SS	SP2-SS	SP3-SS	SP4-SS	SP5-SS	SP6-SS	SP7-SS	SP8-SS
Parameter	DATE COLLECTED	10/27/87	10/27/87	10/27/87	10/27/87	10/27/87	10/27/87	10/27/87	10/27/87
Class									
Fluorene	SEMI		180		110				
4-Nitroaniline	SEMI								
4,6-Dinitro-2-methylphenol	SEMI								
N-nitrosodiphenylamine	SEMI								
4-Bromophenyl Phenyl Ether	SEMI								
Hexachlorobenzene	SEMI								
Pentachlorophenol	SEMI								
Phenanthrene	SEMI	430	1500	310	820		510	130	300
Anthracene	SEMI	130	340	70	180				
Di-n-butylphthalate	SEMI	240	170	280	340	620	380	370	620
Fluoranthene	SEMI	570	1100	540	1100		800	140	440
Pyrene	SEMI	760	1300	500	920		790	130	310
Butyl Benzyl Phthalate	SEMI								
3,3'-Dichlorobenzidine	SEMI								
Benzo(a)anthracene	SEMI	360	720	390	740		510		
bis(2-ethyl hexyl)phthalate	SEMI	300	360	450	420		300	290	820
Chrysene	SEMI	400	840	380	790		560	110	320
Di-n-octyl Phthalate	SEMI	600	300	260	200			400	520
Benzo(b)fluoranthene	SEMI	680	1100	660	1400	450	940	130	490
Benzo(k)fluoranthene	SEMI								
Benzo(a)pyrene	SEMI	450	720	390	840		710		290
Indeno(1,2,3-cd)Pyrene	SEMI	400	530	370	750		600		270
Dibenzo(a,h)anthracene	SEMI				210		150		93
Benzo(g,h,i)perylene	SEMI	340	440	320	670		620		290

ONLY RESULTS ABOVE DETECTION LIMITS REPORTED, ALL RESULTS REPORTED IN ug/kg

TABLE 5-16 (continued)

SOIL SAMPLE I.D.		SP1-SS	SP2-SS	SP3-SS	SP4-SS	SP5-SS	SP6-SS	SP7-SS	SP8-SS
Parameter	Class	DATE COLLECTED	10/27/87	10/27/87	10/27/87	10/27/87	10/27/87	10/27/87	10/27/87
Phenol	SEMI			2100	870				
bis(2-Chloroethyl) ether	SEMI								
2-Chlorophenol	SEMI								
1,3-Dichlorobenzene	SEMI								
1,4-Dichlorobenzene	SEMI								
Benzyl Alcohol	SEMI								
1,2-Dichlorobenzene	SEMI								
2-Methylphenol	SEMI								
bis(2-Chloroisopropyl) ether	SEMI								
4-Methylphenol	SEMI								
N-Nitroso-Dipropylamine	SEMI								
Hexachloroethane	SEMI								
Nitrobenzene	SEMI								
Isophorone	SEMI								
2-Nitrophenol	SEMI								
2,4-Dimethylphenol	SEMI								
Benzoic Acid	SEMI								
bis(2-Chloroethoxyl) methane	SEMI								
2,4-Dichlorophenol	SEMI		190		130				110
1,2,4-Trichlorobenzene	SEMI								
Naphthalene	SEMI								
4-Chloroaniline	SEMI								
Hexachlorobutadiene	SEMI								
4-Chloro-3-methylphenol	SEMI								110
2-Methylnaphthalene	SEMI								
Hexachlorocyclopentadiene	SEMI								
2,4,6-Trichlorophenol	SEMI								
2,4,5-Trichlorophenol	SEMI								
2-Chloronaphthalene	SEMI								
2-Nitroaniline	SEMI								
Dimethyl Phthalate	SEMI								
Acenaphthylene	SEMI				50				
3-Nitroaniline	SEMI		210						
Acenaphthene	SEMI								
2,4-Dinitrophenol	SEMI								
4-Nitrophenol	SEMI								
Dibenzofuran	SEMI		140		1000		510		
2,4-Dinitrotoluene	SEMI								
2,6-Dinitrotoluene	SEMI								
Diethylphthalate	SEMI	42							
4-Chlorophenyl Phenyl Ether	SEMI								

ONLY RESULTS ABOVE DETECTION LIMITS REPORTED, ALL RESULTS REPORTED IN ug/Kg

Safety Plan (URS, 1987), and USEPA CLP protocols (Organic SOW 9/84 and Inorganic SOW 784). The locations of the samples selected were taken under positive bias sampling methods and with knowledge of the results of previous investigations. All samples collected, except volatiles, were homogenized in pre-cleaned, dedicated, stainless steel mixing bowls. The location of the samples are shown in Figure 5-1.

The chemical data for each sample was validated by Versar, Inc. The frequency of occurrence and maximum concentration of detected compounds is summarized in Table 5-17. Thirty-nine organic compounds (10 volatile, 21 semi-volatile, 2 pesticide/PCB, and 6 dioxin compounds) were detected in the shoreline soil. Twenty-eight compounds were detected more than once and 11 compounds only once. The sample which contained the highest concentration of a single organic contaminant was SP5-SS, which had 19,000 ppb of 4,4'-DDT. Sample SP4-SS was the next highest with phenol at 2,100 ppb. The most commonly detected organic contaminants were methylene chloride, acetone, chloroform, 2-butanone, di-n-butylphthalate, and benzo(b)fluoranthene. It should be noted that the only compounds for this group that are not common laboratory contaminants, as defined by the USEPA, are chloroform and benzo(b) fluoranthene. The laboratory reported methylene chloride, acetone, and 2-butanone in the associated method blank for all eight shoreline soil samples. The results for these three volatiles are therefore suspect.

On an individual basis, the sample which contained the highest concentration of organic contaminants was SP5-SS at a total concentration of 20,215 ppb. This number is elevated due to the presence of the pesticide 4,4'-DDT. (No PCBs were detected in any shoreline samples.) The sample with the second highest total organic concentration is SP4-SS at 11,623 ppb. This sample was collected at the end of a storm drain which traverses Gratwick Riverside Park. The sample which contained the lowest concentration of organic contaminants is SP7-SS at 1,811 ppb. There were many metals detected in all eight shoreline soil samples.

TABLE 5-17

FREQUENCY AND MAXIMUM CONCENTRATIONS OF
COMPOUNDS DETECTED IN SHORELINE SOIL SAMPLES

<u>Compounds</u>	<u>No. of Detections (Max. 8)</u>	<u>Maximum Concentration (ppb)</u>
Methylene Chloride*	8	40
Acetone*	8	54
Chloroform	8	49
2-Butanone*	8	55
1,1,1-Trichloroethane	2	10
Toluene*	4	2.0
Phenol	2	2,100
Naphthalene	3	190
Dibenzofuran	3	1,000
Fluorene	2	180
Phenanthrene	7	1,500
Anthracene	4	340
Di-n-butylphthalate*	8	620
Fluoranthene	7	1,100
Pyrene	7	1,300
Benzo(a)anthracene	5	740
Bis(2-ethylhexyl)phthalate*	7	820
Chrysene	7	840
Di-n-octylphthalate*	6	600
Benzo(b)fluoranthene	8	1,400
Benzo(a)pyrene	6	840
Indeno(1,2,3-cd)pyrene	6	750
Dibenz(a,h)anthracene	4	210
Benzo(g,h,i)perylene	6	670
4,4'-DDT	2	19,000
HxCDF	2	6.48
HpCDF	2	20.7
OCDF	2	26.7

* Common laboratory contaminant

TABLE 5-17 - Continued

FREQUENCY AND MAXIMUM CONCENTRATIONS OF
COMPOUNDS DETECTED IN SHORELINE SOIL SAMPLES

<u>Compounds</u>	<u>Sample I.D.</u>	<u>No. of Detections (Max. 8)**</u>	<u>Maximum Concentration (ppb)</u>
Trans-1,2-Dichloroethene	SP7-SS	1	3.0
Trichloroethene	SP7-SS	1	1.0
Chlorobenzene	SP1-SS	1	2.0
Total Xylenes	SP2-SS	1	3.0
Acenaphthylene	SP4-SS	1	50
Acenaphthene	SP2-SS	1	2.0
Diethylphthalate*	SP1-SS	1	42
4,4'-DDE	SP8-SS	1	38
HxCDD	SP6-SS	1	3.82
HpCDD	SP6-SS	1	3.78
OCDD	SP5-SS	1	3.22

* Common laboratory contaminant

Aluminum, arsenic, barium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, potassium, sodium, vanadium, and zinc were present in all eight samples, with iron having the highest concentration at 165,000 ppm followed by calcium at 132,000 ppm. Mercury was detected in two shoreline soil samples with a maximum concentration of 1.3 ppm.

In order to make a more useful interpretation of the organic analytical data, two comparisons were made utilizing the shoreline samples and is presented in Table 5-18. The first comparison to be made is the analytical results of the shoreline soil samples versus the results of the surficial soil samples collected onsite. The purpose of this comparison is to determine if the contamination is primarily focused at the shoreline or distributed throughout the site. The second comparison made is to the background surface soil, labeled 002, collected offsite. Table 5-18 indicates that the concentration of volatile organics in both the surficial and shoreline samples are comparable. The concentration of semi-volatiles is approximately 2 times higher in the surficial soil than the shoreline soil. The opposite can be said about the pesticides/PCBs, where the concentration is approximately 2 times higher in the shoreline samples as compared to the surficial soil. No organic contaminants were detected in the background sample.

A comparison was made between the mean concentrations of metals in shoreline soil samples to NJDEP guidelines and is presented in Table 5-9. The guidelines are used by NJDEP on a case by case basis in evaluating possible cleanup requirements. All metals are within NJDEP guidelines except for cadmium, copper, lead and zinc.

In order to assess the contamination in shoreline soil samples, contaminants considered attributable to the site have been examined. The criteria used to determine these contaminants are as follows:

- a) Contaminants had to be found in more than one sample;

TABLE 5-18
COMPARISON OF ORGANIC CONCENTRATION OF SHORELINE SOIL
TO BACKGROUND AND ONSITE SURFICIAL SOIL

Parameters	Average Concentration (ppb) of 8 Shoreline Samples	Concentration (ppb) of Background Surface Soil Sample	Average Concentration (ppb) of 11 Surficial Soil Samples Onsite
Volatile Organic Compounds	105	0	92
Semi-volatile Organic Compounds	6,192	0	11,877
PAH Fraction of Semi-volatiles	4,775	0	11,164
Pesticides/PCB Compounds	2,404	0	834

Note:

A total of 10 surficial soil samples were collected, but one sample was duplicated. An additional 10 surficial soil samples were collected for volatile analysis only. The average concentration (arithmetic mean) is based on a total of 25 soil samples (5 were duplicate samples).

- b) Mean of organic compounds had to be an order of magnitude above background (i.e., 002 and GW1-SB);
- c) Mean concentrations of inorganic contaminants (elements/compounds) had to be an order of magnitude above background; and/or
- d) The mean of metals had to be above the normal range of values for soil in the Eastern United States.
- e) Any compound or element which was detected in only one sample from the remedial investigation would be considered a contaminant attributable to the site if it was detected in at least two samples from the previous investigations performed at Gratwick Riverside Park.

Based upon the criteria established above contaminants considered attributable to the site in shoreline soil samples have been identified and is presented in Table 5-19. Calcium fulfills the established criteria, however, it is not a toxic metal and would not be utilized in Section 6.0 for the purpose of the health risk assessment. For this reason calcium is not included in Table 5-19. Diethylphthalate also fulfills the established criteria, but it is a common laboratory contaminant and its presence in the samples collected during the remedial investigation as well as the result of previous investigations do not indicate it is persistent enough to warrant it being considered a contaminant attributable to the site.

5.2.3 Summary of Analytical Results of Shoreline Soil/Waste Samples

Based upon the data presented in Sections 5.2.1 and 5.2.2, the following conclusions may be made about the nature and extent of contamination of the shoreline soil at Gratwick Riverside Park:

TABLE 5-19

CONTAMINANTS ATTRIBUTABLE TO THE SITE IN SHORELINE SOIL SAMPLES

ORGANIC COMPOUNDS

1,1,1-Trichloroethene	Benzo(a)anthracene
Toluene	Pyrene
Phenol	Bis(2-ethylhexyl)phthalate
Naphthalene	Chrysene
Dibenzofuran	Di-n-octylphthalate
Fluorene	Benzo(b)fluoranthene
Phenanthrene	Benzo(a)pyrene
Anthracene	Indeno(1,2,3-cd)pyrene
Di-n-butylphthalate	Dibenz(a,h)anthracene
Fluoranthene	Benzo(g,h,i)perylene
4,4'-DDT	HxCDF
OCDF	HpCDF
4,4'-DDE	Acenaphthene

INORGANIC ELEMENTS/COMPOUNDS

Antimony	Cyanide
Cadmium	Total Phenols
Lead	

- o The pesticide contaminants appear to be more concentrated along the shoreline as compared to the surficial soil onsite.
- o The volatiles detected in the shoreline are above the background samples (where no volatiles were detected), but do not appear to be present at high concentrations.
- o The concentration of semi-volatiles is greater in surficial soil samples than in shoreline samples; however, shoreline samples are contaminated primarily with polynuclear aromatic hydrocarbons.
- o Most metals detected in soil appear to be attributable to background sources. Out of the 23 HSL metals that were analyzed, only three metals (i.e., antimony, cadmium and lead) have been identified as contaminants of concern.

The shoreline soil contamination appears to be more highly concentrated in areas where drum removal has occurred, as shown by the results of previous investigations and this RI. In general, contamination levels seem to be very sporadic throughout the eight shoreline soil samples collected and levels seem to be dependent on whatever becomes exposed by erosion. However, the shoreline soil organic contamination does appear to be more highly concentrated in certain locations, such as the areas where the storm drains, which traverse Gratwick Riverside Park, empty into the Niagara River. Samples SP5-SS and SP6-SS are downstream of sample SP4-SS, and may be contaminated due to the migration of contaminants from the outfall of the storm sewer discharge at SP4-SS. Organic contamination in samples collected upstream of SP4-SS is considerably lower than that detected in SP4-SS except for SP2-SS which has a comparable level of organic contamination. Similar results were obtained from the previous investigations along the shoreline.

5.3 Surface Water

5.3.1 Surface Water Sample Results from the Remedial Investigation

A total of 11 surface water samples (7 in the first round and 4 in the second round) were collected during the Remedial Investigation at Gratwick Riverside Park. The samples were collected by directly submerging the sample container and were submitted to the analytical laboratory Ecology & Environment, Inc. The samples were chemically tested for hazardous substance list (HSL) volatiles, semi-volatiles, pesticides/PCBs, metals, cyanide, total phenols, and other miscellaneous inorganic parameters. The location of these samples is shown in Figure 5-1. The results of these analyses are presented in Tables 5-20 (first round) and 5-21 (second round). The first round data was validated by Versar, Inc. and the second round data was validated by URS Consultants. All samples were collected and analyzed in accordance with the procedures in the Work/QA Project Plan (URS, 1987), Health and Safety Plan (URS, 1987), and USEPA CLP protocols (Organic SOW 9/84 and Inorganic SOW 784). The frequency of occurrence and maximum concentration of detected compounds is summarized in Table 5-22.

Six volatile and four semi-volatile compounds were detected in the surface water. No pesticides/PCBs were found in any samples. Only 2 of the compounds detected, i.e. trans 1-2, dichloroethene and bis(2-ethylhexyl)phthalate, were detected in both rounds of sampling. Eight of these ten compounds (methylene chloride, acetone, 2-butanone, toluene, diethylphthalate, di-n-butylphthalate, bis(2-ethylhexyl)phthalate, di-n-octylphthalate) are known common laboratory contaminants, as defined by the USEPA. These eight compounds were detected in the associated trip and method blanks at similar concentrations. The EPA states that compound concentrations must be ten times greater in the sample than the concentration in their associated trip or method blanks. This is not the case, and therefore, the presence of these compounds are suspect.

TABLE 5-20

First Round RI Surface Water Sample Results

SAMPLE I.D.	SP1-SW	SP2-SW	SP3-SW	SP4-SW	SP5-SW	SP9-SW	SP11-SW
DATE COLLECTED	11/11/87	11/11/87	11/11/87	11/11/87	11/11/87	11/12/87	11/12/87
Parameter	Class						
Chloromethane	VOC						
Bromomethane	VOC						
Vinyl Chloride	VOC						
Chloroethane	VOC						
Methylene Chloride	VOC	6	6	6	6	7	6
Acetone	VOC	14	15	21	14	19	10
Carbon Disulfide	VOC						
1,1-Dichloroethene	VOC						
1,1-Dichloroethane	VOC						
trans-1,2-Dichloroethene	VOC				2		
Chloroform	VOC						
1,2-Dichloroethane	VOC						
2-Butanone (or MEK)	VOC	18	18	23	19	22	18
1,1,1-Trichloroethane	VOC						
Carbon Tetrachloride	VOC						
Vinyl Acetate	VOC						
Bromodichloromethane	VOC						
1,2-Dichloropropane	VOC						
trans-1,3-Dichloropropene	VOC						
Trichloroethene	VOC						
Dibromochloromethane	VOC						
1,1,2-Trichloroethane	VOC						
Benzene	VOC						
cis-1,3-Dichloropropene	VOC						
2-Chloroethyl Vinyl Ether	VOC						
Bromoform	VOC						
4-Methyl-2-pentanone	VOC						
2-Hexanone	VOC						
Tetrachloroethene	VOC						
1,1,2,2-Tetrachloroethane	VOC						
Toluene	VOC		2	3	3	3	
Chlorobenzene	VOC						
Ethyl Benzene	VOC						
Styrene	VOC						
Total Xylenes	VOC						

ONLY RESULTS ABOVE DETECTION LIMITS REPORTED, ALL RESULTS REPORTED IN ug/L

TABLE 5-20 (continued)

SAMPLE I.D.		SP1-SW	SP2-SW	SP3-SW	SP4-SW	SP5-SW	SP9-SW	SP11-SW
DATE COLLECTED		11/11/87	11/11/87	11/11/87	11/11/87	11/11/87	11/12/87	11/12/87
Parameter	Class							
Phenol	SEMI							
bis(2-Chloroethyl) ether	SEMI							
2-Chlorophenol	SEMI							
1,3-Dichlorobenzene	SEMI							
1,4-Dichlorobenzene	SEMI							
Benzyl Alcohol	SEMI							
1,2-Dichlorobenzene	SEMI							
2-Methylphenol	SEMI							
bis(2-Chloroisopropyl) ether	SEMI							
4-Methylphenol	SEMI							
N-Nitroso-Dipropylamine	SEMI							
Hexachloroethane	SEMI							
Nitrobenzene	SEMI							
Isophorone	SEMI							
2-Nitrophenol	SEMI							
2,4-Dimethylphenol	SEMI							
Benzoic Acid	SEMI							
bis(2-Chloroethoxyl) methane	SEMI							
2,4-Dichlorophenol	SEMI							
1,2,4-Trichlorobenzene	SEMI							
Naphthalene	SEMI							
4-Chloroaniline	SEMI							
Hexachlorobutadiene	SEMI							
4-Chloro-3-methylphenol	SEMI							
2-Methylnaphthalene	SEMI							
Hexachlorocyclopentadiene	SEMI							
2,4,6-Trichlorophenol	SEMI							
2,4,5-Trichlorophenol	SEMI							
2-Chloronaphthalene	SEMI							
2-Nitroaniline	SEMI							
Dimethyl Phthalate	SEMI							
Acenaphthylene	SEMI							
3-Nitroaniline	SEMI							
Acenaphthene	SEMI							
2,4-Dinitrophenol	SEMI							
4-Nitrophenol	SEMI							
Dibenzofuran	SEMI							
2,4-Dinitrotoluene	SEMI							
2,6-Dinitrotoluene	SEMI							
Diethylphthalate	SEMI	1	1	2				
4-Chlorophenyl Phenyl Ether	SEMI							

ONLY RESULTS ABOVE DETECTION LIMITS REPORTED, ALL RESULTS REPORTED IN ug/L

TABLE 5-20 (continued)

SAMPLE I.D.		SP1-SW	SP2-SW	SP3-SW	SP4-SW	SP5-SW	SP9-SW	SP11-SW
DATE COLLECTED		11/11/87	11/11/87	11/11/87	11/11/87	11/11/87	11/12/87	11/12/87
Parameter	Class							
Fluorene	SEMI							
4-Nitroaniline	SEMI							
4,6-Dinitro-2-methylphenol	SEMI							
N-nitrosodiphenylamine	SEMI							
4-Bromophenyl Phenyl Ether	SEMI							
Hexachlorobenzene	SEMI							
Pentachlorophenol	SEMI							
Phenanthrene	SEMI							
Anthracene	SEMI							
Di-n-butylphthalate	SEMI	15	12	6	8	11	3	5
Fluoranthene	SEMI							
Pyrene	SEMI							
Butyl Benzyl Phthalate	SEMI							
3,3'-Dichlorobenzidine	SEMI							
Benzo(a)anthracene	SEMI							
bis(2-ethyl hexyl)phthalate	SEMI	18	17	18	22	22	3	3
Chrysene	SEMI							
Di-n-octyl Phthalate	SEMI	3	29	3	5	15	59	78
Benzo(b)fluoranthene	SEMI							
Benzo(k)fluoranthene	SEMI							
Benzo(a)pyrene	SEMI							
Indeno(1,2,3-cd)Pyrene	SEMI							
Dibenz(a,h)anthracene	SEMI							
Benzo(g,h,i)perylene	SEMI							

ONLY RESULTS ABOVE DETECTION LIMITS REPORTED, ALL RESULTS REPORTED IN ug/L

TABLE 5-20 (continued)

SAMPLE I.D.	DATE COLLECTED	Class	SP1-SW	SP2-SW	SP3-SW	SP4-SW	SP5-SW	SP9-SW	SP11-SW
			11/11/87	11/11/87	11/11/87	11/11/87	11/11/87	11/12/87	11/12/87
Parameter									
alpha-BHC		PST	*	*		*			
beta-BHC		PST	*	*		*			
delta-BHC		PST	*	*		*			
gamma-BHC (Lindane)		PST	*	*		*			
Heptachlor		PST	*	*		*			
Aldrin		PST	*	*		*			
Heptachlor Epoxide		PST	*	*		*			
Endosulfan I		PST	*	*		*			
Dieldrin		PST	*	*		*			
4,4'-DDE		PST	*	*		*			
Endrin		PST	*	*		*			
Endosulfan II		PST	*	*		*			
4,4'-DDD		PST	*	*		*			
Endosulfan Sulfate		PST	*	*		*			
4,4'-DDT		PST	*	*		*			
Methoxychlor		PST	*	*		*			
Endrin Ketone		PST	*	*		*			
Chlordane		PST	*	*		*			
Toxaphene		PST	*	*		*			
Aroclor-1016		PCB	*	*		*			
Aroclor-1221		PCB	*	*		*			
Aroclor-1232		PCB	*	*		*			
Aroclor-1242		PCB	*	*		*			
Aroclor-1248		PCB	*	*		*			
Aroclor-1254		PCB	*	*		*			
Aroclor-1260		PCB	*	*		*			

ONLY RESULTS ABOVE DETECTION LIMITS REPORTED, ALL RESULTS REPORTED IN ug/L

* DATA REJECTED - VARIOUS CLP DEVIATIONS

TABLE 5-20 (continued)

SAMPLE I.D.		SP1-SW	SP2-SW	SP3-SW	SP4-SW	SP5-SW	SP9-SW	SP11-SW
Parameter	DATE COLLECTED	11/11/87	11/11/87	11/11/87	11/11/87	11/11/87	11/12/87	11/12/87
Class								
Aluminum	MCP	110	417	3940	2320		2380	167
Antimony	MCP							
Arsenic	MCP	22	41	78	73	22	65	55
Barium	MCP							
Beryllium	MCP							
Cadmium	MCP							
Calcium	MCP	33910	106000	9000	123000	35500	99200	133000
Chromium	MCP							
Cobalt	MCP				21			
Copper	MCP	203	601	4490	3990	117	4260	373
Iron	MCP							
Lead	MCP			9.9	30		5.4	
Magnesium	MCP	7930	26900	24900	32800	8390	23800	29800
Manganese	MCP	15	46	597	242	10	556	47
Mercury	MCP							
Nickel	MCP							
Potassium	MCP	1250	4050	5250	7190	1410	5290	3910
Selenium	MCP							
Silver	MCP							
Sodium	MCP	9070	53300	37500	195000	10200	31700	176000
Thallium	MCP							
Vanadium	MCP							
Zinc	MCP		147	44	168	34	44	233
Cyanide	MCP							
Phenols, Total	MCP				9		5	6
pH	MCP	7.49	7.71	7.56	8.12	8.6	7.39	7.64
Specific Conductance	MCP	320	920	820	1770	330	940	1700
Temperature	MCP							
Acidity	MISC							
BOD5	MISC			9		3.4	6.8	
TSS	MISC	9	11	140	75	2	52	21
TDS	MISC	220	530	470	960	200	500	940
SO4	MISC	30	75	57	110	29	54	110
TOC	MISC	7.3	24	31	22	8.2	26	36
COD	MISC		21	32	7.7		45	19
NO3-N	MISC	3.2	9	2.6	3.5	2.7	1.6	2.2
NH3-N	MISC							
TKN	MISC						1.9	1.2
T-Phosphorus	MISC			0.4	0.2		0.4	
Sulfide	MISC	66		2.7	62	19	15	32
Oil&Grease	MISC						2.3	0.8
Hardness	MISC	140	340	320	450	130	340	480
T Alkalinity	MISC	100	270	270	350	100	320	400
Bicarb. Alkalinity	MISC	96	240	230	330	100	270	350

ONLY RESULTS ABOVE DETECTION LIMITS REPORTED, MCP RESULTS REPORTED IN ug/L

MISCELLANEOUS RESULTS REPORTED IN mg/L

TABLE 5-21

Second Round RI Surface Water Sample Results

SAMPLE I.D.		SP2-SW	SP3-SW	SP4-SW	SP9-SW
Parameter	DATE COLLECTED	8/8/88	8/8/88	8/8/88	8/8/88
	Class				
Chloromethane	VOC				
Bromomethane	VOC				
Vinyl Chloride	VOC			2 J	
Chloroethane	VOC				
Methylene Chloride	VOC				
Acetone	VOC				
Carbon Disulfide	VOC				
1,1-Dichloroethene	VOC				
1,1-Dichloroethane	VOC				
trans-1,2-Dichloroethene	VOC			11	
Chloroform	VOC				
1,2-Dichloroethane	VOC				
2-Butanone (or MEK)	VOC				
1,1,1-Trichloroethane	VOC				
Carbon Tetrachloride	VOC				
Vinyl Acetate	VOC				
Bromodichloromethane	VOC				
1,2-Dichloropropane	VOC				
trans-1,3-Dichloropropene	VOC				
Trichloroethene	VOC				
Dibromochloromethane	VOC				
1,1,2-Trichloroethane	VOC				
Benzene	VOC				
cis-1,3-Dichloropropene	VOC				
2-Chloroethyl Vinyl Ether	VOC				
Bromoform	VOC				
4-Methyl-2-pentanone	VOC				
2-Hexanone	VOC				
Tetrachloroethene	VOC				
1,1,2,2-Tetrachloroethane	VOC				
Toluene	VOC				
Chlorobenzene	VOC				
Ethyl Benzene	VOC				
Styrene	VOC				
Total Xylenes	VOC				

ONLY DETECTED RESULTS ARE REPORTED, ALL RESULTS REPORTED IN ug/L

J - Indicates an estimated value

B - Analyte also found in blank

TABLE 5-21 (continued)

SAMPLE I.D.		SP2-SW	SP3-SW	SP4-SW	SP9-SW
DATE COLLECTED	Class	8/8/88	8/8/88	8/8/88	8/8/88
Parameter	Class				
Phenol	SEMI				
bis(2-Chloroethyl) ether	SEMI				
2-Chlorophenol	SEMI				
1,3-Dichlorobenzene	SEMI				
1,4-Dichlorobenzene	SEMI				
Benzyl Alcohol	SEMI				
1,2-Dichlorobenzene	SEMI				
2-Methylphenol	SEMI				
bis(2-Chloroisopropyl) ether	SEMI				
4-Methylphenol	SEMI				
N-Nitroso-Dipropylamine	SEMI				
Hexachloroethane	SEMI				
Nitrobenzene	SEMI				
Isophorone	SEMI				
2-Nitrophenol	SEMI				
2,4-Dimethylphenol	SEMI				
Benzoic Acid	SEMI				
bis(2-Chloroethoxyl) methane	SEMI				
2,4-Dichlorophenol	SEMI				
1,2,4-Trichlorobenzene	SEMI				
Naphthalene	SEMI				
4-Chloroaniline	SEMI				
Hexachlorobutadiene	SEMI				
4-Chloro-3-methylphenol	SEMI				
2-Methylnaphthalene	SEMI				
Hexachlorocyclopentadiene	SEMI				
2,4,6-Trichlorophenol	SEMI				
2,4,5-Trichlorophenol	SEMI				
2-Chloronaphthalene	SEMI				
2-Nitroaniline	SEMI				
Dimethyl Phthalate	SEMI				
Acenaphthylene	SEMI				
3-Nitroaniline	SEMI				
Acenaphthene	SEMI				
2,4-Dinitrophenol	SEMI				
4-Nitrophenol	SEMI				
Dibenzofuran	SEMI				
2,4-Dinitrotoluene	SEMI				
2,6-Dinitrotoluene	SEMI				
Diethylphthalate	SEMI				
4-Chlorophenyl Phenyl Ether	SEMI				

ONLY DETECTED RESULTS ARE REPORTED, ALL RESULTS REPORTED IN ug/L

TABLE 5-21 (continued)

SAMPLE I.D.		SP2-SW	SP3-SW	SP4-SW	SP9-SW
Parameter	DATE COLLECTED	8/8/88	8/8/88	8/8/88	8/8/88
Class					
Fluorene	SEMI				
4-Nitroaniline	SEMI				
4,6-Dinitro-2-methylphenol	SEMI				
N-nitrosodiphenylamine	SEMI				
4-Bromophenyl Phenyl Ether	SEMI				
Hexachlorobenzene	SEMI				
Pentachlorophenol	SEMI				
Phenanthrene	SEMI				
Anthracene	SEMI				
Di-n-butylphthalate	SEMI				
Fluoranthene	SEMI				
Pyrene	SEMI				
Butyl Benzyl Phthalate	SEMI				
3,3'-Dichlorobenzidine	SEMI				
Benzo(a)anthracene	SEMI				
bis(2-ethyl hexyl)phthalate	SEMI			1300 B E	
Chrysene	SEMI				
Di-n-octyl Phthalate	SEMI				
Benzo(b)fluoranthene	SEMI				
Benzo(k)fluoranthene	SEMI				
Benzo(a)pyrene	SEMI				
Indeno(1,2,3-cd)Pyrene	SEMI				
Di benz(a,h)anthracene	SEMI				
Benzo(g,h,i)perylene	SEMI				

ONLY DETECTED RESULTS ARE REPORTED, ALL RESULTS REPORTED IN ug/L

B - Analyte also found in blank

E - Indicates compound exceeded calibration range

TABLE 5-21 (continued)

SAMPLE I.D.		SP2-SW	SP3-SW	SP4-SW	SP9-SW
DATE COLLECTED	Class	8/8/88	8/8/88	8/8/88	8/8/88
Parameter					
Aluminum	MCP	108 * R			774 * R
Antimony	MCP				
Arsenic	MCP	52.6	55.1	97	62.2
Barium	MCP				
Beryllium	MCP				
Cadmium	MCP				
Calcium	MCP	87900	120000	187000	96700
Chromium	MCP				
Cobalt	MCP				
Copper	MCP	325	320	334	4400
Iron	MCP				
Lead	MCP				
Magnesium	MCP	18700	14000	38400	19800
Manganese	MCP	189	760	105	574
Mercury	MCP				
Nickel	MCP				
Potassium	MCP	6660	11800	19100	2980
Selenium	MCP				
Silver	MCP				
Sodium	MCP	95300	92300	219000	22300
Thallium	MCP				
Vanadium	MCP				
Zinc	MCP	16.8	40.4	38.2	23.3
Cyanide	MCP				
Phenols, Total	MCP	13	9	16	7
TOC	MISC	22	18	32	30
Sulfide	MISC	3			11
Oil&Grease	MISC				

ONLY DETECTED RESULTS ARE REPORTED, MCP RESULTS REPORTED IN ug/L

MISCELLANEOUS RESULTS ARE REPORTED IN mg/L

NR - Analysis not requested

R - Indicates spike sample recovery is not within control limits

* - Indicates duplicate analysis is not within control limits

TABLE 5-22

FREQUENCY AND MAXIMUM CONCENTRATIONS OF COMPOUNDS
DETECTED IN SURFACE WATER SAMPLES

Compound	No. of First Round Detections (Max. 7)**	No. of Second Round Detections (Max. 4)***	Maximum Concentration (ppb)	Sample I.D.
Methylene Chloride*	7	0	7	SP9-SW
Acetone*	7	0	21	SP3-SW
Trans-1,2-Dichloroethene	1	1	11	SP4-SW
Vinyl Chloride	0	1	2	SP4-SW
2-Butanone*	7	0	23	SP3-SW
Toluene*	4	0	3	SP2-SW, SP3-SW, SP4-SW, SP5-SW
Diethylphthalate*	3	0	2	SP3-SW
Di-n-butylphthalate*	7	0	15	SP1-SW
Bis(2-ethylhexyl)phthalate*	7	1	1,300	SP4-SW
Di-n-octylphthalate*	7	0	78	SP11-SW

* Common laboratory contaminant.

** Two of the seven samples, SP9-SW and SP11-SW, are considered offsite samples.

*** One of the four samples, SP9-SW, is considered an offsite sample.

Samples SP9-SW and SP11-SW were originally considered "upgradient" background samples. Both samples were collected north of River Road adjacent to the railroad tracks. The field technician observed for sample SP9-SW that the railroad ties were lying in the surface water and an oil sheen covered the entire pool. Due to the close proximity of both these samples to the railroad, neither are considered background samples. During the second round of sampling, the area where SP11-SW was to be collected was "dry", therefore no sample was obtained. Criteria used for establishing contaminants attributable to the site in surface water listed in Table 5-23 are as follows:

- a) A compound or metal must be detected in two or more samples (from either round of sampling); and
- b) A compound or metal must also be a contaminant of concern in soil or groundwater at the site.
- c) Any compound or element which was detected in only one sample from the remedial investigation would be considered a contaminant attributable to the site if it was detected in at least two samples from the previous investigations performed at Gratwick Riverside Park.

5.3.2 Summary of Analytical Results of Surface Water Samples

Surface water samples are highly influenced by the environment (i.e., climatic conditions) and therefore their representativeness is limited. The nature and extent of contamination in the surface water at Gratwick Riverside Park does not appear to be at high concentrations or frequency. The majority of organic compounds detected are referred to by the USEPA as common laboratory contaminants, and may not be attributable to the site.

TABLE 5-23

CONTAMINANTS ATTRIBUTABLE TO THE SITE IN SURFACE WATER SAMPLES

ORGANIC COMPOUNDS

Acetone
Trans-1,2-Dichloroethene
2-Butanone
Toluene

INORGANIC ELEMENTS/COMPOUNDS

Lead
Total Phenols
Manganese

5.4 Groundwater

The evaluation of groundwater at Gratwick Riverside Park makes use of the analytical results from previous investigations and the analytical data sample results from the Remedial Investigation. The following subsections present a summary of the analytical results and a brief discussion of the nature and extent of contamination in the two aquifers defined on site.

5.4.1 Previous Investigations of Groundwater Contamination

In 1979 the City of North Tonawanda contracted Recra Research, Inc. to install five groundwater monitoring wells at the site. The location of these wells is shown in Figure 1-2. Four wells are located onsite, while one was installed upgradient of the site. These samples were analyzed for field parameters, total phenols, halogenated and chlorinated organic scans. Sample MW-13 contained the highest level of contaminants with phenols at 63.1 ppm and halogenated organics at 1,100 ppb. Neither of these contaminants were detected in the upgradient well MW-14.

The Niagara County Health Department conducted well sampling in 1981. Groundwater samples were analyzed for eight metals, total halogenated organics (THO) scan, and total phenols. The metal results were generally below detection limits. THO results were as high as 35 ppb; the highest phenol concentration was 17 ppm.

A monitoring well (labeled USGS-1 in Figure 1-2) was installed onsite at Gratwick Riverside Park in early 1982 by the U.S. Geological Survey as part of a joint study with the NYSDEC and the USEPA. This well, in addition to four of the Recra wells, was sampled in July 1982. These samples were analyzed for inorganic/organic parameters. Several of these parameters (iron, lead, mercury, phenol and tetrachlorethane) in the

groundwater exceeded USEPA limits for drinking water and/or New York State standards for maximum permissible concentrations in groundwater. The results are presented in Table 5-24.

In November 1982, the USGS installed two additional wells labeled USGS-SA-5 and SA-5A, as shown in Figure 1-2. A sample was collected from USGS-SA-5 and was analyzed for organic/inorganic constituents. Parameters which exceeded USEPA limits for drinking water or NYS limits for groundwater, as referenced in USEPA, 1985, included arsenic (2 ppb), cadmium (20 ppb), lead (220 ppb), and alpha-chlordane (1.08 ppb). Other organic compounds detected in this sample include methylene chloride (100 ppb), toluene (170 ppb), and di-n-butylphthalate (11 ppb).

In July 1983, Roy F. Weston, Inc. performed a chemical assessment for the USEPA which included limited well sampling. Two wells (MW-13 and MW-14) previously installed by Recra Research, Inc. were sampled for miscellaneous parameters, metals, total phenols, pesticides/PCBs, semi-volatiles, and volatiles. High TOC readings were reported for both samples. Many of the organic/inorganic parameters detected in MW-13 were not detected in the offsite (and upgradient) sample MW-14. The maximum levels of contaminants detected are reported in Table 5-25.

It should be noted that the analytical results discussed above were not validated. Nevertheless, the data is still a useful indication of the extent of contamination previously encountered at the site.

5.4.2 Groundwater Results from the Remedial Investigation

Eleven shallow and 4 bedrock monitoring wells were installed during the remedial investigation at Gratwick Riverside Park. The samples were collected in accordance with the procedures defined in the Work/QA Project Plan (URS, 1987), Health and Safety Plan (URS, 1987), and USEPA CLP protocols (Organic SOW 9/84 and Inorganic SOW 784). The samples were

TABLE 5-24
ANALYTICAL RESULTS FROM USGS 1982 GROUNDWATER SAMPLING

Compound	Well USGS-1	Well MW-13	Well MW-10	Well MW-11	Well MW-12
Arsenic	1	10	1	1	1
Cadmium	3	1	ND	1	ND
Chromium	3	ND	ND	ND	ND
Copper	56	25	12	22	10
Iron	8,800*	6,400*	4,400*	15,000*	3,100*
Lead	100*	150*	64*	140*	43
Mercury	0.7*	ND	ND	0.1*	0.7*
Nickel	ND	5	3	20	5
Phenol	ND	ND	97*	1,900*	13.7*
Naphthalene	ND	ND	ND	50.3	ND
Butylbenzylphthalate	ND	ND	ND	20.9	ND
2,4-Dimethylphenol	ND	ND	5	ND	ND
Di-n-butylphthalate	BDL	ND	ND	ND	ND
Bis(2-ethylhexyl)phthalate	8	ND	ND	ND	ND
Tetrachloroethene	ND	ND	BDL*	ND	ND
Ethylbenzene	ND	ND	6	ND	ND

Notes: All concentrations are reported in ug/l.

BDL - Below detection limits.

ND - Not detected.

* Exceeds USEPA criteria for maximum permissible concentration in drinking water or NYS standard for maximum concentration in groundwater.

TABLE 5-25
MAXIMUM LEVELS OF CONTAMINANTS DETECTED IN GROUNDWATER SAMPLES
MW-13 AND MW-14

Compound	Concentration (ppb) of Contaminants in Well MW-13	Concentration (ppb) of Contaminants in Well MW-14
Beryllium	1.4	1.0
Cadmium	2.13	4.69
Chromium	6.71	<5.00
Copper	66.1	<20
Lead	68.3	10.7
Nickel	74	62.6
Zinc	69.1	2,660
Total Phenols	10,000	<2.0
Total Organic Carbon	90,000	80,000
2,4-Dimethylphenol	758	ND
Phenol	600	ND
Benzene	110	ND
Chloroform	ND	4.63
Methylene Chloride	18.8	197
Tetrachloroethene	411	ND
Toluene	3,180	ND
Trans-1,2-Dichloroethene	208	ND
Trichloroethene	243	ND

ND - Not detected.

chemically tested for HSL volatiles, semi-volatiles, pesticides/PCBs (first round only), metals, total phenols, cyanide, and miscellaneous inorganic parameters. The location of all sampling points is presented in Figure 5-1. All first round data was validated by Versar, Inc. and all second round data was validated by URS Consultants. The analytical results for groundwater are listed in Tables 5-26 through 5-29.

Thirty-seven organic compounds (20 volatiles and 17 semi-volatiles) were detected in the groundwater samples. No pesticides/PCBs were detected in any of the samples. The samples which contained the highest concentration of total organic compounds were GW-7S and GW-9S at 6,616 ppb and 49,049 ppb, respectively. The highest compound concentrations were 4-methyl-2-pentanone (16,000 ppb) followed by acetone (8,100 ppb), phenol (5,800 ppb), 2-butanone (3,300 ppb), and trichloroethene (2,200 ppb). The most commonly detected volatile compound was acetone, which was found in all 9 of the onsite samples. The most commonly detected semi-volatile compounds are the phthalate esters (di-n-butylphthalate, bis(2-ethylhexyl) phthalate, di-n-octylphthalate), which were found in 7 of the 9 onsite samples.

The volatile organic compounds detected in the groundwater samples which appear to have the highest concentrations are a group of compounds classified as ketones and include acetone, 2-butanone, and 4-methyl-2-pentanone. This group is followed by a group of chlorinated alkenes and includes tetrachlorethane, trichloroethene, and trans-1,2-dichloroethene. All other volatile compounds detected had concentrations much lower than the compounds mentioned above. Phenolic compounds seemed to be present in the highest concentrations in the semi-volatile fractions of the groundwater samples. These semi-volatiles include phenol, 4-methylphenol, 2-methylphenol, and 2,4-dimethylphenol. The other semi-volatiles detected were, in general, present at much lower concentrations. Sample GW-7S had the greatest number of organic compounds, i.e. 15 volatiles and 10 semi-volatiles.

TABLE 5-26

FIRST ROUND RI SHALLOW GROUNDWATER SAMPLE RESULTS

WELL I.D	GM-1S	GM-2S	GM-3S	GM-4S	GM-5S	GM-6S	GM-7S	GM-8S	GM-9S	GM-10S	GM-11S
DATE COLLECTED	12/15/87	12/03/87	12/15/87	12/17/87	12/17/87	12/15/87	12/15/87	12/11/87	12/11/87	12/10/87	12/17/87
Parameter	Class										
Chloromethane	VOC										
Bromomethane	VOC										
Vinyl Chloride	VOC				7	11	8				
Chloroethane	VOC						4				
Methylene Chloride	VOC	1			1		15	15	43	5	
Acetone	VOC	27		167	293	684	163	340	1450	52	873
Carbon Disulfide	VOC						4				
1,1-Dichloroethene	VOC										
1,1-Dichloroethane	VOC				25		32				
trans-1,2-Dichloroethene	VOC				180	58	142		620	2	
Chloroform	VOC				2						
1,2-Dichloroethane	VOC										
2-Butanone (or MEK)	VOC						51	75	170		
1,1,1-Trichloroethane	VOC	9					117				
Carbon Tetrachloride	VOC										
Vinyl Acetate	VOC										
Bromodichloromethane	VOC										
1,2-Dichloropropane	VOC										
trans-1,3-Dichloropropene	VOC										
Trichloroethene	VOC				46	62	94		1190	4	
Dibromochloromethane	VOC										
1,1,2-Trichloroethane	VOC										
Benzene	VOC			1		3	13				
cis-1,3-Dichloropropene	VOC				2						
2-Chloroethyl Vinyl Ether	VOC										
Bromoform	VOC										
4-Methyl-2-pentanone	VOC										
2-Hexanone	VOC										
Tetrachloroethene	VOC										
1,1,2,2-Tetrachloroethane	VOC				5	43	22		420	2	
Toluene	VOC										
Chlorobenzene	VOC	1		1	75	16	89		81	1	1
Ethyl Benzene	VOC				9	2	31		31		
Styrene	VOC								51	1	
Total Xylenes	VOC				54	7	133		160		

ALL RESULTS REPORTED IN ug/L

ONLY RESULTS ABOVE DETECTION LIMITS REPORTED

TABLE 5-26 (continued)

WELL I.D.	DATE COLLECTED	GM-1S	GM-2S	GM-3S	GM-4S	GM-5S	GM-6S	GM-7S	GM-8S	GM-9S	GM-10S	GM-11S
Parameter	Class											
Phenol	SEMI											
bis(2-Chloroethyl) ether	SEMI											
2-Chlorophenol	SEMI											
1,3-Dichlorobenzene	SEMI											
1,4-Dichlorobenzene	SEMI											
Benzyl Alcohol	SEMI											
1,2-Dichlorobenzene	SEMI											
2-Methylphenol	SEMI											
bis(2-Chloroisopropyl) ether	SEMI											
4-Methylphenol	SEMI											
N-Nitroso-Dipropylamine	SEMI											
Hexachloroethane	SEMI											
Nitrobenzene	SEMI											
Isophorone	SEMI											
2-Nitrophenol	SEMI											
2,4-Dimethylphenol	SEMI											
Benzoic Acid	SEMI											
bis(2-Chloroethoxyl) methane	SEMI											
2,4-Dichlorophenol	SEMI											
1,2,4-Trichlorobenzene	SEMI											
Naphthalene	SEMI											
4-Chloroaniline	SEMI											
Hexachlorobutadiene	SEMI											
4-Chloro-3-methylphenol	SEMI											
2-Methylnaphthalene	SEMI											
Hexachlorocyclopentadiene	SEMI											
2,4,6-Trichlorophenol	SEMI											
2,4,5-Trichlorophenol	SEMI											
2-Chloronaphthalene	SEMI											
2-Nitroaniline	SEMI											
Dimethyl Phthalate	SEMI											
Acenaphthylene	SEMI											
3-Nitroaniline	SEMI											
Acenaphthene	SEMI											
2,4-Dinitrophenol	SEMI											
4-Nitrophenol	SEMI											
Dibenzofuran	SEMI											
2,4-Dinitrotoluene	SEMI											
2,6-Dinitrotoluene	SEMI											
Diethylphthalate	SEMI											
4-Chlorophenyl Phenyl Ether	SEMI											

ALL RESULTS REPORTED IN ug/L
 ONLY RESULTS ABOVE DETECTION LIMITS REPORTED
 * DATA REJECTED - EXCEEDED HOLDING TIMES

TABLE 5-26 (continued)

WELL I.D	GW-1S	GW-2S	GW-3S	GW-4S	GW-5S	GW-6S	GW-7S	GW-8S	GW-9S	GW-10S	GW-11S
DATE COLLECTED	12/15/87	12/03/87	12/15/87	12/17/87	12/17/87	12/15/87	12/15/87	12/11/87	12/11/87	12/10/87	12/17/87
Parameter	Class										
Fluorene	SEMI										
4-Nitroaniline	SEMI										
4,6-Dinitro-2-methylphenol	SEMI										
N-nitrosodiphenylamine	SEMI										
4-Bromophenyl Phenyl Ether	SEMI										
Hexachlorobenzene	SEMI										
Pentachlorophenol	SEMI										
Phenanthrene	SEMI										
Anthracene	SEMI										
Di-n-butylphthalate	SEMI	4	3	3	15	4	14	2		3	
Fluoranthene	SEMI										
Pyrene	SEMI										
Butyl Benzyl Phthalate	SEMI										
3,3'-Dichlorobenzidine	SEMI										
Benzo(a)anthracene	SEMI										
bis(2-ethyl hexyl)phthalate	SEMI	14	8	6	9	8	17	8		7	11
Chrysene	SEMI										
Di-n-octyl Phthalate	SEMI	74	18		22	2	5	24	9	9	21
Benzo(b)fluoranthene	SEMI										
Benzo(k)fluoranthene	SEMI										
Benzo(a)pyrene	SEMI										
Indeno(1,2,3-cd)Pyrene	SEMI										
Dibenz(a,h)anthracene	SEMI										
Benzo(g,h,i)perylene	SEMI										

ALL RESULTS REPORTED IN ug/L

ONLY RESULTS ABOVE DETECTION LIMITS REPORTED

TABLE 5-26 (continued)

WELL I.D.	GW-1S	GW-2S	GW-3S	GW-4S	GW-5S	GW-6S	GW-7S	GW-8S	GW-9S	GW-10S	GW-11S
DATE COLLECTED	12/15/87	12/03/87	12/15/87	12/17/87	12/17/87	12/15/87	12/15/87	12/11/87	12/11/87	12/10/87	12/17/87
Parameter	Class										
alpha-BHC	PST										
beta-BHC	PST										
delta-BHC	PST										
gamma-BHC (Lindane)	PST										
Heptachlor	PST										
Aldrin	PST										
Heptachlor Epoxide	PST										
Endosulfan I	PST										
Dieldrin	PST										
4,4'-DDE	PST										
Endrin	PST										
Endosulfan II	PST										
4,4'-DDD	PST										
Endosulfan Sulfate	PST										
4,4'-DDT	PST										
Methoxychlor	PST										
Endrin Ketone	PST										
Chlordane	PST										
Toxaphene	PST										
Aroclor-1016	PCB										
Aroclor-1221	PCB										
Aroclor-1232	PCB										
Aroclor-1242	PCB										
Aroclor-1248	PCB										
Aroclor-1254	PCB										
Aroclor-1260	PCB										

ALL RESULTS REPORTED IN ug/L
ONLY RESULTS ABOVE DETECTION LIMITS REPORTED

RESULTS ABOVE DETECTION LIMITS REPORTED, MCP RESULTS REPORTED IN ug/L
MISCELLANEOUS RESULTS REPORTED IN mg/L

TABLE 5-27

SECOND ROUND RI SHALLOW GROUNDWATER SAMPLE RESULTS

WELL I.D.	DATE COLLECTED	GW-1S	GW-4S	GW-5S	GW-6S	GW-7S BOTTOM	GW-8S	GW-9S BOTTOM	GW-9S	GW-10S	GW-11S
Parameter	Class	8/19/88	8/19/88	8/12/88	8/10/88	8/12/88	8/19/88	8/11/88	8/12/88	8/9/88	8/19/88
Chloromethane	VOC										
Bromomethane	VOC										
Vinyl Chloride	VOC			4 J				69 J	120		
Chloroethane	VOC										
Methylene Chloride	VOC										
Acetone	VOC					8100 B					
Carbon Disulfide	VOC										
1,1-Dichloroethene	VOC			18		300	320				
1,1-Dichloroethane	VOC		2 J	89		140 J	350	930	1300		
trans-1,2-Dichloroethene	VOC		2 J								
Chloroform	VOC										
1,2-Dichloroethane	VOC						150 J				
2-Butanone (or MEK)	VOC					3300	1300				
1,1,1-Trichloroethane	VOC					390	340				
Carbon Tetrachloride	VOC										
Vinyl Acetate	VOC										
Bromodichloromethane	VOC										
1,2-Dichloropropane	VOC										
trans-1,3-Dichloropropene	VOC										
Trichloroethene	VOC		55	220		920	840	1800	2200		
Dibromochloromethane	VOC										
1,1,2-Trichloroethane	VOC										
Benzene	VOC					98 J	98 J				
cis-1,3-Dichloropropene	VOC										
2-Chloroethyl Vinyl Ether	VOC										
Bromoform	VOC										
4-Methyl-2-pentanone	VOC			27		16000 E					
2-Hexanone	VOC			7 J		56 J		540	930		
Tetrachloroethene	VOC		6					68			
1,1,2,2-Tetrachloroethane	VOC			49		340	370	85	95		
Toluene	VOC							55	35 J		
Chlorobenzene	VOC			7 J		72 J	69 J		80		
Ethyl Benzene	VOC								22 J		
Styrene	VOC					195 J	270	190	260		
Total Xylenes	VOC			37							

ALL RESULTS REPORTED IN ug/L
 ONLY DETECTED RESULTS ARE REPORTED
 J - Indicates an estimated value
 B - Analyte also found inblank

TABLE 5-27 (continued)

Parameter	DATE COLLECTED	Class	GW-5S	GW-6S	GW-7S BOTTOM	GW-7S	GW-8S	GW-9S BOTTOM	GW-9S	GW-10S
			8/12/88	8/10/88	8/12/88	8/19/88	8/12/88	8/11/88	8/12/88	8/9/88
Phenol		SEMI			5800	2800		280	280	
bis(2-Chloroethyl) ether		SEMI	92					1 J	1 J	
2-Chlorophenol		SEMI						5 J	7 J	
1,3-Dichlorobenzene		SEMI						3 J	4 J	
1,4-Dichlorobenzene		SEMI						270	340	
Benzyl Alcohol		SEMI	2 J					130	160	
1,2-Dichlorobenzene		SEMI	24		680	480				
2-Methylphenol		SEMI			1900	1200				
bis(2-Chloroisopropyl) ether		SEMI								
4-Methylphenol		SEMI								
N-Nitroso-Dipropylamine		SEMI								
Hexachloroethane		SEMI								
Nitrobenzene		SEMI			53 J	30 J				
Isophorone		SEMI								
2-Nitrophenol		SEMI			630	610		37	50	
2,4-Dimethylphenol		SEMI	11		600 J	180 J				
Benzoic Acid		SEMI								
bis(2-Chloroethoxyl) methane		SEMI								
2,4-Dichlorophenol		SEMI								
1,2,4-Trichlorobenzene		SEMI	1 J		26 J	30 J		3 J	5 J	
Naphthalene		SEMI								
4-Chloroaniline		SEMI								
Hexachlorobutadiene		SEMI								
4-Chloro-3-methylphenol		SEMI								
2-Methylnaphthalene		SEMI				12 J		4 J	6 J	
Hexachlorocyclopentadiene		SEMI								
2,4,6-Trichlorophenol		SEMI								
2,4,5-Trichlorophenol		SEMI								
2-Chloronaphthalene		SEMI								
2-Nitroaniline		SEMI								
Dimethyl Phthalate		SEMI								
Acenaphthylene		SEMI								
3-Nitroaniline		SEMI								
Acenaphthene		SEMI								
2,4-Dinitrophenol		SEMI								
4-Nitrophenol		SEMI								
Dibenzofuran		SEMI								
2,4-Dinitrotoluene		SEMI								
2,6-Dinitrotoluene		SEMI								
Diethylphthalate		SEMI								
4-Chlorophenyl Phenyl Ether		SEMI								

ALL RESULTS REPORTED IN ug/L
 ONLY DETECTED RESULTS ARE REPORTED
 J - Indicates an estimated value

TABLE 5-27 (continued)

WELL I.D		GW-5S	GW-6S	GW-7S BOTTOM	GW-7S	GW-8S	GW-9S BOTTOM	GW-9S	GW-10S
Parameter	DATE COLLECTED	8/12/88	8/10/88	8/12/88	8/19/88	8/12/88	8/11/88	8/12/88	8/9/88
Class									
Fluorene	SEMI								
4-Nitroaniline	SEMI								
4,6-Dinitro-2-methylphenol	SEMI								
N-nitrosodiphenylamine	SEMI								
4-Bromophenyl Phenyl Ether	SEMI								
Hexachlorobenzene	SEMI								
Pentachlorophenol	SEMI								
Phenanthrene	SEMI								
Anthracene	SEMI								
Di-n-butylphthalate	SEMI								
Fluoranthene	SEMI								
Pyrene	SEMI								
Butyl Benzyl Phthalate	SEMI								
3,3'-Dichlorobenzidine	SEMI								
Benzo(a)anthracene	SEMI								
bis(2-ethyl hexyl)phthalate	SEMI								
Chrysene	SEMI								
Di-n-octyl Phthalate	SEMI								
Benzo(b)fluoranthene	SEMI								
Benzo(k)fluoranthene	SEMI								
Benzo(a)pyrene	SEMI								
Indeno(1,2,3-cd)pyrene	SEMI								
Dibenz(a,h)anthracene	SEMI								
Benzo(g,h,i)perylene	SEMI								

ALL RESULTS REPORTED IN ug/l
ONLY DETECTED RESULTS ARE REPORTED
J - Indicates an estimated value

TABLE 5-27 (continued)

WELL I.D		GW-3S	GW-5S	GW-6S	GW-7S	GW-8S	GW-9S	GW-10S
DATE COLLECTED		8/10/88	8/12/88	8/10/88	8/19/88	8/12/88	8/12/88	8/9/88
Parameter	Class							
Aluminum	MCP	NR	4250		361000	2440	16300	5160 * R
Antimony	MCP	NR						
Arsenic	MCP	NR	7010		114 *	73.4	297	196
Barium	MCP	NR			40.2			
Beryllium	MCP	NR			407			
Cadmium	MCP	NR		593000	514000	207000	237000	236000
Calcium	MCP	NR	412000		1460		25.3	38.6
Chromium	MCP	NR			97.7		11	
Cobalt	MCP	NR			55.9	10.7	32.7	30.2
Copper	MCP	NR	142 R	1020	8900000	1250 R	13200 R	6120
Iron	MCP	NR						
Lead	MCP	NR			55.7 *		30.6	59.2
Magnesium	MCP	NR	143	89100	1670000 *	874	8920	3430
Manganese	MCP	NR	18.9	56	734000	221	900	232
Mercury	MCP	NR						
Nickel	MCP	NR			827		30.4	26
Potassium	MCP	NR	241000	6770	233000	17600	19700	29200
Selenium	MCP	NR						
Silver	MCP	NR			74.4			
Sodium	MCP	NR	155000	56200	1270000	218000	179000	139000
Thallium	MCP	NR						
Vanadium	MCP	NR			1950		11	
Zinc	MCP	NR	15.1	66	5980	18.9	99.6	141
Cyanide	MCP		NR			88		50000
Phenols, Total	MCP	58	28		17000	10	1400	15
Total Organic Carbon	MISC	19	100	54	2900	53	32	11
SULFIDE	MISC	18	810		6.5		23	19
Oil and Grease	MISC		NR		48			

ONLY DETECTED RESULTS ARE REPORTED, MCP RESULTS REPORTED IN ug/L

MISCELLANEOUS RESULTS REPORTED IN mg/L

R - Indicates spike sample recovery is not within control limits

* - Indicates duplicate analysis is not within control limits

NR - Analysis not requested

TABLE 5-28

FIRST ROUND RI BEDROCK GROUNDWATER SAMPLE RESULTS

WELL I.D.		GW1-D	GW2-D	GW5-D	GW6-D
Parameter	DATE COLLECTED	12/03/87	12/03/87	12/03/87	12/03/87
	CLASS				
Chloromethane	VOC				
Bromomethane	VOC				
Vinyl Chloride	VOC				
Chloroethane	VOC				
Methylene Chloride	VOC	5.0	1.0	1.0	1.0
Acetone	VOC	10.0	73.0	43.0	21.0
Carbon Disulfide	VOC				
1,1-Dichloroethene	VOC				
1,1-Dichloroethane	VOC				
trans-1,2-Dichloroethene	VOC				
Chloroform	VOC				
1,2-Dichloroethane	VOC				
2-Butanone (or MEK)	VOC		12.0	10.0	9.0
1,1,1-Trichloroethane	VOC				
Carbon Tetrachloride	VOC				
Vinyl Acetate	VOC				
Bromodichloromethane	VOC				
1,2-Dichloropropane	VOC				
trans-1,3-Dichloropropene	VOC				
Trichloroethene	VOC				
Dibromochloromethane	VOC				
1,1,2-Trichloroethane	VOC				
Benzene	VOC				
cis-1,3-Dichloropropene	VOC				
2-Chloroethyl Vinyl Ether	VOC				
Bromoform	VOC				
4-Methyl-2-pentanone	VOC				
2-Hexanone	VOC				
Tetrachloroethene	VOC				
1,1,2,2-Tetrachloroethane	VOC				
Toluene	VOC		1.0		
Chlorobenzene	VOC				
Ethyl Benzene	VOC				
Styrene	VOC				
Total Xylenes	VOC				

ONLY RESULTS ABOVE DETECTION LIMITS REPORTED, ALL RESULTS REPORTED IN UG/L

TABLE 5-28 (continued)

WELL I.D.	GW1-D	GW2-D	GW5-D	GW6-D
DATE COLLECTED	12/03/87	12/03/87	12/03/87	12/03/87
Parameter	class			
Phenol	SEMI			
bis(2-Chloroethyl)ether	SEMI			
2-Chlorophenol	SEMI			
1,3-Dichlorobenzene	SEMI			
1,4-Dichlorobenzene	SEMI			
Benzyl Alcohol	SEMI			
1,2-Dichlorobenzene	SEMI			
2-Methylphenol	SEMI			
bis(2-Chloroisopropyl) eth	SEMI			
4-Methylphenol	SEMI			
N-Nitroso-Dipropylamine	SEMI			
Hexachloroethane	SEMI			
Nitrobenzene	SEMI			
Isophorone	SEMI			
2-Nitrophenol	SEMI			
2,4-Dimethylphenol	SEMI			
Benzoic Acid	SEMI			
bis(2-Chloroethoxyl) metha	SEMI			
2,4-Dichlorophenol	SEMI			
1,2,4-Trichlorobenzene	SEMI			
Naphthalene	SEMI			
4-Chloroaniline	SEMI			
Hexachlorobutadiene	SEMI			
4-Chloro-3-methylphenol	SEMI			
2-Methylnaphthalene	SEMI			
Hexachlorocyclopentadiene	SEMI			
2,4,6-Trichlorophenol	SEMI			
2,4,5-Trichlorophenol	SEMI			
2-Chloronaphthalene	SEMI			
2-Nitroaniline	SEMI			
Dimethyl Phthalate	SEMI			
Acenaphthylene	SEMI			
3-Nitroaniline	SEMI			
Acenaphthene	SEMI			
2,4-Dinitrophenol	SEMI			
4-Nitrophenol	SEMI			
Dibenzofuran	SEMI			
2,4-Dinitrotoluene	SEMI			
2,6-Dinitrotoluene	SEMI			
Diethylphthalate	SEMI			
4-Chlorophenyl Phenyl Ethe	SEMI			

ONLY RESULTS ABOVE DETECTION LIMITS REPORTED, ALL RESULTS REPORTED IN UG/L

TABLE 5-28 (continued)

WELL I.D.	GW1-D	GW2-D	GW5-D	GW6-D
DATE COLLECTED	12/03/87	12/03/87	12/03/87	12/03/87
Parameter	class			
Fluorene	SEMI			
4-Nitroaniline	SEMI			
4,6-Dinitro-2-methylphenol	SEMI			
N-nitrosodiphenylamine	SEMI			
4-Bromophenyl Phenyl Ether	SEMI			
Hexachlorobenzene	SEMI			
Pentachlorophenol	SEMI			
Phenanthrene	SEMI			
Anthracene	SEMI			
Di-n-butylphthalate	SEMI			
Fluoranthene	SEMI			
Pyrene	SEMI			
Butyl Benzyl Phthalate	SEMI			
3,3'-Dichlorobenzidine	SEMI			
Benzo(a)anthracene	SEMI			
bis(2-ethyl hexyl)phthalat	SEMI			
Chrysene	SEMI			
Di-n-octyl Phthalate	SEMI			
Benzo(b)fluoranthene	SEMI			
Benzo(k)fluoranthene	SEMI			
Benzo(a)pyrene	SEMI			
Indeno(1,2,3-cd)Pyrene	SEMI			
Dibenz(a,h)anthracene	SEMI			
Benzo(g,h,i)perylene	SEMI			
ONLY RESULTS ABOVE DETECTION LIMITS REPORTED, ALL RESULTS REPORTED IN UG/L				

TABLE 5-28 (continued)

WELL I.D.	GW1-D	GW2-D	GW5-5	GW6-D
DATE COLLECTED	12/03/87	12/03/87	12/03/87	12/03/87
Parameter	Class			
alpha-BHC	PST			
beta-BHC	PST			
delta-BHC	PST			
gamma-BHC (Lindane)	PST			
Heptachlor	PST			
Aldrin	PST			
Heptachlor Epoxide	PST			
Endosulfan I	PST			
Dieldrin	PST			
4,4'-DDE	PST			
Endrin	PST			
Endosulfan II	PST			
4,4'-DDD	PST			
Endosulfan Sulfate	PST			
4,4'-DDT	PST			
Methoxychlor	PST			
Endrin Ketone	PST			
Chlordane	PST			
Toxaphene	PST			
Aroclor-1016	PCB			
Aroclor-1221	PCB			
Aroclor-1232	PCB			
Aroclor-1242	PCB			
Aroclor-1248	PCB			
Aroclor-1254	PCB			
Aroclor-1260	PCB			

ONLY RESULTS ABOVE DETECTION LIMITS REPORTED, ALL RESULTS REPORTED IN ug/l

TABLE 5-28 (continued)

WELL I.D.		GW1-D	GW2-D	GW5-D	GW6-D
DATE COLLECTED		12/03/87	12/03/87	12/03/87	12/03/87
Parameter	Class				
Aluminum	MCP	408	690	384	237
Antimony	MCP				
Arsenic	MCP	25.9	21.0	14.4	11.7
Barium	MCP				
Beryllium	MCP				
Cadmium	MCP				
Calcium	MCP	476000	620000	549000	588000
Chromium	MCP	13.0			
Cobalt	MCP				
Copper	MCP	995	1810	2330	1150
Iron	MCP				
Lead	MCP				
Magnesium	MCP	81200	67500	120000	89800
Manganese	MCP	60.6	93.3	53.0	64.0
Mercury	MCP				
Nickel	MCP	16.9	5400	7480	6820
Potassium	MCP	7270			
Selenium	MCP				
Silver	MCP	36200	25600	173000	128000
Sodium	MCP				
Thallium	MCP				
Vanadium	MCP				
Zinc	MCP	10.5	44.7	38.3	35.5
Cyanide	MCP				
Phenols, Total	MCP	6.0			9.0
pH	MCP	7.5	6.8	6.9	7.1
Specific Conductance	MCP	3030	3200	3780	3530
Temperature	MCP				
Acidity	MISC	7.0	10.0	17.0	11.0
Biochemical Oxygen Demand	MISC	2.7	2.5	2.1	1.2
Total Suspended Solids	MISC	34.0	64.0	50.0	29.0
Total Dissolved Solids	MISC	2300	2600	2900	2800
Sulfate	MISC	1100	1200	1400	1300
Total Organic Carbon	MISC	11.0	11.0		
Chemical Oxygen Demand	MISC	9.8	9.8	29.0	11.0
Nitrate-Nitrogen	MISC	3.4	3.6	4.2	3.7
Ammonia-Nitrogen	MISC				
Total Kjeldahl Nitrogen	MISC	0.04	0.06	0.02	0.01
Phosphorus	MISC				
Sulfide	MISC	1.4	5.6	2.6	
Oil and Grease	MISC		1.2		
Hardness	MISC	1600	1800	2200	2000
Total Alkalinity, as CaCO ₃	MISC	120	130	140	140
Bicarbonate Alkalinity, as	MISC	110	110	110	120
Moisture	MISC				

ONLY RESULTS ABOVE DETECTION LIMITS REPORTED, MCP PARAMETERS REPORTED IN ug/L
MISCELLANEOUS PARAMETERS REPORTED IN mg/L

TABLE 5-29

SECOND ROUND RI BEDROCK GROUNDWATER SAMPLE RESULTS

WELL I.D. GW1-D GW2-D GW5-D GW6-D

Parameter	DATE COLLECTED	8/9/88	8/9/88	8/11/88	8/10/88
Chloromethane	VOC				
Bromomethane	VOC				
Vinyl Chloride	VOC				12.0
Chloroethane	VOC				
Methylene Chloride	VOC				
Acetone	VOC				
Carbon Disulfide	VOC	21.0	19.0		
1,1-Dichloroethene	VOC				
1,1-Dichloroethane	VOC				
trans-1,2-Dichloroethene	VOC				41.0
Chloroform	VOC				
1,2-Dichloroethane	VOC				
2-Butanone (or MEK)	VOC				
1,1,1-Trichloroethane	VOC				
Carbon Tetrachloride	VOC				
Vinyl Acetate	VOC				
Bromodichloromethane	VOC				
1,2-Dichloropropane	VOC				
trans-1,3-Dichloropropene	VOC				
Trichloroethene	VOC				71.0
Dibromochloromethane	VOC				
1,1,2-Trichloroethane	VOC				
Benzene	VOC				3 J
cis-1,3-Dichloropropene	VOC				
2-Chloroethyl Vinyl Ether	VOC				
Bromoform	VOC				
4-Methyl-2-pentanone	VOC				
2-Hexanone	VOC				
Tetrachloroethene	VOC				
1,1,2,2-Tetrachloroethane	VOC				40.0
Toluene	VOC				
Chlorobenzene	VOC				
Ethyl Benzene	VOC				2 J
Styrene	VOC				
Total Xylenes	VOC				10.0

ONLY DETECTED RESULTS ARE REPORTED, ALL RESULTS REPORTED IN ug/L

J - Indicates an estimated value

B - Analyte also found in blank

TABLE 5-29 (continued)

WELL I.D.	GW1-D	GW2-D	GW5-D	GW6-D
DATE COLLECTED	8/9/88	8/9/88	8/11/88	8/10/88
Parameter	class			
Phenol	SEMI			
bis(2-Chloroethyl) ether	SEMI			
2-Chlorophenol	SEMI			
1,3-Dichlorobenzene	SEMI			
1,4-Dichlorobenzene	SEMI			
Benzyl Alcohol	SEMI			
1,2-Dichlorobenzene	SEMI			
2-Methylphenol	SEMI			
bis(2-Chloroisopropyl) eth	SEMI			
4-Methylphenol	SEMI			
N-Nitroso-Dipropylamine	SEMI			
Hexachloroethane	SEMI			
Nitrobenzene	SEMI			
Isophorone	SEMI			
2-Nitrophenol	SEMI			
2,4-Dimethylphenol	SEMI			
Benzoic Acid	SEMI			
bis(2-Chloroethoxyl) metha	SEMI			
2,4-Dichlorophenol	SEMI			
1,2,4-Trichlorobenzene	SEMI			
Naphthalene	SEMI			2 J
4-Chloroaniline	SEMI			
Hexachlorobutadiene	SEMI			
4-Chloro-3-methylphenol	SEMI			
2-Methylnaphthalene	SEMI			
Hexachlorocyclopentadiene	SEMI			
2,4,6-Trichlorophenol	SEMI			
2,4,5-Trichlorophenol	SEMI			
2-Chloronaphthalene	SEMI			
2-Nitroaniline	SEMI			
Dimethyl Phthalate	SEMI			
Acenaphthylene	SEMI			
3-Nitroaniline	SEMI			
Acenaphthene	SEMI			
2,4-Dinitrophenol	SEMI			
4-Nitrophenol	SEMI			
Dibenzofuran	SEMI			
2,4-Dinitrotoluene	SEMI			
2,6-Dinitrotoluene	SEMI			
Diethylphthalate	SEMI			
4-Chlorophenyl Phenyl Ethe	SEMI			

ONLY DETECTED RESULTS ARE REPORTED, ALL RESULTS REPORTED IN ug/L
 - indicates an estimated value

TABLE 5-29 (continued)

WELL I.D.		GW1-D	GW2-D	GW5-D	GW6-D
DATE COLLECTED	Parameter class	8/9/88	8/9/88	8/11/88	8/10/88
Fluorene	SEMI				
4-Nitroaniline	SEMI				
4,6-Dinitro-2-methylphenol	SEMI				
N-nitrosodiphenylamine	SEMI				
4-Bromophenyl Phenyl Ether	SEMI				
Hexachlorobenzene	SEMI				
Pentachlorophenol	SEMI				
Phenanthrene	SEMI				
Anthracene	SEMI				
Di-n-butylphthalate	SEMI				
Fluoranthene	SEMI				
Pyrene	SEMI				
Butyl Benzyl Phthalate	SEMI				
3,3'-Dichlorobenzidine	SEMI				
Benzo(a)anthracene	SEMI				
bis(2-ethyl hexyl)phthalate	SEMI				
Chrysene	SEMI				
Di-n-octyl Phthalate	SEMI				
Benzo(b)fluoranthene	SEMI				
Benzo(k)fluoranthene	SEMI				
Benzo(a)pyrene	SEMI				
Indeno(1,2,3-cd)Pyrene	SEMI				
Dibenz(a,h)anthracene	SEMI				
Benzo(g,h,i)perylene	SEMI				
ONLY DETECTED RESULTS ARE REPORTED, ALL RESULTS REPORTED IN ug/L					
J - Indicates an estimated value					
B - Analyte also found in blank					

TABLE 5-29 (continued)

WELL I.D.		GW1-D	GW2-D	GW5-D	GW6-D
Parameter	DATE COLLECTED	8/9/88	8/9/88	8/11/88	8/10/88
	Class				
Aluminum	MCP				3090 * R
Antimony	MCP				
Arsenic	MCP				
Barium	MCP	112.0	23.4		187.0
Beryllium	MCP				
Cadmium	MCP				
Calcium	MCP	550000	511000	540000	196000
Chromium	MCP				
Cobalt	MCP				
Copper	MCP				66.0
Iron	MCP	1180	1890	2140 R	8020
Lead	MCP				81.0
Magnesium	MCP	55900	49000	126000	1450
Manganese	MCP	32.5	39.0	37.9	208.0
Mercury	MCP				
Nickel	MCP				
Potassium	MCP	64000	104000	6490	51800
Selenium	MCP				
Silver	MCP				
Sodium	MCP	67100	68100	77200	105000
Thallium	MCP				
Vanadium	MCP				
Zinc	MCP	39.7	119.0	32.4	233.0
Cyanide	MCP				
Phenols, Total	MCP	9.0	12.0		58.0
Total Organic Carbon	MISC	8.2	27.0		67.0
Sulfides	MISC			1.7	30.0
Oil and Grease	MISC	1.4	1.4		3.2

ONLY DETECTED RESULTS ARE REPORTED, MCP PARAMETERS REPORTED IN ug/L
 MISCELLANEOUS RESULTS REPORTED IN mg/L

R - Indicates spike sample recovery is not within control limits
 * - Indicates duplicate analysis is not within control limits

Sample results(s) were segregated based upon the aquifer (lower or upper); the gradient relative to the site (up or down); and location (on or offsite). Table 5-30 summarizes results for the upper aquifer and Table 5-31 summarizes results for the lower aquifer. As shown on Tables 5-30 and 5-31 the upper aquifer samples had more volatile compounds (20) at greater concentrations (maximum total VOCs 34,018 ppb) than the lower aquifer samples (10 compounds with a maximum total VOCs of 179 ppb). Semi-volatile compounds follow the same pattern, 17 semi-volatiles at a maximum total concentration of 15,031 ppb. Only one semi-volatile was detected in the lower aquifer at a maximum total concentration of 2 ppb.

As shown in Table 5-30 the upgradient shallow wells had fewer organic compounds (7) and lower concentrations (maximum total concentration of 133 ppb) than the downgradient shallow wells (37 organic compounds detected with a maximum total concentration of 49,049 ppb). The same pattern follows for the lower aquifer as indicated in Table 5-30. Four organic compounds (volatiles only) were detected in the upgradient deep wells at a maximum concentration of 87 ppb, while the downgradient deep well had 11 compounds at a maximum total concentration of 181 ppb.

Many of the metals detected in the upper aquifer downgradient samples were also detected in the upper aquifer upgradient samples. However, the concentrations are much greater in the downgradient samples. The frequency and concentration of the metals in the upgradient lower aquifer are similar to metals detected in the downgradient lower aquifer.

When identifying the contaminants considered attributable to the site, presented in Table 5-32, the data from wells in the lower aquifer will not be used because there are no contaminants present in the lower aquifer that are not present in the upper aquifer. In addition, contaminant concentrations are significantly below those found in the upper aquifer. The contaminants attributable to the site were selected based upon the following criteria:

TABLE 5-30
COMPARISON OF COMPOUNDS DETECTED IN UPPER AQUIFER MONITORING WELLS

Upgradient Wells: GW-1S and GW-2S

Compound	No. of First Round Detections (Max. 2)	No. of Second Round Detections (Max. 1)*	Max. Concentration (ppb)	Sample I.D.
Methylene Chloride	1	0	1.0	GW-2S
Acetone	2	0	40	GW-1S
2-Butanone	1	0	9	GW-2S
Toluene	2	0	1.0	GW-1S, GW-2S
Di-n-butylphthalate	2	-	4.0	GW-1S
Bis(2-ethylhexyl)phthalate	2	-	14	GW-1S
Di-n-octylphthalate	2	-	74	GW-1S

Downgradient Wells: GW-3S, GW-4S, GW-5S, GW-6S, GW-7S, GW-8S, GW-9S, GW-10S, GW-11S**

	(Max. 9)	(Max. 10)***		
Vinyl Chloride	3	3	120	GW-9S
Chloroethane	1	0	4.0	GW-7S
Methylene Chloride	5	0	43	GW-9S
Acetone	9	1	8,100	GW-7S P
Carbon Disulfide	1	0	4.0	GW-7S
1,1-Dichloroethane	2	3	320	GW-7S
Trans-1,2-dichloroethene	6	6	1,300	GW-9S
Chloroform	1	1	2.0	GW-4S
1,2-Dichloroethane	0	1	150	GW-7S
2-Butanone	3	2	3,300	GW-7S P
1,1-Trichloroethane	1	2	390	GW-7S P
Trichloroethene	6	6	2,200	GW-9S
Benzene	4	2	98	GW-7S, GW-7S P
4-Methyl-2-pentanone	0	2	16,000	GW-7S P
Tetrachloroethene	6	5	930	GW-9S
Toluene	7	5	370	GW-7S
Chlorobenzene	1	2	85	GW-9S P
Ethylbenzene	5	5	80	GW-9S
Styrene	0	1	22	GW-9S
Total Xylenes	4	5	270	GW-7S
Phenol	5	5	5,800	GW-7S P
2-Chlorophenol	0	1	280	GW-9S, GW-9S P
1,4-Dichlorobenzene	0	2	7.0	GW-9S
1,2-Dichlorobenzene	0	3	4.0	GW-9S
2-Methylphenol	5	5	1,500	GW-9S
4-Methylphenol	5	4	1,900	GW-7S P

TABLE 5-30 - Continued

COMPARISON OF COMPOUNDS DETECTED IN UPPER AQUIFER MONITORING WELLS

Downgradient Wells: GW-3S, GW-4S, GW-5S, GW-6S, GW-7S, GW-8S, GW-9S,
GW-10S, GW-11S**

Compound	No. of First Round Detections (Max. 9)	No. of Second Round Detections (Max. 10)***	Max. Concentration (ppb)	Sample I.D.
Isophorone	1	2	53	GW-7S P
2,4-Dimethylphenol	4	5	630	GW-7S P
Benzoic Acid	0	2	600	GW-7S P
1,2,4-Trichlorobenzene	0	1	1.0	GW-5S
Naphthalene	3	4	30	GW-7S
2-Methylnaphthalene	2	3	12	GW-7S
N-nitrosodiphenylamine	0	1	2.0	GW-9S
Di-n-butylphthalate	7	0	15	GW-4S
Bis(2-ethylhexyl)phthalate	7	0	17	GW-7S
Di-n-octylphthalate	7	0	24	GW-8S
Diethylphthalate	1	0	1.0	GW-5S

* GW-2S not sampled in second round because the well was damaged (bent casing and riser). GW-1S analyzed for volatiles only.

** GW-3S not sampled during second round because the lock on the well was violated. First round samples GW-11S data not useable due to holding time violations.

*** GW-7S and GW-9S organics were collected in 2 phases due to the suspected presence of dense, non-aqueous phase liquids. A P refers to the sample taken prior to purging of the well. The well was then purged and sampled similar to the remaining wells. GW-4S and GW-11S were sampled for volatiles only due to insufficient sample volume.

TABLE 5-31

COMPARISON OF COMPOUNDS DETECTED IN LOWER AQUIFER MONITORING WELLS

Upgradient Wells: GW-1D and GW-2D

Compound	No. of First Round Detections (Max. 2)	No. of Second Round Detections (Max. 2)	Max. Concentration (ppb)	Sample I.D.
Methylene Chloride	2	0	5.0	GW-1D
Acetone	2	2	73	GW-2D
2-Butanone	1	0	12	GW-2D
Toluene	1	0	1.0	GW-2D

Downgradient Wells: GW-5D and GW-6D

Vinyl Chloride	1	0	12	GW-6D
Methylene Chloride	2	0	1.0	GW-5D, GW-6D
Acetone	2	0	43	GW-5D
2-Butanone	2	0	10	GW-5D
Trans-1,2-dichloroethene	0	1	41	GW-6D
Trichloroethene	0	1	71	GW-6D
Benzene	0	11	3.0	GW-6D
Tetrachloroethene	0	1	40	GW-6D
Ethylbenzene	0	1	2.0	GW-6D
Total Xylenes	0	1	10	GW-6D
Naphthalene	0	1	2.0	GW-6D

TABLE 5-32

CONTAMINANTS ATTRIBUTABLE TO THE SITE IN GROUNDWATER SAMPLES

ORGANIC COMPOUNDS

Vinyl Chloride	Phenol
Acetone	2-Methylphenol
1,1-Dichloroethane	4-Methylphenol
Trans-1,2-dichloroethene	Isophorone
Chloroform	2,4-Dimethylphenol
2-Butanone	Naphthalene
1,1,1-Trichloroethane	4-Methyl-2-pentanone
Trichloroethene	2-Methylnaphthalene
Benzene	1,2-Dichlorobenzene
Tetrachloroethene	Benzoic Acid
Toluene	Ethylbenzene
Total Xylenes	
Chlorobenzene	

INORGANIC ELEMENTS AND COMPOUNDS

Beryllium	Silver
Cadmium	Cyanide
Mercury	Total Phenols
Iron	Manganese

- o Compounds/metals must be detected in more than one sample (detections may be in different wells or the same well).
- o Mean of data from wells must be an order of magnitude greater than the mean of background wells (i.e., GW-1S, GW-2S).
- o Any compound or element which was detected in only one sample from the remedial investigation would be considered a contaminant attributable to the site if it was detected in at least two samples from the previous investigations performed at Gratwick Riverside Park.

5.4.3 Summary of Analytical Results of Groundwater Samples

Based upon the data presented in Sections 5.4.1 and 5.4.2, the following assessment is made about the nature and extent of contamination of the groundwater at Gratwick Riverside Park. There appears to be an increase in the number and concentration of organics in the upper aquifer as it passes below the site. The same pattern follows in the lower aquifer, although organic compounds are present at much lower concentrations and frequency. It also appears that groundwater contamination is primarily located in the central portion of the site, specifically in wells GW-7S and GW-9S. The number and concentration of organics in the monitoring wells located on the perimeter of the park are much lower than these two wells.

5.5 New York State SCGs

Table 5-33 lists the New York State standards criteria and guidance (SCGs) (which are modeled after the Federal ARARs - Applicable or Relevant and Appropriate Requirements) for groundwater and surface water for

TABLE 5-33

CHEMICAL SPECIFIC ARAR/SCG^a OBSERVED VERSUS
Allowable Contaminant Concentrations

SUBSTANCE	CLASS	GROUNDWATER			SURFACE WATER			SHORELINE	SOIL/SUBSF	SOIL/SURF
		MAX CONC. (UG/L)	ARAR/SCG ^a Value	SOURCE	MAX CONC. (UG/L)	ARAR/SCG ^a Value	SOURCE			
Chloromethane	VOC	4	5	x	7	50	c	40	22	22
Methylene Chloride	VOC	43	5	x	21				26	
Carbon Disulfide	VOC	4	50	x				54	310	150
Acetone	VOC	8,100	50	x						
1,1-Dichloroethane	VOC	320	33 mg/l	h	11	50	c	3	2	
1,2-Dichloroethene (total)	VOC	1,300	5	x						
1,2-Dichloroethane	VOC	150	0.8	c		0.94	i			
Chloroform	VOC	2	0.19	g		0.19	i	49	1	2
Vinyl Chloride	VOC	3	2	c	2	0.3	c			
2-Butanone (or MEK)	VOC	3,300	50	x	23	0.28	i	55	84	93
Trichloroethene	VOC	2,200	0	g		50	c	1	1	13
1,1,1-Trichloroethane	VOC	390	5	x		1	c	10	4	
Benzene	VOC	98	ND	b		0.7	c		3	96
Tetrachloroethene	VOC	930	0.7	da	3	14.3	i	2	10	1
Toluene	VOC	370	5	x		5	a		9	
Ethylbenzene	VOC	80	5	x		50	c	3	22	5
Total Xylenes	VOC	270	50	c		5	d			
Chlorobenzene	VOC	85	5	x		5		2		
Styrene	VOC	22	5	x						
Phenol	VOC	5,800	1	c		5	a*			
2-Chlorophenol	SEMI	1	5	d*		0.1	i			
1,4-Dichlorobenzene	SEMI	7	4.7	d*		5	da			
1,2-Dichlorobenzene	SEMI	4	4.7	d*		5	da			
2-Methylphenol	SEMI	1,500	1	c		5	a*			
4-Methylphenol	SEMI	1,900	1	c		5	a*			
Benzoic Acid	SEMI	600	50	x						
1,2,4-Trichlorobenzene	SEMI	1	5	x		5	aa	190	4,000	260
Naphthalene	SEMI	30	10	c		10	d			
2,4-Dimethylphenol	SEMI	630	5	d*		5	a*	42	84	
Dimethyl Phthalate	SEMI		50	x		50	c	50	1,700	200
2-Methylnaphthalene	SEMI	12	50	x		50		2	840	170
Acenaphthylene	SEMI		50	x		20	d		3,600	210
Acenaphthene	SEMI		20	c						
N-Nitroso sodiphenylamine	SEMI	2	50	x				1,000	4,500	240
Dibenzofuran	SEMI		50	x		50	c		140	
Diethylphthalate	SEMI	1	50	c	2	50	c	180	7,700	450
Flourene	SEMI		50	x		50	c	1,500	49,000	4,500
Phenanthrene	SEMI		50	c		50		340	13,000	1,300
Anthracene	SEMI		50	x		50	c	620	540	710
Di-n-butylphthalate	SEMI	15	50	x	15					
4-methyl-2-pentanone	SEMI		50	x						
Fluoranthene	SEMI	16,000	50	c		50	c	1,100	54,000	8,700

ALL VALUES GIVEN IN ug/l OR ug/kg

a Guideline or standard applies to sum of isomers

+ Standard applies to sum of para (1,4-) and ortho (1,2-) isomers.

* Standard applies to total unchlorinated phenols

** Standard applies to total chlorinated phenols

TABLE 5-33 (continued)

SUBSTANCE	CLASS	GROUNDWATER		SURFACE WATER		SHORELINE	SOIL/SUBST		SOIL/SURF
		MAX CONC. (UG/L)	ARAR/SCGg Value	MAX CONC. (UG/L)	ARAR/SCGg Value		MAX CONC. (UG/KG)	MAX CONC. (UG/KG)	
Pyrene	SEMI		50		50	1,300	29,000	13,000	
Butylbenzophthalate	SEMI		50		50			190	
Benzoc(a)anthracene	SEMI		0.002		0.002	740	19,000	8,800	
Chrysene	SEMI	17	0.002		0.002	840	18,000	8,800	
Di(2-ethyl hexyl)phthalate	SEMI	74	50	1,300	50	820	1,200	800	
Di-n-octyl Phthalate	SEMI		50	78	50	600	100	460	
Benzof(b)fluoranthene	SEMI		0.002		0.002	1,400	310	16,000	
Benzoc(a)pyrene	SEMI		NO		0.0012	840	19,000	9,500	
Indeno(1,2,3-cd)Pyrene	SEMI		0.002		0.002	750	11,000	9,900	
Dibenz(a,h)anthracene	SEMI		50		0.002	210	3,200	2,800	
Benzof(g,h,i)perylene	SEMI		50		50	670	7,600	8,300	
Isophthalone	SEMI	53	50		50				
4-4' DDT	PEST		NO		0.001	19,000		270	
4-4' DDE	PEST		NO		0.001	38			
Aroclor-1252	PCB		0.1		0.001			1,700	
Aroclor-1260	PCB		0.1		0.001			7,200	
TCDF	DIOXIN		0.000035		0.000001		0.32		
MCDF	DIOXIN					3.82			
PCDF	DIOXIN					3.78			
PCDF	DIOXIN					3.22			
PCDF	DIOXIN					6.46			
PCDF	DIOXIN					20.7			
PCDF	DIOXIN					26.7			
Aluminum	MCP	361,000		3,940	100	83,700	69,100	38,600	
Antimony	MCP		3		3	94			
Arsenic	MCP	172	2.5 ng/l		2.2	22	153	13	
Barium	MCP	7,010	1,000	97	1,000	849	3,060	851	
Beryllium	MCP	40.2	3.9 ng/l		3.7		13.2	1.3	
Cadmium	MCP	407	10		10	23	292,000	17	
Calcium	MCP	648,000	50	187,000	50	89,800	292,000	90,000	
Chromium	MCP	1,460			5	264	27.8	45	
Cobalt	MCP	97.7			3	8.2	13.7	19	
Copper	MCP	105	200		200	4,290	111	151	
Iron	MCP	8,900,000	300		200	165,000	39,100	101,000	
Lead	MCP	150	25		30	6,410	151	747	
Magnesium	MCP	1,670,000	35,000		35,000	57,300	79,400	29,000	
Manganese	MCP	754,000	300		300	3,620	31,400	1,500	
Mercury	MCP	0.81	2		0.2	1.3	0.33	0.43	
Nickel	MCP	827	15.4		44.0	301	33.3	49	
Potassium	MCP	241,000				1,440	5,250	7,530	
Silver	MCP	74.4	50		0.1	10	5.13	8.6	
Sodium	MCP	1,270,000	20,000			1,430	1,790	568	
Vanadium	MCP	1,950	300		14	124	39.8	66	
Zinc	MCP	5,980	300		30	2,720	285	1,070	
Cyanide	MCP	70	100		5.2	29	16.0	3.9	
Phenols, Total	MCP	17	1		6.0	2.1	8.10		

ALL OTHER PARAMETERS AND MATERS GIVEN AS ug/L OR ug/kg

METALS, CYANIDE, AND PHENOLS OF SEDIMENTS AND SOILS ARE GIVEN IN mg/kg

ALL OTHER PARAMETERS AND WATERS GIVEN AS ug/L OR ug/kg

Standard calculated with minimum hardness value for the surface water samples tested

§ Standard applies to hexavalent chromium

a Standard applies to dissolved arsenic

+ Standard applies to free cyanide

- a - NYSDEC Surface Water Quality Standards (6 NYCRR, Part 701)
b - NYSDEC Groundwater Quality Regulations (6 NYCRR, Part 703)
c - NY State Ambient Water Quality Guidance Values (6061, 1, 1987)
d - NY State Ambient Water Quality Standards (6061, 1, 1987)
e - NYSDEC Maximum Contaminant Levels for Public Water Supplies (10 NYCRR, Subpart 5-1)
f - NYSDEC Standards, Sources of Water Supply (10 NYCRR, Part 170)
g - USEPA (SAR) Maximum Contaminant Level Goals (40 CFR, Part 141, Subpart F)
h - Clean Water Act, Water Quality Criteria for Human Health (Drinking water only; USEPA, 1985)
i - Clean Water Act, Water Quality Criteria for Human Health (Fish and Drinking Water; USEPA, 1985)

compounds detected in any matrix during sampling and analysis at the site. In all cases, only the most stringent SCG is listed. This list was based primarily upon NYSDEC Surface Water Quality Standards (6 NYCRR, Part 701), NYSDEC Groundwater Quality Regulations (6 NYCRR, Part 703), NY State Ambient Water Quality Standards and Guidance Values, and NYSDOH Maximum Contaminant Levels for Public Water Supplies (10 NYCRR, Subpart 5-1). In addition, two federal regulations were employed in cases where the enforceable values in these federal laws were more stringent than the corresponding NY State law. These regulations include USEPA (SARA) Maximum Contaminant Level Goals (40 CFR, Part 141, Subpart F) and Clean Water Act, Water Quality Criteria for Human Health (drinking water only) (USEPA, 1985). A list of contaminants that exceeded SCGs is given in Table 5-34. As shown in Table 5-34, 41 contaminants are listed for groundwater and 9 contaminants are listed for surface water. Contaminants listed in Table 5-34 as well as contaminants identified in the public health and environmental evaluation (Section 6.0), that pose a significant risk to human health and the environment will be utilized to evaluate remedial alternatives in the Feasibility Study. A determination of the effectiveness of each remedial alternative will be partially based on the alternative's ability to attain SCGs and protect human health and the environment.

TABLE 5-34

CONTAMINANTS THAT EXCEEDED SCGs

GROUNDWATER

Methylene Chloride	
Acetone	
1,1-Dichloroethane	
1,2-Dichloroethene (total)	
1,2-Dichloroethane	
Chloroform	
Vinyl Chloride	Di-n-octyl phthalate
2-Butanone	Isophorone
Trichloroethene	Arsenic
1,1,1-Trichloroethane	Barium
Benzene	Beryllium
Tetrachlorethane	Cadmium
Toluene	Chromium
Ethylbenzene	Iron
Total Xylenes	Lead
Chlorobenzene	Magnesium
Stryrene	Manganese
Phenol	Nickel
1,4-Dichlorobenzene	Silver
2-Methyl phenol	Sodium
4-Methyl phenol	Zinc
Benzoic Acid	Phenols, Total
Naphthalene	
2,4 - Dimethylphenol	
4-methyl-2-pentanone	

Surface Water

Vinyl Chloride
 bis(2-ethylhexyl) phthalate
 Di-n-octylphthalate
 Aluminum
 Copper
 Iron
 Zinc
 Magnesium
 Manganese

6.0 PUBLIC HEALTH AND ENVIRONMENTAL CONCERNS

The following baseline public health and environmental evaluation is an analysis of site conditions, and the impact which the site might have upon public health and the environment, in the absence of remedial measures at the Gratwick Park site. In other words, it is an assessment of the no-action alternative.

6.1 Public Health Evaluation

The public health evaluation is based upon USEPA guidelines presented in the Superfund Public Health Evaluation Manual (USEPA, 1986a). The process includes the following principal steps: (1) selection of indicator chemicals; (2) estimation of concentrations for these indicator chemicals at their point of exposure to human populations; (3) estimation of human intakes; (4) assessment of the toxicity of indicator chemicals for which completed human exposure pathways exist; and (5) calculation of human health risks. Each of these steps is presented sequentially in the following sections, followed by a baseline environmental evaluation of the Gratwick site.

6.1.1 Selection of Indicator Chemicals

In Section 5.0 of this report, "contaminants attributable to the site" were identified for onsite soil (surficial and subsurface), shoreline soil/waste, surface water and groundwater. The contaminants attributable to the site were defined as chemicals whose presence at the site is confirmed, and whose occurrence is reasonably attributable to the site itself rather than to background sources. For practical purposes, contaminants of concern that are the PAHs were separated into two categories, viz. carcinogenic and noncarcinogenic PAHs. PAHs were classified carcinogenic if they were listed as probable or potential human carcinogens in the Health Effects Assessment for PAHs (USEPA, 1984). All

other PAHs detected in onsite media were considered noncarcinogenic PAHs. It was assumed that all carcinogenic PAHs are as potent as benzo(a)pyrene, and that the toxicity of noncarcinogenic PAHs is the same as naphthalene. It was further assumed that the effects of each group of PAHs are additive; therefore, the concentration utilized for chemical evaluation is equal to the sum of the individual compounds comprising the group for each medium. While this characterization over-simplifies the toxic properties and interactions of PAHs, these conservative assumptions prevent underestimation of risk.

As a result of the grouping of PAHs into the two categories, a total of forty-six contaminants attributable to the site were identified at the Gratwick site. These contaminants are listed in Table 6-1.

In accordance with the Superfund Public Health Evaluation Manual, indicator scores for contaminants attributable to the site were developed by utilizing the following algorithm

$$IS_i = (C_{ij} \times T_{ij})$$

Where

IS_i = indicator score for chemical i (unitless)

C_{ij} = concentration of chemical i in medium j (mg/l for water and mg/kg for soil)

T_{ij} = toxicity constant for chemical medium j (units are inverse of concentration units)

The soil concentration utilized for computing the indicator score was the arithmetic mean concentration of all onsite surface soil samples and shoreline soil samples. The water concentration utilized for computing the indicator score was the arithmetic mean concentration of all onsite shallow groundwater samples. (Nondetected parameters in each media were assigned a value equal to one-half of the detection limit for the

TABLE 6-1 (Page 1 of 2)

**GRATWICK-RIVERSIDE PARK
INDICATOR CHEMICAL DATA**

Compound	CAS Number	Soil Conc. (ppm)		Water Conc. (ppm)		Class	Toxicity Data				CPF(1) (mg/kg/d) ⁻¹		RID(1) (mg/kg/d)		Indicator Chemical Scoring					
		Mean	Max	Mean	Max		eTn (kg/mg)	eTc (kg/mg)	wTn (L/mg)	wTc (L/mg)	Oral	Inhal.	Oral	Inhal.	Carcinogens		Noncarcinogens			
															IS Rank	Ind. Y/N	IS Rank	Ind. Y/N		
Vinyl Chloride	75-01-4			1.49E-02	1.20E-01	PC	4.39E-06	2.14E-07	8.77E-02	4.29E-03	2.30E+00	2.95E-01			6.39E-05	5	Y	1.31E-03	12	N
Acetone	67-64-1			7.29E-01	8.10E+00	NC							1.00E-01	ND	0.00E+00			0.00E+00		
Carbon Disulfide	75-15-0						2.12E-05		4.24E-01						0.00E+00			0.00E+00		
1,1-Dichloroethane	75-34-3			3.83E-02	3.20E-01	PC/NC	1.29E-06		2.58E-02		9.10E-02	ND	1.00E-01	1.00E-01	0.00E+00			0.00E+00		
Trans-1,2-Dichloroethene	156-60-5			2.02E-01	1.30E+00	NC	2.65E-06		5.29E-02						0.00E+00			0.00E+00		
Chloroform	67-66-3	4.10E-03	4.90E-02	2.40E-03	2.00E-03	PC/NC		2.81E-06		5.63E-02	8.10E-03	8.10E-02	1.00E-02	ND	1.35E-04	3	Y	1.07E-02	6	N
2-Butanone (MEK)	78-93-3	4.35E-02	9.30E-02	2.61E-01	1.50E-01	NC	3.87E-07		7.75E-03				5.00E-02	9.00E-02	0.00E+00			0.00E+00		
1,1,1-Trichloroethane(TCA)	71-65-6			5.08E-02	3.90E-01	NC	3.67E-08		7.33E-04				9.00E-02	3.00E-01	0.00E+00			2.02E-03	8.5	Y
Trichloroethene(TCE)	79-01-6	3.00E-03	1.30E-02	4.42E-01	2.20E+00	PC	5.28E-06	2.14E-07	1.05E+00	4.29E-03	1.10E-02	1.30E-02			1.90E-03	1	Y	3.72E-05	19	N
Benzene	71-43-2			1.43E-02	9.80E-02	PC	5.85E-06	3.86E-07	1.17E-01	7.71E-03	2.80E-02	2.80E-02			1.10E-04	4	Y	4.64E-01	1	N
4-Methyl-2-Pentanone(MIK)	108-10-1			8.48E-01	1.60E+00	NC							2.00E-02	5.00E-02	0.00E+00			1.67E-03	10	N
Tetrachloroethene(PCE)	127-18-4	8.10E-03	9.60E-02	1.17E-01	9.30E-01	PC/NC	4.81E-07	4.43E-07	9.62E-03	8.88E-03	5.10E-02	3.30E-03	1.00E-02	ND	1.04E-03	2	Y	0.00E+00		
Toluene	108-88-3	2.30E-03	2.00E-03	6.34E-02	3.70E-01	NC	2.60E-07		5.20E-03				3.00E-01	1.00E+00	0.00E+00			1.13E-03	13	Y
Chlorobenzene	108-90-7			1.04E-02	8.50E-02	NC	7.14E-06		1.43E-01				3.00E-02	5.00E-03	0.00E+00			3.30E-04	15	N
Ethylbenzene	100-41-4			2.11E-02	8.00E-02	NC	5.62E-07		1.10E-02				1.00E-01	ND	0.00E+00			1.49E-03	11	Y
Total Xylenes	1330-20-7			7.01E-02	2.70E-01	NC							2.00E+00	4.00E-01	0.00E+00			2.32E-04	17	N
Phenol	108-95-2	3.12E-01	2.10E+00	6.05E-01	5.80E+00	NC	5.02E-06		1.00E-01				6.00E-01	ND	0.00E+00			0.00E+00		
1,2-Dichlorobenzene	95-50-1			4.70E-03	4.00E-03	PC/NC	2.60E-06		5.19E-02		ND	ND	9.00E-02	4.00E-02	0.00E+00			2.44E-04	16	N
2-Methylphenol	96-48-7			1.99E-01	1.50E+00										0.00E+00			0.00E+00		
4-Methylphenol	106-44-5			2.21E-01	1.90E+00										0.00E+00			0.00E+00		
Isophorone	78-59-9			9.10E-03	5.30E-02	PC/NC					4.10E-03	ND	1.50E-01	ND	0.00E+00			0.00E+00		
2,4-Dimethylphenol	105-67-9			8.63E-02	6.30E-01										0.00E+00			0.00E+00		
Benzoic Acid	65-85-0			5.43E-02	6.00E-01	NC							4.00E+00	ND	0.00E+00			0.00E+00		
Diethylphthalate	84-68-2					NC	1.34E-08		2.67E-04				8.00E-01	ND	0.00E+00			0.00E+00		
Di-n-butylphthalate	84-74-2	3.41E-01	7.10E-01			NC	1.90E-06		3.81E-02				1.00E-01	ND	0.00E+00			6.48E-07	20	N
Bis(2-ethylhexyl)phthalate	117-81-7	3.68E-01	8.20E-01			PC/NC		2.86E-08		5.71E-04	1.40E-02	ND	2.00E-02	ND	1.05E-08	9	N	0.00E+00		
Di-n-octylphthalate	117-84-0	2.55E-01	6.00E-01												0.00E+00			0.00E+00		
Non-carcinogenic PAHs(4)		4.75E+00	3.79E+01	1.40E-02	4.20E-02	NC							4.00E-01	ND	0.00E+00			0.00E+00		
Carcinogenic PAHs(5)		5.37E+00	5.69E+01			PC					1.15E+01	6.10E+00			0.00E+00		Y	0.00E+00		
4,4'-DDE	72-55-9	9.67E-03	3.80E-02					5.64E-08		1.13E-01					5.45E-08	8	N	0.00E+00		Y
4,4'-DDT	50-29-3	1.09E+00	1.90E+01			PC/NC		7.97E-06		1.59E-01	3.40E-01	3.40E-01	5.00E-04	ND	8.66E-06	6	N	0.00E+00		

TABLE 6-1 (Page 2 of 2)

**GRATWICK-RIVERSIDE PARK
INDICATOR CHEMICAL DATA**

Compound	CAS Number	Soil Conc. (ppm)		Water Conc. (ppm)			Class	Toxicity Data				CPF(1) (mg/kg/d) ⁻¹		RID(1) (mg/kg/d)		Indicator Chemical Scoring			
		Mean	Max	Mean	Max	Class		sTn (kg/mg)	sTc (kg/mg)	wTn (L/mg)	wTc (L/mg)	Oral	Inhal.	Oral	Inhal.	Carcinogens		Noncarcinogens	
																IS Rank	Ind. Y/N	IS(3) Rank	Ind. Y/N
PCB (7)		3.04E-01	7.20E+00			PC		2.86E-05		5.71E-01	7.70E+00	ND			8.69E-06	6	Y	0.00E+00	
Hexachlorinated Dibenzofuran		9.00E-04	6.48E-03								1.56E+03(6)	1.56E+03(6)			0.00E+00		Y	0.00E+00	
Heptachlorinated Dibenzofuran		1.74E-03	2.07E-02								1.56E+02(6)	1.56E+02(6)			0.00E+00		Y	0.00E+00	
Octachlorinated Dibenzofuran		2.23E-03	2.67E-02								0.00E+00(6)	0.00E+00(6)			0.00E+00			0.00E+00	
Antimony	7440-36-0	1.17E+01	9.40E+01			NC	2.17E-04		4.35E+00				4.00E-04	ND	0.00E+00			2.54E-03	7
Beryllium	7440-41-7	5.44E-01	1.30E+00	5.70E-03	4.02E-02	PC/NC					ND	8.40E+00	5.00E-03	ND	0.00E+00			0.00E+00	
Cadmium	7740-43-9	4.90E+00	2.30E+01	3.39E-02	4.07E-01	PC/NC	2.23E-04		4.45E+00		ND	6.10E+00	5.00E-04	ND	0.00E+00			1.52E-01	3
Iron	7434-81-8			6.73E+02	8.90E+03														
Lead	7439-92-1	6.14E+02	6.41E+03			PC/NC	4.46E-06		8.93E-01		ND	ND	1.40E-04	4.50E-04	0.00E+00			2.74E-02	5
Magnesium	7439-95-4												(8)	(8)	0.00E+00			0.00E+00	
Manganese	7439-98-67			5.93E+01	7.34E+02	NC							5.00E-01	3.00E-04	0.00E+00			0.00E+00	
Mercury	7439-97-6			1.10E-04	8.10E-04	NC	9.21E-04		1.84E+01				3.00E-04	ND	0.00E+00			2.02E-03	8.5
Silver	7440-24-4			8.30E-03	3.29E-02		1.00E-03		2.00E+01						0.00E+00			1.66E-01	2
Cyanide	57-12-6	5.46E+00	2.90E+01	7.10E-03	5.00E-02	NC							2.00E-02	ND	0.00E+00			0.00E+00	
Total Phenols	108-95-2	1.79E-01	3.90E+00	1.60E-03	3.10E-03	NC	5.02E-06		1.00E-01				6.00E-01	ND	0.00E+00			1.61E-04	18

Notes:

PC - Potential Carcinogen; NC - Noncarcinogen; RFD - Risk Reference Dose; CPF - Carcinogenic Potency Factor; ND - Not Determined; NA - Not Available or Not Applicable; Y - Yes; N - No

(1) CPF and RFD obtained from Health Effects Assessment Summary Tables - Second Quarter FY 1989 unless otherwise noted

(2) IS - Indicator Score = [sTc * mean soil conc.(ppm)] + [wTc * mean water conc.(ppm)]

(3) IS - Indicator Score = [sTn * mean soil conc.(ppm)] + [wTn * mean water conc.(ppm)]

(4) Noncarcinogenic PAH's detected in soil include : naphthalene(CAS# 91-20-3), 2-methylnaphthalene(91-57-9), acenaphthylene (CAS# 208-96-8), acenaphthene(CAS# 83-32-9), dibenzofuran(CAS# 132-64-9), fluorene(CAS# 86-73-7), phenanthrene(CAS# 85-01-8), anthracene(CAS# 120-12-7), fluoranthene(CAS# 206-44-0), pyrene(CAS# 129-00-0) and benzo(g,h,i)perylene(CAS# 191-24-2). Noncarcinogenic PAH's detected in groundwater include : naphthalene(CAS# 91-20-3) and 2-methylnaphthalene.

(5) Carcinogenic PAH's detected in soil include : benzo(a)anthracene(CAS# 56-55-3), chrysene(CAS# 218-01-9), benzo(a)fluoranthene, benzo(a)pyrene(CAS# 50-32-8), ideno(1,2,3-cd)pyrene(CAS# 193-39-5) and dibenz(a,h)anthracene(CAS# 53-70-3).

(6) CPF values for dibenzofurans derived by multiplying the CPF for 2,3,7,8-TCDD(viz. 1.56E+05) by the toxic equivalency factor (TEF) for the specific compound. The TEF's for hexachlorinated, heptachlorinated and octachlorinated dibenzofurans are 0.01, 0.001 and 0.00 respectively. These values were obtained from Interim Procedures for Estimating Risk Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-Dioxins and Dibenzofurans (EPA, 1987). It should be noted that Interim draft document is currently being revised and that an updated version will be published in 1989.

(7) PCB's include aroclors 1242 and 1260

(8) RFD obtained from the New York State Department of Health.

purpose of computing the mean concentration.) Mean concentrations in surficial and shoreline soil and shallow groundwater were utilized in the evaluation since human exposure to onsite contamination is most likely to occur via surficial and shoreline soil or shallow groundwater as discussed in Section 6.1.2. Toxicity constants were obtained from Appendix A of the Superfund Public Health Evaluation Manual (USEPA, 1986a).

Chemicals were initially classified as carcinogens or noncarcinogens based on the toxicity constant presented in Table 6-1. Chemicals with reported carcinogenic toxicity constants, i.e. sTc or wTc, were classified as carcinogens and chemicals with reported noncarcinogenic toxicity constants, i.e. sTn or wTn, were classified as noncarcinogens. Based on this initial classification of chemicals, separate indicator scores were developed for potential carcinogens and for noncarcinogens. The criteria utilized for final classification of the chemicals are different than discussed above and are presented later in this section.

As shown on Table 6-1, indicator scores were calculated for 25 of the chemicals listed. Toxicity constants were not reported for 19 of the compounds and two compounds were not detected in surficial soil or shallow groundwater; therefore, indicator chemical scores were not calculated for these compounds. Potential carcinogens and noncarcinogens were ranked based on the indicator scores. Six carcinogens (viz, vinyl chloride, chloroform, trichloroethene (TCE), benzene, tetrachloroethene (PCE) and PCBs) and nine noncarcinogens (viz, 1,1-dichloroethane, 2-butanone tetrachloroethene (PCE), chlorobenzene, phenol, antimony, cadmium, lead and mercury) were selected as indicator chemicals. The six carcinogens are the highest ranked carcinogens. Five noncarcinogens (viz, vinyl chloride, trans 1,2-dichloroethene, TCE, benzene, and silver) ranked higher than the noncarcinogens selected but were not chosen as indicator chemicals because Reference Dose (RfD) values are not reported for these compounds, and therefore, quantification of noncarcinogenic risk would not be possible utilizing these compounds.

Chemicals without indicator scores were evaluated qualitatively based on concentration, prevalence at the site (number of detections), toxicity, and mobility. Based on the qualitative evaluation, four additional chemicals (viz., carcinogenic PAHs, noncarcinogenic PAHs, hexachlorinated dibenzofuran, and heptachlorinated dibenzofuran) were selected as indicator chemicals.

The final classification of chemicals as potential carcinogens or noncarcinogens is based on the availability of toxicity data required for quantifying the human health risk. A chemical was classified a potential carcinogen if a carcinogenic potency factor (CPF) was reported in the literature for the chemical. A chemical was classified as a noncarcinogen if a reference dose (RFD) was reported in the literature for the chemical. A chemical was classified as both a potential carcinogen and noncarcinogen if both a CPF and RFD were reported. Chemicals without a reported CPF or RFD were not classified. The criteria above were utilized to identify chemicals as potential carcinogens or noncarcinogens in Tables 6-1 and 6-2 and throughout the remainder of Section 6.0.

A summary chemical profile has been compiled for each of the seventeen indicator chemicals. This includes a review of the chemical, physical, and biological properties of each compound or group. The findings are summarized in Table 6-2. A more complete profile is presented in Appendix F. The following references were consulted during the preparation of these profiles: Merck, 1976; Sax, 1987; Howard, 1989; Sax, 1984; USEPA, 1984a,b,c; NYS, 1987; and Clayton and Clayton, 1981.

6.1.2 Exposure Pathways

This section describes the completed pathways of human exposure to contaminants emanating from the Gratwick Park site under a "no-action" scenario. A completed exposure pathway is the mechanism by which a population or individual is exposed to contaminants originating

TABLE 6-2

SUMMARY OF CHEMICAL, PHYSICAL, AND BIOLOGICAL PROPERTIES
FOR INDICATOR CHEMICALS AT THE GRATWICK PARK SITE

Indicator Chemical	Toxicological Class (3)	Molecular Wt. (g/mole)	Water Solubility (mg/l)	Vapor Pressure (mmHg@25°C)	Henry's Constant (atm-m ³ /mol-k)	Koc (ml/g)	Log Kow	Fish BCF (l/kg)
Vinyl Chloride	PC	63	2.67x10 ³	2.66x10 ³	8.19x10 ⁻²	57	1.38	1.17
1,1 Dichloroethane	PC/NC	99	5.50x10 ³	1.82x10 ²	4.31x10 ⁻³	30	1.79	NA
Chloroform	PC/NC	119	8.20x10 ³	1.51x10 ²	2.87x10 ⁻³	31	1.97	3.75
2-Butanone (MEK)	NC	72	2.68x10 ⁵	77.5	2.74x10 ⁻⁵	4.5	0.26	0
Trichloroethene (TCE)	PC	131	1.10x10 ³	57.9	9.10x10 ⁻³	126	2.38	10.6
Benzene	PC	78	1.75x10 ³	95.2	5.59x10 ⁻³	83	2.12	5.2
Tetrachloroethene (PCE)	PC/NC	166	1.50x10 ²	17.8	2.59x10 ⁻²	364	2.6	31
Chlorobenzene	NC	113	4.66x10 ²	11.7	3.72x10 ⁻³	330	2.84	10
Phenol	NC	94	9.30x10 ⁴	0.341	4.54x10 ⁻⁷	14.2	1.46	1.4
Noncarcinogenic PAHs (1)	NC	---	---	---	---	---	---	---
Carcinogenic PAHs (1)	PC	---	---	---	---	---	---	---
PCBs	PC	328	3.10x10 ⁻²	7.70x10 ⁻⁵	1.07x10 ⁻³	530000	6.04	100000
Hexachlorinated Dibenzofuran	PC	375	NA	NA	NA	NA	NA	NA
Heptachlorinated Dibenzofuran	PC	409	NA	NA	NA	NA	NA	NA
Antimony	NC	122	Insoluble(2)	1.00	NA	NA	NA	1
Cadmium	NC	112	Insoluble(2)	0.0	NA	NA	NA	81
Lead	NC	207	Insoluble (2)	0.0	NA	NA	NA	49
Mercury	NC	201	Insoluble(2)	0.002	NA	NA	NA	5500

Note: All values are from USEPA's Superfund Public Health Evaluation manual (USEPA, 1986a)

(1) Compounds have been grouped into the appropriate toxicological class and are not discussed individually
(2) The Merck Index, Ninth Edition, 1976.

(3) Toxicological Class: PC - Potential Carcinogen NC - Noncarcinogen

NA - Not Available or Not Applicable

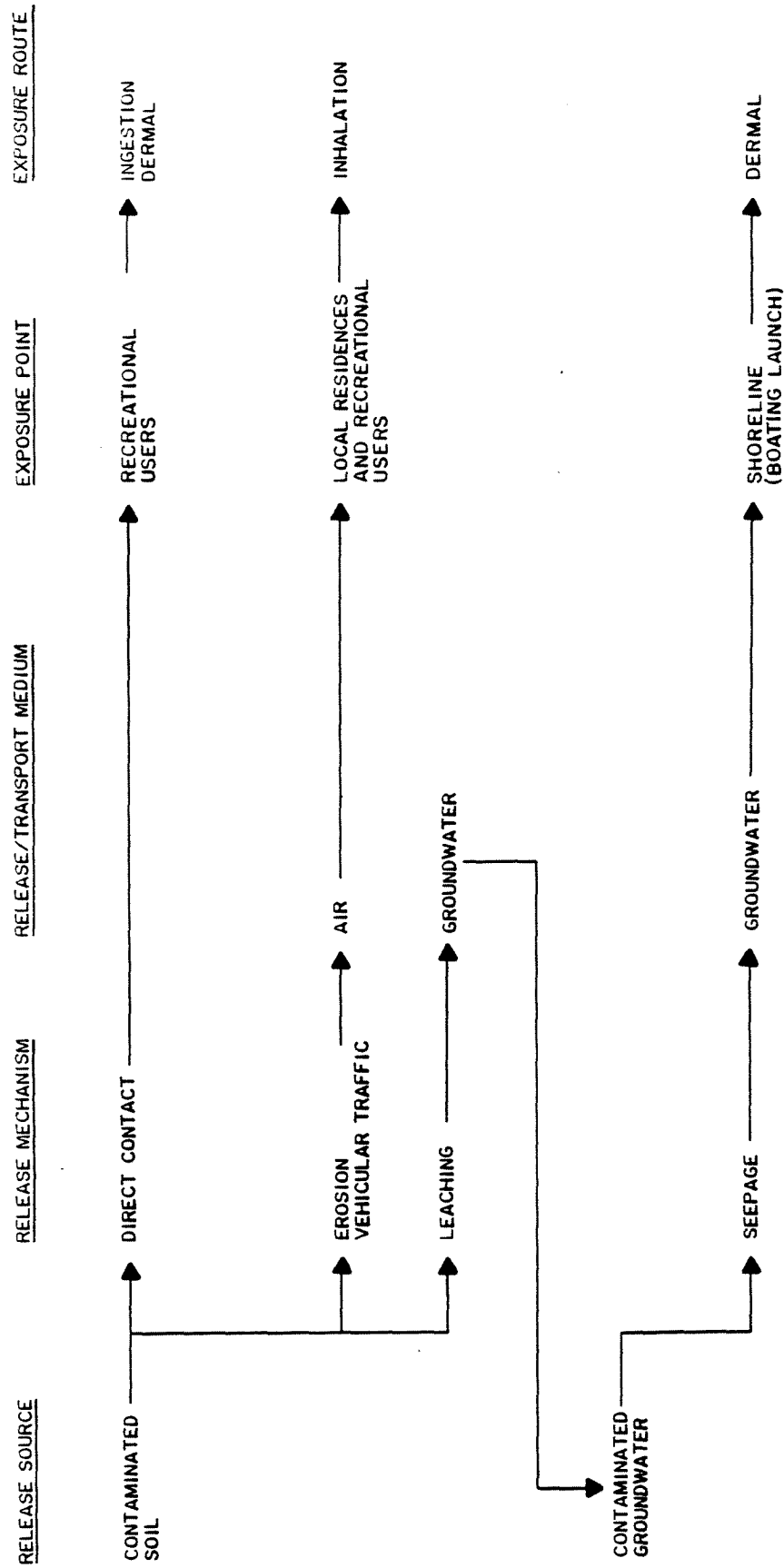
from a site and consists of four necessary elements: (1) a source and mechanism of chemical release; (2) an environmental transport medium (e.g., groundwater, surface water, soil or air); (3) a potential human exposure point; and (4) a likely route of human exposure (e.g., ingestion, dermal absorption, or inhalation).

Figure 6-1 indicates the completed human exposure pathways with potential significance at the Gratwick site. These pathways are discussed in terms of the separate elements which comprise them.

6.1.2.1 Sources of Contamination

The two primary sources of contamination at the Gratwick site are contaminated onsite soil and contaminated groundwater. The nature and extent of contamination within these media were presented in Section 5.0. They are summarized in the following paragraphs.

Contaminants attributable to the site in subsurface and surficial soil include chlorinated alkenes, aromatic hydrocarbons, polynuclear aromatic hydrocarbons (PAHs), phthalate esters, pesticides and PCBs, metals and cyanide. In general, the semi-volatile organic compounds (PAHs and phthalate esters) are more prevalent and are at higher concentrations than the volatile organic compounds. The PAHs are the primary contaminants attributable to the site. Most of the metals detected in surficial and subsurface soil were within the typical range of concentration for soil in the Eastern United States and were not considered contaminants attributable to the site. Surficial soil results do not indicate any obvious pattern of contaminant distribution; however, the highest concentrations of contaminants in the subsurface are found in fill approximately 10-15 feet below the surface in areas of previous drum removal.



With the exception of PCBs, similar types of contaminants attributable to the site are present in shoreline soil; however, in addition to these types of chemicals, dioxins (viz., chlorinated dibenzofurans) are also contaminants attributable to the site in shoreline soil. In general, the concentrations of contaminants attributable to the site in shoreline soil particularly the semi-volatiles, are less than in surficial soil.

Twenty-four organic and six metal contaminants attributable to the site were identified in groundwater as well as cyanide and total phenols. The same general types of chemicals are contaminants of concern in soil and groundwater. However, there are a number of phenolic compounds that are contaminants of concern in groundwater and that are not contaminants of concern in soil. There appears to be an increase in the number and concentration of organics in shallow groundwater as it passes through the site. A similar pattern occurs in the "lower aquifer"; however organic contaminants were detected less frequently and in significantly lower concentrations in the lower aquifer. It also appears that groundwater is more contaminated in the central portion of the site, i.e. in GW-7S and GW-9S, than in other areas of the site.

6.1.2.2 Chemical Release and Transport

Chemicals present in onsite soil are released to human receptors by the three mechanisms listed below:

- o direct contact with human receptors using the site for recreational activities
- o wind erosion and vehicular traffic
- o leaching into groundwater and seepage into near shore surface water

Release from the first two mechanisms listed above is attributable to contaminants present in surficial soil whereas releases to groundwater are attributable to contaminants present in both surficial and subsurface soil.

Chemicals that are not directly released from onsite soil to human receptors are transported via air, and groundwater. Soil particulates resulting from wind erosion of surficial soil and onsite vehicular traffic are transported by air to local area residences. Contaminants released to groundwater are transported to receptors utilizing shoreline surface water for recreation activities.

Groundwater at the site is both a source and transport media for contamination attributable to the site.

6.1.2.3 Potential Human Exposure Points and Routes of Human Exposure

Potential human exposure points and routes of exposure are discussed below:

- o Recreational Users: The Gratwick site is located in the City of North Tonawanda, Niagara County, New York. The site is a park that is open to the public. Consequently, a large population may be exposed by direct contact with surficial contaminants during recreational activities at the park. Such a scenario would include inadvertent ingestion of soil during hand-to-mouth activities, such as smoking or eating, and dermal adsorption of chemicals from soil contacting exposed skin.

- o Local Residences: Some of the onsite roadways are unpaved. Therefore, it is possible that dust resulting from vehicle traffic will migrate to local residences as well as visitors using the park for recreation. Dust from the site may also migrate to potential receptors as a result of wind erosion of nonpaved roadways located on site. Data from the RI has established that there are a number of contaminants present in surficial soil. Consequently inhalation of contaminated dust emanating from the site appears to be a reasonable route of exposure at the Gratwick site.
- o Shoreline (Boat Launch): A boat launch is located in the central portion of the site. Since it is anticipated that shallow groundwater (leachate) will discharge into the Niagara River near the shore, it appears reasonable to assume that people using the facility to launch boats will be exposed to contaminants in the shallow groundwater (leachate). Under this scenario, exposure would include dermal adsorption of contaminants contacting the skin during recreation activities.

6.1.2.4 Routes of Exposure and Completed Pathways

Completed pathways for human exposure, for which detailed risk characterizations will be performed, include the following:

- o Ingestion of contaminated surficial soil from the park or shoreline areas by persons using the site for recreational activities;

- o Dermal contact with contaminated surficial soil from the park or shoreline areas by persons using the site for recreational activities;
- o Inhalation of contaminated dust by persons living near the site; and
- o Dermal contact with contaminated shallow groundwater (leachate) during recreational activities near the shoreline (boat launch).

6.1.3 Estimation of Exposure Point Concentrations

In order to quantify health effects, it is necessary to establish a concentration for each indicator chemical at the point(s) where it comes into contact with a human population (i.e., along completed exposure pathways). In this study, exposure point concentrations for surficial soil are based upon monitoring, rather than modeling, data. Exposure point concentrations for airborne particulate soil and shallow groundwater (leachate) near the shoreline is based on a combination of monitoring and modeling data. Since onsite contaminants have been in place for many years, contaminant concentrations extrapolated from monitoring data are considered a reasonable estimate of future site conditions. Recognizing the uncertainties associated with exposure point assessments, however, two alternate sets of exposure point concentrations have been developed for use in the risk evaluation: one ("representative") set of concentrations based upon average (i.e., arithmetic mean) monitoring data values, and another ("worst case") scenario based upon the highest detected value for each indicator chemical at its point of exposure. Exposure point concentrations are described below.

6.1.3.1 Concentration of Indicator Chemicals in Surficial Soil

The concentration of indicator chemicals in surficial soil is used directly to calculate health risk associated with ingestion and dermal contact by persons using the site for recreational activities. It is also used indirectly to calculate the risk associated with inhalation of contaminants in dust. Representative and maximum concentrations for surficial soil indicator chemicals were previously presented in Table 6-1.

6.1.3.2 Concentration of Indicator Chemicals in Airborne Particulates

The concentration of contaminants in airborne particulates was estimated using modeling techniques from Rapid Assessment of Exposure to Particulate Emission from Surface Contamination Sites (Cowherd, 1985). Two types of particulate emissions were modeled, including wind erosion emissions and emissions resulting from vehicle traffic. These emission estimates are discussed below.

- o Estimation of Wind Erosion Emissions: Factors influencing wind erosion of erodible material include the amount of onsite vegetative cover at the site, the amount of nonerodible elements and climatic factors. In accordance with Cowherd, sites can be characterized by the finite availability ("limited reservoir") of erodible material or by the "unlimited reservoir" of erodible particles. For surface area not covered by continuous vegetation, the classification of surface material as either having a "limited reservoir" or an "unlimited reservoir" of erodible particles is determined by estimating the threshold friction velocity. In accordance with Cowherd, surfaces having a threshold velocity below 75 cm/sec may be considered highly erodible, and therefore, are classified as

"unlimited reservoirs". Surfaces with friction velocities larger than 75 cm/sec tend to be composed of larger aggregates mixed with some erodible material, and are classified as "limited reservoirs".

The friction velocity is determined by the particle size distribution of erodible surface soil. The results of a sieve test of erodible soils at the Gratwick site are presented in Table 6-3. The threshold friction velocity is determined from Figure 3-4 of Cowherd by utilizing the mode of the particle size distribution. The threshold velocity determined by this method is 45 cm/sec; however, the threshold velocity must be corrected if the soil contains larger nonerodible elements such as found at the Gratwick Park site. Based on inspection, the correction factor was determined to be approximately 2; therefore, the final corrected threshold velocity for the exposed soil at the Gratwick site is 90 cm/s. Since the corrected threshold velocity is above 75 cm/sec, erodible material at the site is classified as a "limited reservoir".

Chronic exposure concentrations are based on annual modeling of air emissions. The annual rate of wind erosion emissions with a "limited reservoir" is estimated by a predictive emission factor equation developed by Cowherd:

$$(1) \quad E_{10} = 0.83 \quad \frac{F P(U^+) (1-V)}{(PE/50)^2}$$

TABLE 6-3

RESULTS OF SIEVE ANALYSIS FOR SURFACE SOIL
AT GRATWICK PARK SITE

AMOUNT OF SOIL COLLECTED ON SIEVE (Z)

<u>Sieve Size (mm)</u>	<u>South Service Rd.</u>	<u>West Service Rd.</u>	<u>East Service Rd.</u>
4.74	23.6	13.0	27.0
3.35	12.4	9.0	11.3
2.00	17.7	12.5	16.5
0.42	43.4	39.0	38.0
0.15	2.6	23.0	5.2
0.04	0.4	3.0	2.0
<0.04	0.0	0.5	0.0

Where:

E_{10} = PM₁₀ emission factor, i.e., the average rate of emissions of particles 10 μ m or smaller (respirable particles) per unit area of contaminated surface (mg/m²-hr)

F = frequency of disturbance per month

U^+ = observed (or probable) fastest mile of wind for the period between disturbances (m/s)

$P(U^+)$ = erosion potential quantity of erodible particles present on the surface prior to the onset of wind erosion (g/m²)

V = fraction of contaminated surface area covered by continuous cover

PE = Thornwaite's Precipitation Evaporation Index used as a measure of average soil moisture content.

The emission factor for the Gratwick site resulting from wind erosion is estimated at 8.6 mg/m²-hr. The values used for determining this emission factor are summarized in Table 6-4.

The emission rate for the annualized model is estimated from the emission factor by:

$$R_{10} = (E_{10}) (A) (C_{soil})$$

Where:

R_{10} = emission rate of compound (g/s)

C_{soil} = concentration of compound in respirable particles assumed equal to concentration in soil (g/g)

E_{10} = emission factor (g/m²-s)

A = surface area (m²)

TABLE 6-4

VALUES FOR DETERMINING EMISSION FACTOR (E10)

<u>Equation Component</u>	<u>Value</u>	<u>Source</u> ⁽¹⁾
F	30/month	Assumed ⁽²⁾
U^+	24.1 m/s	Table 4-1 ⁽³⁾
$P(U^+)$	83.8 g/m ²	(4)
V	0.98	Estimated based on current site conditions
PE	110	Figure 4-2
E10	8.6 mg/m ² -hr	Equation 1

Notes:

1. Source of all values is Cowherd (1985) unless otherwise stated.
2. Although vehicular traffic alters the surface by pulverizing material, several vehicle passes may be required to restore the full erosion potential. Based on traffic patterns observed during field activities, it is assumed that the surface will be erodible 100% of the days where emissions are possible (i.e., 240 days per year).
3. Value for closest weather station reported, i.e., Buffalo, NY.
4. $P(U^+) = 6.7 (U^+ - U_t)$, $U^+ > U_t$

$$U_t = u_* \frac{1}{0.4} \ln (z/z_o)$$

Where: u_* - friction velocity (m/s) = 0.9 (2.0 x value from Figure 3-4)
 z - height above surface (cm) = 700 (Given)
 z_o - roughness height (cm) = 4 (Figure 3-6)
 u_t - wind speed at height of 700 cm (m/s) = 11.6

For the Gratwick site,
 $R_{10} = 1.03 \times 10^{-2} \text{ (Csoil)}$

The air concentration at a receptor point results from dispersion of the emitted soil particles. Cowherd et al (1985) provides a series of previously obtained outputs from the ISCLT model for estimating dispersion. The ISCLT mode was run with average meteorological data for seven climatic regions of the United States and for a 10-m by 10-m and 100-m by 100-m area sources. The outputs of these runs are the unscaled dispersion factors that are used to estimate the ambient air concentration by multiplication with a scaling factor (Q_I). Q_I is based on the emission strength (R_{10}) and the climatic region factor (Pr):

$$Q_I = R_{10}/Pr$$

According the Cowherd (1985), Gratwick Park is located in Climatic Region 4, thus $Pr = 0.288$, and
 $Q_I = 3.58 \times 10^{-2} \text{ (Csoil)}$

Table 6-5 presents the emission rates for the long-term modeling of wind erosion.

- o Mechanical Resuspension - The methods of Cowherd et al. (1985) are used to estimate the emissions from onsite traffic along dirt roads. In accordance with Cowherd, the following equation is used:

$$E_{10} = 0.85 \frac{s}{10} \frac{S}{24} \frac{0.8}{7} \frac{W}{6} \frac{0.3}{6} \frac{w}{365} \frac{1.2}{365} \text{ (365-p)}$$

Where:

E10 = PM10 emission factor (kg/VKT where VKT equals vehicle-kilometer of travel)

s = silt content of road surface material (%)=2

S = mean vehicle speed (km/hr) = 48

W = mean vehicle weight (Mg) = 2

w = mean number of wheels = 4

p = number of days with at least 0.254 min. of precipitation per year = 160

The value for s was estimated based on data from sieve tests of road material. Values for S, W, and w are default values given in Table 4-2 of Cowherd. The value for p was determined from Figure 4-4 of Cowherd (1985).

Vehicle Kilometers traveled (VKT) is a function of distance traveled and the frequency of travel and is based on observations during field activities.

$$\begin{aligned}\text{VKT} &= (\text{trips/day}) (\text{distance/trip}) \\ &= 30 \text{ trips/day} \times 0.58 \text{ km/trip} \\ &= 17.4 \text{ km/day}\end{aligned}$$

The emission rate (R10) is:

$$R10 = (E10) (\text{VKT}) F \left(\frac{1 \text{ day}}{86,400 \text{ sec.}} \right) C_{\text{soil}}$$

Where:

R10 = emission rate of compound (g/s)

E10 = emission factor (g/VKT) = 70.5

F = fraction of days traveled per year (0.67)

VKT = vehicle distance traveled (Km/day) = 17.4

Csoil = concentration in soil (g/g)

Therefore,

$$R_{10} = 9.51 \times 10^{-3} C_{soil}$$

For mechanical resuspension, the scaling factor for air dispersion (Q_{II}) is equal to R_{10} . There is no climatic adjustment required for mechanical resuspension emissions.

- o Air Dispersion Modeling - The ambient air concentration at a receptor is estimated from presolved ISCLT computer modeling runs. Cowherd et al. (1985) ran the models for the two types of particle emissions, for two different source areas, and for seven different climatic regions. The results of these runs are unscaled ambient air concentrations due to a unit erosion rate (f_I) or a unit mechanical emission rate (f_{II}). For a specific site, the ambient air concentration is estimated by:

$$\text{Respirable Concentration (X)} = (Q_I)(f_I) + (Q_{II})(f_{II})$$

Unscaled ambient air concentration utilized for long-term dispersion modeling of this site assumed a 100m x 100m source and a downwind receptor distance of 200m. Values for f_I and f_{II} are the average of 3 values for wind directions in the direction of receptors presented in Appendix D of Cowherd (1985). These values are 2.97534us/m³ and 30.38643us/m³ respectively. Estimated respirable concentrations of compounds in airborne particulates are presented in Table 6-5.

TABLE 6-5

CONCENTRATIONS OF INDICATOR CHEMICALS IN AIRBORNE PARTICULATES

Chemical	Rate-R10(g/s) (1)		Rate-R10(g/s) (2)		X(ug/m ³) (3)	
	Mean	Max.	Mean	Max.	Mean	Max.
Trichloroethene	3.09E-11	1.34E-10	2.05E-11	1.24E-10	9.42E-10	2.90E-08
Tetrachloroethene	8.34E-11	9.89E-10	7.70E-11	9.13E-10	3.21E-09	8.28E-07
Phenol	3.21E-09	2.16E-08	2.96E-09	1.99E-08	1.23E-07	2.84E-06
Noncarcinogenic PAHs	4.89E-08	3.90E-07	4.51E-08	3.60E-07	1.88E-06	1.50E-05
Carcinogenic PAHs	5.52E-08	5.86E-07	5.11E-08	5.41E-07	2.12E-06	2.25E-05
PCBs	3.13E-09	7.42E-08	2.89E-09	6.85E-08	1.20E-07	2.84E-06
Antimony	1.21E-07	9.68E-07	1.12E-07	8.94E-07	4.65E-06	3.72E-05
Cadmium	5.05E-08	2.37E-07	4.66E-08	2.19E-07	1.94E-06	9.10E-06
Lead	6.32E-06	6.60E-05	5.84E-06	6.10E-05	2.42E-04	2.54E-03
Hexachlorinated Dibenzofuran	9.27E-12	6.67E-11	8.56E-12	6.16E-11	3.56E-10	2.56E-09
Heptachlorinated Dibenzofuran	1.77E-11	2.11E-10	1.63E-11	1.95E-10	6.78E-10	8.11E-09

Note: (1) $R10 = 1.03 \times 10^{-2} \times C_{soil}$ (g/g)

(2) $R10 = 9.51 \times 10^{-3} \times C_{soil}$ (g/g)

(3) $X = Q_I F_I \times Q_{II} F_{II} = [R10 \text{ (wind erosion)}/0.288] \times 2.9763 + [R10 \text{ (mechanical resuspension)} \times 30.386]$

6.1.3.3 Concentration of Indicator Chemical in Surface Water at Boat Launch

The concentration of contaminants in surface water at the boat launch was estimated by performing a mass balance. It was assumed that all shallow groundwater (leachate) was discharged at the end of a concrete pad approximately 25 feet from the shore and that leachate discharged at this point flowed both toward the shore and downstream (this flow pattern was confirmed by dye tests).

The mass balance is described by the following equation,

$$qC_{gw} + QC_{sw} = (q + Q)C_{bl}$$

Where,

q = flow rate of groundwater per unit width
($m^3/s-m$)

Q = flow rate of river water per unit width
($m^3/s-m$)

C_{gw} = concentration of contaminant in groundwater
(g/m^3)

C_{sw} = concentration of contaminant in river water
(g/m^3)

C_{bl} = concentration in water at boat launch (g/m^3)

If it is assumed that water from the river entering the boat launch area is uncontaminated, then $C_{sw}=0$ and $qC_{gw} = (q+Q) C_{bl}$. Therefore, the concentration of contaminant in water at the boat launch may be derived from the concentration of contamination in groundwater by the following relationship

$$C_{bl} = \frac{qC_{gw}}{(q+Q)}$$

For a unit width (i.e. 1 meter), the groundwater flow (q) is determined by Darcy's equation,

$$q = Kbdh/dl$$

Where,

K = hydraulic conductivity (m/s)

b = thickness of aquifer (m)

dh/dl = hydraulic gradient (m/m)

The river flow rate (Q) into a unit width is computed as follows:

$$Q = V_{xy}h$$

Where,

V_{xy} = the resultant velocity vector along the horizontal plan
of flow (m/s)

h = height of water at discharge point (m)

The values utilized to perform the mass balance are presented on Table 6-6. Based on these values, contaminants in groundwater are diluted by slightly greater than 5 orders of magnitude at the boat launch by water from the Niagara River. For the mass balance analysis it should be noted that groundwater concentrations from the nearest upstream well (viz, GW-7S) were utilized to determine representative (i.e. arithmetic mean) and maximum influent contaminant concentrations for the mass balance equation.

6.1.3.4 Summary

Representative and maximum concentrations of all indicator chemicals, at their point of human exposure, are summarized in Table 6-7.

TABLE 6-6

VALUES UTILIZED FOR MASS BALANCE

<u>Parameter</u>	<u>Value</u>	<u>Source</u>
K	2.3E-05 m/s	Section 4.0 of RI
b	1.8 m	Section 4.0 of RI
dh/dl	5.0E-03 m/m	Section 4.0 of RI
Vxy	3.03E-02 m/s	Measured ¹
h	8.4E-01m	Measured ¹

¹ These values were determined during a dye study conducted in July 1989..

TABLE 6-7

SUMMARY OF EXPOSURE POINT CONCENTRATIONS OF INDICATOR CHEMICALS

Exposure Point	Media	Route	Indicator Chemical	Exposure Point Concentration Representative	Maximum
Site	Soil	Ingestion Dermal	Trichloroethene Tetrachloroethene Phenol Noncarcinogenic PAHs Carcinogenic PAHs PCBs Antimony Cadmium Lead Hexachlorinated Dibenzofuran Heptachlorinated Dibenzofuran	3.00E-03 8.10E-03 3.12E-01 4.75E+00 5.37E+00 3.04E-01 1.17E+01 4.90E+00 6.14E+02 9.00E-04 1.74E-03	1.30E-02 9.60E-02 2.10E+00 3.79E+01 5.69E+01 7.20E+00 9.40E+01 2.30E+01 6.41E+03 6.48E-03 2.07E-02
Local Residences	Air	Inhalation ¹	Trichloroethene Tetrachloroethene Carcinogenic PAHs PCBs Cadmium Lead Hexachlorinated Dibenzofuran Heptachlorinated Dibenzofuran	9.42E-13 3.20E-12 2.12E-09 1.20E-10 1.94E-09 2.42E-07 3.56E-13 6.78E-13	2.90E-11 8.28E-10 2.25E-08 2.84E-06 9.10E-09 2.54E-06 2.56E-12 8.11E-12
Shoreline (Boat Launch)	Surface Water	Dermal	Vinyl Chloride 1,1-Dichloroethane Chloroform 2-Butanone Trichloroethene Benzene Tetrachloroethene Chlorobenzene Phenol	4.92E-08 1.44E-06 ² 2.05E-08 ² 1.27E-05 5.07E-06 5.72E-07 2.20E-07 ² 2.05E-08 ² 2.42E-05	6.61E-08 2.88E-06 ² 2.05E-08 ² 6.91E-05 7.55E-06 8.05E-07 4.60E-07 ² 2.05E-08 ² 4.76E-05

TABLE 6-7 (Cont.)

Exposure Point	Media	Route	Indicator Chemical	Exposure Point Concentration	
				Representative	Maximum
			Noncarcinogenic PAHs	1.40E-07	2.46E-07
			Cadmium	2.09E-07	3.34E-07
			Mercury	2.22E-09	2.71E-09

Notes: Soil Concentrations in mg/kg (ppm)

Groundwater Concentrations₃ in mg/l (ppm)

Air Concentrations in mg/m³ (ppb)

- 1 Exposure point concentrations for the inhalation route are reported for only those compounds with CPF or RfD value for the inhalation route.
- 2 Compound undetected in GW-7S. However, since compound detected in other onsite wells, value of one-half the detection limit was utilized to calculate exposure point concentration.

These values are used in the subsequent quantification of human health risks associated with the Gratwick Park site.

6.1.4 Comparison of Exposure Point Concentrations with ARARs and SCGs

This section provides a comparison between the projected baseline concentrations of indicator chemicals at their point of human exposure (Table 6-7) to federal applicable or relevant and appropriate requirements (ARARs) and New York State standards, criteria and guidance (SCGs).

Soil - No ARARs or SCGs have been identified for the indicator chemicals in soil at the Gratwick Park site.

Air - Exposure point concentrations in air were compared with recommended concentrations published in the New York State Air Guide - 1 " Guidelines For Control of Toxic Ambient Air Contaminants." None of the indicator chemical concentrations exceeded the recommended concentrations.

Surface Water - Exposure point concentrations in surface water (at the boat launch) were compared with ARARs and SCGs presented in Section 5.5. None of the indicator chemical concentrations in surface water exceeded ARARs or SCGs.

6.1.5 Estimation of Human Intake

To assess the potential adverse health effects associated with a site, the amount of human exposure to selected indicator chemicals must be determined. Human exposure is expressed in terms of intake, which is the amount of substance taken into the body per unit time. Because of the relatively long periods of time during which contaminants have been in place at the Gratwick Site, and considering the nature of this contamination and the media in which humans are exposed to it, the

concentrations of indicator chemicals at human exposure points (Table 6-7) are assumed in this study to represent chronic (i.e., long-term) levels.

The calculation of both chronic hazard and carcinogenic risk requires an estimation of lifetime average daily intake (LADI). This lifetime average daily intake represents human exposure averaged over a 70-year lifetime. In calculating LADI values for each exposure route, numerous assumptions must be made. Although these assumptions are deliberately conservative, they are intended to represent realistic, although not highly probable, values for human intake. The constants used for calculating LADI values are provided in Table 6-8. Lifetime exposures for the exposure routes described by Table 6-8 are assumed to be 70 years, since exposure is likely throughout the entire average lifetime. The following paragraphs describe how these values have been calculated for each exposure point. Actual calculations are presented in tabular form in Section 6.1.7.

- o Ingestion of Onsite Surficial Soil - The exposure route of concern involves persons inadvertently ingesting soil from the park area or shoreline area while using the site for recreational activities. The assumptions are made that an infant (age 0 to 2) would be exposed to surficial soil 1 day/week, 20 weeks per year for 2 years, that a child (age 2 to 16) would be exposed to the surficial soil 4 days/week, 30 weeks/year for 14 years, and an adult (age 18 to 70) would be exposed to the surficial soil 4 days week, 30 weeks per year for 54 years. It is further assumed that, during each exposure, both the adult and the child would ingest 100 mg of soil and the exposure would result in 100 percent adsorption of contaminants. The resulting value of LADI is 5.86E-07 kg/kg/day (Table 6-9).

- o Dermal Adsorption of Onsite Surficial Soil - The exposure route involves the same scenario as for soil ingestion. The assumptions are made an infant (age 0-2) would be exposed 1 day/week, 20

TABLE 6-8

ASSUMPTIONS USED IN CALCULATION OF LIFETIME DAILY INTAKES

	<u>Infant</u>	<u>Child</u>	<u>Adult</u>	<u>Reference</u>
Age Range (years)	0-2	2-16	16-70	1
Average Body Weight (Kg)	8.5	32	70	1,2
Total Body Surface (cm ²)	1500 ¹	7200 ¹	18,000	1
Adsorption Fraction of Soil Through Skin (%)	1.8	1.8	1.8	3
Adsorption Fraction of Airborne Particulates (%)	75	75	75	4
Adsorption Fraction of Water Through Skin (%)	12	12	12	3
Dust Adherence (Kg/cm ²)	2.77E-06	2.77E-06	2.77E-06	5
Fluxrate of water across skin (mg/cm ² /hr)	0.5	0.5	0.5	5
Average Soil Ingestion (mg/day)	100	100	100	3
Inhalation Rate (m ³ /day)	4	15	23	1

References: (1) McKone, 1987
 (2) EPA, 1986a
 (3) Hawley, 1985
 (4) Cowherd, 1985
 (5) EPA, 1986b

TABLE 6-9

CHRONIC HAZARD EVALUATION FOR INGESTION OF SURFICIAL SOIL

Indicator Chemical	RfD (mg/kg/day)	Exposure Point Concentration (mg/kg)		Chronic Hazard ¹ Index	
		Represent.	Max.	Represent.	Max.
Tetrachloroethene	1.00E-02	8.10E-03	9.60E-02	4.75E-07	5.63E-06
Phenol	6.00E-01	3.12E-01	2.10E+00	3.05E-07	5.49E-06
Noncarcinogenic PAHs	4.00E-01	4.75E+00	3.70E+01	6.96E-06	5.55E-05
Antimony	4.00E-04	1.17E+01	9.40E+01	1.71E-02	1.38E-01
Cadmium	5.00E-04	4.90E+00	2.30E+01	5.74E-03	2.70E-02
Lead	1.40E-04	6.14E+02	6.41E+03	2.57E+00	2.68E+01
Total Chronic Hazard Index				2.57E+00	2.68E+01

The assumptions are made that an infant (age 0 to 2) would be exposed to surficial soil 1 day/week, 20 weeks a year for 2 years, that a child (age 2 to 16) would be exposed to the surficial soil 4 days/week, 30 weeks/year for 14 years, and an adult (age 16 to 70) would be exposed to the surficial soil 4 days a week 30 weeks a year for 54 years. It is further assumed that during each exposure, both the adult and the child would ingest 100 mg of soil and the exposure would result in 100 percent absorption of contaminants.

Notes:

$$\begin{aligned}
 & \text{1) Chronic Hazard Index} = \frac{\text{Contaminant Concentration} \times \text{LADI}}{\text{RfD}} \\
 & \text{LADI} = \frac{\text{Soil Intake (SI) infant, SI child} + \text{SI, adult}}{(70 \text{ yrs} \times 365 \text{ days/yr})} \\
 & \text{SI} = \frac{(\text{Amount of Soil Ingested}) (\text{Absorption}) (\text{Contacts/Lifetime})}{(\text{body weight})} \\
 & \text{SI, Infant} = \frac{(1 \times 10^{-4} \text{ kg/day}) (1.0) (1 \text{ day/week} \times 20 \text{ weeks/year} \times 2 \text{ years})}{(8.5 \text{ kg})} \\
 & \text{SI} = 4.70 \times 10^{-4} \text{ kg/kg} \\
 & \text{SI, Child} = \frac{(1 \times 10^{-4} \text{ kg/day}) (1.0) (4 \text{ days/wk} \times 30 \text{ wks/yr} \times 14 \text{ yrs})}{(32 \text{ kg})} \\
 & = 5.25 \times 10^{-3} \text{ kg/kg} \\
 & \text{SI, Adult} = \frac{(1 \times 10^{-4} \text{ kg/day}) (1.0) (4 \text{ days/wk} \times 30 \text{ wks/yr} \times 54 \text{ yrs})}{(70 \text{ kg})} \\
 & = 9.26 \times 10^{-3} \text{ kg/kg} \\
 & \text{LADI} = 5.86 \times 10^{-7} \text{ kg/kg/day}
 \end{aligned}$$

weeks per year for 2 years, that a child (age 2 to 16) would be exposed to the surficial soil 4 days/week, 30 days/year for 14 years, and that an adult (age 18 to 70) would be exposed to the surficial soil 4 days per week, 30 weeks/year for 54 years. It is further assumed that both the child and adult would expose 10 percent of their body surface area, and the dust adherence would be $2.77 \text{ E-06 kg/cm}^2$. In addition, the dermal adsorption of a contaminant from soil directly applied to human skin is assumed to be 1.8 percent per day. This is based upon a combined direct skin application adsorption rate of 12 percent per day and soil matrix effect of 15 percent. The resulting LADI value is $4.00\text{E-07 kg/kg/day}$ (Table 6-10).

o Inhalation of Airborne Particulates - The exposure route of concern involves persons inhaling and ingesting airborne particulates. The assumptions are made that an infant (age 0 to 2) would be at home 100 percent of the time and be exposed to particulates from the site for 24 hours per day, and that children and adults would be at home 75 percent of the time and be exposed to particulates from the site an average of 18 hours per day. It is further assumed that respiration rates for infants, children, and adults are $4\text{m}^3/\text{day}$, $15\text{m}^3/\text{day}$, and $23\text{m}^3/\text{day}$, respectively. In addition, it is assumed that exposure results in 75 percent absorption of inhaled contaminants. Under these assumptions, the LADI is $2.05\text{E-01 m}^3/\text{kg/day}$ (Table 6-11).

o Dermal Adsorption of Shallow Groundwater (Leachate) - The exposure route of concern involves persons exposed to shallow groundwater (leachate) at the boat launch. The assumption is made that children (age 2 to 16) and adults (age 16 to 70) are exposed to shallow groundwater (leachate) 30 days per year. It is further assumed that the duration of exposure is 0.1 hours for children and 0.25 hours for adults, and that 10 percent of a child's body surface and 50 percent of an adult's body surface area would be exposed. In addition, a flux rate of 5.0 E-04

TABLE 6-10

CHRONIC HAZARD EVALUATION FOR DERMAL ABSORPTION OF SURFICIAL SOIL

Indicator Chemical	RfD (mg/kg/day)	Exposure Point Concentration (mg/kg)		Chronic Hazard ¹ Index	
		Represent.	Max.	Represent.	Max.
Tetrachloroethene	1.00E-02	8.10E-03	9.60E-02	3.24E-07	3.84E-06
Phenol	6.00E-01	3.12E-01	2.10E+00	2.08E-07	1.40E-06
Noncarcinogenic PAHs	4.00E-01	4.75E+00	3.79E+01	4.75E-06	3.79E-05
Antimony	4.00E-04	1.17E+01	9.40E+01	1.17E-02	9.40E-02
Cadmium	5.00E-04	4.90E+00	2.30E+01	3.92E-03	1.84E-02
Lead	1.40E-04	6.14E+02	6.41E+03	1.75E+00	1.83E+01
Total Chronic Hazard Index				1.75E+00	1.83E+01

The assumptions are made that an infant (age 0 to 2) would be exposed to surficial soil 1 day/week, 20 weeks/year for 2 years, that a child (age 2 to 16) would be exposed to the surficial soil 4 days/week, 30 weeks/year for 14 years, and an adult (age 16 to 70) would be exposed to the surficial soil 4 days/week, 30 weeks/year for 54 years. It is further assumed that during each exposure, both the adult and the child would expose 10 percent of their body surface area and that dust adherence would be 2.77×10^{-6} kg/cm². In addition, the dermal adsorption of a contaminant from soil directly applied to human skin is assumed to be 1.8 percent per day.

Notes:

$$1) \text{ Chronic Hazard Index} = \frac{\text{Contaminant Concentration} \times \text{LADI}}{\text{RfD}}$$

$$\text{LADI} = \frac{\text{Dermal Absorption (DA) infant, DA child + DA, adult}}{(70 \text{ yrs} \times 365 \text{ days/yr})}$$

$$= \frac{(\text{Exposed Body Surface Area}) (\text{Dust Adherence}) (\text{Absorption})}{(\text{Contact/Lifetime})}$$

$$\text{DA, Infant} = \frac{(150 \text{ cm}^2) (2.77 \times 10^{-6} \text{ kg/cm}^2) (0.018/\text{day}) (1 \text{ day/wk} \times 20 \text{ wks/yr} \times 2 \text{ yr})}{(8.5 \text{ kg})}$$

$$= 3.52 \times 10^{-5} \text{ kg/kg}$$

$$\text{DA, Child} = \frac{(720 \text{ cm}^2) (2.77 \times 10^{-6} \text{ kg/cm}^2) (0.018/\text{day}) (4 \text{ days/wk})}{(30 \text{ wks/yr} \times 14 \text{ yrs})}$$

$$= 1.88 \times 10^{-3} \text{ kg/kg}$$

$$\text{DA, Adult} = \frac{(1800 \text{ cm}^2) (2.77 \times 10^{-6} \text{ kg/cm}^2) (0.018/\text{day}) (4 \text{ days/wk} \times 30 \text{ weeks/yr} \times 54 \text{ yrs})}{(70 \text{ kg})}$$

$$= 8.31 \times 10^{-3} \text{ kg/kg}$$

$$\text{LADI} = 4.00 \times 10^{-7} \text{ kg/kg/day}$$

TABLE 6-11

CHRONIC HAZARD EVALUATION FOR INHALATION OF AIRBORNE PARTICULATES

Indicator Chemical	RfD (mg/kg/day) ⁻¹	Exposure Point Concentration (mg/m ³)		Chronic Hazard Index ¹	
		Represent.	Max.	Represent.	Max.
Cadmium	5.00E-04	1.94E-09	9.10E-09	7.95E-07	3.73E-06
Lead	4.30E-04	2.42E-07	2.54E-06	1.15E-04	1.21E-03
Total Chronic Hazard Index				1.15E-04	1.21E-03

The assumption is made that an infant (age 0 to 2) would be exposed to airborne contaminants for 24 hours per day and that children (age 2 to 16) and adults (age 18 to 70) would be exposed to airborne contaminants for 18 hours per day. It is further assumed that respiration rates for infants, children, and adults are 4m³/day, 15m³/day, and 23m³/day, respectively. In addition, it is assumed that 75 percent of inhaled contaminants are absorbed.

Notes:

$$1) \text{ Chronic Hazard Index} = \frac{\text{Contaminant Concentration} \times \text{LADI}}{\text{RfD}}$$

$$\text{LADI} = \frac{\text{Air Intake (AI), infant} + \text{(AI), child} + \text{(AI), adult}}{(70 \text{ yrs} \times 365 \text{ days/yr})}$$

$$\text{AI} = \frac{\text{Respiration Rate} \times \text{Absorption Fraction} \times \text{Exposure Duration}}{\text{body weight}}$$

$$\text{AI, Infant} = \frac{4\text{m}^3/\text{day} \times 0.75 \times 24 \text{ hrs}/24 \text{ hrs} \times 365 \text{ days/yr} \times 2 \text{ yrs}}{8.5 \text{ kg}}$$

$$= 2.58 \times 10^2 \text{ m}^3/\text{kg}$$

$$\text{AI, Child} = \frac{15\text{m}^3/\text{day} \times 0.75 \times 18 \text{ hrs}/24 \text{ hrs} \times 365 \text{ days/yr} \times 14 \text{ yrs}}{32 \text{ kg}}$$

$$= 1.35 \times 10^3 \text{ m}^3/\text{kg}$$

$$\text{AI, Adult} = \frac{23\text{m}^3/\text{day} \times 0.75 \times 18 \text{ hrs}/24 \text{ hrs} \times 365 \text{ days/yr} \times 54 \text{ yrs}}{70 \text{ kg}}$$

$$= 3.64 \times 10^3 \text{ m}^3/\text{kg}$$

$$\text{LADI} = 2.05 \times 10^{-1} \text{ m}^3/\text{kg}$$

kg/cm²/hr and an adsorption rate of 12 percent were assumed. Under these assumptions, that LAD1 is 1.24 E-04 kg/kg/day (Table 6-12).

6.1.6 Toxicity Assessment of Indicator Chemicals

A toxicity assessment describing the nature and extent of potential health hazards that may be associated with the selected indicator chemicals at the Gratwick site through the exposure routes identified in Section 6.1.1 is presented in Appendix F. Appendix F contains information obtained from the following references on human health effects and dose-response assessments for the contaminants of concern: Merck, 1976; Sax, 1984; Sax, 1987; Howard, 1989; USEPA, 1984 a,b,c; NYS, 1987; and Clayton and Clayton, 1981.

6.1.7 Human Risk Characterization

This section describes the quantification of chronic hazards and carcinogenic risk associated with contaminants at the Gratwick Park site. The method, as described below, involves a comparison between projected intakes and acceptable chronic intakes for noncarcinogens, and between calculated risks and target risks for potential carcinogens.

6.1.7.1 Noncarcinogenic Risk Characterization

Noncarcinogenic effects are described using a hazard index approach. The hazard index for chronic exposure to toxic chemicals via each exposure route is calculated by the following equation:

$$HI = (C_1) \frac{(LADI)}{(Rfd)_1} + (C_2) \frac{(LADI)}{(Rfd)_2} + \dots + \frac{(C_i) (LADI)}{(Rfd)_i}$$

Where: HI = Hazard Index

C_i = Concentration of Contaminant "i"

TABLE 6-12

CHRONIC HAZARD INDEX FOR DERMAL ABSORPTION OF
SHALLOW GROUNDWATER (LEACHATE)

Indicator Chemical	RfD (mg/kg/day)	Exposure Point Concentration (mg/m ⁻³)		Chronic Hazard Index ¹	
		Represent.	Max.	Represent.	Max.
1,1 Dichloroethane	1.00E-01	1.44E-06	2.88E-06	1.79E-09	3.57E-09
Chloroform	1.00E-02	2.05E-08	2.05E-08	2.54E-10	2.54E-10
2-Butanone	5.00E-02	1.27E-05	6.91E-05	3.15E-08	1.71E-07
Tetrachloroethene	1.00E-02	2.20E-07	4.60E-07	2.73E-09	5.70E-09
Chlorobenzene	3.00E-02	2.05E-08	2.05E-08	8.47E-11	8.47E-11
Phenol	6.00E-01	2.42E-05	4.76E-05	5.00E-09	9.84E-09
Noncarcinogenic PAHs	4.00E-01	1.40E-07	2.46E-07	4.34E-11	7.63E-11
Cadmium	5.00E-04	2.09E-07	3.34E-07	5.18E-08	8.28E-08
Mercury	3.00E-04	2.22E-09	2.71E-09	9.18E-10	1.12E-09
Total Chronic Hazard Index				9.41E-08	2.74E-07

Notes:

$$1) \text{ Chronic Hazard Index} = \frac{\text{Contaminant Concentration} \times \text{LADI}}{\text{RfD}}$$

$$\text{LADI} = \frac{\text{Dermal Absorption (DA) child} \times \text{DA, adult}}{(70 \text{ yrs} \times 365 \text{ days/yr})}$$

$$\text{DA} = \frac{(\text{Exposed Surface Area})(\text{Flux})(\text{Duration of Exposure})(\text{Absorption})}{(\text{Body Weight})}$$

$$\text{DA, child} = \frac{(720 \text{ cm}^2)(5.0 \times 10^{-4} \text{ kg/cm}^2/\text{hr})(30 \text{ days/year} \times 0.10 \text{ hr/day} \times 14 \text{ yrs})(0.12)}{(32 \text{ kg})}$$

$$= 5.67 \times 10^{-2}$$

$$\text{DA, Adult} = \frac{(9,000 \text{ cm}^2)(5.0 \times 10^{-4} \text{ kg/cm}^2/\text{hr})(30 \text{ days/year} \times 0.25 \text{ hr/day} \times 54 \text{ yrs})(0.12)}{(70 \text{ kg})}$$

$$= 3.12 \text{ kg/kg}$$

$$\text{LADI} = 1.24 \times 10^{-4} \text{ kg/kg/day}$$

LADI = Lifetime Average Daily Intake of
Contaminant "i"

RfD = Reference Dose (Acceptable Chronic Intake)

The hazard index is not a mathematic prediction of incidence or severity of effects, but rather a simple numerical index to help identify potential exposure problems. When the index exceeds unity, there may be a concern for human health. It should be noted that this index is conservative, in that it assumes additivity of multiple sub-threshold exposures to different chemical compounds (which in reality may induce different effects by different mechanisms).

Tables 6-9 through 6-12 indicate values of the chronic hazard index for routes which involve human exposure to noncarcinogenic indicator chemicals. Calculations for LADI, which were described in Section 6.1.5, are presented on these tables, along with the exposure point concentrations which were summarized in Table 6-7. Separate hazard indices have been calculated corresponding to representative and maximum exposure point concentrations. The chronic hazard indices are summarized on Table 6-13.

As shown on Table 6-13, the chronic hazard index for all exposure rates is above unity indicating that there may be a potential exposure problem from noncarcinogens. It should be noted that 100 percent of the total chronic hazard results from exposure to lead in surficial soil via ingestion and dermal absorption. It should be noted further that lead in soil is a concern since blood levels in children appear to increase above background blood levels when lead in residential soil or dust exceeds 500 ppm. (Lead has been identified in two surface soil samples above 500 ppm.)

TABLE 6-13

SUMMARY OF CHRONIC HAZARD INDICES FOR THE GRATWICK PARK SITE

<u>Exposure Route</u>	Chronic Hazard Index	
	<u>Representative</u>	<u>Maximum</u>
Ingestion of Surficial Soil	2.57E+00	2.68E+01
Dermal Absorption of Surficial Soil	1.75E+00	1.83E+01
Inhalation of Airborne Particulates	1.15E-04	1.21E-03
Dermal Absorption of Shallow Groundwater (Leachate)	<u>9.41E-08</u>	<u>2.74E-07</u>
Total Chronic Hazard Index	4.32E+00	4.51E+01

6.1.7.2 Potential Carcinogenic Effects

Potential carcinogenic risks are calculated using a non-threshold model. This model utilizes the following equation to determine incremental cancer risks for each exposure route:

$$\text{Risk} = (\text{CPF}_1)(C_1)(\text{LADI}) + (\text{CPF}_2)(C_2)(\text{LADI}) + \dots + (\text{CPF}_i)(C_i)(\text{LADI})$$

Where, Risk = Incremental risk of incurring cancer as a result of exposure to Gratwick Park contaminants via exposure route under consideration.

$\text{CPF}_i(Q_i^*)$ = Carcinogenic Potency Factor of contaminants "i", which is an upper 95 percent confidence limit on the probability of response per unit intake of a chemical over a lifetime.

C_i = Concentration of Contaminant "i"

LADI = Lifetime Average Daily Intake of Contaminant "i"

Tables 6-14 through 6-17 present incremental carcinogenic risks for exposure routes (Figure 6-1) which involve human exposure to potentially carcinogenic chemicals. Table for 6-18 summarizes the risks from all exposure routes.

As indicated on Table 6-18, potential carcinogenic risks for the Gratwick site are significant when compared to the commonly used benchmark of $1.0\text{E}-06$ (i.e., one excess cancer death per one million population). When representative concentrations (i.e., the arithmetic mean concentrations of appropriate samples) are used, the carcinogenic risk is slightly under two orders of magnitude greater than $1.0\text{E}-06$ (viz., $64.9\text{E}-06$ or $6.49\text{E}-05$). When worst-case concentrations (i.e., maximum

TABLE 6-14

CARCINOGENIC RISK FOR INGESTION OF SURFICIAL SOIL

Indicator Chemical	CPF (mg/kg/day) ⁻¹	Exposure Point Concentration (mg/kg)		Risk ¹	
		Represent.	Max.	Represent.	Max.
Trichloroethene	1.10E-02	3.00E-03	1.30E-02	1.93E-11	8.38E-11
Tetrachloroethene	5.10E-02	8.10E-03	9.60E-02	2.42E-10	2.87E-09
Carcinogenic PAHs	1.15E+01	5.37E+00	5.69E+01	3.61E-05	3.83E-04
PCBs	7.70E+00	3.04E-01	7.20E+00	1.37E-06	3.25E-05
Hexochlorinated Dibenzofuran	1.56E+03	9.00E-04	6.48E-03	8.23E-07	5.92E-06
Heptachlorinated Dibenzofuran	1.56E+02	1.74E-03	2.07E-02	1.59E-07	1.89E-06
Total Risk				3.85E-05	4.23E-04

The assumptions are made that an infant (age 0 to 2) would be exposed to surficial soil 1 day/week, 20 weeks/yr for 2 years, that a child (age 2 to 16) would be exposed to the surficial soil 2 days/week, 30 weeks/year for 13 years, and an adult (age 18 to 70) would be exposed to the surficial soil 4 days a week, 30 weeks/year for 54 years. It is further assumed that during each exposure both the adult and child would ingest 100 mg of soil and the exposure would result in 100 percent absorption of contaminants.

Notes:

- 1) Risk = CPF x Contaminant Concentration x Lifetime Average Daily Intake (LADI)

$$\text{LADI} = \frac{\text{Soil Intake (SI) Infant, (SI) child} + \text{(SI), adult}}{(70 \text{ yrs} \times 365 \text{ days/yr})}$$

$$\text{SI} = \frac{(\text{Amount of Soil Ingested}) (\text{Absorption}) (\text{Contacts/Lifetime})}{(\text{body weight})}$$

$$\text{SI, Infant} = \frac{(1 \times 10^{-4} \text{ kg/day}) (1.0) (1 \text{ day/wk} \times 20 \text{ wks/yr} \times 2 \text{ years})}{(8.5 \text{ kg})}$$

$$\text{SI} = 4.70 \times 10^{-4} \text{ kg/kg}$$

$$\text{SI, Child} = \frac{(1 \times 10^{-4} \text{ kg/day}) (1.0) (4 \text{ days/wk} \times 30 \text{ days/yr} \times 14 \text{ yrs})}{(32 \text{ kg})}$$

$$= 5.25 \times 10^{-3} \text{ kg/kg}$$

$$\text{SI, Adult} = \frac{(1 \times 10^{-4} \text{ kg/day}) (1.0) (4 \text{ days/wk} \times 30 \text{ wks/yr} \times 54 \text{ yrs})}{(70 \text{ kg})}$$

$$= 9.26 \times 10^{-3} \text{ kg/kg}$$

$$\text{LADI} = 5.86 \times 10^{-7} \text{ kg/kg/day}$$

TABLE 6-15

CARCINOGENIC RISK FOR DERMAL ABSORPTION OF SURFICIAL SOIL

Indicator Chemical	CPF (mg/kg/day) ⁻¹	Exposure Point Concentration (mg/kg)		Risk ¹	
		Represent.	Max.	Represent.	Max.
Trichloroethane	1.10E-02	3.00E-03	1.30E-02	1.32E-11	5.72E-11
Tetrachloroethene	5.10E-02	8.10E-03	9.60E-02	1.65E-10	1.96E-09
Carcinogenic PAHs	1.15E+01	5.37E+00	5.69E+01	2.47E-05	2.62E-04
PCBs	7.70E+00	3.04E-01	7.20E+00	1.05E-06	2.22E-05
Hexachlorinated Dibenzofuran	1.56E+03	9.00E-04	6.48E-03	5.62E-07	4.04E-06
Heptachlorinated Dibenzofuran	1.56E+02	1.74E-03	2.07E-02	1.09E-07	1.29E-06
Total Risk				2.64E-05	2.90E-04

The assumptions are made that an infant (age 0 to 2) would be exposed to surficial soil 1 day/week, 20 weeks/year for 2 years, that a child (age 2 to 16) would be exposed to the surficial soil 4 days/week, 30 weeks/year for 14 years, and an adult (age 18 to 70) would be exposed to the surficial soil 4 days/week, 30 weeks/year for 54 years. It is further assumed that both the child and adult would expose 10 percent of their body surface area and that dust adherence would be $2.77\text{E-}06\text{ kg/cm}^2$. In addition, the dermal absorption of a contaminant from soil directly applied to human skin is assumed to be 1.8 percent per day.

Notes:

1) Risk = CPF x Contaminant Concentration x Lifetime Average Daily Intake (LADI)

$$\begin{aligned}
 \text{LADI} &= \frac{\text{Dermal Absorption (DA) Infant, DA child + DA, adult}}{(70 \text{ yrs} \times 365 \text{ days/yr})} \\
 \text{DAI} &= \frac{(\text{Exposed Body Surface Area}) (\text{Dust Adherence}) (\text{Absorption})}{(\text{Contacts/Lifetime}) (\text{body weight})} \\
 \text{DA, Infant} &= \frac{(150\text{cm}^2) (2.77 \times 10^{-6} \text{ kg/cm}^2) (0.018/\text{day}) (1 \text{ day/wk} \times 20 \text{ weeks/yr} \times 2 \text{ yr})}{8.5 \text{ kg}} \\
 &= \frac{3.52 \times 10^{-5} \text{ kg/kg}}{(720 \text{ cm}^2) (2.77 \times 10^{-6} \text{ kg/cm}^2) (0.018/\text{day}) (4 \text{ days/wk} \times 30 \text{ wks} \times 14 \text{ yrs})} \\
 \text{DA, Child} &= \frac{1.88 \times 10^{-3} \text{ kg/kg}}{(38 \text{ kg})} \\
 &= \frac{1.88 \times 10^{-3} \text{ kg/kg}}{(1800 \text{ cm}^2) (2.77 \times 10^{-6} \text{ kg/cm}^2) (0.018/\text{day}) (10 \text{ days/yr} \times 52 \text{ yrs})} \\
 \text{DA, Adult} &= \frac{8.31 \times 10^{-3} \text{ kg/kg}}{(70 \text{ kg})} \\
 \text{LADI} &= 4.00 \times 10^{-7} \text{ kg/kg/day}
 \end{aligned}$$

TABLE 6-16

CARCINOGENIC RISK FOR INHALATION OF AIRBORNE PARTICULATES

Indicator Chemical	CPF (mg/kg/day) ⁻¹	Exposure Point Concentration (mg/m ³)		Risk ¹	
		Represent.	Max.	Represent.	Max.
Trichloroethene	1.30E-02	9.42E-13	2.90E-11	2.51E-15	7.72E-14
Tetrachloroethene	3.30E-03	3.20E-12	8.28E-10	2.16E-15	5.60E-13
Carcinogenic PAHS	6.10E+00	2.12E-09	2.25E-08	2.65E-09	2.81E-08
Hexachlorinated Dibenzofuran	1.56E+03	3.56E-13	2.56E-12	1.13E-10	8.19E-10
Heptachlorinated Dibenzofuran	1.56E+02	6.78E-13	8.11E-12	2.17E-11	2.59E-10
Total Risk				2.78E-09	2.92E-08

The assumption is made that an infant (age 0 to 2) would be exposed to airborne contaminants for 24 hours per day and that children (age 2 to 16) and adults (age 18 to 70) would be exposed to airborne contaminants for 18 hours per day. It is further assumed that respiration rates for infants, children, and adults are 4m³/day, 15m³/day, and 23m³/day, respectively. In addition, it is assumed that 75 percent of inhaled contaminants are absorbed.

Notes:

1) Risk = CPF x Contaminant Concentration x LADI

$$\text{LADI} = \frac{\text{Air Intake (AI), infant + child, + adult}}{(70 \text{ yrs} \times 365 \text{ days/yr})}$$

$$\text{AI} = \frac{\text{Respiration Rate} \times \text{Absorption Fraction} \times \text{Exposure Duration}}{\text{body weight}}$$

$$\text{AI, Infant} = \frac{4\text{m}^3/\text{day} \times 0.75 \times 24 \text{ hrs}/24 \text{ hrs} \times 365 \text{ days/yr} \times 2 \text{ yrs}}{8.5 \text{ kg}}$$

$$= 2.58 \times 10^{-2} \text{ m}^3/\text{kg}$$

$$\text{AI, Child} = \frac{15\text{m}^3/\text{day} \times 0.75 \times 18 \text{ hrs}/24 \text{ hrs} \times 365 \text{ days/yr} \times 14 \text{ yrs}}{32 \text{ kg}}$$

$$= 1.35 \times 10^{-3} \text{ m}^3/\text{kg}$$

$$\text{AI, Adult} = \frac{23\text{m}^3/\text{day} \times 0.75 \times 18 \text{ hrs}/\text{day} \times 365 \text{ days/yr} \times 54 \text{ yrs}}{70 \text{ kg}}$$

$$= 3.64 \times 10^{-3} \text{ m}^3/\text{kg}$$

$$\text{LADI} = 2.05 \times 10^{-1} \text{ m}^3/\text{kg}$$

TABLE 6-17

CARCINOGENIC RISK FOR DERMAL ABSORPTION OF
SHALLOW GROUNDWATER (LEACHATE)

Indicator Chemical	CPF (mg/kg/day) ⁻¹	Exposure Point Concentration (mg/m ³)		Risk ¹	
		Represent.	Max.	Represent.	Max.
Vinyl Chloride	2.30E+00	4.92E-08	6.61E-08	1.40E-11	1.89E-11
1,1 Dichloroethane	9.10E-02	1.44E-06	2.88E-06	1.62E-11	3.25E-11
Chloroform	6.10E-03	2.05E-08	2.05E-08	1.55E-14	1.55E-14
Trichloroethene	1.10E-02	5.07E-06	7.55E-06	6.92E-12	1.03E-11
Benzene	2.90E-02	5.72E-07	8.05E-07	2.06E-12	2.91E-12
Tetrachloroethene	5.10E-02	2.20E-07	4.60E-07	1.39E-12	2.91E-12
Total Risk				4.06E-11	7.00E-11

Notes:

The assumption is made that children (age 2 to 16) and adults (age 16 to 70) are exposed to shallow groundwater (leachate) 30 days per year. It is further assumed that the duration of exposure is 0.1 hour for children and 0.25 hours for adults, and that 10 percent of a child's body surface and 50 percent of an adult's body surface area would be exposed. In addition, a flux rate of 5.0E-04 ug/cm²/hr and an absorption rate of 12 percent were assumed.

- 1) Risk = CPF x Contaminant Concentration x Lifetime Average daily Intake (LADI)

$$\text{LADI} = \frac{\text{Dermal Absorption (DA), Child} + \text{DA, Adult}}{(70 \text{ ys} \times 365 \text{ days/yr})}$$

$$\text{DA} = \frac{(\text{Exposed Surface Area})(\text{Flux})(\text{Duration of Exposure})(\text{Absorption})}{(\text{Body Weight})}$$

$$\text{DA, Child} = \frac{(720\text{cm}^2)(5.0 \times 10^{-4}\text{kg/cm}^2/\text{hr})(30\text{days/yr} \times 0.10\text{hr/day} \times 14\text{years})(0.12)}{(70 \text{ kg})}$$

$$= 5.67 \times 10^{-2}\text{kg/kg/day}$$

$$\text{DA, Adult} = \frac{(9,000 \text{ cm}^2)(5.0 \times 10^{-4}\text{kg/cm}^2/\text{hr})(30\text{days/yr} \times 0.25\text{hr/day} \times 54\text{yrs})(0.12)}{(70 \text{ kg})}$$

$$= 3.12 \text{ kg/kg}$$

$$\text{LADI} = 1.24 \times 10^{-4} \text{ kg/kg/day}$$

TABLE 6-18

TOTAL BASELINE CARCINOGENIC RISKS FOR GRATWICK PARK SITE

<u>Exposure Route</u>	Carcinogenic Risk x 10 ⁻⁶	
	<u>Representative</u>	<u>Maximum</u>
Ingestion of Surficial Soil	38.5	423
Dermal Absorption of Surficial Soil	26.4	290
Inhalation of Airborne Particulates	0.00278	0.0292
Dermal Absorption of Shallow Groundwater (Leachate)	0.0000406	0.0000700
Total Incremental Risk	64.9E-06	713E-06

concentrations of appropriate samples) are used, the carcinogenic risk is over two orders of magnitude greater than $1.0\text{E-}06$ (viz., $713\text{E-}06$ or $7.13\text{E-}04$). As shown on Table 6-18, 100 percent of the carcinogenic risk results from direct exposure to surficial and shoreline soil during recreational activities. Under both representative and worst-case conditions, 59 percent of the risk results from soil ingestion and 41 percent results from dermal contact. The uncertainties associated with assumptions utilized for evaluating risk associated with exposure to surficial soil, as well as other media, are discussed in the following section.

6.1.8 Uncertainty Analysis

Estimating exposure to toxicants from contaminated sites is not a precise science. The estimates of chronic hazard index and carcinogenic risk in the baseline risk assessment are based on numerous assumptions, and therefore, involve a considerable degree of uncertainty. Uncertainty is inherent in the risk assessment process because of the current limits of scientific knowledge regarding human health risk factors. For example extrapolation of animal study data to humans and extrapolation from the high doses used in animal studies to low doses associated with most contaminated sites introduces uncertainty. A large degree of uncertainty also results from estimating the fate and transport of contaminants based on simplified models of complex environmental systems. In addition, exposure estimates are sensitive to assumptions made regarding the population at risk. Estimating human exposure and human intake is largely judgmental, and involves characterization of human behavioral patterns which cannot be defined with precision, particularly when behavioral patterns must be approximated into the relatively distant future, i.e. 70 years. Physiology, as behavior of individuals, within a population at risk also varies widely. In general, conservative assumptions are made to protect those individuals whose behavior results in above average exposure. In order to develop reasonable assessment of risk while insuring protection of individuals whose behavior results in

above average exposure, this assessment has adopted the concept of "reasonable worst case", i.e. the exposure scenarios evaluated have some, though not highly probable, chance of occurrence in the real world. Consequently, assumptions are generally conservative although the assumptions must have some basis in reality. Some of the major assumptions made in this assessment are listed below:

1. Concentrations of contaminants in surficial soil, particularly PAHs are attributable to the site.
2. Concentrations of contaminants in airborne particulates may be approximated by utilizing the Cowherd model.
3. The concentration of indoor and outdoor airborne particulates are equal.
4. There is no anticipated exposure to subsurface soil.
5. The toxicity of carcinogenic and non-carcinogenic PAHs may be approximated by a known value for one compound in each class. In addition, concentrations of each compound in a group may be added.
6. The population at risk will be frequently exposed to contaminants in surficial soil for a full lifetime (70 years).
7. Ingestion of contaminants via soil results in 100 percent absorption.

The assumptions listed above are grouped into categories and discussed below:

o Assumptions regarding exposure point concentrations - Assumptions 1 through 4 concern estimation of exposure point concentrations. In general, assumptions 1, and 3 are conservative, whereas, assumptions 2 and 4 could possibly result in under or over estimation of risk.

As discussed in Section 5.0, three offsite surficial soil samples were collected during the RI. Two of these samples, i.e. 001 and 003, were not considered to be representative of natural background. These samples were not considered background because evidence suggested that the contaminants detected in these samples may have been attributable to previous construction activities (i.e. placement of man-made fill) or previous railroad operations. A number of PAHs were detected in samples 001 and 003. The PAHs were detected in significantly greater concentrations in onsite samples than the offsite samples; however, if samples 001 and 003 were considered background samples, none of the carcinogenic PAHs detected in surficial soil would be considered a contaminant attributable to the site by the criteria established in Section 5.0 (i.e. mean contaminant concentration in onsite samples must be an order of magnitude greater than mean concentration of contaminated background samples). If the carcinogenic PAHs are not considered contaminants of concern, the total carcinogenic risk associated with the assessed exposure pathways at the site would be reduced by almost two orders of magnitude. If background concentrations based on inclusion of samples 001 and 003 are subtracted from onsite concentrations, carcinogenic risk under representative conditions would be reduced by 25 percent and carcinogenic risk under worst case conditions would be reduced by 6 percent. Although the approach described above may be considered conservative, the likelihood of frequent direct human contact with surficial contaminants, because the site is a public park, and the prevalence of PAHs in onsite soil justifies the conservative assessment of exposure to surficial soil contamination.

The assumption that indoor and outdoor concentrations of airborne particulates will be similar is also conservative. In actuality, indoor concentrations are expected to be somewhat lower than outdoor concentrations. However, analysis indicates that exposure to airborne contaminants is insignificant in comparison to other routes of exposure. Consequently, this conservative assumption has little impact on the overall assessment of risk.

The Cowherd model was utilized to evaluate risk associated with airborne particulates. This model was designed for use by field personnel to quickly make "a first cut, order of magnitude estimate" of the contamination and exposure resulting from a waste site or chemical spill, within the 24-hour emergency response time frame. Since the model was designed for rapid assessment, the model is based on many conservative assumptions that may overestimate risk. However, the rapid assessment does not provide estimates of contaminant concentrations at distances less than 200 meters from the source, and therefore, contaminant concentrations are underestimated for receptors located closer to the site. It is not known which of these factors more greatly influences the health risk assessment; therefore, risk could be over or underestimated. However, similar to assumption 3, the uncertainty is inconsequential since the risk associated with airborne particulates is insignificant in comparison to other routes of exposure.

Only surficial soil samples were utilized to characterize exposure to soil contaminants. These soil samples were taken to a depth of approximately 12 to 18 inches. Depending on the occurrence of flooding and erosion, subsurface and or fill material could be exposed with higher or lower concentrations of contaminants. However, based on current data, utilizing surface soil data to evaluate exposure is realistic.

o Assumption regarding contaminant toxicity - Assumption 5 concerns the toxicity of PAHs. For the purpose of this report, the

carcinogenic potency of all potential carcinogenic PAHs was assumed to be that of benzo(a)pyrene and the toxicity of noncarcinogenic PAHs was assumed to be that of naphthalene since these values are the only reported values for PAHs. It was further assumed that the effects of the PAHs are additive and that noncarcinogenic PAHs do not contribute to carcinogenic effects of the mixture. Although these assumptions may oversimplify the toxic properties and interactions of PAHs, the prevalence of PAHs at the site and the significance of risk associated with PAHs seems to justify this conservative approach.

o Assumptions regarding human intake - Assumptions 6 and 7 concern estimation of human intake. In general, these assumptions may be considered conservative yet realistic.

In general, young children are considered to be at the greatest risk for exposure to contaminated surficial soil through ingestion or dermal contact. In the preceding evaluation, conservative assumptions were made regarding the frequency of contact with contaminated surficial soil for older children and adults. In addition exposure during infancy to surficial soil contaminants was also considered. However, assumptions regarding full-lifetime exposure to surficial soil contamination and the greater frequency of exposure to contamination among older children and adults is justified since the site is a public park that is frequently used by individuals of all ages for recreational activities where exposure to surficial contamination is likely.

The assumption that 100 percent of contaminants are absorbed from ingested soil is conservative. Certainly, risk is not underestimated based on this assumption since this is the maximum possible absorption. However, relative non-availability of data and the probable variability of absorptive capacity in the population at risk justifies the conservative approach.

Because of the uncertainties cited above, the results of the baseline public health evaluation should not be taken as a characterization of absolute risk. Rather, it is intended to identify the types and approximate levels of risk associated with various potential exposure routes at the Gratwick Park site, so that remedial efforts can focus upon those aspects of the site which are of greatest concern from a human health standpoint.

6.2 Environmental Assessment

The primary potential environmental impact of the Gratwick Park site is upon the Niagara River which is adjacent to the site. The River is a major natural resource that serves as a drinking water supply source for numerous communities. It is used extensively for recreation, and it is ecologically important for its diverse value to fish and wildlife.

Contaminants from the site are discharged to the river via groundwater and via erosion of shoreline and surficial soil. Based on data collected during the RI, it is estimated that about 2.6 lb/day of HSL organic compounds and 2.0 lb/day of total metals are discharged to the Niagara River through groundwater emanating from the site. In addition to groundwater discharge, erosion of surficial and shoreline soil is of concern since PAHs (range 50 to 18,000 ppb) were detected in surficial and shoreline soil. No estimates of soil loading to the Niagara River have been calculated; however, the contamination from these sources is of concern since PAHs and dioxins are highly toxic materials and are potential carcinogens with high potency factors.

The total impact of the Gratwick site upon the Niagara River and the subsequent impact upon humans, fish or wildlife is beyond the scope of this study. However, this information may be of importance to other parties involved in studying the overall quality of the Niagara River.

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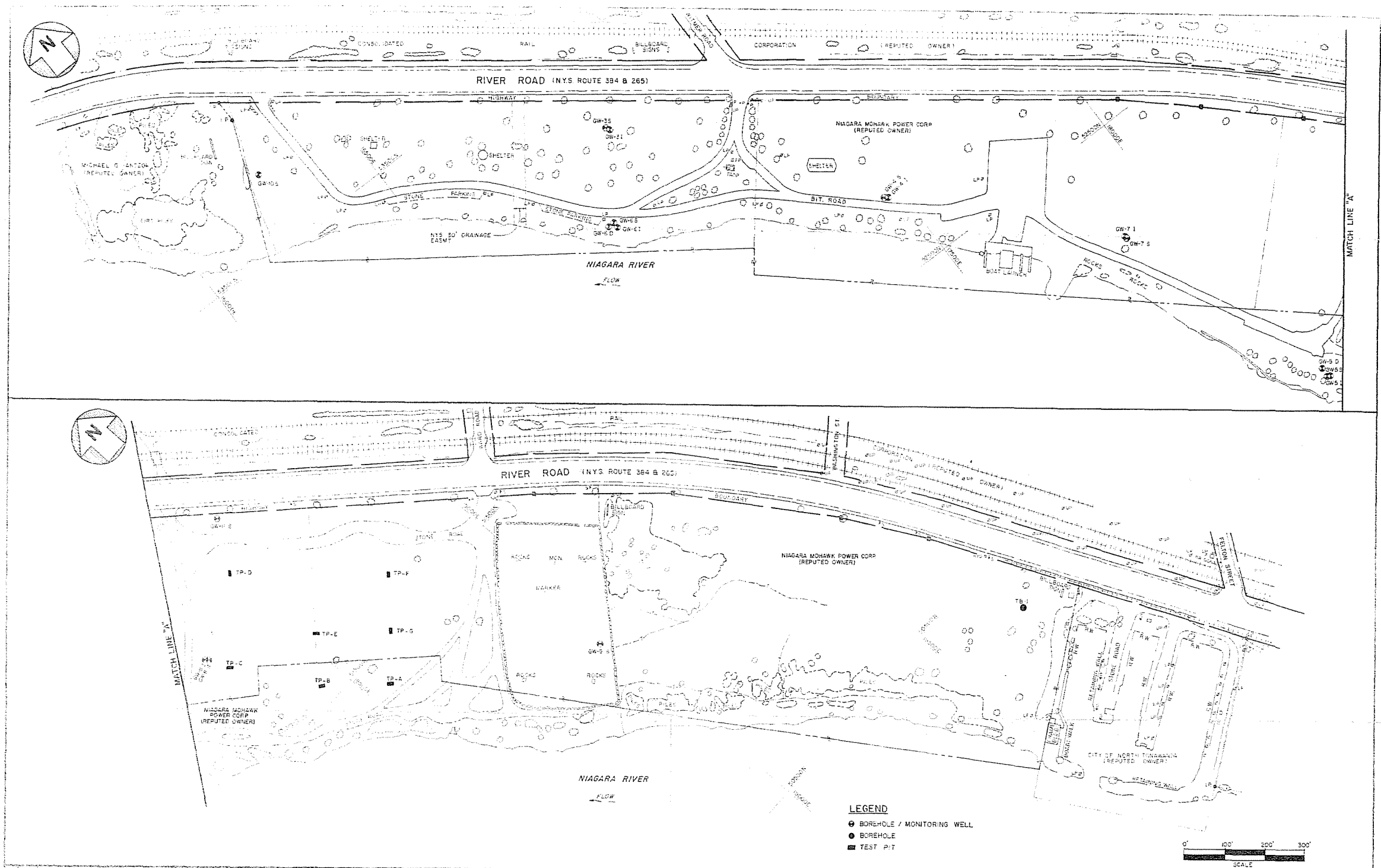
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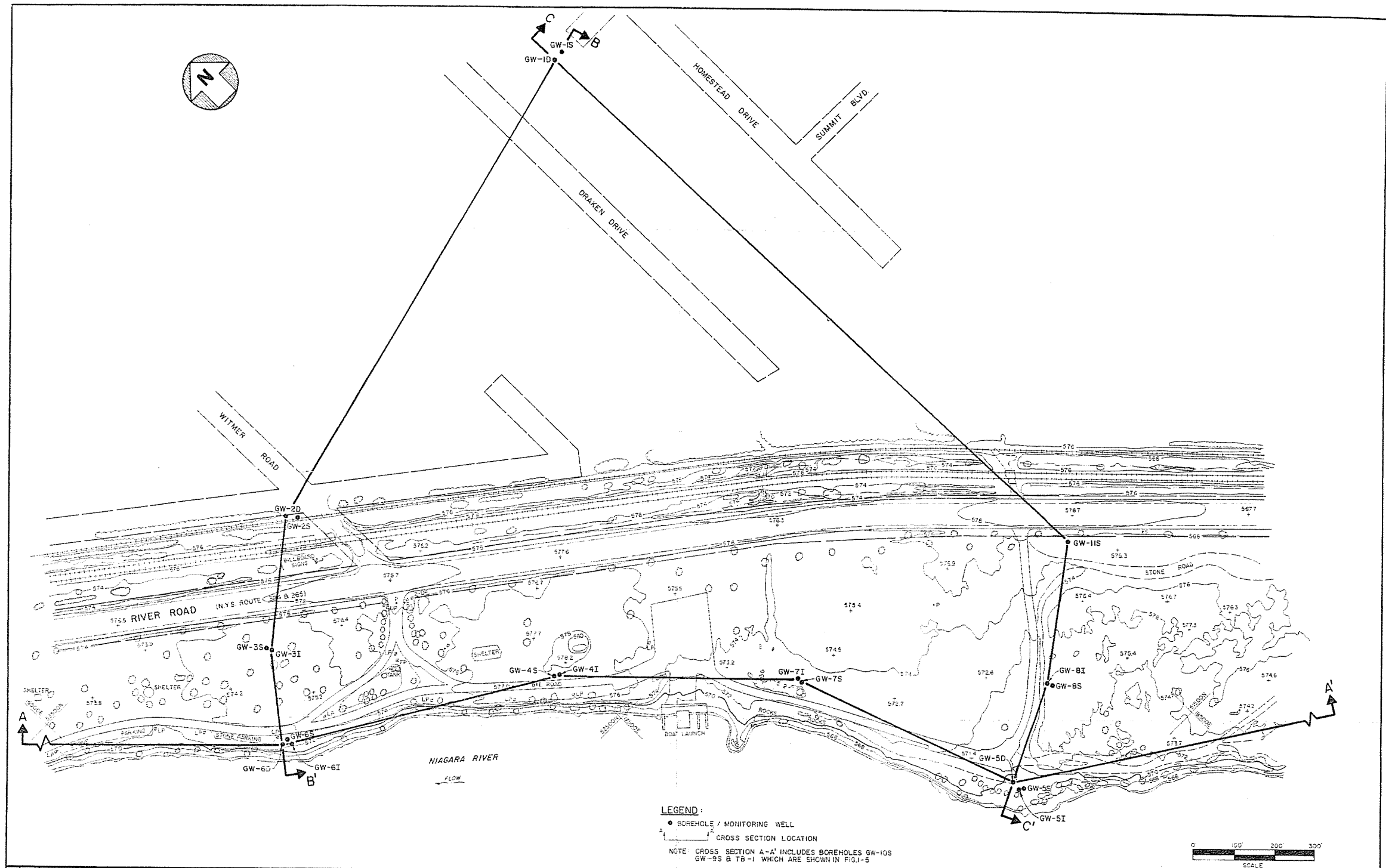


NOTE :
BOREHOLE / MONITORING WELLS GW-1S,
GW-1D, GW-2S AND GW-2D LOCATED
OFFSITE TO EAST (SHOWN ON FIGURE 4-3)

GRATWICK RIVERSIDE PARK
CITY OF NORTH TONAWANDA

SITE PLAN
ONSITE BOREHOLE
MONITORING WELL LOCATIONS

FIGURE 1-5



NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION
REVISIONS					

DESIGNED BY: G.H.F.
 DRAWN BY: R.A.L.
 CHECKED BY: G.H.F.
 PROJ. ENGR.: D.W.R.

URS URS Company, Inc.
 CONSULTING ENGINEERS
 NEW YORK NEW JERSEY

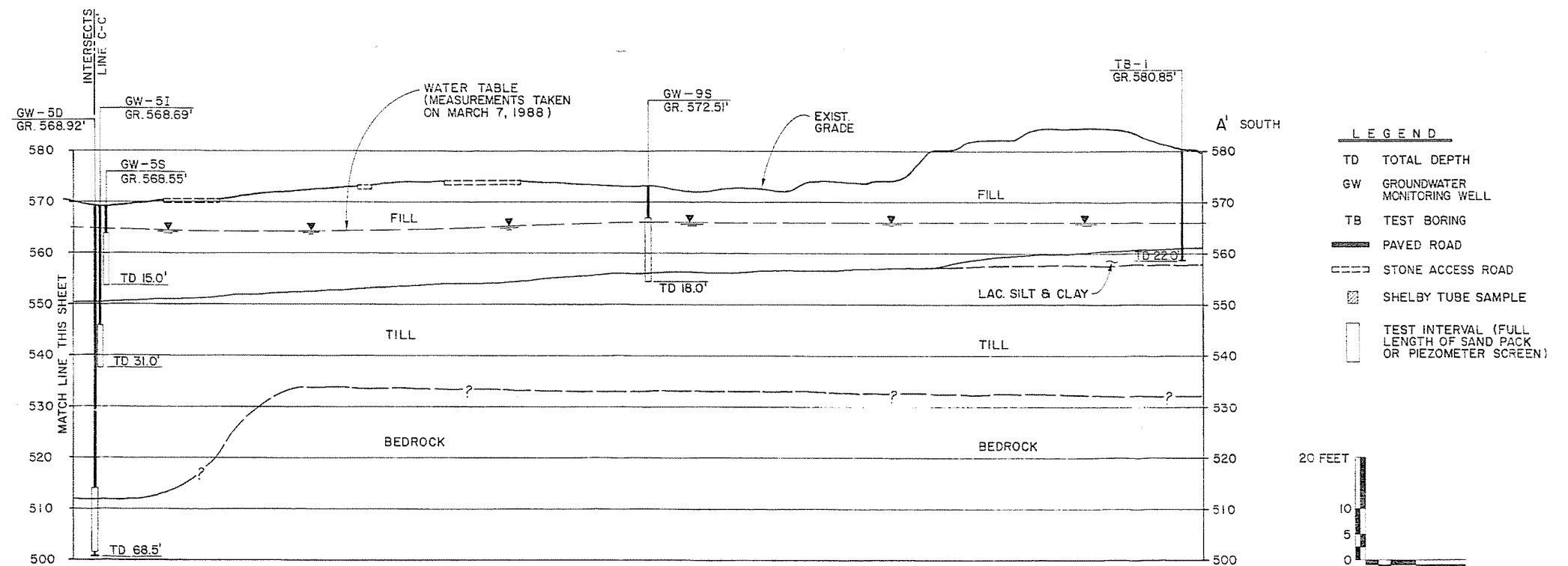
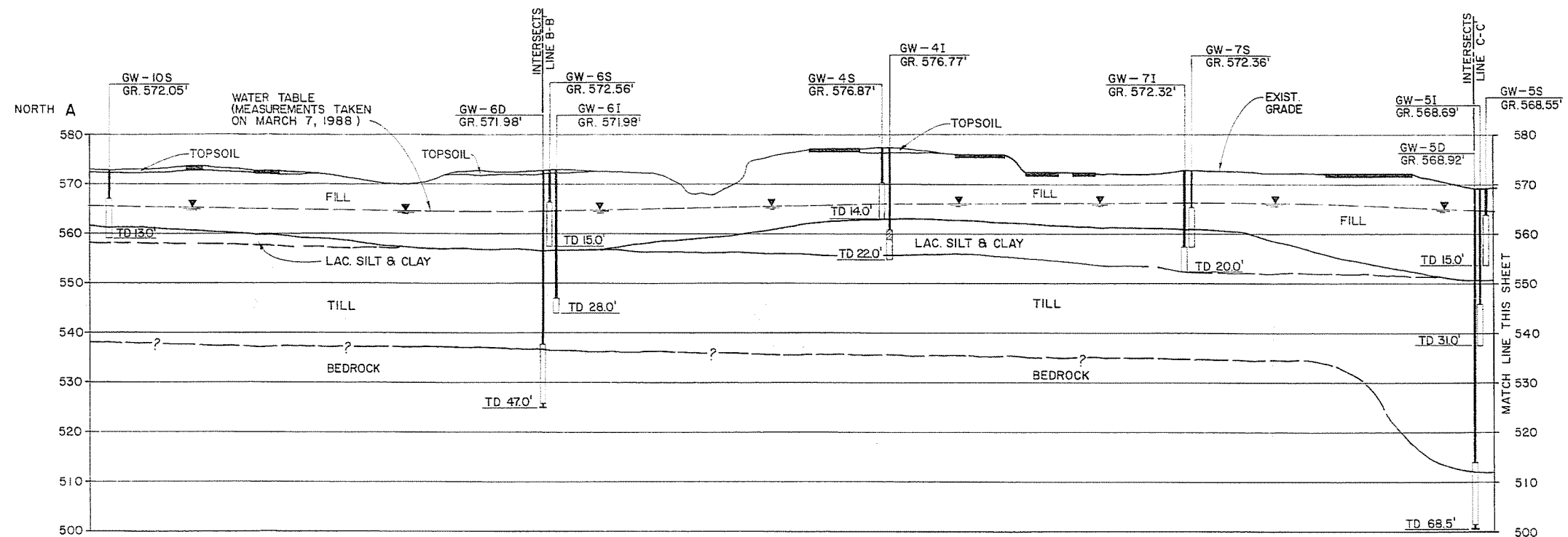
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GRATWICK RIVERSIDE PARK
 CITY OF NORTH TONAWANDA

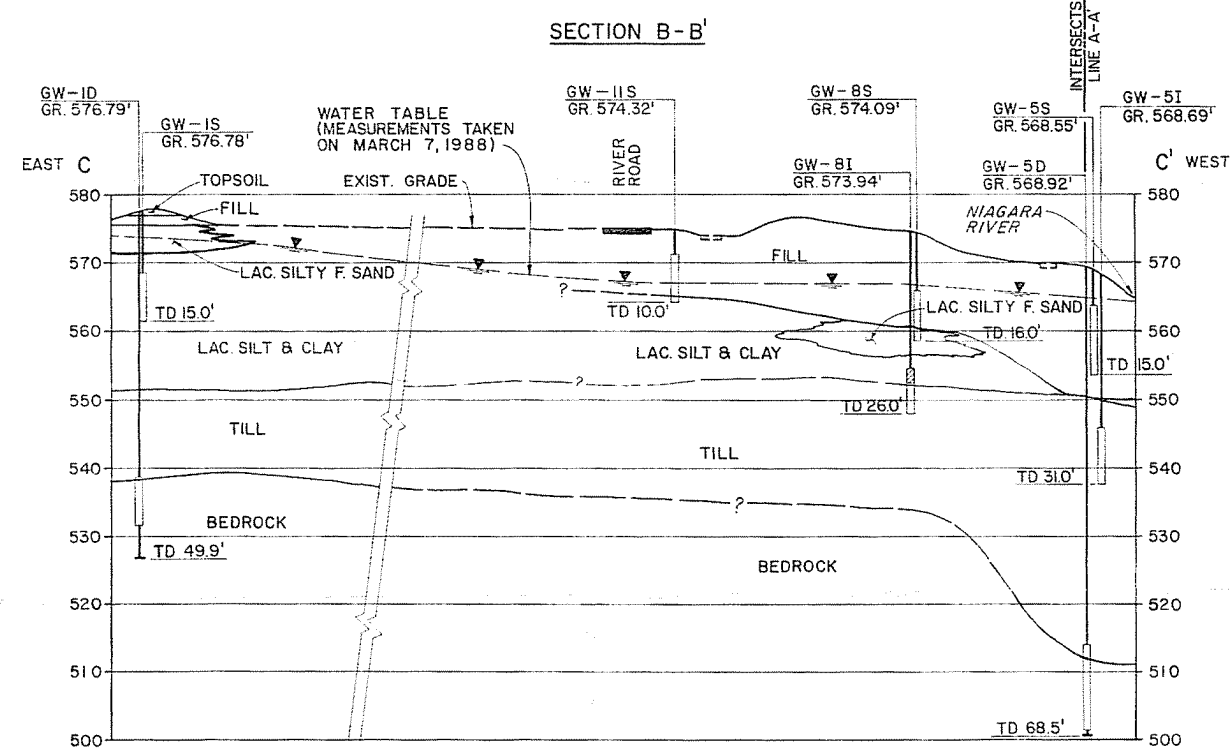
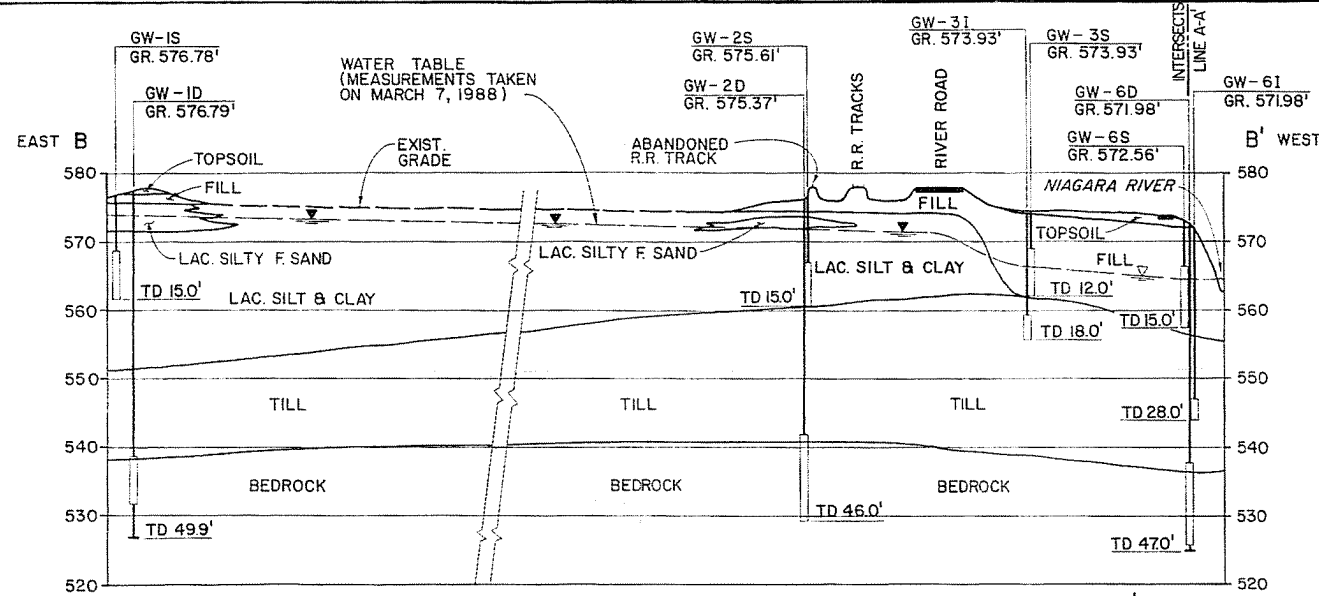
NIAGARA COUNTY NEW YORK

LOCATION OF GEOLOGIC
 CROSS SECTIONS

Scale: AS SHOWN Date: 7/14/89

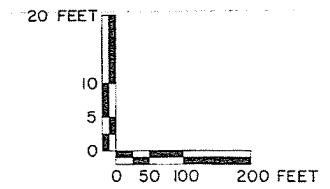


				DESIGNED BY : LUC	URS URS Company, Inc. CONSULTING ENGINEERS NEW YORK NEW JERSEY	GRATWICK RIVERSIDE PARK CITY OF NORTH TONAWANDA NIAGARA COUNTY NEW YORK	GEOLOGIC CROSS-SECTION A-A'	
				DRAWN BY : RAL				
				CHECKED BY : GWP				
				PROJ. ENGR. : DWR				
NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION	JOB No. 35149		
REVISIONS						FIGURE 4-4		



LEGEND

- TD TOTAL DEPTH
- GW GROUNDWATER MONITORING WELL
- TB TEST BORING
- PAVED ROAD
- STONE ACCESS ROAD
- SHELBY TUBE SAMPLE
- TEST INTERVAL (FULL LENGTH OF SAND PACK OR PIEZOMETER SCREEN)



				DESIGNED BY: <u>LJC</u>	URS URS Company, Inc. CONSULTING ENGINEERS NEW YORK NEW JERSEY		GRATWICK RIVERSIDE PARK CITY OF NORTH TONAWANDA	GEOLOGIC CROSS - SECTIONS B-B' AND C-C'		
				DRAWN BY: <u>RAL</u>				Scale: AS NOTED	Date: 7/14/89	FIGURE 4-5
				CHECKED BY: <u>GHF</u>						
NO.	DATE	DESCRIPTION	NO.	DATE	DESCRIPTION	PROJ. ENGR.: <u>DWR</u>	NIAGARA COUNTY	NEW YORK		
REVISIONS						JOB No. 35145				

