RECEIVED

DEC 31 1998

NYSDEC - REG. 9
FOIL
_REL _UNREL

FEASIBILITY STUDY

BUFFALO OUTER HARBOR SITE
BUFFALO, NEW YORK

(SITE REGISTRY 9-15-026)

PREPARED FOR

**NEW YORK STATE DEPARTMENT
OF ENVIRONMENTAL CONSERVATION**

BY

**DVIRKA AND BARTILUCCI
CONSULTING ENGINEERS
WOODBURY, NEW YORK**

JULY 1998

BUFFALO OUTER HARBOR
FEASIBILITY STUDY REPORT

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

List of Appendices

List of Figures

List of Tables

1.0 INTRODUCTION

1.1 Purpose

As part of New York State's Superfund Program to investigate and remediate hazardous waste sites, the New York State Department of Environmental Conservation (NYSDEC) has issued a Work Assignment to Dvirka and Bartilucci Consulting Engineers of Woodbury, New York, under its Superfund Standby Contract to perform a remedial investigation and feasibility study (RI/FS) for the Buffalo Outer Harbor Site located in the City of Buffalo, Erie County, New York. The registry number for this New York State Superfund site is 9-15-026.

The purpose of this RI/FS is to conduct a remedial investigation to determine the nature, extent and source(s) of contamination at the site, and the risk to human health and the environment, and to prepare a feasibility study to identify and evaluate remedial technologies and alternatives, and recommend a long-term, cost-effective, environmentally-sound remediation plan. A Phase I/II Remedial Investigation Report for the Buffalo Outer Harbor Site was prepared in December 1995. Consistent with the federal Superfund Amendments and Reauthorization Act and New York State Superfund Program, the remedial investigation and feasibility study was performed as a phased program for characterization of the site and development of a remedial action plan.

Based upon the results of the Remedial Investigation, the most significantly contaminated portion of the site found during the remedial investigation was near the radio tower at the southern end of the property. The Radio Tower Area continues to present a significant threat due to the high levels of nitrobenzene that fail the toxicity characteristic leaching procedure (TCLP) regulatory limit and remediation is required. The remainder of the site has shown inconsistent TCLP failures for lead, at levels less than the background upper limit for Buffalo, indicative of inconsequential hazardous waste. Due to these findings, the site has been redefined to include only the 6 acre Radio Tower area and to remove the remainder of the property from the site description. However, the following feasibility study not only addresses the 6 acre Radio Tower Area, but also addresses the remaining areas of the property.

This feasibility study for the Buffalo Outer Harbor Site was prepared consistent with existing NYSDEC guidance as prescribed in the Technical and Administrative Guidance Memorandum (TAGM HWR-90-4030) for "Selection of Remedial Actions at Inactive Hazardous Waste Sites." The study presents the effectiveness, implementability and cost of alternative remedial actions for the Buffalo Outer Harbor Site.

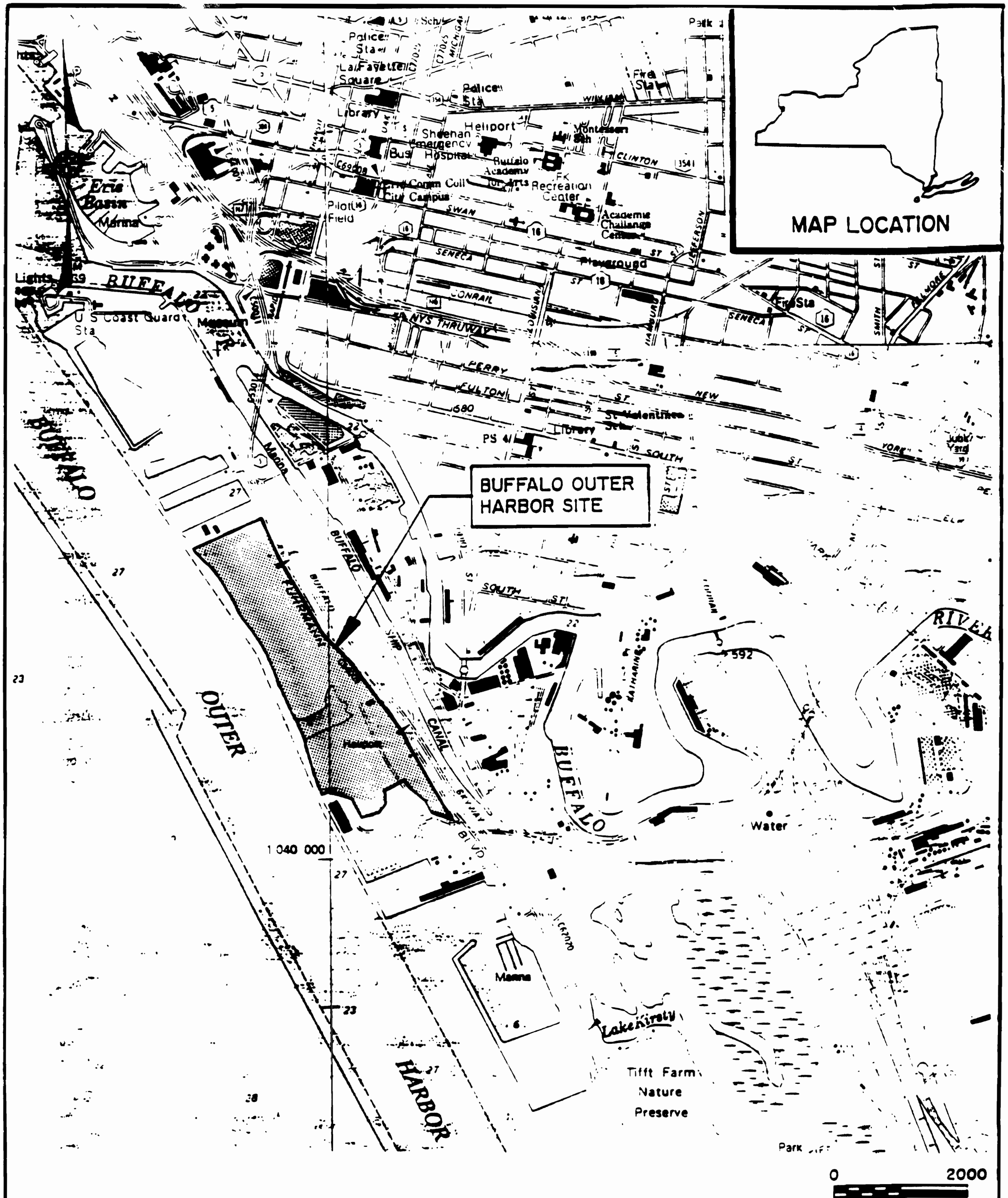
The degree of remediation required to protect human health and the environment at the Buffalo Outer Harbor Site is a function of the current and future use of the site. Use of the site will define potential receptors, possible contaminant migration pathways, and the frequency and intensity of exposures that may occur as a result of contact with existing or residual contamination remaining on the site, which in turn affects the remedy chosen. For example, potential receptors who are presently or will be in the future exposed to contamination at the site may comprise children, the elderly, adult residents, adult workers, etc. and the routes of exposure may be vapors, dust, dermal contact with soil, surface runoff, etc.

This feasibility study addresses the general requirements of the guidance documents for preparation of a feasibility study, while at the same time focuses the study to consider future potential uses of the site, and cost-effective and cost-beneficial remedial measures that will be compatible with and support site development and improvement.

1.2 Site Background

The Remedial Investigation was performed for the entire 113-acre Buffalo Outer Harbor Site which is located approximately 1 mile south of downtown Buffalo, and is bordered on the west by the Buffalo Outer Harbor line (see Figure 1-1). The Buffalo Ship Canal and the Buffalo River are located approximately 500 feet and 2,000 feet to the east of the site, respectively.

The Buffalo Outer Harbor Site is the result of filling activities which occurred over the past 100 years. Fill materials, including incinerator ash, casting sands, blast furnace slag, dredged lake spoils, and miscellaneous construction and demolition debris comprising concrete, brick, wood,



SOURCE: N.Y.S.D.O.T. BUFFALO, N.Y. QUADRANGLE

BUFFALO OUTER HARBOR
BUFFALO, NEW YORK

Dvirka and Bartilucci CONSULTING ENGINEERS

SITE LOCATION MAP

FIGURE 1 - 1

Site Location Map glass and plastics, have been disposed at the site. The majority of the site, which was most recently utilized as a port facility for receipt of dry bulk materials, such as gypsum, sand, salt, iron pellets, coke and possibly coal, is currently vacant except for the Allen Boat Company which operates a boat yard in the center of the site adjacent to the Bell Slip (see Figure 1-2). The Bell Slip provides access to the Allen Boat Company from the Buffalo Outer Harbor.

The site is currently owned by the Niagara Frontier Transportation Authority (NFTA).

The eastern and southern boundaries of the Buffalo Outer Harbor Site are fenced. Access to the site is from Fuhrmann Boulevard. One access road enters the site just north of Allen Boat Company and a second access road is located to the north of the site connecting The Pier restaurant with Fuhrmann Boulevard. The third access road enters the site south of the Allen Boat Company and passes through a continually operated guard booth used for controlling access to the Port Terminal Building. The Euro Unlimited Corporation currently occupies the NFTA Port Terminal A building.

The Buffalo Outer Harbor Site is characterized by relatively flat topography and is predominantly vacant. The only on-site structures include the Allen Boat Company and a small metal building which was a former scale house. Gravel parking areas associated with The Pier restaurant are located at the north end of the site. An asphalt/gravel road traverses the site north-south. Three other asphalt areas are on the site, these being: north of the Allen Boat Company; the former heliport located south of the Allen Boat Company; and directly south of the main entrance gate on the southern portion of the site. Major surface features have been delineated and are shown on a surface features map (see Figure 1-3).

Vegetation is varied over the site and consists predominantly of weeds and grasses with some localized areas of cattail growth and a few trees. There are areas which have stressed or limited vegetation. These are notably associated with the former bulk material storage areas on the northern portion of the site.

Figure 1-2

Site Plan

Figure 1-3

Surficial Features Map

Portions of the site have distinct areas of debris disposal consisting of piles of trash (desks, chairs, household garbage, tires, etc.), asphalt, soil from off-site excavation, and construction and demolition debris. The entire Buffalo Outer Harbor Site shoreline, from the end of the bulkhead north of Terminal B, along the Bell Slip and north to The Pier restaurant, is lined with concrete, asphalt, lumber and reinforced steel. Several large rubble piles of construction and demolition debris are located south of the Bell Slip and west of the north-south road. A dirt road running north-south in this area is lined with wooden pallets, concrete and asphalt debris, timber and construction debris. Evidence of former bulk material storage on-site was identified over a large area which was confirmed through the review of historical aerial photographs. Iron ore pellets, sand and coke were identified on the surface of the site.

1.3 Remedial Investigation Results

Area North of the Bell Slip

As shown on Figure 1-4, the area north of the Bell Slip has be subdivided into three subareas comprising the areas east and west of the asphalt roadway, and a portion of the gravel parking area near The Pier restaurant. The boundaries of the area east of the asphalt roadway are dictated by what is approximated to be limits of the former Fuhrmann Boulevard Landfill. The following presents a discussion of the findings for each of the subareas.

West of the Asphalt Road

The area west of the asphalt road has been characterized as an area filled with primarily dredged sediment from the Buffalo Outer Harbor. Only a few surface soil samples (0 to 6 inches) from this area (4 out of 34) indicated the presence of slightly elevated levels of contaminants, such as carcinogenic polycyclic aromatic hydrocarbons (CaPAHs) and metals, including lead and zinc, and only a few shallow subsurface soil samples (6 out of 19 collected from 2 to 8 feet) exceeded the screening criteria for CaPAHs and metals. One half of the deep subsurface soil samples (10 out of 20 collected from 8 to 20 feet below ground surface) exhibited elevated levels

Figure 1-4

Investigation Areas

of contaminants such as CaPAHs and metals, including lead and zinc. EP Toxicity (EPTOX) and toxicity characteristic leaching procedure (TCLP) analyses conducted for three soil samples collected from the deep subsurface (8 to 20 feet) in this area did not indicate the presence of levels above regulatory limits for characterization as a hazardous waste. As a result of these findings, the surface and subsurface soils in this area can be characterized as nonhazardous and not significantly contaminated and, under current site conditions, do not pose a significant threat to human health or the environment.

East of the Asphalt Road

Similar to the area west of the asphalt road, only a few samples (4 out of 23) collected from the surface soil in this area exceeded the screening criteria. Based on these results, the surface soil in this portion of the site is not significantly contaminated. However, elevated levels of CaPAHs and metals, including lead, zinc, copper, arsenic and chromium, were detected in a fairly high number (20 out of 30) of subsurface soil samples collected in this area from depths between 2 and 22 feet. During sampling conducted as part of a Phase II Site Assessment in 1991, a subsurface soil sample collected from this area exceeded the regulatory levels for EPTOX lead. Confirmatory sampling conducted in this area during the remedial investigation indicated the presence of TCLP lead levels greater than the regulatory limits. The elevated levels of these contaminants are likely attributable to incinerator ash disposed at the former Fuhrmann Boulevard Landfill located in this area. Although hazardous waste disposal has been documented in this area, under current site conditions, this area does not pose a significant threat to human health or the environment.

Eastern Portion of the Gravel Parking Area of The Pier Restaurant

Elevated levels of metals, CaPAHs and polychlorinated biphenyls (PCBs) were detected in 8 out of 14 surface soil samples collected in this area. The source of the elevated levels of these contaminants has not been identified, however, waste disposal at the former Fuhrmann Boulevard Landfill could be a source of contamination. The area exhibiting elevated levels of contaminants appears to be limited to the area not covered by gravel from the parking area. Significantly elevated levels of lead (14,000 mg/kg) and zinc (29,800 mg/kg) were detected in one sample adjacent to the eastern fence line. This sample was collected from a small area of stained soil behind the former scale house. These elevated levels are possibly the result of recent disposal as evidenced by open cans of oil in the area of stained soil. Under current site conditions, the area is utilized for a secondary parking area primarily utilized during summer months. The area is not fenced, however, except during peak summer use, this area would likely not be accessed. Based on information obtained from the Phase I investigation, subsurface soil quality in this area appears to be consistent with that detected in the area east of the asphalt roadway, that is, it is likely associated with the former Fuhrmann Boulevard Landfill. Levels of lead up to 2,400 mg/kg have been detected in the shallow subsurface in this area. Based upon the results of the TCLP analysis performed on subsurface soil in the former Fuhrmann Boulevard landfill, it is possible that characteristically hazardous waste is also present in the subsurface soil in this area. Due to the elevated levels of contaminants detected in the surface soil, under current site conditions, this area could pose a potential threat to human health or the environment, if accessed.

Area South of the Bell Slip

The area south of the Bell Slip has been divided into two separate sections, the Radio Tower Area and the remaining area excluding the Radio Tower Area (see Figure 1-4). The following discussion provides the findings for each of these areas.

Radio Tower Area

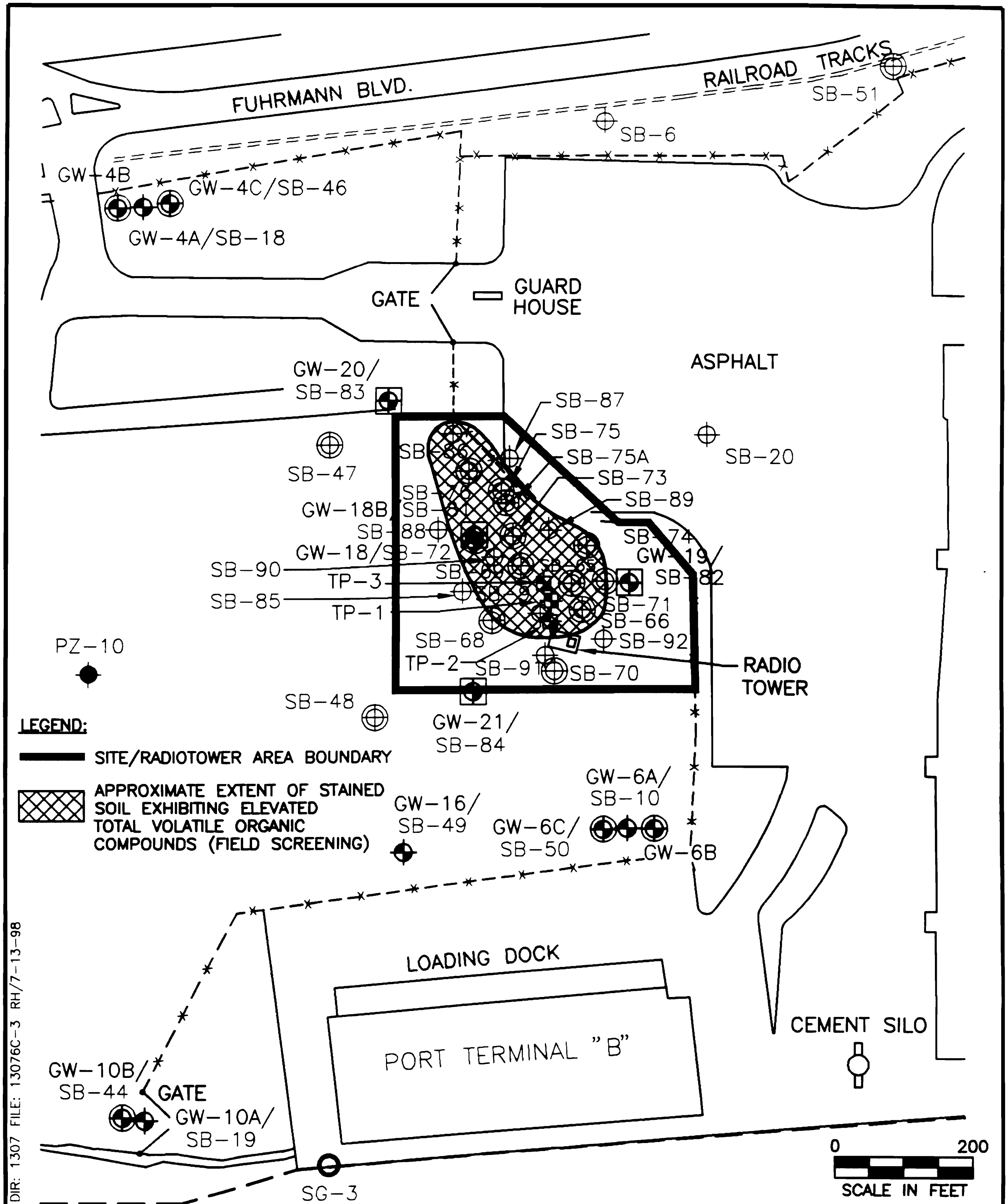
Based on samples collected from this area, significantly elevated levels of contaminants have been detected in the surface soil, subsurface soil and groundwater. The toxic nature and extremely elevated levels of nitrobenzene (as high as 13,000 mg/kg) and antimony (as high as 5,470 mg/kg) detected in the subsurface soil between 4 and 22 feet below ground surface, and the levels of 4-chloroaniline (as high as 3,600 ug/l) detected in the groundwater warrant specific consideration. Based on TCLP results, these contaminated subsurface soils are a characteristic hazardous waste.

Although elevated levels of semivolatile organic compounds (SVOCs) and volatile organic compounds (VOCs) have been detected in the groundwater, the contamination does not appear to be readily migrating toward the Outer Harbor, and therefore, not impacting the Outer Harbor at the present time. However, it is possible that contamination could migrate to the Outer Harbor with time, and therefore, poses a potential significant threat, in particular to the environment.

Similar to the remaining areas of the property, surface soil and shallow subsurface soil (between 0 and 10 feet) samples collected from this area exhibited elevated levels of CaPAHs, PCBs and metals. As defined in Figure 1-4, the limits of the Radio Tower Area are delineated based primarily on elevated levels of contaminants, such as PCBs and metals in the surface soil. As shown on Figure 1-5, the subsurface nitrobenzene contamination was only detected in a portion of the area defined as the Radio Tower Area. Further discussion with regard to remediation of this area will focus on remediation of the nitrobenzene contaminated subsurface soils.

Remaining Area South of the Bell Slip

Elevated levels of CaPAHs and metals, including arsenic, lead and zinc, were detected in about one-half of the surface soil samples (20 out of 43) and subsurface soil samples (14 out of 25) collected in this area. One surface soil sample exhibited the presence of arsenic of 1,301 mg/kg. This sample was a composite sample collected from the extreme southern portion of the site along the railroad spur (see Figure 1-4). The levels of arsenic may be the result of herbicide application in this area. Due to the elevated levels and potential for exposure further investigation may be warranted in this area. The majority of the subsurface in this area has been characterized as containing a substantial amount of construction and demolition debris, and sediment from the dredging of the Buffalo Outer Harbor. A portion of this area also contains industrial fill material. Historical and recent analysis of soil samples collected from this



BUFFALO OUTER HARBOR
FEASIBILITY STUDY

RADIO TOWER AREA

Dvirka and Bartilucci
Consulting Engineers
A Division of William F. Cosulich Associates, P.C.

FIGURE 1-5

industrial fill material has exhibited the presence of elevated levels of metals, including arsenic (up to 35.7 mg/kg), lead (up to 2200 mg/kg) and zinc (up to 2500 mg/kg). One sample was collected for EPTOX lead and the level detected did not exceed the regulatory limit for characterization as a hazardous waste. However, the total lead level in this sample was only 586 mg/kg. Although elevated levels of metals and CaPAHs have been detected in the surface and subsurface soils in this area, under current site conditions, this area does not pose a significant threat to human health or the environment.

Groundwater

Based upon the results of groundwater sampling conducted during the remedial investigation, excluding groundwater in the Radio Tower Area, it does not appear that groundwater at the site is significantly contaminated. Low levels of metals and PAHs just above the Class GA groundwater standards/guidelines were detected in a number of the wells on-site; however, the contamination appears to be localized in extent and does not appear to be impacting surface water or sediment quality in the Outer Harbor. The elevated levels of sodium, manganese, magnesium and iron may be attributed to waste disposal at the former Fuhrmann Boulevard Landfill, bulk storage activities that occurred on-site, such as storage of iron ore pellets, or general groundwater quality in the vicinity of the site.

In addition, water for the City of Buffalo is supplied by a water intake in Lake Erie located 8,000 feet northwest of the site. There is no known use of private wells for potable water supply in the vicinity of the site and, therefore, the limited groundwater contamination from the site will not impact public water supply.

The results of the groundwater samples collected from the Radio Tower Area indicate the presence of significantly elevated levels of 4-chloroaniline, and other semivolatile and volatile organic contaminants, as well as antimony in one shallow well in this area. Downgradient wells currently do not indicate the presence of elevated levels of these contaminants, and therefore, it does not appear that groundwater contamination is migrating towards the Outer Harbor at the present time, and impacting surface water and sediment. However, the intermediate well installed in the native overburden in this area showed the presence of elevated levels of 4-chloroaniline and benzene, which indicates a downward migration of contamination. Although contaminated groundwater in the Radio Tower Area does not pose a threat to water and sediment quality in the Outer Harbor at the present time, based on groundwater flow towards the Bell Slip and Outer Harbor, there is the potential for this contamination to migrate to the Outer Harbor in the future.

Surface Water

The results of the samples collected from the Outer Harbor, Bell Slip and Michigan Avenue Slip do not indicate that surface water in the vicinity of the Buffalo Outer Harbor Site is being impacted by contaminants associated with the site. Only three metals (aluminum, selenium and silver) were detected above the surface water standards. These metals were not detected at elevated levels on the Buffalo Outer Harbor Site and, therefore, are not attributed to site contamination.

Surface Water Sediment

Elevated levels of zinc were detected in two of the three sediment samples collected from the Bell Slip. These levels may be attributed to runoff from the site and/or activities at the Allen Boat Company. Elevated levels of pesticides were detected in nearly all of the sediment samples collected in the Outer Harbor and the Michigan and Bell Slips, including the background sample collected at the entrance at the breakwater. However, pesticides were not detected in elevated levels at the site. As a result, the pesticide contamination in the sediments is attributable to off-site sources.

1.4 Risk Assessment Results

The Qualitative Health Risk Assessment dated December 1995, prepared for the 113 acre Buffalo Outer Harbor Site evaluated chemicals of concern and the affected media with respect to potential exposure pathways and receptors for the site. The potential pathways for exposure of humans and biota to contaminants from the Buffalo Outer Harbor Site include the following:

- Ingestion of contaminated soil containing dissolved or particulate-bound contaminants;
- Inhalation of vapors or airborne particulate-bound contaminants;
- Dermal absorption of contaminants via direct contact with waste, contaminated soil and groundwater; and
- Direct contact with contaminated runoff.

Potential human receptors in the area of the site include on-site workers, individuals accessing the site for fishing, recreation or other purposes, and off-site individuals in the vicinity of the site. The Risk Assessment evaluated each of the areas of the site individually. A summary of the conclusions of the assessment for each of the areas is provided below.

<u>Radio Tower Area</u>

Under the current site conditions, chemicals of concern detected in the subsurface soil and groundwater pose a low risk to humans or wildlife due to low potential for exposure. Although no current known uses of groundwater exist in the site area, remediation of the contaminated soils in the Radio Tower Area should be considered to mitigate this source of groundwater contamination. If future land use considerations will increase human utilization of other areas of the site, access to this area may be restricted, or containment or treatment measures may be undertaken to limit potential exposure. In addition, before commencing any excavation or other activities which may cause exposure to subsurface soil or groundwater from this area, involved parties should be informed of the appropriate safety precautions and personal protection requirements.

Remaining Area South of the Bell Slip

Small sections of elevated CaPAH concentrations in surface soil are distributed throughout the Area South of the Bell Slip. The frequency of human exposure is expected to be higher in this area (when compared to other areas of the site) due to the nearby location of the Allen Boat Company and the access to the Bell Slip for fishing. Due to the carcinogenicity of these compounds and the potential increase in frequency of human exposure through expanded use of the Allen Boat Company or for recreational use of the Bell Slip, these soils should be considered for remediation or access restriction under future use. Surface soils on the southern most portion of the Remaining Area South of the Bell Slip adjacent to Fuhrmann Boulevard, which contained elevated arsenic concentrations, should also be considered for remediation due to the proximity to Fuhrmann Boulevard and the high potential for human exposure.

Under the current site conditions of limited potential for human or wildlife exposure to the subsurface soils or groundwater, chemicals detected in these media do not warrant remediation. Excavation or construction activities in this area should be conducted using appropriate precautions to limit exposure to the chemicals of concern.

Area East of the Asphalt Road

Only one surface soil sample exhibited the presence of elevated levels of CaPAHs in this area. This area of the property is covered with well-tended low grassland, with little or no exposed soil or debris. Health risks are low due to the relatively low concentration and limited extent of chemicals of concern in the area, and the low potential for direct human contact with the surface soils.

Due to the limited potential for human or wildlife exposure to subsurface soils or groundwater, chemicals detected in this area do not warrant remediation under current conditions. However, modification of current site conditions including excavation or construction activities should be conducted using appropriate precautions to limit exposure to chemicals of concern.

Area West of the Asphalt Road

Three localized areas of elevated CaPAH concentrations in surface soil were found in the Area West of the Asphalt Road. Wind erosion and vehicular traffic may cause air transport of soil and dust particles, and therefore, there is the potential for inhalation and/or ingestion of these particles by individuals and wildlife. Direct contact with these soils is also possible for individuals that access this area of the property for parking or recreation. Due to the carcinogenicity of these compounds and the potential increase of frequency of human exposure should the property be developed, these soils should be considered for remediation. CaPAHs were detected in several shallow subsurface samples, but these locations do not appear to correlate with CaPAHs found in surface soils.

Under the current conditions of limited potential for human or wildlife exposure to subsurface soils or groundwater, chemicals detected in this area do not warrant remediation. Again, excavation or construction activities in this area should be conducted using appropriate precautions to limit exposure to the chemicals of concern.

Eastern Portion of the Gravel Parking Area of The Pier Restaurant

Wind erosion and vehicular traffic can cause air transport of soil and dust particles in this area, and therefore, the potential inhalation and/or ingestion of these particles by individuals and wildlife. Potential also exists for direct contact by individuals who access this area of the property for parking or recreation.

PCBs, lead, arsenic, and CaPAHs were detected at elevated levels in these surface soils. The potential for human exposure to these chemicals is high under current and future use scenarios. Therefore, measures should be taken to remediate or restrict access to the surface soil in this area under current and future use scenarios.

Sediments

The potential exposure to lead and CaPAHs in sediments in the Bell Slip area may present a health risk to humans and wildlife. The prevalence of these chemicals in other areas of the Bell Slip and on the shoreline is unknown due to limited sampling. Since dermal exposure as well as ingestion and inhalation of lead and CaPAHs may produce toxic effects, recreational uses (e.g., beach and swimming area) in the Bell Slip area are not recommended. Remediation of surface soils containing lead and CaPAHs may remove the source of these chemicals in sediments. Because sediments containing chemicals of concern were found in the Bell Slip area, the Allen Boat Company operations may be a source of these chemicals.

A more detailed discussion is provided in the Qualitative Risk Assessment Report.

1.5 Remedial Action Objectives

Remedial action objectives are goals developed for the protection of human health and the environment. Definition of these objectives require an assessment of the contaminants and media of concern, exposure routes and receptors, and the remediation goals for each respective exposure route. The remedial action objectives for this site allow for the development of alternatives that would achieve cleanup levels associated with the reasonably anticipated future land use for as much of the site as possible.

The remedial action objectives developed for the Buffalo Outer Harbor Site, based upon existing information, are as follows:

1. Prevent or reduce, to the extent possible, the potential for direct contact exposure (dermal absorption, inhalation and incidental ingestion) with contaminated surface soils and subsurface soils.
2. Prevent or reduce, to the extent possible, the potential for surface runoff from surficially contaminated portions of the site to transport contaminated soils to adjacent surface water.

3. Reduce, to the extent possible, precipitation from infiltrating through contaminated soils and adversely impacting groundwater (Radio Tower Area only).
4. Prevent, to the extent possible, migration of contaminated groundwater to surface water (Radio Tower Area only).

The above objectives are presented in Table 1-1, along with the potential exposure pathways.

In addition, standards, criteria and guidelines (SCGs) are to be considered when formulating, screening and evaluating remedial alternatives. SCGs may be categorized as contaminant-specific, location-specific or action-specific. Federal statutes, regulations and programs may apply to the site where New York State standards do not exist. A summary of preliminary SCGs for the Buffalo Outer Harbor Site is presented in Table 1-2.

Several of the contaminant-specific SCGs listed in Table 1-2 do not apply to soil contamination. Preliminary chemical specific soil and groundwater standards, criteria and guidelines for the Buffalo Outer Harbor Site include proposed screening criteria utilized during the Phase I/Phase II RI to define soil contaminants of concern and New York State Class GA Groundwater Standards and Guidance Values. The soil screening levels for the contaminants of concern have been identified based upon review of applicable guidance documents, such as NYSDEC Technical and Administrative Guidance Memorandum (TAGM): Determination of Soil Cleanup Objectives and Cleanup Levels (January 1994); screening and cleanup levels utilized for various Superfund sites located in New York State with similar contaminants of concern, discussions with NYSDEC and New York State Department of Health (NYSDOH), and screening/cleanup levels developed and used by other states, including Massachusetts and

Table 1-1

REMEDIAL ACTION OBJECTIVES FOR THE BUFFALO OUTER HARBOR SITE

Exposure Pathways	Environmental Media	Remedial Action Objectives
1. Ingestion of contaminated soil	Soil	Reduce exposure or contaminant concentrations to levels approved by NYSDEC/NYSDOH
2. Dermal absorption of contaminants via waste and contaminated soil	Soil	Reduce exposure or contaminant concentrations to levels approved by NYSDEC/NYSDOH
3. Inhalation of fugitive dust or vapors from contaminated soil	Air	Reduce exposure or contaminant concentrations to levels that comply with NYSDEC ambient air guidelines
4. Dermal contact with contaminated groundwater and contamination of biota	Groundwater	Reduce migration of contaminated groundwater to surface water
5. Dermal contact with contaminated runoff	Soil	Reduce contact between precipitation and contaminated soil

Table 1-2

STANDARDS, CRITERIA AND GUIDELINES FOR THE BUFFALO OUTER HARBOR SITE

Statute, Regulation or Program	Applicability	Category
NYSDEC Ambient Water Quality Standards and Guidance Values (TOGS 1.1.1)	Applicable to all sources of groundwater and surface water.	Action-specific; Contaminant-specific; Location-specific
Water Quality Standards for Groundwater (6 NYCRR Part 703.1)	Applicable to all sources of groundwater	Action-specific; Contaminant-specific; Location-specific
NYSDEC Air Guide-1 (New York State Air Guidelines for the Control of Toxic Ambient Air contaminants)	Applicable where remedial activities will impact ambient air quality	Action-specific; Contaminant-specific
Clean Air Act	Applicable where remedial activities will impact ambient air quality	Action-specific; Contaminant-specific
National Primary and Secondary Ambient Air Quality Standards	Applicable where remedial activities will impact ambient air quality	Action-specific; Contaminant-specific
NYSDEC Fugitive Dust Suppression and Particulate Monitoring Program at Inactive Hazardous Waste Sites (TAGM 89-4031)	Applicable where remedial activities will impact ambient air quality	Action-specific
NYSDEC Hazardous Waste Treatment Storage and Disposal Facility Permitting Requirements (6NYCRR Part 373-1)	Applicable to potential treatment, storage and disposal of hazardous wastes	Action-specific; Contaminant-specific
NYSDEC Land Disposal Restrictions (6 NYCRR Part 376)	Applicable to disposal of hazardous wastes	Action-specific; Contaminant-specific
United States Environmental Protection Agency (USEPA) Land Disposal Restrictions (40 CFR Part 268)	Applicable to disposal of hazardous wastes	Action-specific; Contaminant-specific

Table 1-2 (continued)

STANDARDS, CRITERIA AND GUIDELINES FOR THE BUFFALO OUTER HARBOR SITE

Statute, Regulation or Program	Applicability	Category
Occupational Safety and Health Administration (OSHA) Regulations (29 CFR 1900-1999)	Applicable to workers and work place throughout implementation of investigation activities and remedial actions	Action-specific; Contaminant-specific; Location-specific
Hazardous Materials Transportation (49 CFR 170-189)	Applicable to off-site transport of hazardous materials	Action-specific
New York State Uniform Procedures Act	Applicable to projects requiring a State Pollutant Discharge Elimination System permit	Action-specific; Contaminant-specific
New York Water Classifications and Quality Standards (6NYCRR Parts 609; 700-704)	Applicable to alternatives that generate water requiring discharge to a surface water	Action-specific; Contaminant-specific
New York Regulations on State Pollution Discharge Elimination System (SPDES) (6NYCRR Parts 750-758)	Applicable to alternatives that generate water requiring discharge to surface water	Action-specific; Contaminant-specific
Clean Water Act	Applicable for alternatives that generate water residuals requiring treatment with point-source discharges to surface water	Action-specific; Contaminant-specific
Toxic Pollutant Effluent Standards	Applicable to alternatives that generate water residuals containing toxic pollutants that are discharged into navigable water	Action-specific; Contaminant-specific

Table 1-2 (continued)

STANDARDS, CRITERIA AND GUIDELINES FOR THE BUFFALO OUTER HARBOR SITE

Statute, Regulation or Program	Applicability	Category
Wetland Executive Order - Executive Order No. 11990	Potentially applicable to small area south of the Bell Slip designated as a small intermittent ponded water wetland according to National Wetlands Inventory Mapping	Location-specific
Executive Order on Floodplain Management (Executive Order No. 11988 40 CFRs 6.302[b] and Appendix A)	Potentially applicable to remediate actions that would include the development of a floodplain	Location-specific
Floodplain Management Regulation-Development Permits 6NYCRR 500	Potentially applicable to remedial actions that are conducted within floodplain areas	Location-specific

New Jersey. The following levels were utilized as screening criteria for the Buffalo Outer Harbor Site in the Phase I/Phase II Remedial Investigation Report:

- Surface Soil/Subsurface Soil

Total VOCs	10 mg/kg
Total SVOCs	500 mg/kg
Total PAHs	100 mg/kg
Total Carcinogenic PAHs	10 mg/kg
Total PCBs (Surface)	1 mg/kg
Total PCBs (Subsurface)	10 mg/kg
Nitrobenzene	1 mg/kg
Antimony	20 mg/kg
Arsenic	20 mg/kg
Cadmium	10 mg/kg
Copper	200 mg/kg
Chromium	100 mg/kg
Lead	500 mg/kg
Mercury	10 mg/kg
Nickel	40 mg/kg
Zinc	500 mg/kg

- Groundwater - NYSDEC Class GA groundwater standards and guidance values.

Upon completion of the Phase I/II RI further evaluation of the SCG developed for nitrobenzene was completed. The United States Environmental Protection Agency (USEPA) Region III has developed Risk Based Concentrations for contaminants for residential use. The level developed for nitrobenzene for contaminants for residential use in their April 1998 document is 17 mg/kg. USEPA RCRA Land Ban requires that nitrobenzene be reduced to 14 mg/kg prior to disposal in a landfill. Therefore, it was determined that the remediation criteria for nitrobenzene be revised from 1 mg/kg to 14 mg/kg.

As discussed above, applicable action and location-specific SCGs are listed in Table 1-2.

The remedial action alternative selected for the Radio Tower Area, as a goal, is required to attain all SCGs for the site. Under certain conditions, compliance with the SCGs may be waived. These conditions include the following:

- The selected remedial action is an interim remedy or a portion of a total remedy which will attain the SCGs upon completion;
- Compliance with such requirements could result in greater risk to human health and the environment than alternate options;
- Compliance with such requirements is technically impracticable from an engineering perspective;
- The selected remedial action will attain an equivalent standard of performance;
- The requirement has been promulgated by the State, but has not been consistently applied in similar circumstances; or
- Compliance with the SCGs will not provide a balance between protection of human health and the environment at the site with the availability of funds for response at other sites.

1.6 Feasibility Study Description

The Technical and Administrative Guidance Memorandum (TAGM) prepared by NYSDEC entitled "Selection of Remedial Actions at Inactive Hazardous Waste Sites" (NYSDEC document HWR-90-4030, May 15, 1990 Revision) describes the feasibility study (FS) as a process to identify and screen potentially applicable remedial technologies, combine technologies into alternatives and evaluate appropriate alternatives in detail, and select an appropriate remedial action plan. The objective of this feasibility study is to meet the goal of the guidance document, while at the same time, develop alternatives that will consider potential future land uses and development of the site.

The approach of a feasibility study is to initially develop remedial action objectives for medium-specific or operable unit-specific goals to protect human health and the environment. The goals consider the contaminants and contaminant concentrations (as determined by the remedial investigation), the exposure routes and potential receptors (as determined by the qualitative risk assessment), and the acceptable contaminant or risk levels or range of levels.

Technologies which are not technically applicable to contamination found in the areas within the Buffalo Outer Harbor Site, or are unproven and/or are not commercially available, will be eliminated from consideration. Screening of alternatives will consider effectiveness, implementability, relative costs and potential future land use as discussed below. The technologies remaining after initial screening will be assembled into remedial alternatives for detailed evaluation.

Screening of technologies includes a preliminary evaluation of effectiveness and implementability in accordance with NYSDEC criteria. Effectiveness evaluation includes consideration of the following:

1. The potential effectiveness of process options in handling the estimated areas or volumes of contaminated media, and meeting the remediation goals identified by the remedial action objectives.
2. The potential impacts to human health and the environment during the construction and implementation phase.
3. The proven effectiveness and reliability of the process with respect to the contaminants and conditions at the site.

Implementability includes both the technical and administrative feasibility of utilizing the technology or alternative. Administrative feasibility considers institutional factors such as the ability to obtain necessary permits for on-site or off-site actions, and the ability to restrict land use based on specific remediation measures. Technical feasibility considers such aspects as the ability to comply with SCGs, the availability and capacity of treatment, storage and disposal facilities, the availability of equipment and skilled labor to implement the technology, the ability to design, construct and operate the alternative, and acceptability to the regulatory agencies and the public. Costs, except for relative costs, are not considered at this stage of the feasibility study process and are instead included in the detailed evaluation of alternatives.

The results of the screening process includes a list of potentially viable technologies and/or development of alternatives for the site which will be carried forward for detailed evaluation.

The guidance requires that a feasibility study provide an analysis of the potential remedial alternatives based upon consideration of the following nine evaluation criteria for each alternative. The seven criteria are as follows:

- Threshold Criteria
  - Compliance with applicable regulatory standards, criteria and guidelines
  - Protection of human health and the environment
- Balancing Criteria
  - Short-term impacts and effectiveness
  - Long-term effectiveness and permanence
  - Reduction in toxicity, mobility and/or volume of contamination
  - Implementability
  - Cost

In addition to the seven above listed Threshold and Balancing Criteria, the guidance also presents the following modifying criteria:

- State acceptance
- Community acceptance

Qualitative and quantitative factors, which form the basis for evaluating each criteria, were developed from questions provided in the TAGM score sheet prepared by NYSDEC for this purpose. Although the score sheet and associated scoring system are not utilized per se in this document, the evaluation factors presented in the TAGM are fully considered for each criteria and are discussed individually in Sections 2.0 and 3.0 of this document.

Applicable federal and New York State SCGs are identified for this site to provide both action-specific guidelines for remedial work at the site and contaminant-specific cleanup standards for the alternatives under evaluation. In addition to action-specific and contaminant-specific guidelines, there are also location-specific guidelines that pertain to such issues as restrictions on actions at historic sites. These guidelines and standards are described in detail in Section 1.5 of this document and are considered a minimum performance specification for each remedial action alternative under consideration.

Protection of human health and the environment is evaluated on the basis of estimated reductions in both human and environmental exposure to contaminants for each remedial action alternative. The evaluation focuses on whether a specific alternative achieves adequate protection, and how site risks are eliminated, reduced or controlled through treatment, engineering or institutional controls. An integral part of this evaluation is an assessment of long-term residual risks to be expected after remediation has been completed. Evaluation of the human health and environmental protection factor is generally based, in part, on the findings of a site-specific risk assessment. The risk assessment performed for this site incorporates the qualitative estimation of the risk posed by carcinogenic and noncarcinogenic contaminants detected during the remedial investigation. The results of the risk assessment performed for this site are presented in a separate document.

Evaluation of short-term impacts and effectiveness of each alternative examines health and environmental risks likely to exist during the implementation of a particular remedial action. Principal factors for consideration include the expediency with which a particular alternative can be completed, potential impacts on the nearby community and on-site workers, and mitigation measures for short-term risks required by a given alternative during the necessary implementation period.

Examination of long-term impacts and effectiveness for each alternative requires an estimation of the degree of permanence afforded by each alternative. To this end, the anticipated service life of each alternative must be estimated, together with the estimated quantity and characterization of residual contamination remaining on-site at the end of this service life. The magnitude of residual risks must also be considered in terms of the amount and concentrations of contaminants remaining following implementation of a remedial action, considering the persistence, toxicity and mobility of these contaminants, and their propensity to bioaccumulate.

Reduction in toxicity, mobility and volume of contaminants is evaluated on the basis of the estimated quantity of contamination treated or destroyed, together with the estimated quantity of waste materials produced by the treatment process itself. Furthermore, this evaluation considers whether a particular alternative will achieve the irreversible destruction of contaminants, treatment of the contaminants or merely remove of contaminants for disposal elsewhere.

Evaluation of implementability examines the difficulty associated with the installation and/or operation of each alternative on-site and the proven or perceived reliability with which an alternative can achieve system performance goals (primarily the SCGs discussed above). The evaluation must examine the potential need for future remedial action, the level of oversight required by regulatory agencies, the availability of certain technology resources required by each alternative and community acceptance of the alternative.

Cost evaluations presented in this document estimate the capital, and operation and maintenance (O&M) costs, including monitoring, associated with each remedial action alternative. From these estimates, a total present worth for each option is determined.

Regulatory agency and community acceptance evaluates the technical and administrative issues and concerns which the agencies or the community may have regarding each of the alternatives.

1.7 Approach to Feasibility Study

As discussed above, the majority of the Buffalo Outer Harbor Site, excluding the Radio Tower Area, is not highly contaminated and therefore, the site boundaries have been redefined.

Under current conditions and use, the remaining areas of the property do not pose a significant threat to human health or the environment.

The Radio Tower Area is an area of significant and separate concern. Due to very high levels of contamination in this area of the site and potential for migration of contaminated groundwater to the Outer Harbor, the Radio Tower Area requires remediation.

Although a majority of the property is no longer part of the Buffalo Outer Harbor site, this feasibility addresses not only the Radio Tower Area but the remaining areas of the property as well. Because of the significantly elevated levels and hazardous nature of contamination found in the Radio Tower Area, alternatives for remediation of contaminated soil and groundwater in this area will be developed and evaluated consistent with standard feasibility studies. Remedial technologies will be identified and screened, alternatives will be developed and evaluated, and a preferred alternative will be selected. The process for the Radio Tower Area will consider future development of this area for productive use, however, remediation of the high levels of contamination may require selection of remedial alternatives that will limit, and possibly preclude future use of this area.

For the Remaining Areas of the property, since levels of contamination do not pose a significant threat to human health or the environment under current conditions, remedial measures will not be necessary under present use.

As identified in the Risk Assessment, if future land use changes and exposure to the remaining contamination increases, remedial measures may need to be implemented to ensure protection of human health and the environment. Discussion of potential future land use and appropriate remedial measures as a function of land use for the Remaining Area of the property are discussed in Section 2.0.

Due to the low levels of groundwater contamination in the Remaining Areas of the property and no apparent present or anticipated impacts to the Buffalo Outer Harbor due to groundwater contaminant loadings, exclusive of the Radio Tower Area, groundwater remediation will not be evaluated as part of this feasibility study for these areas of the site. Rather, remediation will address soil contamination based on potential site use.

Although the highly contaminated groundwater in the Radio Tower Area, currently, does not appear to be migrating towards or impacting the Outer Harbor, because of the potential for future migration and adverse impact on the surface water and sediment, groundwater remediation in this area will be addressed in the feasibility study. Additionally, as part of any soil removal actions considered for the Radio Tower Area, groundwater treatment may be required during dewatering activities.

Although elevated levels of contaminants were detected in the surface water sediments in the Outer Harbor and Michigan Avenue Slip, the contaminants detected are not readily attributable to on-site contamination. Elevated levels of zinc and lead detected in the sediment in the Bell Slip may be attributable to activities at the Allen Boat Company. These levels do not appear to be impacting human health or the environment under current use and, therefore, surface water and sediment will not be addressed as part of site remediation as long as the Bell Slip is continued to be utilized for its current purpose, that is, noncontact recreation.

2.0 REMEDIAL PLAN FOR THE REMAINING AREAS OF PROPERTY FOR FUTURE SITE USE

The plan for the Remaining Areas of the property will include the identification of remedial measures appropriate for the areas east of the asphalt road, eastern gravel parking area and the remaining area south of the Bell Slip, excluding the Radio Tower Area for future land uses. As discussed in Section 1.0, these areas have been characterized as containing sporadic elevated levels of carcinogenic polycyclic aromatic hydrocarbons (CaPAHs), polychlorinated biphenyls (PCBs) and metals in the surface soil, and more significantly elevated levels of metals and CaPAHs in the subsurface soil in a few areas, such as the former Fuhrmann Boulevard Landfill. Again, although under its current use, these areas of the property are not posing a significant threat to human health and the environment, future use of these areas may increase exposure to contaminants in these areas and, therefore, require remediation. The following sections provide a discussion of the identification of the appropriate remedial measures for the remaining areas of the property under future land use.

2.1 Future Land Use

As discussed in the Remedial Investigation Report prepared for the 113-acre Buffalo Outer Harbor site, the future use of the Buffalo Outer Harbor property is being considered by several public and private entities, but no one specific plan has been selected for implementation. The property has the potential to be developed for several different types of land use including residential, recreational and/or commercial/ industrial. Each land use will dictate the degree of remediation required to protect human health and the environment. Since the future land use is uncertain, it has been decided, based upon discussions with the New York State Department of Environmental Conservation (NYSDEC), New York State Department of Health (NYSDOH), City of Buffalo Planning Department and the current property owner, the Niagara Frontier Transportation Authority (NFTA), that each of the future land use options be considered and remediation requirements be addressed for each option so that future land use of the property can be planned without undue restrictions or uncertainties. Currently, the majority of the property is vacant and is zoned commercial. However, because waterfront property in the City of Buffalo is not largely available for access by the public, it is possible that the use of the property will change, in part, in the future.

Since it is likely that the property will be developed, it is necessary to identify remediation measures that will allow for development of the property and protect human health and the environment. In many cases, development of the property can be consistent with and be a part of the remedial measures. The following section presents the remediation measures that will meet remedial action objectives for the property, while at the same time not inhibiting future development of the property. In fact, many of the measures discussed below will support and be a part of site development and improvement.

2.2 Remedial Measures

As discussed above, although the current owner of the 113-acre Buffalo Outer Harbor Site, NFTA, has a development plan for the property, the future use of the property has not been finally determined. In addition, although there may be consideration regarding near-term use of the property, it is not possible to predict the long-term use. The future use of the site will drive the selection of the remedial measure(s). The matrix presented in Table 2-1, addresses the various potential future land uses and the recommended remedial alternatives associated with each land use. This will allow for integration of future property development with appropriate remedial measures, thereby allowing development of the property, while substantially reducing risks to human health or the environment.

Appropriate remedial measures for the Remaining Areas of the Property include:

1. Pavement/Building Cover (as part of site development)
2. Soil Cover
3. Soil Excavation and Replacement

Table 2-1

RECOMMENDED REMEDIAL PLAN
BUFFALO OUTER HARBOR

LAND USE AND REMEDIAL PLAN MATRIX

Site Areas	Land Use and Preferred Remedial Alternatives			
	Current Use	**Residential**	**Recreational**	**Commercial/Industrial**
NORTH OF BELL SLIP				
West of Asphalt Road	Deed Restriction (Restricted to Current Use)	Limited Soil Cover (1 foot) as part of Site Development and Deed Notification	Limited Soil Cover (1 foot) as part of Development and Deed Notification	Limited Soil Cover (1 foot) as part of Development and Deed Notification
East of Asphalt Road	Deed Restriction (Restricted to Current Use)	Soil Removal and Replacement (0-15 feet)[1]	Pavement/Building Cover (or 3 foot Soil Cover or 3 foot Soil Excavation and Replacement) and Deed Restriction (Activity and Use Limitations)	Pavement/ Building Cover (or 3 foot Soil Cover or 3 foot Soil Excavation and Replacement) and Deed Restriction (Activity and Use Limitations)
Eastern Gravel Parking Area	Deed and Access Restrictions (Restricted to Current Use and Fencing)	Soil Removal and Replacement (0-15 feet)[1]	Pavement/ Building Cover (or 3 foot Soil Cover or 3 foot Soil Excavation and Replacement) and Deed Restrictions (Activity and Use Limitations)	Pavement/ Building Cover (or 3 foot Soil Cover or 3 foot Soil Excavation and Replacement) and Deed Restrictions (Activity and Use Limitations)
SOUTH OF BELL SLIP				
Exclusive of the Radio Tower Area	Deed Restriction (Restricted to Current Use)	Soil Removal and Replacement (0-8 feet)	Pavement/ Building Cover (or 3 foot Soil Cover or 3 foot Soil Excavation and Replacement) and Deed Restrictions (Activity and Use Limitations)	Pavement/ Building Cover (or 3 foot Soil Cover or 3 foot Soil Excavation and Replacement) and Deed Restrictions (Activity and Use Limitations)

Notes:

[1] Complete removal of soil in this area is recommended due to the presence of the former Fuhrmann Boulevard Landfill.

4. Deed and Access Restrictions (Activity and Use Limitations)

The following provides a brief description of each of the remedial measures.

Pavement/Building Cover

Pavement in the form of roadways, parking lots or recreational facilities and structures, such as commercial and industrial buildings or recreational facilities, would be utilized as a means to mitigate surface contact with contaminated soils, as well as to mitigate infiltration of precipitation through the soil.

Soil Cover

A 3-foot thick permeable cover comprising 2 feet of general fill and covered with 6 inches of topsoil, would be placed over the areas of the property. The cover would also have a biotic barrier (bottom 6 inches of the fill) to discourage burrowing animals from accessing the contaminated soil. A thickness of 3 feet, both for cover and excavation as described below, was selected to minimize potential contact with contaminated soil which could be encountered during planting of shrubs and small trees. This barrier would mitigate human and terrestrial contact with the contaminated soil. The top soil will be seeded to vegetate the areas. In addition, this cover would eliminate the potential for runoff of contaminated soil to either the Bell Slip or the Outer Harbor.

Soil Excavation and Replacement

A portion or all of the contaminated soil in the areas of concern would be excavated and disposed off-site and replaced with clean material. The portion of the soil that would be removed would be that to which on-site receptors would most likely be exposed. For most future uses of the property, this would include the first 3 feet of soil. Portions of the property, including the area east of the asphalt road and the eastern gravel parking area, would require more extensive excavation to a depth approximately 15 feet if residential use is selected, since it overlies the former Fuhrmann Boulevard Landfill. The area south of the Bell Slip would require excavation to a depth of 8 feet if residential use is anticipated, due to the elevated levels of contamination and potential for exposure.

Deed and Access Restrictions

Site access restrictions, such as fencing around the areas of concern, posting of signs to notify the public of the presence of contaminated soil, and deed restrictions and notices could comprise activity and use limitations. Deed restrictions could be placed on the property by the property owner. Specifically, the deed restrictions may identify remedial measures that are required prior to development or change in use of the property.

Deed restrictions (and notices) could include a number of conditions, such as the following:

- Land uses to be prohibited and/or restricted;
- Activities to be controlled, such as specific provisions related to disturbance of soil (e.g., grading), installation and maintenance/repair of utilities, and construction of subsurface structures, such as building foundations; and
- Obligations and conditions necessary to maintain a level of no significant risk.

References to the deed restrictions should be included as part of any deed, easement, mortgage, lease, license, occupancy agreement, or any other agreements which indicate a right to use the property. Deeds restrictions could be utilized on areas where there would be no contaminant, isolation, removal or treatment of contaminated media or could be combined with remedial measures to address residual contamination.

2.3 Recommendations

As discussed above, the Remaining Areas of the Property have been delisted. The recommended Land Use and Remedial Plan Matrix as depicted in Table 2-1 has been prepared to be utilized with development. The matrix identifies remedial measures that provide for protection of human health and the environment, without the need for separate costly remediation.

To address concerns regarding potential exposure to contaminated surface soils in the Eastern Gravel Parking Area, it is recommended that access be restricted to this area by placement of a chain-link fence or potential exposure reduced by placement of soil cover. Further evaluation of the elevated arsenic level on the southern portion of the site may also be necessary. In addition, deed restrictions are recommended for all areas of the property.

Deed restrictions will ensure long-term protectiveness and implementation of the remedial plan. These deed restrictions (and deed notices) can either prohibit or guide certain kinds of land uses and activities, and would also serve to notify potential owners, developers or tenants of the presence of contaminants remaining on the property at levels that are not compatible/protective for all property uses. The Land Use and Remedial Plan Matrix should be incorporated into the deed restriction, combined with information regarding soil/groundwater quality, to provide future property owners/developers/tenants with information so that appropriate evaluations can be made prior to developing and using the property. A summary matrix of the results of the remedial investigation, similar to Table 2-2, should also be included with the deed as a notification of the soil and groundwater quality.

Although each of the measures are recommended to include deed restrictions/notification, the NYSDEC currently does not have the authority to implement controls pertaining to land use and activity limitations. As a result, it would be the responsibility of the current property owner NFTA to place restrictions on the current deed so that future owners/developers/tenants of the property understand and adhere to the restrictions imposed on development and use of

Table 2-2
CONTAMINANT SUMMARY
BUFFALO OUTER HARBOR SITE

SITE AREAS	MATRIX	TOTAL NUMBER OF EXCEEDANCES	CONTAMINANT SUMMARY: CONTAMINANT	HIGHEST LEVELS (2)	SCREENING LEVELS	AVERAGE LEVELS	NO. OF EXCEEDANCES
SOUTH OF BELL SLIP							
Radio Tower Area	Surface soil (0 to 6 inches)	5 out of 8 samples above the screening level	PCBs	8 2 mg/kg	1 mg/kg	**2.4 mg/kg**	**4 out of 8**
			Cadmium	12 mg/kg	10 mg/kg	5.8 mg/kg	1 out of 8
			Lead	777 mg/kg	500 mg/kg	390 mg/kg	**4 out of 8**
			Zinc	2350 mg/kg	500 mg/kg	**1164 mg/kg**	**5 out of 8**
			Nickel	47.9 mg/kg	40 mg/kg	24.6 mg/kg	1 out of 8
	Shallow Subsurface soil (6 inches to 8 feet)	5 out of 13 samples above the screening level	CaPAHs	112 mg/kg	10 mg/kg	**13.3 mg/kg**	2 out of 13
			Lead	1170 mg/kg	500 mg/kg	314 mg/kg	2 out of 13
			Antimony	29 mg/kg	20 mg/kg	11 5 mg/kg	1 out of 13
	Deep Subsurface soil (8 to 20 feet)	7 out of 15 samples above the screening level	Total VOCs	351 mg/kg	10 mg/kg	**92.7 mg/kg**	2 out of 7
			Nitrobenzene	13,000 mg/kg	1 mg/kg	**79.4 mg/kg**	**5 out of 15**
			PAHs	5600 mg/kg	100 mg/kg	**406 mg/kg**	2 out of 15
			CaPAHs	16 mg/kg	10 mg/kg	2 9 mg/kg	1 out of 15
			Antimony	5470 mg/kg	20 mg/kg	**439 mg/kg**	**6 out of 15**
			Lead	1720 mg/kg	500 mg/kg	296 mg/kg	2 out of 15
			Chromium	2820 mg/kg	100 mg/kg	**218 mg/kg**	2 out of 15
			Nickel	123 mg/kg	40 mg/kg	23 mg/kg	1 out of 15
			Copper	1480 mg/kg	200 mg/kg	140 mg/kg	1 out of 15
			Zinc	1290 mg/kg	500 mg/kg	253 mg/kg	1 out of 15
			TCLP Nitrobenzene	91 mg/l	2 mg/l	--	1 out of 2
			TCLP 2,4 - Dinitrotoluene	0 6 mg/l	0 3 mg/l	--	1 out of 2
	Groundwater (depth to groundwater 8 feet)	1 out of 1 samples above the screening level for the Phase I investigation (1) 3 out of 5 samples above the screening level for the Phase II investigation (1)	Benzene	15 ug/l (Phase I)	0.7 ug/l	--	--
			Toluene	7 ug/l (Phase I)	5 ug/l	--	--
			Chlorobenzene	170 ug/l (Phase I)	5 ug/l	--	--
			1,3 Dichlorobenzene	150 ug/l (Phase II)	5 ug/l	--	--
			1,4 Dichlorobenzene	33 ug/l (Phase II)	4.7 ug/l	--	--
			1,2 Dichlorobenzene	150 ug/l (Phase II)	4 7 ug/l	--	--
			Napthalene	890 ug/l (Phase I)	10 ug/l	--	--
			4-Chloroaniline	3600 ug/l (Phase II)	5 ug/l	--	--
			Antimony	244 ug/l (Phase I)	3 ug/l	--	--
			Lead	28.4 ug/l (Phase II)	25 ug/l	--	--
			Arsenic	159 ug/l (Phase II)	25 ug/l	--	--
Remaining Area	Surface soil (0 to 6 inches)	20 out of 43 samples above the screening level	CaPAHs	80 mg/kg	10 mg/kg	**18 mg/kg**	11 out of 43
			Arsenic	1301 mg/kg	20 mg/kg	8 mg/kg (3)	2 out of 43
			Zinc	3080 mg/kg	500 mg/kg	414 mg/kg	8 out of 43
			Lead	834 mg/kg	500 mg/kg	220 mg/kg	4 out of 43
			Cadmium	27 mg/kg	10 mg/kg	2.7 mg/kg	1 out of 43
			Chromium	133 mg/kg	100 mg/kg	29 mg/kg	2 out of 43
			Copper	456 mg/kg	200 mg/kg	81 mg/kg	3 out of 43
	Shallow Subsurface soil (6 inches to 8 feet)	8 out of 12 samples above the screening level	CaPAHs	16 mg/kg	10 mg/kg	5.7 mg/kg	**4 out of 12**
			Arsenic	36 mg/kg	20 mg/kg	8 7 mg/kg	1 out of 12
			Lead	1260 mg/kg	500 mg/kg	345 mg/kg	2 out of 12
			Nickel	63 mg/kg	40 mg/kg	24 mg/kg	1 out of 12
			Zinc	834 mg/kg	500 mg/kg	372 mg/kg	**4 out of 12**
	Deep Subsurface soil (8 to 20 feet)	6 out of 13 samples above the screening level	CaPAHs	31 mg/kg	10 mg/kg	9.6 mg/kg	4 out of 13
			PAHs	104 mg/kg	100 mg/kg	25 8 mg/kg	1 out of 13
			Lead	2200 mg/kg	500 mg/kg	283 mg/kg	2 out of 13
			Antimony	74 mg/kg	20 mg/kg	19 mg/kg	1 out of 13
			Arsenic	21 4 mg/kg	20 mg/kg	7 8 mg/kg	1 out of 13
			Copper	247 mg/kg	200 mg/kg	43 mg/kg	1 out of 13
			Nickel	53 mg/kg	40 mg/kg	23 mg/kg	1 out of 13
			Zinc	1880 mg/kg	500 mg/kg	317 mg/kg	1 out of 13
	Groundwater (depth to groundwater 8 feet)	5 out of 11 samples above the screening level for the Phase I investigation (1) 0 out of 1 samples above the screening level for the Phase II investigation (1)	Chloroform	15 ug/l (Phase I)	7 ug/l	--	--
			Endrin	0 024 ug/l (Phase I)	Non-detect	--	--
			4,4 - DDT	0.039 ug/l (Phase I)	Non-detect	--	--
			4,4 - DDD	0 069 ug/l (Phase I)	Non-detect	--	--
			Arsenic	95 ug/l (Phase I)	25 ug/l	--	--
NORTH OF BELL SLIP							
West of Asphalt Road	Surface soil (0 to 6 inches)	4 out of 34 samples above the screening level	CaPAHs	18 mg/kg	10 mg/kg	3 6 mg/kg	3 out of 34
			Lead	815 mg/kg	500 mg/kg	157 mg/kg	2 out of 34
			Zinc	671 mg/kg	500 mg/kg	151 mg/kg	1 out of 34
	Shallow Subsurface soil (6 inches to 8 feet)	6 out of 19 samples above the screening level	CaPAHs	18.4 mg/kg	10 mg/kg	3 8 mg/kg	3 out of 19
			Lead	1160 mg/kg	500 mg/kg	173 mg/kg	1 out of 19
			Copper	753 mg/kg	200 mg/kg	123 mg/kg	2 out of 19
			Nickel	55.6 mg/kg	40 mg/kg	15 4 mg/kg	1 out of 19
			Zinc	1010 mg/kg	500 mg/kg	190 mg/kg	1 out of 19

Table 2-2
CONTAMINANT SUMMARY
BUFFALO OUTER HARBOR SITE

SITE AREAS	MATRIX	TOTAL NUMBER OF EXCEEDANCES	CONTAMINANT SUMMARY: CONTAMINANT	HIGHEST LEVELS (2)	SCREENING LEVELS	AVERAGE LEVELS	NO. OF EXCEEDANCES
West of Asphalt Road (continued)	Deep Subsurface soil (8 to 20 feet)	10 out of 20 samples above the screening level	CaPAHs	38 mg/kg	10 mg/kg	9 1 mg/kg	5 out of 18
			Lead	2850 mg/kg	500 mg/kg	**643 mg/kg**	**8 out of 20**
			Antimony	89 mg/kg	20 mg/kg	19 4 mg/kg	2 out of 18
			Copper	12900 mg/kg	200 mg/kg	**902 mg/kg**	**10 out of 20**
			Chromium	569 mg/kg	100 mg/kg	66 mg/kg	2 out of 18
			Arsenic	57.8 mg/kg	20 mg/kg	16 2 mg/kg	5 out of 18
			Cadmium	32.6 mg/kg	10 mg/kg	4 8 mg/kg	2 out of 18
			Nickel	747 mg/kg	40 mg/kg	**75 mg/kg**	4 out of 18
			Zinc	5290 mg/kg	500 mg/kg	**923 mg/kg**	**10 out of 20**
	Groundwater (depth to groundwater ranges from 5 to 15 feet)	6 out of 12 samples above the screening level for the Phase I investigation (1) 3 out of 6 samples above the screening level for the Phase II investigation (1)	Antimony	124 ug/l (Phase I)	3 ug/l	--	--
			Barium	4050 ug/l (Phase I)	25 ug/l	--	--
			Trichloroethene	7 ug/l (Phase I)	1000 ug/l	--	--
			Cyanide	892 ug/l (Phase II)	5 ug/l	--	--
			Dieldrin	0.032 ug/l (Phase I)	100 ug/l	--	--
			Endrin	0.018 ug/l (Phase I)	Non detect	--	--
			Heptachlor Epoxide	0 026 ug/l (Phase I)	Non detect	--	--
			Beta BHC	0.011 ug/l (Phase I)	Non detect	--	--
East of Asphalt Road	Surface soil (0 to 6 inches)	4 out of 23 samples above the screening level	CaPAHs	18 mg/kg	10 mg/kg	2.2 mg/kg	1 out of 23
			Copper	29,500 mg/kg	200 mg/kg	62 mg/kg (4)	1 out of 23
			Zinc	874 mg/kg	500 mg/kg	205 mg/kg	2 out of 23
	Shallow Subsurface soil (6 inches to 8 feet)	8 out of 15 samples above the screening level	CaPAHs	17 mg/kg	10 mg/kg	2 7 mg/kg	1 out of 13
			Antimony	37 mg/kg	20 mg/kg	16 7 mg/kg	2 out of 13
			Arsenic	34 mg/kg	20 mg/kg	10 6 mg/kg	3 out of 13
			Lead	1200 mg/kg	500 mg/kg	389 mg/kg	**6 out of 15**
			Copper	1460 mg/kg	200 mg/kg	**673 mg/kg**	**5 out of 15**
			Nickel	48.1 mg/kg	40 mg/kg	19 2 mg/kg	2 out of 13
			Zinc	4230 mg/kg	500 mg/kg	**968 mg/kg**	**5 out of 15**
	Deep Subsurface soil (8 to 20 feet)	12 out of 15 samples above the screening level	CaPAHs	38 mg/kg	10 mg/kg	9 1 mg/kg	3 out of 15
			Arsenic	412 mg/kg	20 mg/kg	**41.7 mg/kg**	**5 out of 15**
			Antimony	1170 mg/kg	20 mg/kg	**133 mg/kg**	**6 out of 15**
			Cadmium	27 mg/kg	10 mg/kg	6 4 mg/kg	**3 out of 15**
			Chromium	343 mg/kg	100 mg/kg	58 mg/kg	2 out of 15
			Copper	1560 mg/kg	200 mg/kg	**432 mg/kg**	**5 out of 15**
			Lead	4860 mg/kg	500 mg/kg	**1165 mg/kg**	**10 out of 15**
			Nickel	141 mg/kg	40 mg/kg	38 mg/kg	4 out of 15
			Zinc	4330 mg/kg	500 mg/kg	**1836 mg/kg**	**7 out of 15**
	Groundwater (depth to groundwater 10 feet)	3 out of 5 samples above the screening level for the Phase I investigation (1) 1 out of 2 samples above the screening level for the Phase II investigation (1)	VOCs	Low levels of VOCs (Less than 10 ug/l Phase I)	arious Class GA groundwater andards/guideline	--	--
			PAHs	Low levels of PAHs (less than 5 ug/l Phase I and Phase II)		--	--
			Zinc	349 ug/l (Phase I)	300 ug/l	--	--
			Lead	410 ug/l (Phase II unfiltered)	25 ug/l	--	--
			Thallium	7.2 ug/l (Phase II unfiltered)	4 ug/l	--	--
			Barium	1090 ug/l (Phase II unfiltered)	1000 ug/l	--	--
Eastern Gravel Parking Area	Surface soil (0 to 6 inches)	8 out of 14 samples above the screening level	PCBs	12 mg/kg	1 mg/kg	[illegible]	2 out of 11
			CaPAHs	14.8 mg/kg	10 mg/kg	6.1 mg/kg	3 out of 14
			Arsenic	21 3 mg/kg	20 mg/kg	8 6 mg/kg	1 out of 14
			Cadmium	323 mg/kg	10 mg/kg	**25.9 mg/kg**	2 out of 14
			Chromium	113 mg/kg	100 mg/kg	32 mg/kg	1 out of 14
			Lead	14,000 mg/kg	500 mg/kg	**522 mg/kg (5)**	**6 out of 14**
			Nickel	62.8 mg/kg	40 mg/kg	19.4 mg/kg	1 out of 14
			Zinc	29800 mg/kg	500 mg/kg	**946 mg/kg (6)**	**5 out of 14**
	Groundwater (depth to groundwater 17 feet)	1 out of 1 sample above the screening level for the Phase I and Phase II investigation (1)	Chrysene	0.6 ug/l (Phase II)	0 002 ug/l	--	--
			Lead	500 ug/l (Phase II)	25 ug/l	--	--
			Thallium	6 3 ug/l (Phase II)	4 ug/l	--	--

NOTES:
(1) Does not include exceedances for iron, manganese, magnesium or sodium
(2) Highest level encountered during the Phase I and II Investigation
(3) Does not include 1301 mg/kg (detected in only one sample) in average. Average with 1301 mg/kg is 38 mg/kg
(4) Does not include 29500 mg/kg (detected in only one sample) in average. Average with 29500 mg/kg is 1342 mg/kg
(5) Does not include 14000 mg/kg (detected in only one sample) in average. Average with 14000 mg/kg is 1485 mg/kg
(6) Does not include 29800 mg/kg (detected in only one sample) in average. Average with 29800 mg/kg is 3007 mg/kg

SHADING:
[shaded] Average level exceeds screening level or number of exceedances exceeds 30 %

the property, or the need for remediation. In addition to placement of activity and use limitations on the property by NFTA, these restrictions can be monitored through the State Environmental Quality Review Act (SEQRA) when the property is planned for development. Based upon NFTA's assertion that they are not subject to local zoning, if deed restrictions are not placed, the only means of ensuring that the proper precautions and remedial actions are implemented is through SEQRA. The New York State Department of Health and NYSDEC will need to review and approve proposals for development of the property. Therefore, during this review and approval process, development restrictions or required remedial actions could be made part of the permit to construct.

3.0 REMEDIAL PLAN FOR THE RADIO TOWER AREA

3.1 Identification and Evaluation of Remedial Technologies

3.1.1 Introduction

In general, response actions which satisfy remedial objectives for a site include institutional, containment, isolation, removal or treatment actions. United States Environmental Protection Agency (USEPA) guidance under Comprehensive Environmental Response Compensation and Liability Act (CERCLA) also requires the evaluation of a No-Action Alternative in addition to the above against which to compare the action alternatives. Each response action for each medium of interest must satisfy the remedial action objectives for the site or the specific area of concern. Technology types and process options are identified in this feasibility study by remedial technologies that are available commercially and have been demonstrated successfully. The screening of process options or technology types is performed by determining their ability to meet specific remedial action objectives, their technical implementability, and their short-term and long-term effectiveness. A discussion of selected response actions and their applicability to the Radio Tower Area is provided below.

3.1.2 No Action

The No-Action Alternative will be considered, and as described above, will serve as a baseline to compare and evaluate the effectiveness of other actions. Under the no-action scenario, the contaminated soil and groundwater would remain in its present condition and no remedial activities would be performed.

3.1.3 Deed and Access Restrictions

Deed and access restrictions, such as eliminating access to the Radio Tower Area by fencing and posting of signs, are considered potentially applicable to this portion of the site. Although the

New York State Department of Environmental Conservation (NYSDEC) does not have the authority to impose deed restrictions, the current property owner could impose such restrictions. In addition, the City of Buffalo Community Development, Office for the Environment could be provided with information on recommended restrictions and attempt to ensure they are adhered to through the approval/permit to construct process. Monitoring of the Radio Tower Area could also be part of this alternative. Monitoring would comprise periodic groundwater sampling which would be conducted to evaluate changes over time in environmental/groundwater conditions at the site. Continued groundwater monitoring would be necessary to ascertain the level of any natural attenuation which may occur or any increase in contamination which would necessitate possible further remedial action. Natural attenuation, as opposed to active remediation, relies on naturally occurring physical, chemical and biological processes (dilution, dispersion and degradation) to reduce contaminant concentrations.

Although potentially applicable, NYSDEC would not have any authority regarding the implementation of the restrictions and the responsibility would be essentially with the property owner and local planning/permitting entity. Deed restrictions which prohibit/restrict future use/ development of the site would be a potentially applicable alternative for this area of the site.

3.1.4 Isolation/Containment

Isolation and containment technologies include surface barriers, such as permeable covers and low permeability caps, and subsurface barriers, such as slurry walls. These technologies are designed to prevent direct contact with and migration of contaminants from the area of concern and do not provide any treatment for the isolated/contained waste.

This feasibility study considers five types of isolation remedial technologies for soils in the Radio Tower Area.

Surface Barrier	Permeable Cover (soil and stone)
	Low Permeability Cap (geomembrane or clay/bentonite)
	RCRA Cap (geomembrane and clay/bentonite)
	Pavement/Structure Cover
Subsurface Barrier	Slurry Wall

3.1.4.1 - Surface Barriers

Various forms of surface barriers currently exist to significantly reduce the infiltration of precipitation into waste and contaminated soil, and minimize surface runoff and contact with contaminated material.

Low permeability caps have an advantage over permeable covers in that these technologies would limit infiltration by precipitation in addition to mitigating direct contact with contaminated material. However, low permeability caps are more costly, require a sloped surface to promote runoff and preclude/limit the use of the capped area and additional maintenance. The following is a discussion of various low permeability and permeable caps.

Resource Conservation and Recovery Act (RCRA) Cap

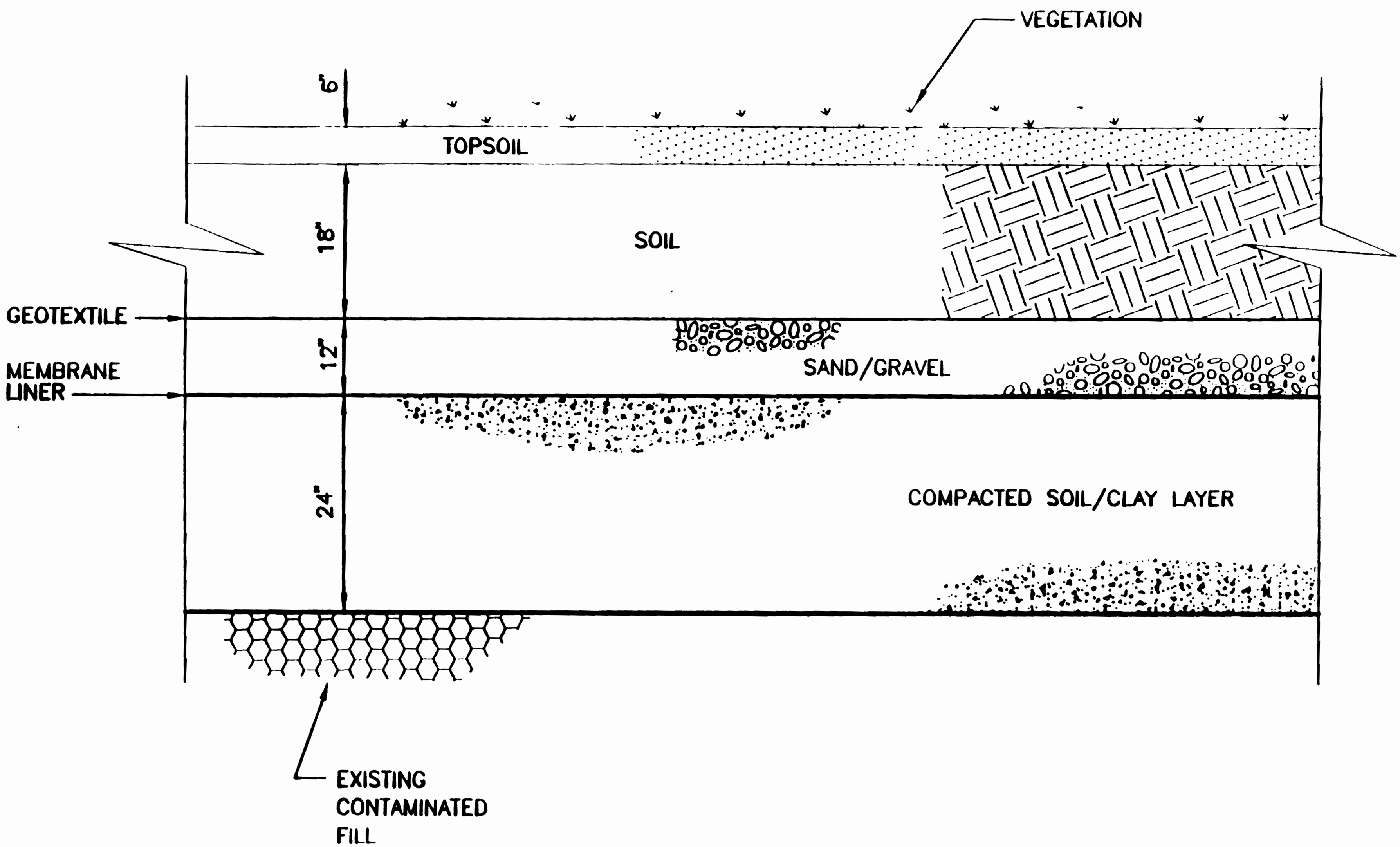
This technology consists of constructing a RCRA cap over contaminated materials in the Radio Tower Area. The cap would prevent direct contact with contaminated soils and would minimize infiltration of precipitation through the contaminated soil and further contamination of groundwater. It would also eliminate contaminated runoff. A RCRA cap comprises three sections. The top section consists of a 2-foot vegetated topsoil and a soil layer. A geotextile is placed between the top section and middle section. The middle section contains a 1-foot sand and gravel filter which prevents clogging of the underlying drainage layer. The bottom section is comprised of a flexible membrane liner (FML) which overlies and protects a second low permeability 2-foot compacted soil/clay layer (see Figure 3-1). The thickness, maintenance requirements and slope (typically a minimum of 4%) of this type of cap would essentially eliminate many potential future land use options for this area. Due to the slopes, the area would not be suitable for residential or commercial/industrial purposes. This type of cap will provide significant protection from infiltration of precipitation into the contaminated subsurface and provides additional protection over other types of low permeability caps presented below, and therefore will be considered further.

Multimedia Cap

This technology consists of a three layered system comprised of a vegetated topsoil upper layer, underlain by a drainage/barrier protection layer followed by a low permeability layer comprised of clay or a FML. The thickness of the multimedia cap with a FML is 3 feet (see Figure 3-2). Similar to the RCRA cap described above, this cover also precludes direct contact with contaminated soil, infiltration of precipitation and runoff of contaminants. The thickness, required maintenance and slope of the cap (minimum 4%) would also significantly reduce utilization of the capped area. Since this type of cap would not provide as much protection as the RCRA cap and is not as effective as a RCRA cap, the multimedia cap is not considered potentially applicable to the site, and it will not be considered further.

Pavement/Structure Cap

An asphalt or concrete structure surface would significantly reduce the amount of infiltration into and contact with contaminated waste and soil, as well as surface runoff of contaminants from the site. In addition, it could be implemented as part of site development, such as construction of buildings and asphalt parking areas. Efforts may need to be undertaken to design appropriate drainage systems to redirect surface runoff that currently infiltrates this area. This type of cover, which would be about 1 1/2 - 2 feet in thickness, would not be as thick as the RCRA cap (5 feet) or the multimedia cap (3 feet),



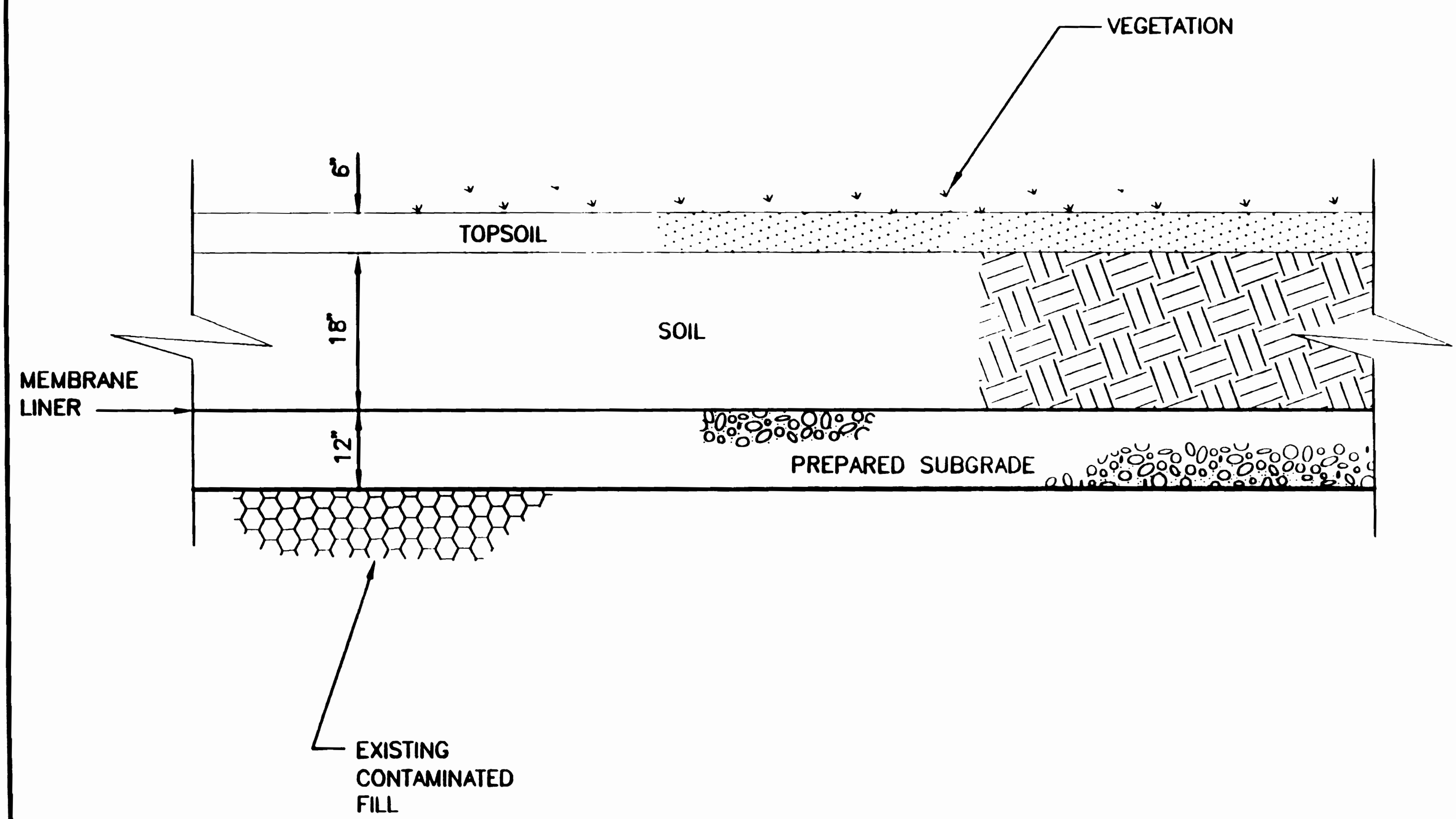
DIRECTORY: 1307
FILE NAME: 1307-PC2
DATE: RDS-03/06/96

Dvirka and Bartilucci
Consulting Engineers

BUFFALO OUTER HARBOR SITE
FEASIBILITY STUDY

RCRA COVER

FIGURE 3-1



DIRECTORY: 1307
FILE NAME: 1307-PC1
DATE: RDS-03/06/96

BUFFALO OUTER HARBOR SITE
FEASIBILITY STUDY

MULTIMEDIA COVER

Dvirka and Bartilucci
Consulting Engineers

FIGURE 3-2

and the slope could be reduced to 2% to promote runoff. Maintenance would be required in order to ensure that cracks due to weathering, settlement or traffic are repaired. This cover would not be as effective as the RCRA or multimedia cap in reducing infiltration, it would not be potentially applicable to the site and, therefore, the pavement/structure cap will not be considered further.

Permeable Cover

This technology provides for the placement of a 3-foot soil and/or gravel cover over the Radio Tower Area. This type of cover would mitigate direct contact with and runoff of contaminated surface soil, however, it does not reduce infiltration of precipitation. Although not as highly contaminated as the deeper subsurface soil, the shallow subsurface soil (2 to 8 feet) (in the vadose zone) exhibits elevated levels of contaminants; therefore, infiltration of precipitation would likely continue to impact groundwater beneath the site. As a result, this technology is not considered potentially applicable to the Radio Tower Area and will not be considered further.

3.1.4.2 - Subsurface Barriers

Generally, subsurface barriers consist of cutoff walls or diversion systems installed to contain, capture or redirect groundwater flow in the vicinity of a contaminated site. One of the most commonly used and effective subsurface barriers is a soil bentonite slurry wall. This technology involves construction of a slurry wall (or other subsurface barrier, such as a grout curtain or vibrating beam wall) completely or partially around the area of concern, typically in conjunction with a low permeability cap. The slurry wall would prevent potential migration of contaminated groundwater from the Radio Tower Area to the nearby surface water. This vertical barrier should be keyed into a low permeability clay layer to prevent migration of contaminants beneath the wall. Extraction wells would be required to provide gradient control across the slurry wall.

Based on current information, groundwater in the Radio Tower Area appears to be migrating to the southeast possibly towards the marina area. Although there is not a low permeability layer beneath the Radio Tower Area in which to key into, it is not impermeable and extraction wells could maintain an upward (and inward flow gradient) which could control groundwater migration. Therefore, a slurry wall (with groundwater gradient control) appears to be potentially applicable to containment of contaminated groundwater in the Radio Tower Area and will be considered further.

3.1.5 Soil Removal

Excavation of contaminated soil in the Radio Tower Area cannot be conducted using simple excavation techniques. The most highly contaminated soil is located beneath the water table approximately 10 to 20 feet below ground surface. This material has exhibited elevated levels of nitrobenzene and metals and levels of nitrobenzene and 2,4-dinitrotoluene above TCLP limits. The shallow subsurface soil (0 to 10 feet) exhibited elevated levels of metals, PCBs and PAHs. Therefore, this soil may also require off-site disposal/treatment prior to replacement on-site.

Excavation of the soil below the water table could be accomplished through sheeting of the area utilizing 50 foot sheet piling. The sheet piles must be installed 28 feet into the native overburden in order to ensure stability of the sheets during excavation. The excavation would be conducted in 50 foot square sections. Each section would need to be dewatered prior to and during construction. This could be completed utilizing extraction wells in each section and/or a sump system. Extracted water may require treatment on-site prior to discharge to the municipal sewer system. Once dewatered, excavation could be completed using a long reach backhoe. Although the area would be dewatered, the excavated material would still need to be placed on a concrete pad and covered and include appropriate drainage controls. Drainage water from the pad would be collected and treated prior to discharge to the municipal sewer system.

Due to concerns with regard to vapor emissions, all excavation activities would need to be completed under a temporary structure. All personnel would likely require level "B" personal protection equipment. As mentioned above, all excavated material would be covered while stored on-site prior to off-site disposal.

Although this technology would be difficult to implement, it will be considered further.

3.1.5.1 - Off-Site Disposal or Incineration

Off-site disposal would require excavation of the contaminated soil and transportation to an approved/permitted secure landfill or incinerator. Due to the high concentrations of nitrobenzene found in the soil strata between 10 and 20 feet and TCLP results in excess of regulatory limits, it is likely that a majority of the soil will require incineration. There are a number of permitted facilities available that could accept the contaminated soils/wastes from the Radio Tower Area. Incineration is effective for the destruction of organic contaminants, however, it would not be effective for destruction of metals. Treated/stabilized (if required) residual soil from the incineration process would be disposed in an off-site secure landfill.

Since the shallow subsurface soil (0 to 10 feet) exhibited elevated levels of PAHs, PCBs and metals, this soil may require off-site landfill disposal or treatment prior to replacement on-site.

3.1.6 Soil Treatment

There are a number of demonstrated/commercially available technologies for the treatment of contaminated soil. Some treatment technologies can be performed in situ and other technologies require treatment of the soil ex situ. Ex situ soil treatment processes would require excavation of the soil prior to treatment. Therefore, similar problems regarding excavation, as discussed above, would be encountered.

Several different types of treatment technologies were reviewed, such as bioremediation, solvent/acid extraction, soil washing, thermal separation/desorption and in situ soil flushing; however, none of the treatment technologies have demonstrated effectiveness in treatment of nitrobenzene contaminated soils. In fact, except for thermal desorption, no other treatment technologies were identified that even attempted to treat nitrobenzene contaminated soils. The treatment technologies that were reviewed are described in more detail below.

3.1.6.1 - Bioremediation

Bioremediation is a process in which microorganisms degrade organic contaminants. The degradation of the contaminants is accomplished by metabolizing the contaminants and either using them as a source of carbon or energy, or possibly not as a source of nutrients at all. Microorganisms can adapt to degrade synthetic compounds depending upon whether or not the compound is toxic, or whether or not it is in high enough concentration to support microbial growth.

Many different methodologies have been utilized to identify applicable microorganisms, including isolation of pure strains from current contaminated situations to utilizing genetic engineering to produce a microorganism capable of degrading a specific compound. Bioremediation also comprises the stimulation of indigenous microorganisms.

Bioremediation is effective for the treatment of organic materials such as volatile organic compounds (VOCs) and semivolatile organic compounds (SVOCs), and is not effective in treatment of inorganics, such as heavy metals. In situ bioremediation generally requires the addition of nutrients, oxygen, moisture and possibly the addition of microbes to the soil through wells or spread on the surface for infiltration into the contaminated material. Ex situ bioremediation requires the addition of water and nutrients, as well as possibly microbes, to excavated soils and rotating the soils to introduce oxygen and provide adequate contact to allow degradation of the chemicals.

One of the most important factors effecting bioremediation is the ability to biodegrade the waste contaminants. In addition, the solubility of the contaminant is also an important factor. A chemical that is tightly adsorbed onto the particle surface or has a very low diffusivity through the aqueous medium can prolong the treatment time.

There are many vendors offering bioremediation systems that would be applicable in remediating VOC and SVOC contaminated soil both in-situ and ex-situ. Although several vendors have experience in soils contaminated with chlorinated solvents, petroleum hydrocarbons and polycyclic aromatic hydrocarbons (PAHs), no vendor has indicated demonstrated experience in remediating soils contaminated with nitrobenzene. W.R. Grace Co. Inc. has performed bioremediation studies utilizing their DARAMEND technology to remediate soil contaminated with nitroaromatic and chlorinated pesticides, which are similar to nitrobenzene in chemical characteristics.

Using this technology, soil was excavated, screened of debris and placed in lined treatment cells. Proprietary DARAMEND soil amendments and additives to stimulate bioremediation are incorporated into the soil. The soils are also tilled and irrigated during the process in order to stimulate bioremediation. Levels of contaminants were reduced through the application of repeated and sequential anoxic and oxic conditions to reduce (or dechlorinate) and aerobically mineralize the contaminants. Bench scale studies applied to organic explosive contaminated soils have shown rapid and extensive removal of the nitroaromatics. Grace reports reducing levels of trinitrotoluene from 7,250 mg/kg to 19 mg/kg in 124 days. Based on this experience, Grace feels that bioremediation of nitrobenzene is potentially applicable. However, further evaluation of the effectiveness of bioremediation with regard to treatment of nitrobenzene is required prior to considering this technology further.

3.1.6.2 - Solvent/Acid Extraction

The solvent extraction process, as it applies to soil remediation, utilizes a solvent to extract organic components from a solid matrix into a liquid solution. The process typically utilizes a single vessel in which the solvent is placed into contact with excavated soil. The solvent is then recovered and recycled, and the extracted organic and/or inorganic contaminants are either disposed or recycled. The decontaminated soils can be backfilled on-site or landfilled depending on removal efficiencies of the process and/or land disposal restrictions.

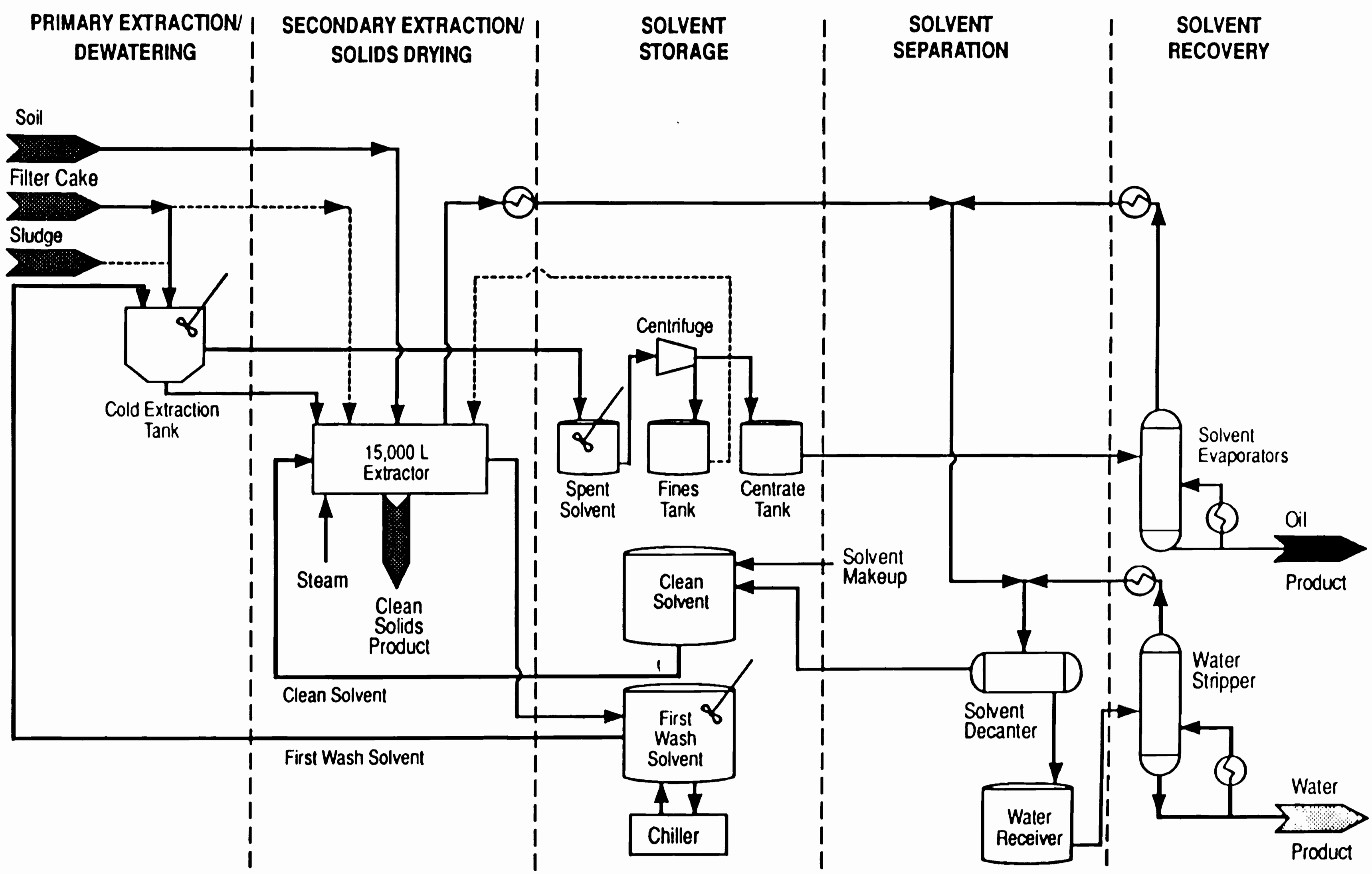
Extraction solvents are not currently available for all contaminants and extraction efficiencies may vary for different types of soils and levels of contaminants. Solvent extraction processes that may be effective in treating the soil in the Radio Tower Area are discussed below. Two of the technologies would remove the organic contaminants, but would not remove metals from the soil. Acids may also be used in place of or in addition to solvents in order to remove the metals from the soils. One process capable of removing metals from the soils is also discussed.

The B.E.S.T. process is a solvent extraction technology designed by Resources Conservation Company that can effectively treat soil, sludge and sediment. The process utilizes a triethylamine solvent which is a biodegradable solvent formed by reacting ammonia and ethyl alcohol. The process utilizes triethylamine's property of inverse miscibility. It is soluble in water below 65°F and insoluble in water greater than 65°F. Cold triethylamine can extract water and water soluble compounds and warm triethylamine can extract organic compounds such as polychlorinated biphenyls (PCBs), pesticides, SVOCs and VOCs (see Figure 3-3).

The B.E.S.T. process has been successfully demonstrated at a pilot scale and at a full scale level. A full scale B.E.S.T. unit was used to treat PCB contaminated sludges at General Refining Superfund Site in Garden City, Georgia. Three pilot scale units have been built and operated to treat soils, sludges and sediments contaminated with PCBs, PAHs, VOCs and pesticides.

Although the B.E.S.T. process has never specifically addressed nitrobenzene contamination, it has been proven successful at reducing elevated levels of 1,2; 1,3 and 1,4 dichlorobenzene during bench scale treatability studies. Levels of 1,4 dichlorobenzene were reduced from 33 ppm to less than 0.34 ppm.

In addition, this process was also utilized for a bench scale treatability study for the Booth Oil Site New York State Superfund Site. Treatment efficiencies for the process were 94.6% for PCBs (run feed levels as high as 14.7 ppm) and 99.9% for VOCs (run feed levels as high as 238 ppm). Total SVOCs were reduced from 611 ppm to 8.2 ppm. However, the treatment



DIR: 1578 FILE: 1578-1(EHG-7/16/98)

Source: RESOURCES CONSERVATION COMPANY

BUFFALO OUTER HARBOR SITE
FEASIBILITY STUDY

B.E.S.T. SOLVENT EXTRACTION SYSTEM

Dvirka and Bartilucci
Consulting Engineers
A Division of William F. Cosulich Associates, P.C.

FIGURE 3-3

process did have the effect of increasing the concentration of total lead and TCLP lead. TCLP lead levels increased from 205 ug/l to 17,800 ug/l indicating that treated soil may require additional treatment prior to replacement on-site. The increase in leachability of heavy metals may be due to the high pH of the triethylamine (pH=10) causing conversion of the metals to the hydroxide form causing the metals to precipitate and exit with the treated soils. This process has a capacity of 5 to 12 tons per hour and may be applicable to treating the PAHs, nitrobenzene and VOCs in the Radio Tower Area.

Another solvent extraction process has been developed by the TERRA-KLEEN Corporation. This process, known as the Soil Restoration Unit, has been utilized to perform a full scale remediation of the Traband PCB Superfund Site in Tulsa, Oklahoma. The unit can remove contaminants from excavated soils, debris and sediment. The mobile soil restoration unit utilizes a proprietary solvent to extract organic contaminants from contaminated soils. The excavated soils are screened to less than 3 inches in the hopper assembly and fed into the unit, which has a capacity of 1 to 2 1/2 tons per hour. Within the unit, the soil is continuously washed with solvents in a counter current process. The contaminants dissolve in the solution and are removed from the soil by the counter current flow. The contaminated solvents are reclaimed and the clean washed soil is transferred to a closed loop dryer system where any excess solvent is removed from the soil and reclaimed.

The Soil Restoration Unit cannot process metal-only wastes, inorganic cyanide wastes or inorganic corrosive wastes. The process may be applicable to the Radio Tower Area to remediate on-site SVOCs and VOCs contamination, however additional treatment may be required to address metal contamination.

Microbial Biotechnology, Inc. has developed an acid extraction system capable of removing metals from contaminated soils. This process was demonstrated under the SITE program and at a full-scale level at the McGuire Wire and Salvage Site in Mora, Montana. This process utilizes acids to solubilize the metals. The effluent is processed through a reverse osmosis system and then a series of cascading ion exchange units that selectively recover individual metals. The process has been utilized to reduce levels of lead from above 2,400 mg/kg to below 160 mg/kg.

One of the limitations of the solvent/acid extraction technology is that soils containing more than 20% moisture must be dried prior to treatment because excess water dilutes the solvent, reducing contaminant solubilization and transport efficiency. This increases handling of the contaminated soils. In addition, both solvent and acid processes would likely be required to address organic and inorganic contamination. Solvent extraction alone would not only address inorganic contamination, it may actually increase the leachability of the metals in the soil, thereby requiring a second treatment phase, such as stabilization. Although potentially applicable, solvent/acid extraction would require excavation and possibly extensive handling/ drying of soils. Once removed and treated, there would still be the residuals requiring additional treatment, such as stabilization or off-site disposal. Due to the extensive handling requirements and the likely need for more than one treatment train, as well as the lack of demonstrated effectiveness in treating nitrobenzene contaminated soil, this alternative will not be considered further.

3.1.6.3 - Soil Washing

Soil washing technologies physically separate soils so that the contaminants, which are primarily associated with the fine size fraction of the soils, are separated from the uncontaminated larger size fraction of the soils. The washing fluid may be composed of water and/or a surfactant capable of removing the contaminants from the soil. Either a solid-solid or liquid-solid separation is conducted where the contaminant can be leached by the fluid, or the contaminant is stripped from the particles with which it is associated.

Soils would require excavation prior to treatment and therefore would have similar problems with regard to sheeting and dewatering and emissions controls as discussed previously.

The products of the soil washing process are clean soil, wash water containing an oily phase, dissolved contaminants and/or precipitated solids, and a finer fraction containing adsorbed organics and precipitated soils. The result is high levels of contaminants concentrated into a relatively small volume of material, thereby simplifying the ultimate treatment or disposal of the contaminated media.

Soil washing technologies can be effective for removing organics and inorganics from the soils depending on contaminant concentrations, soil characteristics and process capability.

The contaminated soils in the Radio Tower Area have been classified as primarily fine coarse sand, trace gravel, little silt and trace clay. In addition, portions of the contaminated soil have also been identified as silt and clay with trace amounts of glass, wood, concrete and cinder. Due to the lack of a significant amount of fines in the soil, it may be difficult to treat the soil utilizing this process. Additionally, the complex waste mixtures in this area containing both organics and inorganics may make it difficult to formulate an effective washing fluid. In addition, there are no soil washing processes demonstrated to address nitrobenzene contamination. As a result, soil washing will not be considered further.

3.1.6.4 - Thermal Separation/Desorption

Thermal separation processes have proven effectiveness in removing PCBs, volatiles, semivolatiles (and some heavy metals) from soil by volatilization. The contaminants are condensed and the condensate is typically treated or disposed of off-site. The levels of organics in the soil are typically reduced to levels in which soils could backfilled on-site. Although the levels of organics are reduced, the levels of heavy metals typically remain unchanged.

Chemical Waste Management has developed the X-TRAX Model 200 Thermal Desorption System. This closed loop process involves feeding the contaminated soil to an externally heated rotary dryer and heating the soils to temperatures between 750 to 950°F. Evaporated contaminants are removed by a recirculating nitrogen carrier gas. A scrubber removes dust particles and 10% to

30% of the organic contaminants from the carrier gas. Scrubber liquid collects in a phase separator from which sludge and organic liquid phases are pumped to a filter press, producing filter cake and filtrate. The filtrate is then separated into organic liquid and water phases. Most contaminants removed from the feed solids are transferred to the organic liquids or the filter cake. The filter cake is typically blended with the feed solids and reprocessed while the concentrated organic liquids are typically treated or disposed off-site (see Figure 3-4).

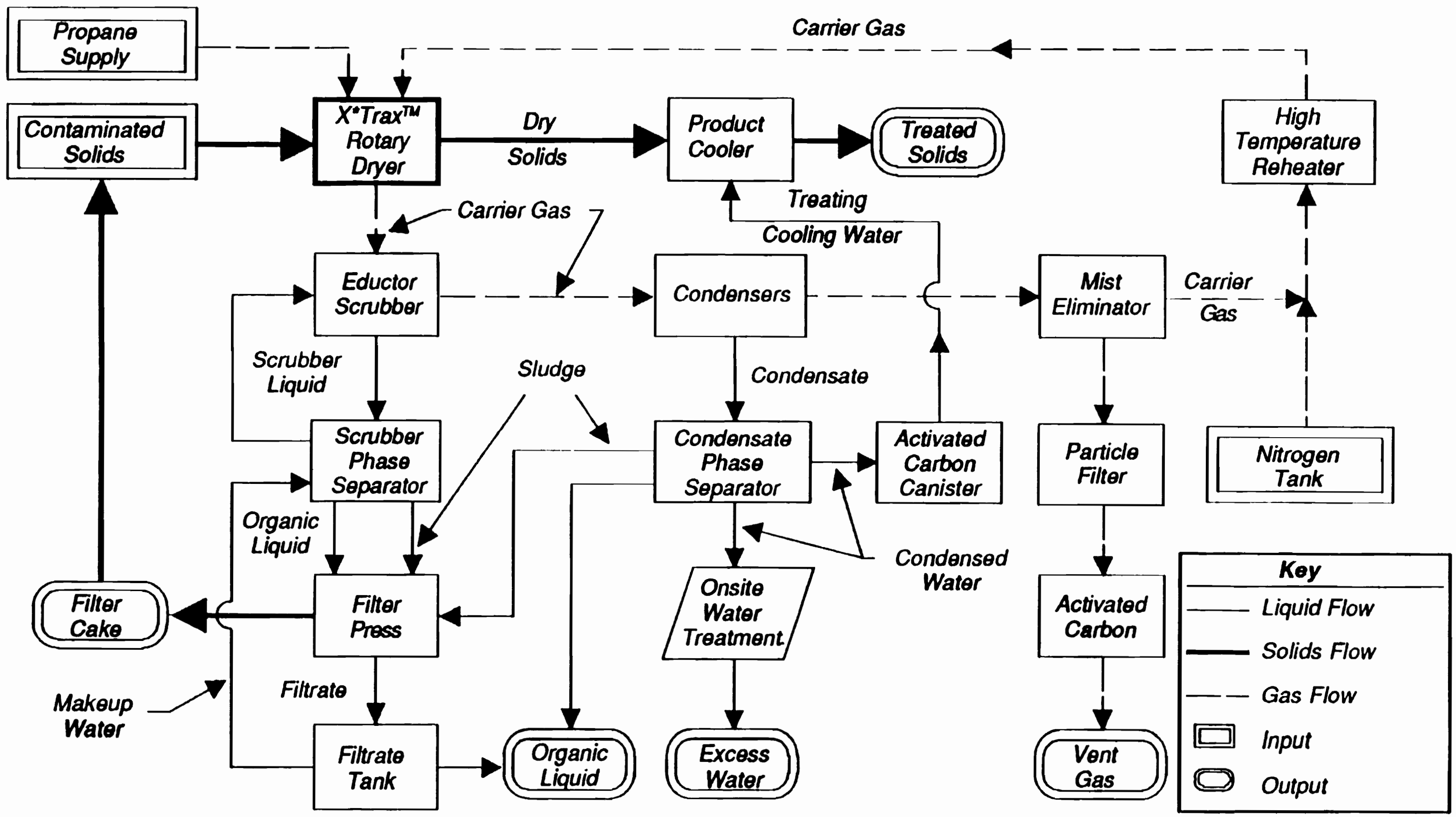
The X-TRAX process has demonstrated effectiveness in treating PCB contaminated soil at the Re-Solve Superfund Site in North Dartmouth, MA. The system was used to treat approximately 50,000 tons of contaminated soil. Although full-scale or pilot scale testing of nitrobenzene contaminated soil has not been conducted, laboratory scale testing of nitrobenzene contaminated soil has been demonstrated. Levels of nitrobenzene in soil were reduced from 43 ppm to less than 0.66 ppm. Similar results have been demonstrated for other contaminants detected in the Radio Tower Area, including other SVOCs, such as isomers of dichlorobenzene, 1,2,4-trichlorobenzene and naphthalene, and VOCs such as benzene, toluene and ethylbenzene.

Unlike solvent extraction, this process would not be affected by typical soil moisture content. Soil moisture content greater than 40% may reduce the process efficiency. Soil moisture content of soil in the Radio Tower Area is not believed to exceed 30%.

Although this process would not be effective in treating the elevated levels of metals, such as antimony which was detected in this area, it should not alter the levels or leachability of the metals. This process appears to be potentially applicable, but may require a treatability study and pilot study to prove its effectiveness on soil in the Radio Tower Area. Based upon this information, thermal desorption will be considered further.

3.1.6.5 - In Situ Soil Washing (Soil Flushing)

In situ soil washing is a process by which water or water containing a surfactant is applied to the unsaturated soil or injected into the groundwater to raise the water table into the



SOURCE: U.S. EPA DEMONSTRATION BULLETIN, FEBRUARY 1993

BUFFALO OUTER HARBOR
BUFFALO, NEW YORK

Dvirka and Bartilucci
Consulting Engineers
A Division of William F. Cosulich Associates, P.C.

THERMAL DESORPTION SYSTEM

FIGURE 3-4

contaminated soil zone. The process includes extraction of the groundwater and treatment/removal of the leached contaminants before the water/groundwater is recirculated.

The technology has been developed to treat nonhalogenated volatile organic compounds and inorganics. It may also be applicable to treat SVOCs, fuels and pesticides.

The technology is only applicable at sites in which flushed contaminants and soil flushing fluid can be contained and recaptured. Therefore, a low permeability boundary is generally required.

Limitations of the technology include the following:

- Low permeable soils are difficult to treat.
- Surfactants can adhere to soil and reduce effective soil porosity.
- Solvent reactions with soil can reduce contaminant mobility.
- Soil flushing is designed to mobilize and receive soluble contaminants in the aqueous phase, but not destroy them. The majority of contaminants likely remain sorbed to fines.
- Soil flushing may "loosen" or desorb, but not remove contaminants from the soil. This may actually increase their mobility in the subsurface.

As discussed above, soils in the Radio Tower Areas have been described as primarily fine coarse sand. In addition, although the native overburden material below the fill has a lower permeability, groundwater contamination has been detected in this material. Therefore, the geology of this area regarding a low permeability "floor" does not appear suitable for use of this technology. Since in situ soil flushing is only applicable to unsaturated soils, it will not be considered further.

3.1.7 Solidification

Solidification technologies may significantly reduce the mobility of inorganic hazardous wastes, but typically do not reduce the toxicity or volume of the wastes. These technologies may not be considered as a permanent remedy.

3.1.7.1 - Solidification

Solidification technologies generally utilize a cementitious matrix to encapsulate contaminants, thereby reducing their potential for leaching. These technologies treat contaminated soil or waste with Portland cement, cement kiln, pozzolans, etc., to produce a stable material. The solidified material experiences a volume increase, generally in the range of 10 to 30 percent. If the solidification process is performed on-site, the stabilized material could be disposed on-site. Although solidification is potentially applicable, the significant volume increase makes it less desirable than the stabilization/chemical fixation discussed below, and therefore, it will not be considered further.

3.1.7.2 - Stabilization/Chemical Fixation

In contrast to solidification, the chemical fixation technologies utilizes a process which involves more than immobilization. International Waste Technologies (IWT) has developed an advanced chemical fixation (ACF) process where organics are chemically bonded into and altered by an alumino-silicate matrix. IWT has a variety of ACF products that could be used for fixation of contaminants such as PCBs, halogenated organics, solvents, PAHs and heavy metals. The process utilizes standard solidification processing, however, the volume expansion and the associated dilution are minimized. The process can be customized to form materials ranging from pebble-sized granules to solid concrete. Volume expansions are usually in the 10 to 20 percent range. Volatilization of organics would likely not occur due to the low heat of reaction. Although the contaminants would be "fixed" and, once treated, would not exceed TCLP levels, the total concentrations of the contaminants of concern (including nitrobenzene) would likely not change.

Therefore, although the contaminants may not leach into the groundwater, the soil would still be a human health and environmental risk. Some type of cover over the material would be required. Therefore, because this technology would require significant handling, has not been demonstrated effective on nitrobenzene contaminated soil and does not provide additional protection over the low permeable cover alternative it will not be considered further.

3.1.8 Evaluation Summary of Remedial Technologies

In this section, the technologies described and evaluated above for each of the contaminated media in the Radio Tower Area are reviewed. Determinations are summarized with regard to which technologies may be most effective in this area. The technologies judged most effective will be combined into remedial alternatives and screened in accordance with the NYSDEC TAGM. A summary and screening of these technologies is presented in Table 3-1.

Based on the evaluation of remedial technologies for soil contaminants identified at the Radio Tower Area, there are a limited number of technologies that appear to be promising for remediation of the soils in this area. These technologies are containment (slurry wall and low permeability cover), excavation and off-site disposal or treatment, and thermal desorption. Institutional actions (fencing, posting of signs, deed restrictions and monitoring) would be combined with these alternatives. In addition, based upon available information on bioremediation, although this technology appears promising for the remediation of the nitrobenzene; however, its effectiveness has not been specifically demonstrated with regard to the treatment of nitrobenzene. Therefore, prior to considering this technology further as an appropriate remediation method, a treatability study was performed on a bench scale level to evaluate its effectiveness on remediating nitrobenzene in soil specific to the Buffalo Outer Harbor Site. The following section provides a description and results of the treatability study.

Table 3-1

BUFFALO OUTER HARBOR SITE
SUMMARY AND SCREENING OF
REMEDIAL TECHNOLOGIES
FOR THE RADIO TOWER AREA

Remedial Technology	Processing Options	Description	Primary Screening Comments
NO ACTION		No action (with fencing, posting of signs and monitoring)	Required for comparison of alternatives
INSTITUTIONAL ACTIONS			
SITE FENCING	None	Perimeter fencing to restrict site access	Potentially applicable
LEGAL RESTRICTIONS	Deed restrictions	Deed covenants to restrict site use	Potentially applicable
MONITORING	Groundwater sampling	Continued monitoring of select wells	Potentially applicable
ISOLATION/CONTAINMENT ACTIONS			
CAPPING	RCRA cap	Clay and synthetic membrane and soil cover	Potentially applicable
	Multimedia cap	Clay or synthetic membrane and soil cover	Potentially applicable, but will not be as effective as a RCRA cap
	Soil/gravel cover	Three feet of soil and/or gravel cover	Not applicable - will not reduce leaching of contaminants to groundwater
	Pavement/structure cap	Asphalt or concrete surface and gravel base	Potentially applicable, but will not be as effective as a RCRA cap
SUBSURFACE BARRIER	Slurry wall	Soil/bentonite slurry wall to limit horizontal migration of contaminated groundwater	Potentially applicable-groundwater contamination has potential to migrate to the surface water

Table 3-1 (continued)

BUFFALO OUTER HARBOR SITE
SUMMARY AND SCREENING OF
REMEDIAL TECHNOLOGIES

Remedial Technology	Processing Options	Description	Primary Screening Comments
REMOVAL ACTIONS			
REMOVAL	Excavation and off-site land disposal of soils	Contaminated soil placed in commercial RCRA permitted landfill facility	Potentially applicable for a portion of the soils
	Excavation and off-site incineration of soil	Organic contaminants destroyed at RCRA permitted incineration facility	Potentially applicable for a portion of soils
TREATMENT ACTIONS (SOIL)			
CHEMICAL/ PHYSICAL TREATMENT	Bioremediation	Degradation of organic contaminants in soils.	Potentially applicable to nitrobenzene contaminated soil.
	Solvent/Acid Extraction	Extraction of organic and inorganic contaminants from soils	Not applicable - not proven effective for nitrobenzene contaminated soil
	Soil Washing	Physical separation of contaminants from soils.	Not applicable - not proven effective for nitrobenzene contaminated soil
	Thermal Desorption	Thermal and physical separation of organic contaminants.	Potentially applicable to nitrobenzene contaminated soil.
	In Situ Soil Flushing	Physical separation of contaminants from soils in situ	Not applicable - not proven effective for nitrobenzene contaminated soil.

Table 3-1 (continued)

BUFFALO OUTER HARBOR SITE
SUMMARY AND SCREENING OF
REMEDIAL TECHNOLOGIES

Remedial Technology	Processing Options	Description	Screening Comments
SOLIDIFICATION/ CHEMICAL FIXATION	Solidification	Solidification of contaminated soil	Not applicable - not proven effective for nitrobenzene contaminated soil.
	Chemical Fixation/ Stabilization	Fixation of contaminated soil	Not applicable - not proven effective for nitrobenzene contaminated soil

3.2 Supplemental Investigation/Treatability Study

A supplemental investigation was undertaken to assess the viability of bioremediation as a means of achieving the clean-up objectives for the Radio Tower Area of the site, as well as to further define the volume of nitrobenzene contaminated soil in this area. The following sections present the results of the supplemental investigation and the results of the bioremediation treatability study.

3.2.1 Field Investigation Program

3.2.1.1 - Grid Survey

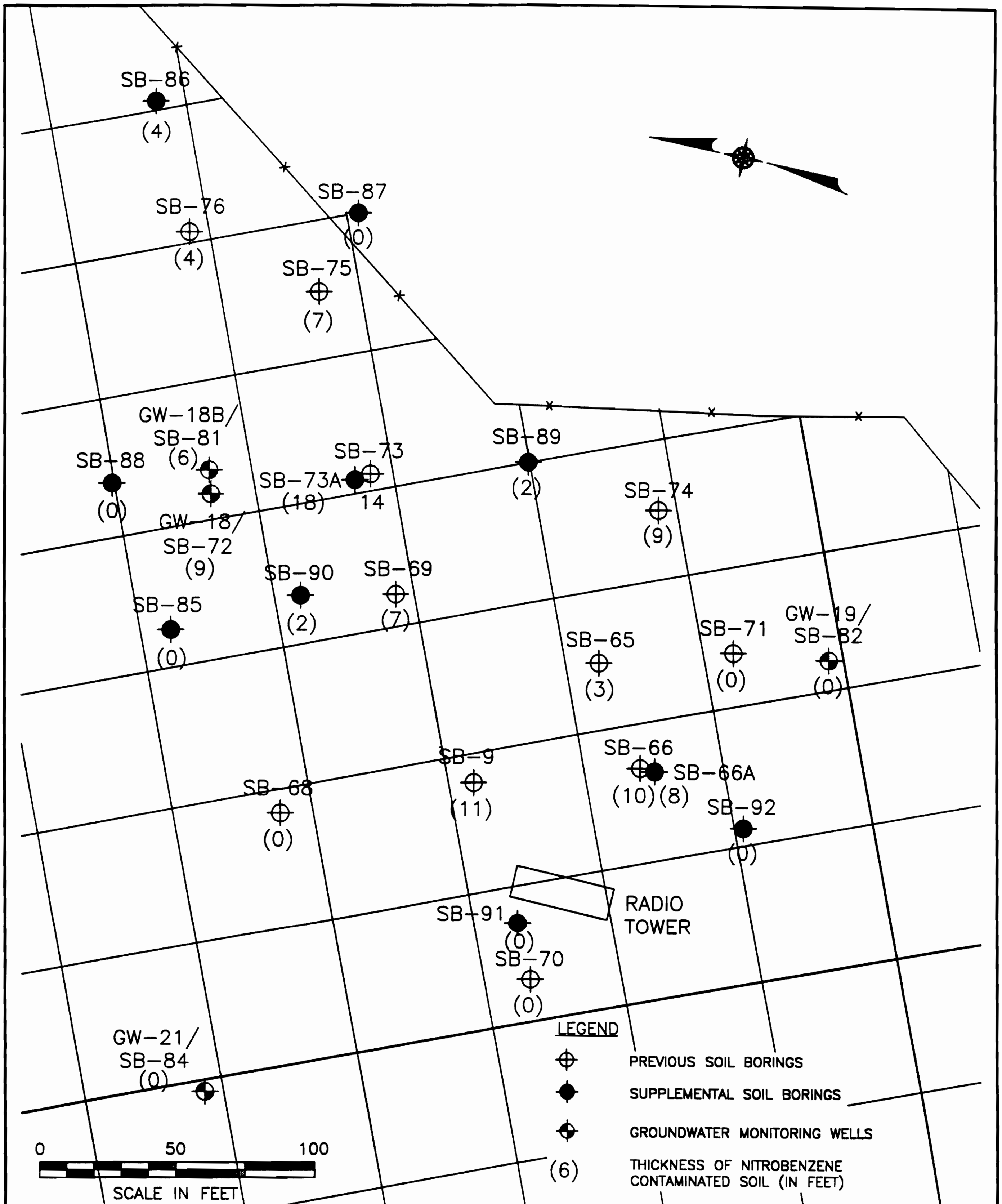
The 100-foot by 100-foot grid for the site was reestablished in the Radio Tower Area, by Y.E.C., Inc. of Valley Cottage, New York. Each of the newly constructed borings were surveyed in order to allow their incorporation on to the existing base map.

3.2.1.2 - Soil Boring Program

Soil borings were advanced at eight locations to better delineate the extent of nitrobenzene contamination. These supplemental borings were designated SB-85, through SB-92. In addition, two soil borings were constructed adjacent to SB-66 and SB-73, in order to collect soil samples for use in the treatability study. These borings were designated SB-66A and SB-73A. Soil boring logs are included as Appendix A. All prior and supplemental boring locations are shown on Figure 3-5. Each soil boring was drilled to the top of native material.

3.2.1.3 - Subsurface Soil Sampling

A composite sample was collected from the eight soil borings from the six split spoons collected from 10 to 22 feet. Each composite sample was analyzed for SVOCs. The composite



BUFFALO OUTER HARBOR
BUFFALO, NEW YORK

SUPPLEMENTAL SITE INVESTIGATION SOIL BORING LOCATIONS

Dvirka and Bartilucci
Consulting Engineers
A Division of William F. Cosulich Associates, P.C.

FIGURE 3-5

DIR: 1307 FILE: 13076C-1 RH-7/13/98

samples collected from SB-66A (12'-22') and SB-73A (10'-22') were also analyzed for TCLP SVOCs and TCLP metals.

One sample was collected for VOC analyses in SB-90. This sample, SB-90 (16'-18'), exhibited a VOC level greater than 5 ppm on the PID during field screening. No other samples exhibited elevated levels of PID readings.

Samples for inclusion in the bioremediation treatability study were collected from SB-66A and SB-73A. At SB-66A, two composite samples were collected and designated SB-66A-BS-1 (0'-12') and SB-66A-BS-2 (12'-22'). Each sample consisted of all recovered soil from 3-inch split spoons and cuttings from the augers within the interval, totaling 2.5 gallons of soil for each of the two samples. At SB-73A, three composite samples were collected and designated SB-73-BS-1 (0'-10'), SB-73A-BS-2 (10'-22') and SB-73A-BS-3 (0'-22'). SB-73A-BS-1 (0'-10') was derived from recovered soil from 3-inch split spoons within the interval and did not include cuttings from the augers. SB-73A-BS-2 (10'-22') was a composite of all recovered soil from the 3-inch spoons and cuttings from the augers within the interval. SB-73A-BS-3 (0'-22') was a composite comprised only of cuttings from the augers.

3.2.2 Nature and Extent of Contamination

3.2.2.1 - Subsurface Soil Results

The results of the chemical analyses are summarized below and are provided in Appendix B. Screening criteria used to determine the significance of analytical results were discussed in Section 1.4.

Exceedances of the screening criteria of 14 mg/kg for nitrobenzene were detected in soil samples SB-73A (10'-22'). The concentration detected was 3,200 mg/kg. Other concentrations of nitrobenzene below the screening criteria ranged from nondetect to 1.8 mg/kg.

The screening criteria for total polycyclic aromatic hydrocarbons (PAHs) of 100 mg/kg was exceeded for SB-73A (10'-22') and SB-89 (10'-22') at 5,228 mg/kg and 122 mg/kg, respectively. The remaining total PAH levels ranged from 5 mg/kg to 36.6 mg/kg.

Soil borings SB-87 (10'-22') and SB-89 (10'-22') exhibited levels of carcinogenic polycyclic aromatic hydrocarbons (CaPAHs) above the screening criteria of 10 mg/kg. The results were 13.86 mg/kg and 31.4 mg/kg, respectively. The other results for total CaPAHs varied between nondetect and 3.71 mg/kg.

The screening criteria for total SVOCs of 500 mg/kg was exceeded in SB-73A (10'-22') with a concentration of 9,249 mg/kg. The remaining results for total SVOCs ranged between 5.1 and 131 mg/kg.

The results of the analyses for the VOCs Toxicity Characteristic Leaching Procedure (TCLP) metals and TCLP SVOCs did not exceed the screening criteria.

3.2.2.2 - Data Validation and Usability

As discussed above, 10 soil boring samples were collected during the supplemental investigation. All of the samples were analyzed for SVOCs. Selected samples were also analyzed for VOCs, TCLP metals and/or TCLP SVOCs depending on sample location. The samples were analyzed by Ecology & Environment, Inc. at the direction of the NYSDEC.

The samples were analyzed in accordance with 12/91 NYSDEC ASP methods and QA/QC requirements. Several of the samples required reanalysis at secondary dilutions due to compound concentrations exceeding the instrument calibration range. The data from the initial analysis should be utilized with the exception of those compounds which exceeded the calibration range those values have been taken from the diluted analysis and have been flagged with a "D" on the sample results summary tables. All data are deemed valid and usable for environmental assessment as qualified above.

3.2.3 Volume of Nitrobenzene Contaminated Soil in the Radio Tower Area

Based upon the analytical results and visual observations of the subsurface soil in the Radio Tower Area, volume estimates of soil requiring remediation in this area were determined which indicate the following:

- approximately 3,000 cubic yards of contaminated soil will require on-site remediation or off-site incineration, since the concentration exceeded 14 mg/kg.

Volume calculations were determined by initially evaluating the thickness of observed contamination in the borings constructed in the Radio Tower Area. Field observations, including PID measurements, visual inspection and odor detection, were combined with analytical results to determine a thickness of contaminated soil in each boring. A total of 26 borings were evaluated. Results of the evaluation are summarized on Table 3-2.

The thickness of contaminated soil was contoured using Surfer Contouring Software. The volume of the contoured surface was also calculated using Surfer and was determined to be 3,000 cubic yards.

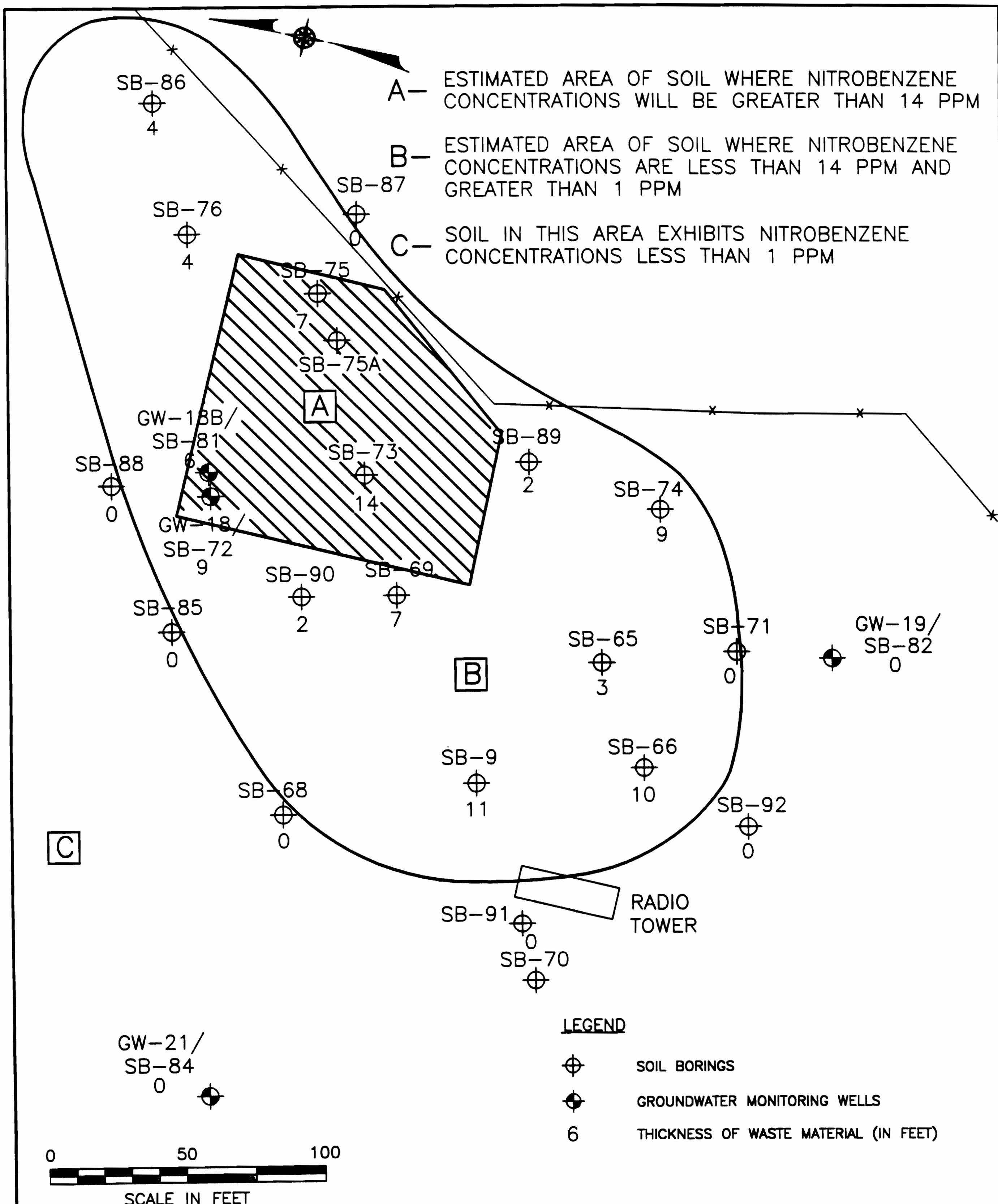
Figure 3-6 delineates an area encompassing three borings with laboratory results indicating nitrobenzene concentrations above 14 mg/kg (SB-72, SB-73 and SB-73A) and one boring, for which a sample was not analyzed in the laboratory, that contained field evidence of relatively high levels of contamination such as a shoe polish odor indicative of nitrobenzene and heavy black staining.

Zone B is an area of soil exhibiting nitrobenzene above 1 mg/kg and less than 14 mg/kg. The volume of Zone B was obtained by subtracting the volume of Zone A from the total volume of contaminated soil. The volume of Zone B is approximately 7,000 cubic yards.

Table 3-2
Evaluation of Areas with Nitrobenzene Contamination in the Radio Tower Area

Boring	Location		Ground Elev	Depth to		Elevation of		Thickness of nitro layer	Nitrobenzene concentration results	Field Observations	Clean Up Zone *
	Feet East	Feet North		nitro top	nitro bottom	nitro top	nitro bottom				
SB-09	9788	9740	582.00	11.2	22.2	570.8	559.8	11.0	14-16'=1,571 ug/kg		B
SB-65	9840	9704	582.60	17.0	20.0	565.6	562.6	3.0	0-8' =nd, 20-22'=nd	17-22' odor, black stain, PID	B
SB-66	9806	9682	582.30	11.0	21.0	571.3	561.3	10.0	0-8' =nd, 12-14'=6,900 ug/kg	11-21' odor, black stain	B
SB-66A	9809	9681	582.30	10.0	18.0	572.3	564.3	8.0	12-22'= <1,000 ug/kg	10-18' odor, black stain	B
SB-68	9763	9806	583.60	15.0	15.0	568.6	568.6	0.0	0-8'=nd, 10-12'=nd	0-26' no odor, no black stain	C
SB-69	9848	9782	582.40	14.0	21.0	568.4	561.4	7.0	0-8' =nd, 12-14'=nd	13-21' odor, black stain, PID	B
SB-70	9722	9704	582.90	15.0	15.0	567.9	567.9	0.0	0-8' =nd, 14-16'=nd	0-28' no odor, no black stain	C
SB-71	9854	9658	583.60	15.0	15.0	568.6	568.6	0.0	0-8'=nd, 14-16=nd	0-26' no odor, no black stain	C
SB-72	9870	9855	582.20	13.0	22.0	569.2	560.2	9.0	0-8' =nd, 16-18'=4,100 ug/kg, 18-20'=48,000 ug/kg	13-22' odor, black stain	A
SB-73	9889	9802	582.60	7.0	21.0	575.6	561.6	14.0	0-8' =nd, 10-12'=41,000ug/kg, 14-16'=1.3%	7-21' odor, black stain	A
SB-73A	9887	9800	582.60	4.0	22.0	578.6	560.6	18.0	10-22'=0.3 %	4-22' odor, black stain, PID	A
SB-74	9899	9695	583.30	5.0	14.0	578.3	569.3	9.0	0-8' <1,000ug/kg, 12-14'=nd	5-14' black stain	B
SB-75	9941	9826	582.10	7.0	14.0	575.1	568.1	7.0	No Sample	7-14' odor, black stain, sheen	A
SB-76	9961	9883	582.90	16.0	20.0	566.9	562.9	4.0	No Sample	16-20' odor, black stain, PID	B
SB-81	9878	9858	584.70	15.0	21.0	569.7	563.7	6.0	0-2'=nd, 20-22'=nd	15-21' black stain, PID	A
SB-82	9859	9623	584.20	15.0	15.0	569.2	569.2	0.0	0-2'=nd, 14-16'=nd	0-18' no odor, no black stain	C
SB-83	10044	10021	585.30	15.0	15.0	570.3	570.3	0.0	0-2'=nd, 14-16'=nd	0-18' no odor, no black stain	C
SB-84	9657	9811	584.00	15.0	15.0	569.0	569.0	0.0	0-2'=nd, 14-16'=nd	0-18' no odor, no black stain	C
SB-85	9815	9856	583.40	15.0	15.0	568.4	568.4	0.0	10-22'<1,000 ug/kg	0-22' no odor, no black stain	C
SB-86	10004	9902	582.63	8.0	12.0	574.6	570.6	4.0	10-22'<1,000 ug/kg	8-12' odor, black stain	B
SB-87	9977	9823	582.88	15.0	15.0	567.9	567.9	0.0	10-22'<1,000 ug/kg	0-22' no odor, no black stain	C
SB-88	9861	9888	584.64	15.0	15.0	569.6	569.6	0.0	10-22'=nd	0-22' no odor, no black stain	C
SB-89	9907	9744	582.36	10.0	12.0	572.4	570.4	2.0	10-22'=nd	10-12' odor, black stain	B
SB-90	9843	9815	582.03	14.0	16.0	568.0	566.0	2.0	10-22'=1,800 ug/kg	14-16' odor, black stain	B
SB-91	9743	9711	581.76	15.0	15.0	566.8	566.8	0.0	10-22'<1,000 ug/kg	0-22' no odor, no black stain	C
SB-92	9793	9641	582.46	15.0	15.0	567.5	567.5	0.0	10-22'<1,000 ug/kg	0-22' no odor, no black stain	C

* Clean up zones: A - Contaminated soil exhibits or is suspected to exhibit concentrations of nitrobenzene greater than 14 ppm. This soil is assumed to fail leachability testing.
B - Soil in this zone is expected to be less than 14 ppm and greater than 1 ppm.
C - Soil in this zone exhibits levles of nitrobenzene less than 1 ppm.



DIR: 1307 FILE: 13076C-2 RH-7/13/98

BUFFALO OUTER HARBOR
BUFFALO, NEW YORK

AREA REQUIRING REMEDIATION

Dvirka and Bartilucci
Consulting Engineers
A Division of William F. Cosulich Associates, P.C.

FIGURE 3–6

For the purposes of development of the remedial alternatives, it is assumed that only the most highly contaminated soil will be remediated (Zone A only). It is also assumed that the volume of soil would increase approximately 20% due to over excavation and mixing during removal. Therefore, the total volume of soil requiring remediaton is assumed to be 3,500 cy.

3.2.4 Bioremediation Treatability Study Results

The bioremediation treatability study was performed by Grace Bioremediation Technologies of Mississauga, Ontario, Canada. A copy of the treatability study report is provided in Appendix C. A summary of the results of the report are provided below.

The initial concentration of the soil obtained from the site was 433 mg/kg of nitrobenzene. This sample was obtained by blending/mixing equal amounts of soil obtained from SB-73A and SB-66A. Within 14 days of application of the treatment additive (DARAMEND), the concentration of nitrobenzene was reduced by 77.4% to 97.8 mg/kg. Following 56 days of treatment the concentration of nitrobenzene was reduced by 99.3% to less than 3 mg/kg. Soil characteristics, such as soil type and concentrations of metals in the soil, did not appear to affect the treatment process. Based on the results of the laboratory scale study, Grace Bioremediation Technologies recommended that a field scale treatment be performed. Grace estimated that on a full scale level the nitrobenzene concentration in the soil, if comparable to the level used in the treatability study, could be reduced to less than 14 mg/kg in 90 days.

Based upon the results of the supplemental investigation and treatability study, bioremediation will be evaluated as an applicable technology/alternative for the Radio Tower Area.

3.3 Excavation and Backfill Evaluation Summary

Based on the screening of remediation technologies discussed in the previous sections, each of the technologies to be evaluated in detail for remediation of the Radio Tower Area will require excavating contaminated soil for either treatment on-site or disposal off-site. Once excavated, the open excavation will need to be backfilled with either treated soil or clean off-site backfill.

As discussed above, the volume of soil requiring remediation is 3,500 cy. This material is located 4 to 22 feet below the ground surface in an area of approximately 110 feet by 100 feet. The water table in this area is approximately 8 feet below ground surface. Overlying soil will need to be removed and staged on-site in order to excavate the underlying contaminated soil.

In order to select the most appropriate and cost effective excavation and backfill option an evaluation of four excavation techniques and four backfill techniques was performed. Combining the alternatives allowed for a total of 16 variations of excavation and backfill options to be evaluated. This section presents a summary of the evaluation. The complete evaluation is provided in Appendix D.

The excavation evaluation consisted of evaluating alternatives that utilized variations of open excavations and sheet piling combined with and without dewatering. Each of the alternatives assume that the work will need to be completed within a sprung structure and will need to be completed in level B. The four excavation alternatives evaluated included the following:

Alternative A: Open excavation to 8 feet and sheet piling to 22 feet (with dewatering).

Alternative B: Open excavation to 22 feet (without dewatering).

Alternative C: Sheet piling entire excavation to 22 feet (with dewatering).

Alternative D: Sheet piling 50 foot by 55 foot cells and excavating within each cell (with dewatering).

The backfill alternatives included evaluating the sequencing for replacement of the soil. The four backfill alternatives included the following:

Alternative 1: Replacement of overlying soil first, followed by treated soil.

Alternative 2: Replacement of treated soil first, followed by overlying soil.

Alternative 3: Replacement of overlying soil first, a portion of the treated soil second, followed by 3 feet of clean backfill.

Alternative 4: Replacement of overlying soil, followed by clean backfill.

As shown, Alternatives 3 and 4 included disposal of a portion of or all of the treated soil off-site. These alternatives were considered in order to address concerns with regard to exposure to residual contaminants that may remain in the soil once it has been treated.

Each of the combined alternatives were evaluated based upon the ease of implementation, impacts to the site and surrounding areas as well as cost.

Based upon the results of the evaluation, Alternative B (Open excavation) would be the most costly excavation alternative to implement primarily due to the cost of providing for a sprung structure over the excavation which is significantly larger than the alternatives that include sheeting due to the required side slopes. The cost for the three remaining excavation alternatives are all competitive. Alternative C (sheet piling entire excavation) appears to be the least expensive alternative.

Regarding the backfill alternatives, in general, the cost for each of the alternatives are competitive. The cost for keeping the excavation open (Alternative 2) for an estimated treatment period of 6 months does not significantly impact the overall cost for excavation with one exception. Alternative D2 is significantly higher in cost since additional sheet piling would be purchased to install all four cells instead of the remaining alternatives (D1, D3 and D4) which reuse sheet piling for the second two cells after the completion of the first two cells.

Based on the evaluation, the cost for excavating and backfilling the soil in the Radio Tower Area is approximately $2,000,000 with a few exceptions as noted above. Although the evaluation of alternatives recommends utilization of Alternative C2 (Sheet piling entire excavation and replacement of the treated soil first), implementation of any of the other alternatives would not significantly impact the cost or timing of the project. Therefore, each of the remedial alternatives evaluated in the following sections will not identify a specific excavation/backfill techniques, but will include a cost of $2,000,000 for excavation and replacement of the soil.

3.4 Description of Remedial Alternatives

Based on the screening of remedial technologies in the previous section, four remedial alternatives (containment, excavation and off-site disposal, on-site thermal desorption and on-site bioremediation), in addition to deed and access restrictions and no action, were developed for the Radio Tower Area. Each of the alternatives addressed primarily the subsurface soil contamination in this area, but also considered groundwater contamination.

The qualitative risk assessment conducted as part of the remedial investigation indicated that exposure to subsurface soil in the Radio Tower Area poses a significant risk to human health and the environment, due to the potential for direct contact. In addition, although there is documented groundwater contamination in this area, the contamination does not appear, at the present time, to be migrating to nearby surface waters (Buffalo Outer Harbor) and is not being utilized as a potable water supply source. Therefore, groundwater remediation, other than containment, including groundwater extraction and treatment for containment purposes, and for dewatering activities in this area, has been deemed not necessary and has not been evaluated.

The following sections describe the remedial alternatives developed for the Radio Tower Area.

3.4.1 Alternative 1 - No Action

Under this alternative, the contaminated soil and groundwater in the Radio Tower Area would remain in its present condition and no remedial activities would be performed. No contamination within this area would be removed, treated or contained. Due to the concentrated, persistent and relatively immobile nature of the contaminants in the Radio Tower Area (nitrobenzene and antimony), it is not believed that natural attenuation (dilution, dispersion or degradation) would be effective in reducing potential human health and environmental risks associated with this area of the site.

3.4.2 Alternative 2 - Deed and Access Restrictions

Under this alternative, limited response actions would be implemented, including deed restrictions to prohibit development and use of the Radio Tower Area, access restrictions, such as placement of fencing around the area of concern, posting of signs warning the public of the presence of hazardous waste and monitoring. Monitoring would comprise sampling of the wells in the Radio Tower Area for a 30-year period.

3.4.3 Alternative 3 - Soil Excavation and Off-site Disposal

Under this alternative, approximately 3,500 cubic yards of contaminated soil from depths varying between 4 and 22 feet below ground surface would be excavated and disposed off-site. An additional 4,500 cy, varying between 0 and 10 feet, would also be excavated in order to reach the highly contaminated soils. Due to the significantly elevated levels of nitrobenzene detected in the deeper soil in this area, including levels determined to exceed the TCLP limits for both nitrobenzene and 2,4-dinitrotoluene as well as levels above the Land Ban, it is likely that all of the soil removed from the lower strata will need to be incinerated. It is likely that the weight of saturated soil would be about 1.0 ton per cubic yard.

As discussed in Section 3.3 and Appendix D, there are various methods available for excavation and backfilling of this material. Final decision on the methods of excavation and backfilling to be utilized will be made during remedial design.

Excavation of the soil from the Radio Tower Area would require coordination with the Niagara Frontier Transportation Authority (NFTA), particularly if the radio tower is still intact. Based on current information, the radio tower is scheduled for removal. Coordination would also be required with respect to maintenance of active power lines that run through the area that are owned/operated by the Niagara Mohawk Power Corporation, and telephone and electric lines that currently service portions of the Port Terminal A building. Discharge of groundwater from any required dewatering process will likely be to the municipal sanitary sewer system and will require approval/coordination with the Buffalo Sewer Authority.

As discussed in Section 3.3 and Appendix D, due to the elevated levels of volatile and semi-volatile organic contamination detected in the Radio Tower Area, it is likely that it will be necessary to install a temporary vapor control structure over the area of excavation. Dust control would also be a concern due to the elevated levels of metals, PCBs and PAHs detected in this area. For dust control during excavation, soils would require periodic wetting or other control measures to reduce emissions. Soils, if temporarily stockpiled, would require cover, as well as a liner. During excavation of the material, workers would likely be required to work in levels of personal protective equipment higher than Level D (i.e., Level C or Level B). For the purposes of estimating costs for the alternatives, Level B personal protective equipment is assumed.

After excavation and removal of the contaminated soil from the site, the excavated area would be backfilled to grade and vegetative cover would be established at the site.

3.4.4 Alternative 4 - Containment

For this alternative, the contaminated soil in the Radio Tower Area would remain in place and be contained and isolated by construction of a low permeability RCRA cap and slurry wall.

It is estimated, based on current information, that the cap and slurry wall would be placed over and around approximately 7,000 square yards. The length of the slurry wall would be about 1,000 feet.

To establish a 4% minimum slope for the cap, contour grading material would need to be placed within the area to be capped. The grading material would need to be transported to the site.

The slurry wall would be constructed around the perimeter of the contaminated subsurface soil within the Radio Tower Area (primary area of concern) to a depth of 40 feet and keyed into the lower permeability native material underlying the area. The cap would extend over the edges of the slurry wall, containing the contamination within this area.

To further mitigate the potential migration of contaminated groundwater beyond the Radio Tower Area, groundwater extraction wells would be placed within the area of the slurry wall to reduce the groundwater head inside of the slurry wall to less than that outside of the wall. This would ensure that any migration of groundwater would be into the area of the slurry wall and not outside of the wall. Extracted groundwater may need to be treated before discharge to the municipal sewer system.

Due to the elevated levels of metals, PCBs and PAHs detected in the surface and subsurface soils in this area, dust control would be required if excavation and grading of these soils were necessary. Dust control would comprise periodic wetting or other measures to reduce emissions. Soil, if temporarily stockpiled, would require a cover and liner.

A program for maintenance of the cap would be required to prevent and repair any damage to the cap. Coordination with NFTA and the Niagara Mohawk Power Corporation would be necessary during construction of the containment system. Coordination would also be required with the Buffalo Sewer Authority for discharge to the municipal sanitary sewer system.

3.4.5 Alternative 5 - Thermal Desorption

For this alternative, approximately 8,000 cubic yards of soil would be excavated from the Radio Tower Area. Soil exhibiting elevated levels of nitrobenzene from approximately 4 to 22 feet below ground surface (3,500 cy), would be excavated and treated on-site utilizing a mobile thermal desorption system. Soil excavated from the upper strata would be stockpiled for replacement in the excavation.

In the thermal desorption process, the organic compounds are thermally and physically separated from the soil particles by volatilization or evaporation. The condensed liquids containing the organic contaminants are transported off-site for disposal. As discussed in Section 3.1.6.4, thermal desorption would not remove the inorganic contaminants from the soil. Therefore, the remaining organically clean soil would be analyzed prior to on-site replacement to determine the need for stabilization if the soils fail TCLP for metals. A vegetative cover or pavement cover would be placed over the backfilled material.

As discussed above, excavation of the soils from this area would require coordination with the NFTA and Niagara Mohawk Power Corporation with regard to the radio tower and other utility lines in this area. Coordination with the Buffalo Sewer Authority would also be required for discharge to the municipal sanitary sewer system.

Due to the significantly elevated levels of volatile and semivolatile organic contamination detected in the deep subsurface soil in this area, it is assumed that it will be necessary to install a vapor control structure over the area of excavation. Dust control would also be a concern due to the elevated levels of contaminants detected on the soil in this area. Dust control would require wetting and temporary cover if stockpiled. Excavated soil would require a liner/containment system prior to treatment. Level B personal protective equipment is assumed.

3.4.6 Alternative 6 - Bioremediation

For this alternative, approximately 8,000 cubic yards of soil would be excavated from the Radio Tower Area and soil contaminated with nitrobenzene (3,500 cy) would be treated through bioremediation in an on-site treatment cell. Soil excavated from the upper strata would be stockpiled for replacement in the excavation.

The soil will be placed in a lined treatment cell. Soil would be treated by a bioremediation treatment process. This process would reduce the nitrobenzene in the soil to below 14 mg/kg. Once treated the soil would be analyzed for residual organic contamination and inorganics and replaced on-site, if appropriate. A vegetative cover or a pavement cover would be placed over the material after backfilling.

As discussed above, excavation of the soil from this area would require coordination with the NFTA and Niagara Mohawk Power Corporation with regard to the radio tower and other utilities. Coordination with the Buffalo Sewer Authority would also be required for discharge to the municipal sanitary sewer system.

Due to the significantly elevated levels of volatile and semivolatile organic contamination detected in this area, it will likely be necessary to install a vapor control structure over the area of excavation, area of stockpiled soil and/or the treatment cell. Dust control would also be required and would likely be in the form of wetting and use of temporary covers. Level B personal protective equipment is assumed.

3.5 Detailed Evaluation of Alternatives

The following detailed evaluation of alternatives provides the basis for selection of the remedial action plan for the Radio Tower Area. A comparative analysis comprised of an assessment of the alternatives against seven evaluation criteria, as defined in the New York State Department of Environmental Conservation (NYSDEC) Technical Assistance Guidance Memorandum (TAGM) for the Selection of Remedial Actions at Inactive Hazardous Waste Sites (HWR-90-4030), is presented below. This evaluation process identifies the overall feasibility, acceptability and cost of the remedial alternatives being evaluated, and determines the relative performance of these alternatives and limitations between the alternatives.

3.5.1 Compliance With New York State Standards, Criteria and Guidelines

Both chemical and action specific standards, criteria and guidelines (SCGs) have been identified for the Radio Tower Area. The chemical specific and action specific SCGs are defined in Section 1.4. Compliance of each of the remedial alternatives with the SCGs is discussed below.

3.5.1.1 - Chemical-specific SCGs

Chemical specific SCGs are typically health or risk based criteria or methodologies which, when applied to site specific conditions, result in the establishment of numerical values. These values establish the acceptable amount or concentration of a chemical that may remain in or be discharged to the environment.

Based upon the soil screening criteria selected for selected for the Buffalo Outer Harbor Site, it is estimated that approximately 8,000 cy of surface/subsurface soil in the Radio Tower Area exceed the criteria. The remedial action alternatives selected for the Radio Tower Area, and their applicability to these guidelines, are presented below.

Alternatives 1 and 2, no action and deed and access restrictions, would not meet any of the chemical specific SCGs for soil or groundwater at the site as the contaminated surface and subsurface soils, and groundwater exceeding remediation guidelines would remain in place. Alternative 1 would also not protect human health or the environment, however, Alternative 2 would limit access to the property and therefore would provide limited protection of human health and the environment.

SCGs for the protection of health and groundwater at the site would be achieved under Alternative 3 (off-site disposal). Alternative 5 (thermal desorption) and 6 (bioremediation), in which excavation and on-site treatment would be implemented would achieve the SCGs for the organic contaminants in the subsurface soil. Excavation and off-site disposal would require end point sampling to determine if SCGs for soil were achieved. Excavation and bioremediation or thermal desorption would also require endpoint sampling, as well as the sampling of treated soils to determine if SCGs for subsurface soil were achieved. Although thermal desorption (Alternative 5) and bioremediation (Alternative 6) would meet the SCGs for the organic contaminants, they would not meet the SCGs for the inorganic contaminants and would not meet the SCGs for the surficial soils which would not be treated. Exposure through surface contact with these soils would be addressed through installation of a vegetative or pavement cover. Although the treatability study has indicated that bioremediation would significantly reduce the levels of nitrobenzene and is expected to meet the SCGs, it may not be as effective at meeting the SCGs at the full scale level.

For Alternative 4, containment would eliminate surface contact with contaminated soil and protect human health and the environment. However, since the contaminated soils would remain in place, the SCGs for soil and groundwater would not be achieved.

In addition to soil and groundwater SCGs at the site, there are also chemical specific SCGs regarding air emissions. These SCGs are intended to ensure that no remedial action results in an unacceptable degradation of air quality. All the alternatives, with the exception of the no action alternative, include excavation/grading and handling of contaminated soil. These activities can result in the release of vapors and dust in sufficient quantities to require engineering controls to prevent exceedance of air quality SCGs. Alternatives 3, 5 and 6 also include excavation of soil with elevated levels of VOCs and SVOCs, such as benzene and nitrobenzene. The excavation of soil with these contaminants would likely require vapor control and treatment. Controls would include the use of dust suppressants and temporary structures with vapor controls. A determination prior to the implementation of any alternatives requiring soil disturbance would be made to identify the potential for site soils to generate dust and vapors, and the degree of control required during remediation. It is believed that engineering controls can be used and will be effective to prevent contravention of air SCGs.

In summary, Alternative 3 would achieve soil SCGs at the site. Alternative 5 would achieve the SCGs for organics for subsurface soils, but not for inorganics or for surface soils. Alternative 6 would likely achieve the SCGs for organics for subsurface soils, but not inorganics or for surface soils. Alternative 4, which involves containment/isolation, does not achieve SCGs, but attempts to reduce concentrations and migration of contaminants in groundwater by placement of the cap and slurry wall. Alternatives 1 and 2 do not achieve the SCGs.

3.5.1.2 - Action-specific SCGs

All of the remedial alternatives would be designed and implemented to comply with action specific SCGs at the site (see Section 1.4). Alternative 3 (excavation and off-site disposal) which requires transportation of the excavated contaminated material off-site, would comply with 6 NYCRR Part 364 and the U.S. Department of Transportation regulations regarding shipment of hazardous waste and hazardous materials. These alternatives would also comply with any disposal restrictions and all material would be disposed of at a permitted facility. Alternatives 3, 4 (containment), 5 (thermal desorption) and 6 (bioremediation) include activities that may release contaminated vapors and/or dust. Air emissions during these activities would be regulated under the NYSDEC's Air Guide-1 (NYSDEC, 1991), Ambient Guideline Concentrations (AGCs) and National Emission Standards for Hazardous Air Pollutants (NESHAPS). New York State or local nuisance, odor or noise regulations may also be applicable during the remedial action. NYSDEC Division of Hazardous Waste Remediation Technical and Administrative Guidance Memoranda (TAGM) 4031 - Fugitive Dust Suppression and Particulate Monitoring Program at Inactive Hazardous Waste Sites would also be applicable during the remedial action. Discharge of groundwater would meet the sewer use requirements/ordinance of the municipal sewer system.

In summary, it is believed that all alternatives, including no action and institutional actions, would achieve action-specific SCGs.

3.5.2 Overall Protection of Human Health and the Environment

Remediation of the Radio Tower Area by implementing the selected alternatives, except for no action, would provide for protection of human health and the environment resulting from ingestion and inhalation of, and dermal contact with contaminated soil to varying degrees as well as impacts to groundwater.

Alternative 4 provides protection to human health and the environment by isolating the contaminated soils through containment and preventing contact with and migration of these soils, as well as groundwater. Alternative 3 removes contaminated soils off-site and would effectively eliminate direct exposure pathways based upon exposure to site surface and subsurface soils and would eliminate future impacts to groundwater. Alternatives 5 and 6 treat contaminated soils and would also effectively eliminate direct exposure pathways based on contact to direct exposure surface and subsurface soils. Alternative 3 provides more protection than Alternatives 5 and 6, since this alternative involves removal of contaminated materials exceeding remediation guidelines off-site and would eliminate any potential for exposure to contaminated residuals. Although Alternatives 5 and 6 treat the contaminated soil, some contamination, such as metals, would remain in the soil.

In summary, Alternative 3, (off-site disposal) relative to the site, is the most protective of human health and the environment since all significantly contaminated soil is removed off-site. Of the remaining alternatives, Alternatives 5 and 6, respectively, would be the most protective of human health and the environment, because they would eliminate potential exposure by treatment; however, some residual contamination could remain. Alternative 6 (bioremediation) would be less protective than Alternative 5 (thermal desorption), because although shown to be effective on a bench scale level it may not be effective on a full scale on reducing the contaminants to below the remediation levels. Alternative 4 (containment) would eliminate surface soil exposure routes and groundwater migration routes of exposure. Alternative 2 (deed and access restrictions) would provide limited protection of human health and the environment by limiting access to the site. Alternative 1 (no action) would not provide any protection of human health or the environment from contaminated soils at the site and would not mitigate migration of contaminated groundwater from the site.

3.5.3 Short-term Impacts and Effectiveness

During construction activities associated with Alternatives 3 (off-site disposal), 4 (containment), 5 (thermal desorption) and 6 (bioremediation), access to the site would be restricted to minimize potential for exposure to contaminants. Site remediation workers would be protected through use of appropriate respiratory and dermal contact protection equipment and clothing as required by the Occupational Safety and Health Administration (OSHA), and a site specific health and safety plan to be developed by the remedial contractor prior to construction. The environment would be protected through measures to prevent fugitive emissions, such as dust suppression and temporary structures with vapor controls, and runoff of contaminated material, such as erosion controls and temporary liners and covers. During transportation of contaminated soil for off-site disposal/treatment, truck trailers would be lined and tarps would be placed over the trailers.

During construction activities associated with Alternative 4, a limited volume of surface and subsurface soils exceeding the SCGs would be excavated, regraded and covered, and a slurry wall would be installed. These activities would occur over a short period likely to be about 6 months. Construction of the low permeability cap and slurry wall would utilize clean material, and therefore, impacts would be more of a nuisance than health or environmental based; however, mitigation measures, including dust and erosion controls would be implemented.

Alternative 3 involves the excavation and off-site disposal of up to 8,000 cy of material and would take about 2 months. During this time, a significant number of trucks (over 200 - 40 cubic yard trailers) would need to travel to and from the site. However, the site is in an industrial and mostly undeveloped area, and adjacent to a major roadway, and therefore, there would be little impact to surrounding areas.

Alternative 5 involves the excavation and on-site treatment of the contaminated soil. This alternative would take about 11 months. Alternative 6 also involves the excavation and on-site treatment of contaminated soil. However, it is anticipated that bioremediation would reduce the contaminants in the soil to below remediation levels within 6 months, therefore, the alternative would take approximately 8 months to implement (2 months for excavation and 6 months for treatment).

Alternative 5 would take longer to implement and complete than Alternatives 3, 4 and 6, and therefore, the adverse short-term impacts could potentially be greater.

All alternatives would be protective of the community, environment and on-site workers with appropriate controls/mitigation measures, but the shorter the construction period, the less the risk of short-term adverse impacts. In summary, since Alternative 1 will require no activity, there will be no short-term impacts due to construction. Alternative 2 will have limited activity, fence installation, and therefore generate little short-term impacts. Alternative 4 provides limited disturbance of site soils, and therefore, would also generate a low degree of short-term impacts. Although Alternative 5 would require more and longer handling of contaminated soils on-site than Alternative 3, Alternative 3 would create significant truck traffic and, therefore, would have greater potential off-site/short-term impacts. Finally, Alternative 6 would require handling of contaminated soil, but would likely take less time than Alternative 5 and therefore have less short-term impacts.

3.5.4 Long-term Effectiveness and Permanence

3.5.4.1 - Permanence

According to NYSDEC TAGM 4030, destruction technologies and separation/treatment technologies are considered permanent remedies for contaminants. On-site containment/isolation is not considered a permanent remedy, because the low permeability cover and slurry likely has a limited lifetime and will require periodic maintenance, and will not destroy the contaminants. Since the contaminated soil in Alternative 3 will be removed off-site, this alternative is considered permanent with respect to the site. In addition, a substantial amount of the soil would likely be incinerated. Alternative 5 (thermal desorption) would treat nitrobenzene contaminated soils and remove contaminated residues off-site for disposal, and any residual contamination (metals), and surface soils that exceed SCGs, would remain on-site. Therefore, this alternative would also be considered permanent with respect to the nitrobenzene contamination at the site. Alternative 6 (bioremediation) would also treat the nitrobenzene contaminated soils with no remaining residuals requiring off-site disposal. Inorganic contamination and surface soils that exceed SCGs, would remain on-site. Therefore, Alternatives 6, 5 and 3, respectively, would be considered the most permanent and effective in the long term followed by Alternatives 4 (containment), 2 (deed and access restrictions) and 1 (no action), respectively.

3.5.4.2 - Waste Remaining at the Site

Alternative 3 provides the least amount of contaminated soil remaining at the site. Excavation conducted as part of this alternative will continue until end point sampling indicates that all contaminated soil exceeding the cleanup criteria have been removed. Alternative 6 (bioremediation) would treat all organic contaminated soil and although metals would remain untreated, they would not increase. Alternative 5 (thermal desorption) also provides on-site treatment of the nitrobenzene contaminated soil, but inorganic contaminants in this soil will remain untreated. Alternative 4 (containment) involves on-site containment/isolation utilizing a low permeability cover and slurry wall. This alternative does not treat any of the contaminated soils which will remain in the area. Therefore, Alternatives 3, 5, 6 and 4, respectively, provide decreasing degrees of prevention of exposure to and migration of contaminants, because of increasing amounts of contaminated soil remaining at the site. Similar to Alternative 4, Alternatives 1 (no action) and 2 (deed and access restrictions), also leave all contamination in the area, but provides no protection.

3.5.4.3 - Environmental Controls

Alternative 4 is the only remedial alternative which requires significant post-remediation maintenance. Alternative 4 would require maintenance of the low permeability cap and possibly the slurry wall, as well as groundwater monitoring. Alternative 2 would also require groundwater monitoring. Alternative 3 (off-site disposal) would not require post-remediation maintenance, but would likely require some monitoring to document the effectiveness of this alternative.

Alternatives 5 (thermal desorption) and 6 (bioremediation) would require some maintenance of the surface cover, as well as monitoring to document the effectiveness.

In summary, Alternative 3 (off-site disposal) is judged to be the most effective in the long term for remediation of soil contamination in the Radio Tower Area, requiring little or no long-term monitoring/maintenance, and is considered a permanent remedy with respect to the site, because contaminated soils will be removed and likely treated (at least in part) off-site. Alternatives 5 and 6 would be next effective in the long-term. Although Alternatives 5 and 6 would treat contaminated soils for organic contaminants, inorganic contaminant levels may not be reduced to levels below site SCGs. On-site containment with a low permeability cap and slurry wall (Alternative 4) is not considered permanent, but would mitigate contaminant exposure and migration. The No Action Alternative (Alternative 1) and deed and access restrictions (Alternative 2) would not be effective in the long term.

3.5.5 Reduction of Toxicity, Mobility and Volume

3.5.5.1 - Reduction of Toxicity

On-site containment (Alternative 4), deed and access restrictions (Alternative 2) and no action (Alternative 1) would not reduce the toxicity of the wastes and contaminated soils; however, containment would provide reduced exposure to and migration of the contaminants. For Alternative 3, contaminated soils would be removed/destroyed off-site, and Alternatives 5 (thermal desorption) and 6 (bioremediation) would reduce organic contaminants in the soil. Therefore, Alternative 3 would be the most effective in reducing toxicity followed by Alternatives 5 and 6, 4, 2 and 1, respectively.

3.5.5.2 - Reduction of Mobility and Volume

Alternatives 3, 4, 5 and 6 would reduce the mobility of the contaminants in soil at the site through removal/destruction, isolation with physical barriers and treatment, respectively. The degree of effectiveness in reduction of contaminant mobility would be in the following descending order: Alternatives 3, 6, 5, 4. The volume of the contaminants would remain unchanged for Alternative 4, but would be reduced for Alternatives 3, 6 and 5, respectively. Alternative 5 would have residual waste that requires off-site disposal. No action (Alternative 1) and deed and access restrictions (Alternative 2) would not reduce the mobility or volume of the contaminants.

3.5.5.3 - Reversibility

Alternatives 5 and 6 provide treatment of the organic contamination at the site, but would not reduce levels of inorganic contamination. Since Alternative 4 does not destroy soil contaminants at the site, it is considered reversible, but isolates the contaminants. Alternative 3 removes all contaminants from the site and is considered irreversible with regard to the site, and perhaps off-site as well. Alternatives 1 and 2, which provide no remediation measures, are reversible.

In summary, Alternative 3 would decrease the mobility, toxicity and volume of the contaminated soil with respect to the site, as well as off-site in part. Alternatives 5 and 6 would be the next effective alternative in decreasing the mobility, toxicity and volume of the contaminants in the area. Neither alternative would address the inorganic contamination. Alternative 5 may increase the mobility of the inorganics and Alternative 6 has not been proven effective in the full scale in reducing extremely elevated levels of nitrobenzene in the soil to below the SCG. Alternative 4 (containment) would decrease the mobility of the contaminants from the soil to air, surface water and groundwater, but not the toxicity and volume. Alternatives 1 and 2 would not reduce the toxicity, mobility or volume of the contaminated soil.

3.5.6 Implementability

3.5.6.1 - Ease of Implementation

For the alternatives being considered for the Radio Tower Area, there are no anticipated implementation impediments regarding remediation. The no action alternative will be the easiest to implement.

The remedial alternatives requiring excavation (Alternatives 3 (off-site disposal), 5 (thermal desorption) and 6 (bioremediation)) and regrading of contaminated material at the site (Alternative 4) may have some difficulty during remediation because of the dust and vapors that would need to be mitigated during these activities. Control systems for air emissions, such as temporary structures with vapor controls, covers, dust suppressants, etc., may be required. Workers involved with excavation at the site may be required to wear higher levels of personal protective equipment than Level D (Level C or B). Because Alternatives 5 and 6 require on-site treatment, this alternative may have additional implementation difficulties regarding emissions controls for the on-site treatment system.

3.5.6.2 - Delays in Implementation

No delays in implementation are anticipated for Alternatives 1, 2 and 4. Each of these alternatives are proven and have been utilized at numerous sites. Alternatives 3, 5 and 6 would require excavation of a significant amount of soil below the water table. Although this type of excavation activity has been completed successfully at numerous sites, it will still be difficult to implement. These alternatives will also likely take longer to implement, in particular for Alternative 5. Alternative 6, has not been utilized on a full scale level to treat nitrobenzene contaminated soil and may experience delays in implementation, due to the need for on-site pilot testing. In addition, the results of this test may indicate that the alternative may not be effective. Although for Alternatives 3 through 6, construction/excavation equipment does experience breakdowns, it is not anticipated that significant delays would occur in the repair/replacement of this equipment. Because of the more complex nature of Alternative 5, the treatment equipment may be more susceptible to the need for repair and modification, and therefore may cause more significant delays.

3.5.6.3 - Coordination of the Remedial Alternatives

All of the alternatives would require coordination with NYSDEC, NFTA and Niagara-Mohawk Power Corporation. As discussed earlier, during the period of time that the radio tower is still intact, additional coordination with NFTA may be required. Coordination would also be required with respect to active utility lines that run through the area that are owned/operated by the Niagara Mohawk Power Corporation. In addition, there are telephone and electric lines in the Radio Tower Area that currently service portions of the Port Terminal A building.

Coordination would also be required with the City of Buffalo with regard to any necessary permits for construction or discharge to the municipal sewer system.

Alternative 5 (thermal desorption) and Alternative 6 (bioremediation) would require coordination with appropriate treatment vendors and Alternative 3 (off-site disposal) would require coordination with the disposal facilities.

3.5.6.4 - Availability of Technologies

Four of the remedial actions/technologies being considered for the Radio Tower Area (Alternatives 1, 2, 3 and 4) are readily available. Thermal desorption (Alternative 5) is a commercially available technology, but has not been demonstrated on a full-scale basis for the treatment of nitrobenzene. Bioremediation (Alternative 6) is also commercially available and also has not been demonstrated on a full-scale basis for remediation of nitrobenzene contaminated soil. Except for Alternatives 5 and 6, the availability of any specific technology is not likely to affect the implementability of any of the alternatives. Based on discussions with an off-site disposal facility

(Chemical Waste Management), including both incineration and secure landfilling, capacity for disposal of 8,000 cy of hazardous/contaminated soil is available.

In summary, Alternative 4 most likely represents the most readily implementable alternative other than no action and deed restrictions. Alternative 3 would likely be the next easiest alternative to be implemented, followed by Alternatives 6 and 5, respectively.

3.5.7 Cost

The assumptions for development of the capital, and operation and maintenance (O&M) costs of each of the remedial alternatives considered for the Radio Tower Area are summarized below. A detailed breakdown of each estimate is provided in Appendix E. A summary table comparing total capital and annual O&M costs, together with the implementation period and present worth (30 years at 5% interest) for each alternative, is presented in Table 3-3.

The following assumptions were utilized in the preparation of the cost estimates:

- Costs are rounded to the nearest thousand dollars.
- All site work costs (e.g., excavation, backfill, etc.) were estimated using Means Site Work Cost Data for 1997, experience in construction and adjusted for hazardous waste site remediation, and discussion with remedial contractors and disposal facilities.
- For the purposes of preparing both conservative and more realistic cost estimates for remediation of this area, Alternative 3 (off-site disposal) has been presented using two different assumptions. Alternative 3A presents the costs for excavation and off-site disposal of all soil in the Radio Tower Area (8,000 cy). Alternative 3B presents the costs for excavation and off-site disposal of only the highly contaminated soils (3,500 cy) the remaining 4,500 cy will be replaced in the excavation.
- Off-site land disposal costs were estimated based upon information provided by Chemical Waste Management. Costs for transportation and disposal of contaminated soil are based on utilization of the TWI Sauget, Illinois facility for incineration 3,500 cy of "hazardous" soil and utilization of the Model City, New York facility for

Table 3-3

ALTERNATIVES COST SUMMARY FOR THE RADIO TOWER AREA

Alternative	Estimated Capital Cost	Estimated Contingency and Engineering Fees	Present Worth of Annual Operating Maintenance and Monitoring Costs (30 years)	Total Estimated Costs Based on Present Worth
1	--	--	--	$ 0
2	$27,000	$0	$143,000	$170,000
3A	$6,689,000	$1,173,000	$0	$7,862,000
3B	$6,171,000	$1,126,000	$143,000	$7,440,000
4	$1,658,000	$749,000	$1,022,000	$3,429,000
5	$3,156,000	$673,000	$143,000	$3,972,000
6	$2,671,000	$601,000	$143,000	$3,415,000

the remaining 4,500 cy of nonhazardous soil. Both the facilities have the capacity to accept the soil from the Buffalo Outer Harbor site.

3.6 Comparative Analysis of Alternatives

Table 3-4 presents a summary of the comparative analysis of alternatives evaluated for soil contamination for each of the evaluation criteria discussed in detail in Section 3.4, and a ranking of alternatives for each criteria based upon the comparative analysis. Table 3-5 presents a summary of the ranking of the soil alternatives for each evaluation criteria and an overall ranking of the alternatives, excluding and including costs.

As discussed previously, the future use of the Radio Tower Area has not been determined. However, because of the significant soil contamination in this area, the contaminated soils should be removed or treated prior to development. The volumes of soil requiring remediation were estimated based on the screening criteria developed for the site. These screening criteria were developed based on unrestricted use of the site and were utilized in a qualitative assessment of sites to determine the need for remediation. If future use of the site is determined, the screening criteria could be reevaluated to develop remediation based upon future use (i.e., commercial, industrial, etc.). Table 3-6 presents the various potential remedial alternatives and likely potential future uses of the Radio Tower Area.

3.7 Preferred Alternative

As shown by the attached tables, exclusive of cost, the result of the ranking of alternatives indicates that excavation and off-site disposal attains the highest ranking score followed by bioremediation and thermal desorption, both of which scored equally. The no action alternative and institutional action alternative are not an acceptable, since they are not protective of human health and the environment.

Table 3-4

ALTERNATIVE COMPARATIVE ANALYSIS SUMMARY
FOR THE
RADIO TOWER AREA

Chemical Specific SCGs

Alternative	Soil	Rank
1	No.	5
2	No.	5
3	Yes, removes all of the contaminated soil which exceeds SCGs, eliminates potential for contact with contaminated soil and eliminates potential leaching of contaminants to groundwater.	1
4	No, but reduces potential for contact with contaminated soil, reduces potential for runoff of contaminated soil to surface water, and reduces potential leaching of contaminants to groundwater and migration of contaminated groundwater.	4
5	Yes, removes organic soil contamination which exceeds SCGs, however, would not address inorganic contamination. Eliminates potential for further organic contamination in groundwater but may increase leachability of metals.	2
6	Yes, will likely effectively remove organic soil contamination which exceeds SCGs, however, would not address inorganic contamination.	3

Action Specific SCGs

Yes for all alternatives

Overall Protection of Human Health and the Environment

Alternative	Soil	Rank
1	No.	6
2	No, but prevents access to site.	5
3	Yes, removes all of the contaminated soil from site, eliminates potential for contact with contaminated soil and eliminates potential leaching of contaminants to groundwater.	1
4	Yes, reduces potential for contact with contaminated soil, reduces potential for runoff of contaminated soil to surface water, and reduces potential leaching of contaminants to groundwater and migration of contaminated groundwater.	4
5	Yes, removes organic soil contamination. Eliminates potential for further organic contamination in groundwater.	2
6	Yes, likely to remove organic soil contamination and eliminates potential for further organic contamination in groundwater.	3

Table 3-4 (continued)

ALTERNATIVE COMPARATIVE ANALYSIS SUMMARY FOR THE RADIO TOWER AREA

Reduction of Toxicity, Mobility and Volume

Alternative	Soil	Rank
1	None.	5
2	None.	5
3	Yes, with respect to the site by removing contamination off-site, and reduction of a significant amount of organic contamination by incineration and inorganic contamination by stabilization.	1
4	No, but reduces exposure to and runoff of surface contaminants, and infiltration and leaching of contaminants to groundwater, as well as potential migration of contaminated groundwater.	4
5	Partially, by reduction of organic contamination.	2
6	Partially, by reduction of organic contamination.	2

Implementability

Alternative	Soil	Rank
1	Simple.	1
2	Minimal with installation of fence.	2
3	Significant difficulties regarding extensive excavation of soil in groundwater and truck traffic.	4
4	Minor difficulty regarding construction of a low permeability cover and slurry wall.	3
5	Significant difficulties regarding extensive excavation of soil in groundwater, and soils handling and treatment. Treatment equipment may experience delays.	6
6	Significant difficulties regarding extensive excavation of soil in groundwater, and soils handling and treatment.	5

Table 3-4 (continued)

ALTERNATIVE COMPARATIVE ANALYSIS SUMMARY FOR THE RADIO TOWER AREA

Cost

Alternative	Cost	Rank
1	0	1
2	$170,000	2
3A	$7,862,000	6
3B	$7,440,000	
4	$3,429,000	4
5	$3,972,000	5
6	$3,415,000	3

Table 3-5

**SUMMARY OF ALTERNATIVE RANKING
FOR THE RADIO TOWER AREA
BASED ON EVALUATION CRITERIA**

Alternative	Compliance with SCGs	Protection of Health and Environment	Short-term Impacts and Effectiveness	Long-term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Implementability	Score Total Exclusive of Cost	Ranking Exclusive of Cost*	Cost**
1. No Action	5	6	1	5	5	1	23	5	0
2. Deed and Access Restrictions	5	5	2	5	5	2	24	5	$170,000
3. Excavation and Off-site Disposal/Treatment	1	1	6	1	1	4	14	1	
A. (8,000 cy)									$7,862,000
B. (3,500 cy)									$7,440,000
4. Low Permeability Cap and Slurry Wall	4	4	3	4	4	3	22	4	$3,429,000
5. Thermal Desorption	2	2	5	2	2	6	19	2	$3,972,000
6. Bioremediation	3	3	4	2	2	5	19	2	$3,415,000

*Lowest total is ranked highest
**Includes capital and long-term (30-year) O&M costs.

Table 3-6

REMEDIATION ALTERNATIVES AND LAND USE MATRIX FOR THE RADIO TOWER AREA

Alternative	Land Use		
	Residential	Recreational	Commercial/ Industrial
1. No Action	No	No	No
2. Deed and Access Restrictions	No	No	No
3. Excavation and Off-site Disposal	Yes	Yes	Yes
4. Containment	No	No	No
5. Thermal Desorption	No	Yes	Yes
6. Bioremediation	No	Yes	Yes

Although excavation and off-site disposal ranks first, this alternative is greater than twice the cost of the thermal desorption and bioremediation alternatives. Both thermal desorption and bioremediation would treat the contaminated soil and allow for replacement on-site, and provide for protection of human health and the environment at a substantially lower cost as compared to the off-site disposal alternative. Containment, which is competitive with the cost for thermal desorption and bioremediation, would likely preclude future development of this area.

Thermal desorption and bioremediation rank equally with regard to the evaluation criteria and are similar with regard to cost, and therefore, either alternative can be implemented. However, implementation of bioremediation would likely be easier than thermal desorption based on less complex equipment which would need to be utilized and reduced soil handling requirements. Therefore, preference is given to implementation of the bioremediation alternative.

APPENDIX A

SUPPLEMENTAL SITE INVESTIGATION BORING LOGS

Driller: Unitech/Jim Evans, Chris Watkins
Inspector: D. Stahl
Rig Type: CME-85 truck
Drilling Method: 4 1/4" id HSA's

Dvirka and Bartilucci Boring Log

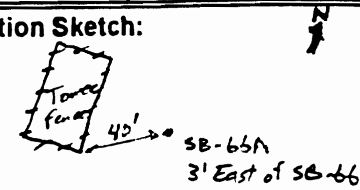
Project Name: Buffalo Outer Harbor
Project #: 1307
Boring Depth: 22.0'

Boring No. 66A
Sheet 1 of 2
Location: 3' east of SB-66

Groundwater Observations			
Date			
Time			
DTW			
Casing/Total Depth			

Start (Date & Time): 7-21-97 / 12:20
Finish (Date & Time): 7-21-97 / 14:15
Weather: o-cast, 75°F, occ. rain.
Elevation of Ground Surface:

Location Sketch:



Sample Interval	Sample No.	Blows	PID (ppm)	Field Description	Well Schematic	Comments
0-2.0'	S-1	4	6.2	Moist, Br. silt, some c-f sand, trace f & to sub & gravel, trace bk cinders trace Rd brick fragments + roots.		PID in b.zone = 0.0 ppm, 12:20 calibrated 12:10.
Rec:	1.8'	6				
		9				
		9				S-1 thru S-11 are 3" split spoons.
2-4.0'	S-2	9	0.6	Moist, Br. silt, some c-f sand, trace f & to sub & gravel, trace bk cinders trace Rd. brick fragments + roots	Boring Backfilled w/ cuttings 22 to ~5' below grade and w/ bentonite powder ~5' to 0'	
Rec:	1.3'	5				
		3				
		3				
4-6.0'	S-3	3	0.4	Wet, Br. silt, some vf sand, trace c & gravel. saturated.		▼≈ 5'
Rec:	1.2'	2				
		2				
		10				
6-8.0'	S-4	10	0.9	Wet, Br. silt, little vf sand, trace clay. saturated.		12:50, 3.0 ppm top of augers, 0 ppm in b.zone
Rec:	1.8'	7				
		6				
		4				
8-10.0'	S-5	2	5.4	Wet, Gy-Br. silt, little clay, trace c-f sand, trace f & gravel, trace brick fragments (red).		
Rec:	1.1'	1				
		1				
		1				
10-12.0'	S-6	2	0.0	Wet, similar material (0.5') over Wet, Gy-Bk silt, little m-f & gravel, trace c-f sand, trace clay.		S-6, odor and bk staining - 13:00, 0 ppm in b.zone.
Rec:	1.3	2				
		2				
		4				13:10, collect BS-1 0-12.0'.
12-14.0'	S-7	1	0.0	Wet, Br silt w/ some bk staining, trace c-f sand, trace f & gravel, trace brick fragments		
Rec:	1.2'	1				
		1				
		2				
14-16.0'	S-8	6	0.0	Wet, Br silt, trace c-f sand, trace f & gravel, trace brick fragments and cinders w/ bk staining		S-8, odor.
Rec:	0.6'	2				
		2				
		3				
16-18.0'	S-9	9	0.0	Same material.		
Rec:	0.7'	7				
		4				13:25, 0 ppm in b.zone
		5				
18-20.0'	S-10	1	0.0	Wet, Br. silt, little f sand, trace c-m sand, trace f sub & to & gravel, w/ shells.		S-10, w/ shells
Rec:	1.7'	2				
		1				
		3				

Soil Stratigraphy Summary

file d&blog.xls revised 8/26/96 by GG

Driller:	**Dvirka and Bartilucci Boring Log**	**Boring ID :** SB-6bA
Inspector:	Project Name: Buffalo Outer II	Sheet 2 of 2
Rig Type:	Project #:	Location:
Drilling Method:	Boring Depth:	

	Groundwater Observations			
Date				Start (Date & Time):
Time				Finish (Date & Time):
DTW				Weather:
Casing/Total Depth				Elevation of Ground Surface:

Location Sketch:

Sample Interval	Sample No.	Blows	PID	Field Description	Well Schematic	Comments
20-22.0'	S-11	5	0.0	Wet, Gy-Br silt and f sand, trace m-f subg to sub O gravel, uniform bedding.		S-11, native material.
Rec=	1.8'	15				14:00, collect BS-2 12-22.0',
		23				
		25				
				B.O.B. = 22.0'		
						1 decon prior 22', augers
						11 spoons (3")
						1 hole mob
						1/450# bag bent. powder.
						1/2 site mob/demob.
						collected TCLP, MS, MSD, SVOC samples at 13:45 from BS-2 bucket after some mixing.

Soil Stratigraphy Summary

file d&blog.xls revised 8/26/96 by GG

Dvirka and Bartilucci Boring Log

Driller: United / J Evans, C Watkins
Inspector: D. Stahl
Rig Type: CME-85 truck
Drilling Method: 4 1/4" id HSA's

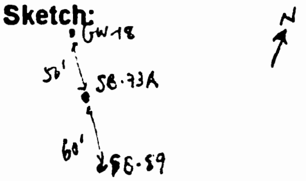
Project Name: Buffalo Outer Harbor
Project #: 1307
Boring Depth: 22.0'

Boring ID: SB-73A
Sheet 1 of 2
Location: 3' South of SB-73

	Groundwater Observations		
Date			
Time			
DTW			
Casing/Total Depth			

Start (Date & Time): 7-22-97/09:25
Finish (Date & Time): 7-22-97/11:55
Weather: Sunny, 75°F
Elevation of Ground Surface:

Location Sketch:



Sample Interval	Sample No.	Blows	PID (ppm)	Field Description	Well Schematic	Comments
0-2.0'	S-1	3	0.0	Moist, br silt, little c-f sand, trace m-f ¢ to sub¢ gravel, w/ red brick fragments.		all spoons are 3".
Rec=	1.6'	5				
		5				09:40, 0 ppm in b. zone
		5				
2-4.0'	S-2	4	0.0	Moist, br silt, trace c-f sand, trace m-f ¢ gravel, trace clay, w/ red brick fragments.	Boring	
Rec=	1.7'	3				
		2				10:05, augers 4' 0.0 ppm in augers and b. zone
		3			Backfilled	
4-5.5'	S-3	4	0.0	Moist, br silt, trace c-f sand, trace f ¢ gravel, trace clay w/ red brick fragments.		
Rec=	1.4'	4			w/ cuttings	S-3, moth ball odor. bounce on wood?
		4				
		37/0				
6-8.0'	S-4	3	0.0	Moist, same (1.0) over Wet, Br. silt, trace f sand, trace clay (0.6').	22 to 25'	S-4, odor
Rec=	1.6'	5				
		2			below	
		2				
8-10.0'	S-5	19	0.0	Wet, br silt, little c-f ¢ gravel, trace c-f sand, trace clay w/ red brick fragments and bk staining.	grade	10:25, augers at 10', 0 ppm in augers + b. zone. collect BS-1 0-10.0' at 10:25.
Rec=	1.7'	14				
		9			and w/	
		11				
10-12.0'	S-6	45	41.1	Wet, br silt, trace c-f ¢ gravel, trace c-f sand, lower 0.3' has very bk staining.	bentonite	S-6, much odor 10:45, 0 in b. zone 0 in augers
Rec=	1.4'	55				
		47			powder	
		17				
12-14.0'	S-7	13	63.7	Wet br silt, some m-f ¢ gravel, much bk staining.	25' to 0'	S-7, odor, post S-7, 0 ppm in b. zone 0 ppm in augers at 14'. 10:50
Rec=	1.2'	16				
		21				
		12				
14-16.0'	S-8	19	0.0	Piece of rubber only - possible tire fragment.		
Rec=	0.1'	19				11:05, Post S-9, 51.7 ppm in auger during intro of rods, 0.7 ppm in augers rods still. In both cases 0.0 ppm in b. zone
		12				
		12				
16-18.0'	S-9	7	1220	Bk-Br silt, some m-f gravel ¢, trace c-f sand, ubiquitous bk staining		
Rec=	1.8'	5				
		7				
		5				
18-20.0'	S-10	3	486	Bk-Br silt, some m-f gravel sub¢ to ¢, trace c-f sand, all black stained.		post S-10, 31.1 in augers, 0.0 in b. zone
Rec=	2.0'	3				
		2				
		16				11:30, collect BS-2 10-22' 2.5 gal bucket.

Soil Stratigraphy Summary

Driller:
Inspector:
Rig Type:
Drilling Method:

Dvirka and Bartilucci Boring Log

Project Name: Buffalo Outer Harbor
Project #: 1307
Boring Depth: 22.0

Boring ID : SB-73A
Sheet 2 of 2
Location:

	Groundwater Observations		
Date			
Time			
DTW			
Casing/Total Depth			

Start (Date & Time):
Finish (Date & Time):
Weather:

Elevation of Ground Surface:

Location Sketch:

Sample Interval	Sample No.	Blows	PID (ppm)	Field Description	Well Schematic	Comments
20-22.0'	S-11	11	119	Same (0.8) over wet Gy-Br silt, trace of sand w/ horizontal layering (1.2').		11:35, collect SVOC, SVOC TCLP, SVOC MS, SVOC MSD.
Rec=	2.0'	15				
		17				
		20				
				B.O.B. = 22.0'		
						11:45, collect BS-3, cuttings only.
						1 decon prior
						22' augers
						11 spoons (3")
						1 hole mob
						1 et. 50# bentonite

Soil Stratigraphy Summary

file d&blog xls revised 8/26/96 by GG

D.[illegible]	[illegible]-Tech/J. Evans, C. Watson
Inspector:	D. Stahl
Rig Type:	CME-85 truck
Drilling Method:	4 1/4" id HSA's

Dvirka and Bartilucci Boring Log

Project Name: Buffalo Outer Harbor

Project #: 1307

Boring Depth: 22.0'

Boring ID : SB-85

Sheet 1 of 2

Location:

Groundwater Observations			
Date			
Time			
DTW			
Casing/Total Depth			

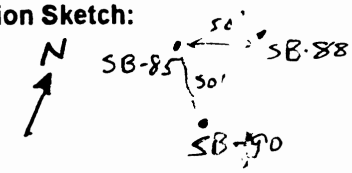
Start (Date & Time): 7-23-97/14:45

Finish (Date & Time): 7-23-97/15:40

Weather: O-cast, 80°F, 5 mph out of south

Elevation of Ground Surface:

Location Sketch:



Sample Interval	Sample No.	Blows	OVA/PID (ppm)	Field Description	Well Schematic	Comments
0-2.0'	S-1	3	0.0	Moist, Br silt, trace f subs to & gravel, trace c-f sand, mottled, trace Rd Brick fragments,		14:50, 0 ppm in b. zone.
Rec=	0.9'	3				
		7				
		8				
2-4.0'	S-2	11	0.0	~~Moist~~-Dry Br silt, trace c-f sand trace f& gravel w/ Rd brick frags and bk cinders.	Backfill Boring w/ Cuttings 22 to 5' and w/ Bentonite Powder 5 to 0'	
Rec=	1.6'	8				
		11				
		11				post S-3, 0 ppm in augers and b. zone. 15:00
4-6.0	S-3	10	0.0	Dry Br silt, trace c-f sand w/ concrete fragments in tip.		
Rec=	0.5'	11				
		3				
		3				15:05, PID fault 3, calibrate OVA 15:10 and use for rest of boring
6-8.0	S-4	2	0.4	Wet, Br silt, some clay w/ Bk staining and organics (roots),		
Rec=	0.6'	2				
		2				
		2				
8-10.0'	S-5	5	0.0	Wet, Br clay, some silt, no Bk staining		S-5, and after uses OVA not PID.
Rec=	1.0'	6				
		3				
		2				post S-7, 15:20, 0 ppm in b. zone and 0 ppm in augers!
10-12.0'	S-6	1	0.0	wet, Br silt, little clay, trace f & gravel		
Rec=	0.2	1				
		3				
		3				
12-14.0	S-7	1	0.4	wet, Br silt, little clay, trace f & gravel, trace c sand.		no odors S-1 thru S-8.
Rec=	1.4'	1				
		2				
		2				
14-18.0'	S-8	WOH/4'	0.2	Wet, Br silt, little clay, no visible staining		
Rec=	1.9					15:30, 0 ppm in b. zone and augers
						collect SVOC's from 10-22' recovered material at 15:35
18-22.0'	S-9	WOH/4'	0.0	Wet, Br silt, trace clay.		
Rec=	1.1					

Soil Stratigraphy Summary B.O.B = 22.0'

pull 4' piece of rebar off lead auger upon it removal.

Inspector: ______________________

Rig Type: ______________________

Drilling Method ______________________

Dvirka and Bartilucci Boring Log

Project Name: ______________________

Project #: ______________________

Boring Depth: ______

Boring ID: ______

Sheet ____ of ____

Location: ______

	Groundwater Observations		
Date			
Time			
DTW			
Casing/Total Depth			

Start (Date & Time) ______________________

Finish (Date & Time): ______________________

Weather: ______________________

Elevation of Ground Surface: ______

Location Sketch:

Sample Interval	Sample No	Blows		Field Description	Well Schematic	Comments
				B.O.B = 22-0		22 lf augers 9 2" spoons 150# bent. 1 boring set-up

Soil Stratigraphy Summary ______________________

Inspector: D-Stahl
Rig Type: CME-85 truck
Drilling Method: 4¼" i.d. HSA's

Project Name: Buffalo Outer Harbor
Project #: 1307
Boring Depth: 22.0'

Boring ID: SB-06
Sheet 1 of 2
Location:

	Groundwater Observations		
Date			
Time			
DTW			
Casing Total Depth			

Start (Date & Time): 7-23-97/16:00
Finish (Date & Time): 7-23-97/17:30
Weather: O-cast, 75°F, 5-10 mph out of south
Elevation of Ground Surface:

Location Sketch:

Sample Interval	Sample No	Blows	OVA (ppm)	Field Description	Well Schematic	Comments
0-2.0'	S-1	4	0.0	Moist, Br. silt, little c-f sand, trace f & gravel w/ red brick frags	Backfill Boring w/ Cuttings 22' to 25' and w/ Bentonite Powder 25' to 0'	16:05, 0 ppm in b.zone post S-1,
Rec=	1.2'	10				
		10				
		11				
2-4.0'	S-2	5	0.0	Moist, Br. silt, trace c-f sand, trace f & gravel w/ red brick frags.		
Rec=	1.4'	5				
		6				
		3				
4-6.0'	S-3	3	0.4	Moist, Br. silt, little m-f & gravel, trace c-f sand, w/ Bk stains, wet, roots in tip of spoon.		16:35, post S-3 OVA = 18 ppm in augers at 4' and 0 ppm in b.zone.
Rec=	0.6'	3				
		4				
		7				
6-8.0'	S-4	2	3.8	Wet, Br silt, trace clay w/ bk staining at 0.3-0.6 of recovered portion w/ roots + sticks.		S-4, no mothball odor
Rec=	2.0'	1				
		3				
		7				
8-10.0'	S-5	10	1.0	Moist, Br silt, little m-f & gravel, trace c-f sand, w/ Bk staining.		16:45, post S-5 0 ppm in b.zone 8 ppm in augers S-5, faint mothball odor,
Rec=	0.3'	5				
		6				
		6				
10-12.0'	S-6	4	3.1	Wet, Br silt, trace clay, trace c-f sand w/ Bk staining		S-6, faint mothball odor.
Rec=	1.2	4				
		3				
		4				S-7, no odor 16:55,
12-14.0'	S-7	3	2.2	Wet, Br silt, little f & gravel, trace c-f sand, trace clay, no staining		0 ppm in b.zone 14 ppm in augers
Rec=	2.0'	2				
		3				
		2				17:00, 0 ppm in b.zone
14-16.0'	S-8	6	3.4	Wet, Br silt, little f & gravel, trace c-f sand, w/ Bk staining 0.8-1.0 of recovered portion w/ roots		
Rec=	1.1'	2				
		2				
		3				S-9, no moth ball odor,
16-18.0'	S-9	2	2.2	Wet, similar material w/ black staining and much roots + wood in lower 0.4' of recovered portion		
Rec=	1.2'	1				S-10, no moth ball odor.
		1				
		3				
18-20.0'	S-10	7	1.8	Wet, Br silt, trace f sand w/ Bk staining and roots		0 ppm in b.zone 11 ppm in augers, at 17:05
Rec=	0.8'	9				
		8				
		13				

Soil Stratigraphy Summary

Boring Log

Inspector:	Project Name:
Rig Type:	Project #:
Drilling Method	Boring Depth:

Sheet 2 of 2

Location:

	Groundwater Observations		
Date			
Time			
DTW			
Casing Total Depth			

Start (Date & Time):

Finish (Date & Time)

Weather:

Elevation of Ground Surface:

Location Sketch:

Sample Interval	Sample No	Blows	OVA (ppm)	Field Description	Well Schematic	Comments
20-22.0'	S-11	4	1.6	Wet, Br silt, trace f sand w/ Bk staining no roots or sticks		17:10, collect composi for SVOC's from 10-22' spoon materi
Rec =	1.0	3				
		7				
		10				
				B.O.B. = 22.0'		
						22 lf augers
						11 2" spoons
						1 50# bent.
						1 boring setup

Soil Stratigraphy Summary

Driller: United / J. Evans, C. Watson	D... and Bartilucci Boring Log	Boring ID: SB-87
Inspector: D. Stahl	Project Name: Buffalo Outer Harbor	Sheet 1 of 2
Rig Type: CME-85 truck	Project #: 1307	Location: west of pavement
Drilling Method: 4 1/4" id HSA's	Boring Depth: 22.0'	

Groundwater Observations			
Date			
Time			
DTW			
Casing/Total Depth			

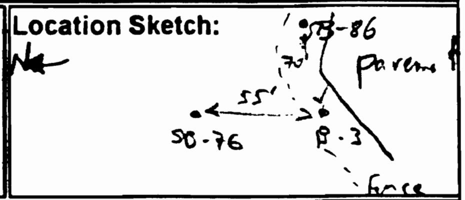
Start (Date & Time): 7-23-97 / 11:20

Finish (Date & Time): 7-23-97 / 12:25

Weather: M. Cloudy, 75°F, 5-10 mph out of S

Elevation of Ground Surface:

Location Sketch:



Sample Interval	Sample No.	Blows	PID (ppm)	Field Description	Well Schematic	Comments
0-2.0'	S-1	6	5.2	0.5' crushed stone, dry over moist Br. silt, some c-f gravel, trace c-f sand (1.5').		
Rec=	0.8'	9				
		6				
		4				
2-4.0'	S-2	4	1.2	Moist Bk c-f sand, some silt, mixed gy + bk grains.	Boring	S-2, bad egg odor strong.
Rec=	0.9'	12				post S-2 10:30
		7				0 ppm in b. zone
		3				0.0 ppm in augers.
4-6.0'	S-3	2	0.0	Wet Br silt, little f & gravel, trace c-f sand, trace clay w/ black staining. grades to some clay in tip.	Backfilled	10:35, 0 ppm in b. zone.
Rec=	1.0'	1				
		1			w/	S-3, no bad egg odor
		1				
6-8.0'	S-4	2	0.0	Wet Gy-Br silt, some clay, trace f & gravel w/ bk stains + spots (1.2') over wet, Br silt, trace f & gravel. (0.6')	cuttings	11:45, 0 ppm in b. zone and 0 in augers
Rec=	1.8'	7				
		10				
		9			to	
8-10.0'	S-5	6	0.0	Wet, Br silt, little f & gravel, trace clay, trace c-f sand.		▼ ≈5'
Rec=	0.1'	8			~5'	
		8				
		4			below	
10-12.0'	S-6	3	0.0	Wet, Br silt, trace f & gravel, trace c-f sand (0.2') over wet & m-f gravel, trace c-f sand (0.2')		S-6, drove piece of c gravel.
Rec=	0.4'	3			grade	
		4				
		5				S-7, no odor
12-14.0'	S-7	4	0.0	Wet, Br silt, trace f & gravel, trace c-f sand (0.7') over wet, Br silt, trace c-f sand w/ bk staining in spots	w/	
Rec=	1.2'	6			bentonite	
		4				12:05, 0 ppm in b-zone + augers
		8				
14-16.0'	S-8	8	0.0	Wet, Br silt, little c-f sand, little f & gravel, w/ bk staining	powder	
Rec=	1.1'	9				
		17			5'-0'	12:15, post S-10,
		3				0 ppm in b. zone and augers
16-18.0'	S-9	2	0.0	Same material w/ Br silt, trace clay in tip.		
Rec=	0.7	2				
		2				
		2				
18-20.0'	S-10	3	0.0	Wet, br silt, little f & to sub & gravel.		
Rec=	0.2	8				
		12				
		10				

Soil Stratigraphy Summary

H_2S-like odor also SO_2-like.

file d&blog xls revised 8/26/96 by GG

Driller:
Inspector:
Rig Type:
Drilling Method:

Dvirka and B... ...ci Boring Log

Project Name: Buffalo Outer Harbor
Project #: 1307
Boring Depth:

Boring ID: SB-87
Sheet 2 of 2
Location:

Groundwater Observations			
Date			
Time			
DTW			
Casing/Total Depth			

Start (Date & Time):
Finish (Date & Time):
Weather:
Elevation of Ground Surface:

Location Sketch:

Sample Interval	Sample No.	Blows	PID (ppm)	Field Description	Well Schematic	Comments
20-22.0'	S-11	7	1.2	Similar (0.5') over wet br silt, little f sand, layered, w/ Bk staining and organics - sticks/roots in upper 0.4' (1.4').		Collect SVOC's composite from 10-22' spoons
Rec=	1.9	6				
		12				
		18				
				B.O.B = 22.0		
						22 lf augers
						11 2" spoons
						1 50# bent
						1 boring set-up

Soil Stratigraphy Summary

Driller: Uni-tech / J. Evans, C. Watson
Inspector: D. Stahl
Rig Type: CME 85 truck
Drilling Method: 4 1/4" id HSA's

Dvirka and Bartilucci Boring Log

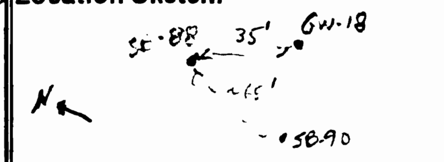
Project Name: Buffalo Outer Harbor
Project #: 1307
Boring Depth: 22.0'

Boring ID: SB-88
Sheet 1 of 2
Location: NW of GW-18

Groundwater Observations			
Date			
Time			
DTW			
Casing/Total Depth			

Start (Date & Time): 7-23-97/09:00
Finish (Date & Time): 7-23-97/10:15
Weather: M. Sunny 65°F
Elevation of Ground Surface:

Location Sketch:



Sample Interval	Sample No.	Blows	PID (ppm)	Field Description	Well Schematic	Comments
0-2.0'	S-1	4	0.8	Moist, br silt, trace c-f sand, trace f s to sub s gravel, w/ mottling + red brick fragments		09:05, 0ppm in b. zone.
Rec:	0.8'	6				
		6				
		7				
2-4.0'	S-2	9	2.3	beside material but Dry br silt, little f s to sub s gravel, trace c-f sand, no mottling w/ red brick and bk cinder in tip of spoon.	Boring	4', drove piece of brick
Rec:	1.0'	9				
		9				09:25, post S-3, 0 ppm in b. zone 0 ppm in augers
		14				
4-6.0'	S-3	2	4.9	Dry br silt, trace c-f sand, trace f s sub s gravel w/ red brick fragments	Backfilled	S-3, partly odor, drove piece of brick
Rec:	0.6'	7				
		6				
		3			w/	
6-8.0'	S-4	10	0.1	Dry red brick in spoon w/ tight gy m-f sand which is cemented in tip of spoon - Dry.	cuttings	
Rec:	0.3'	3				no odors S-4 or S-5
		4				
		4			to	0ppm in augers + b. zone 09:45
8-10.0'	S-5	1	0.2	Wet, Br-Gy clay, trace silt in tip w/ bk staining + roots.		
Rec:	0.2	1			25'	▼ ≈ 8'?
		1				
		2			below	
10-12.0'	S-6	WOH/2'	0.2	Wet, Gy-Br clay, little silt, w/ bk staining in upper 0.4' only.		S-6, very soft clay.
Rec:	2.0'				grade	
					w/	
12-14.0'	S-7	1	0.0	Wet, Br clay, little silt, no staining (1.1') over wet br. silt (0.6').		no odors S-6 + S-7
Rec:	1.7'	2			bentonite	
		2				
		2				
14-16.0'	S-8	WOH/1'	0.2	Wet, Br silt, some clay	powder	S-8, odor not moth balls - faint
Rec:	0.1					
		1			5'-0'	
		1				
16-18.0'	S-9	WOH/4'	0.0	Wet, Br silt, trace clay, trace f s gravel		S-9, odor not moth balls - faint
Rec:	2.0'					10:00, 0 ppm in b. zone + top augers

Soil Stratigraphy Summary: about 3' higher than previous borings in elevation

Driller:

Inspector:

Rig Type:

Drilling Method:

Dvirka and Bartilucci Boring Log

Project Name:

Project #:

Boring Depth:

Boring ID : SB-89

Sheet ____ of ____

Location:

	Groundwater Observations		
Date			
Time			
DTW			
Casing/Total Depth			

Start (Date & Time):

Finish (Date & Time):

Weather:

Elevation of Ground Surface:

Location Sketch:

Sample Interval	Sample No.	Blows	PID (ppm)	Field Description	Well Schematic	Comments
20-22.0	S-10	3	2.2	Wet, Br silt, trace clay, trace f + gravel (1.0') over wet, br m-f + gravel w/ bk staining + organics, trace silt (0.3') over Br, wet f sand, trace silt (0.7').		10:10, collect SVOCs composite from 10-22' recovery.
REC =	2.0	8				
		20				
		21				
				B.O.B = 22.0'		
						22 lf augers 10 2" spoons 1 50# bent 1 boring setup prior steam clean on 7-23 at SB-90

Soil Stratigraphy Summary

file d&blog xls revised 8/26/96 by GG

Driller: Uni-tech/J. Evans, C Watkins
Inspector: D Stahl
Rig Type: CME-85 truck
Drilling Method: 4¼" id HSA's

Dvirka and Bartilucci Boring Log

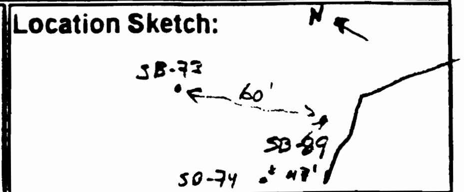
Project Name: Buffalo Outer Harbor
Project #: 1307
Boring Depth: 22.0'

Boring: ____
Sheet 1 of 2
Location: ____

	Groundwater Observations		
Date			
Time			
DTW			
Casing/Total Depth			

Start (Date & Time): 7.22.97/13:05
Finish (Date & Time): 7.22.97/14:15
Weather: M. Sun, 75-80°F
Elevation of Ground Surface: ____

Location Sketch:



Sample Interval	Sample No.	Blows	PID (ppm)	Field Description	Well Schematic	Comments
0-2.0'	S-1	3	0.0	Moist, br silt, trace c-f sand, trace f ǂ to sub ǂ gravel		13:10, 0 ppm in b. zone
Rec=	1.0'	6				
		6				
		7				
2-4.0'	S-2	4	0.0	Moist, br silt, little m-c sand, trace c sand, trace f ǂ to sub ǂ gravel, w/ red brick fragments.	Boring	
Rec=	1.1'	6				
		6				
		3				
4-6.0'	S-3	7	0.0	Wet, br silt, trace c-f sand, trace f ǂ gravel, w/ one red brick fragment.	backfilled w/ cuttings	spooning in wood S-3, 4, 5.
Rec=	0.5'	9				
		12				
		2				
6-8.0'	S-4	6	0.0	Wet similar material.	22' to 25' below	
Rec=	0.4'	5				
		3				
		4				
8-10.0'	S-5	7	0.0	Wet, br silt, trace f ǂ to sub ǂ gravel, trace c-f sand,	grade and w/	
Rec=	0.3'	3				
		2				
		1				13:30
10-12.0'	S-6	1	0.0	Wet, br silt, trace f ǂ to sub ǂ gravel, trace c-f sand, brick fragments – bk staining in lower 0.5'.	bentonite powder 25' to 0'	S-6, odor. mothballs 0 ppm in b. zone 0 ppm in augers
Rec=	1.0'	9				
		4				
		1				S-7, no odor
12-14.0'	S-7	1	0.0	Wet, br silt, trace clay, trace c-f sand, trace f ǂ gravel. w/ black staining		
Rec=	1.6'	4				
		6				
		7				
14-16.0'	S-8	3	0.0	Wet, bk-br silt, little c-f sand, trace f ǂ gravel, w/ black staining		
Rec=	1.5'	2				
		2				
		1				
16-18.0'	S-9	3	0.0	Wet, similar material (0.9) over Wet, bk silt, trace f sand.		S-9, post, 0 ppm in b. zone 13:40
Rec=	1.9'	3				
		4				
		3				
18-20.0'	S-10	3	0.0	Wet bk-br silt, trace f sand, w/ layering horiz, trace shells, black staining.		
Rec=	2.0	3				
		2				
		7				

Soil Stratigraphy Summary ____

Dvirka and Bartilucci Boring Log

Driller:
Inspector:
Rig Type:
Drilling Method:

Project Name: Buffalo Outer Harbor
Project #: 1307
Boring Depth: 22'

Boring ID : SC-89
Sheet 2 of 2
Location:

Groundwater Observations			
Date			
Time			
DTW			
Casing/Total Depth			

Start (Date & Time):
Finish (Date & Time):
Weather:
Elevation of Ground Surface:

Location Sketch:

Sample Interval	Sample No.	Blows	PID (ppm)	Field Description	Well Schematic	Comments
20-22.0'	S-11	13	0.0	Wet Gy.Br silt w/ layering, trace shells.		14:10, collect svocs composite from 10-22' spoons
Rec=	2.0'	17				
		16				
		24				
				B.O.B = 22.0'		
						22 lf auger 11 2" spoons 1 50# bent. 1 boring setup

Soil Stratigraphy Summary

file d&blog.xls revised 8/26/96 by GG

Driller: Uni-tech / J. Evans, C. Watkins
Inspector: D. Stahl
Rig Type: CME-85 truck
Drilling Method: 4 1/4" id HSA's

Dvirka and Bartilucci Boring Log

Project Name: Buffalo Outer Harbor
Project #: 1307
Boring Depth: 22.0'

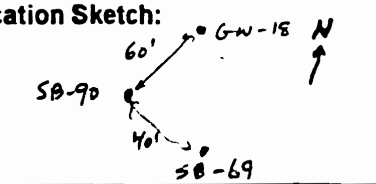
Boring ID : SB-90
Sheet 1 of 2
Location:

Groundwater Observations			
Date			
Time			
DTW			
Casing/Total Depth			

Start (Date & Time): 7-22-97 / 14:30
Finish (Date & Time): 7-22-97 / 15:30
Weather: M. Cloudy, 75°F

Elevation of Ground Surface:

Location Sketch:



Sample Interval	Sample No.	Blows	PID (ppm)	Field Description	Well Schematic	Comments
0-2.0'	S-1	4	0.0	Br. silt, little c-f sand, trace f & gravel, w/ red brick fragments and black cinders.		
Rec:	1.5'	8				
		10				
		17				
2-4.0'	S-2	5	0.0	Similar (0.4') over Moist br. silt, little clay, trace m-f sand (0.5').	Boring Backfilled w/ cuttings 22' to 25' below grade and w/ bentonite powder 25 to 0'	14:40, post S-2, pid - 0 in b. zone and 0 in augers at 4'.
Rec:	0.9'	3				
		2				
		2				
4-6.0'	S-3	2	0.0	Wet, br silt, little m-f & gravel, trace c-f sand, trace clay, trace roots and brick fragments.		S-3, drove piece of c-gravel.
Rec:	0.7'	2				
		2				
		2				
6-8.0'	S-4	WOH	0.0	Similar (0.3') over Wet, Br. clay, little silt (1.6') w/ wet br. silt, trace clay in tip.		14:50, 0 ppm in augers, 0 ppm in b. zone.
Rec:	2.0'	WOH				
		1				
		2				
8-10.0'	S-5	1	0.0	wet, br silt, trace clay, trace c-f sand, trace f & subr gravel, w/ rd brick fragments.		
Rec:	0.6'	1				
		1/1.0'				
		—				
10-14.0'	S-6	WOH/4'	0.0	Wet br silt, little clay, no staining apparent		15:00, augers at 14', 0 ppm in b. zone 0 ppm in augers
Rec:	2.0					
14-16.0'	S-7	3	0.0	Wet, Br silt, trace clay w/ black staining in lower 0.4'.		S-7, moth balls odor
Rec:	2.0'	2				
		3				
		4				
16-18.0'	S-8	2	20.4	Wet, Br silt, trace clay, trace f & gravel, trace c-f sand w/ only trace bk staining.		15:15, collect VOC's in S-8. 4oz. jar. 0 ppm in b. zone and augers w/ augers at 18' at 15:20
Rec:	1.9'	1				
		1				
		2				
18-20.0'	S-9	8	0.0	Wet, Br. silt, trace clay		
Rec:	1.7'	6				
		10				
		12				

Soil Stratigraphy Summary

file d&blog xls revised 8/26/96 by GG

Driller:		Dvirka and Bartilucci Boring Log	Boring ID : SB-90
Inspector:		Project Name: Buffalo Outer Harbor	Sheet 2 of 2
Rig Type:		Project #:	Location:
Drilling Method:		Boring Depth:	

	Groundwater Observations			Start (Date & Time):	Location Sketch:
Date				Finish (Date & Time):	
Time				Weather:	
DTW					
Casing/Total Depth				Elevation of Ground Surface:	

Sample Interval	Sample No.	Blows	PID (ppm)	Field Description	Well Schematic	Comments
10-22.0'	S-10	10	0.0	Wet, Gy-Br silt, trace of sand		
Rec =		12				
		14				
		16				15:25, collect SVOC sample from composited soils 10-22'.
				B.O.B. = 22.0'		
						22 lf augers
						10 2" spoons
						1 50# bag bent.
						1 boring set-up

Soil Stratigraphy Summary

file d&bloc xls revised 8/26/96 by GG

Dr.: [illegible]tech / Jim Evans, Chris Watkins
Inspector: Dee Stahl
Rig Type: CME-85 truck
Drilling Method: 4¼" i.d. HSA's

Dvirka and Bartilucci Boring Log

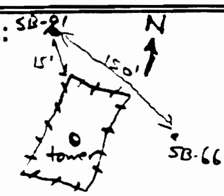
Project Name: Buffalo Outer Harbor
Project #: 1307
Boring Depth: 22.0'

Boring ID: SB-91
Sheet 1 of 2
Location:

Groundwater Observations			
Date			
Time			
DTW			
Casing/Total Depth			

Start (Date & Time): 7-21-97/15:50
Finish (Date & Time): 7-21-97/16:55
Weather: O-cast, 75°F, rain
Elevation of Ground Surface:

Location Sketch:



Sample Interval	Sample No.	Blows	PID (ppm)	Field Description	Well Schematic	Comments
0-2.0'	S-1	7	10.8	Moist, br. silt, bk cinders, little c-f sand.		All spoons are 2"
Rec =	1.2	7				
		8				
		10				
2-4.0'	S-2	3	11.1	Moist, br. m-f sand, some silt, w/ bk cinders	No	
Rec =	0.4	3				
		2			well	
		2				16:05, PID: 0 ppm in b. zone.
4-6.0'	S-3	4	12.0	Wet, bk-br silt, little c-f sand, trace clay, w/ roots.	Installed.	
Rec =	1.4	4				
		2				▼ ~5'.
		2				
6-8.0	S-4	WOH	5.5	Wet, bk-br silt, little c-f sand, trace clay (0.4') over wet, br. clay, some silt (1.6').		
Rec =	2.0'	WOH				
		1				
		4				
8-10.0'	S-5	2	0.3	Wet, Br. silt.		
Rec =	0.9'	1				
		4				
		6				
10-14.0'	S-6	WOH/4'	0.3	Wet, Br silt, w/ much disturbed layering.		16:15, 0 ppm in b. zone.
Rec =	1.6					
14-18.0'	S-7	WOH/4'	0.0	Wet Br. silt, trace clay.		
Rec =	0.8					16:35, collect SB-91 for SVOC's from 10-22' spoons.
16						
18-22.0'	S-8	WOH/2'	0.0	Wet Br. silt, trace clay, trace c-f sand		
Rec =	1.1					

Soil Stratigraphy Summary

Driller: ______
Inspector: ______
Rig Type: ______
Drilling Method: ______

Dvirka and Bartilucci Boring Log

Project Name: Buffalo Outer Harbor
Project #: 1307
Boring Depth: 22.0'

Boring ID: SB-91
Sheet 2 of 2
Location: ______

Groundwater Observations			
Date			
Time			
DTW			
Casing/Total Depth			

Start (Date & Time): ______
Finish (Date & Time): ______
Weather: ______
Elevation of Ground Surface: ______

Location Sketch:

Sample Interval	Sample No.	Blows		Field Description	Well Schematic	Comments
18-22.0'	S-8	11				
		12				
		17				
		23				
				B.O.B = 22.0'		
						22' augers
						8 spoons (2")
						1 hole mob
						1 3/4 50# bags bentonite
						1 decon prior.

Soil Stratigraphy Summary ______

file d&blog.xls revised 8/26/96 by GG

Driller: Uni-tech / Stevens, [illegible]

Inspector: Dean Stahl

Rig Type: CME-85 truck

Drilling Method: 4 1/4" id HSA's

Dvirka and Bartilucci Boring Log

Project Name: Buffalo Outer Harbor

Project #: 1307

Boring Depth: 22.0'

Boring ID: SB-92

Sheet 1 of 2

Location:

Groundwater Observations			
Date			
Time			
DTW			
Casing/Total Depth			

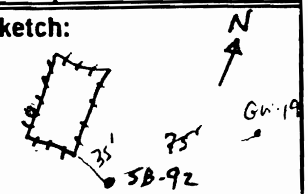
Start (Date & Time): 7-22-97/07:40

Finish (Date & Time): 7-22-97/09:10

Weather: M. Sunny 75°F

Elevation of Ground Surface:

Location Sketch:



Sample Interval	Sample No.	Blows	PID (ppm)	Field Description	Well Schematic	Comments
0-2.0'	S-1	4	14.1	Dry, Br. silt and c-f sand, little m-f & gravel, w/ red brick fragments and bk cinders.		07:55, post S-1, 0 ppm in b-zone
Rec=	1.9'	5				
		12				
		7				
2-4.0'	S-2	3	12.6	Moist Br. silt, little m-f sand, trace c sand, trace f & to sub & gravel, w/ brick frags and cinders	Boring backfilled w/ cuttings 22' to 25' below grade and w/ bentonite powder 25 to 0'	08:05, 0 ppm in augers and b-zone. 08:10, auger at 4', 0.7 ppm in augers, 0 in b-zone. ▼≈5'
Rec=	0.9'	1				
		4				
		7				
4-6.0'	S-3	2	1.2	Moist, same material (0.4') over Wet, Br. silt, trace f sand, trace clay (0.7').		
Rec=	1.1'	2				
		3				
		5				
6-8.0'	S-4	6	0.0	Wet, Br. silt w/ disturbed layering		
Rec=	1.4'	5				
		2				
		2				
8-10.0'	S-5	3	0.0	No recovery.		08:25, augers at 10', 0 ppm in augers and in b-zone.
Rec=	0.0	1				
		1				
		1				
10-14.0'	S-6	WOH/4'	0.0	Wet, Gy-Br. silt, trace f sub & to & gravel, trace clay.		08:32, augers at 14', 0 ppm in augers and in b-zone. S-7, drove piece of c gravel.
Rec=	1.9'					
14-16.0'	S-7	13	0.0	Wet, Br. silt, little c-f sand, trace m-f & gravel, trace clay		
Rec=	0.3'	3				
		2				
		2				
16-18.0'	S-8	3	0.0	Wet, Br. silt, little clay, trace c-f sand, trace f & gravel (1.3') over Wet, Bk-Gy silt, trace vf sand (0.7')		08:40, 0 ppm in b-zone.
Rec=	2.0'	6				
		7				
		8				
18-20.0'	S-9	2	0.0	Wet, Br-Gy silt w/ shell fragments and horiz. bk layering, trace vf sand in tip of spoon.		
Rec=	1.6'	3				
		2				
		6				

Soil Stratigraphy Summary

Dvirka and Bartilucci Boring Log

Driller:
Inspector:
Rig Type:
Drilling Method:

Project Name: Buffalo Outer Harbor
Project #: 1307
Boring Depth:

Boring ID : SB-92
Sheet 2 of 2
Location:

	Groundwater Observations		
Date			
Time			
DTW			
Casing/Total Depth			

Start (Date & Time):
Finish (Date & Time):
Weather:

Elevation of Ground Surface:

Location Sketch:

Sample Interval	Sample No.	Blows	PID (ppm)	Field Description	Well Schematic	Comments
20-22.0'	S-10	1	0.0	Wet, Gy-Br silt, little f sand, trace shell fragments, w/ horiz. layering		Collect SB-92 for SVOC's - composite from 10-22' samples at 08:55.
Rec=	1.9'	2				
		1				
		4				
				B.O.B. = 22.0'		1 decon prior on 7/2 22' augers 10 2" spoons 1 hole mob

Soil Stratigraphy Summary

file d&bloc.xls revised 8/26/96 by GG

APPENDIX B

SUPPLEMENTAL SITE INVESTIGATION ANALYTICAL RESULTS

BUFFALO OUTER HARBOR SITE
PHASE I AND II REMEDIAL INVESTIGATION
SOIL BORING SAMPLING RESULTS
VOLATILE ORGANICS

SAMPLE IDENTIFICATION	SB-90							
SAMPLE DEPTH	16-18'						CONTRACT REQUIRED DETECTION LIMIT	SCREENING LEVEL
DATE OF COLLECTION	07/22/97							
DILUTION FACTOR	1							
PERCENT SOLIDS	82							
VOLATILE ORGANICS	(ug/kg)						(ug/kg)	(ug/kg)
Chloromethane	U						10	----
Bromomethane	U						10	----
Vinyl Chloride	U						10	----
Chloroethane	U						10	----
Methylene Chloride	2 J						10	----
Acetone	U						10	----
Carbon Disulfide	U						10	----
1,1-Dichloroethene	U						10	----
1,1-Dichloroethane	U						10	----
1,2-Dichloroethene (total)	U						10	----
Chloroform	U						10	----
1,2-Dichloroethane	U						10	----
2-Butanone	U						10	----
1,1,1-Trichloroethane	U						10	----
Carbon Tetrachloride	U						10	----
Bromodichloromethane	U						10	----
1,2-Dichloropropane	U						10	----
cis-1,3-Dichloropropene	U						10	----
Trichloroethene	U						10	----
Dibromochloromethane	U						10	----
1,1,2-Trichloroethane	U						10	----
Benzene	24						10	----
Trans-1,3-Dichloropropene	U						10	----
Bromoform	U						10	----
4-Methyl-2-Pentanone	U						10	----
2-Hexanone	U						10	----
Tetrachloroethene	U						10	----
1,1,2,2-Tetrachloroethane	U						10	----
Toluene	490 D						10	----
Chlorobenzene	160						10	----
Ethylbenzene	4 J						10	----
Styrene	U						10	----
Total Xylenes	7 J						10	----
TOTAL VOCs	685							10000

QUALIFIERS
U: Compound analyzed for but not detected
B: Compound found in the blank as well as the sample
J: Compound found at a concentration below the detection limit, value estimated
U*: Result qualified as non-detect based on validation criteria
D: Result taken from reanalysis at a 1:5 dilution

NOTES
----: not established

TO DETERMINE THE DETECTION LIMIT FOR EACH SAMPLE USE THE FOLLOWING EQUATION: (CRDL)*(DF)*(100/ %S)

CRDL: CONTRACT REQUIRED DETECTION LIMIT %S: PERCENT SOLIDS

BUFFALO OUTER HARBOR SITE
PHASE I AND II REMEDIAL INVESTIGATION
SOIL BORING SAMPLING RESULTS
SEMIVOLATILE ORGANICS

SAMPLE IDENTIFICATION	SB-66A	SB-73A	SB-85	SB-86	SB-87	SB-88	SB-89	CONTRACT REQUIRED DETECTION LIMIT	SCREENING LEVELS
SAMPLE DEPTH	12-22'	10-22'	10-22'	10-22'	10-22'	10-22'	10-22'		
DATE OF COLLECTION	07/21/97	07/22/97	07/23/97	07/23/97	07/23/97	07/23/97	07/22/97		
DILUTION FACTOR	1	500	1	1	1	1	5		
PERCENT SOLIDS	76	78	70	83	78	74	81		
SEMIVOLATILE ORGANIC COMPOUND	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Phenol	U	U	U	U	64 J	U	U	330	----
bis(2-Chloroethyl)ether	U	U	U	U	U	U	U	330	----
2-Chlorophenol	U	U	U	U	U	U	U	330	----
1,3-Dichlorobenzene	U	U	100 J	U	130 J	U	U	330	----
1,4-Dichlorobenzene	U	U	330 J	U	91 J	U	U	330	----
1,2-Dichlorobenzene	60 J	100000 J	390 J	U	77 J	U	U	330	----
2-Methylphenol	U	U	U	U	U	U	U	330	----
2,2'-oxybis(1-chloropropane)	U	U	U	U	U	U	U	330	----
4-Methylphenol	U	U	U	U	U	U	U	330	----
N-Nitroso-di-n-propylamine	U	U	U	U	U	U	U	330	----
Hexachloroethane	U	U	U	U	U	U	U	330	----
Nitrobenzene	510	3200000 D*	360 J	270 J	210 J	U	U	330	14000
Isophorone	U	U	U	U	U	U	U	330	----
2-Nitrophenol	U	U	U	U	U	U	U	330	----
2,4-Dimethylphenol	U	U	U	U	U	U	U	330	----
bis(2-Chloroethoxy)methane	U	U	U	U	U	U	U	330	----
2,4-Dichlorophenol	U	U	U	U	U	U	U	330	----
1,2,4-Trichlorobenzene	84 J	81000 J	U	U	110 J	U	U	330	----
Naphthalene	6100 D	5200000 D*	800	640	750	290 J	2400	330	----
4-Chloroaniline	U	150000 J	U	U	U	U	350 J	330	----
Hexachlorobutadiene	U	U	U	U	U	U	U	330	----
4-Chloro-3-methylphenol	U	U	U	U	U	U	U	330	----
2-Methylnaphthalene	U	U	63 J	U	290 J	U	1300 J	330	----
Hexachlorocyclopentadiene	U	U	U	U	U	U	U	330	----
2,4,6-Trichlorophenol	U	U	U	U	U	U	U	330	----
2,4,5-Trichlorophenol	U	U	U	U	U	U	U	800	----
2-Chloronaphthalene	1800	490000	1500	49 J	450	89 J	U	330	----
2-Nitroaniline	U	U	U	U	U	U	U	800	----
Dimethylphthalate	U	U	U	U	U	U	U	330	----
Acenaphthylene	U	U	U	U	U	U	U	330	----
2,6-Dinitrotoluene	U	U	U	U	U	U	U	330	----
3-Nitroaniline	U	U	U	U	U	U	U	800	----
Acenaphthene	120 J	28000 J	440 J	110 J	750	U	3700	330	----
2,4-Dinitrophenol	U	U	U	U	U	U	U	800	----
4-Nitrophenol	U	U	U	U	U	U	U	800	----

BUFFALO OUTER HARBOR SITE
PHASE I AND II REMEDIAL INVESTIGATION
SOIL BORING SAMPLING RESULTS
SEMIVOLATILE ORGANICS

SAMPLE IDENTIFICATION	SB-66A	SB-73A	SB-85	SB-86	SB-87	SB-88	SB-89	CONTRACT REQUIRED DETECTION LIMIT	SCREENING LEVELS
SAMPLE DEPTH	12-22'	10-22'	10-22'	10-22'	10-22'	10-22'	10-22'		
DATE OF COLLECTION	07/21/97	07/22/97	07/23/97	07/23/97	07/23/97	07/23/97	07/22/97		
DILUTION FACTOR	1	500	1	1	1	1	5		
PERCENT SOLIDS	76	78	70	83	78	74	81		
SEMIVOLATILE ORGANIC COMPOUND	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Dibenzofuran	U	U	94 J	84 J	560	U	3300	330	----
2,4-Dinitrotoluene	U	U	U	U	U	U	U	330	----
Diethylphthalate	U	U	U	U	U	U	U	330	----
4-Chlorophenyl-phenylether	U	U	U	U	U	U	U	330	----
Fluorene	65 J	U	110 J	150 J	860	75 J	4800	330	----
4-Nitroaniline	U	U	U	U	U	U	U	800	----
4,6-Dinitro-2-methylphenol	U	U	U	U	U	U	U	800	----
N-Nitrosodiphenylamine	U	U	U	U	U	U	U	330	----
4-Bromophenyl-phenylether	U	U	U	U	U	U	U	330	----
Hexachlorobenzene	U	U	81 J	U	U	U	U	330	----
Pentachlorophenol	U	U	U	U	U	U	U	800	----
Phenanthrene	420 J	U	740	1000	5200 D	300 J	32000 D**	330	----
Anthracene	140 J	U	1300	230 J	1400	140 J	6100	330	----
Carbazole	62 J	U	63 J	100 J	810	U	4100	330	----
Di-n-butylphthalate	U	U	U	U	U	U	U	330	----
Fluoranthene	600	U	820	1300	5200 D	650	14000	330	----
Pyrene	780	U	930	1100	6700 D	850	25000 D**	330	----
Butylbenzylphthalate	U	U	U	290 J	U	U	U	330	----
3-3'-Dichlorobenzidine	U	U	U	U	U	U	U	330	----
Benzo (a) anthracene	430 J	U	660	640	3000	580	7100	330	----
Chrysene	430 J	U	650	650	2500	450	6500	330	----
bis(2-Ethylhexyl)phthalate	540	U	U	U	U	U	U	330	----
Di-n-octylphthalate	U	U	U	U	U	U	U	330	----
Benzo(b)flouranthene	360 J	U	940	490	2100	620	4200	330	----
Benzo(k)flouranthene	260 J	U	U	510	1400	290 J	5200	330	----
Benzo(a)pyrene	340 J	U	630	590	2100	380 J	5600	330	----
Indeno(1,2,3-cd)pyrene	270 J	U	710	640	1900	380 J	2800	330	----
Dibenz(a,h)anthracene	U	U	U	U	860	U	U	330	----
Benzo(g,h,i)perylene	270 J	U	610	620	1900	U	2700	330	----

TOTAL PAHs	10585	[illegible]	9340	8670	36620	5005	122100		100000
TOTAL CARCINOGEN PAHs	2090	0	3590	3520	[illegible]	2700	31400		10000
TOTAL SVOCs	13641	[illegible]	12321	9463	39412	5094	131150		500000

QUALIFIERS
J: Compound found at a concentration below the detection limit, value estimated
U: Compound analyzed for but not detected
D: Results taken from reanalysis at a 1:2 dilution
D*: Results taken from reanalysis at a 1:2000 dilution
D**: Results taken from reanalysis at a 1:10 dilution
TO DETERMINE THE DETECTION LIMIT FOR EACH SAMPLE USE THE FOLLOWING EQUATION: (CRDL)*(DF)*(100/%S)

NOTES
----: Not established
RE: Reanalysis of sample
DL: Sample run at secondary dilution
: value exceeds screening levels

CRDL: CONTRACT REQUIRED DETECTION LIMIT
%S: PERCENT SOLIDS
DF: DILUTION FACTOR

BUFFALO OUTER HARBOR SITE
PHASE I AND II REMEDIAL INVESTIGATION
SOIL BORING SAMPLING RESULTS
SEMIVOLATILE ORGANICS

SAMPLE IDENTIFICATION	SB-90	SB-91	SB-92					CONTRACT REQUIRED DETECTION LIMIT	SCREENING LEVELS
SAMPLE DEPTH	10-22'	10-22'	10-22'						
DATE OF COLLECTION	07/22/97	07/22/97	07/22/97						
DILUTION FACTOR	1	1	2						
PERCENT SOLIDS	76	80	78						
SEMIVOLATILE ORGANIC COMPOUND	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Phenol	U	U	U					330	----
bis(2-Chloroethyl)ether	U	U	U					330	----
2-Chlorophenol	U	U	U					330	----
1,3-Dichlorobenzene	340 J	U	U					330	----
1,4-Dichlorobenzene	140 J	U	U					330	----
1,2-Dichlorobenzene	830	U	U					330	----
2-Methylphenol	U	U	U					330	----
2,2'-oxybis(1-chloropropane)	U	U	U					330	----
4-Methylphenol	U	U	U					330	----
N-Nitroso-di-n-propylamine	U	U	U					330	----
Hexachloroethane	U	U	U					330	----
Nitrobenzene	1800	150 J	370 J					330	14000
Isophorone	U	U	U					330	----
2-Nitrophenol	U	U	U					330	----
2,4-Dimethylphenol	U	U	U					330	----
bis(2-Chloroethoxy)methane	U	U	U					330	----
2,4-Dichlorophenol	U	U	U					330	----
1,2,4-Trichlorobenzene	1300	U	U					330	----
Naphthalene	14000 D	320 J	820					330	----
4-Chloroaniline	4200 D	U	U					330	----
Hexachlorobutadiene	U	U	U					330	----
4-Chloro-3-methylphenol	U	U	U					330	----
2-Methylnaphthalene	160 J	U	150 J					330	----
Hexachlorocyclopentadiene	U	U	U					330	----
2,4,6-Trichlorophenol	U	U	U					330	----
2,4,5-Trichlorophenol	U	U	U					800	----
2-Chloronaphthalene	3300	U	U					330	----
2-Nitroaniline	U	U	U					800	----
Dimethylphthalate	U	U	U					330	----
Acenaphthylene	53 J	U	U					330	----
2,6-Dinitrotoluene	U	U	U					330	----
3-Nitroaniline	U	U	U					800	----
Acenaphthene	600	63 J	200 J					330	----
2,4-Dinitrophenol	U	U	U					800	----
4-Nitrophenol	U	U	U					800	----

BUFFALO OUTER HARBOR SITE
PHASE I AND II REMEDIAL INVESTIGATION
SOIL BORING SAMPLING RESULTS
SEMIVOLATILE ORGANICS

SAMPLE IDENTIFICATION	SB-90	SB-91	SB-92					CONTRACT REQUIRED DETECTION LIMIT	SCREENING LEVELS
SAMPLE DEPTH	10-22'	10-22'	10-22'						
DATE OF COLLECTION	07/22/97	07/22/97	07/22/97						
DILUTION FACTOR	1	1	2						
PERCENT SOLIDS	76	80	78						
SEMIVOLATILE ORGANIC COMPOUND	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)	(ug/kg)
Dibenzofuran	130 J	63 J	170 J					330	----
2,4-Dinitrotoluene	U	U	U					330	----
Diethylphthalate	U	U	U					330	----
4-Chlorophenyl-phenylether	U	U	U					330	----
Fluorene	160 J	110 J	210 J					330	----
4-Nitroaniline	U	U	U					800	----
4,6-Dinitro-2-methylphenol	U	U	U					800	----
N-Nitrosodiphenylamine	U	U	U					330	----
4-Bromophenyl-phenylether	U	U	U					330	----
Hexachlorobenzene	660	U	U					330	----
Pentachlorophenol	U	U	U					800	----
Phenanthrene	800	590	1200					330	----
Anthracene	320 J	180 J	290 J					330	----
Carbazole	150 J	110 J	210 J					330	----
Di-n-butylphthalate	U	U	U					330	----
Fluoranthene	920	1000	1200					330	----
Pyrene	960	1600	1300					330	----
Butylbenzylphthalate	U	U	U					330	----
3-3'-Dichlorobenzidine	U	U	U					330	----
Benzo (a) anthracene	730	810	720					330	----
Chrysene	630	750	620					330	----
bis(2-Ethylhexyl)phthalate	68 J	U	160 J					330	----
Di-n-octylphthalate	U	U	U					330	----
Benzo(b)flouranthene	620	960	550					330	----
Benzo(k)flouranthene	380 J	U	410 J					330	----
Benzo(a)pyrene	600	630	560					330	----
Indeno(1,2,3-cd)pyrene	470	370 J	450					330	----
Dibenz(a,h)anthracene	U	190 J	240 J					330	----
Benzo(g,h,i)perylene	490	440	430					330	----

TOTAL PAHs	21733	8013	9200						100000
TOTAL CARCINOGEN PAHs	3430	3710	3550						10000
TOTAL SVOCs	34811	8336	10260						500000

QUALIFIERS
J: Compound found at a concentration below the detection limit, value estimated
U: Compound analyzed for but not detected
D: Results taken from reanalysis at a 1:5 dilution

NOTES
----: Not established
RE: Reanalysis of sample
DL: Sample run at secondary dilution
: value exceeds screening levels

TO DETERMINE THE DETECTION LIMIT FOR EACH SAMPLE USE THE FOLLOWING EQUATION: (CRDL)*(DF)*(100/%S)

CRDL: CONTRACT REQUIRED DETECTION LIMIT
%S: PERCENT SOLIDS
DF: DILUTION FACTOR

BUFFALO OUTER HARBOR
PHASE I AND II REMEDIAL INVESTIGATION
SOIL BORING SAMPLE RESULTS
TCLP SEMIVOLATILE EXTRACTION

SAMPLE ID	SB-66A	SB-73A	MAXIMUM ALLOWABLE LEVEL
DATE OF COLLECTION	7/21/97	7/22/97	
TCLP CONSTITUENTS	(mg/l)	(mg/l)	(mg/l)
Pentachlorophenol	U	U	100
2,4,5 - Trichlorophenol	U	U	400
2,4,6 - Trichlorophenol	U	0.025 J	2
2-Methylphenol	U	U	200
3-and/or 4 - Methylphenol	U	U	200
Hexachlorobenzene	U	U	0.13
Hexachlorobutadiene	U	U	0.5
Hexachloroethane	U	U	3
Nitrobenzene	U	**210 D**	2
1,4 -Dichlorobenzene	U	0.11	7.5
2,4 - Dinitrotoluene	U	U	0.13
Pyridine	U	U	5

QUALIFIERS
U: Compound analyzed for but not detected
J: Estimated value
D: Result taken from reanalysis at a 1:500 dilution

NOTES
(shaded): Value exceeds Maximum Allowable Level

1307SSB1.WK4/cw

BUFFALO OUTER HARBOR SITE
PHASE I AND II REMEDIAL INVESTIGATION
SOIL BORING SOIL SAMPLE RESULTS
TCLP CONSTITUENTS

SAMPLE ID	SB-66A	SB-73A	MAXIMUM ALLOWABLE LEVEL (mg/l)
DATE OF COLLECTION	7/21/97	7/22/97	
TCLP CONSTITUENTS	(mg/l)	(mg/l)	
Arsenic	U	U	5.0
Barium	0.38 B	0.24 B	100
Cadmium	U	U	1.0
Chromium	U	0.0028 B	5.0
Lead	0.0022 B	0.0033 B	5.0
Mercury	U	U	0.2
Selenium	U	0.0086 B	1.0
Silver	U	U	5.0

QUALIFIERS
U: Compound analyzed for but not detected
B: Constituent found above the IDL but below the CRDL
E: Result qualified as estimated based on validation criteria

NOTES
Value exceeds Maximum Allowable Level

APPENDIX C

BIOREMEDIATION TREATABILITY STUDY REPORT

GRACE Bioremediation Technologies

A Division of W.R. Grace & Co. Canada Ltd.
3451 Erindale Station Road
Mississauga, Ontario
Canada, L5C 2S9
Tel: (905) 272-7480
Fax: (905) 272-7472

FINAL REPORT: DARAMEND® BIOREMEDIATION LABORATORY TREATABILITY INVESTIGATION OF SOIL CONTAINING NITROBENZENE

BUFFALO OUTER HARBOR SITE, BUFFALO, NY

VOLUME I - TECHNICAL REVIEW

Submitted by:

GRACE Bioremediation Technologies
Division - W.R. GRACE & Co. of Canada Ltd.
Project No.: 1023

For:

Dvirka and Bartilucci Consulting Engineers
Woodbury, New York

January, 1998

Executive Summary

The feasibility of soil bioremediation is being investigated for the Buffalo Outer Harbor Site, Buffalo, NY. Dvirka and Bartilucci Consulting Engineers (D&B) requested a technical and cost proposal from GRACE Bioremediation Technologies (GRACE) to investigate the potential for bioremediating soil containing nitrobenzene at the site. This document represents the final report submitted by GRACE summarizing the above-mentioned laboratory treatability investigation.

The investigation focused on evaluation of the efficacy of the DARAMEND® bioremediation technology. This patented technology utilizes repeated and sequential anoxic and oxic conditions to reduce and degrade the nitrobenzene. Four complete anoxic/oxic cycles and 5 sampling events were completed during the 9 week study. Initial and final samples were submitted for analysis by NYSDEC ASP Method 95-2.

The replicated treatability investigation demonstrated that the DARAMEND bioremediation technology rapidly degrades nitrobenzene in Buffalo Outer Harbor soil. The optimal anoxic/oxic cycled treatment required addition of ca. 10% (wt/wt) of soil amendments during treatment. Following 56 days of optimal treatment, the concentration of nitrobenzene had been reduced from 433 mg/kg to 3 mg/kg. Concentrations in the air-dried control were unchanged.

Based on the results of the treatability investigation and our experience with successful field - scale application of the technology at three sites in 1996 and 1997, it is recommended that DARAMEND bioremediation would provide the most effective approach for treatment of nitrobenzene impacted soils at the Buffalo Outer Harbor site.

Table of Contents

1.0 INTRODUCTION

1.1 Project Background

The feasibility of bioremediation is being investigated at the Buffalo Outer Harbor Site, Buffalo, NY, by Dvirka and Bartilucci Consulting Engineers (D&B) as part of New York State's Superfund Program. D&B conducted a treatment evaluation/cost analysis related to bioremediation of soil containing nitrobenzene.

Following a review of background information D&B requested and accepted a proposal from the GRACE Bioremediation Technologies Division of W.R. GRACE & Co. of Canada Ltd. (GRACE). The study was carried out by GRACE and focused on an evaluation of the efficacy of the modified DARAMEND® bioremediation technology. Appropriate controls and a nutrient-based bioremediation protocol, designed by D&B, were included to provide a basis from which to evaluate the effectiveness of DARAMEND treatment.

1.2 Overview of the DARAMEND Technology

The focus of the investigation was evaluation of the efficacy of GRACE's patented DARAMEND bioremediation technology for removal of nitrobenzene. Briefly, the DARAMEND technology enhances and promotes natural bioremediation rates by adjusting conditions in a soil or waste matrix to stimulate biodegradation of target compounds by indigenous microorganisms. The central element OF GRACE's approach to bioremediation is DARAMEND amendments, a family of solid phase organic materials, one or more of which are added on a waste/contaminant specific basis. No inoculation is conducted.

The key to the technology's effectiveness is application of repeated and sequential anoxic and oxic conditions to the contaminated matrix. The treatment results in the sequential reduction and degradation of nitroaromatic organic compounds.

DARAMEND® is a registered trademark of W.R. GRACE.

Anoxic conditions are achieved through addition of DARAMEND amendments, multivalent metals and water to the soil being treated. Oxic conditions are achieved through drying, tilling and, in some cases, addition of DARAMEND amendments.

The technology was developed in 1991 and has been successfully demonstrated at field scale on three sites on soils containing chlorinated herbicides and pesticides. The general applicability of the technology has been verified by testing samples of waste collected from a number of sites throughout North America. The technology has been patented for both pesticides and nitroaromatics applications.

At large-scale the technology would be applied as a form of landfarming, either to soil in-place or soil excavated and placed in a lined treatment cell. A 90 tonne (100 ton) in-place pilot program commenced in October, 1995, in South Carolina and two 200 tonne (220 ton) ex-situ pilot projects commenced in 1996, in Ontario. The U.S. project is characterized by chlorinated pesticide contamination (predominantly Toxaphene and DDT) and the Canadian projects by Metolachlor® in one instance and 2,4-D/2,4,5-T in the other.

2.0 PROJECT SCOPE AND OBJECTIVES

The scope of the treatability study is described in the document "Technical Proposal for DARAMEND™ Bioremediation Laboratory Treatability Investigation of Soil Containing Nitrobenzene" submitted for Dvirka and Bartilucci Consulting Engineers and will not be repeated in detail in this report.

The aim of the bench-scale work was to demonstrate that DARAMEND bioremediation technology can be effectively utilized to remediate the Buffalo Harbor soil (i.e., that the soil's nitrobenzene concentration could be remediated to below 10 mg/kg nitrobenzene). Specific objectives were to:

- characterize the contaminated soil with respect to physical/chemical properties known to affect biodegradation of the target compounds;

- verify the feasibility of bioremediation;

- determine the optimal bioremediation treatment operating parameters (i.e., type and rate of amendments required such as pH modifiers, nutrients, DARAMEND organic amendments, and multivalent metals);

- determine the rate of degradation of nitrobenzene in the soil under optimal treatment conditions; and

- identify the residual concentration of nitrobenzene achievable following eight weeks of treatment and the potential for continued degradation based on data trends established by initial, 2, 4, 5, 6 and 8 week soil analyses.

3.0 MATERIALS AND METHODS

3.1 Soil Collection/Preparation and Characterization

Five, 2.5 gallon pails of soil contaminated with various levels of nitrobenzene were delivered, under chain of custody, to the GRACE laboratory facilities on July 23, 1997. The soil samples had been taken, under the supervision of Mr. Gerry Gould, Field Team Leader, from the Buffalo Outer Harbor Site. Samples were collected at two depths (0-10' and 10-22') from each of two locations. Upon arrival at our Mississauga facility the soil was visually inspected, entered into the GRACE sample log system, and a project log book was created. The soil was stored at <4°C in the dark until needed for set-up of the treatability investigation.

Subsamples from each of the 4 pails of soil were archived as 'soil as received'. The remaining soil was dried, homogenized, and sieved to 4.75 mm following the protocol outlined in the project workplan. Samples were taken from each of the four pails of soil and submitted to the Novamann laboratory, in Mississauga, Ontario, for determination of contaminant concentrations.

Based on the results (Table 1), which indicated that both samples taken from the 1-10' depth contained low concentrations of nitrobenzene, while both samples from the 10-22' depth had higher nitrobenzene concentrations, and discussions between M. Wright, G. Kline, A. Seech, and K. Shaw, it was determined that the most appropriate soil mixture would be a 50:50 combination of the two samples from the 10-22' depth. This mixture resulted in soil with an initial nitrobenzene concentration of 433 mg/kg.

The blended soil was placed in a 20 L (5 gal) pail, and logged into the GRACE sample identification database. The blended soil was used for all subsequent purposes, unless otherwise stated. Five samples of the blended soil were submitted to Nytest Environmental Inc. (Nytest), in Port Washington, NY, for nitrobenzene analysis following NYSDEC ASP Method 95-2 protocol. Three split samples of the blended soil were also sent to Dvirka and Bartilucci for quality control purposes. In addition, the respective unprepared soils were mixed in a 50:50 ratio and split into three pre-preparation samples for analysis at Nytest, as indicated in the project workplan.

Samples of the prepared blended soil were also submitted to the University of Guelph Analytical Services Laboratory in Guelph, Ontario, for physical and chemical characterization, and to BetzDearborn in Mississauga, Ontario, for metals analyses.

3.2 Treatability Investigation

The treatability investigation was initiated on September 11, 1997, and completed on November 6, 1997. The study consisted of ten sets of triplicate glass microcosms, each containing 300 g of soil. An air-dried control was maintained for reference. Six of the triplicate sets of microcosms were treated with one of six different anoxic/oxic cycled DARAMEND treatments (referred to as Cycled Treatments 1 - 6). One triplicate set of microcosms was treated with a standard nutrient-based protocol routinely used for bioremediation applications (no DARAMEND applied) (referred to as Aerobic Treatment 1). The remaining two triplicate sets of microcosms were treated with one of two different aerobic DARAMEND treatments (Aerobic Treatments 2 & 3).

The standard nutrient-based treatment (Aerobic Treatment 1) was designed based on results from the initial soil characterization analysis (Table 2). The soil was determined to be limited in phosphorus. To achieve a C:N:P ratio of approximately 100:5:1, a phosphorus fertilizer, Triple Super Phosphate (TSP) was added to each of the microcosms at a rate of 1,695 mg/kg.

During the following 8 weeks the cycled treatment microcosms underwent 4 complete anoxic/oxic cycles (the air-dried control was undisturbed except for sampling events), maintained in an incubator set to 28 °C (82 °F). Each anoxic phase of treatment was initiated through addition of amendments. No amendments were added during the oxic phase of treatment.

The three aerobic treatments were maintained at a moisture content equivalent to 70% of the soil's water holding capacity throughout the 8 week study. The microcosms were stirred and passively aerated for 15 minutes each week. Following the initial application of amendments at the beginning of the study, no additional materials were added to the microcosms.

During the study, the key response variables monitored were redox, pH, and nitrobenzene concentration. Redox and pH were periodically monitored to ensure optimal operating conditions were maintained. Composite soil samples for determination of nitrobenzene concentrations were taken following the first, second, mid-point of the second, third and fourth anoxic/oxic cycles (weeks 2,4,5,6 and 8). Redox was measured using a Cole Parmer G-27001-62 disposable industrial ORP double junction electrode redox probe, and soil pH was measured using an Horiba Cardy Twin pH meter (Anachemia Science).

Soil samples taken at the end of the study (following 4 cycles) were sent to Nytest for analysis following NYSDEC ASP Method 95-2 protocol. Individual samples were taken from each microcosm, resulting in triplicate results for each treatment. Interm composite samples were sent to Water Technology International Corp.

(WTI) in Burlington, Ontario, for determination of nitrobenzene concentrations. Samples were packed in a cooler with ice and sent to respective laboratories, under chain-of-custody.

3.3 Bacterial Enumeration

Bacterial enumeration was performed on the blended soil as well as on the initial 10 - 22' depth soil sample containing the highest nitrobenzene concentration (the hot soil). In both cases, a one gram sample of soil was mixed with 50 mL of sterilized, deionized water, and 250 µL subsamples of the soil/water mixture were aseptically streaked onto sterile nutrient agar plates. On October 9, 1997, soil samples were removed from each of the aerobic treatment protocols and bacterial enumeration was performed following the same procedure.

3.4 Microbial Activity

Microbial activity levels in untreated blended soil, hot soil, and soil in the treatment microcosms (at the end of each anoxic/oxic cycle), were monitored by measuring total CO_2 evolution. The protocol used was described by Anderson (1982), and modified for use on microcosm systems. Briefly, 20 mL of 1N NaOH (alkali) contained in a glass test tube was placed inside each microcosm and the jar was tightly closed. As CO_2 evolved from the soil it was absorbed by the NaOH. After 24 hours, the test tube was removed and the unreacted portion of NaOH was measured by titration. The amount of CO_2 combined with the alkali was subsequently determined by subtraction.

4.0 RESULTS AND DISCUSSION

4.1 Soil Characterization

Laboratory analysis of the prepared soil (Table 2) indicated the soil was classified as very fine sandy loam, consisting of approximately 23% sand, 41% silt and 36% clay. Neither the pH, nor the metals concentrations were determined to be of concern with respect to biological activity. Biological activity would, however have been limited by available phosphorous as the soil's available phosphorous was low relative to the carbon and nitrogen concentrations. As DARAMEND are degradable organic materials sufficient phosphorous would become available for microbial growth in DARAMEND treatment microcosms. In the case of the standard nutrient protocol, additional phosphorous was provided by addition of TSP as described in section 3.2.

Composite samples were taken from each of the three aerobic treatments following the third anoxic/oxic cycle, and analyzed for available phosphorous by the University of Guelph Analytical Services Laboratory, Guelph, Ontario. Results indicated that relative to the initial concentration of 10 mg/kg, levels of available phosphorous had increased significantly in Aerobic Treatments 1 and 2 (106 mg/kg and 97 mg/kg, respectively). Available phosphorous levels in Aerobic Treatment 2 had remained at 9 mg/kg.

The initial concentration of nitrobenzene (Table 3) in the blended soil was 433 mg/kg (reported on a dry weight basis).

4.2 Microbial Enumeration

Viable cell enumeration was performed on the blended soil as well as on the hot soil. Good results were obtained in both cases. Colonies growing on the plates consisted of (i) small round white and yellow colonies, (ii) larger rough edged white colonies, and (iii) some filamentous fungi. The number of viable, culturable cells in the hot soil was 5 x 10^5 CFU/g soil. Colonies on the blended soil plates were 'too numerous to count', but estimated to be *ca.* 1x10^9 CFU/g soil. These results indicate that there are several different species of microorganisms present in the Buffalo Harbor soil, and that they survive well even in the heavily impacted soil.

Bacterial enumeration performed on samples from the aerobic treatment microcosms also indicated significant levels of microbial growth. The number of viable, culturable cells was 1 x 10^7 CFU/g soil in soil from each of the aerobic treatments.

4.3 Microbial Activity

Microbial activity assays were performed on soil from each of the microcosms five times over the course of the treatability investigation (Table 4). Results indicate selected cycled and aerobic treatments supported levels of CO_2 evolution significantly (α= 0.05) greater than the air-dried control during the first 3 anoxic/oxic cycles of the study. Following the fourth cycle, only Cycled Treatment 1 supported significantly higher CO_2 evolution than the air-dried control. Results obtained following the second and third anoxic/oxic cycles indicate levels of activity significantly greater than the initial value in the air dried control microcosms. Simply transferring the soil into glass microcosms would have provided increased levels of oxygen and supported some microbial activity, even in the air dried control microcosms.

It should be recognized that CO_2 evolution is a good indicator of total microbial activity, but is not always a good indicator of microbial activity targeted toward removal of specific contaminants (i.e., microorganisms appeared to be present and active in all of the treatments, however, the extent to which the activity was directed toward degradation of nitrobenzene differed widely).

4.4 Anoxic/Oxic Cycling Treatments

The treatability study was initiated September 11, 1997 with establishment of the first anoxic phase. Seven days later the soil redox values were measured and the soils switched to oxic conditions to complete the first anoxic/oxic cycle. Each subsequent week the soils were monitored and switched to anoxic or oxic conditions as appropriate.

Soil process monitoring data indicated that the cycled process was successfully implemented. Soil redox potentials fluctuated from strong anoxic conditions (-100 to -500 mV) to strong oxic conditions (> 100 mV) according to the phase of treatment. No redox data was acquired from the air-dried control as the soil was too dry for a consistent determination. pH values were within an acceptable range through the duration of the study.

4.5 Nitrobenzene Removal

Nitrobenzene data from the air-dried control and treatment microcosms are summarized in Table 5 and Figures 1 and 2. Complete laboratory reports are included with this report.

Air-dried control data showed a dramatic increase in nitrobenzene concentration in samples taken following 14 days (1 cycle), 28 days (2 cycles), 35 days (2.5 cycles), and 42 days (3 cycles) of treatment. The initial (t=0) nitrobenzene concentration in untreated blended soil, as determined by Nytest, following NYSDEC ASP Method 95-2, was 433 mg/kg. Nitrobenzene concentrations in the four subsequent air-dried control samples, as determined by (WTI) using U.S. EPA 625 base neutral protocol, were 1600, 827, 820, and 985 mg/kg, respectively.

The observed increase in nitrobenzene concentration was probably a result of the differences in the analytical methodologies employed.

The soil samples taken on treatment day 56 (following the fourth anoxic/oxic cycle), were submitted to Nytest for analysis using NYSDEC ASP Method 95-2 methodology. The mean nitrobenzene concentration of the triplicate air-dried control samples was 473 mg/kg which was not significantly different from the initial value of 433 mg/kg, as determined using a 2-tailed student's T-test.

Data from the cycled treatments indicate that DARAMEND bioremediation is an effective means of degrading nitrobenzene in Buffalo Outer Harbor soil. In the best case (Cycled Treatment 4) the concentration of nitrobenzene was reduced by 77.4 % in a single treatment cycle (14 days).

At the completion of the study nitrobenzene had been reduced by 99.3% in the two most effective treatments (Cycled Treatment 3 and Cycled Treatment 4) to an average of 3 mg/kg (Table 5).

Nitrobenzene data from the air-dried control and aerobic treatments are summarized in Table 5 and Figure 2. The data indicate that nitrobenzene concentrations were reduced in each of the aerobic treatments, however at the end of the study nitrobenzene concentrations remained more than an order of magnitude above the remediation criterion of 10 mg/kg.

4.6 Data Quality

The quality of data obtained in this study was evaluated by determining the coefficient of variation (CoV, the standard deviation divided by the mean) for each treatment and the control. In general data quality was good. The CoV values for most of the treatments were less than 50% with some exceptions.

The nitrobenzene result at day 56 for Cycled Treatment 5 had a CoV value of over 150%. In that treatment, two of the triplicate samples had concentrations less than 3 mg/kg. The third sample concentration was 130 mg/kg. The resulting standard deviation was very high, hence the CoV value was very high as well.

The Aerobic Treatment 1 result at day 56 had a CoV value of 77%. The nitrobenzene concentration in the first triplicate sample was not reported by Nytest (not within reportable range at either dilution level). The standard deviation of the remaining two samples was high, which resulted in a high CoV value as well.

5.0 SUMMARY AND RECOMMENDATIONS

Results of the treatability investigation conducted on nitrobenzene impacted soil from the Buffalo Outer Harbor site indicated that DARAMEND bioremediation technology provides a rapid and effective means of treatment. Nitrobenzene was rapidly degraded to below the remediation criterion (10 mg/kg) in response to several of the DARAMEND treatment protocols. Nitrobenzene degradation was also observed in the standard aerobic treatments, but to a lesser extent and at a much slower rate.

With respect to the stated objectives of the project (Section 2.0), the following can be concluded:

- the soil was characterized as a very fine sandy loam with a high concentration of nitrobenzene (blended soil concentration 433 mg/kg). The soil characteristics suggested no barrier to bioremediation (including antimony concentrations);

- the feasibility of DARAMEND bioremediation was verified within 14 days of treatment as the nitrobenzene concentration was reduced by 77.4%;

- the optimal treatment, in terms of final nitrobenzene concentration as well as rate of degradation, was by Cycled Treatment 4. Anoxic conditions for this treatment were created through addition of a combination of DARAMEND 6390 and iron powder complemented by increasing the soil moisture content to 90% of the soil's water holding capacity;

- For all of the cycled treatments, degradation appeared to be first order while nitrobenzene concentrations exceeded 15 - 20 mg/kg; and

- the concentration of nitrobenzene was less than 20 mg/kg within 28 days of treatment. Following 56 days of treatment the concentration had decreased to <3 mg/kg.

Based on this investigation it is strongly recommended that field-scale treatment be initiated. A conservative estimate of the treatment time, to reduce nitrobenzene to less than the 10 mg/kg target, would be 90 days. This estimate allows for reduced efficiency in switching from anoxic to oxic conditions at field-scale compared to efficiency in the laboratory.

6.0 REFERENCES

Anderson, J.P.E. 1982. Soil respiration. *In* Methods of Soil Analysis, Part 2. Chemical and Microbiological Properties - Agronomy Monograph no. 9 (2nd Edition). ASA-SSSA. Madison, WI, U.S.A.

TABLES

FINAL REPORT: DARAMEND BIOREMEDIATION LABORATORY TREATABILITY INVESTIGATION OF SOIL CONTAINING NITROBENZENE

Table 1. Results from analysis of original four samples from Buffalo Outer Harbor site.

PARAMETER (mg/kg)	ORIGINAL SOIL SAMPLES			
	SB66A 0-10	**SB66A 10-22**	**SB73A 0-10**	**SB73A 10-22**
1,2-dichlorobenzene	ND	ND	ND	35.4
2-chloronaphthalene	45.7	22.3	2.7	238
acenphthylene	1.4	ND	1.2	15.8
benzo(a)anthracene	ND	1.2	1.7	ND
benzo(a)pyrene	ND	1.2	1.6	ND
benzo(b)fluoranthene	ND	ND	2.0	ND
chrysene	ND	1.2	2.5	ND
fluoranthene	ND	2.1	2.9	ND
naphthalene	107	473	7.3	401
nitrobenzene	ND	ND	ND	1,154
phenanthrene	1.3	2.1	2.7	ND
pyrene	1.2	2.5	3.4	ND

ND - not detected

Table 2. Key initial physical and chemical characteristics.

Parameter	Value
Available phosphorous	10
Total nitrogen (%)	0.17
Total organic carbon (%)	2.83
pH	7.6
Water holding capacity (mL/100g)	
Sand (% wt/wt)	55.5
Silt (% wt/wt)	34.3
Clay (% wt/wt)	10.3
Aluminum	8661
Antimony	94.2
Arsenic	<3.5
Cadmium	0.7
Chromium	115.7
Copper	129.9
Iron	22,233
Lead	285.5
Manganese	415.2
Nickel	17.9
Silver	<0.4
Zinc	242.6

All values are mg/kg concentrations on a dry weight basis.
Metal analysis performed by BetzDearborn Inc.; all other analysis performed by University of Guelph Analytical Services Laboratory

Table 3. Nitrobenzene concentrations in pre-preparation and post-preparation blended soil.

COMPOUND	PRE-PREPARATION				POST-PREPARATION			
	R1	R2	R3	MEAN	R1	R2	R3	MEAN
nitrobenzene (mg/kg)	260	980	330	**229**	360	580	360	**433**

Analysis performed by Nytest Environmental Inc. using NYSDEC ASP Method 95-2.

Table 4. CO_2 Evolution Data

TREATMENT/ TIME	Initial (t=0)	1 cycle (14 days)	2 cycles (28 days)	3 cycles (42 days)	4 cycles (56 days)
Air Dried Control	9.36	27.25	473.15	60.72	196.83
Cycled Treatment 1	9.36	36.37	561.73	271.04	326.19
Cycled Treatment 2	9.36	43.71	682.59	316.80	231.73
Cycled Treatment 3	9.36	31.97	569.65	283.36	284.83
Cycled Treatment 4	9.36	168.67	759.15	396.59	0
Cycled Treatment 5	9.36	71.87	733.92	153.41	0
Cycled Treatment 6	9.36	59.84	701.07	164.27	317.39
Aerobic Treatment 1	9.36	75.39	608.67	47.23	57.20
Aerobic Treatment 2	9.36	90.05	694.61	121.73	111.76
Aerobic Treatment 3	9.36	97.68	666.75	180.99	106.19
$LSD_{(0.05)}$		27.36	57.82	79.77	125.54

LSD(0.05) - Least Significant Difference statistical analysis performed using a 95% level of confidence.
Underlined values - represent results that are not statistically different from the air dried control.

Table 5. Influence of soil treatments on nitrobenzene concentrations in Buffalo Outer Harbor soil.

TREATMENT	Initial* (t=0)	1 cycle (14 days)	2 cycles (28 days)	2.5 cycles (35 days)	3 cycles (42 days)	4 cycles* (56 days)	Reduction Rel. to Initial
Air Dried Control	433	1600	827	820	985	473 (15)	-
Cycled 1	433	484	110	15.9	30.5	11 (21)	97.4%
Cycled 2	433	463	180	27.8	33.8	6.9 (77)	98.4%
Cycled 3	433	293	106	26.1	19.6	**3 (42)**	99.3%
Cycled 4	433	97.8	15.4	19.2	17.5	**2.9 (31)**	99.3%
Cycled 5	433	241	56.6	25.7	39.7	45 (163)	89.6%
Cycled 6	433	219	158	15.1	19.5	**5.7 (23)**	98.7%
Aerobic 1	433	601	443	623	521	185 (50)	57.3%
Aerobic 2	433	638	608	542	670	277 (45)	<u>36.1%</u>
Aerobic 3	433	450	1090	703	600	257 (20)	<u>40.8%</u>

Values in parenthesis represent CoV - Coefficient of Variance (st. dev. / mean x 100) of data set.
Underlined values represent % reductions that are not stastistically significant.
Bold values indicate attainment of remediation criteria for nitrobenzene (10 mg/kg).

FIGURES

FINAL REPORT: DARAMEND BIOREMEDIATION LABORATORY TREATABILITY INVESTIGATION OF SOIL CONTAINING NITROBENZENE

Figure 1. Nitrobenzene concentrations in Air Dried Control and Cycled Treatments # 1-6 ($LSD_{(0.05)}$ for 56 days = 181mg/kg).

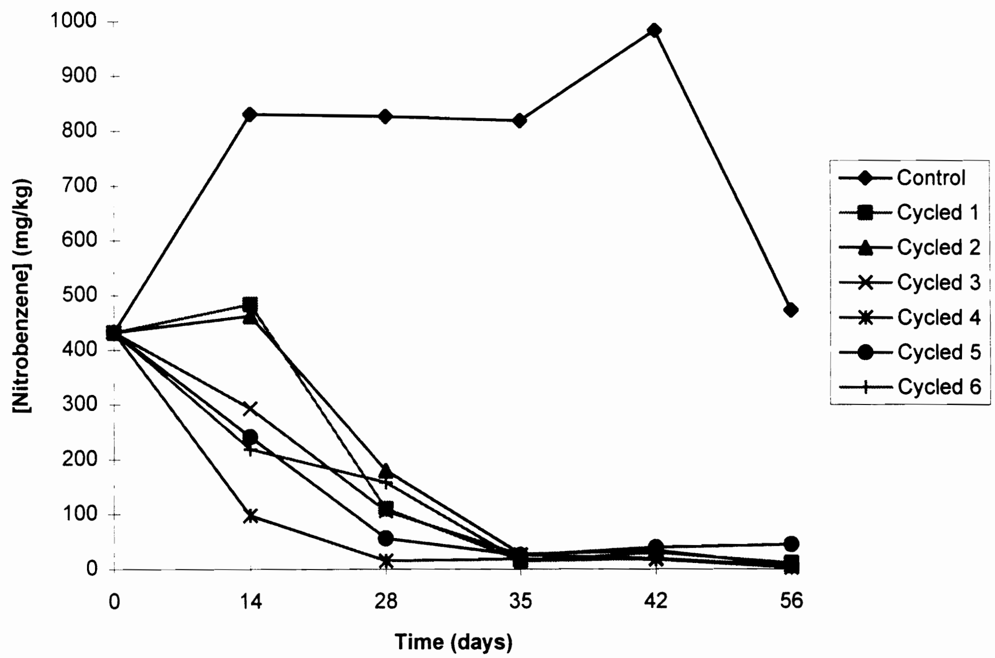
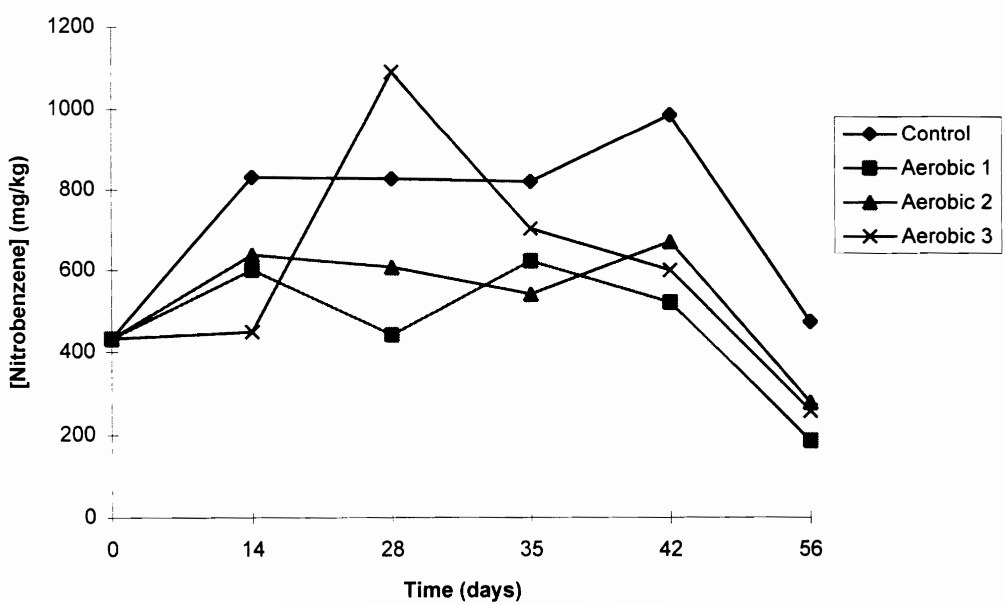
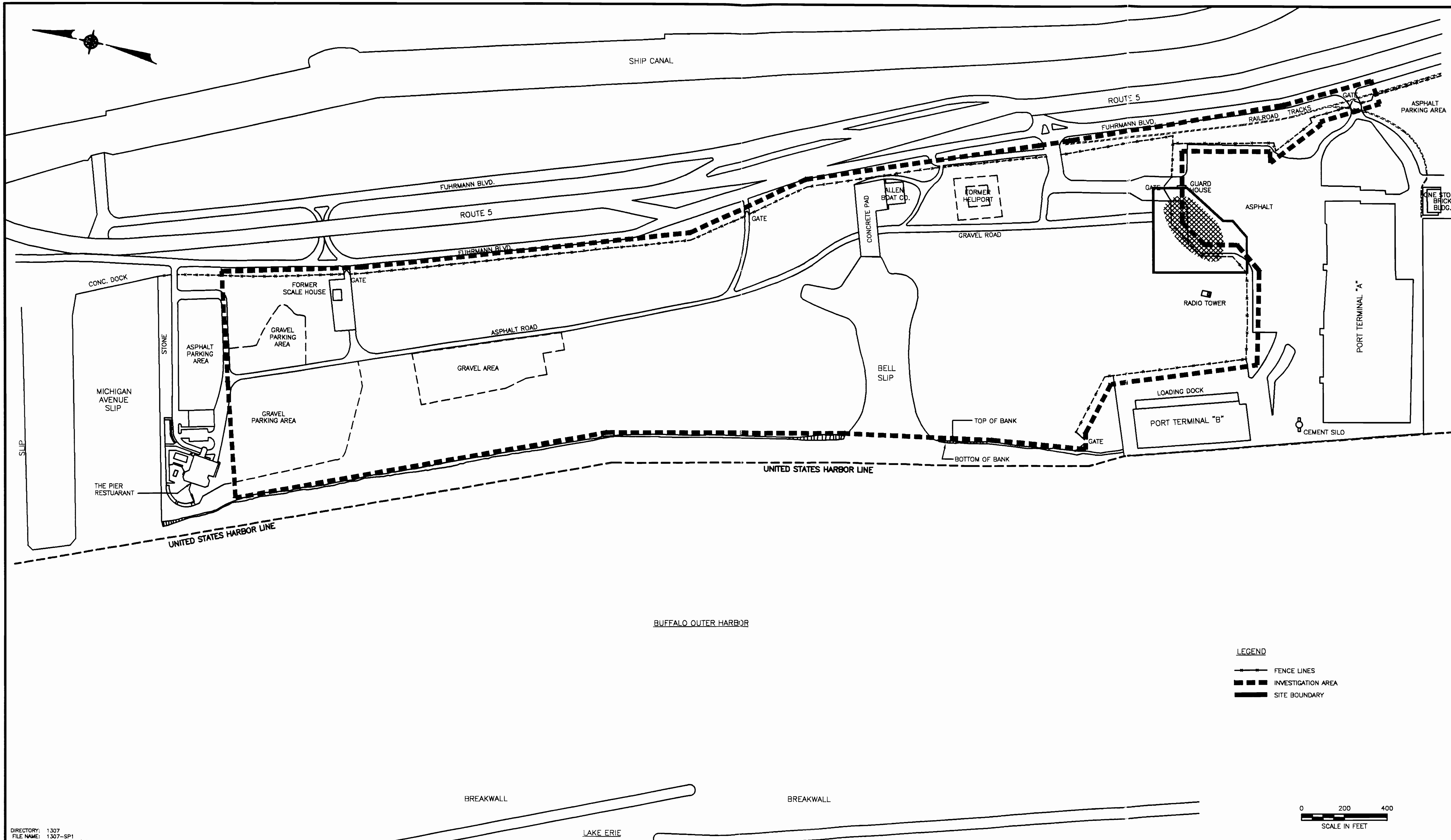


Figure 2. Nitrobenzene concentrations in Air Dried Control and Aerobic Treatments # 1-3 ($LSD_{(0.05)}$ for 56 days = 181 mg/kg).





DIRECTORY: 1307
FILE NAME: 1307-SP1
DATE: RDS-03/01/95

NO.	DATE	REVISION

UNAUTHORIZED ALTERATION OR ADDITION TO THIS DOCUMENT IS A VIOLATION OF SECTION 7209 OF THE NEW YORK STATE EDUCATION LAW.

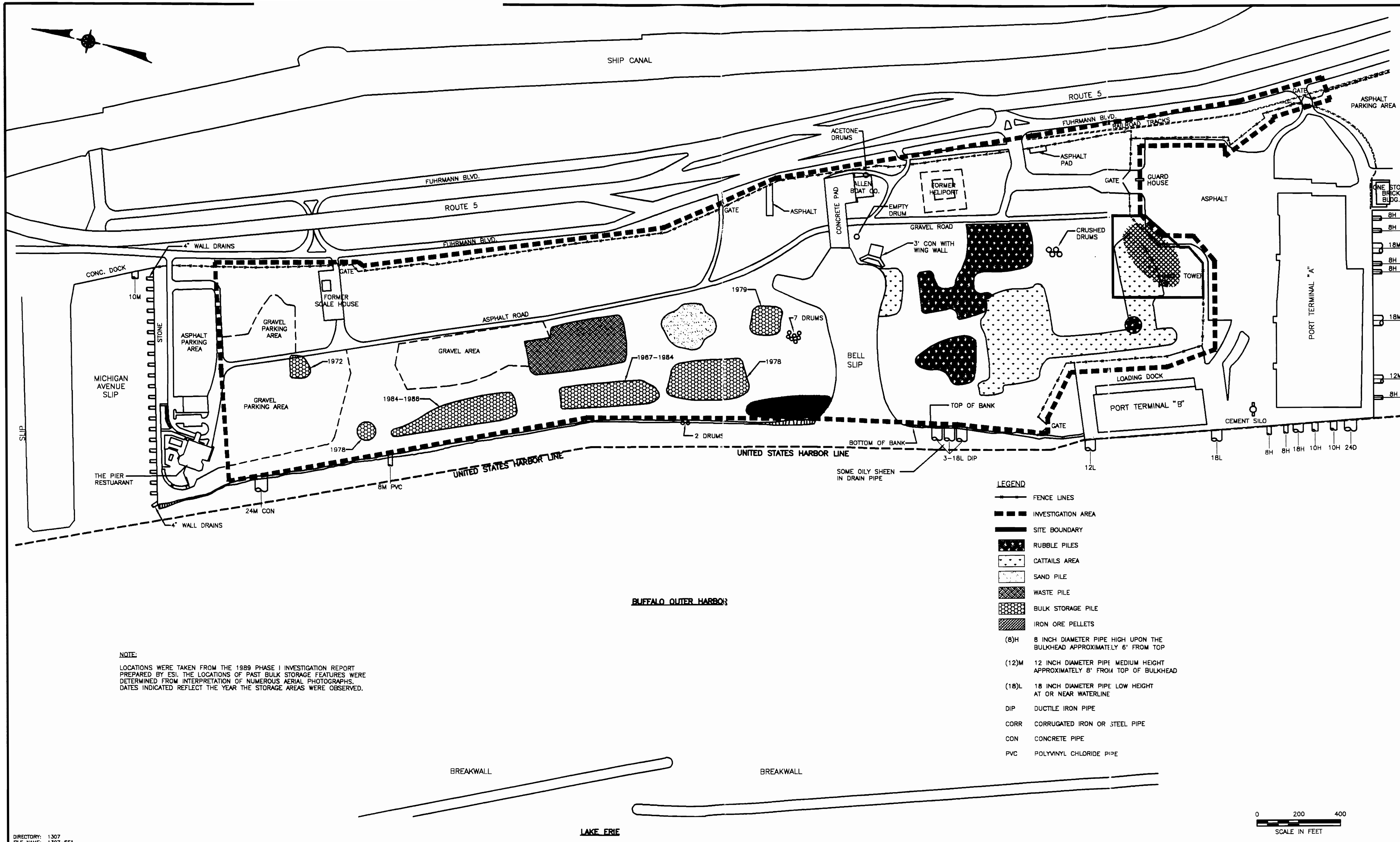
DVIRKA AND BARTILUCCI
CONSULTING ENGINEERS

BUFFALO OUTER HARBOR
BUFFALO, NEW YORK

SITE PLAN

PROJECT NO. 1307
DATE: MARCH 1995
SCALE: 1"=200'

FIGURE 1-2



NOTE:

LOCATIONS WERE TAKEN FROM THE 1989 PHASE I INVESTIGATION REPORT PREPARED BY ESI. THE LOCATIONS OF PAST BULK STORAGE FEATURES WERE DETERMINED FROM INTERPRETATION OF NUMEROUS AERIAL PHOTOGRAPHS. DATES INDICATED REFLECT THE YEAR THE STORAGE AREAS WERE OBSERVED.

DIRECTORY: 1307
FILE NAME: 1307-SF1
DATE: RH-7/13/98

NO.	DATE	REVISION	INT.

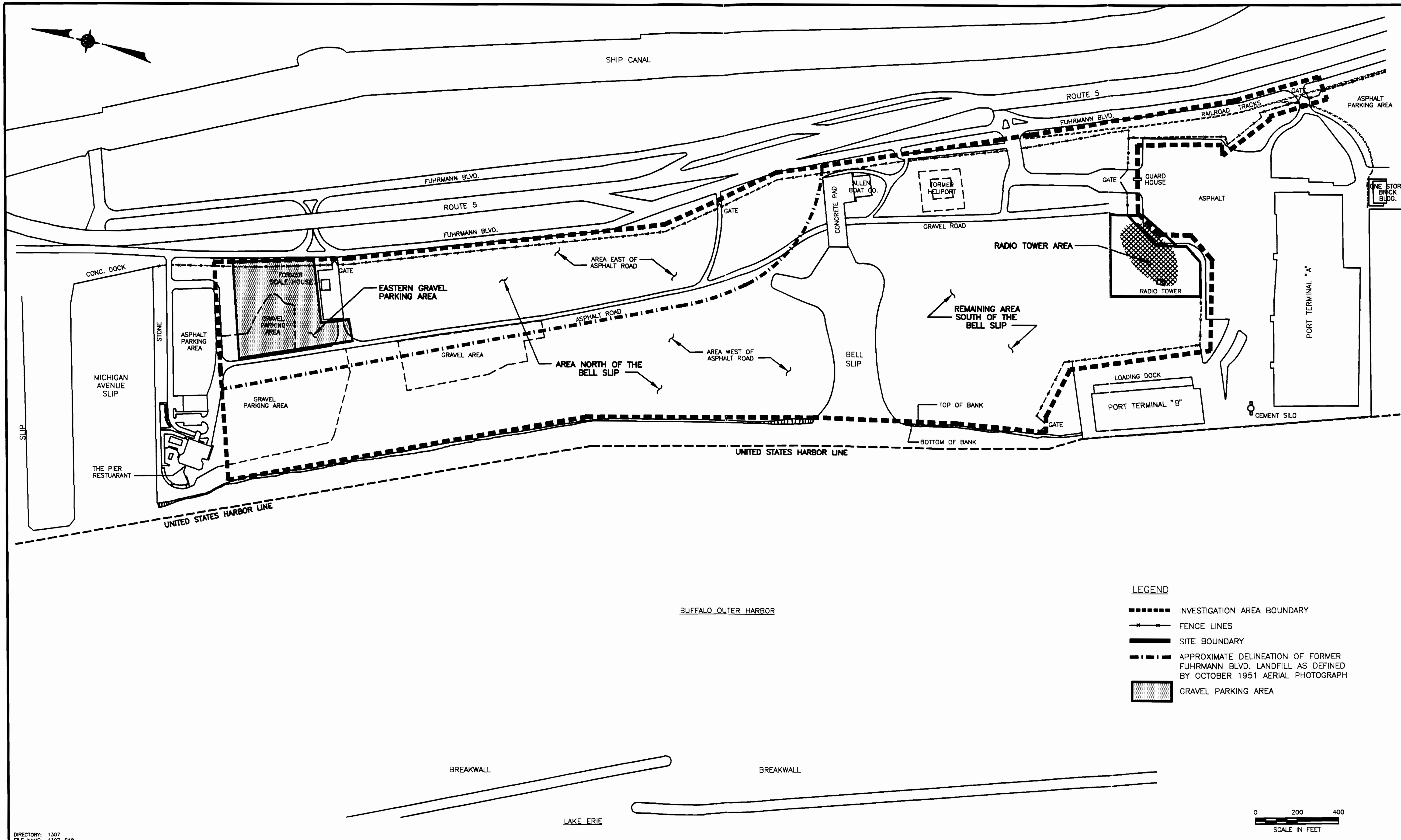
DVIRKA AND BARTILUCCI
CONSULTING ENGINEERS

BUFFALO OUTER HARBOR
BUFFALO, NEW YORK

SURFICIAL FEATURES MAP

PROJECT NO. 1307
DATE: MARCH 1995
SCALE: 1"=200'

FIGURE 1–3



DIRECTORY: 1307
FILE NAME: 1307-SAB
DATE: RH-7/13/98

NO.	DATE	REVISION

UNAUTHORIZED ALTERATION OR ADDITION TO THIS DOCUMENT IS A VIOLATION OF SECTION 7209 OF THE NEW YORK STATE EDUCATION LAW.

DVIRKA AND BARTILUCCI
CONSULTING ENGINEERS

BUFFALO OUTER HARBOR
BUFFALO, NEW YORK

INVESTIGATION AREAS

PROJECT NO. 1307
DATE: MARCH 1995
SCALE: 1"=200'

FIGURE 1-4

APPENDIX D

EXCAVATION AND BACKFILL ALTERNATIVES EVALUATION

Each of the technologies that were evaluated in detail for remediation of the Radio Tower Area required excavating and treating the nitrobenzene contaminated soil on-site or disposing of the contaminated soil off-site. The contaminated soil requiring remediation is located between 4 and 22 feet below ground surface, the majority of which is below the water table. The volume of in-place soil requiring remediation is approximately 3,500 cubic yards and the volume of overlying soil not requiring remediation is estimated to be 4,500 cubic yards. Excavation alternatives comprise open excavation and use of sheeting, with variations of each. The area requiring remediation/excavation is approximately 110 feet by 100 feet.

In addition to the excavation of the contaminated soil, replacement of the soil is also a component of each of these alternatives. If the soil is treated on-site, it may be replaced in the excavation or disposed off-site. If the treated or untreated soil is disposed off-site, clean material from off-site will need to be placed in the excavation. In addition, since the soil overlying the nitrobenzene contaminated soil (upper strata) will not require remediation, this soil can be replaced in the excavation.

In order to select the most appropriate and cost-effective excavation and backfill option, an evaluation of four different excavation techniques and four backfill techniques was performed. Therefore, a total of 16 variations of excavation and backfill options were evaluated. Table D-1 provides a summary of these options.

In addition to the costs, which are discussed later in this section, the following discussion addresses the specific issues considered during the evaluation of each of the alternatives.

Table D-1

BUFFALO OUTER HARBOR SITE
SUMMARY OF EXCAVATION AND BACKFILL TECHNIQUES

Alternatives	Excavation Technique	Backfill Technique
A1	Excavate shallow soil by laying back the side slopes to the water table, install sheeting and dewater during excavation of the contaminated soil.	Replace shallow soil into open excavation first. Replace treated soil/clean off-site material into remaining portion of the excavation.
A2	Excavate shallow soil by laying back the side slopes to the water table, install sheeting and dewater during excavation of the contaminated soil.	Keep excavation open for 6 months for treatment of contaminated soil. Replace treated soil first followed by shallow soil.
A3	Excavate shallow soil by laying back the side slopes to the water table, install sheeting and dewater during excavation of the contaminated soil.	Replace shallow soil first, followed by 2,500 cubic yards of treated soil. Fill 1,000 cubic yards (approximately 3 feet) of clean off-site soil over treated soil.
A4	Excavate shallow soil by laying back the side slopes to the water table, install sheeting and dewater during excavation of the contaminated soil.	Replace shallow soil first and fill remaining portion of the excavation with clean off-site soil and dispose of treated soil off-site.
B1	Excavate without sheeting by laying back the side slopes to the bottom of the excavation. Assume no dewatering.	Replace shallow soil into open excavation first. Replace treated soil/clean off-site material into remaining portion of the excavation.
B2	Excavate without sheeting by laying back the side slopes to the bottom of the excavation. Assume no dewatering	Keep excavation open for 6 months for treatment of contaminated soil. Replace treated soil first followed by shallow soil.

Table D-1 (continued)

BUFFALO OUTER HARBOR SITE
SUMMARY OF EXCAVATION AND BACKFILL TECHNIQUES

Alternatives	Excavation Technique	Backfill Technique
B3	Excavate without sheeting by laying back the side slopes to the bottom of the excavation. Assume no dewatering	Replace shallow soil first, followed by 2,500 cubic yards of treated soil. Fill 1,000 cubic yards (approximately 3 feet) of clean off-site soil over treated soil.
B4	Excavate without sheeting by laying back the side slopes to the bottom of the excavation. Assume no dewatering	Replace shallow soil first and fill remaining portion of the excavation with clean off-site soil and dispose of treated soil off-site.
C1	Install sheeting from ground surface to depth of excavation and dewater during excavation of contaminated soil.	Replace shallow soil into open excavation first. Replace treated soil/clean off-site material into remaining portion of the excavation.
C2	Install sheeting from ground surface to depth of excavation and dewater during excavation of contaminated soil.	Keep excavation open for 6 months for treatment of contaminated soil. Replace treated soil first followed by shallow soil.
C3	Install sheeting from ground surface to depth of excavation and dewater during excavation of contaminated soil.	Replace shallow soil first, followed by 2,500 cubic yards of treated soil. Fill 1,000 cubic yards (approximately 3 feet) of clean off-site soil over treated soil.
C4	Install sheeting from ground surface to depth of excavation and dewater during excavation of contaminated soil.	Replace shallow soil first and fill remaining portion of the excavation with clean off-site soil and dispose of treated soil off-site.

Table D-1 (continued)

BUFFALO OUTER HARBOR SITE
SUMMARY OF EXCAVATION AND BACKFILL TECHNIQUES

Alternatives	Excavation Technique	Backfill Technique
D1	Install four (50 foot by 55 foot) sheet piling coffer dams from ground surface to depth of excavation and dewatering during excavation of contaminated soil.	Replace shallow soil into open excavation first. Replace treated soil/clean off-site material into remaining portion of the excavation.
D2	Install four (50 foot by 55 foot) sheet piling coffer dams from ground surface to depth of excavation and dewatering during excavation of contaminated soil.	Keep excavation open for 6 months for treatment of contaminated soil. Replace treated soil first followed by shallow soil.
D3	Install four (50 foot by 55 foot) sheet piling coffer dams from ground surface to depth of excavation and dewatering during excavation of contaminated soil.	Replace shallow soil first, followed by 2,500 cubic yards of treated soil. Fill 1,000 cubic yards (approximately 3 feet) of clean off-site soil over treated soil.
D4	Install four (50 foot by 55 foot) sheet piling coffer dams from ground surface to depth of excavation and dewatering during excavation of contaminated soil.	Replace shallow soil first and fill remaining portion of the excavation with clean off-site soil and dispose of treated soil off-site.

Excavation Alternatives

Alternative A- Open Excavation to 8 feet and Sheet Piling to 22 feet

Alternative A includes excavating the shallow unsaturated soil without sheeting. This alternative assumes that the sides of the excavation above the water table will be laid back on a 1 on 1 1/2 slope as required by the Occupational Safety and Health Administration (OSHA). The water table is approximately 8 feet below ground surface, and therefore, laying back the slope will increase the size of the excavation by 12 feet on each side. Sheet piling will be installed from a depth of approximately 8 feet to 22 feet. Increasing the size of the excavation will require removal of a portion of the fence separating the site from the paved parking area and likely removal of some of the pavement from the parking area. The volume of non-contaminated soil requiring excavation will increase by approximately 800 cubic yards for a total of 5,300 cubic yards.

Based on the significantly elevated levels of contaminants detected in the soil and vapors expected to be generated during excavation, it is assumed that the excavation would need to be undertaken within a sprung structure. The structure would eliminate the potential for migration of contaminated vapors to the surrounding area. Since the work would be performed within the structure, it is assumed that workers would be in Level B personal protective equipment and treatment of the vapors would occur prior to release from the structure to the atmosphere.

The excavation will be dewatered and water removed from the excavation will need to be disposed. Based on the estimated volume of water to be generated (approximately 25,000 gallons over an estimated 2-month excavation period) and the concentrations of contaminants found in the groundwater, based on preliminary discussions with the Buffalo Sewer Authority, the Authority indicated that they will likely accept the water without pretreatment. However, a formal permit application would be required and discharge flows would need to be addressed prior to formal approval.

Alternative B - Open Excavation to 22 feet

This alternative assumes that the excavation will be completed without sheet piling. Therefore, the entire excavation will be laid back on a 1 on 1 1/2 slope in accordance with OSHA requirements. Assuming that the excavation will be completed to 22 feet below ground surface, (depth of nitrobenzene contaminated soil), the excavation will increase in size approximately 33 feet on all sides. This will impact a large portion of the existing parking area.

The volume of unsaturated soil requiring excavation will increase from approximately 4,500 cubic yards to 7,000 cubic yards. In addition to the significant increase in the volume of unsaturated soil requiring removal, this alternative will also significantly increase the volume of nitrobenzene contaminated soil due to contact with contaminated groundwater as excavation occurs below the water table. At a minimum, the volume of soil requiring remediation would increase from 3,500 cubic yards to about 7,700 cubic yards based on the required side slopes of 1 on 1 1/2. This does not account for any additional increase in volume requiring remediation due to collapse of the side slopes into the excavation during removal.

Excavation would be undertaken utilizing drag line equipment and, as discussed above for Alternative A, would be completed within a sprung structure. The size of this structure would be significantly larger than the other alternatives due to the size of the excavation. All work would be conducted in Level B protective equipment. Since the sides of the excavation will not have sheet piling, dewatering will likely not be effective and is not considered for this alternative, and therefore, disposal of contaminated groundwater will not need to be addressed.

Alternative C- Sheet Piling Entire Excavation to 22 feet

Since this alternative involves sheeting the entire excavation, no increase in volume of soil requiring excavation (8,000 cubic yards) and remediation (3,500 cubic yards) is expected, and there would be minimal damage to the existing fence and parking area. Dewatering is included, and therefore, as discussed in Alternative A, contaminated groundwater from the excavation will need to be disposed to the Buffalo Sewer Authority sewer system. The excavation would have a sprung structure over it and all work would be conducted in Level B.

Alternative D - Sheet Piling 50'x55' Cells and Excavating Within Each Cell

This alternative is similar to Alternative C; however, instead of sheeting only the perimeter of the area to be excavated, four smaller cells will be constructed and the soil will be excavated from each cell separately. This alternative assumes that two cells will be excavated and backfilled, and then the two remaining cells will be excavated and backfilled. This will allow for more effective use of the sheet piling. Dewatering is included in this alternative and contaminated groundwater will need to be disposed to the sewer system. A sprung structure and Level B worker protection is assumed.

Backfill and Compaction Alternatives

Alternative 1 - Replacement of Overlying Soil First

Alternative 1 would involve replacement of the soil from the upper strata into the open excavation after the nitrobenzene contaminated soil was removed. The remaining excavation (less than 8 feet deep) will stay open until either the treated soil can be replaced or clean backfill from an off-site source is placed into the excavation. This alternative is easily implemented since it would not require keeping the excavation open below the water table for an extended period of time if treated soil was replaced, and would not require the excavation to be left open essentially at all if clean off-site soil was used as the upper strata of the fill. If the treated soil is placed back into the excavation, it may not address the concern regarding exposure to possible residual contamination (e.g. elevated levels of metals) that will remain after treatment for nitrobenzene.

Alternative 2 - Replacement of Treated Soil First

This alternative would involve keeping the excavation open until the nitrobenzene contaminated soil is treated and replaced into the excavation. This would require keeping the excavation open for a significant period of time (i.e. 6 months). Once treated the soil is replaced into the open excavation, it will be followed by the overlying soil that has been stockpiled on-site during the treatment period.

Alternative 3 - Replacement of Overlying Soil, Portion of Treated Soil and 3 Feet of Clean Backfill

For this alternative, the soil excavated from the upper strata would be replaced into the excavation initially, and a portion of the treated soil, approximately 2,500 cubic yards, would be replaced into the excavation over the initially replaced soil. A 3-foot layer of clean soil obtained from an off-site source (approximately 1,000 cubic yards) would then be placed over the treated soil. This would eliminate any concern with regard to exposure to residual contamination in the treated soil as discussed in Alternative 1; however, this would require 1,000 cubic yards of treated soil, which cannot be replaced, to be disposed off-site.

Alternative 4 - Replacement of Overlying Soil and Remainder of Excavation with Clean Backfill

For this alternative, the overlying soil would be replaced into the excavation initially, and instead of leaving the excavation open until the contaminated soil is treated, clean off-site soil would be placed into the excavation. All treated soil would be disposed off-site.

Summary of Excavation and Backfill Alternatives

A summary of the advantages, disadvantages and costs of each of the alternatives is provided in Table D-2. The detailed description of costs is provided at the end of the document. As shown on Table D-2, Alternative B (Open Excavation) would be the most costly excavation alternative to implement primarily due to the cost of providing for a sprung structure over the

Table D-2

BUFFALO OUTER HARBOR SITE
SUMMARY OF EXCAVATION AND BACKFILL ADVANTAGES, DISADVANTAGES AND COSTS

Alternatives	Advantages	Disadvantages	Cost*
A1 Open excavation to 8 feet and sheet piling from 8 to 22 feet. Backfill of overlying soil first followed by treated soil.	Allows excavation to be partially backfilled while soil is being treated.	Increases size of excavation. Potential concern with regard to exposure to residual contaminants (i.e. metals) in treated soil backfilled last.	$1,830,000
A2 Open excavation to 8 feet and sheet piling from 8 to 22 feet. Backfill of treated soil first followed by overlying soil.	Reduces concern for exposure to residual contamination in treated soil.	Increases size of excavation. Entire excavation must remain open while soil is being treated.	$1,830,000
A3 Open excavation to 8 feet and sheet piling from 8 to 22 feet. Backfill of overlying soil first, followed by a portion of treated soil and 3 feet of clean off-site soil.	Allows excavation to be partially backfilled while soil is being treated and reduces concern for surface residual contamination.	Increases size of excavation and requires for a portion of the treated soil to be disposed off-site.	$1,960,000
A4 Open excavation to 8 feet and sheet piling from 8 to 22 feet. Backfill of overlying soil first and remainder of excavation with clean off-site soil.	Allows excavation to be completely backfilled while soil is being treated, eliminates concern for surface residual contamination and allows immediate development of the site.	Increases size of excavation. Requires that all treated soil to be disposed off-site.	$2,500,000
B1 Open excavation to 22 feet. Backfill of overlying soil first followed by treated soil.	Allows excavation to be partially backfilled while soil is being treated. No dewatering required.	Increases size of excavation and volume of soil requiring remediation significantly. Potential concern with regard to exposure to residual contaminants (i.e. metals) in treated soil backfilled last.	$2,320,000

Table D-2 (continued)

BUFFALO OUTER HARBOR SITE
SUMMARY OF EXCAVATION AND BACKFILL ADVANTAGES, DISADVANTAGES AND COSTS

	Alternatives	Advantages	Disadvantages	Cost*
B2	Open excavation to 22 feet. Backfill of treated soil first followed by overlying soil.	Reduces concern for exposure to residual contamination in treated soil. No dewatering required.	Increases size of excavation. Entire excavation must remain open while soil is being treated.	$2,320,000
B3	Open excavation to 22 feet. Backfill of overlying soil first, followed by a portion of treated soil and 3 feet of clean off-site soil.	Allows excavation to be partially backfilled while soil is being treated, eliminates concern for surface residual contamination. No dewatering required.	Increases size of excavation and volume of soil requiring remediation. Requires for a portion of the treated soil to be disposed off-site.	$2,450,000
B4	Open excavation to 22 feet. Backfill of overlying soil and remainder of excavation with clean off-site soil.	Allows excavation to be completely backfilled while soil is being treated, reduces concern for surface residual contamination and allows immediate development of the site. No dewatering required.	Increases size of excavation and volume of soil requiring remediation. Requires that all treated soil to be disposed off-site.	$3,340,000
C1	Sheet piling to 22 feet. Backfill of overlying soil first followed by treated soil.	Minimizes size of excavation and volume of soil requiring remediation. Allows excavation to be partially backfilled while soil is being treated.	Potential concerns with regard to exposure to residual contaminants (i.e. metals) in treated soil backfilled last.	$1,900,000
C2	Sheet piling to 22 feet. Backfill of treated soil first followed by overlying soil.	Reduces concern for exposure to residual contamination in treated soil. Minimizes size of excavation and volume of soil requiring remediation.	Entire excavation must remain open while soil is being treated.	$1,900,000

Table D-2 (continued)

BUFFALO OUTER HARBOR SITE
SUMMARY OF EXCAVATION AND BACKFILL ADVANTAGES, DISADVANTAGES AND COSTS

Alternatives		Advantages	Disadvantages	Cost*
C3	Sheet piling to 22 feet. Backfill of overlying soil first, followed by a portion of treated soil and 3 feet of clean off-site soil.	Minimizes size of excavation and volume of soil requiring remediation, allows excavation to be partially backfilled while soil is being treated and reduces concern for surface residual contamination.	Requires for a portion of the treated soil to be disposed off-site.	$2,030,000
C4	Sheet piling to 22 feet. Backfill of overlying soil first and remainder of excavation with clean off-site soil.	Minimizes size of excavation and volume of soil requiring remediation. Allows excavation to be completely backfilled while soil is being treated, eliminates concern for surface residual contamination and allows immediate development of the site.	Requires that all treated soil to be disposed of off-site.	$2,360,000
D1	Sheet piling 50'x55' cells and excavation within each cell. Backfill of overlying soil first followed by treated soil.	Minimizes size of excavation and volume of soil requiring remediation. Allows excavation to be partially backfilled while soil is being treated.	Potential concern with regard to exposure to residual contaminants (i.e. metals) in treated soil backfilled last.	$1,810,000
D2	Sheet piling 50'x55' cells and excavation within each cell. Backfill of treated soil first followed by overlying soil.	Reduces concern for exposure to residual contamination in treated soil. Minimizes size of excavation and volume of soil requiring remediation.	Excavation must remain open while soil is being treated and sheet piling cannot be reused.	$2,580,000

Table D-2 (continued)

BUFFALO OUTER HARBOR SITE
SUMMARY OF EXCAVATION AND BACKFILL ADVANTAGES, DISADVANTAGES AND COSTS

Alternatives	Advantages	Disadvantages	Cost*
D3 Sheet piling 50'x55' cells and excavation within each cell. Backfill of overlying soil first, followed by a portion of treated soil and 3 feet of clean off-site soil.	Minimizes size of excavation and volume of soil requiring remediation, allows excavation to be partially backfilled while soil is being treated and reduces concern for surface residual contamination.	Requires for a portion of the treated soil to be disposed off-site.	$1,940,000
D4 Sheet piling 50'x55' cells and excavation within each cell. Backfill of overlying soil and remainder of excavation with clean off-site soil.	Minimizes size of excavation and volume of soil requiring remediation. Allows excavation to be completely backfilled while soil is being treated, eliminates concern for surface residual contamination and allows immediate development of the site.	Requires that all treated soil to be disposed off-site.	$2,070,000

*Costs obtained from RS Means "Site Work & Landscape Cost Data" 16th Annual Edition -1997. Assumes mid 1998 pricing
Costs include 10 % contingencies.
Costs include Level B work which increases the overall cost by 80 % as per RS Means "Environmental Remediation Cost Data Assemblies 4th Annual Edition - 1998.
Does not include cost for treatment/disposal of soil or groundwater (See Section 3.4 for total cost for alternatives).
Does not include cost for fence or pavement replacement.
Assumes material requiring off-site disposal in alternatives A3,A4,B3,B4,C3,C4,D3 and D4 has been treated.

entire excavation. The cost for this alternative would also significantly increase when disposal/ treatment costs for the additional contaminated soil generated during the open excavation are included. The costs for the remaining three excavation alternatives—Alternative A (Open Excavation to 8 Feet and Sheet Piling from 8 to 22 Feet), Alternative C (Sheet Piling Entire Excavation) and D (Sheet Piling Individual Cells)—are competitive, with Alternative C the least costly, followed by Alternatives D and A.

Regarding the backfill alternatives, in general, the cost for keeping the excavation open (Alternative 2) for an estimated treatment period of 6 months does not significantly impact the overall cost for most of the alternatives, except for excavation Alternative D. Alternative D requires that enough sheet piling be purchased for all four cells in order to keep the entire excavation open for an estimated treatment time of 6 months. (The other Alternatives, D1, D3 and D4, all include sheet piling for two cells since two cells would be excavated and backfilled prior to excavating the second two cells.) The alternatives that would require off-site disposal of soil (Alternatives 3 and 4) are more costly compared to the alternatives that would allow for replacement of all the soil on-site.

Although three alternatives (A1, A2 and D1) are less costly than Alternative C2 (ranging from $70,000 to $90,000 in difference), due to the concern with regard to potential for exposure to residual contamination remaining in the soil after treatment, it is recommended that Alternative C2 ($1.9 million) (sheet piling the entire excavation and replacement of treated soil in excavation first followed by the overlying soil) be implemented. This alternative would allow for better control of the of the contaminated soil requiring excavation, would have minimal impacts on the existing parking area/fence and would allow for all treated soil to be disposed on-site. However, if time is of the essence in order to develop the site, although more costly due to the treated soil being disposed off-site, either Alternative A4 ($2.5 million), C4 ($2.4 million) or D4 ($2.1 million) could be implemented.

Buffalo Outer Harbor
Construction Cost Estimate

Alternative A-1 Excavate the shallow soil be laying back the side slopes to the water table. Install sheeting and dewater to excavate the remaining soil. Replace shallow soil into open excavation first. Replace treated/clean off-site material into remaining portion of the excavation.

Item	Quantity	Unit	Unit Cost	Cost
Excavate volume D without sheeting (dry) 8' below surface	3710	CY	$6.10	$22,631.00
Steel sheet piling	6020	SF	$24.30	$146,286.00
Excavate volume E inside sheet piling coffer dam	5080	CY	$17.50	$88,900.00
Dewater using well points (2 months)	900	LF/MO	$144.00	$129,600.00
		Subtotal		$387,417.00
Backfill uncontaminated soil	5290	CY	$2.90	$15,341.00
Backfill contaminated soil after treatment	3500	CY	$2.90	$10,150.00
		Subtotal		$25,491.00
Compaction	8790	CY	$0.50	$4,395.00
		Subtotal		$4,395.00
		TOTAL		$417,303.00
		Contingencies (10 %)		$41,730.30
		Level B (80%)		$367,226.64
		Safety Enclosure		$996,960.00
		TOTAL		**$1,823,219.94**

*Assumes no fence or pavement replacement necessary.
*Does not include cost of treating/disposing of treated/untreated soil.

Buffalo Outer Harbor
Construction Cost Estimate

Alternative A-2 Excavate the shallow soil be laying back the side slopes to the water table. Install sheeting and dewater to excavate the remaining soil. Keep excavation open for 6 months for treatment of contaminated soil. Replace treated soil first followed by shallow soil.

Item	Quantity	Unit	Unit Cost	Cost
Excavate volume D without sheeting (dry) 8' below surface	3710	CY	$6.10	$22,631.00
Steel sheet piling	6020	SF	$24.30	$146,286.00
Excavate volume E inside sheet piling coffer dam	5080	CY	$17.50	$88,900.00
Dewater using well points (2 months)	900	LF/MO	$144.00	$129,600.00
		Subtotal		$387,417.00
Backfill treated soil	3500	CY	$2.90	$10,150.00
Backfill uncontaminated soil;	5290	CY	$2.90	$15,341.00
		Subtotal		$25,491.00
Compaction	8790	CY	$0.50	$4,395.00
		Subtotal		$4,395.00
		TOTAL		$417,303.00
		Contingencies (10 %)		$41,730.30
		Level B (80%)		$367,226.64
		Safety Enclosure		$996,960.00
		TOTAL		**$1,823,219.94**

*Assumes no fence or pavement replacement necessary.
*Does not include cost of treating/disposing of treated/untreated soil.

Buffalo Outer Harbor
Construction Cost Estimate

Alternative A-3 Excavate the shallow soil be laying back the side slopes to the water table. Install sheeting and dewater to excavate the remaining soil. Replace shallow soil first followed by 2,500 cubic yards of treated soil. Fill 1,000 cubic yards (approximately 3 feet) of clean off-site soil over shallow soil.

Item	Quantity	Unit	Unit Cost	Cost
Excavate volume D without sheeting (dry) 8' below surface	3710	CY	$6.10	$22,631.00
Steel sheet piling	6020	SF	$24.30	$146,286.00
Excavate volume E inside sheet piling coffer dam	5080	CY	$17.50	$88,900.00
Dewater using well points (2 months)	900	LF/MO	$144.00	$129,600.00
		Subtotal		$387,417.00
Backfill uncontaminated soil	5290	CY	$2.90	$15,341.00
Backfill portion of treated soil	2500	CY	$2.90	$7,250.00
Dispose of treated soil off-site	1000	CY	$40.00	$40,000.00
Backfill clean backfill from other location	1000	CY	$2.90	$2,900.00
Provide clean backfill	1000	CY	$27.00	$27,000.00
		Subtotal		$92,491.00
Compaction	8790	CY	$0.50	$4,395.00
		Subtotal		$4,395.00
		TOTAL		$484,303.00
		Contingencies (10 %)		$48,430.30
		Level B (80%)		$426,186.64
		Safety Enclosure		$996,960.00
		TOTAL		**$1,955,879.94**

*Assumes no fence or pavement replacement necessary.

*Does not include cost of treating/disposing of treated/untreated soil.

Buffalo Outer Harbor
Construction Cost Estimate

Alternative A-4 Excavate the shallow soil be laying back the side slopes to the water table. Install sheeting and dewater to excavate the remaining soil. Replace uncontaminated soil and 3,500 cubic yards of clean material. Dispose of treated/untreated material off-site.

Item	Quantity	Unit	Unit Cost	Cost
Excavate volume D without sheeting (dry) 8' below surface	3710	CY	$6.10	$22,631.00
Steel sheet piling	6020	SF	$24.30	$146,286.00
Excavate volume E inside sheet piling coffer dam	5080	CY	$17.50	$88,900.00
Dewater using well points (2 months)	900	LF/MO	$144.00	$129,600.00
		Subtotal		$387,417.00
Backfill uncontaminated soil	3710	CY	$2.90	$10,759.00
Backfill clean soil from off-site location	5080	CY	$2.90	$14,732.00
Dispose of treated soil off-site	5080	CY	$40.00	$203,200.00
Provide clean backfill	5080	CY	$27.00	$137,160.00
		Subtotal		$365,851.00
Compaction	8790	CY	$0.50	$4,395.00
		Subtotal		$4,395.00
		TOTAL		$757,663.00
		Contingencies (10 %)		$75,766.30
		Level B (80%)		$666,743.44
		Safety Enclosure		$996,960.00
		TOTAL		**$2,497,132.74**

*Assumes no fence or pavement replacement necessary.
*Does not include cost of treating/disposing of treated/untreated soil.

Buffalo Outer Harbor
Construction Cost Estimate

Alternative B-1 Excavate without sheeting. Assumes no dewatering. Replace shallow soil into open excavation first. Replace treated/clean off-site material into remaining portion of the excavation.

Item	Quantity	Unit	Unit Cost	Cost
Excavate volume F without sheeting (dry) 8' below surface	6920	CY	$6.10	$42,212.00
Excavate volume G	7700	CY	$10.90	$83,930.00
		Subtotal		$126,142.00
Backfill uncontaminated soil	6920	CY	$2.90	$20,068.00
Backfill treated soil	7700	CY	$2.90	$22,330.00
		Subtotal		$42,398.00
Compaction	14620	CY	$0.50	$7,310.00
		Subtotal		$7,310.00
		TOTAL		$175,850.00
		Contingencies (10 %)		$17,585.00
		Level B (80%)		$154,748.00
		Safety Enclosure		$1,964,160.00
		TOTAL		**$2,312,343.00**

*Assumes no fence or pavement replacement necessary.
*Does not include cost of treating/disposing of treated/untreated soil.

Buffalo Outer Harbor
Construction Cost Estimate

Alternative B-2 Excavate without sheeting. Assumes no dewatering.
Keep excavation open for 6 months for treatment of contaminated soil.
Replace treated soil first followed by shallow soil.

Item	Quantity	Unit	Unit Cost	Cost
Excavate volume F without sheeting (dry) 8' below surface	6920	CY	$6.10	$42,212.00
Excavate volume G	7700	CY	$10.90	$83,930.00
		Subtotal		$126,142.00
Backfill uncontaminated soil	6920	CY	$2.90	$20,068.00
Backfill treated soil	7700	CY	$2.90	$22,330.00
		Subtotal		$42,398.00
Compaction	14620	CY	$0.50	$7,310.00
		Subtotal		$7,310.00
		TOTAL		$175,850.00
		Contingencies (10 %)		$17,585.00
		Level B (80%)		$154,748.00
		Safety Enclosure		$1,964,160.00
		TOTAL		**$2,312,343.00**

*Assumes no fence or pavement replacement necessary.
*Does not include cost of treating/disposing of treated/untreated soil.

Buffalo Outer Harbor
Construction Cost Estimate

Alternative B-3 Excavate without sheeting. Assumes no dewatering.
Replace shallow soil first followed by 2,500 cubic yards of treated
Fill 1,000 cubic yards (approximately 3 feet) of clean off-site
soil over shallow soil.

Item	Quantity	Unit	Unit Cost	Cost
Excavate volume F without sheeting (dry) 8' below surface	6920	CY	$6.10	$42,212.00
Excavate volume G	7700	CY	$10.90	$83,930.00
		Subtotal		$126,142.00
Backfill uncontaminated soil	6920	CY	$2.90	$20,068.00
Backfill portion of treated soil	6700	CY	$2.90	$19,430.00
Dispose of treated soil off-site	1000	CY	$40.00	$40,000.00
Backfill clean backfill from other location	1000	CY	$2.90	$2,900.00
Provide clean backfill	1000	CY	$27.00	$27,000.00
		Subtotal		$109,398.00
Compaction	14620	CY	$0.50	$7,310.00
		Subtotal		$7,310.00
		TOTAL		$242,850.00
		Contingencies (10 %)		$24,285.00
		Level B (80%)		$213,708.00
		Safety Enclosure		$1,964,160.00
		TOTAL		**$2,445,003.00**

*Assumes no fence or pavement replacement necessary.
*Does not include cost of treating/disposing of treated/untreated soil.

Buffalo Outer Harbor
Construction Cost Estimate

AlternativeB-4 Excavate without sheeting. Assumes no dewatering.
Replace uncontaminated soil and 3,500 cubic yards of clean material.
Dispose of treated/untreated material off-site.

Item	Quantity	Unit	Unit Cost	Cost
Excavate volume F without sheeting (dry) 8' below surface	6920	CY	$6.10	$42,212.00
Excavate volume G	7700	CY	$10.90	$83,930.00
		Subtotal		$126,142.00
Backfill uncontaminated soil	6920	CY	$2.90	$20,068.00
Backfill clean soil from off-site location	7700	CY	$2.90	$22,330.00
Dispose of treated soil off-site	7700	CY	$40.00	$308,000.00
Provide clean backfill	7700	CY	$27.00	$207,900.00
		Subtotal		$558,298.00
Compaction	14620	CY	$0.50	$7,310.00
		Subtotal		$7,310.00
		TOTAL		$691,750.00
		Contingencies (10 %)		$69,175.00
		Level B (80%)		$608,740.00
		Safety Enclosure		$1,964,160.00
		TOTAL		**$3,333,825.00**

*Assumes no fence or pavement replacement necessary.
*Does not include cost of treating/disposing of treated/untreated soil.

Buffalo Outer Harbor
Construction Cost Estimate

Alternative C-1 Install sheeting around entire contaminated area from ground surface and excavate within the sheeting. Dewater during excavation. Replace shallow soil into open excavation first. Replace treated/clean off-site material into remaining portion of the excavation.

Item	Quantity	Unit	Unit Cost	Cost
Excavate	8000	CY	$17.50	$140,000.00
Steel sheet piling	9230	SF	$28.00	$258,440.00
Dewater using well points (2 months)	900	LF/MO	$144.00	$129,600.00
		Subtotal		$528,040.00
Backfill uncontaminated soil	4500	CY	$2.90	$13,050.00
Backfill treated soil	3500	CY	$2.90	$10,150.00
		Subtotal		$23,200.00
Compaction	8000	CY	$0.50	$4,000.00
		Subtotal		$4,000.00
		TOTAL		$555,240.00
		Contingencies (10 %)		$55,524.00
		Level B (80%)		$488,611.20
		Safety Enclosure		$792,000.00
		TOTAL		**$1,891,375.20**

*Assumes no fence or pavement replacement necessary.
*Does not include cost of treating/disposing of treated/untreated soil.

Buffalo Outer Harbor
Construction Cost Estimate

Alternative C-2 Install sheeting around entire contaminated area from ground surface and excavate within the sheeting. Dewater during excavation. Keep excavation open for 6 months for treatment of contaminated soil. Replace treated soil first followed by shallow soil.

Item	Quantity	Unit	Unit Cost	Cost
Excavate	8000	CY	$17.50	$140,000.00
Steel sheet piling	9230	SF	$28.00	$258,440.00
Dewater using well points (2 months)	900	LF/MO	$144.00	$129,600.00
		Subtotal		$528,040.00
Backfill uncontaminated soil	4500	CY	$2.90	$13,050.00
Backfill treated soil	3500	CY	$2.90	$10,150.00
		Subtotal		$23,200.00
Compaction	8000	CY	$0.50	$4,000.00
		Subtotal		$4,000.00
		TOTAL		$555,240.00
		Contingencies (10 %)		$55,524.00
		Level B (80%)		$488,611.20
		Safety Enclosure		$792,000.00
		TOTAL		**$1,891,375.20**

*Assumes no fence or pavement replacement necessary.
*Does not include cost of treating/disposing of treated/untreated soil.

Buffalo Outer Harbor
Construction Cost Estimate

Alternative C-3 Install sheeting around entire contaminated area from ground surface and excavate within the sheeting. Dewater during excavation. Replace shallow soil first followed by 2,500 cubic yards of treated soil. Fill 1,000 cubic yards (approximately 3 feet) of clean off-site soil over shallow soil.

Item	Quantity	Unit	Unit Cost	Cost
Excavate	8000	CY	$17.50	$140,000.00
Steel sheet piling	9230	SF	$28.00	$258,440.00
Dewater using well points (2 months)	900	LF/MO	$144.00	$129,600.00
		Subtotal		$528,040.00
Backfill uncontaminated soil	4500	CY	$2.90	$13,050.00
Backfill portion of treated soil	2500	CY	$2.90	$7,250.00
Dispose of treated soil off-site	1000	CY	$40.00	$40,000.00
Backfill clean backfill from other location	1000	CY	$2.90	$2,900.00
Provide clean backfill	1000	CY	$27.00	$27,000.00
		Subtotal		$90,200.00
Compaction	8000	CY	$0.50	$4,000.00
		Subtotal		$4,000.00
		TOTAL		$622,240.00
		Contingencies (10 %)		$62,224.00
		Level B (80%)		$547,571.20
		Safety Enclosure		$792,000.00
		TOTAL		**$2,024,035.20**

*Assumes no fence or pavement replacement necessary.
*Does not include cost of treating/disposing of treated/untreated soil.

Buffalo Outer Harbor
Construction Cost Estimate

Alternative C-4 Install sheeting around entire contaminated area from ground surface and excavate within the sheeting. Dewater during excavation. Replace uncontaminated soil and 3,500 cubic yards of clean material. Dispose of treated/untreated material off-site.

Item	Quantity	Unit	Unit Cost	Cost
Excavate	8000	CY	$17.50	$140,000.00
Steel sheet piling	9230	SF	$28.00	$258,440.00
Dewater using well points (2 months)	900	LF/MO	$144.00	$129,600.00
		Subtotal		$528,040.00
Backfill uncontaminated soil	4500	CY	$2.90	$13,050.00
Backfill clean soil from off-site location	3500	CY	$2.90	$10,150.00
Dispose of treated soil off-site	3500	CY	$40.00	$140,000.00
Provide clean backfill	3500	CY	$27.00	$94,500.00
		Subtotal		$257,700.00
Compaction	8000	CY	$0.50	$4,000.00
		Subtotal		$4,000.00
		TOTAL		$789,740.00
		Contingencies (10 %)		$78,974.00
		Level B (80%)		$694,971.20
		Safety Enclosure		$792,000.00
		TOTAL		**$2,355,685.20**

*Assumes no fence or pavement replacement necessary.
*Does not include cost of treating/disposing of treated/untreated soil.

Buffalo Outer Harbor
Construction Cost Estimate

Alternative D-1 Install four (50'x55') steel sheet piling coffer dams and excavate within coffer dams from ground surface. Dewater during excavation. Replace shallow soil into open excavation first. Replace treated/clean off-site material into remaining portion of the excavation.

Item	Quantity	Unit	Unit Cost	Cost
Assume 2 adjacent cells are built and backfilled. Then 2 additional cells are built and backfilled.				
Steel sheet piling	7489	SF	$20.50	$153,524.50
(reused)	4922	SF	$8.00	$39,376.00
Excavate	8000	CY	$17.50	$140,000.00
Dewater using well points (2 months)	1050	LF/MO	$144.00	$151,200.00
		Subtotal		$484,100.50
Backfill uncontaminated soil	4500	CY	$2.90	$13,050.00
Backfill treated soil	3500	CY	$2.90	$10,150.00
		Subtotal		$23,200.00
Compaction	8000	CY	$0.50	$4,000.00
		Subtotal		$4,000.00
		TOTAL		$511,300.50
		Contingencies (10 %)		$51,130.05
		Level B (80%)		$449,944.44
		Safety Enclosure		$792,000.00
		TOTAL		**$1,804,374.99**

*Assumes no fence or pavement replacement necessary.
*Does not include cost of treating/disposing of treated/untreated soil.

Buffalo Outer Harbor
Construction Cost Estimate

Alternative D-2 Install four (50'x55') steel sheet piling coffer dams and excavate within coffer dams from ground surface. Dewater during excavation. Keep excavation open for 6 months for treatment of contaminated soil. Replace treated soil first followed by shallow soil.

Item	Quantity	Unit	Unit Cost	Cost
Assume 2 adjacent cells are built and backfilled. Then 2 additional cells are built and backfilled.				
Steel sheet piling	29256	SF	$20.50	$599,748.00
Excavate	8000	CY	$17.50	$140,000.00
Dewater using well points (2 months)	900	LF/MO	$144.00	$129,600.00
		Subtotal		$869,348.00
Backfill uncontaminated soil	4500	CY	$2.90	$13,050.00
Backfill clean soil from off-site location	3500	CY	$2.90	$10,150.00
		Subtotal		$23,200.00
Compaction	8000	CY	$0.50	$4,000.00
		Subtotal		$4,000.00
		TOTAL		$896,548.00
		Contingencies (10 %)		$89,654.80
		Level B (80%)		$788,962.24
		Safety Enclosure		$792,000.00
		TOTAL		**$2,567,165.04**

*Assumes no fence or pavement replacement necessary.
*Does not include cost of treating/disposing of treated/untreated soil.

Buffalo Outer Harbor
Construction Cost Estimate

Alternative D-3 Install four (50'x55') steel sheet piling coffer dams and excavate within coffer dams from ground surface. Dewater during excavation. Replace shallow soil first followed by by 2,500 cubic yards of treated soil. Fill 1,000 cubic yards (approximately 3 feet) of clean off-site soil over shallow soil.

Item	Quantity	Unit	Unit Cost	Cost
Assume 2 adjacent cells are built and backfilled. Then 2 additional cells are built and backfilled.				
Steel sheet piling	7489	SF	$20.50	$153,524.50
(reused)	4922	SF	$8.00	$39,376.00
Excavate	8000	CY	$17.50	$140,000.00
Dewater using well points (2 months)	1050	LF/MO	$144.00	$151,200.00
		Subtotal		$484,100.50
Backfill uncontaminated soil	4500	CY	$2.90	$13,050.00
Backfill portion of treated soil	2500	CY	$2.90	$7,250.00
Dispose of treated soil off-site	1000	CY	$40.00	$40,000.00
Backfill clean backfill from off-site location.	1000	CY	$2.90	$2,900.00
Provide clean backfill	1000	CY	$27.00	$27,000.00
		Subtotal		$90,200.00
Compaction	8000	CY	$0.50	$4,000.00
		Subtotal		$4,000.00
		TOTAL		$578,300.50
		Contingencies (10 %)		$57,830.05
		Level B (80%)		$508,904.44
		Safety Enclosure		$792,000.00
		TOTAL		**$1,937,034.99**

*Assumes no fence or pavement replacement necessary.
*Does not include cost of treating/disposing of treated/untreated soil.

Buffalo Outer Harbor
Construction Cost Estimate

Alternative D-4 Install four (50'x55') steel sheet piling coffer dams and excavate within coffer dams from ground surface. Dewater during excavation. Replace uncontaminated soil and 3,500 cubic yards of clean material. Dispose of treated/untreated material off-site.

Item	Quantity	Unit	Unit Cost	Cost
Assume 2 adjacent cells are built and backfilled. Then 2 additional cells are built and backfilled.				
Steel sheet piling	7489	SF	$20.50	$153,524.50
(reused)	4922	SF	$8.00	$39,376.00
Excavate	8000	CY	$17.50	$140,000.00
Dewater using well points (2 months)	353	LF/MO	$144.00	$50,832.00
		Subtotal		$383,732.50
Backfill uncontaminated soil	4500	CY	$2.90	$13,050.00
Backfill clean soil from off-site location	3500	CY	$2.90	$10,150.00
Dispose of treated soil off-site	3500	CY	$40.00	$140,000.00
Provide clean backfill	3500	CY	$27.00	$94,500.00
		Subtotal		$257,700.00
Compaction	8000	CY	$0.50	$4,000.00
		Subtotal		$4,000.00
		TOTAL		$645,432.50
		Contingencies (10 %)		$64,543.25
		Level B (80%)		$567,980.60
		Safety Enclosure		$792,000.00
		TOTAL		**$2,069,956.35**

*Assumes no fence or pavement replacement necessary.
*Does not include cost of treating/disposing of treated/untreated soil.

APPENDIX E

DETAILED COST ANALYSIS FOR THE RADIO TOWER AREA

TABLE E-1
BUFFALO OUTER HARBOR SITE
RADIO TOWER AREA
COST ESTIMATE - ALTERNATIVE 2
DEED AND ACCESS RESTRICTIONS ALTERNATIVE

Item	Quantity	Units	Unit Cost	Total
Access Restriction Costs				
Site fencing and sign posting	2000	LF	$14	$27,000
Monitoring Costs Per Event				
Groundwater sampling	2	Mandays	$750	$1,500
Purge water disposal	5	Drums	$100	$500
Equipment, materials and supplies	-	Lump Sum	$1,000	$1,000
Sample analysis	5	Samples	$1,200	$6,000
	Estimated per event monitoring costs			$9,000
	Present Worth of Annual Groundwater Monitoring Cost for 30 yrs (i=5%)*			$143,000
	Remedial Alternative 2 Total Estimated Costs			**$170,000**

*Sampling frequency includes 2 times per year for the first 5 years, 1 times per year for the next 5 years and once per year for the next 20 years.

TABLE E-2
BUFFALO OUTER HARBOR SITE
RADIO TOWER AREA
COST ESTIMATE - ALTERNATIVE 3A
EXCAVATION AND OFF-SITE DISPOSAL
(REMOVE 8,000 CY SOIL OFF-SITE)

Capital Costs Item	Quantity	Units	Unit Cost	Total
Mobilization/demobilization*	-	Lump Sum	$200,000	$200,000
Site Preparation				
Clearing and grubbing	1	Acres	$2,800	$3,000
Excavation and Backfilling of Soil**	-	Lump Sum	$2,000,000	$2,000,000
Disposal of soil				
Transport to and disposal at TWI, Illinois	3500	CY	$1,120.00	$3,920,000
Transport to and disposal at Model City	4500	CY	$115.00	$518,000
Site Restoration				
Buy/haul/place 6" topsoil	900	CY	$18.00	$16,000
Seed, fertilize and mulch	5200	SY	$1.00	$5,000
Site fencing and sign posting	2000	LF	$14	$27,000
		Estimated Capital Cost		**$6,689,000**
Contingency and Engineering Fees				
Contingency allowance (15%)***				$673,000
Engineering fees****				$500,000
		Estimated Contingency and Engineering Fees		$1,173,000
		TOTAL ESTIMATED CAPITAL COST		**$7,862,000**
		Remedial Alternative 3A Total Estimated Costs		**$7,862,000**

*Includes bonds, insurance and temporary facilities.
**Costs include sprung structure and level B equipment. See Appendix C for additional detail.
***Does not include cost for excavation and backfill of soil. Contingency already included.
**** Includes construction inspection.

TABLE E-2B
BUFFALO OUTER HARBOR SITE
RADIO TOWER AREA
COST ESTIMATE - ALTERNATIVE 3B
EXCAVATION AND OFF-SITE DISPOSAL
(REMOVE 3,500 CY SOIL OFF-SITE)

Capital Costs Item	Quantity	Units	Unit Cost	Total
Mobilization/demobilization*	-	Lump Sum	$200,000	$200,000
Site Preparation				
Clearing and grubbing	1	Acres	$2,800	$3,000
Excavation and Backfilling of Soil**	-	Lump Sum	$2,000,000	$2,000,000
Disposal of Soil				
Transport to and disposal at TWI, Illinois	3500	CY	$1,120.00	$3,920,000
Site Restoration				
Buy/haul/place 6"topsoil	900	CY	$18.00	$16,000
Seed, fertilize and mulch	5200	SY	$1.00	$5,000
Site fencing and sign posting	2000	LF	$14	$27,000
		Estimated Capital Cost		**$6,171,000**
Contingency and Engineering Fees				
Contingency allowance (15%)***				$626,000
Engineering fees****				$500,000
Estimated Contingency and Engineering Fees				$1,126,000
TOTAL ESTIMATED CAPITAL COST				**$7,297,000**

Monitoring Costs Per Event

Groundwater sampling	2	Mandays	$750	$1,500
Purge water disposal	5	Drums	$100	$500
Equipment, materials and supplies	-	Lump Sum	$1,000	$1,000
Sample analysis	5	Samples	$1,200	$6,000
	Estimated per event monitoring costs			$9,000
	Present Worth of Annual Groundwater Monitoring Cost for 30 yrs (i=5%)*****			$143,000
	Remedial Alternative 3B Total Estimated Costs			**$7,440,000**

*Includes bonds, insurance and temporary facilities
**Costs include sprung structure and level B equipment. See Appendix C for additional detail.
***Does not include cost for excavation and backfill of soil. Contingency already included.
**** Includes construction inspection.
*****Sampling frequency includes 2 times per year for the first 5 years, 1 times per year for the next 5 years and once per year for the next 20 years.

TABLE E-3
BUFFALO OUTER HARBOR SITE
RADIO TOWER AREA
COST ESTIMATE - ALTERNATIVE 4
CONTAINMENT

Capital Costs Item	Quantity	Units	Unit Cost	Total
Mobilization/demobilization*	-	Lump Sum	$100,000	$100,000
Site Preparation				
Clearing and grubbing	1	Acres	$2,800	$3,000
Low Permeabiltiy Cover				
Buy/haul/place grading material (2 feet)	2500	CY	$15.00	$38,000
Buy/haul/place clay	4600	SQ YD	$50.00	$230,000
Install flexible membrane liner	7500	SQ YD	$9.00	$68,000
Buy/haul/place 1' sand/gravel layer	2500	SQ YD	$18.00	$45,000
Buy/haul/place geotextile	7500	SQ YD	$3.00	$23,000
Buy/haul/place 1.5' soil layer	4000	CY	$15.00	$60,000
Buy/haul/place 6" topsoil	1300	CY	$18.00	$23,000
Seed, fertilize and mulch	6000	SQ YD	$1.00	$6,000
Slurry Wall				
Installation of slurry wall (40 feet deep)	40000	SF	$20.00	$800,000
Groundwater Treatment				
Extraction wells	5	Wells	$1,000	$5,000
Submersible pumps and piping	5	Each	$5,000	$25,000
Treatment plant	-	Lump Sum	$100,000	$100,000
Misc.(controls, discharge piping, etc.)	-	Lump Sum	$50,000	$50,000
Other Costs				
Health and safety program	-	Lump Sum	$25,000	$25,000
Dust control	-	Lump Sum	$10,000	$10,000
Runoff control	-	Lump Sum	$10,000	$10,000
Equipment decontamination	-	Lump Sum	$10,000	$10,000
Site fencing and sign posting	2000	LF	$14	$27,000
	Estimated Capital Cost			**$1,658,000**
Contingency and Engineering Fees				
Contingency allowance (15%)				$249,000
Engineering fees **				$500,000
	Estimated Contingency and Engineering Fees			$749,000
	TOTAL ESTIMATED CAPITAL COST			**$2,407,000**
Annual Operating and Maintenance Costs				
Cap				
Site inspection	1	Manday	$600	$600
Miscellaneous site work	1	Manday	$1,200	$1,200
Site work materials	-	Lump Sum	$5,000	$5,000
	Annual cost			$6,800
	Present worth of annual operation & maintenance cost for 30 yrs (i=5%)			$204,000
Monitoring Costs Per Event				
Groundwater sampling	2	Mandays	$750	$1,500
Purge water disposal	5	Drums	$100	$500
Equipment, materials and supplies	-	Lump Sum	$1,000	$1,000
Sample analysis	5	Samples	$1,200	$6,000
	Estimated per event monitoring costs			$9,000
	Present Worth of Annual Groundwater Monitoring Cost for 30 yrs (i=5%)***			$143,000
Groundwater Treament Costs				
Annual operation and maintenance cost	-	Annual Cost	$50,000	$50,000
Effluent monitoring	-	Annual Cost	$15,000	$15,000
	Estimated cost per year			$65,000
	Present Worth of Annual Operating & Maintenance Cost for 30 yrs (i=5%)**			$675,000
	Remedial Alternative 4 Total Estimated Costs			**$3,429,000**

*Includes bonds, insurance and temporary facilities
** Includes construction inspection.
***Sampling frequency includes 2 times per year for the first 5 years, 1 times per year for the next 5 years and once per year for the next 20 years.

TABLE E-4
BUFFALO OUTER HARBOR SITE
RADIO TOWER AREA
COST ESTIMATE - ALTERNATIVE 5
EXCAVTION AND THERMAL DESORPTION

Capital Costs Item	Quantity	Units	Unit Cost	Total
Mobilization/demobilization*	-	Lump Sum	$200,000	$200,000
Site Preparation				
Clearing and grubbing	1	Acres	$2,800	$3,000
Excavation and Backfilling of Soil**	-	Lump Sum	$2,000,000	$2,000,000
Treatment of Soil				
Treatment by thermal desorption	3500	CY	$250.00	$875,000
Disposal of residual waste	120000	lbs	$0.25	$30,000
Site Restoration				
Buy/haul/place 6" topsoil	900	CY	$18.00	$16,000
Seed, fertilize and mulch	5200	SQ YD	$1.00	$5,000
Site fencing and sign posting	2000	LF	$14	$27,000
		Estimated Capital Cost		**$3,156,000**
Contingency and Engineering Fees				
Contingency allowance (15%)***				$173,000
Engineering fees****				$500,000
Estimated Contingency and Engineering Fees				$673,000
TOTAL ESTIMATED CAPITAL COST				**$3,829,000**
Annual Operating and Maintenance Costs				
Monitoring Costs Per Event				
Groundwater sampling	2	Mandays	$750	$1,500
Purge water disposal	5	Drums	$100	$500
Equipment, materials and supplies	-	Lump Sum	$1,000	$1,000
Sample analysis	5	Samples	$1,200	$6,000
	Estimated per event monitoring costs			$9,000
	Present Worth of Annual Groundwater Monitoring Cost for 30 yrs (i=5%)*****			$143,000
	Remedial Alternative 5 Total Estimated Costs			**$3,972,000**

*Includes bonds, insurance and temporary facilities
**Costs include sprung structure and level B equipment. See Appendix C for additional detail.
***Does not include cost for excavation and backfill of soil. Contingency already included.
**** Includes construction inspection.
*****Sampling frequency includes 2 times per year for the first 5 years, 1 times per year for the next 5 years and once per year for the next 20 years.

TABLE E-5
BUFFALO OUTER HARBOR SITE
RADIO TOWER AREA
COST ESTIMATE - ALTERNATIVE 6
EXCAVTION AND BIOREMEDIATION

Capital Costs Item	Quantity	Units	Unit Cost	Total
Mobilization/demobilization*	-	Lump Sum	$200,000	$200,000
Site Preparation				
Clearing and grubbing	1	Acres	$2,800	$3,000
Excavation and Backfilling of Soil**	-	Lump Sum	$2,000,000	$2,000,000
Treatment				
Treatment by bioremediation	3500	CY	$120.00	$420,000
Site Restoration				
Buy/haul/place 6" topsoil	900	CY	$18.00	$16,000
Seed, fertilize and mulch	5200	SQ YD	$1.00	$5,000
Site fencing and sign posting	2000	LF	$14	$27,000
		Estimated Capital Cost		**$2,671,000**
Contingency and Engineering Fees				
Contingency allowance (15%)***				$101,000
Engineering fees****				$500,000
	Estimated Contingency and Engineering Fees			$601,000
	TOTAL ESTIMATED CAPITAL COST			**$3,272,000**

Annual Operating and Maintenance Costs
Monitoring Costs Per Event

Groundwater sampling	2	Mandays	$750	$1,500
Purge water disposal	5	Drums	$100	$500
Equipment, materials and supplies	-	Lump Sum	$1,000	$1,000
Sample analysis	5	Samples	$1,200	$6,000
	Estimated per event monitoring costs			$9,000
	Present Worth of Annual Groundwater Monitoring Cost for 30 yrs (i=5%)*****			$143,000

Remedial Alternative 6B Total Estimated Costs	**$3,415,000**

*Includes bonds, insurance and temporary facilities
**Costs include sprung structure and level B equipment. See Appendix C for additional detail.
***Does not include cost for excavation and backfill of soil. Contingency already included.
**** Includes construction inspection.
*****Sampling frequency includes 2 times per year for the first 5 years, 1 times per year for the next 5 years and once per year for the next 20 years.