REMEDIAL INVESTIGATION AND FEASIBILITY STUDY

at the

GRATWICK-RIVERSIDE PARK SITE

NIAGARA COUNTY, NEW YORK

FEASIBILITY STUDY WITH APPENDIX G

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. - Director

URS Consultants, Inc.
570 Delaware Avenue
Buffalo, New York 14202

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Appendix G has been appended to the Feasibility Study volume.

7.0 INTRODUCTION

7.1 Purpose and Organization of FS Report

Investigations and subsequent studies at hazardous waste sites are designed to:

- Determine the extent to which contamination exists in the various environmental media at the site;
- Identify the risk to human health and to the environment associated with that contamination;
- Establish specific goals for remedial actions;
- Develop and evaluate alternative methods by which those goals can be reached; and
- Select the remedy best suited to the site for reaching those goals.

Information required for the first two items listed above is provided by the Remedial Investigation (RI), which is summarized in Section 7.2. The objective of the Feasibility Study (FS) is to accomplish the last three items on the list and the purpose of this report is to present the results of that study and describe the remedial action(s) selected.

This report is organized as follows:

Section 8 presents the goals, or Remedial Action Objectives, established for the site followed by a listing of several generalized activities, or General Response Actions, to be applied to each environmental media to satisfy the objectives. An estimation of the volume or area of the media of interest is also presented. The balance of the section is devoted to the development of alternative methods by which the Response Actions may be implemented. To begin, a list of general categories of potentially applicable technologies for each Action is prepared and supplemented with specific process options which may be used to implement the technology. The combinations are screened to remove those not technically feasible and, if possible, to choose a single process for use with each feasible technology.

Section 9 describes the development and screening of remedial action alternatives. Feasible technologies are combined to form alternative measures for use in meeting the remedial objectives at the site. These are screened primarily on the basis of environmental and public health criteria.

Section 10 presents a detailed analysis of the alternatives passing the initial screen, a comparative evaluation of those alternatives, and the selection of the best remedy for the site.

Section 11 describes a conceptual design for the selected remedial alternative and presents a preliminary cost estimate for remediation.

In addition, Appendix G is an integral part of this FS and should be consulted. It discusses the groundwater modeling efforts.

7.2 Remedial Investigation Summary

Part I of this report, Sections 1 through 6, presents the results of a Remedial Investigation conducted at the Gratwick-Riverside Park. The purpose of this investigation was to collect data and characterize the site in sufficient detail to allow an identification and evaluation of remedial alternatives as part of the Feasibility Study. The key findings of the Remedial Investigation, upon which the Feasibility Study is based, are as follows:

- The 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 (see Figure 1-1 of RI). 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 including municipal and industrial wastes, incinerator ash, road construction debris, molding sand, and metal and fiber drums. The landfill site 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.

- 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 greater than 2.3 x 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 4.8x10^{-7} cm/sec. Measurements of hydraulic conductivity were taken in the upper 10 feet of the bedrock. Measurements averaged 7.4 x 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 result in flow reversal near the shoreline. Water levels tend to rise during night-time hours. 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 with semi-volatile organic compounds (SVOCs), mainly PAHs, in fill approximately 10 to 15 feet below the surface. The highest observed concentration of SVOCs was 277,520 ppb. Shoreline soil was found to contain lower levels of SVOCs than surficial soil on-site. 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.

- Groundwater in both the upper and bedrock aquifers becomes contaminated with both volatile and semi-volatile organic compounds as it passes below the site. The highest observed concentration of total organic compounds was 49,049 ppb in GW-9S. The volatile organic compound (VOC) detected in the highest concentration was 4-methyl-2-pentanone at 16,000 ppb in GW-7S. The VOCs most commonly detected were ketones and the SVOCs most commonly detected were the phthalate esters. The upper aquifer was found to contain more volatile compounds (20) at higher concentrations (maximum total VOCs of 34,018 ppb) than the bedrock aquifer (10 compounds with maximum total VOCs of 179 ppb). The upper aquifer also had more SVOCs (17) at higher concentrations (maximum total SVOCs of 15,031 ppb) than the bedrock aquifer (1 SVOC with a maximum concentration of 2 ppb).

- The Remedial Investigation identified several organic (28) and metal (13) contaminants that exceeded federal Applicable or Relevant and Appropriate Requirements (ARARs) or New York State Standards, Criteria, and Guidance (SCGs) (hereafter referred to as only as SCGs) for groundwater. The concentration ranges for these contaminants and their corresponding SCG values are listed in Table 7-1. Other miscellaneous parameters of interest from the standpoint of remedial treatment technologies are also included in Table 7-1.

- 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 64.9E-06 or over an order of magnitude greater than the commonly used benchmark of 1.0E-06

TABLE 7–1 (PAGE #1 of 2)

SUMMARY OF GROUNDWATER MONITORING DATA

SUBSTANCE	UNITS	CONCENTRATION RANGE		ARAR/ SCG value	NUMBER OF TIMES		SHALLOW AQUIFER		BEDROCK AQUIFER	
		MIN	MAX		ARAR/SCG	DETECT	AVG	MAX	AVG	MAX
Methylene chloride	ug/l	1	43	5	1	6	8	43	5	5
Acetone	ug/l	27	8,100	50	10	11	566.4	8,100	25.9	73
1,1–Dichloroethane	ug/l	18	320	0.033	5	5	36	320	5	<10
1,2–Dichloroethene (total)	ug/l	2	1,300	5	9	12	5	<10	5	<10
1,2–Dichloroethane	ug/l	–	150	0.8	1	1	16.4	150	5	<10
Chloroform	ug/l	–	2	0.19	2	2	5	<10	5	<10
Vinyl chloride	ug/l	4	120	2	6	6	17	120	10.3	12
2–Butanone	ug/l	9	3,300	50	5	6	229	3,300	10.3	12
Trichloroethene	ug/l	4	2,200	0	12	12	353	2,200	13.3	71
1,1,1–Trichloroethane	ug/l	117	390	5	3	3	43	390	5	<10
Benzene	ug/l	1	98	ND	6	6	14	98	4.8	3
Tetrachloroethene	ug/l	5	930	0.7	11	11	96	930	9.4	40
Toluene	ug/l	1	370	5	9	13	57	370	4.5	1
Ethylbenzene	ug/l	1	80	5	8	10	20	80	4.6	2
Total xylenes	ug/l	7	270	50	6	9	62	270	5.6	10
Chlorobenzene	ug/l	31	85	5	3	3	11	85	5	<10
Styrene	ug/l	–	22	5	1	1	6	22	5	<10
Phenol	ug/l	3	5,800	1	10	10	574	5,800	10	<20
1,4–Dichlorobenzene	ug/l	5	7	4.7	2	2	10	<20	10	<20
2–Methylphenol	ug/l	2	1,500	1	10	10	191	680	10	<20
4–Methylphenol	ug/l	3	1,900	1	9	9	211	1,900	10	<20
Benzoic acid	ug/l	180	600	50	2	2	86	600	50	<100
Naphthalene	ug/l	2	30	10	2	4	13	26	9	2
2,4–Dimethylphenol	ug/l	5	630	5	5	5	85	630	10	<20
4–methyl–2–pentanone	ug/l	27	16,000	50	1	2	737.2	16,000	10	<20
Di–n–octyl phthalate	ug/l	2	87	50	2	10	19	87	10	<20
Isophorone	ug/l	2	53	50	1	3	14	53	10	<20
Phenols, total	ug/l	10	17,000	1	11	11	1,282	17,000	16.3	58

Note: Averages were calculated using half the detection limit for those compounds not detected

TABLE 7-1 (PAGE #2 of 2)

SUBSTANCE	UNITS	CONCENTRATION RANGE		ARAR/SCG	NUMBER OF TIMES		SHALLOW AQUIFER		BEDROCK AQUIFER	
		MIN	MAX	value	ARAR/SCG	DETECT	AVG	MAX	AVG	MAX
Arsenic	ug/l	7	172	0.0025	4	4	20	172	5	<10
Barium	ug/l	68	7,010	1,000	3	16	1,088	7,010	200	200
Beryllium	ug/l	3.59	40	0.0039	4	4	8	40.2	5	<10
Cadmium	ug/l	100	407	10	2	2	34	407	5	<10
Chromium	ug/l	12.6	1,460	50	4	10	118	1,460	11	13
Iron	ug/l	120	8,900,000	300	14	17	637,838	8,900,000	2,440	8,020
Lead	ug/l	18.9	150	25	9	10	38	150	15	81
Magnesium	ug/l	143	1,670,000	35,000	7	17	157,617	1,670,000	68,788	126,000
Manganese	ug/l	17	734,000	300	8	16	56,033	734,000	74	208
Nickel	ug/l	15.4	827	15.4	8	9	104	827	40	40
Silver	ug/l	32.9	74	50	1	2	15	74.4	10	<20
Sodium	ug/l	45,000	1,270,000	20,000	17	17	246,747	1,270,000	85,025	173,000
Zinc	ug/l	15.1	5,980	300	3	14	687	5,980	70	233
Cyanide	ug/l	–	70,000	10	3	3	7,072	70,000	10	<20
pH	s.u.	6.9	12	n/a	n/a	n/a	10	11.76	7.1	7.5
Specific conductance	umho/cm	860	4,220	n/a	n/a	n/a	2,580	3,990	3,385	3,780
Total suspended solids	mg/l	29	2,500	n/a	n/a	n/a	893	2,500	44	64
Total dissolved solids	mg/l	670	3,400	n/a	n/a	n/a	1,579	3,400	2,640	2,900
Sulfates	mg/l	82	1,700	n/a	n/a	n/a	420	1,700	1,250	1,400
Total organic carbon	mg/l	2	140	n/a	n/a	n/a	198	2,900	16	67
Biological oxygen demand	mg/l	16	540	n/a	n/a	n/a	202	940	14.9	29
NH3 – N	mg/l	–	26	n/a	n/a	n/a	5.2	2.6	0.05	0.05
TKN	mg/l	1.1	25	n/a	n/a	n/a	6.7	25	0.1	0.1
Phosphorous	mg/l	0.01	5	n/a	n/a	n/a	0.83	5.2	0.05	0.06
Oil and Grease	mg/l	1.2	17	n/a	n/a	n/a	9.1	17	3.4	3.2
Hardness	mg/l	330	3,200	n/a	n/a	n/a	1,314	3,200	1,900	2,200
Total alkalinity	mg/l	160	4,000	n/a	n/a	n/a	1,025	4,000	133	140
Bicarbonate alkalinity	mg/l	110	2,500	n/a	n/a	n/a	660	2,500	113	120
Acidity	s.u.	7	17	n/a	n/a	n/a	n/a	n/a	11.3	17

Note: Averages were calculated using half the detection limit for those compounds not detected
Data from two rounds of sampling of 11 monitoring wells during RI
December 1987 – 11 samples; and August 1988 – 11 samples

(ie. one excess cancer death per one million population). When worst-case concentrations are used, the carcinogenic risk is 713E-06 or over two orders of magnitude greater than the commonly used benchmark of 1.0E-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 following indicator chemicals were selected on the basis of a ranking procedure described in the Superfund Public Health Evaluation Manual:

Organics	Metals
Vinyl Chloride	Antimony
Chloroform	Cadmium
Trichloroethene	Mercury
Tetrachloroethene	Lead
1,1-dichloroethane	
2-butanone	
Chlorobenzene	
Phenol	
Benzene	
Noncarcinogenic PAHs	
Carcinogenic PAHs	
PCBs	
Hexachloro-Dibenzofuran	
Heptachloro-Dibenzofuran	

- Of the above compounds, tetrachloroethene, PAHs, PCBs, and mercury are included in the List of Priority Toxics identified in the 1989 report entitled "Reduction of Toxic Loadings to the Niagara River from Hazardous Waste Sites in the United States" written by the USEPA and NYSDEC. The full List of

Priority Toxics consists of the following fifteen chemicals: benz(a)anthracene, benzo(a)pyrene, benzo(b) fluoranthene, benzo(k)fluoranthene, chlordane, chrysene, dieldrin, hexachlorobenzene, mercury, mirex, octachlorostyrene, PCBs, DDT and metabolites, dioxin, and tetrachloroethylene. URS has estimated that approximately 2.6 lbs/day of TCL organic compounds and 2.0 lbs/day metals are discharged to the Niagara River by groundwater passing below the site. These values are comparable to the estimate of 1.3 lb/day as presented in the Reduction of Toxic Loadings report. In the Report, sites have been grouped into three Categories: Category I - sites contributing >50 lbs/day to the Niagara River; Category II - sites contributing 1-50 lbs/day to the River; and Category III - sites contributing <1 lb/day to the River. Both estimates therefore, place Gratwick Park at the lower end of Category II.

- 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 on-site surficial soil. 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.

8.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

8.1 Introduction

The identification of remedial technologies and process options described in this section, consists of the following principal steps:

(1) establishing remedial action objectives;

(2) identifying general response actions to satisfy these objectives;

(3) targeting specific physical dimensions (e.g., area, volume) of contaminated media to which the general response actions will be applied; and

(4) identifying and screening specific remedial technologies/ process options which fall within the general response categories.

8.2 Remedial Action Objectives

Remedial action objectives are medium-specific. At the Gratwick site, the two principal contaminated media are soil and groundwater. The former creates the primary potential health risk at the site, direct contact with contaminated surficial soil (via ingestion and dermal absorption), and accounts for 100% of the calculated incremental chronic health and carcinogenic risk. In addition, the erosion of contaminated shoreline soils into the Niagara River is expected to have an adverse environmental impact. Contaminated groundwater is of concern primarily from an environmental standpoint since this groundwater discharges into the adjacent Niagara River. Reducing migration of contaminated groundwater into the Niagara River was the major objective of a study completed by USEPA and NYSDEC in 1989. The objectives of this study have been incorporated into the goals for the FS.

Based upon the foregoing discussion, the following remedial objectives have been 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.

8.3 General Response Actions

General response actions are, like remedial action objectives, medium-specific. These general response actions are actually categorical approaches to remediation, into which fit various specific technologies and process options. For contaminated soil and groundwater at the Gratwick site, the following general response actions have been identified:

- For contaminated soil, general response actions include: no action; institutional action; containment; excavation and off-site disposal (e.g., in a secure landfill); physical controls; and on-site treatment; and

- o For contaminated <u>groundwater</u>, general response actions include: no action; institutional action; containment; collection; and treatment.

8.4 Extent of Remediation

Before remedial alternatives can be developed, it is first necessary to identify the physical extent of contaminated media to which they will be applied.

8.4.1 Soil

The most significant source of contamination at the Gratwick site from a public health standpoint is surficial soil. Further, the health risk assessment identified polycyclic aromatic hydrocarbons (PAHs) as the major contaminant of concern. By locating the areas in which PAHs were detected, one could potentially identify the source(s) of contamination. Analytical results from surface soil samples SPS-1 through SPS-10 (see Figure 5-1) were reviewed for the presence of PAHs. With the exception of SPS-1 (at the southern edge of the site), all surface soil samples contained PAHs. The sample having the highest concentrations was SPS-9 with greater than 93,000 ppb of PAHs detected. Shoreline soil samples SP1-SS through SP8-SS were similarly reviewed for the presence of PAHs. Again, every sample contained PAHs; the average total concentration of which was approximately 4,000 ppb. The use of this data from the RI, however, left several gaps in determining the full areal extent of contamination especially in areas on the eastern portion of the site close to River Road. Few samples were taken in this area, and even these were not analyzed for PAHs. However, samples were taken in these areas during the 1986 sampling effort by Niagara Mohawk and the Niagara County Health Department. While some of these results have been labeled as "unconfirmed" and "suspicious", they were reviewed during this effort for the presence of contaminants. PAHs or PCBs (whose presence indicates contamination) were generally detected in these samples along the eastern portion of the site. Therefore, it is assumed that surficial soil over the entire surface area of the site, that is 53-acres, contains PAHs.

The depth of contamination can be assessed by a review of boring logs and chemical and air screening data from soil borings and test pits. Boring logs indicate the presence of fill to an average depth of 15 feet across the entire site. Chemical analyses were performed on soil borings at various depths when installing monitoring wells GW-3, GW-4, GW-5, GW-6, and GW-8. Soil contaminants, particularly PAHs, were found at each of these well locations with the exception of GW-8. The well with the highest concentration of soil contaminants was GW-6. Soil contaminants were detected up to a depth of 26' (at GW-5) which is within the till layer. By reviewing the OVA and TIP readings taken in the borings in addition to the chemical data, it can be seen that contamination extends below the fill layer into the underlying lacustrine silt and clay and till layers. It is assumed that the contaminants have migrated to these fairly impermeable layers from the fill which is considered the source of contamination at the site.

The extent of soil contamination may be summarized therefore, as covering the entire 53-acre surface of the site and extending the entire depth of the fill layer, an average of 15 feet. The volume of soil corresponding to this area and depth is approximately 1.3 million cubic yards.

8.4.2 Groundwater

Based upon the analytical data presented in Section 5.4 there appears to be an increase in the number and concentration of organics in the upper aquifer as it passes below the site with contamination greatest in wells GW-7S and GW-9S. There appears to be little contamination of the bedrock aquifer aside from the volatile organics detected in GW-6D during the second round. Their presence in the second round suggests downhole migration or drilling contamination from the upper aquifer rather than contamination of the bedrock aquifer itself. The concentration ranges for contaminants that exceeded the SCGs for groundwater are included in Table 7-1. Contaminant concentrations tapered off to the north; no monitoring wells were located to the south. A review of pH values, however, shows that in seven of the nine on-site monitoring wells, pH values were greater than 11 as compared to values of 6.9 and 7.7 in the two upgradient wells.

Groundwater remediation efforts, therefore should address the entire upper aquifer, concentrating on the central portion of the site with future monitoring of the bedrock aquifer to indicate whether or not there is a need to remediate the bedrock aquifer.

9.0 DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

9.1 Identification of Remedial Technologies For Soil

The purpose of this section is to identify potential remedial technologies which are best suited to the site based on technical implementability. Remedial technologies are selected for each general response action and are shown in Table 9-1 along with the corresponding process options for each technology. Remedial action objectives for each media are also shown in the table.

9.1.1 No Action

"No Action" is included as required by the National Contingency Plan (NCP) and is self explanatory.

9.1.2 Institutional Action

Institutional actions for the prevention of direct human contact include permanent deed restrictions controlling use and development of the site. In addition, the existing groundwater monitoring wells would be used for the long-term monitoring program.

9.1.3 Capping

A variety of capping systems could be feasibly implemented to cover the contaminated soil to minimize direct human contact, surface water infiltration and erosion. Capping options include:

- RCRA cap;
- NYS Part 360 cap;
- multilayered cap with a synthetic geomembrane; and
- soil cap.

TABLE 9–1
(PAGE 1 of 2)

REMEDIAL ACTION OBJECTIVES, GENERAL RESPONSE ACTIONS, REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

Environmental Media	Remedial Action Objectives (from site characterization)	General Response Actions (for all remedial action objectives)	Remedial Technology Types (for general response actions)	Process Options
Soil	No Action	No Action	No Action	No Action
	Human Health			
	Prevent direct human contact	Institutional action	Institutional action	Deed restrictions
		Containment	Capping	RCRA, NYS Part 360, multilayered with synthetic geomembrane, soil
	Environmental Protection			
	Prevent erosion of on-site surficial and shoreline soil into the Niagara River	Physical Controls	Erosion Control	Rip rap, dikes, trees,structural development, sheet pile breakwater
		Excavation/Removal	Excavation and off-site disposal	Excavation and disposal at a RCRA or commercial facility
		Treatment	Biological Treatment	Bioreclamation
			Physical/Chemical Treatment	In-situ chemical treatment, soil flushing, solidification/ stabilization, vitrification
			Thermal Treatment	Incineration, infrared

TABLE 9–1
(PAGE 2 of 2)

REMEDIAL ACTION OBJECTIVES, GENERAL RESPONSE ACTIONS, REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

Environmental Media	Remedial Action Objectives (from site characterization)	General Response Actions (for all remedial action objectives)	Remedial Technology Types (for general response actions)	Process Options
Groundwater	No Action	No Action	No Action	No Action
	Environmental Protection			
	Limit migration of contaminated groundwater	Institutional action	Institutional action	Deed restrictions, long-term monitoring
		Containment	Vertical Barriers	Slurry wall, sheet pile breakwater
		Collection	Groundwater Extraction	Subsurface drain/withdrawal system, withdrawal wells
	Reduce Contaminant levels in groundwater	Treatment	Off-site treatment	POTW, commercial facility
			On-site treatment	Site specific process options -Full Treatment -Pretreatment

All capping options would include grading, vegetative cover and surface water drainage provisions as part of the design.

9.1.4 Erosion Controls

Controls to prevent the erosion of contaminated surficial and shoreline soils into the Niagara River include:

- placement of rip rap or trees on the river bank;
- dikes;
- structural development; and
- sheet pile breakwater.

9.1.5 Excavation and Offsite Disposal

This technology involves the excavation, transportation and offsite disposal of the 1.3 million cubic yards of contaminated soil identified as the source of contamination. The soil could be taken to a commercial secure landfill (ie. RCRA facility) for disposal, or to a commercial treatment facility. Landfilling of the soil could be subject to the land disposal restrictions promulgated by the USEPA (40 CFR Part 148 et al, June 23, 1989).

9.1.6 On-site Biological Treatment

Bioreclamation or in-situ biological treatment involves the injection, collection, treatment and reinjection of water applied to the soil. The feasibility of bioreclamation depends upon the biodegradability of the organic contaminants, environmental factors that affect microbial activity and site hydrogeology.

9.1.7 On-site Physical/Chemical Treatment

Four physical/chemical treatment options capable of treating organic and inorganic wastes are in-situ chemical treatment, soil flushing, solidification/stabilization and vitrification. In-situ chemical treatment is a process in which treatment agents are delivered directly to the contaminated soil to destroy or immobilize contaminants. The treatment agents are transferred to the contaminated soil by a drilling and/or mixing operation. Soil flushing involves the injection of a solvent into the subsurface, recovery of the injected solvent (with the contaminants) downgradient of the contaminated area and treatment of the collected solvent in an above-ground system. The treated solvent may then be re-injected into the subsurface. For the solidification/stabilization option, the contaminated soil is mixed with various substances to produce a solidified product which immobilizes the contaminants. The stabilized soil-like material may be returned as backfill. Vitrification is a process that reduces and immobilizes soil contamination by electrically and thermally converting contaminated soil into a chemically inert, stable glass and crystalline product.

9.1.8 On-site Thermal Treatment

Thermal treatment via incineration or infrared means is considered technically feasible at the site. Both processes require the excavation of the contaminated soil for treatment. Infrared thermal units with silicon carbide elements are used to generate thermal radiation for thermal destruction of the contaminants in the soil. Incineration by rotary kiln involves the controlled combustion of organic contaminants in the waste. Both processes produce flue gas, ash and scrubber water as residuals which must be properly treated prior to release or disposal. The ash may be replaced on-site if contaminant levels can be demonstrated to be below current Toxicity Characteristic Leaching Procedure (TCLP) limits (formerly EP Toxicity) and other applicable regulatory standards.

9.2 Identification of Remedial Technologies for Groundwater

9.2.1 No Action

"No Action" is included as required by the NCP and is self explanatory.

9.2.2 Institutional Action

Future development of the site is possible; however, use of groundwater from the site should be prohibited. To insure this, permanent deed restrictions prohibiting groundwater use are included in the "Institutional Action". A long-term (30-year) environmental monitoring program using the existing monitoring wells is also included in the "Institutional Action". The scope of such a program will be developed in conjunction with appropriate regulatory agencies. The program would include one upgradient monitoring well pair (one well in the upper aquifer and one well in the bedrock aquifer) and three downgradient monitoring well pairs.

9.2.3 Vertical Barriers

Impermeable vertical subsurface barriers would reduce or eliminate migration of contaminants from the site or reduce the amount of groundwater to be collected and treated by intercepting the inflow of "clean" groundwater to the site. Available barrier options include sheet piles and slurry walls (soil-bentonite or cement-bentonite).

9.2.4 Groundwater Extraction

Groundwater can be extracted for treatment using either a subsurface drain and withdrawal system or withdrawal wells alone.

9.2.5 Groundwater Treatment and Discharge

Either off-site or on-site treatment of leachate are considered technically feasible for the site. Off-site treatment of the leachate collected by a groundwater extraction system requires transportation of the leachate to either a Publicly Owned Treatment Works (POTW) or to a commercial facility for treatment and disposal. The nature of the leachate and treatment requirements would dictate which facility would be used. On-site full treatment or pretreatment could be achieved by a number of physical, chemical and biological process options but as with off-site treatment, the nature of the leachate would dictate which process option to use. Discharge options for treated leachate include discharge to the Niagara River, discharge to the local POTW or discharge to groundwater.

9.3 Screening of Remedial Technologies/Process Options

9.3.1 General

The criteria for the screening of remedial technologies/process options is predicated on seeking remedial actions that, in whole or in part, result in a permanent and significant decrease in the toxicity, mobility and/or volume of hazardous substances, pollutants, or contaminants to the maximum extent practicable. Preference is given to those remedial technologies/process options that provide permanent protection to human health and the environment from the risks posed by the hazardous substances at the site. Specifically, the criteria to be used is based on a hierarchy of remedial technologies in which the order of preferable technologies (i.e. from most desirable to least desirable) is:

- o Destruction - Irreversible destruction or detoxification of all or most of the hazardous waste to levels satisfying remedial action objectives and resulting in no residue containing unacceptable levels of hazardous constituents. This will achieve a permanent reduction in the toxicity of all or most of the hazardous waste.

- Separation/Treatment - Separation or concentration of the hazardous wastes from the waste, resulting in a treated waste stream with acceptable levels of hazardous waste (in relation to the remedial action objectives) and a concentrated waste stream with high contaminant levels for treatment. This will achieve a permanent and significant reduction in the volume of waste mixed with hazardous waste.

- Solidification/Chemical Fixation - Significant and permanent reduction in the mobility of hazardous waste. This may or may not significantly reduce the toxicity or volume of hazardous wastes.

- Control and Isolation - Significant reduction in the mobility of hazardous wastes but with no significant reduction in the toxicity or volume of the hazardous wastes. This also includes physical barriers to control migration of leachate; solidification/fixation of hazardous wastes; and pumping and treatment of contaminated groundwater.

Preference will be given to those remedial technologies which have been successfully demonstrated on a full scale or a pilot scale at a Federal or State Superfund site, a Federal facility, a PRP site overseen by a state environmental agency or USEPA, under a SITE program, a RCRA Part B permit, or a RCRA Research and Development permit. A remedial technology which has a documented history of successful treatment, such as a granular activated carbon unit, will also be given preference.

Process options are screened to limit the number of process options which represent each remedial technology. The criteria used to screen process options are effectiveness, implementability and cost; however, effectiveness is considered to be most important at this stage.

The evaluation of process options for effectiveness focuses upon:

- Potential effectiveness in handling the estimated areas or volumes of media;
- Meeting remedial action objectives;
- Potential impacts on human health and the environment during the construction and implementation phases; and
- Estimated success and reliability when applied to the contaminants and conditions at the site.

The evaluation of process options with respect to implementability will mainly address administrative feasibility rather than technical implementability since this criterion is considered first when selecting process options from the universe of process options.

The evaluation of process options with respect to costs plays a minor role at this stage of the evaluation of options. Only relative capital and operation and maintenance (O&M) costs are used to evaluate the process options.

9.3.2 Soil Capping

9.3.2.1 RCRA Cap

A RCRA cap would permanently and significantly decrease infiltration into the fill and in this way reduce the mobility of the hazardous substances at the site. A RCRA cap would also provide permanent protection to human health and the environment against the risks associated with contact with the contaminated soil and migration of the hazardous substances. RCRA caps are recommended by the USEPA for secure landfills for hazardous wastes and are thus considered a successfully proven and effective capping option. However, a RCRA cap would be the most expensive capping option and would also require the most intensive construction effort. In particular, the low permeability (recompacted) soil layer must be constructed carefully and efficiently by experienced crews in order to meet the stringent QA/QC requirements applied to these layers to ensure that the required degree of impermeability is achieved. Matching existing grades with the cap would also be difficult because of the cap's 6-foot thickness. The low permeability soil layer could potentially be damaged by cracking caused by differential settling of the nonhomogeneous fill layer (e.g. buried drums) presently existing beneath the site and the general fill needed to provide an even surface and slope for the cap. Moreover, the additional degree of protection provided by a RCRA cap, when compared to the other capping options, would not justify its cost. For these reasons, a RCRA cap was rejected.

9.3.2.2 NYS Part 360 Cap

A New York State Part 360 cap, considered to be a New York State SCG (Standard, Criteria, and Guidance), consists of a 12 inch venting layer of sand, a minimum of 18 inches low permeability layer (or HDPE), a minimum of 30 inches soil protection layer, and six inches of topsoil. In order to reduce the cap thickness, the gas venting layer could consist of a geosynthetic capable of performing the function of 12 inches of sand. The total thickness of this cap would be approximately 4.5 feet.

The Part 360 cap would significantly decrease infiltration into the fill and thereby reduce the mobility of the hazardous substances at the site. This type of cap would also provide permanent protection to human health and the environment against the risks associated with contact with the contaminated soil and migration of the hazardous substances. A Part

360 cap is recommended by the NYSDEC as an effective environmental control for landfills and is thus considered a successfully proven capping option. However, as discussed earlier, low permeability soil layers require an intensive construction effort to ensure that the required degree of impermeability is achieved, which increases the difficulty of implementing this option as well as the cost of construction compared to other capping options. In addition, the low permeability soil layer could potentially be damaged by cracking caused by differential settling of the nonhomogeneous fill layer (e.g. buried drums) presently existing beneath the site and the general fill needed to provide an even surface and slope for the cap. The 4.5-foot thickness of this cap and the required amount of subgrade fill to meet the minimum 4% slope required would substantially raise the ground level and create problems with matching the cap with existing grades. The center of the site would be raised by 15 to 20 feet above existing elevations. Therefore, the Part 360 cap was also rejected.

9.3.2.3 Multilayered Cap with a Synthetic Geomembrane

A multilayered cap with a synthetic geomembrane would significantly decrease infiltration into the fill and thereby reduce the mobility of the hazardous substances at the site. This type of cap would also provide protection to human health and the environment against the risks associated with contact with the contaminated soil and migration of the hazardous substances. Multilayered caps with synthetic geomembranes are recommended by the NYSDEC as an effective environmental control for landfills and are thus considered a successfully proven capping option. These caps would be less subject to breakdowns caused by the differential settling of existing fill and the general fill needed to provide an even surface and slope for the cap because of the flexibility of the synthetic geomembrane. This cap is also much thinner than the RCRA or Part 360 caps and would therefore be much easier to match with the existing grade. Synthetic geomembranes are quickly and easily installed compared to low permeability soil layers and are also less expensive. The multilayered permeability soil layers and are also less expensive. The multilayered cap with synthetic geomembrane is a feasible option to be considered further.

9.3.2.4 Soil Cap

A soil cap with site regrading would provide protection to human health and the environment against the risks associated with contact with the contaminated soil and erosion of the contaminated soil. A soil cap would not provide an impermeable layer to reduce infiltration and would be least effective in reducing migration of the hazardous substances from the site. Instead, it would promote migration of the contaminants of concern, thereby resulting in a long-term decline in the amount of toxics at the site. This cap will be retained for further consideration as a capping option.

9.3.3 Erosion Controls

9.3.3.1 Trees and Rip Rap

Although trees and rip rap are effective erosion control systems, these options do not provide protection against the migration of hazardous substances in the groundwater and are therefore rejected.

9.3.3.2 Dike

The construction of an earthen dike along the entire shoreline of the site would significantly reduce the mobility of the hazardous substances at the site by providing protection against erosion of shoreline soil and migration of the hazardous substances. To provide protection against migration of hazardous substances in groundwater, the dike would have to be constructed with an impermeable barrier as a principal component. Construction of such a dike could be difficult since provisions (e.g. coffer dam) would have to be made in order to install the dike in the river. Construction could potentially create short-term health and environmental risks since contaminated soil may have to be excavated for construction of the dike. The cost of constructing a dike is therefore, expected to be high. A dike would also be difficult to implement from the standpoint of administrative feasibility. In particular, regulatory approval would be difficult to obtain for construction of a dike in the Niagara River. These drawbacks are sufficient justification to reject a dike as an erosion control option.

9.3.3.3 Structural Development

Structural development of the entire shoreline of the site would significantly reduce the mobility of the hazardous wastes at the site by providing protection against erosion of the shoreline soil and migration of groundwater from the site. Development would protect the environment against the risks posed by migration of the hazardous substances. Structural development could take the form of a bulkhead wharf comprised of concrete or wood which could be used as a walk or dock. An impermeable barrier could be incorporated into the structure to ensure that the migration of hazardous substances in the groundwater is significantly reduced. However, as with the construction of a dike, the construction of these structures would entail excavation of the contaminated soil along the shoreline and installation in the river. Because of the drawbacks associated with construction of erosion control structures, specifically, high construction cost, difficultly of implementation, potential health and environmental risks, and the uncertainty regarding administrative feasibility, this option was rejected as an erosion option.

9.3.3.4 Sheet Pile Breakwater

A sheet pile breakwater constructed along the entire shoreline of the site would also significantly reduce the mobility of the hazardous substances at the site by preventing erosion of the shoreline soil and significantly reducing migration of groundwater into the Niagara River. The environmental risks posed by the migration of the hazardous substances could be further reduced if the sheet piling were grouted (e.g. soil bentonite). Sheet piling is used extensively as both an erosion control and containment system and is therefore considered to be an effective and successfully proven option. Installation of sheet piling should not require excavation of the contaminated soil and thus construction costs would be lower, health and environmental risks would be reduced, and implementation simplified. An asphalt or concrete walkway could be placed over the sheet pile breakwater to prevent infiltration from precipitation or runon from the site. Therefore, a sheet pile breakwater is the most feasible and preferred erosion control option.

9.3.4 On-site Treatment of Contaminated Soil

Several process options, viz. bioreclamation, in-situ chemical treatment, soil flushing, vitrification, immobilization/stabilization, incineration, and infrared thermal treatment, were identified as technically implementable at the site. However, the vast quantity of soil (i.e. 1.3 million cubic yards) that must be treated to remediate the site renders these treatment options impractical, mainly on the basis of economics. The estimated cost of soil treatment ranges between $60-$70 per cubic yard for treatments such as immobilization/stabilization and bioreclamation to $350-$370 per cubic yard for treatments such as vitrification and incineration. Therefore, the estimated overall cost for soil treatment ranges between $78,000,000 and $481,000,000. This cost is particularly prohibitive when it is considered that the total quantitated risk at the site is only 64.9×10^{-6} under the no-action scenario and that some of these treatment technologies, although implementable, are largely untried on Superfund sites. Consequently, none of the soil treatment technologies are considered appropriate for site remediation and will not be carried forward in the analysis of alternatives.

9.3.5 Vertical Barriers for Groundwater Containment

9.3.5.1 Slurry Walls

Slurry walls constructed on the upgradient (east), north or south boundaries of the site are considered to be potentially feasible. A slurry wall on the downgradient side of the site adjacent to the Niagara River is not technically feasible due to the extension of fill into the River bed.

Two types of slurry walls technically feasible for the site are soil-bentonite and cement-bentonite. While a cement-bentonite wall is more capable of handling weight-bearing loads (i.e. traffic), a soil-bentonite wall is considered more appropriate for the site because of its lower permeability, lower cost, and higher degree of chemical resistance. (Cement-bentonite is susceptible to attack by strong acids and bases. Since the pH was >11 in seven of the nine on-site monitoring wells, cement-bentonite is considered less feasible.)

9.3.5.2 Sheet Piles

Since sheet pile is more permeable (10^{-5} cm/sec for sheet piling versus 10^{-7} cm/sec for slurry wall) and more expensive when compared to a soil-bentonite slurry wall, this option was rejected for use on the upgradient, north and south boundaries of the site as vertical barriers for groundwater containment. However, a sheet pile breakwater is considered feasible as a vertical barrier and for erosion control along the shoreline (see Section 9.3.4), if it is grouted through the thickness of the fill to the underlying till layer.

NYSDEC Region 9, Division of Fish and Wildlife, Bureau of Fisheries was contracted regarding the installation of a sheet pile breakwater along the shoreline. Of primary concern to the Region 9 Fisheries Unit is the potential for adversely impacting or destroying nearshore shallow-water habitat through encroachment by the breakwater along the Niagara River shoreline. In order to assess the potential for habitat loss associated with the selection of this technology, the NYSDEC Region 9 Fisheries Unit has requested representative cross-section views through the shoreline and nearshore areas of the River. Further details of their request are provided in Section 11.4 which discusses additional investigations needed during the design phase.

9.3.6 Groundwater Extraction

9.3.6.1 Subsurface Drain and Withdrawal System

Groundwater extraction may be performed through a subsurface drain and withdrawal system (i.e. pumps) in the upper aquifer. While the installation of subsurface drains is technically feasible, the aquifer already consists of fill material with an average hydraulic conductivity greater than 10^{-3} cm/sec. The benefits associated with the costly excavation of contaminated soil to install subsurface drains having a hydraulic conductivity of 10^{-1} cm/sec would be marginal. Therefore, a subsurface drain and withdrawal system was rejected.

9.3.6.2 Withdrawal Wells

A series of properly-spaced withdrawal wells across the downgradient edge of the site would be both feasible and cost-effective in extracting groundwater from the upper aquifer (and bedrock if necessary).

9.3.7 Groundwater Treatment and Discharge

9.3.7.1 Off-site Groundwater Treatment

Off-site treatment of contaminated groundwater collected by a groundwater extraction system could be accomplised by transporting groundwater to a publicly owned treatment works (POTW) or private (commercial) treatment facility. The untreated (contaminated) groundwater could be trucked or piped to an off-site facility for treatment; however, costs would be extremely high. Alternately, the contaminated groundwater could be pretreated on-site to meet local sewer discharge limits and then discharged into the sewer for further treatment at the POTW. Approximately 15,768,000 (30 gpm) to 105,120,000 (200 gpm) gallons of leachate would require transportation and/or treatment each year depending on the remedial measure implemented at the site (see Appendix G for details).

The cost for disposing of leachate at a POTW or private hazardous waste treatment facility is highly variable. It depends not only upon the chemical nature and extent of pretreatment of the leachate, but also upon: the size, design and operating conditions of the plant; the regulatory status of the plant regarding acceptance of extraneous waste streams; the owner of the facility generating leachate (e.g., public or private); and, to some extent, the overall political and economic climate at the time of disposal. A local POTW might be able to treat leachate from the Gratwick site, provided that future institutional and regulatory concerns could be adequately addressed. Disposal of hazardous waste at a commercial facility is similarly feasible but extremely costly. Off-site transportation and treatment of groundwater was rejected because of comparatively higher costs, however, off-site treatment of pretreated groundwater at a POTW will be carried forward in the analysis of alternatives.

9.3.7.2 Discharge of Groundwater

Of the three discharge options identified in Section 9.2.5, only discharge to a POTW or the Niagara River are considered viable options. Reinjection of the groundwater after treatment is considered impractical since the treated water would have to be reinjected upgradient of the collection wells due to space limitations and thus treated water would have to be retreated. In addition reinjection is considered environmentally unsound since it would likely cause groundwater mounding in the area of reinjection, resulting in breaching of the site cap or a change in the hydraulic gradient which could lead to off-site migration of contaminants.

The choice between discharge to a POTW or the Niagara River is highly dependent on the discharge criteria associated with each option. The local POTW in the area of the Gratwick site, i.e. the North Tonawanda Treatment Plant, is a physical/chemical plant. The major removal operations include primary clarification, sand filtration and carbon adsorption. A pretreatment program has been implemented and ordinance limits have been established for a number of parameters including metals (viz. cadmium, total chromium, copper, lead, mercury, nickel, zinc, arsenic, silver, and beryllium), total cyanide, phenol, and oil and grease. If groundwater is discharged to the North Tonawanda Treatment Plant, on-site pretreatment will be required, the extent of pretreatment depending on the concentrations of parameters of concern to the treatment plant. If groundwater is discharged to the Niagara River it is almost certain that complete treatment, i.e. treatment to remove organics, metals and inorganics, will be required.

The final level of treatment required for discharge to either the POTW or the Niagara River has not been established yet. The selection of unit operations for on-site groundwater treatment discussed in the next section, and cost estimates developed for the economic evaluation of the treatment options include both partial and complete treatment schemes. Either means of treatment could therefore be selected once the discharge criteria are established for this site.

9.3.7.3 On-site Groundwater Treatment

A large number of biological and physical/chemical processes are available, and have been used, for treatment of contaminated water. Based on groundwater data from on-site wells that were sampled for both BOD and COD, the BOD/COD ratio is approximately 0.55 indicating that a large portion of organic material is not readily biodegradable. In addition, it is possible that some of the TCL organics or other TCL compounds such as cyanide may be biotoxic and thus inhibit the biological system. Because of the likely inefficiency of the biological system and the possibility of system upsets, a biological system is not considered feasible at the Gratwick site.

The process train considered most feasible for full treatment at the Gratwick site consists of physical/chemical unit operations including: flow equalization, cyanide reduction, neutralization, precipitation/flocculation/sedimentation, air stripping, and aqueous phase carbon adsorption. The objective of flow equalization is to dampen fluctuations in influent flow and contaminant concentrations and thereby improve downstream process performance. Equalization should be considered in the planning and design of all leachate treatment facilities since the composition and volume of leachate will fluctuate with time. The relatively high cyanide concentrations in the groundwater would require treatment with an oxidizing agent such as sodium hypochlorite. Cyanide destruction can be accomplished effectively at pH greater than 11 s.u. The pH of seven of the nine on-site shallow wells sampled during the first round of groundwater sampling was above 11.0 s.u. Neutralization will be required following cyanide destruction to reduce groundwater pH to acceptable levels before discharge. Precipitation/flocculation/

sedimentation is required to remove metals from the groundwater prior to discharge. Air stripping is recommended since it is the simplest and most economical method of removing volatile organics. Carbon adsorption will be utilized to remove semi-volatile organics and any residual volatile organics that are not effectively removed by the air stripper.

The process train feasible for pre-treatment of the groundwater prior to discharge to the POTW is expected to consist of: flow equalization, cyanide reduction, and neutralization.

As part of the design phase for on-site groundwater treatment, bench-scale or pilot-scale testing would be required to determine the effectiveness of selected unit processes, individually and collectively, with actual groundwater from the Gratwick site and to establish final design parameters for these processes. Based upon the testing program, certain processes might have to be added, deleted or modified. The testing program is discussed further in Section 11.4.

9.4 Summary of Selected Remedial Technologies/Process Options

The remedial technologies and corresponding process options selected for consideration in the development of alternatives are shown in Table 9-2.

9.5 Development of Alternatives for the Site

Remedial alternatives are the site and media-specific remedial technologies and associated process options which when combined and implemented will achieve the remediation goals for the site. The formulation of remedial alternatives from those remedial technologies is based specifically on the following criteria:

TABLE 9-2

SUMMARY OF SELECTED REMEDIAL TECHNOLOGIES
AND PROCESS OPTIONS

REMEDIAL TECHNOLOGY	PROCESS OPTION
NO ACTION	
INSTITUTIONAL ACTION	DEED RESTRICTIONS
	LONG-TERM GW MONITORING
CAPPING	MULTILAYERED CAP WITH A SYNTHETIC GEOMEMBRANE
	SOIL CAP
EROSION CONTROL	SHEET PILE BREAKWATER
VERTICAL BARRIER	SOIL BENTONITE SLURRY WALL
GW EXTRACTION	WITHDRAWAL WELLS
GW TREATMENT	ON-SITE FULL TREATMENT: -FLOW EQUALIZATION -CYANIDE DESTRUCTION -NEUTRALIZATION -PRECIPITATION/SEDIMENTATION -AIR STRIPPING -CARBON ADSORPTION
	ON-SITE PRETREATMENT: -FLOW EQUALIZATION -CYANIDE DESTRUCTION -NEUTRALIZATION
GW DISCHARGE	LOCAL POTW

- Alternatives may include a range of general response categories including: no action, institutional action, containment, excavation/removal, physical controls, collection and treatment.

- Alternatives must address all principal health and environmental remedial action objectives identified for the site and specifically, for the media.

In order to determine which combination of remedial technologies (caps, slurry walls, sheet pile breakwater, withdrawal wells) should be further considered, a three-dimensional groundwater flow model and infiltration analysis were performed as detailed in Appendix G. The groundwater flow model was based on results of activities conducted during the RI and calibrated to existing site conditions. Various combinations of remedial technologies were then added to existing conditions in order to assess their effectiveness in achieving the remedial objectives for the site. In all, over fifty simulations were performed. Based on the results, it was shown that the most effective remedial alternatives included a sheet pile breakwater, a cap, groundwater extraction, and groundwater treatment. The addition of slurry walls generally increased effectiveness but was evaluated primarily on the basis of cost. As previously mentioned, there are two feasible capping options: a multilayered cap with synthetic geomembrane (MSG) and the soil cap. Consequently, a total of six alternatives were developed for the site as shown on Table 9-3.

After developing the six alternatives for the site, more detailed groundwater flow analyses were performed (see Appendix G) to better quantify the amount of groundwater to be collected with each alternative. Estimated steady-state flows in the groundwater extraction system for the four alternatives requiring site remediation as shown on Table 9-3 are as follows:

TABLE 9-3

REMEDIAL ALTERNATIVES

<u>ALTERNATIVE 1:</u>	NO ACTION				
<u>ALTERNATIVE 2:</u>	INSTITUTIONAL ACTION				
<u>ALTERNATIVE 3:</u>	SHEET PILE BREAKWATER		MSG CAP	WITHDRAWAL WELLS	GROUNDWATER TREATMENT
<u>ALTERNATIVE 4:</u>	SHEET PILE BREAKWATER	SLURRY WALL	MSG CAP	WITHDRAWAL WELLS	GROUNDWATER TREATMENT
<u>ALTERNATIVE 5:</u>	SHEET PILE BREAKWATER	SLURRY WALL	SOIL CAP	WITHDRAWAL WELLS	GROUNDWATER TREATMENT
<u>ALTERNATIVE 6:</u>	SHEET PILE BREAKWATER		SOIL CAP	WITHDRAWAL WELLS	GROUNDWATER TREATMENT

Alternative 3:	100 gpm
Alternative 4:	30 gpm
Alternative 5:	60 gpm
Alternative 6:	100 gpm

The above rates represent steady-state flow conditions, and do not include higher initial rates that will be required to attain the desired water elevation or drawdown in the wells within the site. However, in order to maintain a conservative approach for the design of the treatment system for the remedial alternatives, model-estimated flows have been doubled except for Alternative 6 which represents only partial containment. The flows used to evaluate each alternative were as follows:

Alternative 3:	200 gpm
Alternative 4:	60 gpm
Alternative 5:	120 gpm
Alternative 6:	150 gpm

10.0 DETAILED EVALUATION OF ALTERNATIVES AND SELECTION OF A REMEDY

10.1 General

In this section, the alternatives developed in the previous section and summarized in Table 9-3 are subjected to a detailed evaluation in order to select the most appropriate and cost effective remedy for the site. The scoring system presented in the Division of Hazardous Waste Remediation Technical and Administrative Guidance Memorandum on the Selection of Remedial Actions (TAGM HWR-89-4030) (NYSDEC, 1989) is used as an aid in the evaluation process. An evaluation is performed in which the alternatives are compared using the results of the scoring system. A recommended remedial alternative is then selected following the comparative analysis of alternatives.

10.2 Scoring System

10.2.1 Procedure

The selection of a site remedy based on a scoring system approach involves a quantitative evaluation of the alternatives using the following criteria:

- o Short-term impacts and effectiveness;
- o Long-term effectiveness and permanence;
- o Reduction of toxicity, mobility or volume of hazardous waste;
- o Implementability;
- o Compliance with NYS SCGs; and
- o Overall protection of human health and the environment.
- o Cost

In the scoring system each alternative is numerically rated against the factors developed for each criterion as detailed in TAGM HWR-89-4030

(NYSDEC, 1989). The results of the scoring are presented in Table 10-1 and discussed in detail below. Present worth costs have been summarized in the following subsections but are presented in detail in Section 10.3.

10.2.2 Alternative 1 - No Action

Short-term Impacts and Effectiveness - Score: 10 out of 10

Since no construction is required to implement this alternative, there are no associated risks to the community, environment or workers.

Long-term Effectiveness and Permanence - Score: 2 out of 15

This alternative is neither an effective nor permanent remedy to the risks posed by the contaminants at the site. However, points were given for relatively low O&M requirements.

Reduction in Toxicity, Mobility and Volume of Hazardous Waste: Score 0 out of 15

This alternative does not reduce the toxicity, mobility nor the volume of hazardous waste at the site.

Implementability - Score: 10 out of 15

The no action alternative is easily implemented compared to the other alternatives. However, it fails to provide a reliable remedy to the problem. Moreover, it does not provide any means by which to monitor contaminant levels or mobility. The potential need for future remedial action is not addressed under this alternative.

Compliance with SCGs - Score: 5 out of 10

Implementation of this alternative would not result in compliance with chemical-specific SCGs (groundwater regulations) nor any appropriate agency advisories, guidelines

TABLE 10-1 (PAGE 1 of 6)

SCORING SYSTEM FOR REMEDIAL ALTERNATIVES

SHORT-TERM IMPACTS AND EFFECTIVENESS (Relative Weight = 10)

FACTOR	BASIS FOR EVALUATION	WEIGHT	ALTERNATIVE NUMBER					
			1	2	3	4	5	6
1. Protection of community during remedial actions	- Are there significant short-term risks to the community that must be addressed? (if no, go to factor 2)	Yes - 0 No - 4	4	4	0	0	0	0
	- Can the risk be easily controlled?	Yes - 1 No - 0	-	-	1	1	1	1
	- Does the mitigative effort to control risk impact the community life-style?	Yes - 0 No - 2	-	-	2	1	1	2
2. Environmental Impacts	- Are there significant short-term risks to the environment that must be addressed? (if no, go to factor 3)	Yes - 0 No - 4	4	3	3	0	0	3
	- Are the available mitigative measures reliable to minimize potential impacts?	Yes - 3 No - 0	-	-	-	1	1	-
3. Time to implement the remedy	- What is the required time to implement the remedy?	<2 yr - 1 >2 yr - 0	1	1	0	0	0	0
	- Required duration of the mitigative effort to control short-term risk.	<2 yr - 1 >2 yr - 0	1	1	0	0	0	0
SUBTOTAL (MAXIMUM = 10)			10	9	6	3	3	6

SCORING SYSTEM FOR REMEDIAL ALTERNATIVES

LONG-TERM EFFECTIVENESS AND PERMANENCE (Relative Weight = 15)

FACTOR	BASIS FOR EVALUATION	WEIGHT	ALTERNATIVE NUMBER					
			1	2	3	4	5	6
1. Permanence of the remedial alternative	– Will the remedy be classified as permanent in accordance with Section 2.1(a),(b) or (c) of the NYSDEC TAGM for the "Selection of Remedial Actions at Inactive Hazardous Waste Sites", Sept. 13, 1989? (if yes, go to factor 3)	Yes – 5 No – 0	0	0	0	0	0	0
2. Lifetime of remedial actions	– Expected lifetime or duration of effectiveness of the remedy	25–30 yr – 4 20–25 yr – 3 15–20 yr – 2 <15 yr – 0	0	0	3	4	4	2
3. Quantity and nature of waste or residual left at the site after remediation	i. Quantity of untreated hazardous waste left at the site	None – 3 <25% – 2 25–50% – 1 >50% – 0	0	0	0	0	0	0
	ii. Is there any treated residual left at the site? (if no, go to factor 4)	Yes – 0 No – 2	0	0	0	0	0	0
	iii. Is the treated residual toxic?	Yes – 0 No – 1	0	0	0	0	0	0
	iv. Is the treated residual mobile?	Yes – 0 No – 1	0	0	0	1	1	0
4. Adequacy and reliability of controls	i. Operation and maintenance required for a period of:	<5 yr – 1 >5 yr – 0	0	0	0	0	0	0
	ii. Are environmental controls required as a part of the remedy to handle potential problems? (if no, go to "iv")	Yes – 0 No – 2	2	2	1	1	0	0
	iii. Degree of confidence that controls can adequately handle potential problems	Moderate to very confident – 1 Somewhat to not confident – 0	0	0	1	1	1	1
	iv. Relative degree of long-term monitoring required (compare with other alternatives)	Minimum – 2 Moderate – 1 Extensive – 0	0	0	1	2	2	2
SUBTOTAL (MAXIMUM = 15)			2	2	6	9	8	5

SCORING SYSTEM FOR REMEDIAL ALTERNATIVES

REDUCTION IN TOXICITY, MOBILITY AND VOLUME OF HAZARDOUS WASTE (Relative Weight = 15)

FACTOR	BASIS FOR EVALUATION	WEIGHT	ALTERNATIVE NUMBER					
			1	2	3	4	5	6
1. Volume of hazardous waste reduced (reduction in volume or toxicity)	i. Quantity of hazardous waste destroyed or treated	100% - 10 80-99% - 8 60-80% - 6 40-60% - 4 20-40% - 2 <20% - 0	0	0	0	0	0	0
	ii. Are there any concentrated hazardous wastes produced as a result of (i)? (if no, go to factor 2)	Yes - 0 No - 2	-	-	2	2	2	2
	iii. How is the concentrated hazardous waste stream disposed?	On-site land disposal - 0 Off-site secure land disposal - 1 On-site or off-site destruction or treatment - 2	-	-	-	-	-	-
2. Reduction in mobility of hazardous waste	i. Method of Reduction - Reduced mobility by containment - Reduced mobility by alternative treatment technology	 1 3	0	0	2	3	1	2
	ii. Quantity of wastes immobilized	<100% - 2 >60% - 1 <60% - 0	-	-	2	2	2	1
3. Irreversibility of the destruction or treatment of hazardous waste	- Completely irreversible - Irreversible for most of the hazardous waste constituents - Irreversible for only some of the hazardous waste constituents - Reversible for most of the hazardous waste constituents	3 2 1 0	-	-	3	3	3	3
SUBTOTAL (MAXIMUM = 15)			0	0	9	10	8	8

SCORING SYSTEM FOR REMEDIAL ALTERNATIVES

IMPLEMENTABILITY (Relative Weight = 15)

FACTOR	BASIS FOR EVALUATION	WEIGHT	ALTERNATIVE NUMBER					
			1	2	3	4	5	6
1. Technical Feasibility								
a. Ability to construct technology	i. Not difficult to construct. No uncertainties in construction ii. Somewhat difficult to construct. No uncertainties in construction iii. Very difficult to construct and/or significant uncertainties in construction	3 2 1	3	3	2	1	1	2
b. Reliability of technology	i. Very reliable in meeting the specified process efficiencies or performance goals ii. Somewhat reliable in meeting the specified process efficiencies or performance goals	3 2	0	1	2	3	2	3
c. Schedule of delays due to technical problems	i. Unlikely ii. Somewhat likely	2 1	2	2	1	0	0	1
d. Need of undertaking additional remedial action, if necessary	i. No future remedial action may be anticipated ii. Some future remedial actions may be necessary	2 1	1	1	1	2	2	1
2. Administrative Feasibility a. Coordination with other agencies	i. Minimal coordination is required ii. Required coordination is normal iii. Extensive coordination is required	2 1 0	2	2	1	1	1	1
3. Availability of Services and Materials								
a. Availability of prospective technologies	i. Are technologies under consideration generally commercially available for the site-specific application?	Yes – 1 No – 0	1	1	1	1	1	1
	ii. Will more than one vendor be available to provide a competitive bid?	Yes – 1 No – 0	0	0	1	1	1	1
b. Availability of necessary equipment and specialists	i. Additional equipment and specialists may be available without significant delay	Yes – 1 No – 0	1	1	1	0	0	1
SUBTOTAL (MAXIMUM = 15)			10	11	10	9	8	11

SCORING SYSTEM FOR REMEDIAL ALTERNATIVES

COMPLIANCE WITH STANDARDS, CRITERIA, AND GUIDANCE NYS (SCGs) (Relative Weight = 10)

FACTOR	BASIS FOR EVALUATION	WEIGHT	ALTERNATIVE NUMBER					
			1	2	3	4	5	6
1. Chemical-specific	Meets chemical-specific SCGs	Yes - 2.5 No - 0	0.0	0.0	2.5	2.5	2.5	2.0
2. Action-specific	Meets action-specific SCGs	Yes - 2.5 No - 0	2.5	2.5	1.5	1.5	0.5	1.0
3. Location-specific	Meets location-specific SCGs	Yes - 2.5 No - 0	2.5	2.5	2.5	2.5	2.5	2.5
4. Compliance with appropriate criteria, advisories and guidelines	The alternative meets all relevant and appropriate Federal and State guidelines that are not promulgated	Yes - 2.5 No - 0	0.0	0.0	2.5	2.5	2.5	2.5
SUBTOTAL (MAXIMUM = 10)			5	5	9	9	8	8

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT (Relative Weight = 20)

FACTOR	BASIS FOR EVALUATION	WEIGHT	ALTERNATIVE NUMBER					
			1	2	3	4	5	6
1. Use of site after remediation	Unrestricted use of the land and water (if yes, go to end of table)	Yes - 20 No - 0	0	0	0	0	0	0
2. Human health and the environment exposure after the remediation	i. Is the exposure to contaminants via air route acceptable?	Yes - 3 No - 0	0	0	2	3	2	2
	ii. Is the exposure to contaminants via groundwater/surface water acceptable?	Yes - 4 No - 0	0	0	2	2	2	2
	iii. Is the exposure to contaminants via sediments/ soil acceptable?	Yes - 3 No - 0	0	0	2	2	2	2
3. Magnitude of residual public health risks after the remediation	i. Health risk ii. Health risk	<1 in 1,000,000 - 5 <1 in 100,000 - 2	0	0	3	3	3	3
4. Magnitude of residual environmental risks after the remediation	i. Less than acceptable ii. Slightly greater than acceptable iii. Significant risk still exists	5 3 0	0	0	3	3	3	3
SUBTOTAL (MAXIMUM = 20)			0	0	12	13	12	12

SCORING SYSTEM FOR REMEDIAL ALTERNATIVES

COST (Relative Weight = 15)

FACTOR	BASIS FOR EVALUATION	WEIGHT	ALTERNATIVE NUMBER					
			1	2	3	4	5	6
1. Immediate	Capital costs	Lowest – 5 Others – 0	5	5	0	0	1	1
2. Annual	Operating and maintenance costs	Lowest – 4 Others – 0	4	4	0	0	1	1
3. Future								
a. Capital Costs	i. No future capital costs ii. Future capital costs expected	2 0	2	2	0	0	0	0
b. Land Costs	i. No effect on future land value ii. Future land value decreased after remediation	2 0	2	2	1	0	0	1
4. Overall	Present worth cost	Lowest – 2 Others – 0	2	2	0	0	0	1
SUBTOTAL (MAXIMUM = 15)			15	15	1	0	2	4

TOTAL SCORE (MAXIMUM = 100)	42	42	53	53	49	54

NOTES:
Alt 1 – No Action
Alt 2 – Institutional Action
Alt 3 – Sheetpile Breakwater, MSG Cap, Withdrawal Wells, Groundwater Pretreatment
Alt 4 – Sheetpile Breakwater, Slurry Wall, MSG Cap, Withdrawal Wells, Groundwater Pretreatment
Alt 5 – Sheetpile Breakwater, Slurry Wall, Soil Cap, Withdrawal Wells, Groundwater Pretreatment
Alt 6 – Sheetpile Breakwater, Soil Cap, Withdrawal Wells, Groundwater Pretreatment

or objectives. It would be in compliance with location-specific (i.e. restricting activities in the Niagara River since it is both a navigable and scenic waterway) and action-specific SCGs (i.e. technology standards).

Overall Protection of Human Health and the Environment - Score: 0 out of 20

If this alternative were implemented, the risks to human health and the environment posed by the contaminants at the site would remain.

Cost - Score: 15 out of 15

There is no cost associated with this alternative.

TOTAL SCORE - 42 out of 100

10.2.3 Alternative 2 - Institutional Action

Short-term Impacts and Effectiveness - Score: 9 out of 10

Since minimal construction would be required to implement this alternative (assuming that existing groundwater monitoring wells can be used for the long-term monitoring program), there would be few associated risks to the community, environment or to workers.

Long-term Effectiveness and Permanence - Score: 2 out of 15

This alternative is neither an effective nor permanent remedy to the risks posed by the contaminants at the site.

Reduction in Toxicity, Mobility and Volume of Hazardous Waste - Score 0 out of 15

This alternative does not reduce the toxicity, mobility nor the volume of hazardous waste at the site.

Implementability - Score: 11 out of 15

Although this alternative can be implemented without difficulty, it fails to provide a reliable remedy to the problem. The need for future remedial action is not addressed although long-term groundwater monitoring is included under this alternative.

Compliance with SCGs - Score: 5 out of 10

Implementation of this alternative would not result in compliance with chemical-specific SCGs or any appropriate agency advisories, guidelines or objectives. However, location and action-specific SCGs would be met.

Overall Protection to Human Health and the Environment - Score: 0 out of 20

If this alternative were implemented, the risks to human health and the environment posed by contaminants at the site would remain.

Cost - Score: 15 out of 15

This alternative has the second lowest relative cost compared to the other alternatives. The estimated present worth of the capital and operation and maintenance (O&M) costs is approximately $170,000 (See Section 10.3).

TOTAL SCORE - 42 out of 100

10.2.4 <u>Alternative 3 - Sheet Pile Breakwater/MSG Cap/Withdrawal Wells/Groundwater Pretreatment</u>

Short-term Impacts and Effectiveness - Score: 6 out of 10

The intrusive (i.e. below ground) work required for the construction of the sheet pile breakwater, withdrawal wells, or the groundwater treatment facility may cause contaminant migration and thus create short-term risks. However, it is anticipated that effective mitigative efforts can be implemented to control these risks. These mitigative efforts will include the containment of contaminated soil on-site and the collection and treatment of contaminated groundwater caused by construction activities. No environmental risk is anticipated. The disadvantage of this alternative is that the time for implementation is expected to be greater than 2 years.

Long-term Effectiveness and Permanence - Score: 6 out of 15

Since the long-term effectiveness and reliability of this alternative is uncertain, an efficient operation and maintenance program is required to ensure continuing control. In particular, the MSG cap would require routine inspection to locate and repair break-throughs caused by drums or differential settling of the site. Since the only means by which the contaminants in the soil can be removed is by the leaching action of infiltration and groundwater flow, it is anticipated that some contaminants will remain. Moreover, the mobility of remaining contaminants is controlled only by the sheet pile breakwater. Because of these conditions, the risk posed by the contaminants may still persist; however, it will be lower.

Reduction in Toxicity, Mobility and Volume of Hazardous Waste - Score: 9 out of 15

This alternative will result in a significant reduction in the volume of contaminated groundwater migrating from the site and therefore, significantly reduce threats to human health and the environment posed by these contaminants. However, some risk will remain since migration of the hazardous wastes will not be completely controlled.

Implementability - Score: 10 out of 15

Problems may be caused by the nature of the buried material at the site, which includes construction debris and drums, particularly when excavating through this material and compacting fill over this material. Construction delays may occur.

Compliance with SCGs - Score: 9 out of 10

This alternative will result in substantial compliance with chemical-specific SCGs as well as agency advisories, guidance and objectives. Special considerations and permits may be required to fulfill action and location-specific SCGs.

Overall Protection of Human Health and the Environment - Score: 12 out 20

This alternative will result in appreciable reduction in leachable contaminants and control of remaining contamination. Residual risks to health and the environment will be minimal and therefore limited future use of the site is possible.

Cost - Score: 1 out of 15

The estimated present worth of the capital and O&M costs is approximately $22,160,000.

TOTAL SCORE - 53 out of 100

10.2.5 <u>Alternative 4 - Sheet Pile Breakwater/Slurry Wall/MSG Cap/Withdrawal Wells/Groundwater Pretreatment</u>

Short-term Impacts and Effectiveness - Score: 3 out of 10

The intrusive activities required to implement this alternative - the slurry walls in particular - may result in risks to the community, environment and to workers as excavation of contaminated soil may cause migration of or exposure to hazardous waste. Furthermore, the mitigative measures required to provide protection may not be completed reliable. Implementation of this alternative and the mitigative efforts required to control short-term risk is expected to require more than 2 years. Since this alternative may create short-term risks during construction, it would not be effective until implemented.

Long-term Effectiveness and Permanence - Score: 9 out of 15

This alternative is expected to provide long-term effectiveness but would require an intensive operation and maintenance program to insure continual control. In particular, the MSG cap would require routine inspection to locate and repair breakthroughs caused by drums and/or the differential settling of the site. Further, continued use of the sites as a park may compromise the integrity of the synthetic geomembrane. Although it is expected that this alternative will provide adequate and reliable control of the contaminants at the site, it will not remove all contaminants from the soil or reduce the toxicity of the remaining contaminants. However, the remaining contaminants will be effectively contained at the site in the long term.

Reduction in Toxicity, Mobility and Volume of Hazardous Waste - Score: 10 out of 15

This alternative will not significantly reduce the volume or toxicity of the hazardous waste at the site but it will effectively reduce its mobility and thereby eliminate the principal threats associated with these contaminants.

Implementability - Score: 9 out of 15

Implementation of this alternative will be difficult because of the intrusive work required. This may result in schedule delays as well. The reliability of this alternative is uncertain, but monitoring will be performed to determine the need for future remedial action.

Compliance with SCGs - Score: 9 out of 10

This alternative would result in compliance with chemical-specific SCGs. Special considerations and permits may be required to fulfill action and location-specific SCGs.

Overall Protection of Human Health and the Environment - Score: 13 out of 20

This alternative will effectively control the contamination at the site thereby minimizing residual health and environmental risks. However, to insure this, future use of the site following remediation will have to be limited to keep the system of controls intact.

Cost - Score: 0 out 15

The estimated present worth of the capital and O&M costs for Alternative 4 is approximately $22,840,00, the highest among the six alternatives.

TOTAL SCORE: 53 out of 100

10.2.6 Alternative 5 - Sheet Pile Breakwater/Slurry Wall/Soil Cap/ Withdrawal Wells/Groundwater Pretreatment

Short-term Impacts and Effectiveness - Score: 3 out of 12

The intrusive construction activities required to implement this alternative - the slurry walls in particular - may result in risks to the community, environment and to workers as excavation of contaminated soil may cause migration of or exposure to hazardous waste. Furthermore, the mitigative efforts required during construction may not provide total protection. Implementation of this alternative or the mitigative efforts is expected to require more than 2 years. Since this alternative may create short-term risks during construction, it would not be effective until implemented.

Long-term Effectiveness and Permanence - Score: 8 out of 15

Since the long-term effectiveness and reliability of this alternative is uncertain, particularly with respect to the soil cap, an efficient operation and maintenance program would be required to insure continual control. The soil cap may require periodic repair during the performance period. The permeability of the soil cap will permit a significant amount of infiltration into the contaminated soil. This may promote further leaching of contaminants to the groundwater that will be collected and treated and thus reduce the amount of leachable contaminants remaining at the site following remediation. Any remaining contaminants will be effectively contained at the site in the long term.

Reduction in Toxicity, Mobility and Volume of Hazardous Waste - Score: 8 out of 15

This alternative will not significantly reduce the volume or toxicity of the hazardous waste at the site but it will effectively reduce its mobility and thereby eliminate the principal threats associated with these contaminants.

Implementability - Score: 8 out of 15

Implementation of this alternative will be difficult because of the intrusive work required. This may result in schedule delays as well. The reliability of this alternative is uncertain but monitoring will be performed to determine the need for future remedial action.

Compliance with SCGs - Score: 8 out 10

This alternative would result in compliance with chemical-specific SCGs. Special considerations and permits may be required to fulfill action and location-specific SCGs. It also complies with appropriate agency advisories, guidelines and objectives.

Overall Protection of Human Health and the Environment - Score: 12 out of 20

This alternative will effectively control the contamination at the site thereby minimizing residual health and environmental risks. However, to ensure this, future use of the site following remediation will have to be limited to keep the system of controls intact.

Cost - Score: 2 out of 15

The estimated present worth of the capital and O&M costs for this alternative is approximately $19,980,000.

TOTAL SCORE: 49 out of 100

10.2.7 Alternative 6 - Sheet Pile Breakwater/Soil Cap/Withdrawal Wells/Groundwater Pretreatment

Short-term Impacts and Effectiveness - Score: 6 out of 10

The intrusive (i.e. below ground) work required for the construction of the sheet pile breakwater, withdrawal wells or the groundwater pretreatment facility may cause contaminant migration and thus create short-term risks. However, it is anticipated that effective mitigative efforts can be implemented to control these risks. These mitigative efforts will include the containment of contaminated soil on-site and the collection and treatment of contaminated groundwater caused by construction activities. No environmental risk is anticipated. The disadvantage of this alternative is that the time for implementation is expected to be approximately 2 years.

Long-term Effectiveness and Permanence - Score: 5 out of 15

Since the long-term effectiveness and reliability of this alternative is uncertain, particularly with respect to the soil cap, an efficient operation and maintenance program would be required to ensure continual control. The soil cap may require periodic repair during the performance period. The permeability of the soil cap will permit a significant amount of the infiltration into the contaminated soil. This may promote further leaching of contaminants to the groundwater that will be collected and treated and thus reduce the amount of leachable contaminants remaining at the site following remediation.

Reduction in Toxicity, Mobility and Volume of Hazardous Waste - Score: 8 out of 15

This alternative will not significantly reduce the toxicity of the hazardous waste at the site but it will significantly reduce the volume of contaminated groundwater migrating from and consequently the principal threats to human health and the environment posed by these contaminants. However, the migration of the hazardous wastes will not be completely controlled by implementing this alternative.

Implementability - Score: 11 out of 15

Implementation of this alternative will be difficult because of the intrusive work required. This may result in schedule delays as well. Monitoring will be performed to assess the effectiveness of this alternative which will facilitate assessment of the need for future remedial action.

Compliance with SCGs - Score: 8 out 10

This alternative would be substantially in compliance with chemical-specific SCGs. Special considerations and permits may be required to fulfill action and location-specific SCGs.

Overall Protection of Human Health and the Environment - Score: 12 out of 20

This alternative will result in appreciable reduction in leachable contaminants and control of remaining contamination. A permeable soil cap will allow infiltration to flush contaminants out of the soil. These contaminants will then be captured by the groundwater pumping wells. The sheet pile breakwater will eliminate the erosion of the contaminated shoreline soils and will help to reduce the migration of groundwater to the Niagara River. Deed restrictions will be needed in order to maintain the integrity of the components of this remedial alternative. Residual risks to health and the environment will be minimal and therefore future use of the site is possible.

Cost - Score: 4 out of 15

The estimated present worth of the capital and O&M costs is approximately $18,110,00.

TOTAL SCORE: 54 out of 100

10.3 Economic Evaluation of Alternatives

10.3.1 General

Present worth costs for each of the six alternatives were summarized in the preceding section. The following discussions provide the details of the capital and operation and maintenance (O&M) costs for each of the technologies which are based on a site area of 53 acres and a depth of contamination of 15 feet.

The specific aspects and quantities of each component which are used as the basis for the capital and annual O&M costs are discussed in detail below (Section 10.3.2). The capital and annual O&M costs for each component are presented on separate tables (Tables 10-2 to 10-13) and accompany the discussions. The sources of the unit prices are referenced on the tables. Several cost items are estimated as a percentage of the total cost. These items include standard items such as mobilization/demobilization, construction administration, design engineering, bonds and insurance; escalation (to account for increased construction costs at the time construction is anticipated to occur); contingencies (for example to account for change orders during construction); markups to reflect bonding requirements and construction at sites containing hazardous waste, and the limited number of contractors available to work under these conditions; and provisions for health and safety protection, specifically for workers, but also for the community and the environment as required. The accuracy of the estimated costs lies within a range of -30% to +50% of the actual construction costs.

Table 10-14 presents the capital and O&M costs developed for each of the six alternatives. For the cost-effectiveness evaluation of the alternatives, the capital and annual O&M costs are converted to their equivalent present worth. A 30-year performance period with a 10 percent annual interest rate is used in the determination of the present worth of the cost of each alternative.

10.3.2 Cost Estimates for Individual Components

10.3.2.1 Groundwater Monitoring

Capital Cost:

Long term monitoring of the groundwater using four wells in the upper aquifer and four wells in the bedrock aquifer is recommended. Three out of these four well pairs currently exist: GW-1, GW-5, and GW-6. An additional well pair in the southern portion of the site needs to be installed and is the basis for the capital cost estimate of $8,000 as shown in Table 10-2.

Annual O&M Costs:

Items which comprise the O&M costs of long-term groundwater monitoring are the sampling and laboratory analysis of eight groundwater samples. For the present, it is assumed that the entire Target Compound List (TCL) as given in the New York State Analytical Services Protocols (ASP) document will be analyzed. Contingencies, administration and engineering have been added for future report preparation and data reviews. The total annual O&M cost for groundwater monitoring is estimated to be approximately $17,000. A breakdown of the costs is provided in Table 10-3.

TABLE 10-2

GRATWICK-RIVERSIDE PARK
CAPITAL COST ESTIMATE

GROUNDWATER MONITORING

ITEM	UNITS	QUANTITY	UNIT COST	SOURCE	TOTAL COST
Mobilization/ Demobilization	task	1	$330	1	$330
Drilling	ft	60	$17	1	$1,020
4″ S.S Riser Installed	ft	54	$26	1	$1,404
4″ S.S. Screen Installed	ft	10	$66	1	$660
Protective Casing	ea	2	$165	1	$330
Drums for Residuals	ea.	5	$44	1	$220
Standby Time	hr	4	$99	1	$396
Pressure Grouting (for deep well)	ft	20	$8	1	$160

SUBTOTAL $4,520

Contractor Markup (25%)	$1,130
Construction, Administration, and Design Engineering (15%)	$678
Change Order Contingencies (10%)	$452
Escalation to Midpoint of Construction (5% per year over 3 years)	$712
Bonds and Insurance (10%)	$452

TOTAL $7,944

say <u>$8,000</u>

NOTE: Need four (4) well pairs, however, three (3) existing well pairs may be used, therefore only one (1) additional well pair installation has been estimated.

SOURCES: 1 - Actual subcontractor invoice costs (1988) for Weston Mills Hazardous Waste Site, pro-rated for 1990. Includes Level ″C″ Protection.

TABLE 10-3

GRATWICK-RIVERSIDE PARK
ANNUAL O & M COST ESTIMATE

GROUNDWATER MONITORING

ITEM	UNITS	QUANTITY	UNIT COST	SOURCE	TOTAL COST
Sampling					
-Labor	mandays	4	$300	1	$1,200
-Equipment	misc	-	$150	1	$150
Analyis					
-TCL	sample	8	$1,350	2	$10,800

SUBTOTAL $12,150

Administration and Engineering (15%)	$1,823
Change Order Contingencies (10%)	$1,215
Bonds and Insurance (10%)	$1,215

TOTAL ANNUAL COSTS $16,403

say **$17,000**

NOTE: Involves sampling and analysis of four (4) well pairs for a total of eight (8) samples for the TCL list one per year for thirty (30) years

SOURCES:

1 - URS estimating. Includes Level "C" Protection.

2 - Recent laboratory quote

10.3.2.2 Sheet Pile Breakwater

Capital Costs:

The installation of a sheet pile breakwater along the shoreline of the Niagara River would require the following:

- o driving steel sheeting to an average depth of 15 feet and keying into the confining unit along the water's edge of the Niagara River, an approximate length of 4,900 feet;
- o backfilling from the sheeting to an approximate elevation of 570 feet msl or the edge of the cap, whichever is deemed appropriate;
- o grouting the sheet pile and the granular portions of the fill to the confining unit, an average depth of 12 feet, over the 4,900 foot length.
- o topping the backfill with a layer of asphalt in order to prevent infiltration and promote surface water drainage from the site.

The installation of this sheet pile breakwater may be difficult but implementable. During the design phase it will be determined if installation may be accomplished from the site, or if necessary from a barge in the river. The total capital cost is estimated to be $5,132,000. A breakdown of the capital costs for the sheet pile breakwater is presented in Table 10-4.

Annual O&M Costs:

There are no O&M costs associated with this sheet pile breakwater.

TABLE 10-4

GRATWICK-RIVERSIDE PARK
CAPITAL COST ESTIMATE

SHEET PILE BREAKWATER

ITEM	UNITS	QUANTITY	UNIT COST	SOURCE	TOTAL COST
Sheet Piling -Material	linear ft	4,900	$131	1	$641,900
-Installation	linear ft	4,900	$200	1	$980,000
Backfill (Installed)	linear ft	4,900	$52	1	$254,800
Grouting (Installed)	linear ft	4,900	$67	1	$328,300
Asphalt Walkway	square yd	10,900	$5.50	1	$59,950

SUBTOTAL $2,264,950

Mobilization/Demobilization (5%)	$113,248
Contractor Markup (25%)	$566,238
Construction, Administration, and Design Engineering (15%)	$339,743
Change Order Contingencies (10%)	$226,495
Escalation to Midpoint of Construction (5% per year over 4 years)	$488,097
Level "C" Health and Protection Requirements (40%)	$905,980
Bonds and Insurance (10%)	$226,495

TOTAL $5,131,244

say **$5,132,000**

SOURCES: 1 - Means, 1989

10.3.2.3 Slurry Wall

Capital Costs:

The installation of a 3-foot thick slurry wall along the property line of three sides of the site (upgradient, north, and south) would require approximately 5,700 linear feet of wall to an average depth of 15 feet, keyed into the confining unit. The cost of this slurry wall is contingent on the ability to place excavated fill material on-site prior to placement of the cap. Unless this condition is met, the disposal of contaminated soil at a commercial facility would render this technology cost-prohibitive. The total capital cost associated with the installation of a soil-bentonite slurry wall is $2,184,000, with a breakdown of the costs presented in Table 10-5.

Annual O&M Costs:

There are no annual O&M costs associated with the slurry wall.

10.3.2.4 MSG and Soil Caps

Capital Costs:

It is assumed that the approximately 10-foot high waste piles on the southern portion of the site which must be regraded cover an area of approximately 500 feet by 500 feet (5.7 acres). Other than this regrading, no other intrusive activities will be performed for the cap. For installation of the MSG cap, large trees on the site will be cut at ground level leaving the stumps and root systems in place. Other large objects on the site will also be removed.

The estimated capital cost for the MSG cap is $13,240,000 and for the soil cap is $9,700,000. A breakdown of the capital cost for each cap

TABLE 10-5

GRATWICK-RIVERSIDE PARK
CAPITAL COST ESTIMATE

SLURRY WALLS

ITEM	UNITS	QUANTITY	UNIT COST	SOURCE	TOTAL COST
Slurry Wall	sq. ft	84,750	$11	1	$932,250
Excavated Fill -Haul	cy	9,500	$3	2	$28,500
-Place and Grade	cy	9,500	$5	3	$47,500

SUBTOTAL $1,008,250

Mobilization/Demobilization (5%)	$50,413
Contractor Markup (25%)	$252,063
Construction, Administration, and Design Engineering (15%)	$151,238
Level "C" Health and Safety Requirements (40%)	$403,300
Escalation to Midpoint of Construction (5% per year over 4 years)	$217,278
Bonds and Insurance (10%)	$100,825

TOTAL $2,183,365

say **$2,184,000**

SOURCES:
1 - Estimate from actual construction at ACIA
2 - URS estimate
3 - Helen Kramer Landfill Construction Costs

is given in Table 10-6. The basis for the capital cost estimate is given below.

To provide a uniform and sloped surface for the cap, general fill will be placed and compacted over the entire 53 acres based on the following configuration:

- o a normal slope of 1% (for cost estimating purposes) with a crown in the middle of the site
- o a 2.5-foot crown at the midpoint between the Niagara River shoreline and River Road along the entire length of the site (5,000 ft)
- o width of site (i.e. from Niagara River shoreline to River Road) is assumed to average 460 feet.

The selected cap will be placed over 53 acres and will be comprised of:

- o vegetative cover (soil or MSG cap);
- o 6" topsoil (soil or MSG cap);
- o 12" sand drainage layer (MSG cap only);
- o 12" general fill layer (soil cap only); and
- o 60 mil HDPE liner (MSG cap only).

Surface water drainage ditches will be placed along the 3 sides of the site (6,000 ft) and will convey surface water runoff to the Niagara River. Unit costs for soil (viz. general fill, sand and topsoil) work are based on in-place volumes and account for the variability in working volumes of soil (e.g. increased haul volumes resulting from soil rebound during excavation).

TABLE 10-6

GRATWICK- RIVERSIDE PARK
CAPITAL COST ESTIMATE

MSG AND SOIL CAPS

COMPONENT	ITEM	UNITS	QUANTITY	UNIT COST	SOURCE	TOTAL COST MSG CAP	TOTAL COST SOIL CAP
1. GRADING	Grade Hazardous Waste Piles	cy	93,000	$5	1	$465,000	$465,000
2. CLEARING	Remove Large Obstacles	ac	53	$2,000	1	$106,000	$106,000
3. GENERAL FILL	Furnish and Deliver	cy	107,000	$7	1	$749,000	$749,000
	Haul	cy	107,000	$3	2	$321,000	$321,000
	Place and Grade	cy	107,000	$5	1	$535,000	$535,000
	Compact/Smooth Roll	ac	53	$600	3	$31,800	$31,800
4. 60 mil HDPE GEOMEMBRANE	Furnish, Deliver, and Install	sf	2,310,000	$0.80	4	$1,848,000	NA
5. 1 FOOT SAND DRAINAGE LAYER	Furnish and Deliver	cy	86,000	$7	1	$602,000	NA
	Haul	cy	86,000	$3	2	$258,000	NA
	Place and Grade	cy	86,000	$5	1	$430,000	NA
6. 1 FOOT GENERAL FILL	Furnish and Deliver	cy	86,000	$7	1	NA	$602,000
	Haul	cy	86,000	$3	2	NA	$258,000
	Place and Grade	cy	86,000	$5	1	NA	$430,000
7. 6 INCH TOPSOIL LAYER	Furnish and Deliver	cy	43,000	$20	1	$860,000	$860,000
	Haul	cy	43,000	$3	2	$129,000	$129,000
	Place and Grade	cy	43,000	$5	1	$215,000	$215,000
8. COVER	Seed, Mulch, and Fertilize	ac	53	$3,300	3	$174,900	$174,900
9. DRAINAGE	Surface Drainage Ditches	ft	6,000	$17	2	$102,000	$102,000

	MSG CAP	SOIL CAP
SUBTOTAL	$6,826,700	$4,978,700
Mobilization/Demobilization (5%)	$341,335	$248,935
Contractor Markup (25%)	$1,706,675	$1,244,675
Construction, Administration and Design Engineering (15%)	$1,024,005	$746,805
Change Order Contingencies (10%)	$682,670	$497,870
Level "C" Health and Safety Requirements (40% applied to item 1)	$186,000	$186,000
Level "D" Health and Safety Requirements (5% applied to items 2 to 9)	$318,085	$225,685
Escalation to Midpoint of Construction (5% per year for 4 years)	$1,471,154	$1,072,910
Bonds and Insurance (10%)	$682,670	$497,870
TOTAL	$13,239,294	$9,699,450
say	$13,240,000	$9,700,000

NOTE: NA - Not Applicable

SOURCES:
1 - Helen Kramer Landfill Construction Costs
2 - URS Estimate
3 - Lockport City Landfill Construction Costs
4 - Quote from Gundle Liner, Inc.

Annual O&M Costs:

The estimated annual O&M costs for the MSG cap are $69,000 and for the soil cap are $68,000. A breakdown of the O&M costs for each cap is given in Table 10-7.

It is assumed that inspection of the cap will be performed on a routine basis averaging 6 times per year and requiring 8 hours per day. Maintenance of the vegetative cover will require 640 manhours per year primarily for cutting grass and refilling eroded areas. Equipment costs are included under vegetative cover maintenance.

For the O&M cost estimate it was assumed that 2 cap breakthroughs would occur each year and that as a result a total area of 800 square feet would require repair. It was further assumed that the damaged area would be excavated to a depth of 2 feet and that the excavated material would be transported off-site to a secure landfill for disposal in the event that the breakthrough resulted in contamination of the general fill and capping material. The cap would then be completely restored to its original configuration.

10.3.2.5 Withdrawal Wells

Capital Costs:

Results of the groundwater modeling efforts showed that approximately six withdrawal wells in the upper aquifer would be adequate. This is subject to site-specific pump test results and the selected alternative; therefore, for cost estimating purposes, it is assumed that six withdrawal wells will be installed in the upper aquifer to a depth of 15 feet. Each well will contain a submersible pump with a capacity of 50 gpm; four spare pumps will be kept on-site. A force main connecting each of the withdrawal wells to the leachate collection system has been

TABLE 10–7

GRATWICK–RIVERSIDE PARK
ANNUAL O & M COST ESTIMATE

MSG AND SOIL CAP

COMPONENT	ITEM	UNITS	ANNUAL QUANTITY	UNIT COST	SOURCE	TOTAL COST	
						MSG CAP	SOIL CAP
1. INSPECTION	Inspection of Cap	hr	48	$25	1	$1,200	$1,200
2. MAINTENANCE	Maintain Vegetative Cover and Topsoil	hr	640	$30	1	$19,200	$19,200
3. REPAIR CAP BREAK-THROUGHS	a. Excavation, Removal, and Disposal of Damaged Cap	cy	60	$400	2	$24,000	$24,000
	b. Replacement of General Fill	cy	30	$15	1	$450	$450
	c. Replacement of HDPE Liner	sf	800	$0.80	1	$640	NA
	d. Replacement of Sand Drainage Layer	cy	30	$15	1	$450	NA
	e. Replacement of Additional General Fill Layer	cy	30	$15	1	NA	$450
	f. Replacement of Topsoil	cy	15	$28	1	$420	$420
	g. Re-Vegetate	ac	0.02	$3,300	1	$66	$66

SUBTOTALS $46,426 $45,786

Mobilization/Demobilization (5% applied to item 3)	$1,301	$1,269
Contractor Markup (25% applied to item 3)	$6,507	$6,347
Level "C" Health Protection (40% applied to item 3a)	$9,600	$9,600
Level "D" Health Protection (5% applied to items 3b to 3g)	$101	$69
Contingencies (10%)	$4,643	$4,579

TOTAL ANNUAL COSTS **$68,578** **$67,650**

say **<u>$69,000</u>** **<u>$68,000</u>**

NOTE: NA - Not Applicable

SOURCES: 1 - URS Estimate
2 - Quote from CECOS International

included. The estimated capital cost of constructing these wells is $129,000. A breakdown of the capital costs is given in Table 10-8.

Annual O&M Costs:

Annual operation and maintenance costs are expected to be minimal and as such will be included with the selected leachate treatment or disposal option.

10.3.2.6 Groundwater Treatment

General:

In order to establish a basis for design, the groundwater data presented in Table 7-1 was utilized to develop design concentrations, (i.e. expected influent concentration) for the contaminants expected to be present in groundwater flowing into the treatment system. The design concentration for each parameter is assumed to be equal to the maximum concentration detected in the upper aquifer. However, in cases where the maximum concentration is significantly greater than the average concentration, this assumption would result in an overly conservative basis for equipment sizing and costs. If the maximum concentration is greater than four times the average concentration, the design concentration is then assumed to be equal to four times the average concentration. The design concentrations are presented in Table 10-9. The groundwater collection rates are assumed to be 200, 60, 120 and 150 gpm for Alternatives 3, 4, 5 and 6, respectively, for design purposes.

As presented in Section 9.0, there are a number of discharge options possible following groundwater treatment. For cost estimating purposes the two options developed were a full treatment option and a pretreatment option. Process flow schematics for these two options are illustrated in Figures 10-1 and 10-2. For the full treatment option, the effluent

TABLE 10–8

GRATWICK–RIVERSIDE PARK
CAPITAL COST ESTIMATE

WITHDRAWAL WELLS

ITEM	UNITS	QUANTITY	UNIT COST	SOURCE	TOTAL COST
6 Wells in Upper Aquifer	linear ft	90	$18	1	$1,620
Pumps	ea	6	$1,800	1	$10,800
Pumps (Spare)	ea	4	$1,800	1	$7,200
Force Main	linear ft	10,000	$4	1	$40,000

SUBTOTAL $59,620

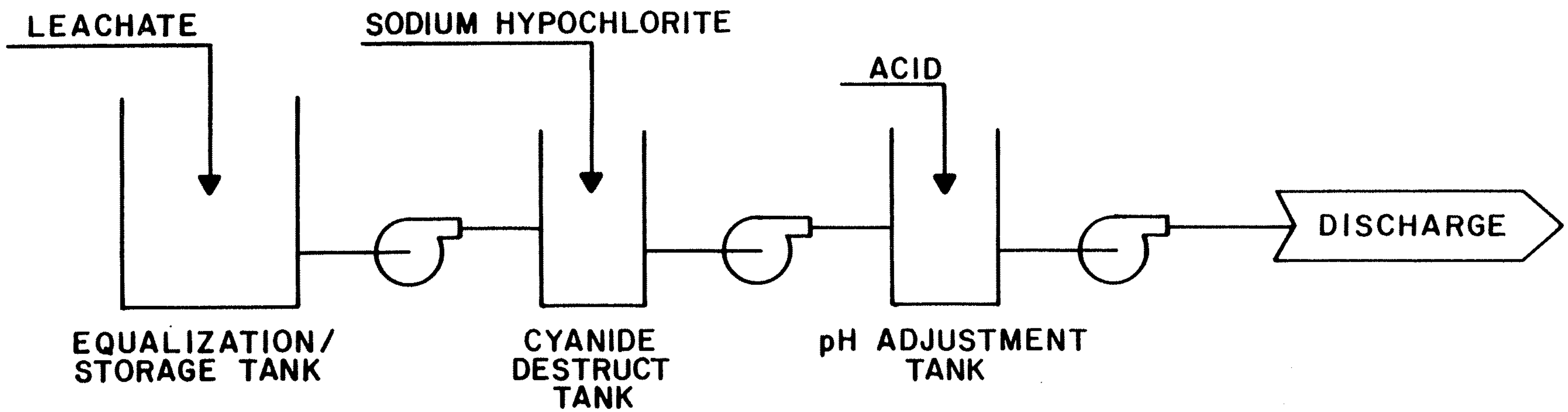
Mobilization/Demobilization (5%)	$2,981
Contractor Markup (25%)	$14,905
Construction, Administration, and Design Engineering (15%)	$8,943
Level "C" Health and Safety Requirements (40%)	$23,848
Escalation to Midpoint of Construction (5% per year over 4 years)	$12,848
Bonds and Insurance (10%)	$5,962

TOTAL $129,107

say <u>$129,000</u>

SOURCES: 1 – Means, 1989

A-3126

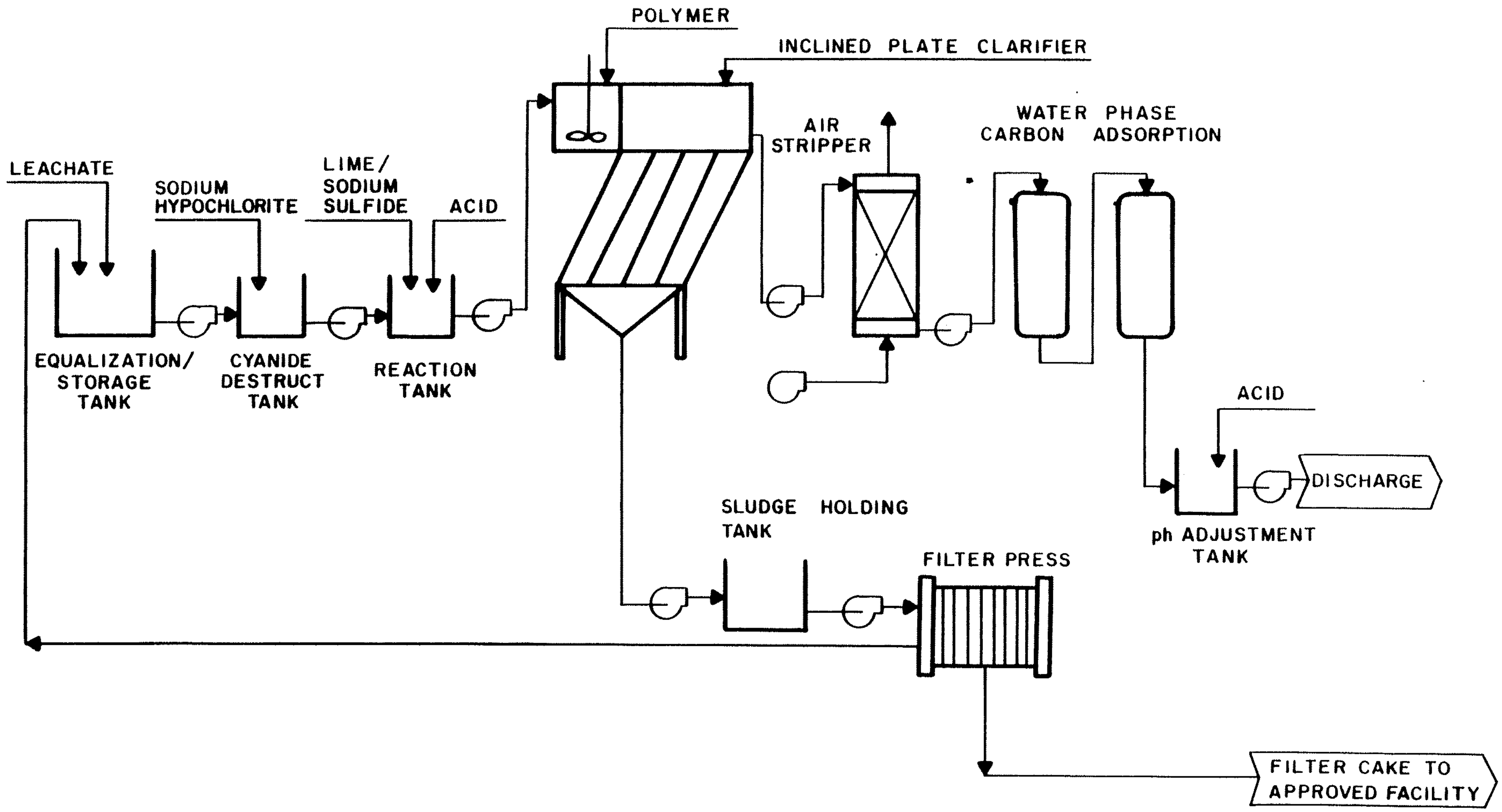


URS CONSULTANTS

GROUNDWATER TREATMENT SYSTEM
(PRETREATMENT OPTION)

FIGURE 10-1

A-3113A



URS CONSULTANTS

GROUNDWATER TREATMENT SYSTEM
(FULL TREATMENT OPTION)

FIGURE 10-2

limitation is assumed to be the groundwater standard for each parameter. For the pretreatment option, the effluent limitation is assumed to be the pretreatment program ordinance limits for the local POTW. The local POTW in the area of the Gratwick site is the North Tonawanda Plant which is a physical/chemical plant. At present, the major removal operations include primary clarification, sand filtration, and carbon adsorption. A pretreatment program has been implemented and ordinance limits have been established for a number of parameters including metals, total cyanide, phenol, and oil and grease. These effluent limitations are included in Table 10-9.

Although two options were evaluated, only the pretreatment option is utilized for developing costs for alternatives in Sections 10.2 and 10.3.3. At this time, the pretreatment option is considered the most practical and economical alternative. However, depending on future negotiations with the State and the City of North Tonawanda, further restrictions may be placed on the discharge from the Gratwick site. As a result, some or all of the cost associated with full treatment may be applicable in the future. Consequently, the costs associated with full treatment are also presented in this section as a reference to be used during the design phase as more data concerning discharge limitations becomes available and to present a preliminary estimate of the upper limit for groundwater treatment cost.

- Equipment Sizing:

The design criteria and equipment sizing for the treatment system are summarized in Table 10-10. Equipment sizing is based on a flow rate of 60 gpm.

TABLE 10-9 (PAGE #1 of 2)
GRATWICK-RIVERSIDE PARK

SUMMARY OF GROUNDWATER TREATMENT DESIGN DATA

SUBSTANCE	UNITS	DESIGN CONCENTRATION	PRETREATMENT STANDARDS	EFFLUENT LIMITATION
Methylene chloride	ug/l	32	–	5
Acetone	ug/l	2,265.6	–	50
1,1-Dichloroethane	ug/l	320	–	0.033
1,2-Dichloroethene (total)	ug/l	5	–	5
1,2-Dichloroethane	ug/l	40	–	0.8
Chloroform	ug/l	5	–	0.19
Vinyl chloride	ug/l	68	–	2
2-Butanone	ug/l	916	–	50
Trichloroethene	ug/l	1,412	–	0
1,1,1-Trichloroethane	ug/l	172	–	5
Benzene	ug/l	56	–	ND
Tetrachloroethene	ug/l	384	–	0.7
Toluene	ug/l	228	–	5
Ethylbenzene	ug/l	80	–	5
Total xylenes	ug/l	248	–	50
Chlorobenzene	ug/l	44	–	5
Styrene	ug/l	22	–	5
Phenol	ug/l	2,296	4,000	1
1,4-Dichlorobenzene	ug/l	10	–	4.7
2-Methylphenol	ug/l	680	–	1
4-Methylphenol	ug/l	844	–	1
Benzoic acid	ug/l	344	–	50
Naphthalene	ug/l	26	–	10
2,4-Dimethylphenol	ug/l	340	–	5
4-methyl-2-pentanone	ug/l	2,950	–	50
Di-n-octyl phthalate	ug/l	76	–	50
Isophorone	ug/l	53	–	50
Phenols, total	ug/l	5,128	–	1
Arsenic	ug/l	80	4,900	0.0025
Barium	ug/l	4,352	–	1,000
Beryllium	ug/l	32	10	0.0039
Cadmium	ug/l	136	300	10
Chromium	ug/l	472	4,700	50
Iron	ug/l	2,551,352	–	300
Lead	ug/l	150	4,600	25
Magnesium	ug/l	630,468	–	35,000
Manganese	ug/l	224,132	–	300
Nickel	ug/l	416	3,400	15.4
Silver	ug/l	60	6,000	50
Sodium	ug/l	986,988	–	20,000
Zinc	ug/l	2,748	14,000	300

TABLE 10-9 (PAGE #2 of 2)
GRATWICK-RIVERSIDE PARK

SUMMARY OF GROUNDWATER TREATMENT DESIGN DATA

SUBSTANCE	UNITS	DESIGN CONCENTRATION	PRETREATMENT STANDARDS	EFFLUENT LIMITATION
Cyanide	ug/l	28,288	5,000	10
pH	s.u.	12	-	n/a
Specific conductance	umho/cm	3,990	-	n/a
Total suspended solids	mg/l	2,500	-	n/a
Total dissolved solids	mg/l	3,400	-	n/a
Sulfates	mg/l	1,680	-	n/a
Total organic carbon	mg/l	792	-	n/a
Biological oxygen demand	mg/l	808	-	n/a
NH3 - N	mg/l	21	-	n/a
TKN	mg/l	25	-	n/a
Phosphorous	mg/l	3.32	-	n/a
Oil and Grease	mg/l	17	-	n/a
Hardness	mg/l	5,256	-	n/a
Total alkalinity	mg/l	4,100	-	n/a
Bicarbonate alkalinity	mg/l	2,500	-	n/a

Note: Data from two rounds of sampling of 11 monitoring wells during RI
December 1987 - 11 samples; and August 1988 - 11 samples

TABLE 10-10

GRATWICK-RIVERSIDE PARK
EQUIPMENT SIZING

GROUNDWATER TREATMENT
(60 GPM SYSTEM)

EQUIPMENT DESCRIPTION	DESIGN CRITERIA	SIZE
Equalization Storage Tank	24 Hour Retention Time	90,000 gal
Cyanide Destruct Tank	10 Minute Retention Time	600 gal
Reaction Tank	30 Minute Retention Time	2,000 gal
Sludge Tank	Sludge Flowrate = 3 gpm 1 Week Retention Time	30,000 gal
pH Adjustment Tank	10 Minute Retention Time	600 gal
Equalization Tank Agitator	0.15 HP per 1000 gal	15 HP
Cyanide Destruct Tank Agitator	3 HP per 1,000 gal	2 HP
Reaction Tank Agitator	2 HP per 1,000 gal	5 HP
pH Adjustment Tank Agitator	3 HP per 1,000 gal	2 HP
Inclined Plate Clarifier	Over Flow Rate = 0.25 gal per sq ft	240 sq ft
Filter Press	Suspended Solids = 1000 mg/l 40% Solids in Filter Cake Cake Density = 70 lb per cu ft Sludge Dewatered 5 times per week	40 cu ft
Air Stripper	Water Temperature = 55 F Air to Water Ratio = 100:1	Column Diameter = 2 ft Column Height = 21 ft
Blower	Same As Above	800 cfm
Carbon Adsorption System	Carbon Polish to Remove Phenol and 4-methyl-2 pentanone	Dual Adsorber System with 20,000 lbs of carbon in each adsorber
Compresser	60 cfm @ 15 psi	20 HP
* - Process Pumps (12)		60 gpm
* - Sludge Pumps (2)		3 gpm
* - Sludge Pumps (2)		20 gpm
* - Metering Pumps (10)		0.5 gpm

NOTE: * - Number of Pumps required is given in parenthesis.
It is assumed that a spare pump is installed.

Capital Cost:

Equipment costs were obtained from Process Plant Construction Estimating Standards (Richardson Engineering Service, 1988), Site Work Cost Data (R.S. Means Company, 1988) and vendor quotations. Data used for sizing equipment is preliminary as a treatability study has not yet been performed. Consequently, an estimate of capital costs has been prepared based on knowledge of major equipment and published factors for equipment installation (Peters et. al, 1980). The estimated total capital costs are $452,000 for the pretreatment system (60 gpm) and $2,059,000 for the full treatment system (60 gpm). A breakdown of the costs for the two treatment system options is presented in Table 10-11. The capital costs presented in Table 10-11 pertain to Alternative 4. The capital costs for groundwater treatment systems for Alternatives 3, 5 and 6, are based on the costs for Alternative 4 and a scaling factor to account for the difference in system capacities. The cost for these three alternatives was determined by the equation given below:

$$\text{Cost for Alternative 3, 5 or 6} = (\text{cost of Alt 4}) \times \left(\frac{\text{capacity of Alt. 3, 5 or 6}}{\text{capacity of Alt. 4}}\right)^{0.6}$$

Therefore, the estimated costs for the pretreatment systems under Alternatives 3 (200 gpm), 5 (120 gpm) and 6 (150 gpm) are $931,000, $685,000 and $783,000 respectively.

Annual O&M Costs:

The basis for O&M costs is presented in Table 10-12. O&M costs are shown in Table 10-13. The estimated annual O&M costs for Alternatives 3, 4, 5 and 6 under the pretreatment option are $203,000, $94,000, $142,000 and $165,000 respectively, and $1,106,000, $438,000, $732,000 and $874,000

TABLE 10-11 (PAGE #1 of 2)

GRATWICK- RIVERSIDE PARK
CAPITAL COST ESTIMATE

GROUNDWATER TREATMENT (60 GPM CAPACITY)
(A) PRETREATMENT OPTION

ITEM	UNITS	# OF ITEMS	UNIT COST	SOURCE	TOTAL COST
EQUIPMENT COSTS					
Equalization Tank	ea	1	$48,000	1	$48,000
Cyanide Destruct Tank	ea	1	$300	2	$300
pH Adjust Tank	ea	1	$300	2	$300
Equalization Tank Agitator	ea	1	$14,800	1	$14,800
Cyanide Destruct Tank Agitator	ea	1	$5,800	1	$5,800
pH Adjust Tank Agitator	ea	1	$5,800	1	$5,800
Process Pumps	ea	6	$1,500	1	$9,000
Metering Pumps	ea	4	$2,000	1	$8,000
SUBTOTAL EQUIPMENT					$92,000
ADDITIONAL DIRECT COSTS					
Equipment Installation (50% of Equipment)					$46,000
Instrumentation and Controls (20% of Equipment)					$18,400
Piping (60% of Equipment)					$55,200
Electrical (10% of Equipment)					$9,200
Buildings (20% of Equipment)					$18,400
Service Facilities and Yard Improvements (20% of Equipment)					$18,400
TOTAL DIRECT COSTS					$257,600

Contractor Markup (25% of Direct)	$64,400
Construction, Administration, and Design Engineering (15% of Direct)	$38,640
Change Order Contingencies (10% of Direct)	$25,760
Escalation to Midpoint of Construction (5% per year over four years)	$55,513
Level "C" Health Protection Requirements (20% of Equipment Installation)	$9,200
TOTAL	$451,113
say	$452,000

SOURCES:

1 - Richardson, 1988
2 - Means, 1988

TABLE 10-11 (PAGE #2 of 2)

GRATWICK- RIVERSIDE PARK
CAPITAL COST ESTIMATE

GROUNDWATER TREATMENT (60 GPM CAPACITY)
(B) FULL TREATMENT OPTION

ITEM	UNITS	# OF ITEMS	UNIT COST	SOURCE	TOTAL COST
EQUIPMENT COSTS					
Equalization Tank	ea	1	$48,000	1	$48,000
Reaction Tank	ea	1	$1,800	2	$1,800
Cyanide Destruct Tank	ea	1	$300	2	$300
Sludge Tank	ea	1	$36,000	1	$36,000
pH Adjust Tank	ea	1	$300	2	$300
Equalization Tank Agitator	ea	1	$14,800	1	$14,800
Reaction Tank Agitator	ea	1	$8,300	1	$8,300
Cyanide Destruct Tank Agitator	ea	1	$5,800	1	$5,800
pH Adjust Tank Agitator	ea	1	$5,800	1	$5,800
Inclined Plate Clarifier	ea	1	$35,000	3	$35,000
Filter Press with Feed Pumps	ea	1	$38,000	3	$38,000
Air Stripper with Blower	ea	1	$25,000	3	$25,000
Carbon Adsorption System	ea	1	$155,000	3	$155,000
Compressor	ea	1	$6,800	3	$6,800
Process Pumps	ea	12	$1,500	1	$18,000
Sludge Pumps	ea	2	$500	1	$1,000
Metering Pumps	ea	10	$2,000	1	$20,000
SUBTOTAL EQUIPMENT					$419,900
ADDITIONAL DIRECT COSTS					
Equipment Installation (50% of Equipment)					$209,950
Instrumentation and Controls (20% of Equipment)					$83,980
Piping (60% of Equipment)					$251,940
Electrical (10% of Equipment)					$41,990
Buildings (20% of Equipment)					$83,980
Service Facilities and Yard Improvements (20% of Equipment)					$83,980
TOTAL DIRECT COSTS					$1,175,720

Contractor Markup for Overhead and Profit (25% of Direct)	$293,930
Construction, Administration, and Design Engineering (15% of Direct)	$176,358
Change Order Contingencies (10% of Direct)	$117,572
Escalation to Midpoint of Construction (5% per year over four years)	$253,368
Level "C" Health Protection Requirements (20% of Equipment Installation)	$41,990
TOTAL	$2,058,938
say	$2,059,000

SOURCES:

1 - Richardson, 1988
2 - Means, 1988
3 - Vendor Quotation

TABLE 10–12

GRATWICK–RIVERSIDE PARK
BASIS FOR ANNUAL O & M COST ESTIMATE

GROUNDWATER TREATMENT

ITEM	FULL TREATMENT BASIS	PRETREATMENT BASIS	UNIT COST
Operating and Maintenance Labor	1 man, 8 hrs per day 7 days per week	1 man, 4 hrs per day 5 days per week	$25 per hour
Maintenance	3% of Capital Costs	3% of Capital Costs	3% of Capital Costs
Insurance and Taxes	1% of Capital Costs	1% of Capital Costs	1% of Capital Costs
Maintenance Reserve and Contingency Costs	1% of Capital Costs	1% of Capital Costs	1% of Capital Costs
Granulated Activated Carbon	2 lb per 1000 gal (*)	N/A	$1.25 per lb (*)
Energy			
–Electricity	HP x .747 x hrs of operation	HP x .747 x hrs of operation	$0.07 per kWh
Chemicals			
–Calcium Hydroxide (Lime)	250 mg/l	N/A	$60.00 per Ton (**)
–Sulfuric Acid	250 mg/l	250 mg/l	$96.00 per Ton (100% Basis) (**)
–Sodium Hypochlorite	350 mg/l	350 mg/l	$182.00 per Ton (100% Basis) (***)
–Polymer	1 mg/l	N/A	$1.25 per lb
Filter Cake Disposal	1000 mg/l T.S.S. 40% solids in cake Cake Density = 70 lb per cu ft	N/A	$350.00 per cu yd (****)
Monitoring Costs			
–Conventional Parameters	Monthly	Monthly	$300
–TCL Parameters	Quarterly	Quarterly	$1350
Sewer Use Charge			
–Flow	60 gpm	60 gpm	$0.05 per 1000 gal (*****)
–BOD Surcharge	250 mg/l	500 mg/l	$0.03 per lb (*****)
–SS Surcharge	0 mg/l	700 mg/l	$0.03 per lb (*****)

NOTES:
* – Estimate and quote from Calgon Carbon Corporation
** – Chemical Marketing Reporter
*** – Quote from Riverside Chemical Corporation
**** – Quote from Cecos International
***** – Estimate Provided by City of North Tonawanda Treatment Plant

TABLE 10-13 (PAGE #1 of 2)

GRATWICK-RIVERSIDE PARK
ANNUAL O & M COST ESTIMATE

GROUNDWATER TREATMENT
(A) PRETREATMENT OPTION

ITEM	UNITS	QUANTITY				UNIT COST	TOTAL COST			
		ALT. 3	ALT. 4	ALT. 5	ALT. 6		ALT. 3	ALT. 4	ALT. 5	ALT. 6
O & M Labor	HRS	1,040	1,040	1,040	1,040	$25.00	$26,000	$26,000	$26,000	$26,000
Maintenance							$27,925	$13,560	$20,553	$23,498
Insurance and Taxes							$9,308	$4,520	$6,851	$7,833
Maintenance Reserve and Contingency Costs							$9,308	$4,520	$6,851	$7,833
Energy										
-Electricity	KWH	654,372	196,312	392,623	490,779	$0.07	$45,806	$13,742	$27,484	$34,355
Chemicals										
-Sulfuric Acid	LB	219,175	65,753	131,505	164,381	$0.048	$10,520	$3,156	$6,312	$7,890
-Sodium Hypochlorite	LB	306,845	92,054	184,107	230,134	$0.091	$27,923	$8,377	$16,754	$20,942
Monitoring Costs										
-Conventional Parameters	EA	12	12	12	12	$300	$3,600	$3,600	$3,600	$3,600
-TCL Parameters	EA	4	4	4	4	$1,350	$5,400	$5,400	$5,400	$5,400
Sewer Use Charge										
-Flow	KGAL	105,120	31,536	63,072	78,840	$0.05	$5,256	$1,577	$3,154	$3,942
-BOD Surcharge	LB	438,350	131,505	263,010	328,763	$0.03	$13,151	$3,945	$7,890	$9,863
-SS Surcharge	LB	613,691	184,107	368,214	460,268	$0.03	$18,411	$5,523	$11,046	$13,808
TOTAL O & M COST							$202,608	$93,920	$141,895	$164,963
						say	**$203,000**	**$94,000**	**$142,000**	**$165,000**

NOTES: Basis for Alternative Costs:					
	Alternative 3:	200	gpm	100	HP
	Alternative 4:	60	gpm	30	HP
	Alternative 5:	120	gpm	60	HP
	Alternative 6:	150	gpm	75	HP

TABLE 10-13 (PAGE #2 of 2)

GRATWICK-RIVERSIDE PARK
ANNUAL O & M COST ESTIMATE

GROUNDWATER TREATMENT
(B) FULL TREATMENT OPTION

ITEM	UNITS	QUANTITY				UNIT COST	TOTAL COST			
		ALT. 3	ALT. 4	ALT. 5	ALT. 6		ALT. 3	ALT. 4	ALT. 5	ALT. 6
O & M Labor	HRS	2,920	2,920	2,920	2,920	$25.00	$73,000	$73,000	$73,000	$73,000
Maintenance							$127,205	$61,770	$93,626	$107,039
Insurance and Taxes							$42,402	$20,590	$31,209	$35,680
Maintenance Reserve and Contingency Costs							$42,402	$20,590	$31,209	$35,680
Granulated Activated Carbon	LB	210,240	63,072	126,144	157,680	$1.25	$262,800	$78,840	$157,680	$197,100
Energy										
-Electricity	KWH	1,210,588	490,779	817,965	981,558	$0.07	$84,741	$34,355	$57,258	$68,709
Chemicals										
-Calcium Hydroxide	LB	219,175	65,753	131,505	164,381	$0.03	$6,575	$1,973	$3,945	$4,931
-Sulfuric Acid	LB	219,175	65,753	131,505	164,381	$0.048	$10,520	$3,156	$6,312	$7,890
-Sodium Hypochlorite	LB	306,845	92,054	184,107	230,134	$0.091	$27,923	$8,377	$16,754	$20,942
-Polymer	LB	877	263	526	658	$1.25	$1,096	$329	$658	$822
Filter Cake Disposal	CY	1,160	348	696	870	$350	$405,880	$121,764	$243,528	$304,410
Monitoring Costs										
-Conventional Parameters	EA	12	12	12	12	$300	$3,600	$3,600	$3,600	$3,600
-TCL Parameters	EA	4	4	4	4	$1,350	$5,400	$5,400	$5,400	$5,400
Sewer Use Charge										
-Flow	KGAL	105,120	31,536	63,072	78,840	$0.05	$5,256	$1,577	$3,154	$3,942
-BOD Surcharge	LB	219,175	65,753	131,505	164,381	$0.03	$6,575	$1,973	$3,945	$4,931
TOTAL O & M COST							$1,105,376	$437,292	$731,276	$874,077
						say	$1,106,000	$438,000	$732,000	$874,000

NOTES: Basis for Alternative Costs:

Alternative 3:	200	gpm	185	HP
Alternative 4:	60	gpm	75	HP
Alternative 5:	120	gpm	125	HP
Alternative 6:	150	gpm	150	HP

respectively under the full treatment option. A breakdown of the O&M costs for each system is presented in Table 10-13.

10.3.3 Cost Estimates for Alternatives

Table 10-14 summarizes the capital and annual O&M costs for each alternative based on the component costs given previously. For the economic evaluation of alternatives, the total cost (i.e. capital and annual O&M costs) for an alternative are converted to their present worth based on a performance period of 30 years and a 10% interest rate. The present worth of costs of each alternative is also presented in Table 10-14. These costs are discussed below.

10.3.3.1 Alternative 1 - No Action

The No Action alternative has no cost associated with it.

10.3.3.2 Alternative 2 - Institutional Action

The Institutional Action alternative has monitoring well installation and long-term groundwater monitoring (i.e. sampling and analyses) costs associated with it. Total capital costs are $8,000; annual O&M costs are $17,000; and the total present worth of the costs for this alternative is $169,000.

10.3.3.3 Alternative 3 - Sheet Pile Breakwater/MSG Cap/Withdrawal Wells/Groundwater Pretreatment

The capital costs associated with this alternative include installation of withdrawal and groundwater monitoring wells, and construction of a sheet pile breakwater, an MSG cap, and groundwater pretreatment facilities. The majority of the capital cost will be expended on construction of the MSG cap. The total capital costs amount

TABLE 10–14

GRATWICK–RIVERSIDE PARK
COST ESTIMATES FOR REMEDIAL ALTERNATIVES

COST	ALTERNATIVE					
	1	2	3	4	5	6
CAPITAL COSTS						
–Groundwater Monitoring Wells	NA	$8,000	$8,000	$8,000	$8,000	$8,000
–Sheet Pile Breakwater	NA	NA	$5,132,000	$5,132,000	$5,132,000	$5,132,000
–Slurry Wall	NA	NA	NA	$2,184,000	$2,184,000	NA
–MSG Cap	NA	NA	$13,240,000	$13,240,000	NA	NA
–Soil Cap	NA	NA	NA	NA	$9,700,000	$9,700,000
–Withdrawal Wells	NA	NA	$129,000	$129,000	$129,000	$129,000
–Groundwater Treatment (Pretreatment)	NA	NA	$931,000	$452,000	$685,000	$783,000
TOTAL CAPITAL COST	NA	$8,000	$19,440,000	$21,145,000	$17,838,000	$15,752,000
ANNUAL O & M COSTS						
–Groundwater Monitoring Wells	NA	$17,000	$17,000	$17,000	$17,000	$17,000
–MSG Cap	NA	NA	$69,000	$69,000	NA	NA
–Soil Cap	NA	NA	NA	NA	$68,000	$68,000
–Groundwater Treatment (Pretreatment)	NA	NA	$203,000	$94,000	$142,000	$165,000
TOTAL ANNUAL O&M COST	NA	$17,000	$289,000	$180,000	$227,000	$250,000
PRESENT WORTH OF O & M COST	$0	$161,000	$2,724,000	$1,697,000	$2,140,000	$2,357,000
PRESENT WORTH OF TOTAL COST (CAPITAL PLUS O&M)	**$0**	**$169,000**	**$22,164,000**	**$22,842,000**	**$19,978,000**	**$18,109,000**

NOTE Present worth analysis based on a 30 year performance period at 10% interest per year
NA – Not Applicable
Alt 1. – No Action
Alt 2. – Institutional Action
Alt 3. – Sheet Pile Breakwater, MSG Cap, Withdrawal Wells, Groundwater Pretreatment
Alt 4. – Sheet Pile Breakwater, Slurry Wall, MSG Cap, Withdrawal Wells, Groundwater Pretreatment
Alt 5. – Sheet Pile Breakwater, Slurry Wall, Soil Cap, Withdrawal Wells, Groundwater Pretreatment
Alt 6. – Sheet Pile Breakwater, Soil Cap, Withdrawal Wells, Groundwater Pretreatment

to $19,440,000. The annual O&M costs for this alternative cover groundwater monitoring, MSG cap repair and maintenance, and groundwater collection and pretreatment. Groundwater collection and pretreatment forms the bulk of the annual O&M cost. The total annual O&M costs are $289,000. The total present worth of Alternative 3 is $22,164,000.

10.3.3.4 Alternative 4 - Sheet Pile Breakwater/Slurry Wall/MSG Cap/ Withdrawal Wells/Groundwater Pretreatment

The capital costs for the alternative include the installation of withdrawal and groundwater monitoring wells, and construction of a sheet pile breakwater, a slurry wall, an MSG cap, and groundwater pretreatment facilities. Again, the majority of the capital cost will be expended on construction of the MSG cap. The total capital cost amounts to $21,145,000. The annual O&M costs for this alternative are associated with groundwater monitoring, MSG cap repair and maintenance, and groundwater collection and pretreatment, which requires the greatest expenditure of annual O&M costs. The total annual O&M costs are $180,000. The total present worth of the costs for Alternative 4 is $22,842,000.

10.3.3.5 Alternative 5 - Sheet Pile Breakwater/Slurry Wall/Soil Cap/ Withdrawal Wells/Groundwater Pretreatment

The capital costs for this alternative include the installation of withdrawal and groundwater monitoring wells, and construction of a sheet pile breakwater, a slurry wall, a soil cap, and groundwater pretreatment facilities. The construction of the soil cap represents the bulk of the capital cost. The total capital costs amount to $17,838,000. The annual O&M costs for this alternative cover groundwater monitoring, soil cap repair and maintenance and groundwater collection and pretreatment, which again requires the greatest expenditure of annual O&M costs. The total annual O&M costs are $227,000. The total present worth of Alternative 5 is $19,978,000.

10.3.3.6 Alternative 6 - Sheet Pile Breakwater/Soil Cap/Withdrawal Wells/Groundwater Pretreatment

The capital cost of $15,752,000 for Alternative 6 includes the installation of withdrawal and groundwater monitoring wells, and construction of a sheet pile breakwater, a soil cap and groundwater pretreatment facilities. The annual O&M cost of $250,000 for the alternative covers groundwater monitoring, soil cap repair and maintenance, and groundwater collection and pretreatment. The estimated total present worth of Alternative 6 is $18,109,000.

10.4 Comparison of Alternatives

To facilitate the discussion below, reference should be made to Table 10-1.

Short-term Impacts and Effectiveness

Alternatives 1 (no action) and 2 (institutional action) received the highest scores compared to the other remedial alternatives since these remedial actions at the site would not adversely impact the community and the environment in the short-term during implementation. Alternatives 4 (sheet pile, breakwater, slurry wall, MSG cap, withdrawal wells and groundwater pretreatment) and 5 (sheet pile breakwater, slurry wall, soil cap, withdrawal wells and groundwater pretreatment) were given very low scores (3) because of the intrusive construction work associated with the slurry wall. Alternative 3 (sheet pile breakwater, MSG cap, withdrawal wells and groundwater pretreatment) and Alternative 6 (Sheet pile breakwater, soil cap, withdrawal wells and groundwater pretreatment) received a medial score (6).

Long-term Effectiveness and Permanence

Alternative 4 received the highest score for this criterion (9) while Alternatives 1 and 2 were given the lowest score (2). Alternative 5 scored the second highest score (8) with Alternatives 3 and 6 again receiving a medial scores (6 and 5 respectively). Alternative 4 received a high score not only for its long term effectiveness in controlling the risks associated with the contaminants at the site, but because of the high degree of reliability and performance associated with the components of this alternative.

Reduction in Toxicity, Mobility and Volume of Hazardous Waste

Alternative 4 again received the highest score for this criterion (10); however, Alternative 3 scored the second highest score (9) with Alternatives 5 and 6 finishing third (8). Neither Alternative 1 nor 2 received any points for this criterion. The greatest strengths offered by Alternative 4 include effective mitigation of the principal threats posed by the contaminants and significant reduction in contaminant mobility.

Implementability

Alternatives 2 and 6 received the highest score for implementability (11) with Alternatives 1 and 3 receiving the second highest score (10). Alternatives 4 and 5 scored fourth and fifth with (9) and (8), respectively. All alternative scores for this criterion were close to each other. The high scores for Alternatives 1 and 2 reflect the absence of problems and delays associated with implementation. The remaining four alternatives received higher scores than Alternative 1 and 2 for reliability and the high probability that once implemented, future remedial actions would be unnecessary.

Compliance with SCGs

Alternatives 3 and 4 both received the highest score for this criterion (9). Alternatives 5 and 6 scored the next highest score (8) and Alternatives 1 and 2 each received the lowest score (5). The scores for Alternatives 3 and 4 indicate that once implemented, either alternative will provide substantial compliance with the site specific SCGs and appropriate criteria, advisories and guidelines.

Overall Protection of Human Health and Environment

Alternative 4 received the highest score for this criterion (14) with Alternatives 3, 5 and 6 each given the next highest score (12). Alternatives 1 and 2 did not receive any points for this criterion. Alternatives 3, 4, 5 and 6 were deemed to provide overall protection through effective control of contamination and significant reduction of risks to human health and the environment.

Cost

Alternatives 1 and 2 were given the maximum score of 15 each since they represented the least cost approach. The present worth of the capital and O&M costs for the other four alternatives were within the range of $18,000,000 to $23,000,000. Alternatives 3, 4, 5 and 6 were therefore scored (1, 0, 2 and 4) relative to their costs.

Total Scores

Alternative 6 scored the highest (54) of the six alternatives with Alternatives 3, 4 and 5 following closely with scores of 53, 53 and 49, respectively. Alternatives 1 and 2 had the lowest scores (42 each). The closeness of the scores for Alternatives 3, 4 and 5 indicates that these three alternatives will achieve the remedial objectives with relatively equal success.

10.5 Selection of Remedial Approach

Based on the detailed evaluation of alternatives the recommended remedial approach for the Gratwick site is Alternative 6 (Sheet Pile Breakwater/Soil Cap/Withdrawal Wells/Groundwater Pretreatment). Alternatives 1 and 2 were determined ineffective and were therefore not considered in the final analysis.

11.0 CONCEPTUAL DESIGN AND PRELIMINARY COST ESTIMATE OF SELECTED REMEDIAL ALTERNATIVE

11.1 Conceptual Design

The selected remedial approach for the Gratwick site (Alternative 6) consists of a grouted sheet pile breakwater, a soil cap, withdrawal wells, a groundwater pretreatment system, and discharge to the North Tonawanda publicly owned treatment works (POTW). The conceptual design for each of these individual components is discussed below. A summary of the basis of design for this alternative is given in Table 11-1. The site layout of the components is shown on Figure 11-1.

Sheet Pile Breakwater

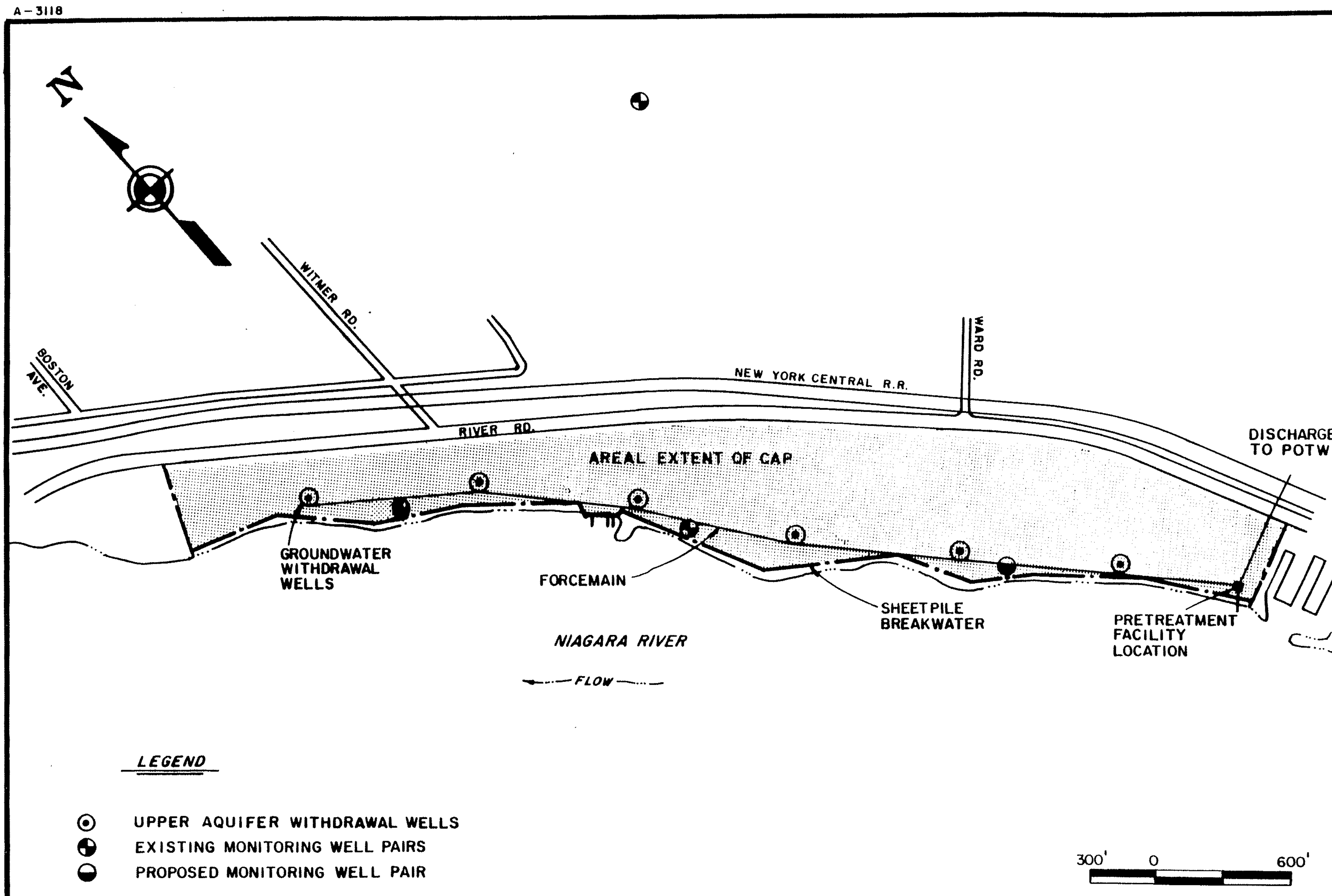
The sheet pile breakwater will be placed along the entire length of the site adjacent to the Niagara River, a distance of approximately 4,900 feet. A detail of the sheet pile breakwater is presented in Figure 11-2. It will be installed as close to the water's edge as possible and will be driven down into the confining layer below the upper aquifer, a distance of approximately 15 feet. The sheet piling will be made of structural steel and grouted to an average depth of 12 feet over its length. The top of the sheet piling will extend to an approximate elevation of 570 feet msl. Backfill will be placed behind the sheet piling (i.e. on the landward side towards River Road) up to the top of the sheet piling and back to match the existing grade of 570 feet msl or the cap edge, whichever is appropriate. Asphalt will be placed over the backfill, across the entire 4,900 foot length, and will extend from the top of the sheet piling to the edge of the cap, an average width of 20 feet. In addition, within the permeable backfill behind the sheet piling, a drainage system will be placed. This drainage system will be used as a backup to the primary system, and if and when the groundwater pumping is terminated.

TABLE 11-1
GRATWICK-RIVERSIDE PARK
BASIS FOR DESIGN

Component	Design Parameter
Sheet Pile Breakwater	
Sheet Piling	Length = 4,900 feet Depth = 15 feet Elevation at Top = 570 feet msl
Grouting	Length = 4,900 feet Depth = 12 feet
Backfill	Elevation at Surface = 570 feet msl
Asphalt	Length = 4,900 feet Average Width = 20 feet Depth = 1-2 inches
Soil Cap	
	Area = 53 acres Slope = 1% (minimum)
Topsoil	Depth = 6 inches
Vegetative Cover	Area = 53 acres
Soil Layer	Depth = 12 inches
General Fill Placement	2.5-foot crown at midsection sloping at 1% to existing grades on edge of site
Regrading Piles	Area = 5.7 acres
Clearing	Area = 53 acres

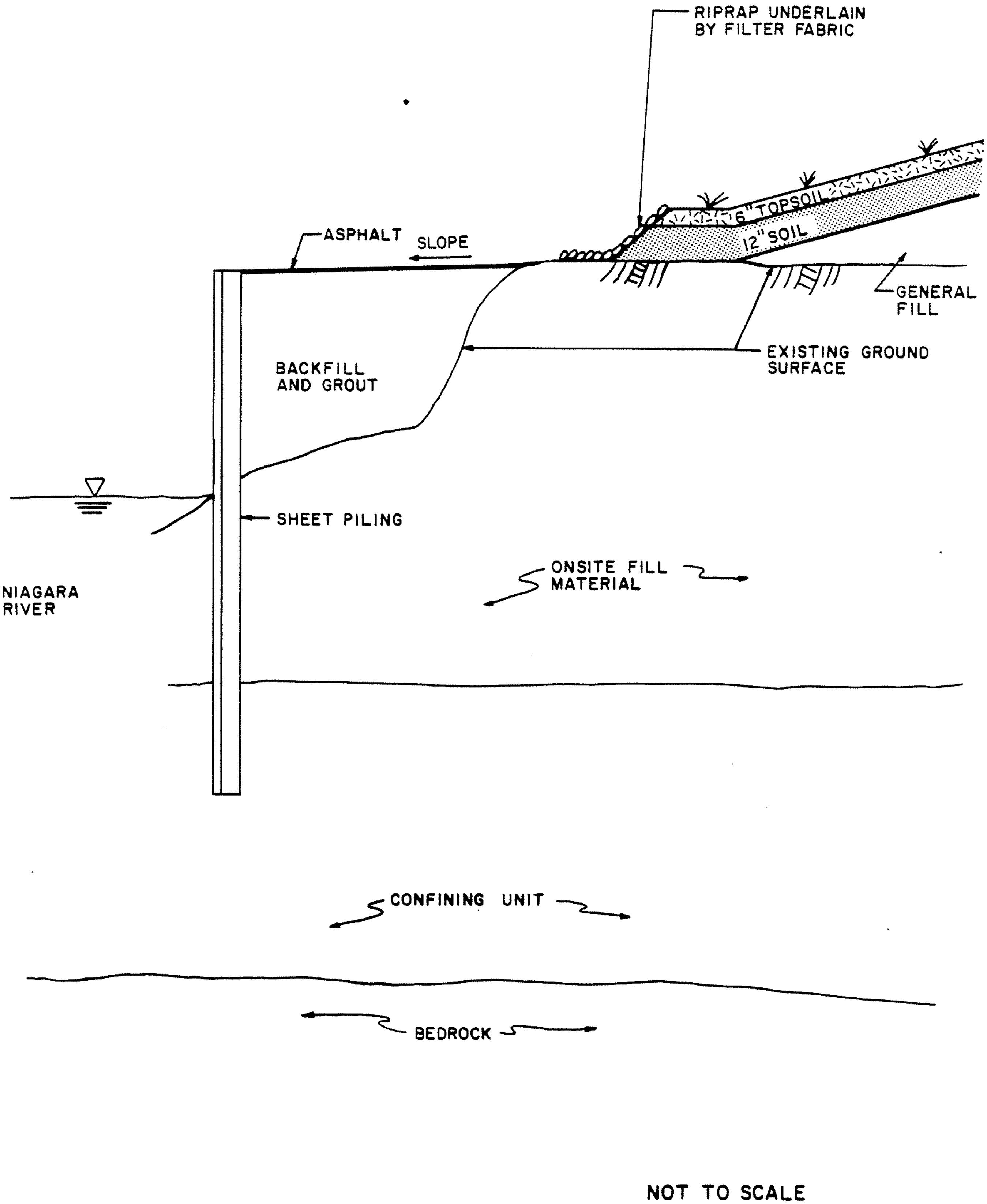
TABLE 11-1 (Continued)
GRATWICK-RIVERSIDE PARK
BASIS FOR DESIGN

Component	Design Parameter
Withdrawal Wells	
Upper Aquifer Wells	Number = 6 Average Depth = 15 feet Each Including a submersible pump Capacity - 50 GPM
Forcemain	Length = 10,000 feet
Groundwater Treatment	
Effluent Limitations	City of North Tonawanda's pretreatment ordinance limits (Table 10-9)
Design Concentrations	Groundwater Sampling Results obtained during RI (Table 10-9)
Flow	150 GPM
Equalization/Storage Tank	Volume = 216,000 gallons Retention Time = 24 hours Agitator - 20 HP mixer
Cyanide Destruct Tank	Volume = 1,500 gallons Retention Time = 10 minutes Agitator - 4 HP mixer Chemical Addition-Sodium Hypochlorite
pH Adjustment Tank	Volume = 1,500 gallons Retention time = 10 minutes Agitator - 4 HP mixer
Process Pumps	Number = 6 Individual Capacity = 150 GPM
Metering Pump	Number = 4 Individual Capacity = 0.5 GPM



SELECTED REMEDIAL ALTERNATIVE SITE LAYOUT

FIGURE 11-1



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SHEET PILE BREAKWATER

FIGURE 11-2

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Soil Cap

Prior to construction of the cap, the existing piles on the southern portion of the site will be regraded to a uniform height. These piles cover an area of approximately 5.7 acres (500 feet by 500 feet) and average 10 feet in height.

Filter fabric will be placed below the soil cap to differentiate between the current surface soils and the soil cap. To provide a uniform sub-base for the cap and to promote surface water drainage, general fill, obtained from an off-site source, will be placed over the site. The general fill will be graded to provide a minimum slope of 1 percent over the site. Due to the existing flatness of the site, the general fill will be placed so as to form a 2.5-foot high ridge or crown at the mid-section (assumed to average 460 feet in width) over the entire length of the site (5000 feet). The general fill will slope uniformly at a minimum 1% down each side of the crown (an average distance of 230 feet each way) to match existing grades at the edges of the site. The general fill will be compacted prior to placement of the cap. Subsequent to compaction of the general fill, 12" of soil will be placed on top followed by 6" of topsoil, and seeding.

A proposed final grading plan (i.e. showing the proposed elevations of the surface) is shown in Figure 11-3.

Withdrawal Wells

To extract groundwater for pretreatment from the site, six withdrawal wells will be installed in the upper aquifer. This number may be changed following the results of pump tests to be performed during the design phase. Each well in the upper aquifer will extend 15 feet below the existing ground surface. Each well will contain a submersible pump capable of pumping up to 50 GPM. The actual number of wells and pump

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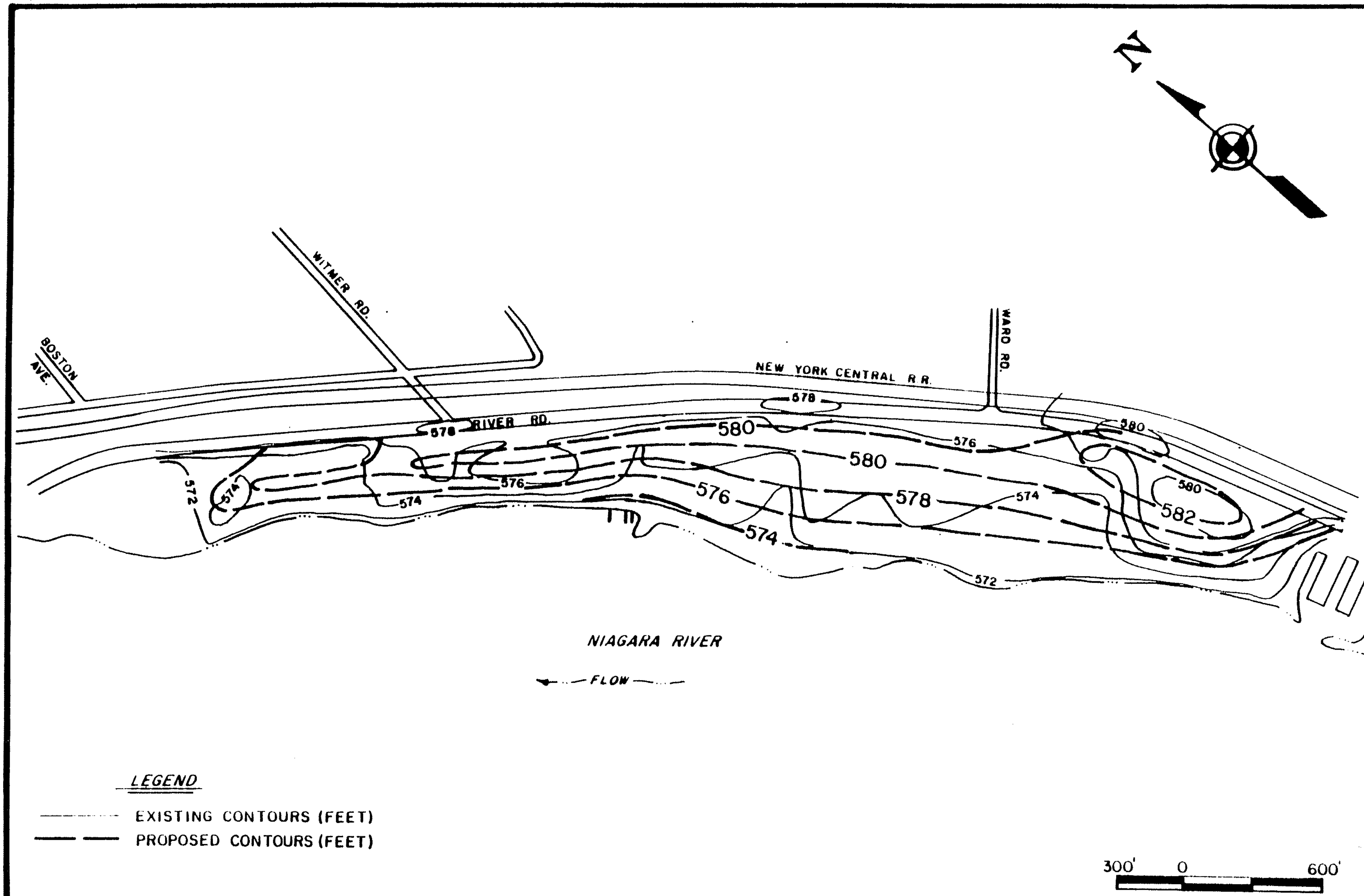

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PROPOSED FINAL GRADING PLAN

FIGURE 11-3

capacity will depend on well yield as determined through pump tests. 10,000 feet of force main will convey the groundwater from the wells to the pretreatment system. The wells in the upper aquifer will be pumped at a continual rate estimated to be <50 gpm for steady-state conditions.

Groundwater Pretreatment

Groundwater pretreatment is predicated on discharging treated effluent to the City of North Tonawanda's POTW. This particular POTW has a pretreatment program, and therefore, the effluent limitations used for sizing the proposed Gratwick system are based on the City of North Tonawanda's pretreatment ordinance limits. The design concentrations for the pretreatment system are based on groundwater sampling results obtained during the RI. The sewer discharge limits and design concentrations are given in Table 10-9. The pretreatment system design is based on a flow rate of 150 GPM.

The pretreatment system consists of an equalization/storage tank, a cyanide destruct tank and a pH adjustment tank as shown in Figure 10-1. The equalization/storage tank which will receive groundwater collected by the withdrawal wells will have a capacity of 216,000 gallons and provide a 24-hour retention time. A 20 HP agitator will be used in this tank for mixing. The cyanide destruct tank will have a capacity of 1500 gallons and a retention time of 10 minutes. Sodium hypochlorite will be added to the cyanide destruct tank. A 4 HP agitator will be used in this tank for mixing. The pH adjustment tank will have a capacity of 1500 gallons and a retention time of 10 minutes. Acid addition will be used for pH adjustment. A 4 HP agitator will be used in this tank for mixing. Six 150 GPM process pumps and four 0.5 GPM metering pumps, will be required for this pretreatment system.

All pretreatment unit processes will be located in a building located at the southern edge of the site which is located nearer to the City of North Tonawanda POTW.

Groundwater Monitoring Wells

To monitor groundwater quality at the site, four well pairs (four wells for the upper aquifer and four wells for the bedrock aquifer) will be used. Three of the four well pairs are existing; therefore, only one additional well pair will be installed in the southern end of the site. The well for the upper aquifer will be installed to a depth of 15 feet and the well for the bedrock aquifer will be installed to a depth of 45 feet.

11.2 Preliminary Cost Estimate

The total capital cost (escalated to the anticipated midpoint of construction, 1993) required for the implementation of the remedy is $15,752,000. The total annual O&M costs are $250,000. The 1989 present worth of the total cost (capital plus O&M) using a 30-year performance period and 10 percent annual interest rate is $18,109,000. For a breakdown of the capital and annual O&M costs, refer to Table 11-2. The capital and annual O&M costs were developed in Section 10, therefore, reference should also be made to this section for additional details.

The preliminary cost estimate was prepared making numerous assumptions which could be subject to change pending future investigations (see Section 11.4) or developments. Therefore, a discussion regarding the sensitivity of the cost estimate to these assumptions is required to put these costs into perspective.

The cost for the sheet pile breakwater could increase if during the design phase it is determined that the piling must be keyed deeper into the till or bedrock; or if it is deemed necessary to use a barge for sheet

TABLE 11-2

GRATWICK-RIVERSIDE PARK

PRELIMINARY COST ESTIMATE

CAPITAL COSTS

Component		Cost
1.	Groundwater Monitoring Well	$ 8,000
2.	Sheet Pile Breakwater	5,132,000
3.	Soil Cap	9,700,000
4.	Withdrawal Wells	129,000
5.	Groundwater Pretreatment System	783,000
	TOTAL	$15,752,000

ANNUAL O&M COSTS

Component		Cost
1.	Groundwater Monitoring	$ 17,000
2.	Soil Cap Repair & Maintenance	68,000
3.	Groundwater Collection/Pretreatment	165,000
	TOTAL	$250,000

TOTAL PRESENT WORTH

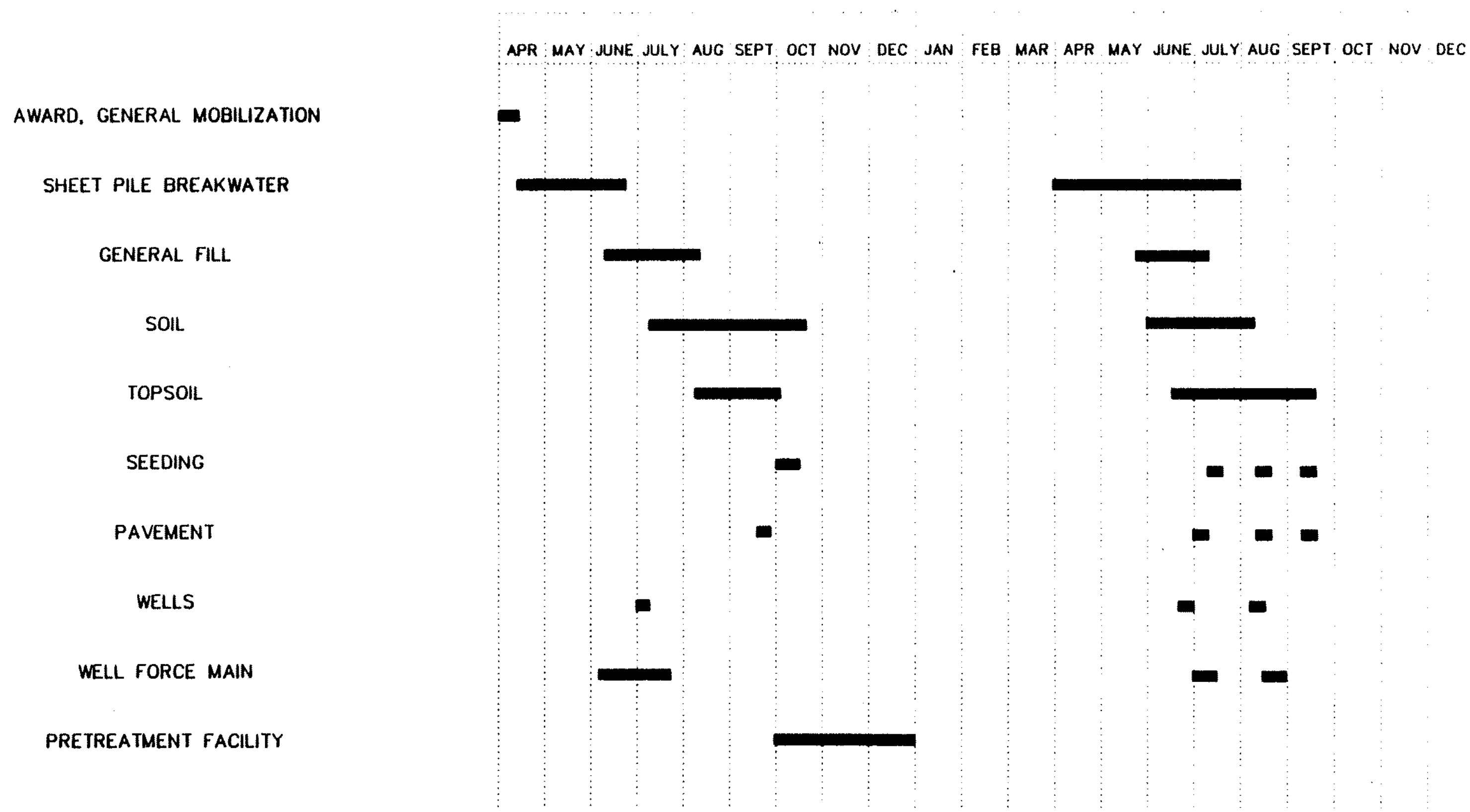
Capital Costs	$ 15,752,000
Annual O&M Costs at 10 percent annual interest for 30 years	$ 2,357,000
TOTAL PRESENT WORTH	$ 18,109,000

pile installation. The installation costs for the sheet pile breakwater may increase if the subsurface contains a high proportion of rocks or other large objects such as drums, which would hinder installation. Similarly, if the results of future pumping tests, groundwater modeling, or groundwater monitoring indicate that conditions vary from what was assumed the costs may be significantly affected.

Groundwater treatment is also highly sensitive to the effluent limitations that will ultimately apply. Should the City of North Tonawanda POTW not agree to accept the pretreated groundwater, more stringent effluent limitations will apply which will require the implementation of the more expensive full treatment system discussed in Section 10. The results of a future groundwater treatability study may also affect the design and cost of the treatment system.

11.3 Implementation Schedule

Implementation of the proposed alternative will involve a phased approach and require a minimum of two complete construction seasons. In order to optimize the schedule, construction should begin as early in the construction year as possible, and proceed through December. A preliminary implementation schedule is given in Figure 11-4. Given the areal extent of the site, it will require more than one season to construct the cap alone, which should lag behind installation of the sheet pile breakwater. Approximately one-third of the cap and breakwater may be completed the first year. Once the breakwater is completely constructed water may back up behind it onsite and create ponding. In order to avoid this situation, prior to completion of the breakwater, construction of the pretreatment facility, and the majority of the withdrawal well system should be complete. The remainder of the breakwater and cap may be finished the second year.



IMPLEMENTATION SCHEDULE

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FIGURE 11-4

1"=100' 9/11/90

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11.4 Additional Investigations

Prior to implementation of the selected remedial alternative, additional investigations will have to be undertaken in order to better characterize certain aspects of the site. Such investigations include:

a. Treatability Studies
b. Exploratory Borings
c. Pump Tests
d. Groundwater Modeling
e. Utilities and Storm Sewer Investigation
f. River Characterization
g. Impact on Nearshore Habitat

a. Treatability Studies - Initial investigations have indicated that after pretreatment of groundwater, discharge to the local POTW via the sewer system, i.e. the North Tonawanda Treatment Plant, is possible and probably preferable to other discharge options. The Treatment Plant has sufficient capacity to accept groundwater discharge from the Gratwick site. In addition, since the Treatment Plant is a physical/chemical treatment plant it is likely that minimal pretreatment will be required at the site prior to discharge to the sewer system. Under the pretreatment process developed for this report, only equalization, cyanide destruction and pH adjustment are required prior to discharge. If after negotiations this level of pretreatment is considered adequate, treatability testing will likely not be required. However, if after negotiations it is determined that further treatment is required, or, if North Tonawanda is not willing to accept the discharge from the Gratwick site, it will be necessary to conduct a treatability test to determine design parameters for the additional unit operations required for full treatment. Since neither the discharge location, e.g. sewer system or Niagara River, nor the discharge criteria are clearly defined at this time, it is not known exactly what the scope of the treatability testing will be. However, the treatability study should include one or more of the following tests:

- pilot-scale air stripper test
- bench-scale carbon adsorption test
- bench-scale test for inorganics removal

These components of the treatability study are described below:

Pilot-scale Air Stripper Test: Pilot-scale testing will be performed to evaluate the effectiveness of a packed air stripping column in removing volatile organic chemicals (VOCs). Contaminated groundwater will be pumped to the pilot air stripping column directly from pump tests and/or from a temporary storage tank. Air will be blown into the bottom of the column up through the packing. Testing will consist of approximately 10 runs. In the tests, the liquid loading rate, i.e. the groundwater flow rate, and the air to water ratio will be varied. Influent and effluent samples will be collected at regular intervals, and these samples will subsequently be analyzed to determine the VOC concentrations before and after stripping. The results of the testing will be utilized to obtain the following design parameters:

- Mass transfer coefficient (K_La) for contaminants of concern
- Column packing height
- Optimum air:water ratio
- Column diameter
- Liquid loading rate
- Removal efficiency for contaminants of concern

Bench-Scale Carbon Adsorption Test: Following air stripping, further treatment may be required to remove organic compounds. Therefore, a laboratory bench-scale test using activated carbon will be performed. Adsorption isotherms for total organic carbon (TOC) will be developed for different types of carbon in batch tests. The type of carbon with the best adsorptive capacity determined by the batch tests will be utilized for the bench-scale column test. Samples collected from the air stripper effluent will be fed to the bench-scale column apparatus to develop breakthrough curves for TOC, VOCs and semi-volatiles. The results of the bench-scale test will be utilized to develop the following design parameters:

- Adsorptive capacity of carbon for contaminants of concern
- Removal efficiency for contaminants of concern
- Carbon requirements to achieve discharge criteria

Bench-Scale Test for Inorganics Removal: Bench-scale testing will be performed for chemical precipitation of metals from the groundwater. The purpose of these tests will be to determine appropriate precipitants and dosages, and to determine settling times, sludge production rates, and simulated effluent qualities. Specific tests to be performed as part of bench-scale testing will include: titration curves, jar testing, long tube testing, and sludge thickening.

Titration curves will be developed utilizing sulfuric acid, caustic, and/or lime on groundwater with or without air stripping. The purpose of the titration curves will be to establish the precipitant dosage required to adjust the pH of the groundwater in order to remove metals by precipitation. Laboratory jar tests will then be utilized to optimize the dosage of precipitant and flocculants, e.g. polymers, required for metals removal. Performance evaluation for the jar tests will be based on turbidity measurements of the supernatant prior to and after chemical precipitation. Selected supernatant samples will also be analyzed for total suspended solids and metals. Long tube tests will be performed to determine settling rates and clarifier overflow rates. In order to establish the design criteria for dewatering and disposal, a bench-scale test will be performed to evaluate sludge thickening and dewatering characteristics. Sludge thickening tests will be used to determine the practicality of using a sludge thickener and the area required for thickening if thickening is feasible. The sludge will be dewatered by simulating conventional equipment such as the plate and frame filter press and the belt filter press. Results of the test will be used to determine the best method for dewatering and design parameters for sizing the equipment.

b. Exploratory Borings - Along the proposed location of the sheet pile breakwater, exploratory borings should be performed to confirm the depth to the confining unit (which is approximated at 15 feet). In addition, several borings should be performed in the vicinity of the starting point of the sheet piling (anticipated to be at the south end of the site), again to more accurately determine the depth to the confining unit. Borings for the sheet piling do not have to continue along the entire length of the sheet pile wall as once a sheet pile is driven, it will provide an adequate estimate of depth for the next sheet pile. One additional boring should be performed in the proposed location of the groundwater pretreatment facility. This boring should be driven five feet into the till in order to define the depth of piles which will be required since bearing capacity of the natural soil is inadequate for the proposed load of the facility.

c. Pump Tests - In order to better determine the hydrogeologic properties (hydraulic conductivity and storativity) of the upper aquifer and to assess the ability of the aquifer to yield the desired pumping rate, pump tests should be performed at two locations. Values for hydraulic conductivity and storativity must be known with a reasonable degree of accuracy in order to predict the water table resulting from applied stresses (pumping) as well as to determine non-steady-state conditions that will prevail at the onset of pumping. It is recommended that the pump tests be performed at two different rates to see if the aquifer will yield water at these rates. The first pump test should be located in the southern (and wider) portion of the site; the second pump test in the northern portion. Three piezometers should be located equidistant around each pumping well, to the north, east, and south at a maximum distance of 100 feet (estimated to be the edge of the radius of influence). The pump tests are expected to continue for a duration of 3-5 days and if feasible, will coincide with the treatability studies.

d. Groundwater Modeling - The three-dimensional groundwater flow model used in this FS was adequate to assess the effectiveness of various remedial technology configurations. A more detailed series of groundwater flow studies are required during the design phase to: 1) better quantify the amount of groundwater to be collected; 2) aid in the design of an effective withdrawal well system; 3) assess the impact of the selected remedial alternative on the hydrogeologic system in the vicinity of the site; and 4) provide recommendations on how to mitigate that impact, if required.

e. Utilities and Storm Sewer Investigation - Prior to commencing intrusive activities at the site an investigation into the locations of utilities must be conducted. These utilities are to include, but not be limited to: electric, gas, telephone, water, and sanitary sewer. (Water and gas lines are known to exist on the site.) Their presence, along with the possible presence of other utilities may necessitate a change in the conceptual design if they cannot be relocated. In addition, three storm sewers are known to traverse the site. These storm sewers start in the ditch between River Road and the railroad tracks. Outlets to the three sewers are along the shoreline in the vicinity of shoreline samples SP2-SS, SP3-SS, and SP4-SS (see RI Figure 5-1), all of which were found to contain high concentrations of organic contaminants. The condition of these sewers, which appear to be five-foot lengths of two and five-foot diameter concrete conduit, is unknown. An investigation into their condition should be performed to determine if they may remain as is, or if they must be included in the remediation effort (e.g. grouted) to prevent contaminant migration. If these sewers are determined to be inadequate, an alternate storm sewer system must be developed and included in the site remdiation.

f. River Characterization - Characterization of the strata beneath the Niagara River is necessary for the design of the sheet pile breakwater. If the sheet piling is to be keyed into the till, then an adequate thickness of till extending up to thirty feet into the River must be present beneath the site. An adequate thickness (to be determined during the design phase) is required in order to resist such anticipated forces as wave action, ice formation, and water level changes. In order to determine the thickness of till, either one of two approaches may be taken. Approximately twenty borings from a barge alternating between distances of 20 and 40 feet from the shoreline may be drilled along the entire length of the site. Alternately, geophysical studies may be conducted from a boat traveling the entire length of the site which could determine the depth of the top of till and bedrock.

g. Impact on Nearshore Habitat - In order to assess the potential impact of the proposed breakwater on the nearshore shallow-water habitat of the Niagara River, the NYSDEC Region 9 Division of Fish and Wildlife Bureau of Fisheries has requested the following:

- Details of the sheetpile toe protection measures.

- Representative cross-section views through the shoreline and nearshore areas of the River at a minimum of every 500 feet along the proposed length of the breakwater.

- The cross-sections should show the location and elevation of the mean high water mark (as determined by the Corps of Engineers). The mean high water mark should be staked at each cross-section location across the site.

- The cross-sections should show the elevation of the River bottom for a distance of approximately 50 feet waterward of the mean high water marks.

Once the cross-sections are developed and the mean high water marks staked, the Bureau of Fisheries has indicated that they will inspect the site and make an assessment of the potential for adversely impacting the nearshore habitat.

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ADDENDUM 1

ADDENDUM 1

During a July 1989 shoreline inspection by the Niagara County Health Department a black tar-like substance was encountered. At the end of July 1989 the State Department of Health took a sample of this tar. The analyses showed a PCB level of 16,000 ppm. A shoreline removal was carried out at the end of August 1989 using a NYSDEC standby spill contractor. The area affected was near the northwestern extent of the park by the sheltered picnic area. A total of approximately 50 cubic yards of material was removed and disposed of.

At the time of the shoreline removal a "pothole" was noticed in the park access road near the removal area. The pothole had a viscous black oil at a level of about one foot below the road surface. A sample was taken which showed a level of 10,000 ppm phenols and 7,900 ppm PCBs. In April 1990 boreholes were drilled radially around the pothole. An estimate of the volume and extent of the contamination was determined. The findings of the shoreline removal and the pothole investigation indicated two separate source areas which did not overlap. Samples were taken during the pothole investigation. Analyses of these samples showed high levels of phenols (up to 23,000 ppm) along with detected levels of dioxin (2,3,7,8-TCDD). Dioxin was detected at a level of 5 ppb.

Results of these investigations are presented in the following pages.

Five composite sediment samples were collected by URS Consultants on October 12, 1989 at Gratwick Riverside Park. These samples were sent to Ecology and Environment, Inc. for PCB analyses.

The five composite sediment samples were collected north of the shoreline area, as shown on the accompanying figure, where previously high PCB values were reported. Three areas were hand-excavated along the shoreline approximately 12-18 inches from the water's edge. A one and a half inch stainless steel pole and drive hammer were used to collect the samples. A great deal of rock and glass were encountered while driving the pole into the sediment. The deepest hole from which samples were collected was 18 inches in depth. The analytical results for the five composite samples are reported in the following table. The quality control results are reported in the table. The only sample in which PCBs were detected is Comp. 005 which contained cinder and clay and had no noxious odors. This sample was collected upstream of the concrete slab.

New York State Department of Environmental Conservation
50 Wolf Road, Albany, New York 12233

REC'D SEP 0 5 1989

SEP 1

Thomas C. Jorling
Commissioner

JOB # 35149

FILE
CHUCK
CRAIG
AMY
BOB MURPHY

Mr. Robert Murphy
URS Consultants
570 Delaware Avenue
Buffalo, NY 14202

Dear Mr. Murphy:

Re: Shoreline Removal, Gratwick Park,
Niagara County, Site No. 9-32-060

As you know, a sample of a black, tar-like substance was taken from the shoreline at the north end of Gratwick Park (see enclosed map). The New York State Department of Health had the sample analyzed and on August 16, 1989 this office was informed of the preliminary results for PCBs. The tar contained a PCB concentration of 16,000 parts per million (ppm). A typical action level for PCBs is 50 ppm. On August 17, 1989 Niagara Mohawk (Nimo) was contacted. In the past when drums have been discovered Nimo has performed removal actions. On this occasion they offered to place a temporary fence around the area, however would not commit to any type of a removal.

Due to the level of contamination present action needed to be taken quickly. On August 23, 1989 a meeting was held at the site to discuss possible alternatives. A representative of American Environmental Services (AES), a New York State Department of Environmental Conservation standby spill contractor, was present at this meeting. On August 29 and 30, 1989 AES performed a removal of the contamination found in the area where the tar sample was taken. The material was placed inside two roll-off containers (one 25 yd^3 and one 30 yd^3) which had been lined with plastic. The containers were covered with a tarp and placed in the fenced area at the south end of the park (near dog walk) where they will be staged until AES can arrange for proper disposal. It is anticipated that the roll-offs will be removed from the site in early October 1989.

The area that had been excavated along the shoreline was backfilled with crushed stone. The area at the top of the fill, where the heavy machinery had operated from, was covered with soil and re-seeded.

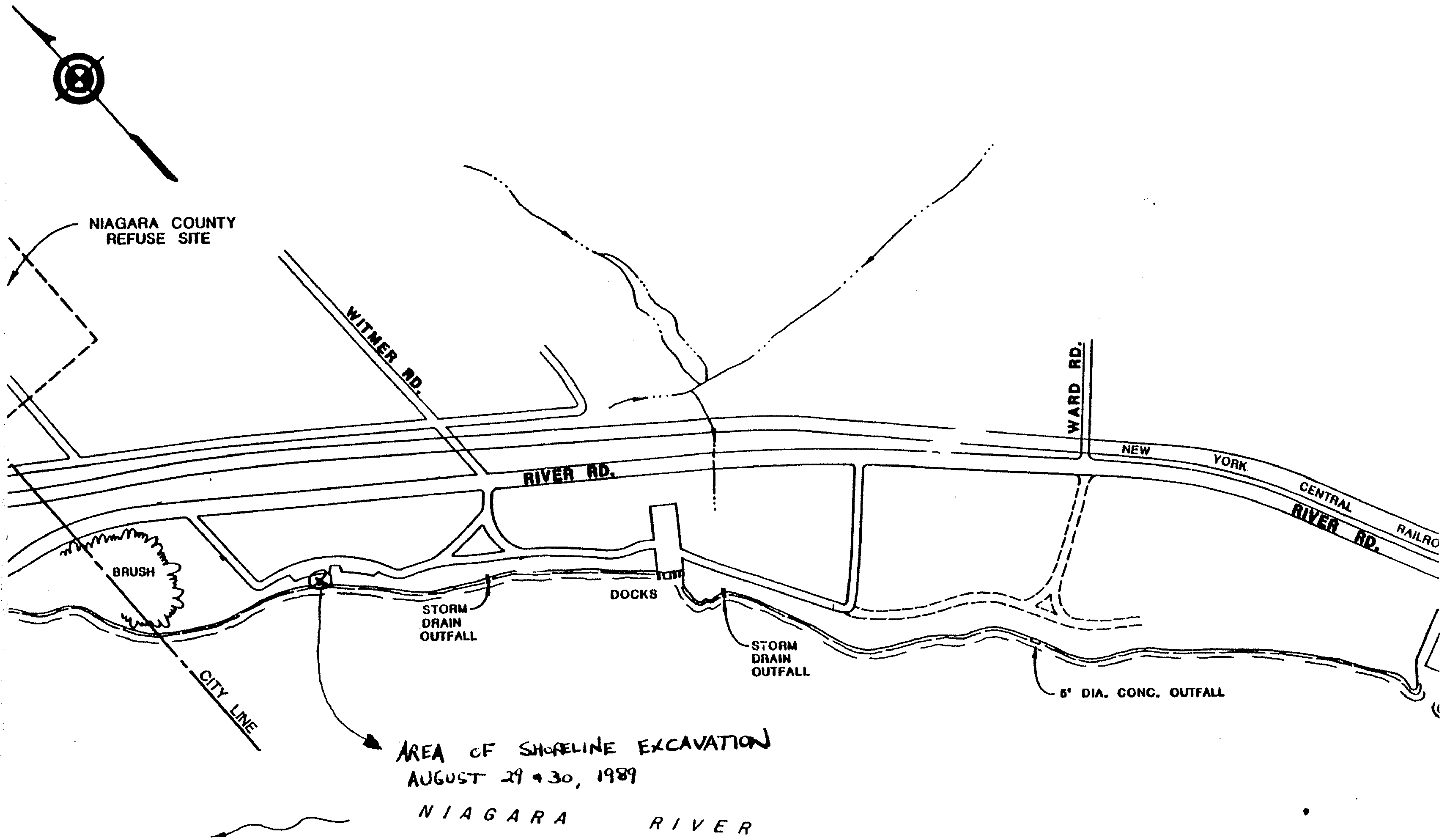
If you have any questions feel free to contact me at 518/457-0315.

Sincerely,

James A. Moras

James A. Moras
Project Manager
Western Remedial Section B
Division of Hazardous Waste Remediation

Enclosure
cc: J. Mis - City Attorney
M. Eisenhower - City Engineer


NIAGARA COUNTY
REFUSE SITE
WITMER RD.
RIVER RD.
WARD RD.
NEW YORK CENTRAL RAILRO
RIVER RD.
BRUSH
CITY LINE
STORM
DRAIN
OUTFALL
DOCKS
STORM
DRAIN
OUTFALL
5' DIA. CONC. OUTFALL
AREA OF SHORELINE EXCAVATION
AUGUST 29 + 30, 1989
NIAGARA RIVER

URS

AN INTERNATIONAL PROFESSIONAL SERVICES ORGANIZATION

URS CONSULTANTS, INC.

570 DELAWARE AVENUE
BUFFALO, NEW YORK 14202-1207
(716) 883-5525
FAX (716) 883-0754

Bitka

November 28, 1989

Mr. James A. Moras
Project Manager
Western Remedial Section B
Division of Hazardous Waste Remediation
NYS Department of Environmental Conservation
50 Wolf Road
Albany, New York 12233

RE: PCB RESULTS FOR FIVE SEDIMENT SAMPLES COLLECTED AT GRATWICK RIVERSIDE PARK

Dear Mr. Moras:

Enclosed are the PCB results for the five sediment samples collected at Gratwick Riverside Park by URS Consultants on October 12, 1989 and analyzed by Ecology & Environment, Inc.

Should you have any questions, please do not hesitate to contact the undersigned.

Sincerely,

URS CONSULTANTS

Mary E. Bitka

Mary E. Bitka
Senior Environmental Chemist

MEB/ys
Enc.

11-28-9L
35149

ECOLOGY AND ENVIRONMENT'S, INC.
A N A L Y T I C A L   S E R V I C E S   C E N T E R

RESULTS OF SOIL ANALYSIS FOR PRIORITY POLLUTANT
POLYCHLORINATED BIPHENYLS

(all results in mg/kg as received)

U2/176/028

Compound	E & E Lab. No. 89-	53374	53375	53376	53377	53378
	Sample Identity	Comp. 001	Comp. 002	Comp. 003	Comp. 004	Comp. 005
PCB-1242		<1.0	<1.0	<1.0	<1.0	<1.0
PCB-1254		<1.0	<1.0	<1.0 P	<1.0	2.8 †
PCB-1221		<1.0	<1.0	<1.0	<1.0	<1.0
PCB-1232		<1.0	<1.0	<1.0	<1.0	<1.0
PCB-1248		<1.0	<1.0	<1.0	<1.0	<1.0
PCB-1260		<1.0	<1.0	<1.0	<1.0	<1.0
PCB-1016		<1.0	<1.0	<1.0	<1.0	<1.0

†Pattern is distorted - contains extraneous peaks and peak ratios are off.
P= Present below measurable detection limit.

ECOLOGY AND ENVIRONMENT'S, INC.
A N A L Y T I C A L   S E R V I C E S   C E N T E R

RESULTS OF SOIL ANALYSIS FOR PRIORITY POLLUTANT
POLYCHLORINATED BIPHENYLS

(all results in mg/kg as received)

U2/176/028.1

Compound	E & E Lab. No. 89-	Method Blank 1	Method Blank 2	Method Blank 3	Method Blank 4	
	Sample Identity					
PCB-1242		<1.0	<1.0	<1.0	<1.0	
PCB-1254		<1.0 P	<1.0	<1.0	<1.0	
PCB-1221		<1.0	<1.0	<1.0	<1.0	
PCB-1232		<1.0	<1.0	<1.0	<1.0	
PCB-1248		<1.0	<1.0	<1.0	<1.0	
PCB-1260		<1.0	<1.0	<1.0	<1.0	
PCB-1016		<1.0	<1.0	<1.0	<1.0	

P= Present below measurable detection limit.

QUALITY CONTROL FOR ACCURACY: PERCENT RECOVERY
FOR SPIKED SOIL SAMPLES

U2/176/028.2

Parameter	E & E Laboratory No. 89- Blank Spike	Original Value (mg/kg)	Amount Added (mg/kg)	Amount Determined (mg/kg)	Percent Recovery
PCB-1242		<1	1.7	1.4	82

11563

A-2424

(176028)

URS CORPORATION

CHAIN OF CUSTODY RECORD

PROJECT NO.: 35149-00-004

SITE NAME: Gratwick Riverside Park

SAMPLERS (SIGNATURE): [signature]

STATION NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO OF CONTAINERS	PCB's						REMARKS
001	10/12/89	1000	X		Shoreline Samples 53374	1	1						open under hood — contains product
002	|	1100	X		| 75	1	1						
003	|	1200	X		| 76	1	1						
004	|	1330	X		| 77	1	1						
005	|	1430	X		53378	1	1						

RELINQUISHED BY (SIGNATURE):	DATE/TIME:	RECEIVED BY (SIGNATURE):	RELINQUISHED BY (SIGNATURE):	DATE/TIME:	RECEIVED BY (SIGNATURE):
[signature]	10-12-89 1700				
RELINQUISHED BY (SIGNATURE):	**DATE/TIME:**	**RECEIVED BY (SIGNATURE)**	**RELINQUISHED BY (SIGNATURE):**	**DATE/TIME:**	**RECEIVED BY (SIGNATURE):**
RELINQUISHED BY (SIGNATURE):	**DATE/TIME:**	**RECEIVED FOR LABORATORY BY (SIGNATURE):**	**DATE/TIME**	**REMARKS**	
		[signature]	10-12-89 1700		

Distribution: Original accompanies shipment, copy to coordinator field files

File
35149
Corresp
Faxed

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BUFFALO, NEW YORK 14202-1207
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PARAMUS, NJ
NEW ORLEANS
SAN FRANCISCO
SAN MATEO
SEATTLE
VIRGINIA BEACH
WASHINGTON, D.C.

May 2, 1990

Mr. James A. Moras
Assistant Sanitary Engineer
Western Remedial Section B
Division of Hazardous Waste Remediation
NYS Department of Environmental Conservation
50 Wolf Road
Albany, New York 12233

RE: RESULTS OF TEST BORING PROGRAM NEAR "POTHOLE"
GRATWICK-RIVERSIDE PARK

Dear Mr. Moras:

As per your instructions, twelve (12) test borings were advanced at Gratwick-Riverside Park near a suspect "pothole" at the northwest end of the park. The location of these borings is shown in Figure 1. The black viscous liquid or tar that was observed emanating from the "pothole" was also observed in eleven (11) of the twelve (12) test borings. Samples from ten (10) locations were sent for chemical analysis and the results will be forwarded to you as soon as they are available. Boring logs are given in Attachment A.

The following four (4) general types of material were encountered during the investigation:

- General Fill -

  Includes the road sub-base and sandy silt with some clay and gravel mixed with various fill materials including paper and wood fragments.

- Yellow and Pink Resins -

  Hard powders and resins similar to those found to be phenolic resins during the Remedial Investigation.

- Light Blue Sandy Fill -

  Found at the bottom of every boring. Similar powdery blue substances tested during the Remedial Investigation were found to contain high levels of cyanide. May also be the disintegrated top of the "slag" layer identified during the RI.

- Black Viscous Product -

  Product was found in a layer that ranged from zero (0) to over three (3) feet thick above the resins and "slag". The material was a crystalline solid or thick tar-like substance when first recovered from depth. However, this material became a viscous liquid when subjected to the higher temperatures (80+° F) of the atmosphere (this occurred within minutes of sampling). The material was difficult to wash from the sampling equipment as it cooled to a solid when washed with deionized water or methanol. The product was dissolved to a greater extent (although still reluctantly) by hexane.

o Black Viscous Product - Continued

The product layer thinned considerably away from the "pothole". An isopach map of the approximate thickness of the product layer is depicted in Figure 2.

The product was sometimes associated with broken glass, paper, copper wire, or metal especially near the "pothole".

If you have any questions concerning this project, please feel free to call me, Tom Knickerbocker or Chuck Hurley at any time.

Very truly yours,

URS CONSULTANTS, INC.

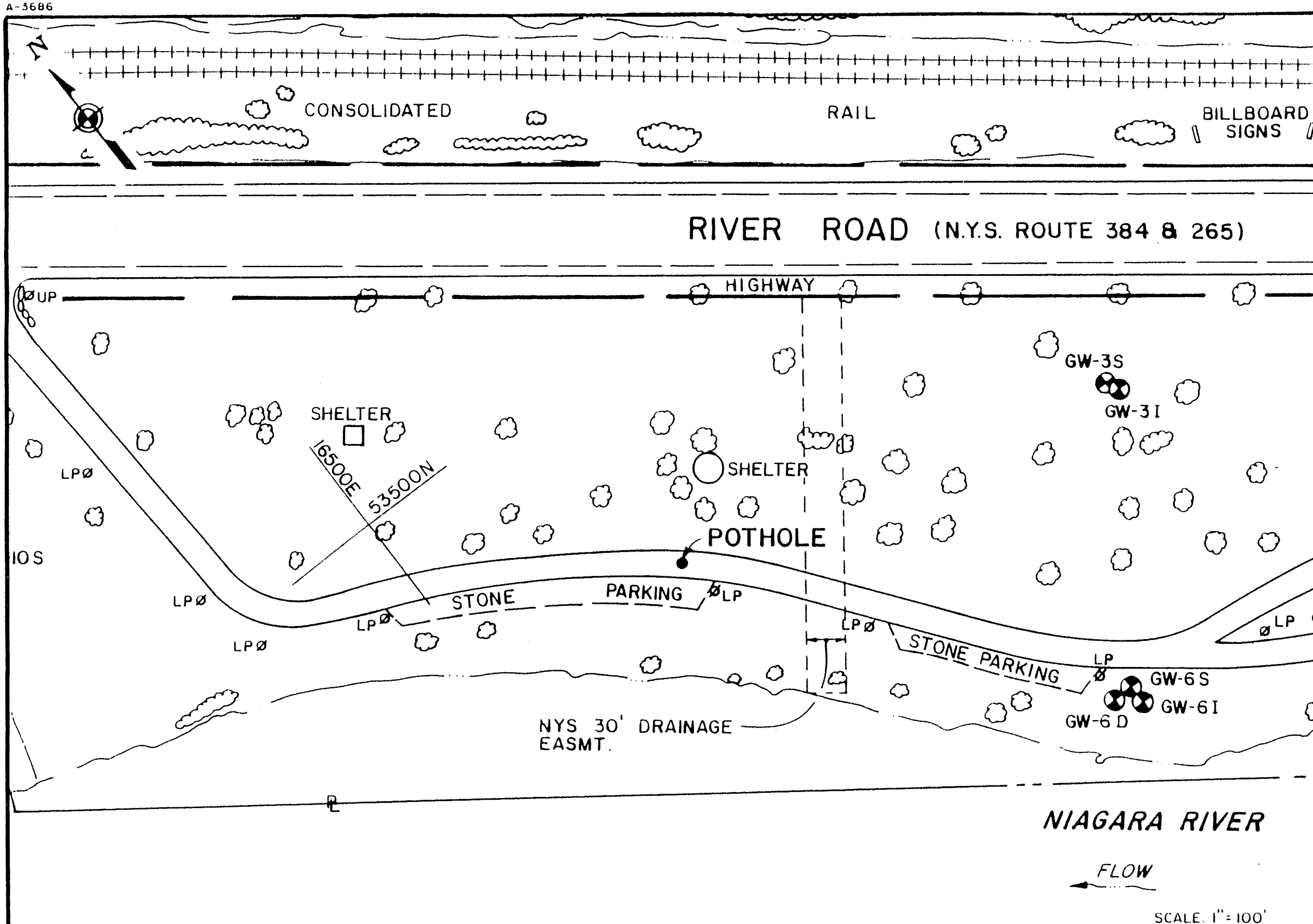
Bruce J. Przybyl
Project Geologist

BJP/YS
Enc.

5-2-90L
35149

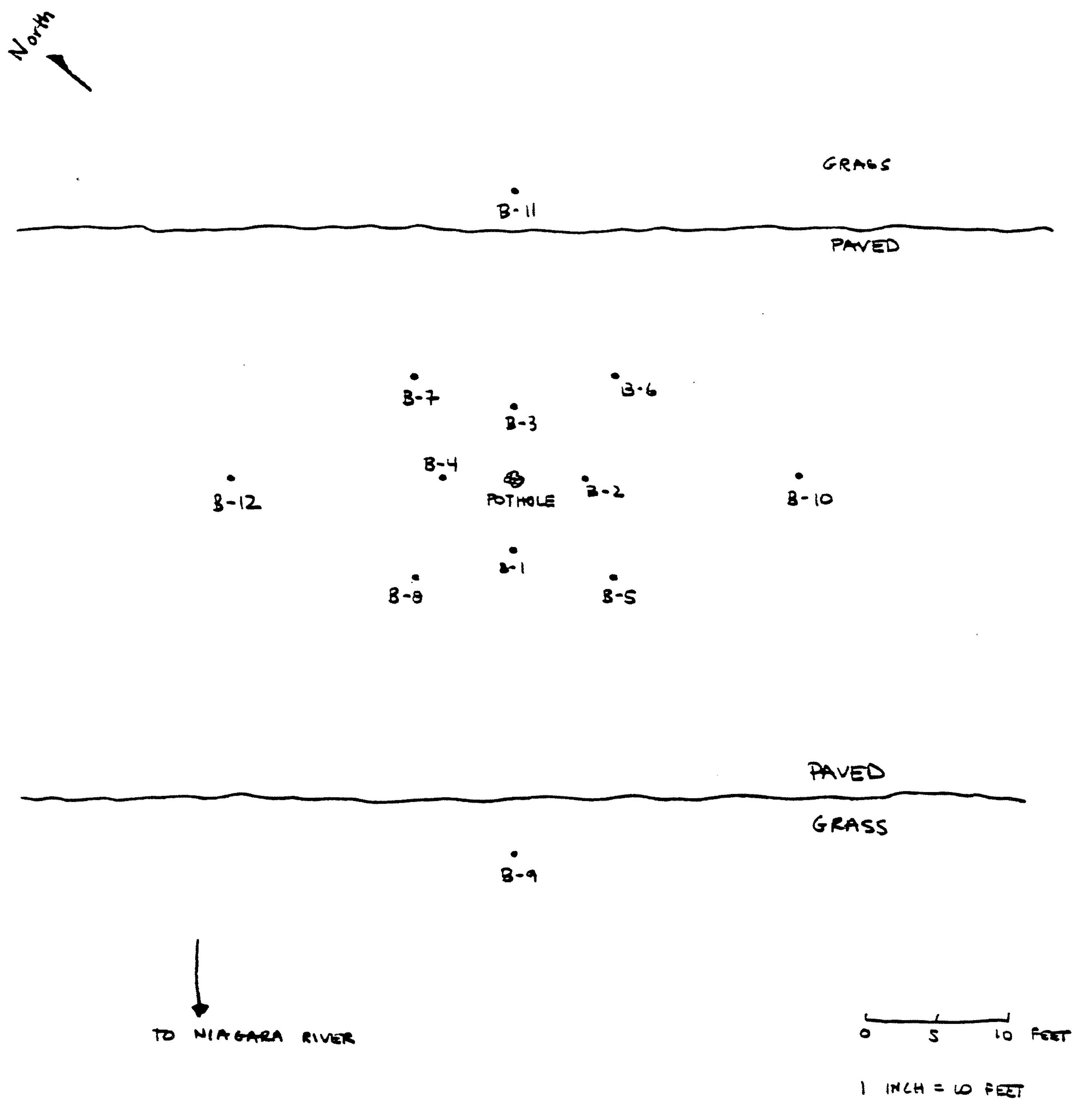
cc: Charles Hurley, URS
Tom Knickerbocker, URS
File: 35149 (correspondence)

A-3686



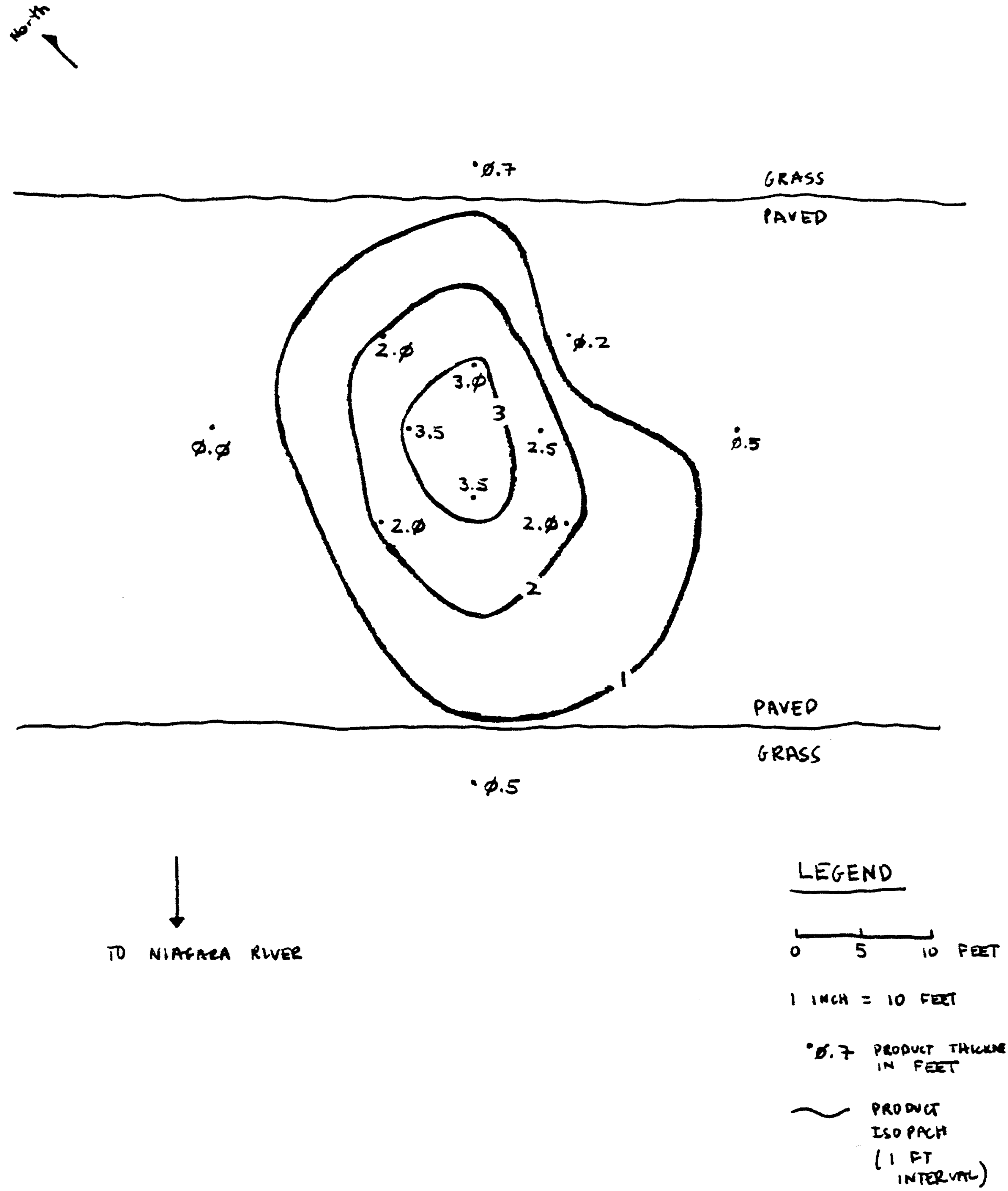
URS
CONSULTANTS, INC.

LOCATION OF POTHOLE



BORING LOCATION MAP

FIGURE 1



THICKNESS OF PRODUCT

FIGURE 2

ATTACHMENT A

BORING LOGS

URS CONSULTANTS, Inc.

TEST BORING LOG
BORING NO. B-1

PROJECT: GRATWICK - RIVERSIDE PARK POTHOLE INVEST.	SHEET NO. 1 OF 1
CLIENT: NYSDEC	JOB NO.: 35149
BORING CONTRACTOR: BUFFALO DRILLING COMPANY	BORING LOCATION:
GROUND WATER:	GROUND ELEVATION:
	DATE STARTED: 4/25/90
	DATE FINISHED: 4/26/90
	DRILLER: KENNETH HUBER
	GEOLOGIST: B. PRZYBYL, M. GUTMANN
	REVIEWED BY:

DATE	TIME	LEV	TYPE		CAS.	SAMP	CORE	TUBE
				TYPE				
				DIA.				
				WT.				
				FALL				

* POCKET PENETROMETER READING

DEPTH FT	STRATA	SAMPLE NO.	TYPE	BLOWS PER 6"	RECOVERY RQD %	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	CLASS USCS	REMARKS
0–0.5		-	-		-	BLACK	HARD	ASPHALT	-	
0.5–2.7 (1, 2)		1	SS	8, 8, 8, 8	40	BROWN	MEDIUM DENSE	SUBBASE - SANDY SILT WITH SOME CLAY MIXED WITH GRAVEL; SOME DARK FILL AND SANDY SOIL	-	DRY
2.7–6 (3, 4, 5)		2	SS	5, 8, 17	15	BLACK	MEDIUM DENSE	PRODUCT - STICKY, STRINGY, TAR LIKE FILL. STRONG CHEMICAL OR MEDICINAL ODOR	-	APPROX WATER LEVEL; SATURATED PINK/RED TINT TO WATER
		3	SS	8, 8, R	75		VERY DENSE			← BROKEN GLASS AND COPPER WIRE FOUND ASSOCIATED WITH PRODUCT
6–8 (7)		4	SS	24, 28, 20, 19	100	BLUE TO WHITE	DENSE	SANDY OR POWDERY FILL	-	

A-3205

COMMENTS: SENT SAMPLE OF PRODUCT FOR CHEMICAL ANALYSES INCLUDING: TCL VOLATILES, SEMI-VOLATILES, PEST/PCBS, & METALS; TOTAL PHENOLS; DIOXIN

PROJECT NO. 35149
BORING NO. B-1

URS CONSULTANTS, Inc.

TEST BORING LOG
BORING NO. B-2

PROJECT: GRATWICK - RIVERSIDE PARK POTHOLE INVEST.	SHEET NO. 1 OF 1
CLIENT: NYSDEC	JOB NO.: 35149
BORING CONTRACTOR: BUFFALO DRILLING COMPANY	BORING LOCATION:
GROUND WATER:	GROUND ELEVATION:
	DATE STARTED: 4/26/90
	DATE FINISHED: 4/26/90
	DRILLER: KENNETH HUBER
	GEOLOGIST: B. PRZYBYL, M. GUTMANN
	REVIEWED BY:

DATE	TIME	LEV	TYPE		CAS.	SAMP	CORE	TUBE
				TYPE				
				DIA.				
				WT.				
				FALL				

* POCKET PENETROMETER READING

DEPTH FT	STRATA	SAMPLE NO.	TYPE	BLOWS PER 6"	RECOVERY ROD %	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	CLASS USCS	REMARKS
0–0.5		–	–		–	BLACK	HARD	ASPHALT	–	
0.5–3		1	SS	8, 12, 17	15	BROWN	LOOSE → VERY LOOSE	SUBBASE – SAND AND GRAVEL, SOME FILL MATERIAL MIXED IN		DRY
		2	SS	2, 1, 1, 1	15					APPROX WATER LEVEL (≈3 ft)
3–3.5	VOID					–	–	VOID SPACE	–	SATURATED PINK/RED TINT TO WATER
3.5–5.8		3	SS	14, 32, 44, 52	80	BLACK	LOOSE/SOFT → VERY DENSE	PRODUCT – STICKY, STRINGY TAR LIKE FILL. STRONG CHEMICAL OR MEDICINAL ODOR.		
5.8–6.3						YELLOW	VERY DENSE	POWDER AND RESIN	–	
6.3–8		4	SS	5, 10, 10, 23	90	BLUE TO WHITE	MEDIUM DENSE	SANDY AND POWDERY FILL	–	

COMMENTS: SENT SAMPLE OF PRODUCT FOR CHEMICAL ANALYSES INCLUDING: TOTAL PHENOLS ; TOTAL PCBs

PROJECT NO. 35149
BORING NO. B-2

A-3205

URS CONSULTANTS, Inc.

PROJECT: GRATWICK - RIVERSIDE PARK POTHOLE INVEST.	TEST BORING LOG BORING NO. B-3
CLIENT: NYSDEC	SHEET NO. 1 OF 1
BORING CONTRACTOR: BUFFALO DRILLING COMPANY	JOB NO.: 35149
	BORING LOCATION:
	GROUND ELEVATION:
	DATE STARTED: 4/26/90
	DATE FINISHED: 4/26/90
	DRILLER: KENNETH HUBER
	GEOLOGIST: B. PRZYBYL, M. GUTMANN
	REVIEWED BY:

GROUND WATER:

DATE	TIME	LEV	TYPE		CAS.	SAMP	CORE	TUBE
				TYPE				
				DIA.				
				WT.				
				FALL				

* POCKET PENETROMETER READING

DEPTH FT	STRATA	SAMPLE NO.	TYPE	BLOWS PER 6"	RECOVERY RQD %	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	CLASS USCS	REMARKS
0		-	-		-	BLACK	HARD	ASPHALT	-	
1		1	SS		15	BROWN	LOOSE	SUBBASE - SANDY SILT WITH SOME CLAY MIXED WITH GRAVEL; SOME SILTY SAND FILL	-	DRY
2–5		2	SS	7, 7, 20, 7	30	BLACK	MEDIUM DENSE	PRODUCT - STICKY, STRINGY TAR LIKE FILL. STRONG CHEMICAL OR MEDICINAL ODOR.	-	APPROX WATER LEVEL (~3 ft); SATURATED; PINK / RED TINT TO WATER
4–6		3	SS	12, 32, 45, 46	100	PINK (5–6 ft)	VERY DENSE	POWDER AND RESIN	-	SLIGHT OIL SHEEN ON WATER
6–8		4	SS	13, 8, 7, 11	20	BLUE TO WHITE	MEDIUM DENSE	SANDY AND POWDERY FILL	-	
8–10		5	SS		100			CONTINUES TO 10 FEET	-	

COMMENTS: SENT SAMPLE OF PRODUCT FOR CHEMICAL ANALYSES INCLUDING: TOTAL PHENOLS; TOTAL PCBs

PROJECT NO. 35149
BORING NO. B-3

A-3205

URS CONSULTANTS, Inc.

TEST BORING LOG
BORING NO. B-4

PROJECT: GRATWICK - RIVERSIDE PARK POTHOLE INVEST.	SHEET NO. 1 OF 1
CLIENT: NYSDEC	JOB NO.: 35149
BORING CONTRACTOR: BUFFALO DRILLING COMPANY	BORING LOCATION:
GROUND WATER:	GROUND ELEVATION:
	DATE STARTED: 4/26/90
	DATE FINISHED: 4/26/90
	DRILLER: KENNETH HUBER
	GEOLOGIST: B. PRZYBYL, M. GUTMANN
	REVIEWED BY:

DATE	TIME	LEV	TYPE		CAS.	SAMP	CORE	TUBE
				TYPE				
				DIA.				
				WT.				
				FALL				

* POCKET PENETROMETER READING

DEPTH FT	STRATA	SAMPLE NO.	SAMPLE TYPE	BLOWS PER 6"	RECOVERY RQD %	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	CLASS USCS	REMARKS
0–0.2		–	–		–	BLACK	HARD	ASPHALT	–	DRY
0.2–2.5		1	SS	5, 6, 6, 8	30	BROWN	LOOSE	SUB BASE - SANDY SILT WITH SOME CLAY MIXED WITH GRAVEL. SOME WOOD CHIPS	–	
2.5–6		2	SS	9, 16, 20, 21	60	BLACK	MEDIUM DENSE → DENSE	PRODUCT - STICKY, STRINGY, TAR LIKE FILL STRONG CHEMICAL OR MEDICINAL ODOR	–	APPROX WATER LEVEL (~3 ft). SATURATED PINK/RED TINT TO WATER
		3	SS	27, 29, 30	80					☆ METAL PIECE RECOVERED IN SPOON. ☆ METAL WRAPPED AROUND AUGERS
6–8		4	SS	6, 12, 28, 12	90	BLUE TO WHITE	MEDIUM DENSE	SANDY OR POWDERY FILL	–	

COMMENTS: SENT SAMPLE OF PRODUCT FOR CHEMICAL ANALYSES INCLUDING: TOTAL PHENOLS; TOTAL PCBs

PROJECT NO. 35149
BORING NO. B-4

A-3205

URS CONSULTANTS, Inc.

TEST BORING LOG
BORING NO. B-5

PROJECT: GRATWICK - RIVERSIDE PARK POTHOLE INVEST.	SHEET NO. 1 OF 1
CLIENT: NYSDEC	JOB NO.: 35149
BORING CONTRACTOR: BUFFALO DRILLING COMPANY	BORING LOCATION:
GROUND WATER:	GROUND ELEVATION:
	DATE STARTED: 4/27/90
	DATE FINISHED: 4/27/90
	DRILLER: KENNETH HUBER
	GEOLOGIST: B. PRZYBYL, M. GUTHANN
	REVIEWED BY:

DATE	TIME	LEV	TYPE		CAS.	SAMP	CORE	TUBE
				TYPE				
				DIA.				
				WT.				
				FALL				

* POCKET PENETROMETER READING

DEPTH FT	SAMPLE NO.	TYPE	BLOWS PER 6"	RECOVERY RQD %
0	-	-		-
1	1	SS	4, 6, 4	60
2–3	2	SS	5, 10, 6, 22	75
4–5	3	SS	9, 10, 24, 28	90
6–8	4	SS	6, 3, 10, 4	100

COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	CLASS USCS	REMARKS
BLACK	HARD	ASPHALT	-	DRY
BROWN	LOOSE	SUBBASE - SAND AND GRAVEL	-	
BROWN	LOOSE	SANDY SILT FILL, SOME CLAY	-	APPROX. WATER LEVEL
BLACK	MEDIUM DENSE	PRODUCT - STICKY, STRINGY, TAR LIKE FILL. STRONG CHEMICAL OR MEDICINAL ODOR	-	SATURATED. PINK/RED TINT TO WATER. SOME BROKEN GLASS ASSOCIATED WITH PRODUCT
YELLOW	VERY DENSE	POWDER AND RESIN	-	
BLUE TO WHITE	LOOSE	SANDY OR POWDERY FILL.	-	

A-3205

COMMENTS: SENT SAMPLE OF PRODUCT FOR CHEMICAL ANALYSES INCLUDING: TOTAL PHENOLS; TOTAL PCBs

PROJECT NO. 35149
BORING NO. B-5

URS CONSULTANTS, Inc.

TEST BORING LOG
BORING NO. B-6

PROJECT: GRATWICK - RIVERSIDE PARK POTHOLE INVEST.	SHEET NO. 1 OF 1
CLIENT: NYSDEC	JOB NO.: 35149
BORING CONTRACTOR: BUFFALO DRILLING COMPANY	BORING LOCATION:
GROUND WATER:	GROUND ELEVATION:
	DATE STARTED: 4/27/90
	DATE FINISHED: 4/27/90
	DRILLER: KENNETH HUBER
	GEOLOGIST: B. PRZYBYL, M. GUTMANN
	REVIEWED BY:

DATE	TIME	LEV	TYPE		CAS.	SAMP	CORE	TUBE
				TYPE				
				DIA.				
				WT.				
				FALL				

* POCKET PENETROMETER READING

DEPTH FT	SAMPLE NO.	SAMPLE TYPE	BLOWS PER 6"	RECOVERY ROD %	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	CLASS USCS	REMARKS
0–0.2	-	-		-	BLACK	HARD	ASPHALT	-	DRY
0.2–1					BROWN	MEDIUM DENSE	SUBBASE - SAND & GRAVEL	-	
1–3	1	SS	25, 5, 5	40	BROWN	LOOSE	SANDY SILT FILL SOME CLAY	-	APPROX. WATER LEVEL (~3 ft)
3–3.2	2	SS	2, 7, 20, 5	75	BLACK	MED. DENSE	PRODUCT - STICKY, ODEROUS	-	
3.2–4.5					BROWN	LOOSE	SANDY SILT FILL SOME CLAY	-	SATURATED
4.5–5.3	3	SS	3, 7, 28, 20	100	YELLOW	LOOSE	POWDER AND RESIN	-	
5.3–6					WHITE TO BLUE	DENSE	SANDY AND POWDERY FILL	-	

COMMENTS DID NOT SEND SAMPLE FOR CHEMICAL ANALYSIS

PROJECT NO. 35149
BORING NO. B-6

A-3205

URS CONSULTANTS, Inc.

TEST BORING LOG
BORING NO. B-7

PROJECT: GRATWICK - RIVERSIDE PARK POTHOLE INVEST.	SHEET NO. 1 OF 1
CLIENT: NYSDEC	JOB NO.: 35149
BORING CONTRACTOR: BUFFALO DRILLING COMPANY	BORING LOCATION:
	GROUND ELEVATION:
	DATE STARTED: 4/27/90
	DATE FINISHED: 4/27/90
	DRILLER: KENNETH HUBER
	GEOLOGIST: B. PRZYBYL, M. GUTMANN
	REVIEWED BY:

GROUND WATER:					CAS.	SAMP	CORE	TUBE
DATE	TIME	LEV	TYPE	TYPE				
				DIA.				
				WT.				
				FALL				

* POCKET PENETROMETER READING

DEPTH FT	SAMPLE NO.	TYPE	BLOWS PER 6"	RECOVERY RQD %	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	CLASS USCS	REMARKS
0	–	–		–	BLACK	HARD	ASPHALT	–	DRY
0–3	1	SS	8, 6, 4	25	BROWN	LOOSE	SUB BASE - SANDY SILT & GRAVEL w/ SOME FILL MATERIAL; PAPER.	–	
	2	SS	7, 7, 8, 14	95					APPROX. WATER LEVEL (at ~3 ft)
3–5					BLACK	MEDIUM DENSE	PRODUCT - STICKY, STRINGY TAR LIKE FILL STRONG CHEMICAL OR MEDICINAL ODOR. GRADES TO PRODUCT MIXED w/ BROWN SOIL	–	SATURATED
5–6	3	SS	7, 20, 50, R	80	YELLOW AND RED	VERY DENSE	POWDER AND RESIN	–	
6–8	4	SS	36, 7, R	25	BLUE	DENSE / VERY DENSE	SANDY AND POWDERY FILL	–	

COMMENTS: SENT SAMPLE OF PRODUCT FOR CHEMICAL ANALYSES INCLUDING: TOTAL PHENOLS; TOTAL PCBs

PROJECT NO. 35149
BORING NO. B-7

A-3205

URS CONSULTANTS, Inc.

TEST BORING LOG
BORING NO. B-8

PROJECT: GRATWICK - RIVERSIDE PARK POTHOLE INVEST.
CLIENT: NYSDEC
BORING CONTRACTOR: BUFFALO DRILLING COMPANY

SHEET NO. 1 OF 1
JOB NO.: 35149
BORING LOCATION:
GROUND ELEVATION:
DATE STARTED: 4/27/90
DATE FINISHED: 4/27/90
DRILLER: KENNETH HUBER
GEOLOGIST: B. PRZYBYL, M. GUTMANN
REVIEWED BY:

GROUND WATER:					CAS.	SAMP	CORE	TUBE
DATE	TIME	LEV	TYPE	TYPE				
				DIA.				
				WT.				
				FALL				

* POCKET PENETROMETER READING

DEPTH FT	STRATA	SAMPLE NO.	SAMPLE TYPE	BLOWS PER 6"	RECOVERY ROD %	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	CLASS USCS	REMARKS
0		-	-		-	BLACK	HARD	ASPHALT		DRY
0–2		1	SS	10, 5, 3	30	BROWN	LOOSE → DENSE	SANDY SILT WITH SOME CLAY MIXED WITH GRAVEL; SOME FILL MATERIAL PRESENT		
2–4		2	SS	30, 23, 9, 7	20	↓	DENSE → LOOSE	↓		APPROX. WATER LEVEL; SATURATED
4–6		3	SS	5, 10, 25, 7	100	BLACK	MEDIUM DENSE	PRODUCT - STICKY, STRINGY, TAR LIKE FILL STRONG CHEMICAL OR MEDICINAL ODOR		← SOME BROKEN GLASS ASSOCIATED WITH PRODUCT
6–8		4	SS	16, 7, 11, 9	70	BLUE TO WHITE	MEDIUM DENSE	SANDY OR POWDERY FILL		

A-3205

COMMENTS: SENT SAMPLE OF PRODUCT FOR CHEMICAL ANALYSES INCLUDING: TOTAL PHENOLS; TOTAL PCBs

PROJECT NO. 35149
BORING NO. B-8

URS CONSULTANTS, Inc.

TEST BORING LOG	
BORING NO.	B-9
PROJECT: GRATWICK - RIVERSIDE PARK POTHOLE INVEST.	SHEET NO. 1 OF 1
CLIENT: NYSDEC	JOB NO.: 35149
BORING CONTRACTOR: BUFFALO DRILLING COMPANY	BORING LOCATION:
GROUND WATER:	GROUND ELEVATION:
	DATE STARTED: 4/27/90
	DATE FINISHED: 4/27/90
	DRILLER: KENNETH HUBER
	GEOLOGIST: B. PRZYBYL, M. GUTMANN
	REVIEWED BY:

DATE	TIME	LEV	TYPE		CAS.	SAMP	CORE	TUBE
				TYPE				
				DIA.				
				WT.				
				FALL				

* POCKET PENETROMETER READING

DEPTH FT	STRATA	SAMPLE NO.	SAMPLE TYPE	BLOWS PER 6"	RECOVERY ROD %	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	CLASS USCS	REMARKS
0–3		1	SS	6, 6, 7, 7	50	BROWN	LOOSE	SILTY SOIL w/ SOME CLAY - ORGANIC MAT NEAR TOP - SOME FILL MATERIAL MIXED IN		DRY
		2	SS	5, 5, 6, 20	75					APPROX WATER LEVEL (~3 ft)
3–3.5						BLACK	MEDIUM DENSE	PRODUCT - TAR LIKE MATERIAL - SLIGHT ODOR		SATURATED
3.5–6		3	SS	16, 100, R	25	BLUE TO WHITE	DENSE / VERY DENSE	SANDY OR POWDERY FILL		
7										
8										

COMMENTS: SENT SAMPLE OF PRODUCT FOR CHEMICAL ANALYSIS INCLUDING: TOTAL PHENOLS; TOTAL PCBs

PROJECT NO. 35149

BORING NO. B-9

A-3205

URS CONSULTANTS, Inc.

TEST BORING LOG
BORING NO. B-10

PROJECT: GRATWICK - RIVERSIDE PARK POTHOLE INVEST.
CLIENT: NYSDEC
BORING CONTRACTOR: BUFFALO DRILLING COMPANY

SHEET NO. 1 OF 1
JOB NO.: 35149
BORING LOCATION:
GROUND ELEVATION:
DATE STARTED: 4/27/90
DATE FINISHED: 4/27/90
DRILLER: KENNETH HUBER
GEOLOGIST: B. PRZYBYL, M. GUTMANN
REVIEWED BY:

GROUND WATER:

DATE	TIME	LEV	TYPE		CAS.	SAMP	CORE	TUBE
				TYPE				
				DIA.				
				WT.				
				FALL				

* POCKET PENETROMETER READING

DEPTH FT	SAMPLE NO.	TYPE	BLOWS PER 6"	RECOVERY RQD %	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	CLASS USCS	REMARKS
0	-	-		-	BLACK	HARD	ASPHALT	-	DRY
					BROWN	LOOSE	SUBBASE - SANDY SILT WITH SOME CLAY MIXED WITH GRAVEL;		
1	1	SS	3, 4, 3	10			FILL - SANDY SILT AND GRAVEL MIXED WITH PAPER, WOOD CHIPS AND OTHER FILL MATERIAL		
2–4	2	SS	17, 22, 10, 13	50		DENSE		-	APPROX. WATER LEVEL (~2.7 ft); SATURATED
4–5	3	SS	36, 57, 36, 20	100		VERY DENSE			
5					BLACK	DENSE	PRODUCT - STICKY TAR	-	
5–6					YELLOW	DENSE	POWDER AND RESIN	-	
6					BLACK	DENSE	PRODUCT - MIXED W/ RESIN	-	
6–8	4	SS	18, 26, 26, 19	100	BLUE TO WHITE	DENSE	SANDY OR POWDERY FILL	-	

COMMENTS: SENT SAMPLE OF PRODUCT FOR CHEMICAL ANALYSES INCLUDING: TCL VOLATILES, SEMI-VOLATILES, PEST/PCBs, & METALS; TOTAL PHENOLS; DIOXIN

PROJECT NO. 35149
BORING NO. B-10

A-3205

URS CONSULTANTS, Inc.

TEST BORING LOG
BORING NO. B-11

PROJECT: GRATWICK - RIVERSIDE PARK POTHOLE INVEST.
CLIENT: NYSDEC
BORING CONTRACTOR: BUFFALO DRILLING COMPANY

SHEET NO. 1 OF 1
JOB NO.: 35149
BORING LOCATION:
GROUND ELEVATION:
DATE STARTED: 4/27/90
DATE FINISHED: 4/27/90
DRILLER: KENNETH HUBER
GEOLOGIST: B. PRZYBYL, M. GUTHMANN
REVIEWED BY:

GROUND WATER:

DATE	TIME	LEV	TYPE		CAS.	SAMP	CORE	TUBE
				TYPE				
				DIA.				
				WT.				
				FALL				

* POCKET PENETROMETER READING

DEPTH FT	STRATA	SAMPLE NO.	SAMPLE TYPE	BLOWS PER 6"	RECOVERY RQD %	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	CLASS USCS	REMARKS
0–2		1	SS	15, 5, 3, 7	25	BROWN	LOOSE	SILTY SOIL w/ SOME CLAY - ORGANIC MAT NEAR TOP - FILL MATERIAL INCLUDING PAPER AND WOOD PRESENT	-	DRY
~3		2	SS	8, 5, 3, 2	75	BLACK	LOOSE	PRODUCT - STRINGY TAR	-	APPROX WATER LEVEL
						BROWN	LOOSE	SILTY SOIL w/ FILL MATERIAL	-	SATURATED
~4		3	SS	12, 16, 24, 36	50	BLACK	MED. DENSE	PRODUCT - STRINGY TAR	-	
						PINK AND YELLOW	DENSE → VERY DENSE	POWDER AND RESIN	-	
6–8		4	SS	48, 22, 16, 7	100	BLUE TO WHITE	DENSE	SANDY OR POWDERY FILL	-	

COMMENTS SENT SAMPLE OF PRODUCT FOR CHEMICAL ANALYSES INCLUDING: TOTAL PHENOLS, TOTAL PCBs

PROJECT NO. 35149
BORING NO. B-11

A-3205

URS CONSULTANTS, Inc.

TEST BORING LOG
BORING NO. B-12

PROJECT: GRATWICK - RIVERSIDE PARK POTHOLE INVEST.	SHEET NO. 1 OF 1
CLIENT: NYSDEC	JOB NO.: 35149
BORING CONTRACTOR: BUFFALO DRILLING COMPANY	BORING LOCATION:
GROUND WATER:	GROUND ELEVATION:
	DATE STARTED: 4/27/90
	DATE FINISHED: 4/27/90
	DRILLER: KENNETH HUBER
	GEOLOGIST: B. PRZYBYL, M. GUTHANN
	REVIEWED BY:

DATE	TIME	LEV	TYPE		CAS.	SAMP	CORE	TUBE
				TYPE				
				DIA.				
				WT.				
				FALL				

* POCKET PENETROMETER READING

DEPTH FT	SAMPLE NO.	TYPE	BLOWS PER 6"	RECOVERY RQD %	COLOR	CONSISTENCY HARDNESS	MATERIAL DESCRIPTION	CLASS USCS	REMARKS
0	-	-		-	BLACK	HARD	ASPHALT	-	DRY
0–1.5	1	SS	4, 4, 2	20	BROWN	LOOSE	SUB BASE - SANDY SILT AND GRAVEL	-	
1.5–6	2	SS	2, 1, 1, 1	60	BROWN	VERY LOOSE	FILL - SANDY GRAVEL AND SILT MIXED WITH PAPER, WOOD CHIPS AND OTHER FILL MATERIAL	-	APPROX. WATER LEVEL; SATURATED
	3	SS	4, 3, 8, 9	20		LOOSE			
6–8	4	SS	16, 31, 34, 19	100	BLUE TO WHITE	VERY DENSE	SANDY OR POWDERY FILL	-	

COMMENTS: DID NOT SEND SAMPLE FOR CHEMICAL ANALYSIS

A-3205

PROJECT NO. 35149
BORING NO. B-12

E+E06150A-0002

TMS

TMS ANALYTICAL SERVICES, INC.

7726 Moller Road Indianapolis, Indiana 46268 317-875-5894 FAX 317-872-6189

June 21, 1990

Gary Hahn
Ecology & Environment, Inc.
4285 Genesee Street
Buffalo, NY 14225

Dear Mr. Hahn,

Enclosed are analytical results for the analysis of 2 samples for 2,3,7,8-TCDD. These tar samples were analyzed according to the procedures outlined in the "EPA Contract Laboratory Program Statement of Work for Rapid Turnaround for Dioxin Analysis Multi-Media", November 1988. These samples were received for analysis on June 15, 1990 at 10:10. The analytical results of CASE No. E&E06150, BATCH A, were faxed on June 20, 1990 at 14:15.

The hardcopy report was shipped by UPS overnight on June 21, 1990, to arrive on June 22, 1990.

If you should have any questions regarding these data or this report, please feel free to contact my at (317) 875-5894.

Sincerely,

Stephen A. Barnett

Stephen A. Barnett
Vice President
of Operations

TCDD FINAL DATA REPORT SHEET

FILE RECEIVED DATE:
FILE RECEIVED TIME:

SITE: E&E
CASE: 0615
TPCODE: A
DATE: 06/18/90

AREA #	CLIENT SAMPLE #	ANALYSIS DATE	ANALYSIS TIME	NATIVE RATIO	SURROGATE ACC	TCDD CONC.	RERUN CODE	VALID CODE	UNITS	COMMENTS
METHBLANK	METHBLNK	06/18/90	1520	892*	96.02	0.309 U			NG/GM	
METHSPIKE	METHSPKE	06/18/90	1529	1.05	98.36	0.976			NG/GM	97.6% OF THEORETICAL VALUE
PE	PE	06/18/90	1546	1.01	96.05	0.978			NG/GM	97.8% OF THEORETICAL VALUE
73904.01	73904.01	06/18/90	1554	1.00	207.67**	5.205	A		NG/GM	NO RECOVERY
73912.01	73912.01	06/18/90	1602	1.00	207.67**	5.104	A		NG/GM	NO RECOVERY

QUALIFICATION FLAGS:

* 257/259 RATIO OUTSIDE OF ACCEPTABLE RANGE
** SURROGATE OUTSIDE OF ACCEPTABLE RANGE
*** HIGH DETECTION LIMIT

RERUN CODES:
A AUTOMATIC RERUN
R REQUESTED RERUN

E+E0615A-0004

GC/MS/MS WORKSHEET REPORT FORM

SITE: EME
CASE: 0615
TRCODE: A
DATE: 06/18/90

SURROGATE CONC 0.05 RF NATIVE 2.333 ION RATIO: 0.926 TO 1.131
INTERNAL STD CONC 1.05 RF SURROGATE 2.906 CORRECTION FACTOR: 0.005

LAB SAMPLE #	AREA #	CLIENT SAMPLE #	ANALYSIS DATE	ANALYSIS TIME	SAMPLE AMOUNT	ION 257	ION 259	ION 263	ION 268	RATIO 257/259	SURR ACC	RAW VALUE	UNITS
JUN1856	METHBLANK	METHBLNK	06/18/90	1520	5.03	892	1	293841	642414	892	96.02	-0.011	NG/GM
JUN1857	METHSPIKE	METHSPKE	06/18/90	1529	5.02	133529	127600	323302	686987	1.05	98.36	0.976	NG/GM
JUN1859	PE	PE	06/18/90	1546	5.00	128742	127241	310088	674745	1.01	96.05	0.978	NG/GM
JUN1860	73904.01	73904.01	06/18/90	1554	5.01	1	1	1	1	1.00	207.67	5.205	NG/GM
JUN1861	73912.01	73912.01	06/18/90	1602	5.11	1	1	1	1	1.00	207.67	5.104	NG/GM

ecology and environment, inc.
International Specialists in the Environment
ANALYTICAL SERVICES CENTER
4285 Genesee Street, Cheektowaga, New York 14225, Telephone: (716) 631-0360
Telecopier Phone: (716) 631-0378

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From: GAYLE KROETSCH

Special Instructions:

TEST CODE :SPHOLD1 JOB NUMBER :9001.048

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : URS COMPANY INC.
TEST NAME : PHENOLS DISTILLED UNITS : MG/KG
PARAMETER : Phenols Distilled

SAMPLE ID	RESULTS	Q	DET. LIMIT
EE-90-73904 B-1	12000		0.50
EE-90-73905 B-2	19000		0.50
EE-90-73906 B-3	14000		0.50
EE-90-73907 B-4	20000		0.50
EE-90-73908 B-5	23000		0.50
EE-90-73909 B-7	9200		0.50
EE-90-73910 B-8	9300		0.50
EE-90-73911 B-9	13000		0.50
EE-90-73912 B-10	2400		0.50
EE-90-73913 B-11	960		0.50

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
L = PRESENT BELOW STATED DETECTION LIMIT
NA = NOT APPLICABLE

METALS SECTION JOB NUMBER :9001.048

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : URS COMPANY INC.
RESULTS IN WET WEIGHT
SAMPLE ID LAB : EE-90-73904 MATRIX: SOLID
SAMPLE ID CLIENT: B-1

PARAMETER		RESULTS	Q	DET. LIMIT	UNITS
Arsenic	(FU)	ND		0.50	MG/KG
Mercury	(Vap)	ND		0.10	MG/KG
Aluminum	(ICP)	600		10	MG/KG
Antimony	(ICP)	ND		6.0	MG/KG
Barium	(ICP)	9.4		1.0	MG/KG
Beryllium	(ICP)	ND		0.20	MG/KG
Cadmium	(ICP)	0.74		0.50	MG/KG
Chromium	(ICP)	36		1.0	MG/KG
Cobalt	(ICP)	ND		1.0	MG/KG
Copper	(ICP)	38		1.0	MG/KG
Iron	(ICP)	3900		2.5	MG/KG
Manganese	(ICP)	68		0.50	MG/KG
Nickel	(ICP)	30		1.5	MG/KG
Silver	(ICP)	ND		1.0	MG/KG
Vanadium	(ICP)	ND		1.0	MG/KG
Zinc	(ICP)	47		1.0	MG/KG
Calcium	(ICP)	3500		20	MG/KG
Magnesium	(ICP)	830		20	MG/KG
Potassium	(ICP)	72		40	MG/KG
Sodium	(ICP)	6400		20	MG/KG
Lead	(ICP)	12		5.0	MG/KG
Selenium	(FU)	ND		0.10	MG/KG
Thallium	(FU)	ND		0.20	MG/KG

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
L = PRESENT BELOW STATED DETECTION LIMIT

METALS SECTION JOB NUMBER :9001.048

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : URS COMPANY INC.
RESULTS IN WET WEIGHT
SAMPLE ID LAB : EE-90-73912 MATRIX: SOLID
SAMPLE ID CLIENT: B-10

PARAMETER		RESULTS	Q	DET. LIMIT	UNITS
Arsenic	(FU)	ND		1.0	MG/KG
Mercury	(Vap)	ND		0.10	MG/KG
Aluminum	(ICP)	26000		10	MG/KG
Antimony	(ICP)	ND		6.0	MG/KG
Barium	(ICP)	160		1.0	MG/KG
Beryllium	(ICP)	3.6		0.20	MG/KG
Cadmium	(ICP)	0.92		0.50	MG/KG
Chromium	(ICP)	31		1.0	MG/KG
Cobalt	(ICP)	ND		1.0	MG/KG
Copper	(ICP)	4.9		1.0	MG/KG
Iron	(ICP)	4500		2.5	MG/KG
Manganese	(ICP)	680		0.50	MG/KG
Nickel	(ICP)	14		1.5	MG/KG
Silver	(ICP)	ND		1.0	MG/KG
Vanadium	(ICP)	ND		1.0	MG/KG
Zinc	(ICP)	20		1.0	MG/KG
Calcium	(ICP)	150000		20	MG/KG
Magnesium	(ICP)	8400		20	MG/KG
Potassium	(ICP)	600		40	MG/KG
Sodium	(ICP)	920		20	MG/KG
Lead	(ICP)	14		5.0	MG/KG
Selenium	(FU)	ND		1.0	MG/KG
Thallium	(FU)	ND		0.20	MG/KG

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
L = PRESENT BELOW STATED DETECTION LIMIT

TEST CODE :SPCB 1 JOB NUMBER :9001.048

Ecology and Environment, Inc.
Analytical Services Center

CLIENT :URS COMPANY INC.
TEST NAME:PCB-SOIL -SOLID UNITS : MG/KG
RESULTS IN WET WEIGHT

LAB SAMPLE ID: EE-90-73905
CLIENT SAMPLE ID: B-2

PARAMETER	RESULTS	Q	DET.LIMIT
PCB-1016	ND	C	300
PCB-1242	ND	C	300
PCB-1254	ND	C	300
PCB-1221	ND	C	300
PCB-1232	ND	C	300
PCB-1248	ND	C	300
PCB-1260	ND	C	300

LAB SAMPLE ID: EE-90-73906
CLIENT SAMPLE ID: B-3

PARAMETER	RESULTS	Q	DET.LIMIT
PCB-1016	ND	C	150
PCB-1242	ND	C	150
PCB-1254	ND	C	150
PCB-1221	ND	C	150
PCB-1232	ND	C	150
PCB-1248	ND	C	150
PCB-1260	ND	C	150

LAB SAMPLE ID: EE-90-73907
CLIENT SAMPLE ID: B-4

PARAMETER	RESULTS	Q	DET.LIMIT
PCB-1016	ND	C	18
PCB-1242	ND	C	18
PCB-1254	ND	C	18
PCB-1221	ND	C	18
PCB-1232	ND	C	18
PCB-1248	ND	C	18
PCB-1260	ND	C	18

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
L = PRESENT BELOW STATED DETECTION LIMIT

TEST CODE :SPCB 1 JOB NUMBER :9001.048

Ecology and Environment, Inc.
Analytical Services Center

CLIENT :URS COMPANY INC.
TEST NAME:PCB-SOIL -SOLID UNITS : MG/KG
RESULTS IN WET WEIGHT

LAB SAMPLE ID: EE-90-73908
CLIENT SAMPLE ID: B-5

PARAMETER	RESULTS	Q	DET.LIMIT
PCB-1016	ND	C	20
PCB-1242	ND	C	20
PCB-1254	ND	C	20
PCB-1221	ND	C	20
PCB-1232	ND	C	20
PCB-1248	ND	C	20
PCB-1260	ND	C	20

LAB SAMPLE ID: EE-90-73909
CLIENT SAMPLE ID: B-7

PARAMETER	RESULTS	Q	DET.LIMIT
PCB-1016	ND	C	5.0
PCB-1242	ND	C	5.0
PCB-1254	ND	C	5.0
PCB-1221	ND	C	5.0
PCB-1232	ND	C	5.0
PCB-1248	ND	C	5.0
PCB-1260	ND	C	5.0

LAB SAMPLE ID: EE-90-73910
CLIENT SAMPLE ID: B-8

PARAMETER	RESULTS	Q	DET.LIMIT
PCB-1016	ND	C	50
PCB-1242	ND	C	50
PCB-1254	ND	C	50
PCB-1221	ND	C	50
PCB-1232	ND	C	50
PCB-1248	ND	C	50
PCB-1260	ND	C	50

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
L = PRESENT BELOW STATED DETECTION LIMIT

TEST CODE :SPCB 1 JOB NUMBER :9001.048

Ecology and Environment, Inc.
Analytical Services Center

CLIENT :URS COMPANY INC.
TEST NAME:PCB-SOIL -SOLID UNITS : MG/KG
RESULTS IN WET WEIGHT

LAB SAMPLE ID: EE-90-73911
CLIENT SAMPLE ID: B-9

PARAMETER	RESULTS	Q	DET.LIMIT
PCB-1016	ND	C	10
PCB-1242	ND	C	10
PCB-1254	ND	C	10
PCB-1221	ND	C	10
PCB-1232	ND	C	10
PCB-1248	ND	C	10
PCB-1260	ND	C	10

LAB SAMPLE ID: EE-90-73913
CLIENT SAMPLE ID: B-11

PARAMETER	RESULTS	Q	DET.LIMIT
PCB-1016	ND	C	10
PCB-1242	ND	C	10
PCB-1254	ND	C	10
PCB-1221	ND	C	10
PCB-1232	ND	C	10
PCB-1248	ND	C	10
PCB-1260	ND	C	10

LAB SAMPLE ID: METHOD BLANK

PARAMETER	RESULTS	Q	DET.LIMIT
PCB-1016	ND		0.06
PCB-1242	ND		0.06
PCB-1254	ND		0.06
PCB-1221	ND		0.06
PCB-1232	ND		0.06
PCB-1248	ND		0.06
PCB-1260	ND		0.06

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
L = PRESENT BELOW STATED DETECTION LIMIT

TEST CODE :SP&PCB1 JOB NUMBER :9001.048

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : URS COMPANY INC.
RESULTS IN WET WEIGHT
TEST NAME : PESTICIDE-PCB
SAMPLE ID LAB : EE-90-73904
SAMPLE ID CLIENT: B-1

UNITS : MG/KG
MATRIX : SOLID

PARAMETER	RESULTS	Q	DET. LIMIT
Aldrin	ND		1.0
alpha-BHC	ND		1.0
beta-BHC	ND		1.0
gamma-BHC (Lindane)	ND		1.0
delta-BHC	ND		1.0
Chlordane	ND		8.0
4,4'-DDD	ND		2.0
4,4'-DDE	ND		2.0
4,4'-DDT	ND		5.0
Dieldrin	ND		2.0
Endosulfan I	ND		2.0
Endosulfan II	ND		2.0
Endosulfan Sulfate	ND		5.0
Endrin	ND		2.0
Endrin Aldehyde	ND		5.0
Heptachlor	ND		1.0
Heptachlor Epoxide	ND		1.0
PCB-1016	ND		20
PCB-1221	980		20
PCB-1232	ND		20
PCB-1242	ND		20
PCB-1248	ND		20
PCB-1254	ND		20
PCB-1260	ND		20
Toxaphene	ND		50
Methoxychlor	ND		16

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
L = PRESENT BELOW STATED DETECTION LIMIT

TEST CODE :SP&PCB1 JOB NUMBER :9001.048

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : URS COMPANY INC.
RESULTS IN WET WEIGHT
TEST NAME : PESTICIDE-PCB UNITS : MG/KG
SAMPLE ID LAB : EE-90-73912 MATRIX : SOLID
SAMPLE ID CLIENT: B-10

PARAMETER	RESULTS	Q	DET. LIMIT
Aldrin	ND		1.0
alpha-BHC	ND		1.0
beta-BHC	ND		1.0
gamma-BHC (Lindane)	ND		1.0
delta-BHC	ND		1.0
Chlordane	ND		8.0
4,4'-DDD	ND		2.0
4,4'-DDE	ND		2.0
4,4'-DDT	ND		5.0
Dieldrin	ND		2.0
Endosulfan I	ND		2.0
Endosulfan II	ND		2.0
Endosulfan Sulfate	ND		5.0
Endrin	ND		2.0
Endrin Aldehyde	ND		5.0
Heptachlor	ND		1.0
Heptachlor Epoxide	ND		1.0
PCB-1016	ND		20
PCB-1221	ND		20
PCB-1232	ND		20
PCB-1242	ND		20
PCB-1248	ND		20
PCB-1254	ND		20
PCB-1260	ND		20
Toxaphene	ND		50
Methoxychlor	ND		16

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
L = PRESENT BELOW STATED DETECTION LIMIT

TEST CODE :SPURG 1 JOB NUMBER :9001.048

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : URS COMPANY INC.
RESULTS IN WET WEIGHT
TEST NAME : PURGEABLES - SOIL
SAMPLE ID LAB : EE-90-73904
SAMPLE ID CLIENT: B-1

UNITS : UG/KG
MATRIX : SOLID

PARAMETER	RESULTS	Q	DET. LIMIT
Chloromethane	ND		8000
Bromomethane	ND		8000
Vinyl Chloride	ND		8000
Chloroethane	ND		8000
Methylene Chloride	5100	B	4000
1,1-Dichloroethene	ND		4000
1,1-Dichloroethane	ND		4000
trans-1,2-Dichloroethene	ND		4000
Chloroform	ND		4000
1,2-Dichloroethane	ND		4000
1,1,1-Trichloroethane	ND		4000
Carbon Tetrachloride	ND		4000
Bromodichloromethane	ND		4000
1,2-Dichloropropane	ND		4000
trans-1,3-Dichloropropene	ND		4000
Trichloroethene	ND		4000
Dibromochloromethane	ND		4000
1,1,2-Trichloroethane	ND		4000
Benzene	ND		4000
cis-1,3-Dichloropropene	ND		4000
2-Chloroethylvinyl Ether	ND		4000
Bromoform	ND		4000
Tetrachloroethene	ND		4000
1,1,2,2-Tetrachloroethane	ND		4000
Toluene	22000		4000
Chlorobenzene	PRESENT	L	4000
Ethylbenzene	ND		4000
Acetone	11000	B	4000
Carbon Disulfide	ND		4000
2-Butanone	ND		8000
Vinyl Acetate	ND		4000
2-Hexanone	ND		8000
Styrene	ND		4000
Total Xylenes	ND		4000
4-Methyl-2-Pentanone	ND		8000

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
L = PRESENT BELOW STATED DETECTION LIMIT

TEST CODE :SPURG 1 JOB NUMBER :9001.048

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : URS COMPANY INC.
RESULTS IN WET WEIGHT
TEST NAME : PURGEABLES - SOIL UNITS : UG/KG
SAMPLE ID LAB : EE-90-73912 MATRIX : SOLID
SAMPLE ID CLIENT: B-10

PARAMETER	RESULTS	Q	DET. LIMIT
Chloromethane	ND		8000
Bromomethane	ND		8000
Vinyl Chloride	ND		8000
Chloroethane	ND		8000
Methylene Chloride	42000	B	4000
1,1-Dichloroethene	ND		4000
1,1-Dichloroethane	ND		4000
trans-1,2-Dichloroethene	ND		4000
Chloroform	ND		4000
1,2-Dichloroethane	ND		4000
1,1,1-Trichloroethane	ND		4000
Carbon Tetrachloride	ND		4000
Bromodichloromethane	ND		4000
1,2-Dichloropropane	ND		4000
trans-1,3-Dichloropropene	ND		4000
Trichloroethene	PRESENT	L	4000
Dibromochloromethane	ND		4000
1,1,2-Trichloroethane	ND		4000
Benzene	ND		4000
cis-1,3-Dichloropropene	ND		4000
2-Chloroethylvinyl Ether	ND		8000
Bromoform	ND		4000
Tetrachloroethene	ND		4000
1,1,2,2-Tetrachloroethane	ND		4000
Toluene	5000		4000
Chlorobenzene	PRESENT	L	4000
Ethylbenzene	ND		4000
Acetone	12000	B	4000
Carbon Disulfide	ND		4000
2-Butanone	ND		8000
Vinyl Acetate	ND		4000
2-Hexanone	ND		8000
Styrene	ND		4000
Total Xylenes	ND		4000
4-Methyl-2-Pentanone	ND		8000

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
L = PRESENT BELOW STATED DETECTION LIMIT

TEST CODE :SBNBNA1 JOB NUMBER :9001.048

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : URS COMPANY INC.
RESULTS IN WET WEIGHT
TEST NAME : BASE NEUTRAL
SAMPLE ID LAB : EE-90-73904
SAMPLE ID CLIENT: B-1

UNITS : UG/KG
MATRIX : SOLID

PARAMETER	RESULTS	Q	DET. LIMIT
Bis(2-Chloroethyl)Ether	ND		66000
1,3-Dichlorobenzene	ND		66000
1,4-Dichlorobenzene	ND		66000
1,2-Dichlorobenzene	ND		66000
Bis(2-Chloroisopropyl) Ether	ND		66000
N-Nitrosodipropylamine	ND		66000
Hexachloroethane	ND		66000
Nitrobenzene	ND		66000
Isophorone	ND		66000
Bis (2-Chloroethoxy) Methane	ND		66000
1,2,4-Trichlorobenzene	ND		66000
Naphthalene	ND		66000
Hexachlorobutadiene	ND		66000
Hexachlorocyclopentadiene	ND		66000
2-Chloronaphthalene	ND		66000
Dimethyl Phthalate	ND		66000
Acenaphthylene	ND		66000
Fluorene	PRESENT	L	66000
Acenapthene	ND		66000
2,4-Dinitrotoluene	ND		66000
2,6-Dinitrotoluene	ND		66000
Diethylphthalate	ND		66000
4-Chlorophenyl Phenyl Ether	PRESENT	L	66000
N-Nitrosodiphenylamine	ND		66000
4-Bromophenyl Phenyl Ether	ND		66000
Hexachlorobenzene	ND		66000
Phenanthrene	PRESENT	L	66000
Anthracene	ND		66000
Di-N-Butyl-Phthalate	ND		66000
Fluoranthene	ND		66000
Benzidine	ND		320000
Pyrene	ND		66000
Butyl Benzyl Phthalate	ND		66000
3,3'-Dichlorobenzidine	ND		130000
Benzo(A)Anthracene	ND		66000
Bis(2-Ethylhexyl)Phthalate	ND		66000
Chrysene	ND		66000

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
L = PRESENT BELOW STATED DETECTION LIMIT

TEST CODE :SBNBNA1 JOB NUMBER :9001.048

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : URS COMPANY INC.
RESULTS IN WET WEIGHT
TEST NAME : BASE NEUTRAL
SAMPLE ID LAB : EE-90-73904
SAMPLE ID CLIENT: B-1

UNITS : UG/KG
MATRIX : SOLID

PARAMETER	RESULTS	Q	DET. LIMIT
Di-N-Octyl Phthalate	ND		66000
Benzo(B)Fluoranthene	ND		66000
Benzo(K)Fluoranthene	ND		66000
Benzo(A)Pyrene	ND		66000
Indeno(1,2,3-cd)Pyrene	ND		66000
Dibenzo(A,H)Anthracene	ND		66000
Benzo(G,H,I)Perylene	ND		66000
Benzyl Alcohol	ND		66000
4-Chloroaniline	ND		66000
2-Methylnaphthalene	ND		66000
2-Nitroaniline	ND		320000
3-Nitroaniline	ND		320000
Dibenzofuran	2600000	X	66000
4-Nitroaniline	ND		320000

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
L = PRESENT BELOW STATED DETECTION LIMIT
X = EXCEEDS CALIBRATION LIMIT

TEST CODE :SAPBNA1 JOB NUMBER :9001.048

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : URS COMPANY INC.
RESULTS IN WET WEIGHT
TEST NAME : ACID PHENOL
SAMPLE ID LAB : EE-90-73904
SAMPLE ID CLIENT: B-1

UNITS : UG/KG
MATRIX : SOLID

PARAMETER	RESULTS	Q	DET. LIMIT
Phenol	270000		66000
2-Chlorophenol	ND		66000
2-Nitrophenol	ND		66000
2,4-Dimethylphenol	ND		66000
2,4-Dichlorophenol	ND		66000
4-Chloro-3-Methylphenol	ND		66000
2,4,6-Trichlorophenol	PRESENT	L	66000
2,4-Dinitrophenol	ND		320000
4-Nitrophenol	ND		320000
4,6-Dinitro-2-Methylphenol	ND		320000
Pentachlorophenol	ND		320000
2-Methylphenol	ND		66000
4-Methylphenol	ND		66000
Benzoic Acid	ND		320000
2,4,5-Trichlorophenol	ND		320000

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
L = PRESENT BELOW STATED DETECTION LIMIT

TEST CODE :SBNBNA1 JOB NUMBER :9001.048

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : URS COMPANY INC.
RESULTS IN WET WEIGHT
TEST NAME : BASE NEUTRAL UNITS : UG/KG
SAMPLE ID LAB : EE-90-73912 MATRIX : SOLID
SAMPLE ID CLIENT: B-10

PARAMETER	RESULTS	Q	DET. LIMIT
Bis(2-Chloroethyl)Ether	ND		33000
1,3-Dichlorobenzene	ND		33000
1,4-Dichlorobenzene	ND		33000
1,2-Dichlorobenzene	ND		33000
Bis(2-Chloroisopropyl) Ether	ND		33000
N-Nitrosodipropylamine	ND		33000
Hexachloroethane	ND		33000
Nitrobenzene	ND		33000
Isophorone	ND		33000
Bis (2-Chloroethoxy) Methane	ND		33000
1,2,4-Trichlorobenzene	ND		33000
Naphthalene	ND		33000
Hexachlorobutadiene	ND		33000
Hexachlorocyclopentadiene	ND		33000
2-Chloronaphthalene	ND		33000
Dimethyl Phthalate	ND		33000
Acenaphthylene	ND		33000
Fluorene	PRESENT	L	33000
Acenapthene	ND		33000
2,4-Dinitrotoluene	ND		33000
2,6-Dinitrotoluene	ND		33000
Diethylphthalate	ND		33000
4-Chlorophenyl Phenyl Ether	ND		33000
N-Nitrosodiphenylamine	ND		33000
4-Bromophenyl Phenyl Ether	ND		33000
Hexachlorobenzene	ND		33000
Phenanthrene	ND		33000
Anthracene	ND		33000
Di-N-Butyl-Phthalate	ND		33000
Fluoranthene	ND		33000
Benzidine	ND		160000
Pyrene	ND		33000
Butyl Benzyl Phthalate	ND		33000
3,3'-Dichlorobenzidine	ND		66000
Benzo(A)Anthracene	ND		33000
Bis(2-Ethylhexyl)Phthalate	ND		33000
Chrysene	ND		33000

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
L = PRESENT BELOW STATED DETECTION LIMIT

TEST CODE :SBNBNA1 JOB NUMBER :9001.048

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : URS COMPANY INC.
RESULTS IN WET WEIGHT
TEST NAME : BASE NEUTRAL
SAMPLE ID LAB : EE-90-73912
SAMPLE ID CLIENT: B-10

UNITS : UG/KG
MATRIX : SOLID

PARAMETER	RESULTS	Q	DET. LIMIT
Di-N-Octyl Phthalate	ND		33000
Benzo(B)Fluoranthene	ND		33000
Benzo(K)Fluoranthene	ND		33000
Benzo(A)Pyrene	ND		33000
Indeno(1,2,3-cd)Pyrene	ND		33000
Dibenzo(A,H)Anthracene	ND		33000
Benzo(G,H,I)Perylene	ND		33000
Benzyl Alcohol	ND		33000
4-Chloroaniline	ND		33000
2-Methylnaphthalene	ND		33000
2-Nitroaniline	ND		160000
3-Nitroaniline	ND		160000
Dibenzofuran	630000	X	33000
4-Nitroaniline	ND		160000

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
L = PRESENT BELOW STATED DETECTION LIMIT
X = EXCEEDS CALIBRATION LIMIT

TEST CODE :SAPBNA1 JOB NUMBER :9001.048

Ecology and Environment, Inc.
Analytical Services Center

CLIENT : URS COMPANY INC.
RESULTS IN WET WEIGHT
TEST NAME : ACID PHENOL UNITS : UG/KG
SAMPLE ID LAB : EE-90-73912 MATRIX : SOLID
SAMPLE ID CLIENT: B-10

PARAMETER	RESULTS	Q	DET. LIMIT
Phenol	34000		33000
2-Chlorophenol	ND		33000
2-Nitrophenol	ND		33000
2,4-Dimethylphenol	ND		33000
2,4-Dichlorophenol	ND		33000
4-Chloro-3-Methylphenol	ND		33000
2,4,6-Trichlorophenol	ND		33000
2,4-Dinitrophenol	ND		160000
4-Nitrophenol	ND		160000
4,6-Dinitro-2-Methylphenol	ND		160000
Pentachlorophenol	ND		160000
2-Methylphenol	ND		33000
4-Methylphenol	ND		33000
Benzoic Acid	ND		160000
2,4,5-Trichlorophenol	ND		160000

QUALIFIERS: C = COMMENT ND = NOT DETECTED
J = ESTIMATED VALUE B = ALSO PRESENT IN BLANK
L = PRESENT BELOW STATED DETECTION LIMIT

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Results of Soil Analysis for Tentatively Identified
Volatile Organic Compounds by GC/MS
(all results in ug/kg)

9001.048

Compound			
	E & E Lab No. 90-	73904	73912
Compound	Sample Identity	B-1	B-12
terpene isomer		16000	8200
1,3-dichlorobenzene		2700	ND
1,4-dichlorobenzene		39000	14000
1,2-dichlorobenzene		5900	3500
butylbenzene isomer		ND	7000
unknown oxygenated hydrocarbon		ND	5200

ND = Not detected

ECOLOGY & ENVIRONMENT, INC.

A N A L Y T I C A L S E R V I C E S C E N T E R

Results of Soil Analysis for Tentatively Identified
Volatile Organic Compounds by GC/MS
(all results in ug/kg)

9001.048

Compound		
	E & E Lab No. 90-	73904
Compound	Sample Identity	B-1
chlorophenol isomer		115,000
biphenyl		65,000
1,1'-oxybisbenzene		230,000
monochlorobiphenyl isomer (19.9)*		110,000
phenoxyphenol isomer		55,000
monochlorobiphenyl isomer (21.0)		85,000
monochlorobiphenyl isomer (21.2)		46,000
an oxygenated biphenyl		145,000
oxygenated polyaromatic hydrocarbon		75,000
phenoxyphenol isomer		85,000
xanthenone isomer		435,000
oxygenated polyaromatic hydrocarbon (25.4)		5,350,000
oxygenated polyaromatic hydrocarbon (26.8)		50,000
methylenebisphenol isomer (27.1)		130,000
unknown		320,000
methylenebisphenol isomer (28.1)		50,000
unknown oxygenated polyaromatic hydrocarbon		230,000
unknown polyaromatic hydrocarbon		85,000
benzobisbenzofuran isomer (32.5)		135,000
benzobisbenzofuran isomer (32.9)		95,000

* = Values are approximate retention times.

ECOLOGY & ENVIRONMENT, INC.

ANALYTICAL SERVICES CENTER

Results of Soil Analysis for Tentatively Identified
Volatile Organic Compounds by GC/MS
(all results in ug/kg)

9001.048

Compound		
	E & E Lab No. 90-	73912
	Sample Identity	B-12
1,1'-oxybisbenzene		530,000
unknown polycyclic hydrocarbon		230,000
unknown (24.6)*		140,000
unknown polyaromatic hydrocarbon (24.8)		130,000
unknown polycyclic hydrocarbon (25.0)		300,000
xanthenone isomer		170,000
unknown oxygenated polyaromatic hydrocarbon (25.3)		170,000
unknown polycyclic hydrocarbon (25.5)		270,000
unknown polycyclic hydrocarbon (25.6)		200,000
unknown polycyclic hydrocarbon (25.8)		150,000
unknown oxygenated polycyclic hydrocarbon (26.0)		530,000
unknown oxygenated polycyclic hydrocarbon (26.2)		370,000
unknown oxygenated polyaromatic hydrocarbon		330,000
unknown oxygenated polyaromatic hydrocarbon (26.5)		160,000
unknown polyaromatic hydrocarbon (26.7))		400,000
unknown polycyclic hydrocarbon (26.8)		160,000
unknown polycyclic hydrocarbon (27.3)		170,000
unknown oxygenated polyaromatic hydrocarbon (27.6)		160,000
unknown oxygenated polycyclic hydrocarbon (29.1)		600,000
unknown oxygenated polycyclic hydrocarbon (31.0)		310,000

* = Values are approximate retention times.

APPENDIX G

ASSESSMENT OF REMEDIAL TECHNOLOGIES FOR GROUNDWATER COLLECTION

APPENDIX G

Assessment of Remedial Technologies for Groundwater Collection

To develop and evaluate remedial technologies associated with groundwater containment, collection, and treatment, a three-dimensional groundwater flow model was used. The model was based on the results of activities conducted during the Remedial Investigation and calibrated to water levels measured in the monitoring wells on March 7, 1989, a day when the potentiometric surfaces were considered to be at a level representative of average conditions.

Approach

The 3-D computer model used in this study is the Modular Three-Dimensional Finite-Difference Groundwater Flow Model (MODFLOW), prepared by the U.S. Geological Survey (McDonald and Harbaugh, 1984). Groundwater flow within the aquifer is simulated using a block-centered finite-difference approach. Layers can be simulated as confined, unconfined, or a combination of both. Flow from external stresses, such as withdrawal from wells and flow through riverbeds, can also be simulated. The finite-difference equations can be solved using either the Strongly Implicit Procedure or Slice-Successive Overrelaxation. The model may be used for either 2-D or 3-D application, and is capable of analyzing both steady-state and transient flow conditions. In this case 3-D steady-state conditions were used for calibrating the model, and transient conditions were used in the analysis of remedial alternatives.

Three hydrogeologic units were identified in Section 4.3.3 of the RI as being present at the Gratwick site: upper aquifer (consisting of fill and lacustrine fine sand), confining unit (consisting of till and lacustrine clay and silt) and the bedrock aquifer. Hydrogeologic properties for each of these units on a well-by-well basis (water levels, saturated thickness, hydraulic conductivity) are found in the RI and associated appendices.

Upper Aquifer - Measurements of the water table in the upper aquifer for March 7, 1989 ranged from 573.9 feet in GW-1S to 564.6 feet in GW-6S; and 563.9 feet in the Niagara River at the gaging station on Tonawanda Island. The saturated thickness is approximately 10 feet. Hydraulic conductivity values ranged from 5.5 10^{-6} cm/sec in GW-5S to >10^{-2} cm/sec in a number of wells. The average horizontal hydraulic conductivity was >2.3×10^{-3} cm/sec.

Confining Unit - Measurements of water levels in the confining unit for the same day ranged from 563.7 feet in GW-6I to 573.9 feet in GW-1S. The saturated thickness is approximately 20 feet. Hydraulic conductivity values ranged 4.3×10^{-8} cm/sec in GW-3I to 2.9×10^{-6} cm/sec in GW-4I. The average horizontal hydraulic conductivity was 1.8×10^{-7} cm/sec.

Bedrock Aquifer - Three wells were drilled into the bedrock aquifer: GW-1D, GW-5D, and GW-6D. There was virtually no gradient in the bedrock aquifer; the water level was 564.6 feet in GW-1D, 564.5 in GW-5D, and 564.4 in GW-6D. Hydraulic conductivity values ranged from 4.2×10^{-3} cm/sec in GW-5D to 1.3×10^{-2} cm/sec in GW-6D with an average of 7.4×10^{-3} cm/sec. These values were calculated from slug tests conducted in the top 10 feet of bedrock - in the fractured zone. Therefore the saturated thickness used to represent this unit was 10 feet.

Using the hydrogeologic information above, a three-dimensional groundwater flow model was developed as described below.

Areal Extent - The configuration of the site required the use of a long and narrow grid system. The dimensions of the grid were 4972 feet in the north-south direction parallelling the Niagara River, and 1672 feet in the east-west direction. The western boundary is along the Niagara River, and the eastern boundary is far enough from the edge of the site to include GW-1. The northern and southern model boundaries are approximately 60 feet from the respective property lines.

Finite Difference Cell Conditions - Conditions in each finite-difference cell may be set separately to: 1) no-flow, 2) general head, 3) constant, or 4) variable head. A no-flow boundary does not allow groundwater flow into or out of the cell across the modeled boundary. A general-head boundary, on the contrary, allows inflow or outflow to the cell in proportion to set values of external head. A constant head maintains the water level specified for that cell. A variable head allows the computer program to calculate groundwater elevations in the cells and to determine flow between cells.

Water levels in the Niagara River were set to a constant head in the upper aquifer and confining unit both of which are expected to discharge into the River. Cells in the bedrock aquifer along the Niagara River were set to general head as it is not known whether this aquifer discharges to the River. Along the northern, eastern, and southern boundaries, cells in all three units were set to general head boundaries to allow inflow to and outflow from the modeled region, as no known recharge/discharge areas were modeled. The remaining interior cells in all three layers were modeled as variable head.

Infiltration for Existing Conditions - An infiltration analysis performed for the site was presented in Section 4.4.3 of the RI. Results presented in Table G-1 indicated that for existing conditions at the site, approximately 36 percent of the precipitation (12.63 inches per year) enters the groundwater as infiltration.

Model Calibration to Existing Conditions - Calibration of the local-scale three-dimensional groundwater flow model to existing conditions was achieved through a comparison of measured to simulated water levels in onsite monitoring wells. Table G-2 provides details of this comparison. All simulated water levels were within a foot of those measured on March 7, 1988, with the exception of GW-3S and GW-3I. Water levels measured in GW-3S between the period of December, 1989 through August, 1988 ranged from 566.26 to 566.68 feet; and in GW-3I from 561.4 to 568.5 feet. The simulated water level for GW-3I was within the range of values measured;

TABLE G-1

GRATWICK-RIVESIDE PARK
INFILTRATION ANALYSIS
LAT 42°56′

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	ANNUAL	% OF TOTAL
T (F)	24	25	33	45	56	65	70	69	62	52	40	30		
I heat	0	0	0.04	1.74	4.41	7.15	8.85	8.51	6.19	3.35	0.83	0	41.07	
Unadj PET	0	0	0	0.04	0.08	0.12	0.14	0.13	0.11	0.07	0.02	0		
PET	0	0	0	1.34	3.02	4.61	5.42	4.68	3.12	1.71	0.49	0		
P	2.8	2.5	2.66	2.78	2.89	2.84	2.8	3.47	3.14	2.97	3.26	3.19	35.3	
CR/O	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
R/O	0.28	0.25	0.27	0.28	0.29	0.28	0.28	0.35	0.31	0.3	0.33	0.32	3.53	10%
I	2.52	2.25	2.39	2.5	2.6	2.56	2.52	3.12	2.83	2.67	2.93	2.87	31.76	
I-PET	2.52	2.25	2.39	1.16	-0.42	-2.05	-2.9	-1.56	-0.29	0.96	2.44	2.87		
ΣNeg(I-PET)					-0.42	-2.47	-5.37	-6.93	-7.22					
ST	2	2	2	2	1.59	0.54	0.11	0.05	0.04	1	2	2		
ΔST	0	0	0	0	-0.41	-1.05	-0.43	-0.06	-0.01	0.96	1	0	0	
AET	0	0	0	1.34	3.01	3.61	2.95	3.18	2.84	1.71	0.49	0	19.13	54%
PERC	2.52	2.25	2.39	1.16	0	0	0	0	0	0	1.44	2.87	12.63	36%

TABLE G-2

COMPARISON OF MEASURED TO SIMULATED WATER LEVELS

Upper Aquifer	Row	Column	Measured Water Level (ft)	MODFLOW Water Level (ft)	Difference (ft)
GW-1S	1	Boundary	573.9	574.0	Ø
GW-3S	12	11	566.4	567.8	+1.3
GW-4S	13	12	566.0	566.4	+0.4
GW-5S	15	14	564.9	564.6	-0.3
GW-6S	15	11	564.6	564.5	-0.1
GW-7S	13	12	566.4	566.4	Ø
GW-8S	13	13	566.6	566.5	-0.1
GW-9S	13	14	566.1	566.2	+0.1
GW-10S	14	9	565.7	565.3	-0.4
GW-11S	11	13	567.0	567.4	+0.4
Confining Unit					
GW-3I	12	11	568.5	566.5	-2.0
GW-4I	13	12	566.0	565.6	-0.4
GW-5I	15	14	564.2	565.1	+0.9
GW-6I	15	11	563.7	564.5	+0.8
GW-7I	13	12	565.8	565.6	-0.2
GW-8I	13	13	566.6	565.6	-1.0
Bedrock Aquifer					
GW-1D	1	12	564.6	564.8	+0.2
GW-5D	15	14	564.5	564.7	+0.2
GW-6D	15	11	564.4	564.7	+0.3

the simulated water level for GW-3S was within 1.2 feet of the maximum observed level in this well. The calculated model was accepted since this value is on the conservative side,indicating the presence of additional water.

Model Calibration - The discussion of the results of model calibration presented below applies to the final run of numerous computer simulations using combinations of hydraulic conductivity values (both horizontal and vertical), infiltration, saturated thickness, and inflow to the site from the upgradient watershed. Of these parameters, the hydrogeologic system is most sensitive to hydraulic conductivity. The final values of hydraulic conductivity producing the "best fit" of simulated results to actual field measurements selected to represent the hydrogeologic system are as follows:

- 0 Horizontal hydraulic conductivity values vary across the site from $5x10^{-3}$ cm/sec to $5x10^{-2}$ cm/sec. In general, lower values are near the Niagara River. Vertical hydraulic conductivity values are on the same order of magnitude, i.e. $K_h:K_v = 1.0$.

- o Confining Unit: Kh values for the site were $1x10^{-7}$ cm/sec near the river and $5x10^{-6}$ cm/sec for the remainder of the site; Kv values were two orders of magnitude lower.

- o Bedrock Aquifer: Kh values for the entire aquifer were set to $4x10^{-3}$ cm/sec; Kv values were one order of magnitude lower.

General Flow Regime - Lateral groundwater flow in the three units is, as expected, towards the river. Model results indicate that the till and lacustrine silt and clay units act as an impermeable boundary between the upper and bedrock aquifers. There is very little vertical flow through the confining unit suggesting that the two aquifers have no hydraulic connection (a fact further suggested by the difference in hydraulic gradients for these two aquifers). This point will have a significant impact on remedial technologies for the bedrock aquifer.

Infiltration for Capped Conditions

In order to evaluate the relative effectiveness of capping options in reducing the quantity of leachate produced at the site, an infiltration analysis was performed using the Hydrologic Evaluation of Landfill Performance (HELP) computer model. This model, which was developed by the United States Army Corps of Engineers Waterways Experiment Station for the USEPA (Schroeder, et. al., 1984), is a quasi-two-dimensional hydrologic model of water movement across, into, through and out of landfills. Its solution technique accounts for the effects of surface storage (snow), runoff, infiltration, percolation, evapotranspiration, soil moisture storage and lateral drainage. The HELP model was applied to the site using default climatological data provided by the model for the 5-year simulation period 1974 to 1978 for Syracuse, New York, the closest inland city to Niagara Falls with default values.

The model allows five types of layers: vertical percolation (uppermost seeded layer), lateral drainage (such as sand), barrier soil (clay), barrier soil with liner (such as HDPE), and waste. Three proposed capping options as discussed in Section 9 of the FS were represented as follows:

	MSG	Soil	Part 360
Vegetative Cover	Yes	Yes	Yes
Vertical Percolation	6"	6"	36"
Lateral Drainage	12"	N/A	N/A
Barrier Soil	12" with liner	12"	18"
Waste	60"	60"	60"

Input required for each of these layers includes: thickness, hydraulic conductivity, porosity, evaporation coefficient, field capacity, and wilting point. Not all parameters are used for each layer but they must be input. As specific details of each cap design are not finalized, default values suggested by the model documentation were used. Leakage through the geomembrane was simulated at 1 and 5 percent, a conservative estimate as no leakage due to degradation is expected for a very long time. Results for these caps were used in the groundwater simulations and are as follows:

	MSG Cap 1% Leakage	MSG Cap 5% Leakage	Soil Cap	Part 360	Existing Conditions
Runoff	30%	27%	2-20%	29%	10%
Evapotranspiration	69%	68%	48-55%	64%	54%
Drainage	<1%	<1%	---	N/A	N/A
Infiltration	1%	5%	25-50%	7%	36%

Model Simulations of Remedial Technologies - The purpose of this study was to assess the effect of implementing remedial technologies at the site. Remedial technologies considered were slurry walls, sheet piling (along the Niagara River), surficial caps, and withdrawal wells.

Steady-state results of the calibrated groundwater flow model were used as initial conditions (at time = 0 years) to transient simulations in order to assess the impact of remedial technologies over a 30-year time period. Twenty transient simulations (Nos. 1 through 19) were analyzed as listed on Table G-3. A discussion of each simulation is given below. Water levels in the upper aquifer withdrawal wells were set at 560.0 feet. The pumping rates required to maintain this level varied for each of the simulations. Note that initial simulations were performed prior to the development of alternatives and aided in their selection. Once alternatives were developed additional simulations (A through Q) were performed as detailed below.

TABLE G-3
GROUNDWATER FLOW SIMULATIONS

Simulation	Vertical Barriers	Cap	Withdrawal Wells	Steady-State Pumping Rate (GPM)	Comments
1	4 sided slurry wall	None	2 Upper Aquifer	29	Water overflows the site
1A	4 sided slurry wall	Yes	2 Upper Aquifer	3	Hypothetical Perfect Cap
2	Slurry Wall along River	No	2 Upper Aquifer	70	Offsite migration of groundwater
3	Slurry Wall along River and sides	No	2 Upper Aquifer	60	Offsite migration of groundwater
4	Upgradient slurry wall	No	2 Upper Aquifer	44	Offsite migration of groundwater
5	None	No	2 Upper Aquifer	50	Offsite migration of groundwater
6	None	No	2 Upper Aquifer on Upgradient side of site	72	Offsite migration of groundwater
7	4 sided slurry wall	Yes	2 Upper Aquifer	10	No drawdown in center of site
8	4 sided slurry wall	No	3 Upper Aquifer; 2 on Downgradient side and 1 center	30	Not adequate drawdown
9	None	Yes	3 Upper Aquifer	120	Potential for offsite migration Need a withdrawal well in Bedrock Aquifer
10	4 sided slurry wall	Yes	2 Upper Aquifer 1 Bedrock Aquifer	10 + 2	Not adequate drawdown

TABLE G-3 (Continued)

Simulation	Vertical Barriers	Cap	Withdrawal Wells	Steady-State Pumping Rate (GPM)	Comments
11	4 sided slurry wall	Yes	2 Upper Aquifer 1 Bedrock Aquifer	10 + 8	Not adequate drawdown
12	3 sided slurry wall sheet piling along River	Yes	3 Upper Aquifer 1 Bedrock Aquifer	12 + 8	No offsite migration
13	Sheet piling along River	Yes	3 Upper Aquifer 1 Bedrock Aquifer	90 + 8	Potential for offsite migration
14	Upgradient slurry wall sheet piling along River	Yes	3 Upper Aquifer 1 Bedrock Aquifer	44 + 8	No offsite migration
15	3 sided slurry wall sheet piling along River	Yes	3 Upper Aquifer 1 Bedrock Aquifer	10 + 8	No offsite migration
16	Sheet piling along River	Yes	3 Upper Aquifer 1 Bedrock Aquifer	88 + 8	No offsite migration
17	4 sided sheet piling	Yes	3 Upper Aquifer 1 Bedrock Aquifer	32 + 8	No offsite migration
18	3 sided slurry wall sheet piling along River	Yes	3 Upper Aquifer 1 Bedrock Aquifer	48 + 8	Offsite migration of groundwater
19	Sheet piling along River	Yes	3 Upper Aquifer 1 Bedrock Aquifer	>125 + 8	No offsite migration

Simulation 1 - This simulation assumed the installation of a slurry wall keyed into the confining unit enclosing the entire site, two withdrawal wells in the upper aquifer located at the north and south ends of the site on the downgradient side, and no cap. Results of the simulation show that by containing the site within a slurry wall without adding a cap, the site becomes in effect, an "overflowing bathtub" with offsite migration of contaminants.

Simulation 1A - This is a modification of Simulation 1 whereby a cap has been added which allows no infiltration. While this type of cap may not be practical, results of this simulation indicate that approximately 3 gpm of leakage occurs across the slurry walls and/or upward through the confining unit.

Simulation 2 - In the interest of reducing the cost associated with constructing a fully-enclosing slurry wall around the site, the possibility of having just a slurry wall along the shoreline was explored. This would prevent the inflow of river water to the site. For this simulation there were two withdrawal wells in the upper aquifer and no cap. Results show that even by pumping at the steady-state rate of 70 gpm, there is still offsite migration of groundwater from the site.

Simulation 3 - To minimize the inflow of "clean" groundwater to the site, Simulation 2 was modified by adding slurry walls along the northern and southern boundaries of the site. Results show that the presence of these two additional walls reduces the pumping rate to 60 gpm but still allows migration of groundwater to the river.

Simulation 4 - As the majority of flow to the withdrawal wells is from the upgradient watershed, a simulation was performed with just an upgradient slurry wall. The presence of this slurry wall reduced the pumping rate to 44 gpm but allowed quite a bit of groundwater migration to the Niagara River.

Simulation 5 - In the interest of reducing the entire cost associated with slurry walls, this simulation contained no slurry walls, no cap, and two withdrawal wells in the upper aquifer. Results again showed that at a steady-state pumping rate of 50 gpm offsite migration of groundwater occurred.

Simulation 6 - Simulation 6 is a modification of Simulation 5, with the withdrawal wells moved to the upgradient side of the site. The steady-state pumping rate increases to 72 gpm, yet it allows offsite migration of groundwater.

From the preceding runs, it is obvious that a vertical barrier on the downgradient (river) edge of the site is necessary, as well as a cap for the prevention of offsite groundwater migration.

Simulation 7 - By adding a soil cap, two withdrawal wells in the upper aquifer, and an enclosing slurry wall, the steady-state pumping rate is reduced to 10 gpm. This configuration, however, does not provide drawdown through the central portion of the site.

Simulation 8 - An additional withdrawal well was added to Simulation 7, and the cap was removed. The pumping rate increased to 30 gpm, but without the presence of a cap, this still did not provide adequate drawdown across the site.

Simulation 9 - The addition of a soil cap to Simulation 8 and the removal of the slurry wall results in a pumping rate of 120 gpm. There is a potential for offsite migration of groundwater.

It may be seen from the results of Simulations 1 - 9 that regardless of the number of withdrawal wells in the upper aquifer, or their respective pumping rates, modifications to flow in the upper aquifer have no effect on the bedrock aquifer. In order to remediate the bedrock aquifer in the vicinity of GW-6D, a withdrawal well would have to be installed in the bedrock aquifer itself. Several withdrawal rates were simulated in order to assess their impact on the bedrock aquifer across the site area. A withdrawal rate of 300 ft^3/day (2 gpm) produces a small effect in the vicinity of GW-6D. A withdrawal rate of 1,500 ft^3/d (8 gpm) draws water from the entire northern half of the site. A withdrawal rate of 5,000 ft^3/d (30 gpm) will draw water from about two-thirds of the site. As it is not known whether groundwater in the bedrock aquifer south of GW-5D is contaminated, it is felt that a withdrawal rate of 8 gpm would be adequate. This could be reviewed periodically through long-term monitoring of the site.

Simulation 10 - A withdrawal well in the bedrock aquifer was added to Simulation 7 which contained an enclosing slurry wall and soil cap resulted in a pumping rate of 10 gpm in the upper aquifer, and 2 gpm in the bedrock aquifer. These rates were determined to be low as they did not provide adequate drawdown of the water surface across the site in either aquifer. (Simulation 10 was actually performed prior to simulation 9.)

Simulation 11 - Simulation 10 was modified to pump 8 gpm from the bedrock aquifer. While this was adequate for the bedrock aquifer it did not provide adequate drawdown in the upper aquifer.

At this point of the study, it was determined that the construction of a slurry wall along the shoreline of the Niagara River was not feasible. For the purposes of both erosion control and prevention of groundwater migration, sheet piling along the River was chosen and was carried through subsequent simulations.

Simulation 12 - Sheet piling along the shoreline, slurry walls along the three remaining boundaries, a soil cap, three withdrawal wells in the upper aquifer, and one withdrawal well in the bedrock aquifer achieve the remedial objectives mentioned previously with a total pumping rate of 20 gpm (12 upper and 8 bedrock).

Simulation 13 - Using Simulation 12 but removing the three slurry walls provides the potential for offsite migration with a total pumping rate of 98 gpm (90 upper and 8 bedrock).

Simulation 14 - Using Simulation 12 but removing 2 sides of the slurry wall (leaving the upgradient slurry wall) achieves the remedial objectives with a pumping rate of 52 gpm (44 upper and 8 bedrock).

In addition to the soil cap, a multi-layered cap with a synthetic geomembrane (MSG) is under consideration. Results of the capping analysis indicate that infiltration for the MSG cap is approximately 5 percent of existing precipitation. This cap was used in Simulations 15-17.

Simulation 15 - A simulation similar to Simulation 12 (sheet piling along the river, three-sided slurry wall, three withdrawal wells in the upper aquifer and one in the bedrock) with an MSG cap eliminates offsite groundwater migration and reduces the steady-state pumping rate to 18 gpm (10 upper and 8 bedrock).

Simulation 16 - In order to eliminate the cost of the slurry wall, this simulation was performed with just sheet piling along the river, an MSG cap, and the above withdrawal wells. While this configuration prevents offsite migration of groundwater, the total pumping rate increases to 96 gpm (88 upper and 8 bedrock).

Simulation 17 - Although sheet piling is not the preferred vertical barrier except along the shoreline, given the potential difficulty in constructing slurry walls, this simulation included enclosing the site in sheet piling, an MSG cap, and the above withdrawal wells. Again, this configuration prevented offsite groundwater migration, but the pumping rate increased to 40 gpm (32 upper and 8 bedrock).

At this point the design of the soil cap was modified and infiltration for the soil cap was increased to depict the changes. This cap allows approximately 60% of the existing conditions to infiltrate and was used in Simulations 18 and 19.

Simulation 18 - This simulation is similar to Simulation 12 (sheet piling along the River, three-sided slurry wall, three withdrawal wells in the upper aquifer, one withdrawal well in the bedrock aquifer) with the exception of the cap. This soil cap allows more infiltration which results in 56 gpm of (48 upper and 8 bedrock), and does not achieve objectives.

Simulation 19 - This simulation included sheet piling along the River, the modified soil cap, and the above withdrawal wells. A pumping rate of 125 gpm in the upper aquifer still did not prevent offsite migration of groundwater.

Summary - Results of the preceding analyses show that Simulations 12, and 14 through 18 best contained groundwater at the site. Simulation 19 allowed some migration of the groundwater into the Niagara River, which may be acceptable depending on contaminant loadings. Four (15, 16, 18 and 19) were considered potential remedial alternatives for the site.

All these simulations contain the following:

- sheet piling along the Niagara River
- a cap (either the MSG or soil cap)
- three withdrawal wells in the upper aquifer
- one withdrawal well in the bedrock aquifer pumping at 8 gpm.

The difference between the simulations is the presence or lack of slurry walls along the remaining three sides of the site and the use of either a soil or MSG cap. As these simulations show pumping rates varying from 18 to 93 gpm, a cost-benefit analysis was performed (see Section 4 of the FS) in order to choose the most cost effective remedial alternative.

The pumping rates given are steady-state rates which will be achieved after a period of time. Initial pumping rates which will be required to adequately drawdown the upper aquifer will be higher, depending on the alternative chosen. For the purpose of the Detailed Analysis, and the design of a treatment system, pumping rates have been increased as follows:

Simulation 15 used for Alternative 4 from 18 gpm to 30 gpm
Simulation 16 used for Alternative 3 from 96 gpm to 100 gpm
Simulation 18 used for Alternative 5 from 56 gpm to 60 gpm.
Simulation 19 used for Alternative 6 was not changed (125 gpm)

Further, there is a degree of uncertainty associated with flow rates obtained from computer modeling. In order to provide a conservative estimate of flow to the groundwater pretreatment system, the above flows have been doubled resulting in the following design flows:

Alternative 3	200 gpm
Alternative 4	60 gpm
Alternative 5	120 gpm
Alternative 6	250 gpm.

At this time, a second groundwater flow model was developed. A finer mesh was used in the upper aquifer, and the confining unit and bedrock aquifer were eliminated. This was feasible given the results of Simulations 1 through 19 which confirmed the earlier prediction that the low permeability of the confining unit separates the upper and bedrock aquifers into two non-hydraulically connected units. Withdrawal wells placed in either of the aquifers had no effect on the other. This model was similarly calibrated to existing site conditions. It had a larger areal extent and finer discretization. The advantage of this approach was to allow for a more accurate simulation of pumping within the site's boundaries as well as to determine the influence of the disturbance created both on and off site by groundwater withdrawal. All hydrologic parameters are the same as those previously described except for the following.

Aquifer - The aquifer was modeled as a single layer, unconfined unit. The saturated thickness is approximately 10 ft. The value of hydraulic conductivity was selected based on the calibration run.

Areal Extent - The dimensions of the grid were 5100 ft. in the north-south direction paralleling the Niagara River and 1850 ft. in the east-west direction. The western boundary is along Niagara River and the eastern boundary includes GW-1. The northern and southern boundaries are approximately 125 ft. from the respective property lines.

Finite Difference Cell Conditions - Water levels in the Niagara River were set to a constant head. Along the northern, eastern, and southern boundaries, cells were set to general head boundaries to allow inflow to and outflow from the modeled region, as no known recharge/discharge areas were modeled. The remaining interior cells were modeled as variable head.

Infiltration for Existing Conditions - Same as before

Model Calibration to Existing Conditions - Calibration of the local scale model was achieved by comparing the modeled results with the conditions observed on March 7, 1988. Water levels in the following wells were used:

1S, 3S, 4S, 6S, 7S, 8S, 9S, 10S, 11S. Detailed comparisons between observed and simulated levels are presented in Table G-4. All simulated water levels were within a foot of those measured, with the exception of GW-11S. However, the model was accepted since the modeled valve in GW-11S was higher than the observed value indicating the presence of additional water, which is a conservative assumption.

Model Calibration - The discussion of the results of model calibration presented below applies to the final run of numerous computer simulations using combinations of hydraulic conductivity values (both horizontal and vertical), infiltration, saturated thickness, and inflow to the site from the upgradient watershed. Of these parameters, the hydrogeologic system is most sensitive to hydraulic conductivity. The final values of hydraulic conductivity producing the "best fit" of the simulated results to actual field measurements selected to represent the hydrogeologic system are as follows:

$$K_v:K_h = 1.0$$
$$K_v = 1.06 \times 10^{-2} \text{ cm/s}$$

General Flow Regime - Since the system was modeled as one layer, only horizontal flow is present. The direction of flow is toward the Niagara River.

Infiltration for Capped Conditions - See previous discussion.

The components of Simulations A through Q are presented on Table G-5 and the results are summarized on Table G-6. In these simulations, the remedial technologies were imposed and the pumping rate required to maintain the water level at 560.0 feet in the withdrawal wells was calculated.

TABLE G-4

COMPARISON OF MEASURED TO SIMULATED WATER LEVELS - LOCAL SCALE

Upper Aquifer	Row	Column	Measured Water Level (ft)	MODFLOW Water Level (ft)	Difference (ft)
GW-1S		Boundary	573.9	574.0	Ø
GW-3S	18	9	566.4	567.2	+0.7
GW-4S	25	8	566.0	566.4	+0.4
GW-5S	15	14	564.9	564.6	-0.3
GW-6S	18	6	564.6	565.0	+0.4
GW-7S	28	8	566.4	566.4	Ø
GW-8S	32	8	566.6	566.4	-0.2
GW-9S	38	8	566.1	566.4	+0.3
GW-10S	10	7	565.7	565.5	-0.2
GW-11S	32	16	567.0	569.5	+2.5

TABLE G–5

GRATWICK–RIVERSIDE PARK
GROUNDWATER SIMULATIONS

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
SOIL CAP	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	Part 360
VERTICAL BARRIERS																	
Upgradient	X	X	X	X	X	X									X	X	
Sides			X			X	X	X	X	X					X	X	
Downgradient							X	X	X	X	X	X					
Slurry Wall	X	X	X												X	X	
Sheet Piling				X	X	X	X	X	X	X	X	X					X
EXTRACTION																	
No Pumping	X			X			X		X		X		X		X		
Partial Pumping		X			X			X		X		X		X		X	X
Full Pumping			X			X											

TABLE G-6
(PAGE 1 of 3)

GRATWICK-RIVERSIDE PARK
LOCAL SCALE GROUNDWATER FLOW SIMULATIONS

RUN	NO. OF WELLS	WITH-RAWA	UPGRADIENT IN	UPGRADIENT OUT	DOWNGRADIENT IN	DOWNGRADIENT OUT	NORTH IN	NORTH OUT	SOUTH IN	SOUTH OUT	RECHARGE	BARRIERS			GROUND SURF. ELEV.	INIT. WATER ELEV.	FINAL WATER ELEV.	MAX. WATER EVEL LOCATIO
		GPM	GPM		GPM		GPM		GPM		GPM	UPGR	DOWNGR	SIDES	FT	FT	FT	
EXISTIN CONDS	0	0	86	0	0	116	0	0	0	0	31							
A	0	0	0	0	0	41	5	0	4	0	31	SW			574	569.3	577.3	UPGR,CENTER
B1	7	53	0	0	30	17	5	0	5	0	31	SW			574	569.3	577.3	UPGR,CENTER
B2	7	44	0	0	21	18	5	0	4	0	31	SW			574	569.3	577.3	UPGR,CENTER
B3	7	32	0	0	10	19	5	0	4	0	31	SW			574	569.3	577.3	UPGR,CENTER
C	7	83	0	0	52	1	0	0	0	0	31	SW		SW	574	569.3	577.3	UPGR,CENTER
D	0	0	27	0	0	66	4	0	3	0	31	SP			574	569.3	574.9	UPGR,CENTER
E1	7	68	30	0	24	24	4	0	3	0	31	SP			574	569.3	574.9	UPGR,CENTER
E2	7	59	30	0	16	25	4	0	3	0	31	SP			574	569.3	574.9	UPGR,CENTER
E3	7	47	30	0	6	26	4	0	3	0	31	SP			574	569.3	574.9	UPGR,CENTER

TABLE G-6
(PAGE 2 of 3)

GRATWICK-RIVERSIDE PARK
LOCAL SCALE GROUNDWATER FLOW SIMULATIONS

RUN	NO. OF WELLS	WITH-RAWA	UPGRADIENT IN	OUT	DOWNGRADIENT IN	OUT	NORTH IN	OUT	SOUTH IN	OUT	RECHARGE	BARRIERS			GROUND SURF. ELEV.	INIT. WATER ELEV.	FINAL WATER ELEV.	MAX. WATER EVEL LOCATIO
		GPM	GPM		GPM		GPM		GPM		GPM	UPGR	DOWNGR	SIDES	FT	FT	FT	
F	13	128	31	0	66	1	1	0	1	0	31	SP		SP	574	569.3	574.6	UPGR,CENTER
G	0	0	12	5	0	38	0	0	0	0	31		SP	SW	572	563.9	575.4	OWNGR,CENTE
H1	7	100	79	0	0	8	0	0	0	0	31		SP	SW	572	563.9	570.5	DOWNGR,SIDES
H3	7	105	82	0	0	8	0	0	0	0	31		SP	SW	572	563.9	570.5	DOWNGR,SIDES
I	0	0	14	4	0	38	0	2	0	2	31		SP	SP	572	563.9	575.4	OWNGR,CENTE
J1	7	102	81	0	0	8	0	1	0	1	31		SP	SP	572	563.9	570.0	DOWNGR,SIDES
J2	9	127	95	0	1	2	0	0	0	0	31		SP	SP	572	563.9	567.1	DOWNGR,SIDES
J3	7	104	83	0	0	6	0	1	0	1	31		SP	SP	572	563.9	570.0	DOWNGR,SIDES
J4	9	128	98	0	1	2	0	2	0	0	31		SP	SP	572	563.9	567.1	DOWNGR,SIDES
J5	9	118	92	0	0	4	0	0	0	0	31		SP	SP	572	563.9	567.5	DOWNGR,SIDES
K	0	0	24	0	0	33	0	12	0	12	31		SP		572	563.9	575.2	OWNGR,CENTE

TABLE G-6
(PAGE 3 of 3)

GRATWICK-RIVERSIDE PARK
LOCAL SCALE GROUNDWATER FLOW SIMULATIONS

RUN	NO. OF WELLS	WITH-RAWA	UPGRADIENT IN	UPGRADIENT OUT	DOWNGRADIENT IN	DOWNGRADIENT OUT	NORTH IN	NORTH OUT	SOUTH IN	SOUTH OUT	RECHARGE	BARRIERS			GROUND SURF. ELEV.	INIT. WATER ELEV.	FINAL WATER ELEV.	MAX. WATER EVEL LOCATIO
		GPM	GPM		GPM		GPM		GPM		GPM	UPGR	DOWNGR	SIDES	FT	FT	FT	
L1	7	100	87	0	0	6	0	6	0	7	31		SP		572	563.9	568.5	DOWNGR,SIDES
L3	7	102	89	0	0	6	0	6	0	6	31		SP		572	563.9	568.5	DOWNGR,SIDES
M1	7	100	96	0	13	41	0	0	0	0	31				573	566.4	560	CENTER
M2	7	110	98	0	21	40	0	0	0	0	31				573	566.4	558	CENTER
N1	17	192	96	0	61	1	2	0	3	0	31				573	565	561	OWNGR,CENTE
N2	17	181	125	0	16	2	5	0	7	0	31				573	565	560	OWNGR,CENTE
O	0	0	0	0	0	33	0	0	0	0	31	SW		SW	574	569.3	577.4	UPGR,CENTER
P1	7	53	0	0	30	9	0	0	0	0	31	SW		SW	574	569.3	577.4	UPGR,CENTER
P2	7	65	0	0	41	8	0	0	0	0	31	SW		SW	574	569.3	577.4	UPGR,CENTER
Q	7	85	92	0	1	4	0	5	0	6	7		SP		572	563.9	568.1	DOWNGR,SIDES

Simulation A - This simulation assumed the installation of a slurry wall on the upgradient side and no withdrawal wells. The infiltration was assumed to be that of the existing conditions, which corresponds also to the soil cap infiltration. The results show significant flooding on the site and about 35% of the original discharge of groundwater from the site to the Niagara River.

Simulations B1, B2, B3 - Seven withdrawal wells were added to Simulation "A" and placed at different locations within the site. The same flooding problem on the site is present, the original migration off-site (to the Niagara River) is reduced to about 15%.

Simulation C - This simulation assumed installation of 2 reaches of slurry wall: parallel to the Niagara River on the downstream side and perpendicular to the river on both sides. Seven withdrawal wells were used and the infiltration remained at the original level. Flooding problems on the site were present; offsite migration was eliminated.

Simulation D - Simulation D is analogical to the Simulation "A" but with a sheetpile breakwater instead of a slurry wall. Flooding problems occurred and the offsite migration was reduced to about 55% of the original level. The pumping rate was 27 gpm.

Simulations E1, E2, E3 - Seven withdrawal wells were added to Simulation "D" setup in various locations within the site. The flooding problem was present; offsite migration was reduced to about 20% of the original level. The pumping rate varied between 47 and 68 gpm.

Simulation F - Two stretches of sheet piling were installed: one parallel to the Niagara River on the downgradient side and two perpendicular. Thirteen withdrawal wells were used, infiltration remained unchanged. Offsite migration was eliminated, flooding problems occurred onsite. The pumping rate was 128 gpm.

Simulation G - This simulation assumes the installation of a downgradient sheet pile breakwater and side gradient slurry walls. The infiltration remains at the original level. The results indicate downstream flooding and offsite migration to the Niagara River reduced to about 35% of the original amount.

Simulations H1, H3 - Seven withdrawal wells were added to Simulation "G" setup. The offsite migration was reduced to about 5% of the original level and flooding problems were eliminated. The pumping rates were 100 and 105 gpm.

Simulation I - Sheet piling was simulated on the downgradient and side gradient sides. Infiltration remained unchanged. No withdrawal wells were present. Downstream flooding occurred; offsite migration was reduced to about 35% of the original level.

Simulations J1, J2, J3, J4, J5 - Different numbers of withdrawal wells (7 or 9) were added to Simulation "I" setup in different locations within the site's boundaries. No flooding problems occurred. Offsite migration was less than seven percent of the original level. The pumping rate varied between 102 and 128 gpm.

Simulation K - Simulation K contains a downgradient slurry wall, no withdrawal wells and the original infiltration. Downgradient flooding problems occurred as well as down and side gradient migration at about 50% of the original level.

Simulations L1, L3 - Seven withdrawal wells were added to Simulation "K" setup in different locations within the site's boundaries. These two runs simulated Alternative 6. No flooding problems occurred; offsite migration was at 15% of the original level. The pumping rates were 100 and 102 gpm. Based on this Simulation, the design flow rates for Alternative 6 were adjusted to 150 gpm.

Simulations M1, M2 - Simulations M1, M2 contained seven withdrawal wells at different locations; no vertical barriers, and the original infiltration. No flooding problems occurred. Offsite migration was at about 35% of the original level. The pumping rates were 100 and 110 gpm.

Simulations N1, N2 - An increased number of wells were added to the Simulation "M" setup in order to eliminate offsite migration. Seventeen wells were necessary to achieve this objective, with a withdrawal rate of about 190 gpm. The pumping rates were 181 and 192 gpm.

Simulation O - This run contains a slurry wall on the upgradient and sidegradient sides, original infiltration, and no withdrawal wells. Results show significant upstream flooding and a reduction of offsite migration to about 30% of the original level.

Runs P1, P2 - Seven withdrawal wells were added to Simulation "O" in different locations within the site's boundaries. Flooding results; offsite migration is reduced to about 8% of the original level. The pumping rates wee 53 and 65 gpm.

Run Q - This run simulates a downgradient sheet pile breakwater, seven withdrawal wells and a Part 360 cap, reducing infiltration from 36% of the precipitation to about 7%. It is a modification of Runs L1, L2, which did not include a Part 360 cap. There are no flooding problems; offsite migration is reduced to about 13%. The withdrawal rate is about 85 gpm, or 15 gpm less than for Simulations L1 and L2. The pumping rate was 85 gpm.

Following completion of the groundwater simulations, residual loadings to the Niagara River were calculated. It is estimated from Rounds 1 and 2 data, that 2.6 lb/day of organics and 2.0 lb/day of metals are currently being discharged to the Niagara River (based on an existing flow rate from the site to the River of 116 gpm from the calibrated groundwater flow model). Simulations A through Q, which allow less flow, also proportionally reduce the loadings to the River. These are presented in Table G-7.

TABLE G-7

GRATWICK-RIVERSIDE PARK

ESTIMATE OF THE CONTAMINANT LOADINGS TO THE NIAGARA RIVER FROM GROUNDWATER FLOW SIMULATIONS

Run	Total Flow to River	Withdrawal Rate	AVERAGE LOADINGS TO THE NIAGARA RIVER				
			Volatile Organics	Semi-volatile Oganics	Total Organics	Total Metals	Total Organics & Metals
	gpm	gpm	lb/day	lb/day	lb/day	lb/day	lb/day
Existing Conditions	116	0	1.6	1.0	2.6	2.0	4.6
A	41	0	0.6	0.4	1.0	0.7	1.7
B1	17	53	0.2	0.2	0.4	0.3	0.7
B2	18	44	0.2	0.2	0.4	0.3	0.7
B3	19	32	0.3	0.2	0.5	0.3	0.8
C	0	83	0.0	0.0	0.0	0.0	0.0
D	66	0	0.9	0.6	1.5	1.1	2.6
E1	24	68	0.3	0.2	0.5	0.4	0.9
E2	25	59	0.3	0.2	0.5	0.4	0.9
E3	26	47	0.4	0.2	0.6	0.4	1.0
F	0	128	0.0	0.0	0.0	0.0	0.0
G	43	0	0.6	0.4	1.0	0.7	1.7
H1	8	100	0.1	0.1	0.2	0.1	0.3
H2	8	105	0.1	0.1	0.2	0.1	0.3
I	46	0	0.6	0.4	1.0	0.8	1.8
J1	10	102	0.1	0.1	0.2	0.2	0.4
J2	2	127	0.0	0.0	0.0	0.0	0.0
J3	8	104	0.1	0.1	0.2	0.1	0.3
J4	4	128	0.1	0.0	0.1	0.1	0.2
J5	4	118	0.1	0.0	0.1	0.1	0.2
K	57	0	0.8	0.5	1.3	1.0	2.3
L1	19	100	0.3	0.2	0.5	0.3	0.8
L3	18	102	0.2	0.2	0.4	0.3	0.7
M1	41	100	0.6	0.4	1.0	0.7	1.7
M2	40	110	0.5	0.4	0.9	0.7	1.6
N1	0	198	0.0	0.0	0.0	0.0	0.0
N2	2	181	0.0	0.0	0.0	0.0	0.0
O	31	0	0.4	0.3	0.7	0.5	1.2
P1	9	53	0.1	0.1	0.2	0.2	0.4
P2	8	65	0.1	0.1	0.2	0.1	0.3
Q	4	85	0.1	0.0	0.1	0.1	0.2

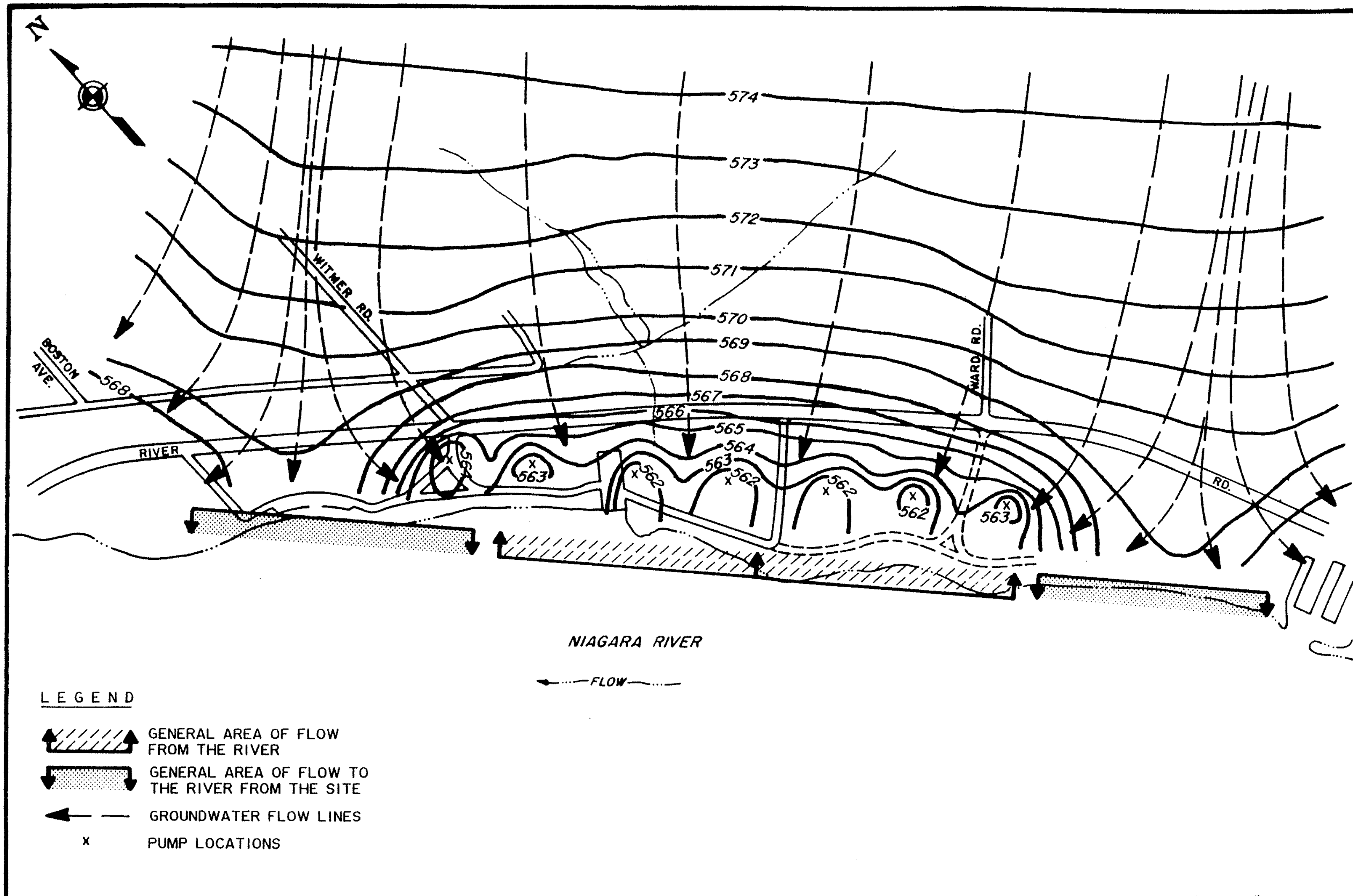
NOTE : Average Volatile Organic Concentration: 1.13 ppm
Average Semivolatile Organic Concentration: 0.75 ppm
Average Metals Concentration: 1.4 ppm
Above average concentrations are calculated from Rounds 1 and 2 data.

<u>REFERENCES</u>

McDonald, M.G., and A.U. Harbaugh. <u>A Modular Three-Dimensional Finite-Difference Ground-Water Flow Model</u>. U.S. Department of the Interior, U.S. Geological Survey, Reston, Virginia, 1984.

Schroeder, P.R., J. M. Morgan, T.M. Walski, and A.C. Gibson, <u>The Hydrologic Evaluation of Landfill Performance (HELP) Model, Volume I, User's Guide for Version I</u>, prepared for USEPA, 1983, EPA/530-SW-84-009; and Version II guidance documents received with HELP Version II, 1988.

A-3424



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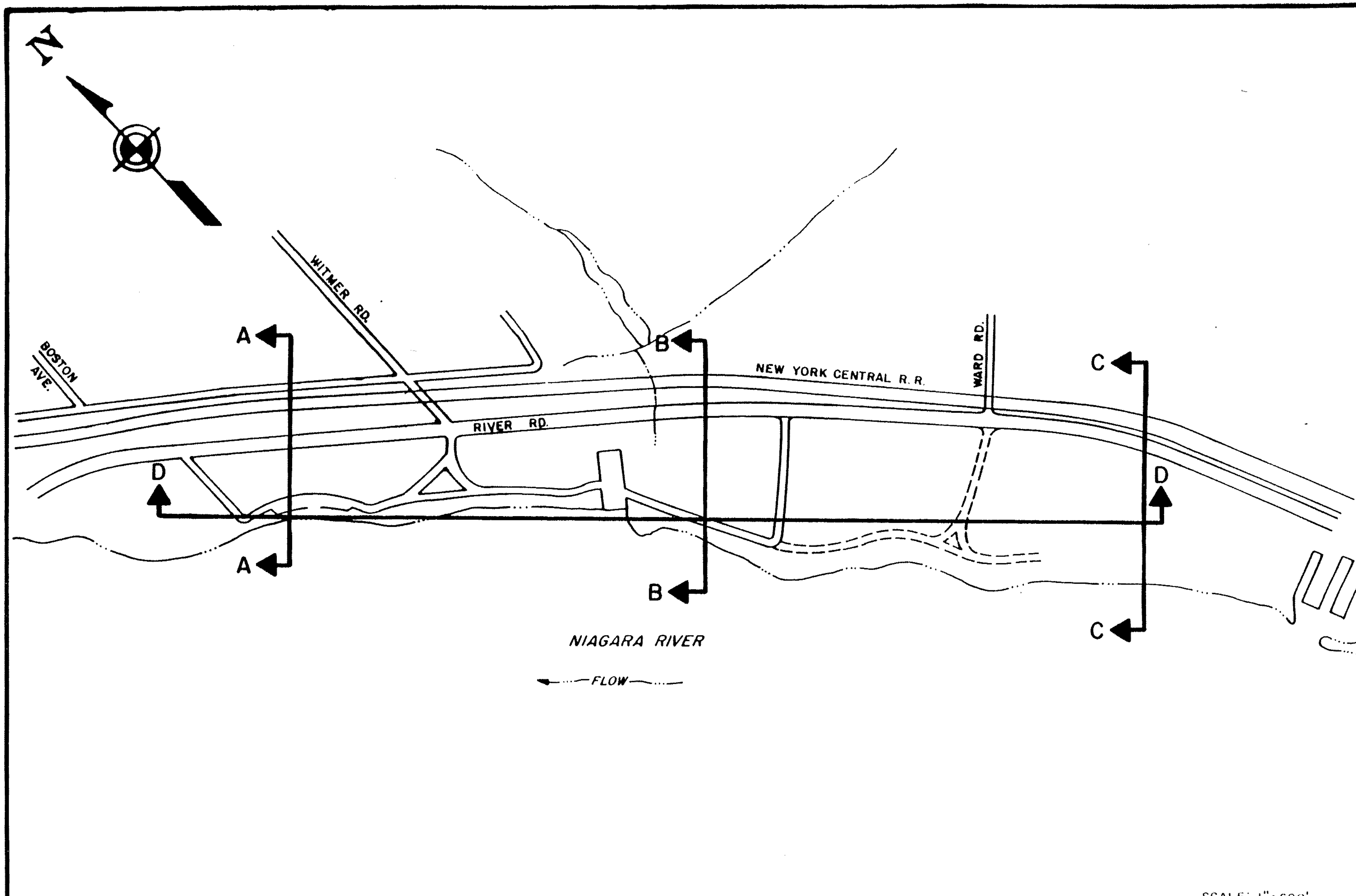
GROUNDWATER CONTOURS FOLLOWING REMEDIAL ALTERNATIVE IMPLEMENTATION

FIGURE G-1

A-3426



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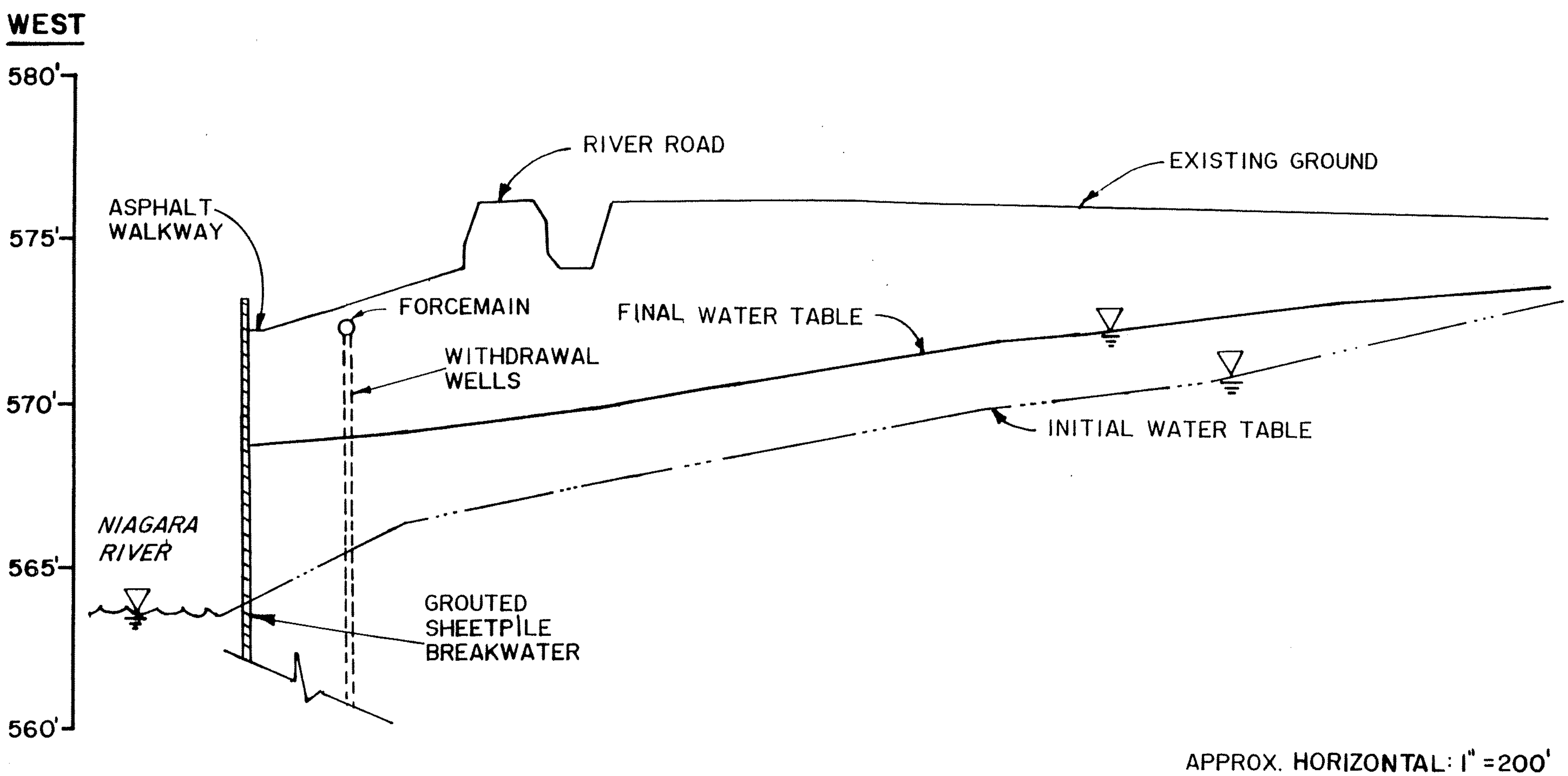
SECTION LOCATION MAP

FIGURE G-2

A-3422



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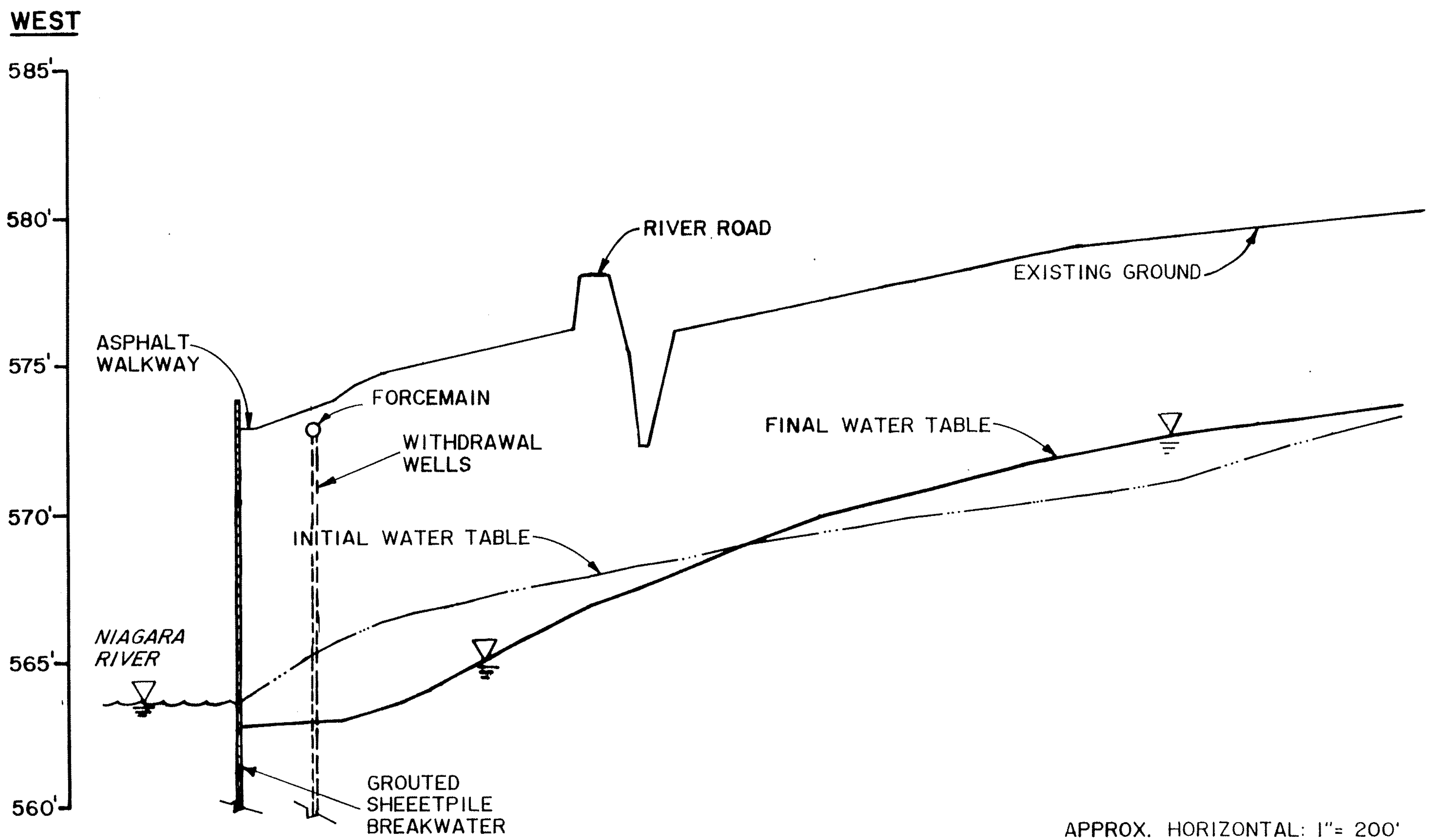
SECTION A

FIGURE G-3

A-3395



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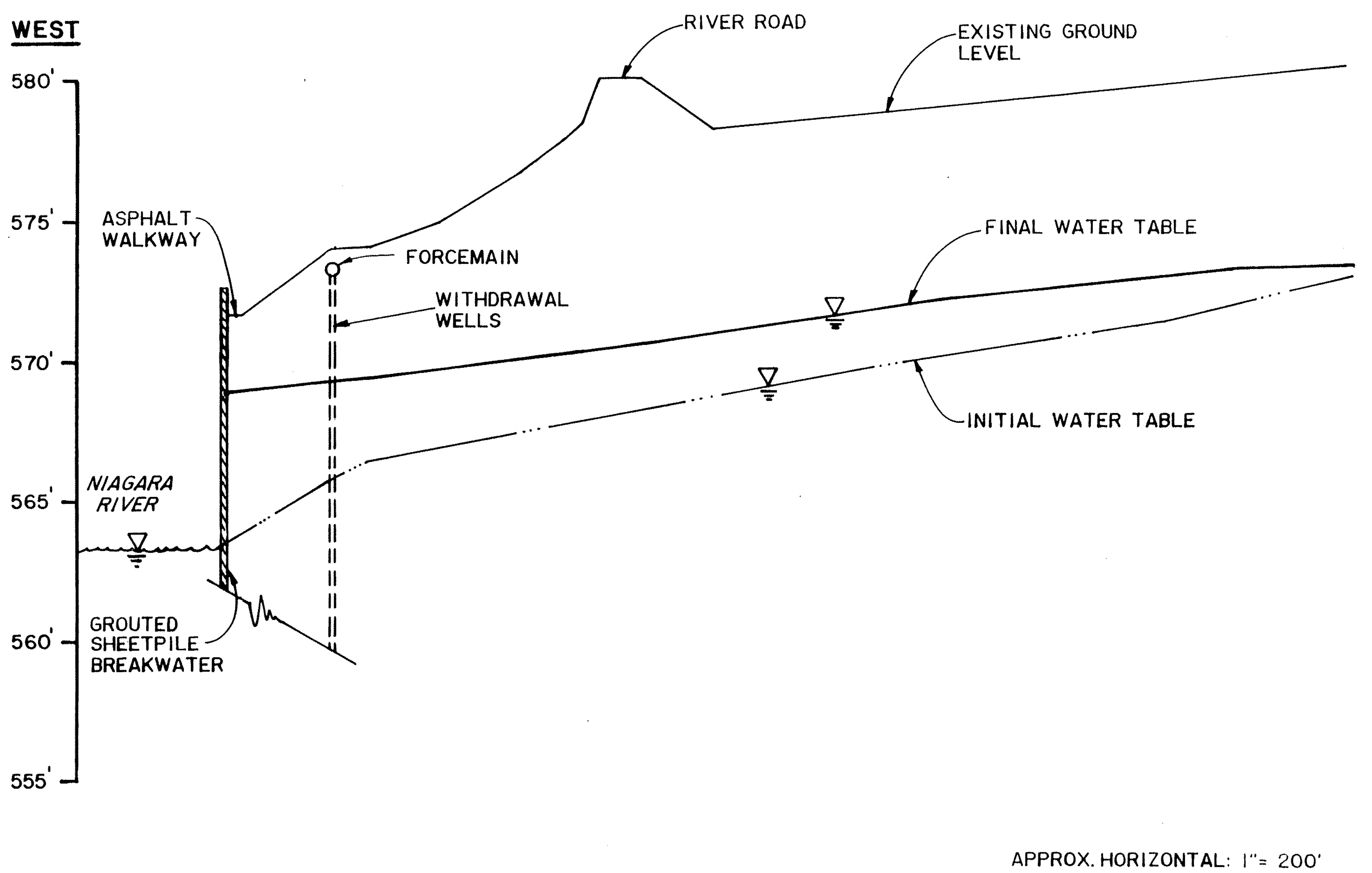
SECTION B

FIGURE G-4

A-3396



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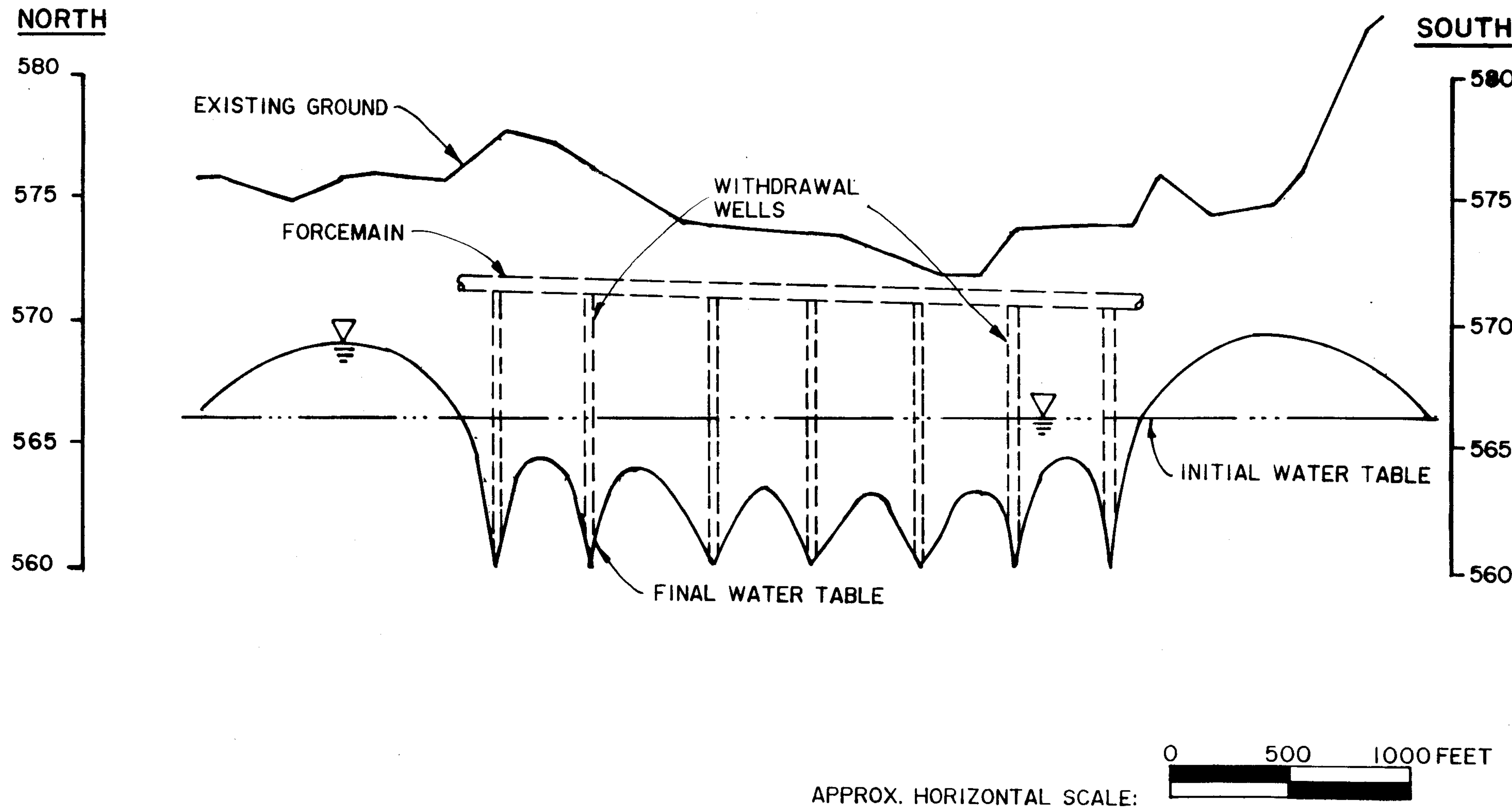
SECTION C

FIGURE G-5

A-3423



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SECTION D

FIGURE G-6