Feasibility Study Report for the Former Frontier Chemical Waste Process, Inc. Site Niagara Falls, New York

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New York State Department of Environmental Conservation

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List of Abbreviations and Acronyms

ARARs	applicable or relevant and appropriate requirements
BG	bedrock groundwater
bgs	below ground surface
C & D	construction and debris
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COPC	chemicals of potential concern
DNAPL	dense non-aqueous phase liquid
E & E	Ecology and Environment, Inc.
EPA	United States Environmental Protection Agency
FS	Feasibility Study
ft/ft	feet per foot
ft/sec	feet per second
gpm	gallons per minute
ISCO	ISCO Chemical Company
MCL	maximum contaminant level
mg/kg	milligram per kilogram
NYSDEC	New York State Department of Environmental Conservation
O&M	operation and maintenance
OU	operable unit
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
POTW	publicly owned treatment works
ppm	parts per million
PRAP	Proposed Remedial Action Plan
RAO	remedial action objective
RCRA	Resource Conservation and Recovery Act

List of Abbreviations and Acronyms (cont.)

ROD	Record of Decision
SCGs	standards, criteria, and guidelines
SRI	Supplemental Remedial Investigation
SVE	soil vapor extraction
SVOC	semivolatile organic compound
TAGM	Technical Administrative Guidance Memorandum
TBCs	to be considered criteria
TOGS	Technical and Operational Guidance Series
UV	ultraviolet
VOC	volatile organic compound

1 Introduction

This report presents the results of an on-site feasibility study (FS) of alternatives for the environmental remediation of Operable Unit No. 1 and Operable Unit 2 for the former Frontier Chemical Waste Process, Inc. (Frontier Chemical) site located in Niagara Falls, New York. The site is listed as a Class 2 site on the New York State Department of Environmental Conservation (NYSDEC) Registry of Inactive Hazardous Waste Sites (Site No. 9-32-110).

1.1 Background

In response to apparent soil and groundwater contamination at the site, NYSDEC commissioned a Supplemental Remedial Investigation/Feasibility Study (SRI/FS) of the site. The SRI and FS were completed on behalf of NYSDEC under Superfund Standby Contract Work Assignment # D003493-30.

The objective of the SRI was to characterize the nature and extent of on-site and off-site contamination in order to provide data for completing the FS. The scope of work for the SRI is described in work plan documents approved by NYSDEC. The SRI included a qualitative human health risk evaluation identifying potential risks to human health and the environment due to contaminants present on-site and off-site. The results of the SRI were summarized in a separate report prepared by Ecology and Environment Engineering, P.C. (E & E), *Final Supplemental Remedial Investigation (SRI) for the Former Frontier Chemical Waste Process, Inc. Site, Niagara Falls, New York* (February 2003).

This on-site *Feasibility Study Report for the Former Frontier Chemical Waste Process, Inc. Site* addresses contamination and remediation issues for the Frontier Chemical property. Off-site contamination issues in the vicinity of the Frontier Chemical property were not evaluated as part of this report.

The FS is focused on the assessment of the feasibility of a select group of remedial alternatives. Additional details regarding the appropriateness of the focused approach are discussed in Section 3 (Identification of Technologies and Development of Alternatives).

A technical review (preliminary screening) of applicable technologies was completed by E & E and the results were discussed with NYSDEC prior to development of alternatives. The FS addresses two operable units (OUs) and remedial alternatives and their associated remedial technologies, which are presented below.

1.1.1 Operable Unit 1 (Overburden Soil and Groundwater)

Overburden Soil

- Alternative No. 1: No action.
- Alternative No. 2: Institutional controls (i.e., access restrictions, deed restrictions, long-term monitoring).
- Alternative No. 3: Cover (asphalt pavement cover in areas already containing some asphalt or concrete and soil cover to limit potential for direct contact with impacted near-surface soil). Includes long-term maintenance of the cover.
- Alternative No. 4: Excavation and on-site treatment of soils (soils generally containing greater than 10 parts per million [ppm] total volatile organic compounds [VOCs]).
- Alternative No. 5: Excavation and off-site treatment/disposal of soils (soils generally containing greater than 10 ppm total VOCs).

Overburden Groundwater

- Alternative No. 1: No action.
- Alternative No. 2: Institutional controls (i.e., access restrictions, deed restrictions, long-term groundwater monitoring).
- Alternative No. 3: Hydraulic containment (collection trench with sand seam extraction well) and ex situ treatment of overburden groundwater with discharge to a publicly owned treatment works (POTW).

1.1.2 Operable Unit 2 (Bedrock Groundwater)

- Alternative No. 1: No action.
- Alternative No. 2: Institutional controls (i.e., access restrictions, deed restrictions, long-term monitoring).
- Alternative No. 3: Hydraulic containment (groundwater extraction from wells placed across the A and B bedrock fracture zones) and ex situ treatment of groundwater with discharge to a POTW.

The C zone bedrock groundwater (Operable Unit 3) will be further assessed as part of future remedial activities and is not included in this report.

Additional details regarding the criteria used during preliminary screening and the components of these remedial alternatives are presented in Section 3.

1.2 Purpose and Organization of Report

The purpose of the on-site FS is to identify and evaluate technologies that are available to remediate the on-site areas identified in the SRI as requiring remedial action. The technologies most appropriate for the on-site conditions are then developed into remedial action alternatives that are evaluated based on their environmental benefits and cost. The information presented in this FS report will be used by NYSDEC to select on-site remedial action(s). The on-site remedial action(s) selected for the site will be summarized by NYSDEC in a Proposed Remedial Action Plan (PRAP), which will be released for public comment. After receipt of public comments NYSDEC will issue a Record of Decision (ROD).

This FS report consists of the following six sections.

- Section 1 includes information regarding site background, site location, site description, site history, a summary of previous site investigations, site geology/hydrology, nature and extent of contamination, contaminant fate and transport, and public health and environmental risks.

- Section 2 presents the identification of standards, criteria, and guidelines and the development of remedial action objectives (RAOs).

- Section 3 identifies appropriate technologies and the development of alternatives.

- Section 4 is the detailed evaluation of the alternatives for remediating the affected media.

- Section 5 presents a comparative analysis of alternatives, summarizes the rationale for the selected remedy, and presents a preliminary cost estimate for the remedy.

- Section 6 provides a summary and conclusions.

- Section 7 contains the references.

1.3 Scope of Work

E & E completed the following scope of work for the FS.

- Identified standards, criteria, and guidelines (SCGs) that may apply to the specific conditions at the site. These generally include state requirements that are used as a basis for establishing cleanup goals for the site and other regulatory requirements that may apply to proposed remedial actions.

- Identified proposed cleanup goals (SCG goals) and remedial objectives for contaminants of concern at the site.

- Completed preliminary screening of remedial technologies to develop a focused list of technologies/alternatives that appear implementable and effective based on the site conditions and list of contaminants identified during the SRI.

- Developed and combined on-site remedial alternatives for detailed analysis that were evaluated on the basis of:
  - Compliance with applicable or relevant and appropriate SCGs and remediation goals;
  - Overall protection of human health and the environment;
  - Short-term impacts and effectiveness;
  - Long-term effectiveness and permanence;
  - Reduction of toxicity, mobility, and volume;
  - Implementability; and
  - Cost.

- Compared the alternatives based on the seven criteria identified above.

- Provided conclusions regarding the FS.

- Prepared this report summarizing the findings of the FS.

The FS and report was completed in general accordance with:

- The scope of work described in the *Work Plan for the Supplemental Remedial Investigation/Feasibility Study at the Former Frontier Chemical Waste Process, Inc., Site, Site No. 9-32-110* (September 2002);

- Procedures recommended in the NYSDEC Division of Hazardous Waste Remediation, TAGM 4025 Guidance, *Guidelines for Remedial Investigation/Feasibility Studies* (March 1989);

- NYSDEC Division of Hazardous Waste Remediation TAGM 4030 Guidance, *Selection of Remedial Actions at Inactive Hazardous Waste Sites*, as revised May 1990; and

- U.S. Environmental Protection Agency (EPA) *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (October 1988).

1.4 Site Information

1.4.1 Site Description

Frontier Chemical is an inactive 9-acre parcel located at 4626 Royal Avenue within the City of Niagara Falls, New York (see Figure 1-1). The Niagara River lies within 1 mile south of this site.

The site is bordered to the north by property identified as Niagara Junction Railway Company, to the northwest by property identified as the Niagara County Industrial Development Agency, to the south by Elken Metal Company, to the southwest by Frank's Vacuum Truck Service, and to the east by 47th Street, beyond which is Strator. Both Elken Metal Company and Frank's Vacuum Truck Service are located on Royal Avenue.

The facility treated chemical wastes from 1974 until December 1992, when the facility closed. When in operation, approximately 25,140 tons of chemical wastes were treated each year.

1.4.2 Site History

The site was originally developed in 1906 by ISCO Chemical Company (ISCO) as a caustic-chlorine plant. During World War II, the International Minerals and Chemicals Corporation bought the site and operated the facility as a caustic soda/potash and chlorine plant. In 1974 Frontier Chemical, which provided hazardous and nonhazardous chemical treatment, moved their company to the site from Pendleton, New York. Frontier Chemical expanded its on-site operations, which included wastewater treatment, fuels blending, and bulking chemicals for off-site disposal.

In 1985, Frontier Chemical and a sister company, BLT Services, Inc., became wholly owned subsidiaries of Environmental Services Associates, Inc. (ESA). In February 1990, ROE Consolidated Holdings assumed operational control of ESA, which had operational control of the site. The current site owner is 5335 River Road, Inc.

Several environmental investigations have been conducted at the site over the past 21 years. Table 1-1 in the SRI report provides a chronological history of activities conducted at the site. A summary of each investigation is included in Section 1.2.1 of the SRI report.

The facility ceased operations in December 1992. Beginning in 1999, most of the site's buildings were demolished and some rubble remains on-site.

1.4.3 Subsurface Conditions

The overburden thickness ranges from 14.7 feet to 17.1 feet. It consists of up to 2 feet of fill material (topsoil, silt, sand, and gravel with some cinder blocks, glass, wood, slag, bricks, crushed stone, concrete, and asphalt) followed by 12 feet to 15 feet of silty clays overlying the bedrock. The natural soils encountered generally consist of brown to red to green silty clays or fine sand and silt, with trace gravel at most localities.

Bedrock underneath the site is classified as Lockport Dolomite. The upper bedrock contains several water-bearing fracture zones. The first zone (Zone 1) is a 2- to 5-foot-thick weathered zone with an estimated 1-foot-thick high-permeability zone (A-fracture zone). This zone is followed by an 8- to 10-foot unweathered thick-bedded zone of lower permeability (Zone 2). At the base of Zone 2 is a 1- to 2-foot-thick high-permeability marker bed labeled as the B-fracture zone. The B-fracture zone varies in thickness from 1 foot to 4 feet. Beneath this zone is Zone 3, which is a medium- to thick-bedded fossiliferous zone. Within this zone, the C-fracture zone was identified through in situ aquifer testing (i.e., packer tests) (Ecco, Inc. 1990). The C-fracture zone is approximately 20 feet below the B-fracture marker bed and is not as distinct and permeable as the A and B zones.

1.4.4 Site Hydrology

The Frontier Chemical site is located in an industrial section of Niagara Falls. Approximately 25% of the surface area at the site is covered by grass/vegetation and the other 75% of the surface area is covered by buildings, building foundations, and pavement. Water on the grassed areas tends to collect in topographic lows before draining into the overburden. Surface drainage on the paved surfaces generally flows southward into storm sewer outfalls (Falls Street tunnel) and then to the city of Niagara Falls sewage treatment facility. Large areas of standing water were noted on the paved areas of the site during the SRI. It appears that some of the storm sewer outfalls, especially in the central area of the site, may be blocked.

The silty-clay material that comprises most of the overburden is saturated, but due to the low permeability does not tend to yield water. Overburden groundwater generally flows to the southeast. However, there appears to be a groundwater depression in the central portion of the site. The horizontal gradient in the overburden is estimated to be approximately 1.95 feet per 100 feet towards the southeast but ranges between 4.5 feet to 25 feet per 100 feet around the groundwater depression. The vertical gradient between the overburden and A-fracture zone is 1.58 feet/foot towards the bedrock, signifying recharge areas. The average overburden hydraulic conductivity is approximately 2.1×10^{-6} feet per second based on slug and pump-test activities (Ecco, Inc. 1991).

Three laterally extensive horizontal fracture zones in the upper bedrock were identified during drilling activities. Groundwater flow in the A-fracture zone is to the south/southeast, with a horizontal gradient of approximately 1.3 feet per 100 feet. The vertical gradient between the A- and B-fracture zones is 1.04 feet per foot towards the B-fracture zone. Previous investigations estimated horizontal flow within the A-fracture zone to be 2.0 feet per 100 feet in a southerly and easterly direction, with hydraulic conductivity ranging from 5.6×10^{-8} ft/sec to 5.2×10^{-5} ft/sec based on slug and pump-test activities (Ecco, Inc. 1991). Although this previous data appear to suggest extreme heterogeneity in the A-fracture zone, the low permeability results are from the east and western portion of the site and the higher permeability results are from the central and southern portion of the site, with hydraulic conductivity ranging from 2.5×10^{-5} ft/sec to 5.2×10^{-5} ft/sec (Ecco, Inc. 1991).

The next fracture zone (the B-fracture zone) consists of a 1- to 2-foot-thick fracture zone approximately 8 feet to 10 feet beneath the A-fracture zone. Groundwater flow in the B-fracture zone is towards the east and the south, with a groundwater “mound” in the west-central area of the site. The horizontal gradient ranges from 2.3 feet per 100 feet from the north to the south and 4.7 feet per 100 feet from the groundwater mound in the west to the east. Groundwater flow was primarily in a southerly and easterly direction, similar to the A-fracture zone, and a groundwater mound was present in the west-central area of the site. Previous investigations estimated average horizontal flow within the B-fracture zone to be 2.4 feet per 100 feet and the average hydraulic conductivity was approximately 1.4×10^{-5} ft/sec based on pump-test activities (Ecco, Inc. 1991).

The third identified fracture zone (the C-fracture zone) is approximately 20 feet below the B-fracture zone. Groundwater flow direction and rate were not determined because demolition activities destroyed all but two C-fracture zone wells. The vertical gradient between the B- and C-fracture zones is 0.17 foot/foot towards the B-fracture zone, signifying discharge areas.

The site is bordered on the east and south by large-diameter (6 feet by 5 feet and 6 feet by 7 feet) unlined open rock sewer tunnels (New Road and Falls Street tunnels, respectively) that are at about the same elevation as the B-fracture zone. Therefore, it is expected that groundwater from the B-fracture zone enters the sewer tunnels. It is also expected that groundwater from the A-fracture zone migrates south/east and downward and enters the tunnels (including the unlined open rock tunnel access shafts). Additionally, the tunnel access shaft sections above the top of rock (in the overburden) are lined with brick and therefore likely allow overburden groundwater infiltration.

During periods of no precipitation the New Road tunnel (which flows into the Falls Street tunnel) and the Falls Street tunnel water is treated by the city of Niagara Falls sewage treatment plant (a POTW) before discharge to the river. The flow from the Falls Street tunnel at the Frontier site is diverted by several diversion weirs (adjacent to or nearby and downstream of the Frontier site) to the lined Southside interceptor tunnel. The Southside interceptor tunnel conveys the water directly to the POTW for treatment.

In summary, under periods of no precipitation, contaminated groundwater that may infiltrate the tunnels adjacent to the site is diverted to the POTW.

During periods of precipitation, the potential exists for flow to go over the diversion weirs and flow in an easterly direction down the Falls Street tunnel toward the South Gorge interceptor. In order for the flow to continue down the Falls Street tunnel past the diversion weirs, the volume of water would have to exceed the holding capacity of the Southside interceptor tunnel. The POTW uses the Southside interceptor tunnel for water storage before treatment under high flow conditions. Water that is diverted in the Falls Street tunnel to the South Gorge interceptor is diverted north to the Gorge Pumping Station, where it is pumped back (in a southeast direction) to the POTW. However, under periods of heavy precipitation (high flow in the system) the South Gorge interceptor also overflows to the South Gorge interceptor outfall, which is a discharge point to the Niagara River.

In summary, under periods of precipitation (with sufficient precipitation to cause overflow of the weirs between the Frontier Chemical site and the South Gorge interceptor), groundwater that may infiltrate the tunnels from the Frontier Chemical site has the potential to be discharged (untreated) to the Niagara River at the South Gorge interceptor outfall. However, under high flow the potential contaminant concentration in the water in the Falls Street tunnel is expected to be significantly lower than during dry conditions.

It should also be noted the general groundwater elevation in the area of the POTW system is above the unlined Falls Street tunnel. Therefore, it is expected that an inward gradient exists surrounding the Falls Street tunnel that would limit the potential for contaminated groundwater in the tunnel (associated with the Frontier site) from exiting the tunnel.

A figure depicting the flow from the Falls Street tunnel (at the Frontier site) to the POTW is included as Figure 1-2.

1.4.5 Nature and Extent of Contamination

Results of sample analyses from the various sample media collected during the SRI indicated there were multiple source areas on-site as well as unidentified off-site sources to the north and northeast of the site. Because the site is inactive and underwent several removal actions, further contributions of contaminants are not expected at any of the former on-site source areas. No specific sources were identified during E & E’s field investigations.

Site soils and groundwater are mainly contaminated by VOCs. Significant semivolatile organic compound (SVOC) contamination (predominantly polycylic aromatic hydrocarbons [PAHs] and phenols) is also present to a lesser degree, along with dioxins and metals. There are also minor amounts of pesticides in excess of criteria. Contamination levels in groundwater decrease with depth (i.e., the highest levels of contaminants were detected in overburden groundwater, and concentrations decrease in the underlying A-fracture, B-fracture, and C-fracture bedrock zones). Lateral contaminant migration in the groundwater is generally to the southeast. Overall contaminant concentrations in both overburden and bedrock groundwater have declined since 1990. In addition, most of the higher areas of groundwater contamination have migrated either vertically deeper into the bedrock or laterally approximately 100 feet. It appears that the New Road and Falls Street tunnels intercept the majority of the groundwater exiting the site.

1.4.6 Contamination Fate and Transport

The primary transport pathways for site contaminants include surface water flow; infiltration; overburden and bedrock groundwater flow; subsurface utilities and their bedding material; and volatilization.

Based on the persistence and behavioral characteristics of the predominant contaminants detected at the site and the observed presence of chemicals in the various media tested, the potential significant migration pathways include surface water flow, groundwater (including infiltration), and volatilization.

Surface water flow may be a site mechanism that allows lateral migration of contaminants, if present, in surface soils or as residuals on demolition debris, decommissioned tanks, etc. No surface soils were collected for analytical testing during the SRI.

The overburden groundwater samples collected at the site include numerous VOCs as well as select SVOCs (primarily phenols) and inorganic compounds, likely the result of leaching from site soils. In general, the contaminants are expected to flow at rates less than groundwater. Groundwater migration is expected to spread the contamination in the direction of groundwater flow (southeasterly) and vertically downward to lower water-bearing zones. As the contamination migrates, the natural organic carbon in the soil will adsorb many of the detected compounds, thus slowing the advance of the plume. Horizontal migration rates of select VOCs and SVOCs were calculated to be about two to 71 times slower than overburden groundwater. The horizontal vertical migration is calculated to be approximately 6 feet per year. VOCs will also be attenuated in response to dispersion, volatilization, and degradation, among other factors.

Analytical test results from the bedrock groundwater monitoring wells indicate the presence of numerous site contaminants, including VOCs, SVOCs (primarily phenols), and inorganic compounds. The contaminants in the fractured bedrock are expected to flow at rates less than groundwater, which is estimated to be 90 feet and 290 feet per year for fracture zones A and B, respectively. (Based on the limited number of wells in the C-fracture zone, estimates of groundwater flow velocity in this zone could not be determined.) In addition, the New Road and Falls Street tunnels are expected to intercept the A-zone and B-zone bedrock groundwater. It is anticipated that some portions of the bedrock groundwater flow may be impacting off-site properties before entering the tunnels, based on the measured direction of groundwater flow. It is also probable that downward migration of VOCs into the lower bedrock (C-zone fracture system and below) is occurring via connected vertical fractures in the bedrock.

VOCs within the site overburden groundwater and soils may also volatilize into the unsaturated soil zone. Soil vapors may discharge into the atmosphere and into on-site or off-site subsurface structures such as basements, manholes, or sumps. In addition, volatilization of VOCs may occur at groundwater discharge locations such as sumps, stormwater tunnels, and/or surface water features.

1.4.7 Qualitative Human Health Risk Evaluation

In 2002 E & E conducted a qualitative human health risk evaluation as part of the SRI. New York State regulatory criteria for soil and groundwater were used as a preliminary screening tool to identify chemicals of potential concern (COPCs).

The Frontier Chemical site is currently an inactive industrial site and is surrounded by other industrial sites. A perimeter fence limits access. Current human receptors would include site visitors who enter for specific purposes, such as site investigation, and possibly trespassers. Generally, current site visitors are not expected to have direct contact with subsurface soil contamination, and contact with surface soil will be limited since most of the site is paved or covered by site structures. Contaminant levels in surface soils are not known because no samples were collected, but it is not unreasonable to expect that non-volatile contamination in surface soil might be similar to the levels in shallow subsurface soil. (Due to volatilization, VOC levels in surface soil are expected to be lower than in subsurface soil.) Site visitors may also be exposed to VOCs via inhalation of vapors that have migrated from subsurface soil to the air.

In the future, the site could remain inactive or it might be redeveloped for other industrial or commercial uses. It is assumed the site will not be used for residential purposes. If the site were redeveloped for commercial or industrial use, site workers could be exposed to soil contaminants by the same pathways that currently exist for visitors, but the magnitude of potential worker exposures would be much greater due to the expected higher intake rates, greater exposure frequency, and longer exposure duration. In addition, because soil excavation and other disturbances during redevelopment could unearth subsurface soils, future workers could potentially have direct contact with some of the contamination that is now inaccessible.

Considering that site and regional groundwater is contaminated and that potable water is supplied to the site and surrounding area, it is unlikely that site groundwater would be used as a source of drinking water. The site and surrounding area are served by the city water system, which draws its supply from the Niagara River.

Under an industrial use scenario, groundwater could conceivably be used in the plant processes, potentially exposing future workers to contamination by incidental contact and by inhalation of volatile contaminants released from the water to ambient air. If so, the magnitude of potential worker exposures would not be as great as it would from drinking water use. Nevertheless, due to the extremely high levels of some VOCs present in the groundwater, worker exposures might reach levels associated with unacceptably high cancer risks and other adverse health effects.

02:000699_NV05_06-B1104
Fig1-1.cdr-1/23/04-GRA

SOURCE: Niagara Falls Quadrangle, 7.5 Minute Series Topographic Map 1980.

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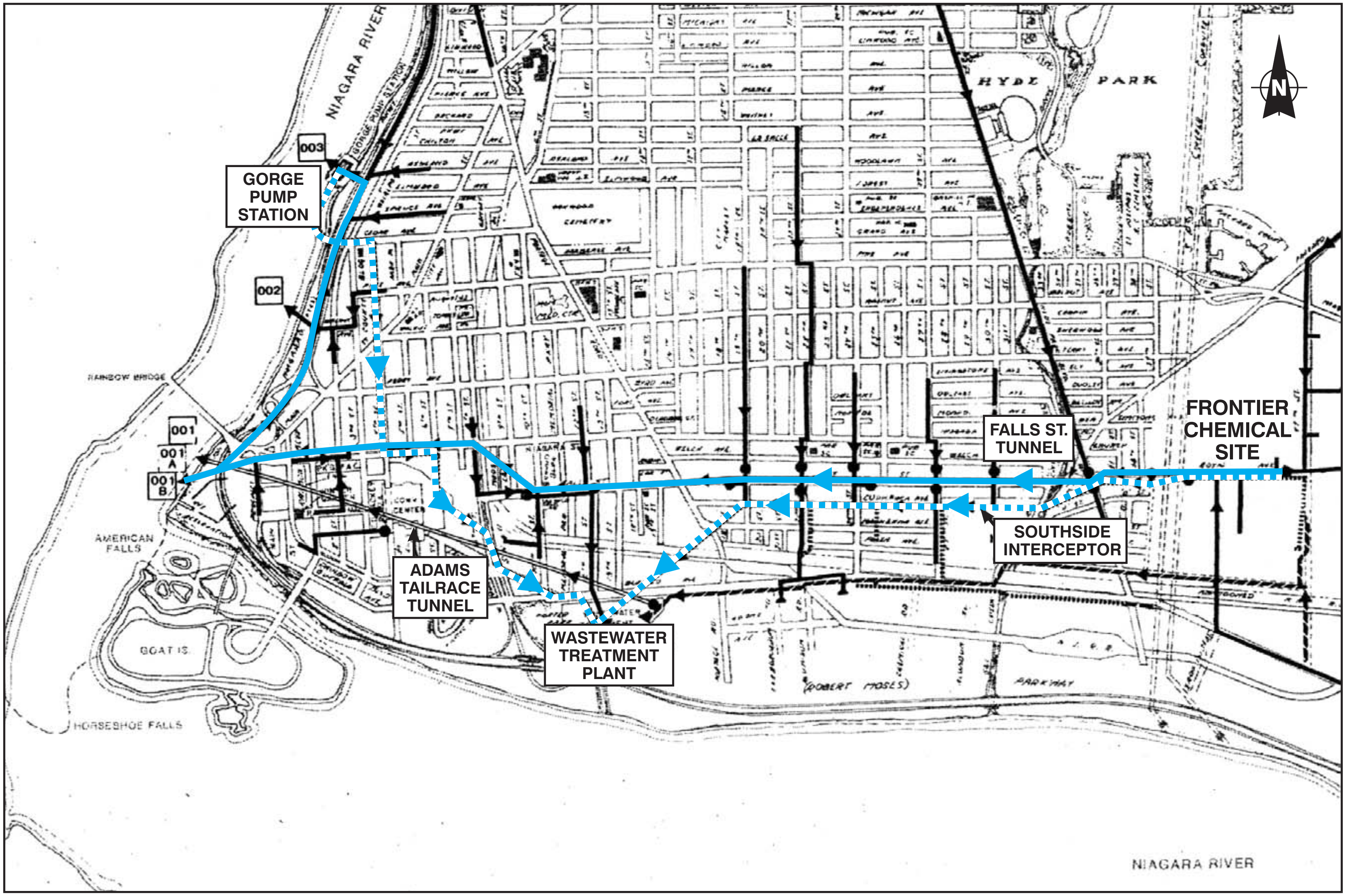
SCALE

0 0.5 1 Mile

Figure 1-1 SITE LOCATION MAP
FORMER FRONTIER CHEMICAL WASTE PROCESS, INC.

02:000699_NV05_06-B1104
Fig1-2.CDR-1/23/03-GRA



SOURCE: Major Wastewater Collection Facilities and Industrial Discharges, Figure Provided by City of Niagara Falls Sewage Treatment Plant

Figure 1-2 Flow Path from Former Frontier Chemical Waste Process, Inc. to Wastewater Treatment Plant

2 Identification of Standards, Criteria, and Guidelines and Remedial Action Objectives

2.1 Introduction

This FS addresses contamination in subsurface soils and groundwater at the Frontier Chemical site. Chemicals analyzed include VOCs, SVOCs, pesticides/polychlorinated biphenyls (pest/PCBs), metals, and cyanide. In addition, dioxin analysis was performed on subsurface soils and total hardness analysis was performed on site groundwater.

Based on a preliminary screening of the analytical results, the SRI report identified potential risks posed by site contamination by evaluating contaminant concentrations and identifying potential exposure routes. This evaluation was conducted for both human and environmental receptors.

The evaluation identified the following potential risks at the site:

- Direct contact exposure to contaminated subsurface soils by future construction workers involved in soil excavation at the central and south-central portions of the site.
- Direct contact exposure to contaminated groundwater by utility workers or future construction workers involved with site excavation.
- Direct inhalation of organic vapors by trespassers, utility workers, or future site workers. Organic vapors may be released from contaminated groundwater into utility manholes, buildings, etc. through cracks and subsurface connections.

Thus, RAOs were developed (see Section 2.3) to reduce or eliminate these potential risks by eliminating these routes of exposure or reducing the contaminant concentrations. Furthermore, environmental media are to meet applicable chemical-specific standards at the site. To define the area or volume of each medium that must be addressed to meet the RAOs, chemical-specific cleanup goals were developed for each medium at this site.

SCGs are used at inactive hazardous waste sites to establish the locations where remedial actions are warranted and to establish cleanup goals. SCGs include state requirements. The following sections present potentially applicable SCGs and other standards and establish proposed cleanup goals and specific RAOs for contaminated on-site media. Also presented are estimates of areas and volumes of contaminated on-site media.

2.2 Potentially Applicable Standards, Criteria, and Guidelines (SCGs) and Other Criteria

SCGs include applicable or relevant and appropriate requirements and other applicable requirements.

- *Applicable Requirements* are legally enforceable standards or regulations such as groundwater standards for drinking water that have been promulgated under state law.

- *Applicable or Relevant and Appropriate Requirements* (ARARs) include those requirements that have been promulgated under state law that may not be "applicable" to the specific contaminant released or the remedial actions contemplated but are sufficiently similar to site conditions to be considered relevant and appropriate. If a relevant or appropriate requirement is well suited to a site, it carries the same weight as an applicable requirement during the evaluation of remedial alternatives.

- *To Be Considered Criteria (TBCs)* are non-promulgated advisories or guidance issued by state agencies that may be used to evaluate whether a remedial alternative is protective of human health and the environment in cases where there are no standards or regulations for a particular contaminant or site condition. These criteria may be considered with SCGs in establishing cleanup goals for protection of human health and the environment.

The following sections present the three categories of SCGs: chemical-specific, location-specific, and action-specific.

2.2.1 Chemical-Specific SCGs

Chemical-specific SCGs are typically technology or health-risk-based numerical limitations on the contaminant concentrations in the ambient environment. They are used to assess the extent of remedial action required and to establish cleanup goals for a site. Chemical-specific SCGs may be directly used as actual cleanup goals or as a basis for establishing appropriate cleanup goals for the contaminants of concern at a site. Chemical-specific SCGs for on-site soil and groundwater at the Frontier Chemical site are identified in Tables 2-3 and 2-9. The list of chemical-specific SCGs was developed using the risk-based criteria presented as part of the qualitative risk assessment for the SRI.

2.2.2 Location-specific SCGs

Location-specific SCGs are site- or activity-specific. Examples of location-specific SCGs include building code requirements and zoning requirements.

Location-specific SCGs are commonly associated with features such as wetlands, floodplains, sensitive ecosystems, or historic buildings that are located on or close to the site (see Table 2-10) .

2.2.3 Action-specific SCGs

Action-specific SCGs are usually administrative or activity-based limitations that guide how remedial actions are conducted. These may include record-keeping and reporting requirements; permitting requirements; design and performance standards for remedial actions; and treatment, storage, and disposal requirements (see Table 2-10).

2.2.4 Proposed Cleanup Goals

Proposed cleanup goals are developed by evaluating the available SCGs for each contaminant. In general, this process selects standards as preliminary screening values. If no standards exist for a given contaminant, the most appropriate criterion or guidance value is selected as a preliminary screening value. Where appropriate, the preliminary screening values then are compared to site-specific background values for naturally occurring compounds to confirm that no preliminary screening value is set below site background concentrations. If the site-specific background concentration is higher than the SCG-based preliminary screening value, then the background concentration is selected as the preliminary screening value. These preliminary screening values are compared to site data to identify which contaminants may require cleanup. These contaminants are then considered with regard to other factors influencing the need for cleanup, including comparison with regional background levels and an evaluation of contamination. The cleanup goals proposed by this process are compared again to site data in order to identify areas that must be addressed in the FS.

This process is completed for each medium. Because the nature of the SCGs is different for each medium, the details of this process are medium-specific. These details are presented in each medium-specific discussion below. Each section describes and presents figures showing the extent of contamination exceeding the proposed cleanup goals, and these areas and volumes form the basis for the remedial technology selection and alternative development sections in this FS.

2.3 Remedial Action Objectives

This section presents the objectives for on-site remedial actions that may be taken to protect human health and the environment. The RAOs were developed based on information contained in the SRI, which provided the following:

- Identified contaminants present in the environmental media in the study area.
- Evaluated existing or potential exposure pathways in which the contaminants may affect human health and the environment.
- Identified pathways having a moderate to high likelihood for exposure.

- Identified chemical-specific SCGs that apply to the likely exposure routes to establish the contaminants of concern and proposed cleanup goals for purposes of remediation.

Based on the contaminants of concern and proposed cleanup goals, RAOs are presented for the environmental media in the study area.

2.3.1 Soils

The RAOs for site subsurface soils are:

- Eliminate to the extent practicable the potential for direct human or animal contact with the contaminated subsurface soils;
- Reduce the risk of further contamination of the groundwater by reducing the potential for leaching of contaminants into the groundwater; and
- Eliminate to the extent practicable the potential for human exposures to organic vapors in site buildings, structures, and subsurface utilities.

2.3.2 Groundwater

The RAOs for on-site groundwater are:

- Prevent to the extent practicable the further off-site migration of contaminated groundwater;
- Reduce, control, or eliminate to the extent practicable the groundwater contamination present within the overburden;
- Reduce, control, or eliminate to the extent practicable the groundwater contamination present within the bedrock groundwater zones of concern; and
- Eliminate to the extent practicable the potential for human exposures to contaminated groundwater.

Due to the long history of industrial activities at the site there are a variety of contaminants detected in the subsurface (soil and groundwater). However, for the purpose of this FS the primary contaminants of concern are VOCs (total VOCs). The following information supports focusing the FS on total VOCs.

- Historic operations at the site included treatment and storage of chemical wastes that primarily included a variety of VOCs.
- VOCs were the contaminants detected most frequently and at the highest concentrations.

- In general, other types of contamination detected were located proximate to the areas significantly contaminated with VOCs.

Other contamination is discussed in the SRI and FS. However, for the purpose of delineation of contamination the focus is on total VOCs. If soil removal/treatment and/or groundwater extraction/treatment is conducted as part of the on-site remedy, the other contaminants included in the removed/treated media would also be treated. The following two sections discuss the contaminated media (soil and groundwater) of concern.

2.4 Soils

Subsurface sampling was conducted as described in the SRI. The subsurface soils were analyzed for VOCs, SVOCs, pest/PCBs, dioxin, metals, and cyanide.

Contaminant levels in surface soils are not known because no samples were collected. For the purpose of this FS it is assumed that contamination in surface soil is similar to concentrations in shallow subsurface soil. Under current site conditions, direct contact with surface soil is limited because 75% of the site is covered by pavement, concrete, or building floors and the site is secured by fencing. Additionally, it is assumed that surface soil in the areas of contaminated subsurface soil above proposed cleanup goals is also contaminated above surface soil cleanup goals.

2.4.1 Selection of Proposed Soil Cleanup Goals Standards

There are no standards promulgated for soils.

Criteria and Guidance Values

The main criteria and guidance values identified for soils at the Frontier Chemical site are contained in NYSDEC TAGM 4046 (January 1994). Criteria and guidance values for the contaminants detected at this site are presented in Table 2-1.

Background

Background soil sample data are used to ensure that preliminary screening values for metals are not set below background levels. No site-specific soil background levels were available for this site. Therefore, the lowest published values for Eastern USA background levels in TAGM 4046 were used. In addition, many of the metal screening values recommended by TAGM 4046 are based on background concentrations.

The TAGM 4046 values for cadmium (1 mg/kg) and chromium (10 mg/kg) were updated from the 1994 value to 10 mg/kg and 50 mg/kg respectively. This update has not been published in a revised TAGM (NYSDEC September 1999).

Selection Process

The proposed cleanup goal for subsurface soil is presented in Table 2-2. The following logical basis was used to select the preliminary cleanup values presented in this table:

- NYSDEC TAGM 4046 values were selected as the preliminary cleanup values, except for lead. For lead, the EPA *Revised Soil Lead Guidance* value was used. Because lead is a common contaminant at many waste sites, this metal has received increased attention, resulting in this commonly accepted value for site cleanups. Therefore, the EPA value is used instead of the TAGM 4046 value (site background).

- The preliminary cleanup values then were compared to the maximum observed concentration for each compound in order to determine which compounds may require cleanup.

- Finally, the contaminants identified for cleanup were reviewed to determine whether they are site-related and whether cleanup is warranted.

Based on this process, it was found that 35 organic compounds and 14 metals were present above the preliminary cleanup values in subsurface soil samples, as summarized in Table 2-2. Organic compounds included 21 VOCs, 10 SVOCs, and four pesticides. Dioxins and cyanide were not present above the preliminary cleanup values.

2.4.2 Selection of Contaminants of Concern

Based on the above analysis, subsurface soil in the central and south-central portions of the site are considered contaminated and in need of remediation. The area of subsurface soil contamination is encompassed by PZ-01-04, PZ-01-05, PZ-01-06, PZ-01-07, PZ-01-10, GP-01-08, MW-01-10B, and MW-88-7B(R) (see Figure 2-1 [back pocket]). The contaminants of concern are presented in Table 2-3.

All the detected VOCs were found in samples from the central and south-central portion of the site. Four contaminants (1,1-dichloroethene, 2-butanone, 4-methyl-2-pentanone, and chloroethane) were removed from the list of preliminary cleanup goals because each was detected in less than three of 31 samples and were only detected once above preliminary cleanup goals. Chloroform was detected once above the preliminary cleanup values in the north part of the site. Since the one detection for chloroform is considered isolated (in an area where other significant contamination was not found) and was found at 12 feet to 14 feet below ground surface (bgs), it was removed from the list of selected contaminants of concern.

Five SVOCs (4-chloro-3-methylphenol, benzo(b)fluoranthene, benzo(k)fluoranthene, hexachlorobenzene, and indeno(1,2,3-cd)pyrene) were removed from the selected list of contaminants of concern. Hexachlorobenzene was detected in one sample from an area outside the main area of contamination (south-central potion of the site) at a depth of 8 feet to 10 feet bgs. Therefore, the hexachlorobenzene detection was considered isolated and not significant and was removed from the list. The other four compounds were detected less than twice each at levels only slightly above the preliminary cleanup values.

Four pesticides (aldrin, dieldrin, endrin, and heptachlor epoxide) were detected at concentrations above preliminary cleanup values. These pesticides were removed from the list of contaminants of concern because the concentrations were not elevated enough to present a significant concern and the soil is also significantly contaminated with other compounds. The exception to this trend was a pesticide detected at one location outside the main area of contamination (south-central potion of the site) that was eliminated because it was detected at a depth of 11 feet to 12.5 feet bgs.

Eleven metals were detected above preliminary cleanup values for the site. Most of these metals were detected in all 31 samples collected and at concentrations above preliminary cleanup values. Site background samples were not collected to use in determining cleanup goals. Therefore, the background numbers used in Table 2-1 were numbers obtained from TAGM 4046. For this reason, metal concentrations from samples not contaminated with any other chemical constituents (e.g., VOCs, SVOCs, pest/PCBS) from the north portion of the site were used to gauge selected contaminants of concern. Based on these samples several metals (calcium, magnesium, manganese, potassium, and thallium) were eliminated from the list of selected contaminants of concern since they are likely to be naturally occurring and may be associated with background conditions.

In addition to the contaminants of concern noted in Table 2-3, cleanup criteria will include a limit of 10 ppm for the sum of all VOCs and 500 ppm for the sum of all SVOCs as noted in TAGM 4046.

2.4.3 Soil Contamination Summary

Based on the distribution and concentration of contamination detected in soil, the areas of subsurface soil that need to be addressed in this FS are those located in the central and south-central portions of the site, which are contaminated with VOCs, SVOCs, and metals. This represents approximately 173,000 square feet (4 acres) of surface area that will be targeted to an average depth of 5.5 feet (depth to the water table; approximately 35,000 cubic yards in place) for remediation. Figure 2-1 provides the proposed boundaries of contamination to be further addressed in this FS.

2.5 Groundwater

Groundwater sampling was conducted as detailed in the SRI. Groundwater was analyzed for VOCs, SVOCs, pest/PCBs, metals, cyanide, and total hardness.

2.5.1 Selection of Groundwater Cleanup Goals

Standards

Standards identified for groundwater at the Frontier Chemical site are the NYSDEC Class GA maximum contaminant levels (MCL) (June 1998 and 2000 addendum) taken from the NYSDEC Division of Water Technical and Operational Guidance Series (TOGS) (1.1.1) Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations, indicating the potential use of this groundwater as a drinking water source. All New York State groundwater is considered Class GA by NYSDEC.

Guidance

The NYSDEC Class GA water guidance values were also taken from TOGS 1.1.1. The guidance values were used for compounds for which NYSDEC Class GA standards have not been established.

The proposed cleanup goal screening process for groundwater is presented in Table 2-4.

The following method was used to select the preliminary cleanup values presented in the table:

- The NYSDEC Class GA standard, if it existed, was selected as the preliminary cleanup value;
- If a groundwater standard did not exist for a constituent, the NYSDEC Class GA guidance value, if it existed, was used;
- The preliminary cleanup values were then compared to the maximum observed concentrations of each compound to determine which compounds may require cleanup; and
- Finally, the contaminants identified for cleanup were reviewed to determine whether they are site-related and whether cleanup actually is warranted.

The groundwater contaminant exceedances for overburden, A-fracture zone, B-fracture zone, and C-fracture zone groundwater are summarized in Table 2-4.

Overburden Groundwater

Based on this process, overburden groundwater samples were found to contain 43 organic compounds, 12 metals, and cyanide present above the preliminary cleanup values, as summarized in Table 2-5. Organic compounds included 27 VOCs, 12 SVOCs, and 4 pesticides (aldrin, alpha-chlordane, dieldrin, and endrin). The 13 metals include antimony, arsenic, beryllium, calcium, chromium, copper, iron, lead, manganese, nickel, selenium, sodium, and thallium.

A-Fracture Zone Groundwater

The A-fracture zone groundwater was found to contain 46 organic compounds, 11 metals, and cyanide present above the preliminary cleanup values, as summarized in Table 2-6. Organic compounds included 25 VOCs, 14 SVOCs, 6 pesticides (4-4'-DDT, aldrin, alpha-chlordane, dieldrin, endrin, and heptachlor epoxide) and 1 PCB (Aroclor 1254). The 11 metals include antimony, arsenic, beryllium, chromium, iron, lead, magnesium, manganese, selenium, sodium, and thallium.

B-Fracture Zone Groundwater

The B-fracture zone groundwater was found to contain 39 organic compounds, 12 metals, and cyanide present above the preliminary cleanup values, as summarized in Table 2-7. Organic compounds included 23 VOCs, 10 SVOCs, 5 pesticides (aldrin, alpha-chlordane, dieldrin, endrin, and heptachlor epoxide) and 1 PCB (Aroclor 1254). The twelve metals include antimony, arsenic, beryllium, copper, iron, lead, magnesium, manganese, mercury, selenium, sodium, and thallium.

C-Fracture Zone Groundwater

The C-fracture zone groundwater was found to contain 16 organic compounds and 2 metals present above the preliminary cleanup values, as summarized in Table 2-8. Organic compounds included 13 VOCs, 2 SVOCs, and 1 pesticide (dieldrin). The two metals are iron and sodium.

2.5.2 Selection of Contaminants of Concern

Based on the above analysis, a groundwater contamination plume was identified that extends from the central portion of the site and flows south. The contaminants of concern are presented in Table 2-9.

Detected VOCs were concentrated in groundwater in the central and south-central portion of the site. The contamination is generally greatest in the overburden groundwater and decreases with depth through the fracture zones. Seventy-two samples were collected from the four zones of groundwater. Four contaminants (1,1,2,2-tetrachloroethane, 1,1,2-trichloroethane, chloroethane, and isopropylbenzene) were each found in less than eight of 72 samples and were each detected only once or twice above preliminary cleanup values. These four compounds were removed from the list of selected contaminants of concern. The compounds 2-butanone and ethylbenzene were found in eight or less of the 72 samples and were only above preliminary cleanup goals six and four times, respectively. Therefore, these two compounds were also removed from the list of selected contaminants of concern.

For SVOCs, all of the phenolic compounds were grouped and the sum of all phenolic compounds will be used to assess cleanup goals. In addition, five compounds were each detected above preliminary cleanup goals three times or less in 50 samples collected for SVOC analysis. These compounds (4-chloroaniline, bis(2-chloroethyl)ether, bis(2-ethylhexyl)phthalate, hexachlorobutadiene, and naphthalene) were removed from the selected list of contaminants of concern.

Out of six pesticide detections, three were detected at concentrations not considered significantly higher than preliminary cleanup goals: 4-4'-DDT, alpha-chlordane, and heptachlor epoxide were detected one, six, and two times the levels above preliminary cleanup goals, respectively, and were therefore removed from the list of contaminants of concern. Aroclor 1254 was detected in three of 44 samples; each detection was at a concentration only slightly higher than preliminary cleanup values and in areas of other groundwater contamination in the A-fracture zone and B-fracture zone; therefore, the compound was removed from the list of contaminants of concern.

Thirteen metals were detected above preliminary cleanup values for the site. Most of these metals were detected in all 44 samples collected and at concentrations above preliminary cleanup values. Several metals (iron, magnesium, manganese, sodium, and thallium) were considered background constituents and eliminated from the list of selected contaminants of concern. Five metals (beryllium, chromium, copper, mercury, and nickel) were detected above preliminary cleanup goals in five or less of 44 samples collected. Therefore, considering that the detections were primarily in areas containing significant levels of other contamination and were detected in a limited number of samples, these compounds were eliminated from the list of selected contaminants of concern.

2.5.3 Summary of Groundwater Contamination

Given that there are multiple groundwater zones at the site, groundwater RAOs focus on groundwater extraction from the overburden and the upper bedrock, which included A-fracture and B-fracture zones. One overburden plume and one bedrock groundwater plume will be addressed in this FS, based on VOC, SVOC, pesticide, metals, and cyanide contamination.

The estimated extent of on-site contaminated groundwater covers the general footprint of soil contamination, approximately 173,000 square feet (4 acres) and is offset slightly in the downgradient (south) direction. The most significant groundwater contamination extends down from the groundwater surface in the overburden to the bottom of the B-fracture zone (about 40 feet bgs). The volume of contaminated groundwater cannot be accurately estimated due to the presence of on-site highly contaminated soil and potential dense non-aqueous phase liquid (DNAPL) contamination present in the subsurface (the quantity of DNAPL contamination is unknown) that provide an ongoing source of groundwater contamination.

It should be noted that there is insufficient data to properly define and/or develop remedial alternatives to address groundwater contamination present in the C-fracture bedrock zone. As discussed with NYSDEC, the C-fracture zone will be further assessed as part of remediation associated with A-fracture and B-fracture zones.

Table 2-1 Proposed Cleanup Goals – Screening Process for Soils – Frontier Chemical Site (mg/kg)

Analyte	NYSDEC TAGM 4046[c]	Background	Preliminary Screening Value	Maximum Concentration	Proposed Cleanup Goal
VOCs by Method OLM04.2					
1,1,1-Trichloroethane	0.8	—	0.8	510	0.8
1,1-Dichloroethane	0.2	—	0.2	45	0.2
1,1-Dichloroethene	0.4	—	0.4	0.5	0.4
1,2,4-Trichlorobenzene	3.4		3.4	140	3.4
1,2-Dichlorobenzene	7.9	—	7.9	680	7.9
1,3-Dichlorobenzene	1.6	—	1.6	210	1.6
1,4-Dichlorobenzene	8.5	—	8.5	430	8.5
2 – Butanone (MEK)	0.3	—	0.3	0.94	0.3
4-Methyl-2-pentanone	1.0		1.0	6.5	1.0
Acetone	0.2	—	0.2	48	0.2
Benzene	0.06	—	0.06	9.8	0.06
Bromodichloromethane	—	—	10	0.036	—
Bromoform	—	—	81	0.082	—
Carbon Disulfide	2.7	—	2.7	0.007	—
Carbon Tetrachloride	0.6	—	0.6	0.018	—
Chlorobenzene	1.7	—	1.7	830	1.7
Chloroethane	1.9	—	1.9	5.3	1.9
Chloroform	0.3	—	0.3	0.96	0.3
cis-1,2-Dichloroethene	—	—	780	24	—
Dibromochloromethane	—	—	7.6	0.023	—
Ethylbenzene	5.5	—	5.5	19	5.5
Isopropylbenzene (Cumene)	—	—	7,800	17	—
Methylcyclohexane	—	—	—	0.005	—
Methylene Chloride	0.1		0.1	13	0.1
Tetrachloroethene	1.4	—	1.4	2700	1.4
Toluene	1.5	—	1.5	56	1.5
trans-1,2-Dichloroethene	0.3		0.3	0.006	—
Trichloroethene	0.7	—	0.7	150	0.7
Vinyl chloride	0.2	—	0.2	4.9	0.2
Xylenes (total)	1.2	—	1.2	40	1.2
SVOCs by Method OLM04.2					
1,1'-Biphenyl	—	—	3,900	0.54	—
2,4,6-Trichlorophenol	—	—	58	0.13	—
2,4-Dichlorophenol	0.4	—	0.4	0.27	—
2,4-Dimethylphenol	—	—	1,600	0.085	—
2-Chlorophenol	0.8	—	0.8	0.09	—

Table 2-1 Proposed Cleanup Goals – Screening Process for Soils – Frontier Chemical Site (mg/kg)

Analyte	NYSDEC TAGM 4046[c]	Background	Preliminary Screening Value	Maximum Concentration	Proposed Cleanup Goal
2-Methylnaphthalene	36.4	—	36.4	6.6	—
2-Methylphenol	0.100		0.100	0.04	—
4-Chloro-3-methylphenol	0.240	—	0.240	0.4	0.240
4-Chloroaniline	0.220	—	0.220	0.07	—
4-Methylphenol	0.9	—	0.9	0.12	—
4-Nitrophenol	0.100	—	0.100	0.076	—
Acenaphthene	50	—	50	0.34	—
Acenaphthylene	41	—	41	2.2	—
Acetophenone	—	—	7,800	5.9	—
Anthracene	50	—	50	1.8	—
Benz(a)anthracene	0.224	—	0.224	1.3	0.224
Benzo(a)pyrene	0.061	—	0.061	2.4	0.061
Benzo(b)Fluoranthene	1.1	—	0.87	3.1	0.87
Benzo(g,h,i)perylene	50	—	50	0.79	—
Benzo(k)Fluoranthene	1.1	—	1.1	1.9	1.1
Bis(2-ethylhexyl) phthalate	50	—	46	1	—
Butyl benzyl phthalate	50	—	50	1	—
Carbazole	—	—	32	0.26	—
Chrysene	0.4	—	0.4	3	0.4
Dibenz(a,h)anthracene	0.014	—	0.014	0.39	0.014
Dibenzofuran	6.2	—	6.2	1.6	—
Di-n-butyl phthalate	8.1	—	8.1	0.098	—
Fluoranthene	50	—	50	4.3	—
Fluorene	50	—	50	0.65	—
Hexachlorobenzene	0.41	—	0.4	0.42	0.4
Hexachlorobutadiene	—	—	8.2	1.7	—
Hexachloroethane	—	—	46	1.4	—
Indeno(1,2,3-cd)pyrene	3.2	—	0.87	1.1	0.87
Naphthalene	13	—	13	10	—
N-nitrosodiphenylamine	—	—	130	0.44	—
Phenanthrene	50	—	50	4.3	—
Phenol	0.03	—	0.03	8.7	0.03
Pyrene	50	—	50	1.9	—
Pesticide/PCB by Method OLM04.2					
4,4'-DDD	2.9	—	2.7	0.2	—
4,4'-DDE	2.1	—	1.9	0.12	—
4,4'-DDT	2.1	—	1.9	0.1	—

Table 2-1 Proposed Cleanup Goals – Screening Process for Soils – Frontier Chemical Site (mg/kg)

Analyte	NYSDEC TAGM 4046[c]	Background	Preliminary Screening Value	Maximum Concentration	Proposed Cleanup Goal
Aldrin	0.041	—	0.038	0.073	0.038
alpha-BHC	0.11	—	0.11	0.012	—
alpha-Chlordane	0.54	—	0.54	0.120	—
beta-BHC	0.2	—	0.2	0.08	—
delta-BHC	0.3	—	0.3	0.05	—
Dieldrin	0.044	—	0.04	0.23	0.04
Endosulfan I	0.9	—	0.9	0.12	—
Endosulfan II	0.9	—	0.9	0.11	—
Endosulfan sulfate	1.0	—	1.0	0.072	—
Endrin	0.10	—	0.10	0.25	0.10
Endrin aldehyde	—	—	—	0.21	—
Endrin ketone	—	—	—	0.052	—
gamma-BHC	0.06	—	0.06	0.0015	—
gamma-Chlordane	0.54	—	0.54	0.26	—
Heptachlor	0.10	—	0.10	0.027	—
Heptachlor epoxide	0.02	—	0.02	0.22	0.02
Methoxychlor	—	—	390	0.053	—
Total 2,3,7,8-TCDD equivalent					
TCDD equivalent	—	—	0.0000043	0.0000027	—
Metals by Method ILM04.0					
Aluminum	SB	33,000	33,000	13,900	—
Antimony	SB	—	31	12.5	—
Arsenic	7.5	3	0.43	19.2	0.43
Barium	300	15	300	205	—
Beryllium	0.16	0	0.16	3.5	0.16
Cadmium	10.0	0.1	10.0	8.3	—
Calcium	SB	130	130	114,000	130
Chromium	50	1.5	50	562	50
Cobalt	30	2.5	30	24.6	—
Copper	25	1	25	232	25
Iron	2,000	2,000	2,000	33,600	2,000
Lead	—	200	400	1,160	400
Magnesium	SB	100	100	48,500	100
Manganese	SB	50	50	760	50
Mercury	0.1	0.001	0.1	2.9	0.1
Nickel	13	0.5	13	60.6	13
Potassium	SB	8,500	8,500	12,600	8,500
Selenium	2	0.1	2	1.7	—
Silver	SB	—	390	1.8	—
Sodium	SB	6,000	6,000	2,300	—

Table 2-1 Proposed Cleanup Goals – Screening Process for Soils – Frontier Chemical Site (mg/kg)

Analyte	NYSDEC TAGM 4046[c]	Background	Preliminary Screening Value	Maximum Concentration	Proposed Cleanup Goal
Thallium	SB	—	5.5	7.1	5.5
Vanadium	150	1	150	25.2	—
Zinc	20	9	20	312	20
Total Cyanide by Method ILM04.0					
Cyanide	—	—	1,600	0.72	—

NYSDEC Technical and Administrative Guidance Memorandum 4046, January 1994.

Key:

— = No screening value available/applicable.
EPA = United States Environmental Protection Agency.
mg/kg = Milligrams per kilogram.
NYSDEC = New York State Department of Environmental Conservation.
PCB = Polychlorinated biphenyl.
SB = Site background
SVOCs = Semi-volatile organic compounds.
TAGM = Technical and Administrative Guidance Memorandum.
TBCs = To be considered.
VOCs = Volatile organic compounds.

Table 2-2 Frequency of Detection and Exceedance of Screening Criteria for Subsurface Soil Samples – Frontier Chemical Site (mg/kg)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Cleanup Goal [(1)]
VOCs by Method OLM04.2					
1,1,1-Trichloroethane	10/31	5	0.002	510	0.8
1,1-Dichloroethane	11/31	5	0.002	45	0.2
1,1-Dichloroethene	3/31	1	0.003	0.5	0.4
1,2,4-Trichlorobenzene	12/31	8	0.002	140	3.4
1,2-Dichlorobenzene	17/31	8	0.002	680	7.9
1,3-Dichlorobenzene	15/31	11	0.002	210	1.6
1,4-Dichlorobenzene	15/31	8	0.002	430	8.5
2-Butanone	3/31	1	0.009	0.94	0.3
4-Methyl-2-pentanone	2/31	1	0.62	6.5	1.0
Acetone	8/31	3	0.005	48	0.2
Benzene	6/31	4	0.003	9.8	0.06
Bromodichloromethane	1/31	0	0.036	0.036	—
Bromoform	2/31	0	0.014	0.082	—
Carbon disulfide	3/31	0	0.002	0.007	—
Carbon tetrachloride	1/31	0	0.018	0.018	—
Chlorobenzene	16/31	7	0.002	830	1.7
Chloroethane	1/31	1	5.3	5.3	1.9
Chloroform	10/31	1	0.004	0.96	0.3
cis-1,2-Dichloroethene	14/31	0	0.002	24	—
Dibromochloromethane	2/31	0	0.012	0.023	—
Ethylbenzene	3/31	2	0.21	19	5.5
Isopropylbenzene	5/31	0	0.003	17	—
Methylcyclohexane	6/31	NA	0.001	0.005	—
Methylene chloride	7/31	4	0.003	13	0.1
Tetrachloroethene	19/31	9	0.003	2700	1.4
Toluene	20/31	8	0.001	56	1.5
trans-1,2-Dichloroethene	3/31	0	0.002	0.006	—
Trichloroethene	20/31	10	0.002	150	0.7
Vinyl chloride	5/31	2	0.002	4.9	0.2
Xylenes, Total	16/31	4	0.001	40	1.2
SVOCs by Method OLM04.2					
1,1´-Biphenyl	6/31	0	0.043	0.54	—
2,4,6-Trichlorophenol	2/31	0	0.062	0.13	—
2,4-Dichlorophenol	4/31	0	0.061	0.27	—
2,4-Dimethylphenol	1/31	0	0.085	0.085	—
2-Chlorophenol	1/31	0	0.09	0.09	—

Table 2-2 Frequency of Detection and Exceedance of Screening Criteria for Subsurface Soil Samples – Frontier Chemical Site (mg/kg)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Cleanup Goal (1)
2-Methylnaphthalene	12/31	0	0.052	6.6	—
2-Methylphenol	1/31	0	0.04	0.04	—
4-Chloro-3-methylphenol	7/31	1	0.072	0.4	0.240
4-Chloroaniline	1/31	0	0.07	0.07	—
4-Methylphenol	3/31	0	0.051	0.12	—
4-Nitrophenol	1/31	0	0.076	0.076	—
Acenaphthene	8/31	0	0.041	0.34	—
Acenaphthylene	9/31	0	0.041	2.2	—
Acetophenone	6/31	0	0.12	5.9	—
Anthracene	11/31	0	0.048	1.8	—
Benz(a)anthracene	11/31	4	0.043	1.3	0.224
Benzo(a)pyrene	9/31	9	0.072	2.4	0.061
Benzo(b)fluoranthene	10/31	2	0.066	3.1	0.87
Benzo(g,h,i)perylene	9/31	0	0.036	0.79	—
Benzo(k)fluoranthene	10/31	1	0.057	1.9	1.1
Bis(2-ethylhexyl)phthalate	17/31	0	0.036	1	—
Butyl benzyl phthalate	8/31	0	0.035	1	—
Carbazole	5/31	0	0.043	0.26	—
Chrysene	11/31	4	0.049	3	0.4
Dibenz(a,h)anthracene	6/31	6	0.038	0.39	0.014
Dibenzofuran	10/31	0	0.044	1.6	—
Di-n-butyl phthalate	4/31	0	0.057	0.098	—
Fluoranthene	13/31	0	0.039	4.3	—
Fluorene	8/31	0	0.044	0.65	—
Hexachlorobenzene	7/31	1	0.091	0.42	0.4
Hexachlorobutadiene	6/31	0	0.049	1.7	—
Hexachloroethane	1/31	0	1.4	1.4	—
Indeno(1,2,3-cd)pyrene	10/31	1	0.045	1.1	0.87
Naphthalene	14/31	0	0.053	10	—
N-Nitrosodiphenylamine	1/31	0	0.44	0.44	—
Phenanthrene	13/31	0	0.11	4.3	—
Phenol	13/31	13	0.037	8.7	0.03
Pyrene	12/31	0	0.053	1.9	—
Pesticide/PCB by Method OLM04.2					
4,4´-DDD	5/31	0	0.0025	0.2	—
4,4´-DDE	9/31	0	0.0019	0.12	—
4,4´-DDT	12/31	0	0.00086	0.1	—
Aldrin	11/31	1	0.0012	0.073	0.038

Table 2-2 Frequency of Detection and Exceedance of Screening Criteria for Subsurface Soil Samples – Frontier Chemical Site (mg/kg)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Cleanup Goal [(1)]
alpha-BHC	3/31	0	0.0028	0.012	—
alpha-Chlordane	15/31	0	0.00022	0.120	—
beta-BHC	16/31	0	0.00072	0.08	—
delta-BHC	6/31	0	0.00019	0.05	—
Dieldrin	7/31	1	0.00052	0.23	0.04
Endosulfan I	5/31	0	0.00048	0.12	—
Endosulfan II	5/31	0	0.0014	0.11	—
Endosulfan sulfate	3/31	0	0.0068	0.072	—
Endrin	2/31	1	0.063	0.25	0.10
Endrin aldehyde	7/31	NA	0.00051	0.21	—
Endrin ketone	10/31	NA	0.00051	0.052	—
gamma-BHC	2/31	0	0.00098	0.0015	—
gamma-Chlordane	15/31	0	0.00022	0.26	—
Heptachlor	3/31	0	0.003	0.027	—
Heptachlor epoxide	18/31	3	0.00027	0.22	0.02
Methoxychlor	3/31	0	0.0031	0.053	—
Total 2,3,7,8-TCDD equivalent					
TCDD equivalent	3/3	0	.0000000006	0.0000027	—
Metals by Method ILM04.0					
Aluminum	31/31	0	1430	13900	—
Antimony	30/31	0	0.9	12.5	—
Arsenic	29/31	29	1.8	19.2	0.43
Barium	31/31	0	12.5	205	—
Beryllium	31/31	30	0.14	3.5	0.16
Cadmium	31/31	5	0.071	8.3	—
Calcium	31/31	31	4420	114000	130
Chromium	31/31	22	5.9	562	10
Cobalt	31/31	0	3.1	24.6	—
Copper	31/31	8	9	232	25
Iron	31/31	31	6250	33600	2,000
Lead	31/31	2	10.4	1160	400
Magnesium	31/31	31	1930	48500	100
Manganese	31/31	31	114	760	50
Mercury	14/31	11	0.062	2.9	0.1
Nickel	31/31	18	5.4	60.6	13
Potassium	31/31	1	651	12600	8,500
Selenium	5/31	0	1	1.7	—
Silver	26/31	0	0.14	1.8	—

Table 2-2 Frequency of Detection and Exceedance of Screening Criteria for Subsurface Soil Samples – Frontier Chemical Site (mg/kg)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Cleanup Goal [(1)]
Sodium	31/31	0	126	2300	—
Thallium	11/31	1	1.2	7.1	5.5
Vanadium	31/31	0	5.6	25.2	—
Zinc	31/31	31	23.1	312	20
Total Cyanide by ILM04.0					
Cyanide	26/30	0	0.059	0.72	—

[1] Cleanup Goal selected in Table 2-1 of this document.

Key:

— = No screening value available/applicable.
mg/kg = Milligrams per kilogram.
NA = Not applicable (no criteria available).
PCB = Polychlorinated biphenyl.
SVOCs = Semi-volatile organic compounds.
VOCs = Volatile organic compounds.

Table 2-3 Contaminants of Concern for Soils – Frontier Chemical Site (mg/kg)

Analyte	Cleanup Criteria [1]
Total VOCs[2]	<10
1,1,1-Trichloroethane	0.8
1,1-Dichloroethane	0.2
1,2,4-Trichlorobenzene	3.4
1,2-Dichlorobenzene	7.9
1,3-Dichlorobenzene	1.6
1,4-Dichlorobenzene	8.5
Acetone	0.2
Benzene	0.06
Chlorobenzene	1.7
Ethylbenzene	5.5
Methylene chloride	0.1
Tetrachloroethene	1.4
Toluene	1.5
Trichloroethene	0.7
Vinyl chloride	0.2
Xylenes, Total	1.2
Total SVOCs[2]	<500
Benz(a)anthracene	0.224
Benzo(a)pyrene	0.061
Chrysene	0.4
Dibenz(a,h)anthracene	0.014
Phenol	0.03
Arsenic	0.43
Beryllium	0.16
Chromium	10
Copper	25
Iron	2,000
Lead	400
Mercury	0.1
Nickel	13
Zinc	20

[1] Based on Cleanup Goal in Table 2-1 of this document.
[2] Maximum values allowed for soil cleanup objectives for total analytes as listed, per NYSDEC Technical and Administrative Guidance Memorandum 4046

Key:
mg/Kg = Milligrams per kilogram.

Table 2-4 Proposed Cleanup Goal Screening Process for Groundwater – Frontier Chemical Site (µg/L)

Analyte	NYSDEC Class GA Groundwater Standard	NYSDEC Class GA Groundwater Guidance	Maximum Concentration	Proposed Cleanup Goal
VOCs by Method OLM04.2				
1,1,1-Trichloroethane	5	—	18,000	5
1,1,2,2-tetrachloroethane	5	—	8 J	5
1,1,2-Trichloro-1,2,2-trifluoroethane	5	—	3,500	5
1,1,2-Trichloroethane	1	—	7 J	1
1,1-Dichloroethane	5	—	7,000	5
1,1-Dichloroethene	5	—	1,300 J	5
1,2,4-Trichlorobenzene	5	10	7,600	5
1,2-Dichlorobenzene	3	—	69,000	3
1,2-Dichloroethane	0.6	—	460 J	0.6
1,3-Dichlorobenzene	5	10	41,000	5
1,4-Dichlorobenzene	5	10	43,000	5
2-Butanone	—	50	960	50
2-Hexanone	—	50	4 J	—
4-Methyl-2-pentanone	—	—	2,700	—
Acetone	—	50	8,700	50
Benzene	1	—	30,000	1
Carbon disulfide	—	60	41 J	—
Chlorobenzene	5	—	36,000	5
Chloroethane	5	—	7 J	5
Chloroform	7	—	430 J	7
cis-1,2-Dichloroethene	5	—	270,000	5
Cyclohexane	—	—	3 J	—
Ethylbenzene	5	—	210 J	5
Isopropylbenzene	5	—	400 J	5
Methylene Chloride	5	—	19,000	5
Styrene	5	—	4 J	—
Tetrachloroethene	5	—	74,000	5
Toluene	5	—	4,100	5
trans-1,2-Dichloroethene	5	—	410 J	5
Trichloroethene	5	—	250,000	5
Vinyl Chloride	2	—	26,000	2
Xylene (total)	5	—	720	5

Table 2-4 Proposed Cleanup Goal Screening Process for Groundwater – Frontier Chemical Site (μg/L)

Analyte	NYSDEC Class GA Groundwater Standard	NYSDEC Class GA Groundwater Guidance	Maximum Concentration	Proposed Cleanup Goal
SVOCs by Method OLM04.2				
2,4,5-Trichlorophenol	1[a]	—	95 J	1
2,4,6-Trichlorophenol	1[a]	—	170 J	1
2,4-Dichlorophenol	1[a]	—	85	1
2,4-Dimethylphenol	1[a]	—	10	1
2-Chlorophenol	1[a]	—	110 J	1
2-Methylnaphthalene	—	—	1 J	—
2-Methylphenol	1[a]	—	24 J	1
4-Chloro-3-methylphenol	1[a]	—	120 J	1
4-Chloroaniline	5	—	130 J	5
4-Methylphenol	1[a]	—	310	1
4-Nitrophenol	1[a]	—	30	1
Acetophenone	—	—	1,000	—
Benzaldehyde	—	—	1 J	—
Bis(2-chloroethyl)ether	1	—	23	1
Bis(2-ethylhexyl)phthalate	5	—	100	5
Caprolactam	—	—	17	—
Carbazole	—	—	1 J	—
Dibenzofuran	—	—	1 J	—
Di-n-octyl phthalate	—	—	6 J	—
Fluorene	—	50	1 J	—
Hexachlorobutadiene	0.5	—	1 J	0.5
Isophorone	—	50	14 J	—
Naphthalene	—	10	31	10
Pentachlorophenol	1[a]	—	5 J	1
Phenanthrene	—	50	2 J	—
Phenol	1[a]	—	11,000	1
Pesticide/PCBs by Method OLM04.2				
Aroclor 1254	0.09[b]	—	1.3	0.09
4,4'-DDD	0.3	—	0.29 J	—
4,4'-DDE	0.2	—	0.09 J	—
4,4'-DDT	0.2	—	0.24 J	0.2
Aldrin	ND	—	0.053 J	ND
alpha-BHC	—	—	0.054 J	—
alpha-Chlordane	0.05	—	0.17 J	0.05
beta-BHC	—	—	0.091 J	—
delta-BHC	—	—	0.05 J	—
Dieldrin	0.004	—	0.044 J	0.004
Endosulfan I	—	—	0.18 J	—

Table 2-4 Proposed Cleanup Goal Screening Process for Groundwater – Frontier Chemical Site (µg/L)

Analyte	NYSDEC Class GA Groundwater Standard	NYSDEC Class GA Groundwater Guidance	Maximum Concentration	Proposed Cleanup Goal
Endosulfan II	—	—	0.060 J	—
Endosulfan sulfate	—	—	0.058 J	—
Endrin	ND	—	0.086 J	ND
Endrin aldehyde	5	—	0.05 J	—
Endrin ketone	5	—	0.067 J	—
gamma-BHC	—	—	0.029 J	—
gamma-Chlordane	0.05	—	0.046 J	—
Heptachlor	0.04	—	0.039 J	—
Heptachlor epoxide	0.03	—	0.061	0.03
Metals by Method ILM04.0				
Aluminum	—	—	12,800	—
Antimony	3	—	19.9 J	3
Arsenic	25	—	1,040	25
Barium	1,000	—	204	—
Beryllium	—	3	95.5 J	3
Cadmium	5	—	2.4 J	—
Calcium	—	—	618,000 J	—
Chromium	50	—	354	50
Cobalt	—	—	24.3 J	—
Copper	200	—	602	200
Iron	300[c]	—	40,400	300
Lead	25	—	655	25
Magnesium	—	35,000	109,000	35,000
Manganese	300[c]	—	947	300
Mercury	0.7	—	1.0	0.7
Nickel	100	—	143 J	100
Potassium	—	—	12,600,000	—
Selenium	10	—	44.5	10
Silver	50	—	6.7 J	—
Sodium	20,000	—	1,460,000	20,000
Thallium	—	0.5	8.2 J	0.5
Vanadium	—	—	205	—
Zinc	—	2,000	1,930	—

Table 2-4 Proposed Cleanup Goal Screening Process for Groundwater – Frontier Chemical Site (µg/L)

Analyte	NYSDEC Class GA Groundwater Standard	NYSDEC Class GA Groundwater Guidance	Maximum Concentration	Proposed Cleanup Goal
Total Cyanide by Method ILM04.0				
Cyanide	200	—	1,230 J	200
Total Hardness by Method EPA 130.2				
Total Hardness	—	—	1.82	—

Source: NYSDEC, June 1998, Ambient Water Quality Standard and Guidance Values, Class GA Groundwater.

[a] Applies to the sum of a phenolic compounds.
[b] Applies to the sum of all PCBs.
[c] Iron and manganese total is 500 µg/L.

Key:

— = No standard/guidance value available/applicable.
J = Estimated value.
µg/L = Micrograms per liter.
NYSDEC = New York State Department of Environmental Conservation.
PCB = Polychlorinated biphenyl.
SVOCs = Semi-volatile organic compounds.
VOCs = Volatile organic compounds.

Table 2-5 Frequency of Detection and Exceedance of Screening Criteria for Overburden Groundwater Samples - Frontier Chemical Site (µg/L)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Screening Criteria (1)
VOCs by Method OLM04.2					
1,1,1-Trichloroethane	12/29	11	4	8,500	5
1,1,2,2-Tetrachloroethane	1/29	1	8	8	5
1,1,2-Trichloro-1,2,2-trifluoroethane	4/29	4	65	3,400	5
1,1,2-Trichloroethane	1/29	0	1	1	—
1,1-Dichloroethane	16/29	14	2	7,000	5
1,1-Dichloroethene	9/29	8	3	550	5
1,2,4-Trichlorobenzene	7/29	7	9	7,600	5
1,2-Dichlorobenzene	16/29	14	2	69,000	3
1,2-Dichloroethane	5/29	5	1	460	0.6
1,3-Dichlorobenzene	13/29	12	2	41,000	5
1,4-Dichlorobenzene	14/29	13	2	43,000	5
2-Butanone	3/29	2	45	960	50
2-Hexanone	0/29	0	ND	ND	—
4-Methyl-2-pentanone	3/29	0	16	650	—
Acetone	12/29	9	6	5,500	50
Benzene	9/29	9	2	30,000	1
Carbon disulfide	0/29	0	ND	ND	—
Chlorobenzene	16/29	13	1	36,000	5
Chloroethane	1/29	1	6	6	5
Chloroform	7/29	5	4	230	7
cis-1,2-Dichloroethene	22/29	19	1	120,000	5
Cyclohexane	0/29	0	ND	ND	—
Ethylbenzene	4/29	1	1	210	5
Isopropylbenzene	1/29	1	400	400	5
Methylene chloride	6/29	6	220	19,000	5
Styrene	0/29	0	ND	ND	—
Tetrachloroethene	18/29	17	3	74,000	5
Toluene	14/29	10	2	6,700	5
trans-1,2-Dichloroethene	5/29	2	3	16	5
Trichloroethene	21/29	19	2	250,000	5
Vinyl chloride	12/29	12	22	6,300	2
Xylenes, Total	7/29	6	4	720	5

Table 2-5 Frequency of Detection and Exceedance of Screening Criteria for Overburden Groundwater Samples - Frontier Chemical Site (µg/L)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Screening Criteria (1)
SVOCs by Method OLM04.2					
2,4,5-Trichlorophenol	2/12	2	3	8	1
2,4,6-Trichlorophenol	5/12	3	1	67	1
2,4-Dichlorophenol	5/12	5	3	42	1
2,4-Dimethylphenol	2/12	2	8	10	1
2-Chlorophenol	5/12	5	4	43	1
2-Methylnaphthalene	0/12	0	ND	ND	—
2-Methylphenol	5/12	5	1	18	1
4-Chloro-3-methylphenol	4/12	4	3	120	1
4-Chloroaniline	3/12	2	1	130	5
4-Methylphenol	6/12	6	2	100	1
4-Nitrophenol	1/12	1	30	30	1
Acetophenone	7/12	0	4	140	—
Benzaldehyde	0/12	0	ND	ND	—
Bis(2-chloroethyl)ether	0/12	0	ND	ND	—
Bis(2-ethylhexyl)phthalate	1/12	0	2	2	—
Caprolactum	0/12	0	ND	ND	—
Carbazole	0/12	0	ND	ND	—
Dibenzofuran	1/12	0	1	1	—
Di-n-octyl phthalate	0/12	0	ND	ND	—
Fluorene	1/12	0	1	1	—
Hexachlorobutadiene	0/12	0	ND	ND	—
Isophorone	0/12	0	ND	ND	—
Naphthalene	2/12	1	6	31	10
Pentachlorophenol	1/12	0	1	1	—
Phenanthrene	0/12	0	ND	ND	—
Phenol	7/12	7	6	4,600	1
Pesticide/PCB by Method OLM04.2					
Aroclor 1254	0/12	0	ND	ND	—
4,4´-DDD	3/12	0	0.01	0.021	—
4,4´-DDE	3/12	0	0.025	0.056	—
4,4´-DDT	3/12	0	0.011	0.11	—
Aldrin	1/12	1	0.029	0.029	ND
alpha-BHC	4/12	0	0.0098	0.054	—
alpha-Chlordane	3/12	2	0.037	0.17	0.05
beta-BHC	6/12	0	0.0096	0.091	—
delta-BHC	2/12	0	0.0013	0.017	—

Table 2-5 Frequency of Detection and Exceedance of Screening Criteria for Overburden Groundwater Samples - Frontier Chemical Site (µg/L)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Screening Criteria (1)
Dieldrin	3/12	2	0.0022	0.023	0.004
Endosulfan I	5/12	0	0.012	0.18	—
Endosulfan II	3/12	0	0.012	0.022	—
Endosulfan sulfate	2/12	0	0.023	0.033	—
Endrin	2/12	2	0.019	0.022	ND
Endrin aldehyde	3/12	0	0.011	0.014	—
Endrin ketone	0/12	0	ND	ND	—
gamma-BHC	0/12	0	ND	ND	—
gamma-Chlordane	0/12	0	ND	ND	—
Heptachlor	1/12	0	0.021	0.021	—
Heptachlor epoxide	3/12	0	0.0021	0.015	—
Metals by Method ILM04.0					
Aluminum	12/12	0	312	12,800	—
Antimony	5/12	5	3.1	19.9	3
Arsenic	11/12	5	6.1	193	25
Barium	12/12	0	7.8	178	—
Beryllium	5/12	1	0.19	13.7	3
Cadmium	8/12	0	0.39	1.6	—
Calcium	12/12	0	12,200	215,000	—
Chromium	12/12	1	1.5	354	50
Cobalt	12/12	0	1.2	17.1	—
Copper	10/12	1	2.7	602	200
Iron	12/12	12	697	26,800	300
Lead	10/12	3	7.4	35.5	25
Magnesium	12/12	0	554	34,500	—
Manganese	12/12	3	19.2	889	300
Mercury	7/12	0	0.12	0.62	—
Nickel	12/12	3	3.5	143	100
Potassium	12/12	0	138,000	1,640,000	—
Selenium	8/12	4	5.2	17.6	10
Silver	5/12	0	1.1	2.7	—
Sodium	12/12	10	6,150	819,000	20,000
Thallium	3/12	3	2.5	6.2	0.5
Vanadium	12/12	0	1.6	422	—
Zinc	12/12	0	13.4	187	—

Table 2-5 Frequency of Detection and Exceedance of Screening Criteria for Overburden Groundwater Samples - Frontier Chemical Site (µg/L)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Screening Criteria (1)
Total Cyanide by ILM04.0					
Cyanide	11/12	3	1	522	200
Total Hardness by Method EPA 130.2					
Hardness (As $CaCO_3$)	12/12	0	0.0463	0.708	—

[1] New York State Department of Environmental Conservation, Technical and Operational Guidance Series 1.1.1: Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations, June 1998 with April 2000 addendum.

Key:

— = Analyte less than cleanup goal or no cleanup goal applicable/available.
µg/L = Micrograms per liter.
ND = Not detected.
PCB = Polychlorinated biphenyl.
VOCs = Volatile organic compounds.
SVOCs = Semi-volatile organic compounds.

Table 2-6 Frequency of Detection and Exceedance of Screening Criteria for A-Fracture Zone Bedrock Groundwater Samples - Frontier Chemical Site (µg/L)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Screening Criteria (1)
VOCs by Method OLM04.2					
1,1,1-Trichloroethane	7/23	7	47	18,000	5
1,1,2,2-Tetrachloroethane	0/23	0	ND	ND	—
1,1,2-Trichloro-1,2,2-trifluoroethane	2/23	2	230	3,500	5
1,1,2-Trichloroethane	1/23	1	7	7	1
1,1-Dichloroethane	16/23	12	1	4,300	5
1,1-Dichloroethene	5/23	4	5	1,300	5
1,2,4-Trichlorobenzene	9/23	7	1	4,200	5
1,2-Dichlorobenzene	16/23	15	1	61,000	3
1,2-Dichloroethane	2/23	2	20	140	0.6
1,3-Dichlorobenzene	15/23	13	1	19,000	5
1,4-Dichlorobenzene	15/23	13	2	26,000	5
2-Butanone	3/23	3	53	610	50
2-Hexanone	0/23	0	ND	ND	—
4-Methyl-2-pentanone	8/23	0	73	2,700	—
Acetone	11/23	9	13	3,500	50
Benzene	15/23	15	4	15,000	1
Carbon disulfide	1/23	0	10	10	—
Chlorobenzene	19/23	16	1	21,000	5
Chloroethane	0/23	0	ND	ND	—
Chloroform	5/23	2	2	430	7
cis-1,2-Dichloroethene	18/23	16	2	270,000	5
Cyclohexane	1/23	0	13	13	—
Ethylbenzene	2/23	1	3	26	5
Isopropylbenzene	2/23	1	5	180	5
Methylene chloride	7/23	7	130	13,000	5
Styrene	1/23	0	4	4	—
Tetrachloroethene	12/23	10	2	47,000	5
Toluene	15/23	12	1	3900	5
trans-1,2-Dichloroethene	7/23	5	2	410	5
Trichloroethene	21/23	17	2	22,000	5
Vinyl chloride	8/23	8	3	26,000	2
Xylenes, Total	5/23	4	1	240	5

Table 2-6 Frequency of Detection and Exceedance of Screening Criteria for A-Fracture Zone Bedrock Groundwater Samples - Frontier Chemical Site (µg/L)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Screening Criteria (1)
SVOCs by Method OLM04.2					
2,4,5-Trichlorophenol	1/18	1	13	13	1
2,4,6-Trichlorophenol	6/18	5	1	64	1
2,4-Dichlorophenol	6/18	6	7	85	1
2,4-Dimethylphenol	5/18	5	3	10	1
2-Chlorophenol	6/18	6	3	45	1
2-Methylnaphthalene	1/18	0	1	1	—
2-Methylphenol	8/18	8	1	24	1
4-Chloro-3-methylphenol	7/18	7	3	65	1
4-Chloroaniline	2/18	1	2	63	5
4-Methylphenol	12/18	12	11	310	1
4-Nitrophenol	0/18	0	ND	ND	—
Acetophenone	9/18	0	11	1,000	—
Benzaldehyde	1/18	0	1	1	—
Bis(2-chloroethyl)ether	1/18	1	23	23	1
Bis(2-ethylhexyl)phthalate	1/18	1	100	100	5
Caprolactum	2/18	0	3	5	—
Carbazole	1/18	0	1	1	—
Dibenzofuran	0/18	0	ND	ND	—
Di-n-octyl phthalate	0/18	0	ND	ND	—
Fluorene	0/18	0	ND	ND	—
Hexachlorobutadiene	1/18	1	1	1	0.5
Isophorone	4/18	0	7	14	—
Naphthalene	2/18	2	20	21	10
Pentachlorophenol	0/18	0	ND	ND	—
Phenanthrene	1/18	0	2	2	—
Phenol	14/18	13	1	4,400	1
Pesticide/PCB by Method OLM04.2					
Aroclor 1254	2/17	2	0.28	1.3	0.09
4,4´-DDD	3/17	0	0.04	0.29	—
4,4´-DDE	3/17	0	0.016	0.09	—
4,4´-DDT	6/17	1	0.0075	0.24	0.2
Aldrin	4/17	4	0.015	0.053	ND
alpha-BHC	3/17	0	0.017	0.02	—
alpha-Chlordane	3/17	2	0.011	0.14	0.05

Table 2-6 Frequency of Detection and Exceedance of Screening Criteria for A-Fracture Zone Bedrock Groundwater Samples - Frontier Chemical Site (µg/L)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Screening Criteria (1)
beta-BHC	8/17	0	0.0074	0.14	—
delta-BHC	2/17	0	0.013	0.025	—
Dieldrin	7/17	7	0.0052	0.044	0.004
Endosulfan I	2/17	0	0.0047	0.01	—
Endosulfan II	1/17	0	0.026	0.026	—
Endosulfan sulfate	3/17	0	0.037	0.058	—
Endrin	7/17	7	0.0097	0.086	ND
Endrin aldehyde	1/17	0	0.05	0.05	—
Endrin ketone	1/17	0	0.025	0.025	—
gamma-BHC	3/17	0	0.01	0.029	—
gamma-Chlordane	3/17	0	0.01	0.046	—
Heptachlor	2/17	0	0.014	0.039	—
Heptachlor epoxide	2/17	1	0.02	0.061	0.03
Metals by Method ILM04.0					
Aluminum	15/17	0	16.2	2,640	—
Antimony	6/17	6	4.1	9.9	3
Arsenic	16/17	9	6.3	1,040	25
Barium	17/17	0	3.8	204	—
Beryllium	8/17	2	0.16	95.5	3
Cadmium	11/17	0	0.25	2.4	—
Calcium	17/17	0	3,940	425,000	—
Chromium	16/17	1	1.7	343	50
Cobalt	14/17	0	1.3	9.7	—
Copper	11/17	0	3.8	134	—
Iron	17/17	17	1,370	39,500	300
Lead	14/17	5	2.3	157	25
Magnesium	17/17	1	85.2	52,000	35,000
Manganese	17/17	2	20.3	947	300
Mercury	6/17	0	0.11	0.37	—
Nickel	17/17	0	2.7	73.3	—
Potassium	17/17	0	54,000	12,600,000	—
Selenium	11/17	3	3.3	44.5	10
Silver	9/17	0	0.7	6	—
Sodium	17/17	16	14,800	1,460,000	20,000
Thallium	4/17	4	4.1	9.8	0.5
Vanadium	17/17	0	1.8	579	—
Zinc	16/17	0	10.4	231	—

Table 2-6 Frequency of Detection and Exceedance of Screening Criteria for A-Fracture Zone Bedrock Groundwater Samples - Frontier Chemical Site (µg/L)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Screening Criteria [1]
Total Cyanide by ILM04.0					
Cyanide	16/17	3	2.5	936	200
Total Hardness by Method EPA 130.2					
Hardness (As $CaCO_3$)	17/17	0	0.054	1.360	—

[1] New York State Department of Environmental Conservation, Technical and Operational Guidance Series 1.1.1: Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations, June 1998 with April 2000 addendum.

Key:

— = Analyte less than cleanup goal or no cleanup goal applicable/available.
µg/L = Micrograms per liter.
ND = Not detected.
PCB = Polychlorinated biphenyl.
VOCs = Volatile organic compounds.
SVOCs = Semi-volatile organic compounds.

Table 2-7 Frequency of Detection and Exceedance of Screening Criteria for B-Fracture Zone Bedrock Groundwater Samples - Frontier Chemical Site (µg/L)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Screening Criteria (1)
VOCs by Method OLM04.2					
1,1,1-Trichloroethane	8/18	7	4	10,000	5
1,1,2,2-Tetrachloroethane	0/18	0	ND	ND	—
1,1,2-Trichloro-1,2,2-trifluoroethane	2/18	2	220	240	5
1,1,2-Trichloroethane	0/18	0	ND	ND	—
1,1-Dichloroethane	13/18	10	1	2,800	5
1,1-Dichloroethene	2/18	1	2	28	5
1,2,4-Trichlorobenzene	7/18	6	1	1,100	5
1,2-Dichlorobenzene	12/18	12	4	12,000	3
1,2-Dichloroethane	0/18	0	ND	ND	—
1,3-Dichlorobenzene	12/18	11	4	8,400	5
1,4-Dichlorobenzene	12/18	12	7	9,600	5
2-Butanone	1/18	1	750	750	50
2-Hexanone	1/18	0	4	4	—
4-Methyl-2-pentanone	6/18	0	21	590	—
Acetone	7/18	6	3	8,700	50
Benzene	12/18	12	5	5,100	1
Carbon disulfide	1/18	0	41	41	—
Chlorobenzene	15/18	13	1	13,000	5
Chloroethane	1/18	1	7	7	5
Chloroform	1/18	1	55	55	7
cis-1,2-Dichloroethene	15/18	13	1	1,600	5
Cyclohexane	1/18	0	3	3	—
Ethylbenzene	2/18	2	61	68	5
Isopropylbenzene	0/18	0	ND	ND	—
Methylene chloride	6/18	6	11	8,600	5
Styrene	0/18	0	ND	ND	—
Tetrachloroethene	10/18	10	12	6,000	5
Toluene	11/18	8	2	2,500	5
trans-1,2-Dichloroethene	7/18	3	2	10	5
Trichloroethene	11/18	10	3	10,000	5
Vinyl chloride	8/18	8	28	400	2
Xylenes, Total	4/18	2	2	360	5

Table 2-7 Frequency of Detection and Exceedance of Screening Criteria for B-Fracture Zone Bedrock Groundwater Samples - Frontier Chemical Site (µg/L)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Screening Criteria (1)
SVOCs by Method OLM04.2					
2,4,5-Trichlorophenol	1/14	1	95	95	1
2,4,6-Trichlorophenol	6/14	4	1	170	1
2,4-Dichlorophenol	5/14	5	2	72	1
2,4-Dimethylphenol	0/14	0	ND	ND	—
2-Chlorophenol	5/14	5	4	110	1
2-Methylnaphthalene	0/14	0	ND	ND	—
2-Methylphenol	4/14	4	2	22	1
4-Chloro-3-methylphenol	7/14	7	2	12	1
4-Chloroaniline	0/14	0	ND	ND	—
4-Methylphenol	8/14	8	2	200	1
4-Nitrophenol	1/14	1	2	2	1
Acetophenone	8/14	0	2	220	—
Benzaldehyde	0/14	0	ND	ND	—
Bis(2-chloroethyl)ether	0/14	0	ND	ND	—
Bis(2-ethylhexyl)phthalate	1/14	0	2	2	—
Caprolactum	0/14	0	ND	ND	—
Carbazole	0/14	0	ND	ND	—
Dibenzofuran	0/14	0	ND	ND	—
Di-n-octyl phthalate	0/14	0	ND	ND	—
Fluorene	0/14	0	ND	ND	—
Hexachlorobutadiene	0/14	0	ND	ND	—
Isophorone	0/14	0	ND	ND	—
Naphthalene	0/14	0	ND	ND	—
Pentachlorophenol	1/14	1	5	5	1
Phenanthrene	0/14	0	ND	ND	—
Phenol	8/14	8	7	11,000	1
Pesticide/PCB by Method OLM04.2					
Aroclor 1254	1/14	1	0.18	0.18	0.09
4,4´-DDD	1/14	0	0.043	0.043	—
4,4´-DDE	1/14	0	0.037	0.037	—
4,4´-DDT	1/14	0	0.095	0.095	—
Aldrin	2/14	2	0.0059	0.032	ND
alpha-BHC	0/14	0	ND	ND	—
alpha-Chlordane	2/14	2	0.06	0.085	0.05

Table 2-7 Frequency of Detection and Exceedance of Screening Criteria for B-Fracture Zone Bedrock Groundwater Samples - Frontier Chemical Site (µg/L)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Screening Criteria (1)
beta-BHC	4/14	0	0.015	0.035	—
delta-BHC	0/14	0	ND	ND	—
Dieldrin	1/14	1	0.038	0.038	0.004
Endosulfan I	1/14	0	0.031	0.031	—
Endosulfan II	2/14	0	0.01	0.06	—
Endosulfan sulfate	2/14	0	0.033	0.041	—
Endrin	3/14	3	0.01	0.035	ND
Endrin aldehyde	0/14	0	ND	ND	—
Endrin ketone	1/14	0	0.067	0.067	—
gamma-BHC	0/14	0	ND	ND	—
gamma-Chlordane	0/14	0	ND	ND	—
Heptachlor	0/14	0	ND	ND	—
Heptachlor epoxide	1/14	1	0.23	0.23	0.03
Metals by Method ILM04.0					
Aluminum	12/14	0	78.2	1,230	—
Antimony	2/14	2	7.2	9.4	3
Arsenic	13/14	7	4.1	339	25
Barium	14/14	0	3.4	125	—
Beryllium	4/14	2	2.3	16.3	3
Cadmium	9/14	0	0.4	2.6	—
Calcium	14/14	0	3,670	618,000	—
Chromium	12/14	0	0.71	20.8	—
Cobalt	12/14	0	1.4	24.3	—
Copper	10/14	1	3.6	201	200
Iron	14/14	14	472	18,100	300
Lead	10/14	7	3.3	655	25
Magnesium	14/14	3	103	109,000	35,000
Manganese	14/14	1	11.7	479	300
Mercury	4/14	1	0.12	1	0.7
Nickel	13/14	0	2.2	69.1	—
Potassium	14/14	0	18,800	10,400,000	—
Selenium	9/14	2	2.2	16.7	10
Silver	9/14	0	0.68	6.7	—
Sodium	14/14	14	37,600	1,430,000	20,000
Thallium	4/14	4	2.7	8.2	0.5
Vanadium	14/14	0	0.68	165	—
Zinc	12/14	0	15.7	1,930	—

Table 2-7 Frequency of Detection and Exceedance of Screening Criteria for B-Fracture Zone Bedrock Groundwater Samples - Frontier Chemical Site (µg/L)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Screening Criteria (1)
Total Cyanide by ILM04.0					
Cyanide	11/14	3	2	1,230	200
Total Hardness by Method EPA 130.2					
Hardness (As $CaCO_3$)	14/14	0	0.0154	1.820	—

[1] New York State Department of Environmental Conservation, Technical and Operational Guidance Series 1.1.1: Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations, June 1998 with April 2000 addendum.

Key:

— = Analyte less than cleanup goal or no cleanup goal applicable/available.
µg/L = Micrograms per liter.
ND = Not detected.
PCB = Polychlorinated biphenyl.
VOCs = Volatile organic compounds.
SVOCs = Semi-volatile organic compounds.

Table 2-8 Frequency of Detection and Exceedance of Screening Criteria for C-Fracture Zone Bedrock Groundwater Samples - Frontier Chemical Site (µg/L)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Screening Criteria [(1)]
VOCs by Method OLM04.2					
1,1,1-Trichloroethane	1/2	1	910	910	5
1,1,2,2-Tetrachloroethane	0/2	0	ND	ND	—
1,1,2-Trichloro-1,2,2-trifluoroethane	0/2	0	ND	ND	—
1,1,2-Trichloroethane	0/2	0	ND	ND	—
1,1-Dichloroethane	1/2	1	77	77	5
1,1-Dichloroethene	0/2	0	ND	ND	—
1,2,4-Trichlorobenzene	1/2	1	57	57	5
1,2-Dichlorobenzene	1/2	1	210	210	3
1,2-Dichloroethane	0/2	0	ND	ND	—
1,3-Dichlorobenzene	1/2	1	210	210	5
1,4-Dichlorobenzene	1/2	1	210	210	5
2-Butanone	0/2	0	ND	ND	—
2-Hexanone	0/2	0	ND	ND	—
4-Methyl-2-pentanone	0/2	0	ND	ND	—
Acetone	0/2	0	ND	ND	—
Benzene	2/2	2	4	440	1
Carbon disulfide	0/2	0	ND	ND	—
Chlorobenzene	1/2	1	680	680	5
Chloroethane	0/2	0	ND	ND	—
Chloroform	0/2	0	ND	ND	—
cis-1,2-Dichloroethene	1/2	1	11	11	5
Cyclohexane	0/2	0	ND	ND	—
Ethylbenzene	0/2	0	ND	ND	—
Isopropylbenzene	0/2	0	ND	ND	—
Methylene chloride	1/2	1	100	100	5
Styrene	0/2	0	ND	ND	—
Tetrachloroethene	1/2	1	95	95	5
Toluene	1/2	1	170	170	5
trans-1,2-Dichloroethene	0/2	0	ND	ND	—
Trichloroethene	1/2	1	420	420	5
Vinyl chloride	0/2	0	ND	ND	—
Xylenes, Total	0/2	0	ND	ND	—

Table 2-8 Frequency of Detection and Exceedance of Screening Criteria for C-Fracture Zone Bedrock Groundwater Samples - Frontier Chemical Site (µg/L)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Screening Criteria (1)
SVOCs by Method OLM04.2					
2,4,5-Trichlorophenol	0/1	0	ND	ND	—
2,4,6-Trichlorophenol	0/1	0	ND	ND	—
2,4-Dichlorophenol	0/1	0	ND	ND	—
2,4-Dimethylphenol	0/1	0	ND	ND	—
2-Chlorophenol	0/1	0	ND	ND	—
2-Methylnaphthalene	0/1	0	ND	ND	—
2-Methylphenol	0/1	0	ND	ND	—
4-Chloro-3-methylphenol	0/1	0	ND	ND	—
4-Chloroaniline	1/1	0	3	3	—
4-Methylphenol	0/1	0	ND	ND	—
4-Nitrophenol	0/1	0	ND	ND	—
Acetophenone	1/1	0	13	13	—
Benzaldehyde	0/1	0	ND	ND	—
Bis(2-chloroethyl)ether	0/1	0	ND	ND	—
Bis(2-ethylhexyl)phthalate	1/1	1	79	79	5
Caprolactum	1/1	0	17	17	—
Carbazole	0/1	0	ND	ND	—
Dibenzofuran	0/1	0	ND	ND	—
Di-n-octyl phthalate	0/1	0	ND	ND	—
Fluorene	1/1	0	6	6	—
Hexachlorobutadiene	0/1	0	ND	ND	—
Isophorone	0/1	0	ND	ND	—
Naphthalene	0/1	0	ND	ND	—
Pentachlorophenol	0/1	0	ND	ND	—
Phenanthrene	0/1	0	ND	ND	—
Phenol	1/1	1	31	31	1
Pesticide/PCB by Method OLM04.2					
Aroclor 1254	0/1	0	ND	ND	—
4,4´-DDD	0/1	0	ND	ND	—
4,4´-DDE	1/1	0	0.0094	0.0094	—
4,4´-DDT	0/1	0	ND	ND	—
Aldrin	0/1	0	ND	ND	—
alpha-BHC	0/1	0	ND	ND	—
alpha-Chlordane	0/1	0	ND	ND	—

Table 2-8 Frequency of Detection and Exceedance of Screening Criteria for C-Fracture Zone Bedrock Groundwater Samples - Frontier Chemical Site (µg/L)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Screening Criteria (1)
beta-BHC	1/1	0	0.0078	0.0078	—
delta-BHC	0/1	0	ND	ND	—
Dieldrin	1/1	1	0.013	0.013	0.004
Endosulfan I	0/1	0	ND	ND	—
Endosulfan II	0/1	0	ND	ND	—
Endosulfan sulfate	1/1	0	0.013	0.013	—
Endrin	0/1	0	ND	ND	—
Endrin aldehyde	0/1	0	ND	ND	—
Endrin ketone	0/1	0	ND	ND	—
gamma-BHC	0/1	0	ND	ND	—
gamma-Chlordane	0/1	0	ND	ND	—
Heptachlor	0/1	0	ND	ND	—
Heptachlor epoxide	0/1	0	ND	ND	—
Metals by Method ILM04.0					
Aluminum	0/1	0	ND	ND	—
Antimony	0/1	0	ND	ND	—
Arsenic	0/1	0	ND	ND	—
Barium	1/1	0	3.4	3.4	—
Beryllium	0/1	0	ND	ND	—
Cadmium	1/1	0	0.56	0.56	—
Calcium	1/1	0	61,100	61,100	—
Chromium	1/1	0	3.9	3.9	—
Cobalt	0/1	0	ND	ND	—
Copper	1/1	0	6.5	6.5	—
Iron	1/1	1	40,400	40,400	300
Lead	1/1	0	14.6	14.6	—
Magnesium	1/1	0	14,100	14,100	—
Manganese	1/1	0	250	250	—
Mercury	0/1	0	ND	ND	—
Nickel	1/1	0	35.7	35.7	—
Potassium	1/1	0	75,300	75,300	—
Selenium	0/1	0	ND	ND	—
Silver	1/1	0	1.5	1.5	—
Sodium	1/1	1	92,700	92,700	20,000
Thallium	0/1	0	ND	ND	—
Vanadium	1/1	0	11.6	11.6	—
Zinc	1/1	0	18.4	18.4	—

Table 2-8 Frequency of Detection and Exceedance of Screening Criteria for C-Fracture Zone Bedrock Groundwater Samples - Frontier Chemical Site (µg/L)

Analyte	Frequency of Detection	Frequency of Detection Above Screening Criteria	Minimum	Maximum	Screening Criteria (1)
Total Cyanide by ILM04.0					
Cyanide	1/1	0	1.2	1.2	—
Total Hardness by Method EPA 130.2					
Hardness (As $CaCO_3$)	1/1	NA	0.174	0.174	—

[1] New York State Department of Environmental Conservation, Technical and Operational Guidance Series 1.1.1: Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations, June 1998 with April 2000 addendum.

Key:

— = Analyte less than cleanup goal or no cleanup goal applicable/available.
µg/L = Micrograms per liter.
ND = Not detected.
PCB = Polychlorinated biphenyl.
VOCs = Volatile organic compounds.
SVOCs = Semi-volatile organic compounds.

Table 2-9 Contaminants of Concern for Groundwater – Frontier Chemical Site (µg/L)

Analyte	Cleanup Criteria[b]
1,1,1-Trichloroethane	5
1,1,2-Trichloro-1,2,2-trifluoroethane	5
1,1-Dichloroethane	5
1,1-Dichloroethene	5
1,2,4-Trichlorobenzene	5
1,2-Dichlorobenzene	3
1,2-Dichloroethane	0.6
1,3-Dichlorobenzene	5
1,4-Dichlorobenzene	5
Acetone	50
Benzene	1
Chlorobenzene	5
Chloroform	7
cis-1,2-Dichloroethene	5
Methylene Chloride	5
Tetrachloroethene	5
Toluene	5
trans-1,2-Dichloroethene	5
Trichloroethene	5
Vinyl Chloride	2
Xylene (total)	5
Phenol[b]	1
Aldrin	ND
Dieldrin	0.004
Endrin	ND
Antimony	3
Arsenic	25
Lead	25
Selenium	10
Cyanide	200

[a] Based on Cleanup Goal in Table 2-4 of this document.
[b] Sum of phenolic compounds.

Key:

µg/L = Micrograms per liter.
ND = Not detected.

Table 2-10 Location- and Action-Specific SCGs, Former Frontier Chemical Waste Process, Inc. Site

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
Local Action-Specific SCGs					
	Effluent discharge to Niagara Falls POTW		See report text	Potentially Applicable	
	Maximum Permissible Sound Levels		Establishes allowable noise emissions from construction equipment and property line noise limits	Potentially Applicable	
	Nuisance Noise and Vibration Control		Sets limitations on certain nuisance noise and vibrations	Potentially Applicable	
	Construction-Related Street Closure and Placement of Equipment or Materials on Streets, Sidewalks, and other Public Ways		Construction-related street closure and placement of equipment or material on local streets	Potentially Applicable	
	Air Pollution Control		Establishes limitations for emissions of various air pollutants such as combustion engine exhaust and particulates.	Potentially Applicable	
	Solid Waste		Waste haulers local requirements	Potentially Applicable	Relevant to off-site transport of remediation derived wastes
State Action-Specific SCGs					
	Transportation of Hazardous Materials	6 NYCRR 364	Regulates transportation of hazardous materials	Potentially Applicable	Relevant to off-site transport of remediation derived wastes
New York State Vehicle and Traffic Law, Article 386; Environmental Conservation Law Articles 3 and 19.	Noise from Heavy Motor Vehicles	6 NYCRR 450	Defines maximum acceptable noise levels.	Potentially Applicable	Marginally applicable; appears to apply to over-the-road vehicles, not construction equipment.

Table 2-10 Location- and Action-Specific SCGs, Former Frontier Chemical Waste Process, Inc. Site

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
Environmental Conservation Law, Articles 3, 15, 17, 19 and 70; Administrative Procedures Act, Article 301	Uniform Procedures	6 NYCRR 621	Establishes the procedures used in the processing of applications for permits	Applicable	
Environmental Conservation Law, Articles 3, 15, and 17	New York State Pollutant Discharge Elimination System	6 NYCRR 750 - 758	Establishes permit requirements for point source discharges into state waters.	Potentially Applicable	Supersedes need to obtain NPDES permits since New York has an approved SPDES program. New York SPDES program does not require a permit for discharge of uncontrolled stormwater runoff as per 6 NYCRR 751.3(a)(7). Discharge to municipal sewers appears to be under local jurisdiction.
Environmental Conservation Law, Articles 3 and 19.	Prevention and Control of Air Contaminants and Air Pollution	6 NYCRR 200 - 202	Establishes general provisions and requires construction and operation permits for emission of air pollutants.	Potentially Applicable	2001 - Identifies NYC as non-attainment area for ozone, CO, and PM_{10}
Environmental Conservation Law, Article 15; also Public Health Law Articles 1271 and 1276 (Part 288 only)	Air Quality Classifications and Standards	6 NYCRR 256, 257, and 288	Establishes air quality classification system and air quality standards for various pollutants including particulates and non-methane hydrocarbons.	Potentially Applicable	
Environmental Conservation Law, Articles 3, 19, 23, 27, and 70	Hazardous Waste Management System - General	6 NYCRR 370	Provides definition of terms and general standards applicable to 6 NYCRR 370 - 374, 376.	Potentially Applicable	
	Identification and Listing of Hazardous Waste	6 NYCRR 371	Identifies characteristic hazardous waste and lists specific wastes.	Potentially Applicable	

Table 2-10 Location- and Action-Specific SCGs, Former Frontier Chemical Waste Process, Inc. Site

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
	Hazardous Waste Manifest System and Related Standards	6 NYCRR 372	Establishes manifest system and record keeping standards for generators and transporters of hazardous waste and for treatment, storage, and disposal facilities.	Potentially Applicable	Relevant to transportation and off-site treatment of hazardous waste
	Hazardous Waste Treatment, Storage, and Disposal Facility Permitting Require-ments	6 NYCRR 373	Regulates treatment, storage, and disposal of hazardous waste.	Potentially Applicable	Relevant to off-site treatment/disposal of hazardous waste
	Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities	6 NYCRR 374	Subpart 374-1 establishes standards for the management of specific hazardous wastes. (Subpart 374-2 establishes standards for the management of used oil.)	Potentially Applicable	
Environmental Conservation Law, Articles 1, 3, 27, and 52; Administrative Procedures Act Articles 301 and 305.	Inactive Hazardous Waste Disposal Site	6 NYCRR 375	Identifies process for investigation and remedial action at state funded Registry site; provides exception from NYSDEC permits.	Potentially Applicable	
Environmental Conservation Law, Articles 3 and 27.	Land Disposal Restrictions	6 NYCRR 376	Identifies hazardous wastes that are restricted from land disposal. Defines treatment standards for hazardous waste.	Potentially Applicable	

Table 2-10 Location- and Action-Specific SCGs, Former Frontier Chemical Waste Process, Inc. Site

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
Environmental Conservation Law, Articles 1, 3, 8, 19, 23, 27, 52, 54, and 70.	Solid Waste Management Facilities	6 NYCRR 360	360-1: General provisions; includes identification of "beneficial use" potentially applicable to non-hazardous oily waste/soil (360-1.15). 360-2: Regulates construction and operation of landfills, including construction & demolition (C&D) debris landfills	Potentially Applicable	May be applicable for establishing off-site treatment and disposal options for excavated contaminated non-hazardous soil and debris.
Federal Action-Specific SCGs					
Comprehensive Environmental Response, Compensa-tion, and Liability Act of 1980 and Superfund Amendments and Reauthorization Act of 1986 (SARA)	National Contingency Plan	40 CFR 300, Subpart E	Outlines procedures for remedial actions and for planning and implementing off-site removal actions.	Potentially Applicable	
Occupational Safety and Health Act	Worker Protection	29 CFR 1904, 1910, and 1926	Specifies minimum requirements to maintain worker health and safety during hazardous waste operations. Includes training requirements and construction safety requirements.	Potentially Applicable	Under 40 CFR 300.38, requirements of OSHA apply to all activities that fall under jurisdiction of the National Contingency Plan.
Executive Order	Delegation of Authority	Executive Order 12316 and Coordination with Other Agencies	Delegates authority over remedial actions to federal agencies		

Table 2-10 Location- and Action-Specific SCGs, Former Frontier Chemical Waste Process, Inc. Site

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
Clean Water Act	National Pollutant Discharge Elimination System (NPDES)	40 CFR 122 and 125	Issues permits for discharge into navigable waters. Establishes criteria and standards for imposing treatment requirements on permits.	Potentially Applicable	New York SPDES program incorporates the NPDES program by reference.
Safe Drinking Water Act	Underground Injection Control Program	40 CFR 144	Establishes performance standards, well requirements, and permitting requirements for groundwater re-injection wells.	Potentially Applicable	Potentially applicable for remedial alternatives utilizing Fenton's reagent chemistry in which non-hazardous reagents are introduced to the subsurface via injection wells.
	Underground Injection Control Program: Technical Criteria and Standards	40 CFR 146	Establishes technical criteria and standards that must be met in groundwater re-injection permits for Class V wells. Class V wells include wells used in experimental technologies.	Potentially Applicable	
Clean Air Act	National Primary and Secondary Ambient Air Quality Standards	40 CFR 50	Establishes emission limits for six pollutants (SO_2, PM_{10}, CO, O_3, NO_2, and Pb).	Potentially Applicable	
	National Emission Standards for Hazardous Air Pollutants	40 CFR 61	Provides emission standards for 8 contaminants. Identifies 25 additional contaminants, including PCE and TCE, as having serious health effects but does not provide emission standards for these contami-nants.	Potentially Applicable	
Toxic Substances Control Act	Rules for Controlling PCBs	40 CFR 761	Provides guidance on storage and disposal of PCB-contaminates materials	Potentially Applicable	

Table 2-10 Location- and Action-Specific SCGs, Former Frontier Chemical Waste Process, Inc. Site

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
Resource Conservation and Recovery Act	Criteria for Municipal Solid Waste Landfills	40 CFR 258	Establishes minimum national criteria for management of non-hazardous waste.	Potentially Applicable	Applicable to remedial alternatives that involve generation of non-hazardous waste. Non-hazardous waste must be hauled and disposed of in accordance with RCRA.
	Hazardous Waste Management System - General	40 CFR 260	Provides definition of terms and general standards applicable to 40 CFR 260 - 265, 268.	Potentially Applicable	Applicable to remedial alternatives that involve generation of a hazardous waste (*e.g.*, contaminated soil). Hazardous waste must be handled and disposed of in accordance with RCRA.
	Identification and Listing of Hazardous Waste	40 CFR 261	Identifies solid wastes that are subject to regulation as hazardous wastes.	Potentially Applicable	
	Standards Applicable to Generators of Hazardous Waste	40 CFR 262	Establishes requirements (e.g., EPA ID numbers and manifests) for generators of hazardous waste.	Potentially Applicable	
	Standards Applicable to Transporters of Hazardous Waste	40 CFR 263	Establishes standards that apply to persons transporting manifested hazardous waste within the United States.	Potentially Applicable	
	Standards Applicable to Owners and Operators of Treatment, Storage, and Disposal Facilities	40 CFR 264	Establishes the minimum national standards that define acceptable management of hazardous waste.	Potentially Applicable	
	Standards for owners of hazardous waste facilities	40 CFR 265	Establishes interim status standards for owners and operators of hazardous waste treatment, storage, and disposal facilities.	Potentially Applicable	

Table 2-10 Location- and Action-Specific SCGs, Former Frontier Chemical Waste Process, Inc. Site

Act/Authority	Criteria/Issues	Citation	Brief Description	Status	Comments
	Land Disposal Restrictions	40 CFR 268	Identifies hazardous wastes that are restricted from land disposal.	Potentially Applicable	
	Hazardous Waste Permit Program	40 CFR 270, 124	USEPA administers hazardous waste permit program for CERCLA/Superfund Sites. Covers basic permitting, application, monitoring, and reporting requirements for off-site hazardous waste management facilities.	Potentially Applicable	

Note: Location-specific SCGs apply to sites that contain features such as wetlands, floodplains, sensitive ecosystems, or historic buildings that are located on or close to the site. Based on the SRI, wetlands, floodplains, sensitive ecosystems, or historic buildings are not located on or close to the site. Thus, location-specific SCGs were not identified for this site.

3 Identification of Technologies and Development of Alternatives

3.1 Introduction

This section presents the results of the preliminary screening of remedial actions that may be used to control the contaminants of concern and to achieve the on-site RAOs. Potential remedial actions, including general response actions that may be accomplished using various remedial technologies, have been evaluated during the preliminary screening on the basis of effectiveness, implementability, and relative cost. The purpose of the preliminary screening is to eliminate remedial actions that may not be effective based on anticipated on-site conditions or that cannot be implemented technically at the site and that will be evaluated in greater detail to narrow the list of alternatives.

The general response actions considered herein are intended to include those actions that are most appropriate for the site and, therefore, are not exhaustive. A select, focused group of general response actions and remedial technologies for groundwater and soil was considered.

This section also presents a description of the on-site remedial action alternatives that have been developed for the Frontier Chemical site. The alternatives were developed using the general response actions and remedial technologies that passed the preliminary screening. These alternatives are evaluated in greater detail on the basis of environmental benefits and cost in Sections 4, Detailed Analysis of Alternatives and Section 5, Comparative Analysis of Alternatives.

3.2 General Response Actions

Based on the information presented in the SRI report and the remedial action objectives established in Section 2, this section identifies general response actions, or classes of responses, for contaminated areas. General response actions describe classes of technologies that can be used to meet the remediation objectives for each medium of concern.

To satisfy the RAOs for the Frontier Chemical site, remediation will be required for soil (surface and subsurface) and groundwater (overburden and bedrock). The site contains four zones of groundwater contaminated primarily with chlorinated solvents and phenolic compounds. Metals, pesticides, and cyanide contamination is also a concern. As previously discussed, three zones (overburden, A-fracture, and B-fracture) will be addressed by this FS.

Highly contaminated soil (greater than 10 ppm total VOCs) is located in the central and south-central portions of the site. This represents an appreciable area at the site, and the total volume of soil with contamination over the proposed cleanup objectives (see Section 2) is about 35,000 cubic yards. The extent of contamination in surface soils is not defined but assumed to exist in the same areas as subsurface soil contamination.

General response actions that are available to meet the RAOs under consideration are identified below.

General response actions for the contaminated groundwater include:

- No action;
- Institutional controls;
- Containment (using extraction/collection);
- In situ treatment; and
- Ex situ treatment.

General response actions for the contaminated soils include:

- No action;
- Institutional controls;
- Cover/containment;
- In situ treatment; and
- Excavation and ex-situ treatment.

3.2.1 Criteria for Preliminary Screening

In accordance with guidance documents issued by NYSDEC (TAGM 4030) and the EPA (Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA [October 1988]), the criteria used for preliminary screening of general response actions and remedial technologies include the following.

- **Effectiveness**. The effectiveness evaluation focuses on the degree to which a remedial action is protective of human health and the environment. An assessment is made of the extent to which an action: (1) reduces the mobility, toxicity, and volume of contamination at the site; (2) meets the remediation goals identified in the RAOs; (3) effectively handles the estimated areas and volumes of contaminated media; (4) reduces impacts to human health and the environment in the short-term during the construction and implementation phase; and (5) has been proven or shown to be reliable in the long-term with respect to the contaminants and conditions at the site. Alternatives that do not provide adequate protection of human health and the environment are eliminated from further consideration.

- **Implementability.** The implementability evaluation focuses on the technical and administrative feasibility of a remedial action. Technical feasibility refers to the ability to construct and operate a remedial action for the specific conditions at the site and the availability of necessary equipment and technical specialists. Technical feasibility also includes the future maintenance, replacement, and monitoring that may be required for a remedial action. Administrative feasibility refers to compliance with applicable rules, regulations, statutes, and the ability to obtain permits or approvals from other government agencies or offices and the availability of adequate capacity at permitted treatment, storage, and disposal facilities and related services. Remedial actions that do not appear to be technically or administratively feasible or that would require equipment, specialists, or facilities that are not available within a reasonable period of time are eliminated from further consideration.

- **Relative Cost.** In the preliminary screening of remedial actions, relative costs are considered rather than detailed cost estimates. The capital costs and operation and maintenance costs of the remedial actions are compared on the basis of engineering judgment, where each action is evaluated as to whether the costs are high, moderate, or low relative to other remedial actions based on knowledge of site conditions. A remedial action is eliminated during preliminary screening on the basis of cost if other remedial actions are comparably effective and implementable at a much lower cost.

The results of the preliminary screening are summarized below. Those general response actions and remedial technologies that appear to meet the remedial action objectives for one or more of the environmental media (i.e., groundwater and/or soil) are described.

3.3 Identification of Remedial Technologies

This section identifies the potential remedial action technologies that may be applicable to remediation of the media at the Frontier Chemical site identified above as requiring attention.

3.3.1 Groundwater

An evaluation of the analytical and field data for on-site groundwater indicates that contamination above the SCGs is present in groundwater throughout the

Frontier Chemical site. In addition, contamination in the form of DNAPL is likely present on-site.

It is recognized by engineers and regulatory agencies that groundwater restoration in the presence of DNAPL in bedrock is impractical because no remedial technologies are available for completely removing subsurface DNAPL in fractured bedrock. There are a limited number of technologies available to remediate contaminated groundwater (dissolved phase) in fractured bedrock. These technologies include natural attenuation and groundwater extraction. In situ technologies such as chemical oxidation (an innovative technology) may be an applicable technology for remediation of dissolved phase contamination. However, in situ chemical oxidation has not been proven effective for DNAPL remediation in a fractured bedrock environment.

The following subsections discuss the preliminary screening of various general response actions and remedial technologies that were considered for remediation of groundwater.

3.3.1.1 No Action

The No Action alternative involves taking no further action to remedy groundwater conditions at the site. NYSDEC and EPA guidance requires that the No Action alternative automatically pass through the preliminary screening and be compared with the other alternatives in the detailed analysis of alternatives (see Section 4).

3.3.1.2 Institutional Controls

Institutional controls include actions such as access restrictions, deed restrictions, and long-term groundwater monitoring. Access restrictions can include public notifications, fencing, and signs. Deed restrictions on future use can be put in place to limit/control future site use and activities.

While it does not actively clean up a plume, long-term monitoring can be useful to demonstrate that exposures are not occurring. Long-term monitoring generally uses an array of monitoring wells that are regularly sampled and tested by an analytical laboratory for compounds of concern. These wells are placed such that they would detect migration toward potential receptors.

Long-term monitoring is distinct from natural attenuation as it does not attempt to demonstrate that the contaminants are being degraded and/or that they will be attenuated before reaching a receptor. However, under long-term monitoring, natural attenuation may be demonstrated.

Institutional controls are most applicable to limited, restricted-use remedial action alternatives or those alternatives that may leave some level of groundwater contamination.

3.3.1.3 Containment

The purpose of groundwater containment is to isolate or restrict the flow of contaminated groundwater. This is generally accomplished by removing water from the subsurface, such as by pumping from extraction wells or collection trenches.

The process of collecting contaminated groundwater comprises two types of technologies: extraction and collection.

- Groundwater extraction systems create an artificial hydraulic gradient that is used to control, contain, or remove groundwater contaminant plumes. Groundwater extraction can be achieved by using pumping wells. Pumping methods involve the active manipulation and management of groundwater using well systems. The selection of an appropriate well system depends upon a number of factors, including the depth of contamination and the hydrological and geologic characteristics of the aquifer.

- Groundwater collection uses trenches and buried conduits to utilize the naturally occurring hydraulic gradient to convey and collect contaminated groundwater by gravity flow. Subsurface drains function essentially like extraction wells in a single directional groundwater flow path and therefore can perform many of the same functions as wells.

Containment technologies that rely on groundwater extraction are occasionally supplemented with a low permeability subsurface barrier wall to improve the effectiveness of the extraction system. However, due to the nature of the subsurface conditions (clayey soils in the overburden with fractured bedrock below) the use of low permeability barriers is not expected to provide sufficient effectiveness and costs benefits. Therefore, as discussed with NYSDEC, the use of low permeability barriers is not considered further.

Groundwater Extraction/Collection

Groundwater extraction/collection is a commonly used method to control the migration of contaminated groundwater and to collect contaminated groundwater for subsequent treatment. Groundwater extraction wells are generally installed with a drill rig. Well screens and filter packs are generally installed to intercept the saturated thickness of the contaminated water-bearing zone. Groundwater collection trenches can be constructed using conventional excavation equipment. Extraction wells and collection trenches can be installed to provide a hydraulic barrier for control of migration of contaminated groundwater or at specific locations for source area remediation.

- **Effectiveness.** Groundwater extraction wells and collection trenches appear to be an effective remedy that could be used in conjunction with other technologies to meet the remedial action objectives for the groundwater. Extraction wells, in conjunction with a groundwater treatment system, would reduce the mobility, toxicity, and volume of contaminated groundwater. Extraction wells and collection trenches can be installed with limited site disturbance and relatively low potential for impacts to human health and the environment during installation, as compared with other technologies that are more intrusive. Extraction wells and collection trenches are a proven and reliable technology for removal of groundwater for remediation. Extraction is not effective for remediation of DNAPL.

- **Implementability.** For the subsurface conditions at the Frontier Chemical site, groundwater extraction wells and collection trenches are an implementable technology for removal of groundwater for subsequent treatment. The materials, equipment, and labor necessary to install extraction wells are readily available. Extraction wells and collection trenches can be reliably installed to the required depth and the screened interval can be installed to meet the subsurface conditions.

- **Cost.** The relative costs for extraction wells and collection trenches are expected to be moderate as compared with other remedial technologies used to remove groundwater for treatment. Capital costs would include materials, equipment, and labor to install the extraction wells, collection trench, submersible pumps, and piping and associated appurtenances. Operation and maintenance costs would include long-term pumping costs to remove groundwater for treatment, routine maintenance on wells and piping, and costs for groundwater monitoring.

In summary, groundwater extraction wells and collection trenches appear to be an effective and implementable technology for removal of contaminated groundwater from the ground for subsequent treatment using other remedial technologies.

3.3.1.4 In situ Groundwater Treatment

As with any treatment technology, in situ treatment technologies address contamination through removal, destruction, or immobilization of contaminants. For organic contaminants in groundwater, applicable technologies would either remove or destroy the contaminants. Removal technologies are limited to those that transfer the contaminants to the gas phase, allowing recovery of the gas and thus cleanup of the groundwater. The traditional technology used to effect this type of removal is air sparging.

Destruction technologies convert the contaminants into innocuous by-products such as carbon dioxide and chloride ions. Representative technologies include reactive iron walls and anaerobic biodegradation (including natural attenuation).

There are also direct-oxidation technologies available for treating chlorinated solvents. For example, use of strong oxidizers such as potassium permanganate and Fenton’s Reagent have been used as reagents for the direct oxidation of a variety of solvents. However, chemical oxidation (an innovative technology) has not been proven effective on organic solvents such as trichloroethane (TCA) and 1,2-dichloroethane (DCA) (which are found on-site).

The primary limitation to the use of in situ technologies at the site is the presence of high levels of VOC contamination (including the possible presence of residual DNAPL). In general, many of the in situ technologies are not effective at adequately treating high levels of VOC contamination, have limitations associated with use in fractured bedrock, and/or are not effective at reducing other types of contamination such as metals (which are also present on-site). Therefore, in situ remediation is not considered a viable option for this site and is not discussed further.

3.3.1.5 Ex situ Treatment

This general response action involves aboveground treatment of removed groundwater from the subsurface using other technologies for subsequent discharge/disposal. This could involve: (1) treating the groundwater to the cleanup goals (groundwater standards) and discharging the treated water back into the site groundwater or (2) pretreating the groundwater to sufficiently meet the pretreatment standards for the Niagara Falls wastewater POTW before discharge to the existing sewer system.

In order to re-inject treated groundwater on-site, contaminant concentrations must be reduced to levels below groundwater standards. Considering the significant on-site VOC concentrations and other contaminants of concern in the groundwater, a large-scale water treatment system would be necessary to achieve groundwater standards. Additionally, on-site subsurface re-injection of treated groundwater could potentially mobilize DNAPL and associated contaminated groundwater beyond site areas, causing the contamination to spread. Because it is anticipated that on-site contaminant concentrations can be reduced to levels acceptable to the POTW with an adequate pre-treatment system, re-injection is unnecessary. Therefore, treated groundwater will be discharged to the existing sewer system. The discharge limits to the sewer system provided by the POTW are presented in Table 3-1.

Given that VOCs are the primary contaminants of concern, ex situ treatment will focus on selecting the most suitable technologies to treat VOCs. Depending on the selection of VOC treatment, the most appropriate technology to reduce the metal concentrations will then be incorporated into the overall treatment train.

Based on industry experience with ex situ treatment at numerous organically contaminated (including chlorinated solvent and phenolic compound) sites, four primary technologies have been found to be most technically effective and cost-effective for treating extracted VOC-contaminated groundwater: biological degradation, carbon adsorption, air stripping, and UV oxidation. Additional technologies to remove metals or suspended materials will be needed either as a pre- or post-treatment step.

Considering the expected groundwater extraction flow rates, biological degradation requires the use of large tanks/vessels (such as a batch reactor) that would take up a large area of the site. Although biological degradation is an effective treatment for VOC contamination in groundwater, it is not as effective in removing metals and other contaminants. Therefore, this technology will not be considered further. Air stripping, carbon adsorption, and UV oxidation technologies to remediate on-site groundwater are evaluated below.

Air Stripping

Air stripping is a mass-transfer process in which VOCs are transferred from water to the air stream by pumping the contaminated groundwater through a packed air-stripping tower. The towers range from approximately 15 feet to 40 feet high or may be constructed according to proprietary low-profile designs. The air-stripping tower typically has a spray nozzle at the top that sprays groundwater down the tower. A fan forces the air upward against the groundwater flow. At the bottom of the tower is a sump that collects the decontaminated groundwater. Liquid phase carbon may be used to further treat the groundwater for final polishing before discharge to the POTW. Discharge to the POTW will require a sewer-use permit.

Following transfer to the gas phase, the VOCs can either be further treated (using carbon or other technologies) or released to the atmosphere. The need for off-gas treatment from the air stripper is determined by the requirements of an air discharge permit, which evaluates, on a site-specific basis, the need for off-gas control. In some cases, off-gas treatment is not required.

Air stripping using packed towers is a well-established, effective remedial technology for the removal of VOCs from groundwater. The preferred ex situ technology depends upon extraction rates and concentrations. Air stripping is most appropriate for situations where the contaminants to be treated are volatile and where there are no significant concentrations of dissolved ions that may precipitate (e.g., iron). Air stripping is generally the most preferred of the groundwater treatment methods because it is less expensive than the other technologies over a wide range of concentration/flow rate conditions.

- **Effectiveness.** Air stripping is expected to be an effective technology for treating the groundwater to achieve the sewer discharge requirements. This is a proven and reliable technology for treatment of water containing VOCs. Air emissions may need to be treated before discharge, based on the anticipated levels, for protection of human health and the environment. Metals such as iron and manganese can precipitate onto the trays in the air stripper, requiring more frequent maintenance. Therefore, pretreatment of the groundwater for metals may be required.

- **Implementability.** The labor, equipment, and materials for installation of an air stripper at the site are readily available. It may be necessary to treat the air emissions from the stripper by catalytic oxidation, carbon, or other appropriate method to meet NYSDEC requirements for allowable concentrations of VOCs to be released to the ambient air.

The process equipment that would be required to implement an air stripping treatment system would include construction of a shelter building, an electrical power source, instrumentation and controls system equipment, an equalization tank to receive influent water from the groundwater extraction well(s)/collection trench, potential metals treatment process, an air stripper unit with an air blower, an off-gas treatment system to remove organic vapors from air before discharge to the atmosphere, activated carbon for polishing the groundwater, and discharge piping for effluent water leading to the existing sewer system. If an air stripper is used at this site for treatment, treatability studies may be required in order to complete the design based on the required discharge limit. The system will need to substantially comply with appropriate state and federal air permit requirements. Additionally, a sewer-use permit will be required from the local POTW, which should be attainable.

- **Cost.** The relative costs for air stripping are expected to be moderate to high as compared with other remedial technologies used to treat contaminated groundwater. Capital costs would include the process equipment noted above and installation. Operation and maintenance costs would include changing filters on a regular basis, cleaning and replacing trays or packing media in the air stripper, maintaining the off-gas system, and electrical power consumption.

In summary, air stripping appears to be an effective and implementable technology for ex situ treatment of contaminated groundwater before discharge to the sewer system, when used in conjunction with other technologies to treat air emissions (e.g., catalytic oxidation, carbon adsorption).

Carbon Adsorption

Carbon adsorption is used to remove dissolved organic compounds from groundwater. This process has been shown to be effective at removing low-solubility organic substances over a broad concentration range. Carbon adsorption can be designed for either column or batch application, but groundwater treatment typically uses columns. In column applications, the contaminated water is passed through a bed of activated carbon, and the contaminants are adsorbed into the carbon. Once the carbon has been used to its maximum adsorptive capacity, it is removed for disposal, destruction, or, most likely, regeneration. During off-site regeneration, adsorbed contaminants are desorbed by either solvent stripping or thermal desorption.

- **Effectiveness.** Use of carbon may be an ineffective method for primary treatment of site groundwater due to the elevated concentrations of chlorinated VOCs detected in the groundwater. The carbon usage rate for groundwater treatment is expected to be high, particularly during initial startup when higher concentrations are anticipated. Thus, it is anticipated that significant quantities of activated carbon would be consumed, which would result in the need for frequent carbon change-out, at least initially, in the extraction process.

Carbon may also be used in a treatment process for final groundwater polishing following the use of one of the other treatment technologies such as air stripping.

- **Implementability.** The labor, equipment, and materials for installation of a carbon adsorption system at the site are readily available.

  The process equipment required for this technology would include construction of a shelter building, an electrical power source, instrumentation and controls system equipment, granular activated carbon treatment columns or containers, associated internal piping (heat-traced), and discharge piping for effluent water leading to the existing sewer system. Additionally, a sewer use permit will be required from the local POTW, which should be attainable.

- **Cost.** The cost of this technology when used as a method of treatment for groundwater is expected to be high due to labor and materials needed for frequent carbon change-out.

In summary, the use of liquid phase carbon adsorption as the primary means of groundwater treatment may not be cost-effective as compared with other available treatment technologies for VOC remediation of groundwater.

UV Oxidation

UV oxidization uses ultraviolet light together with an oxidizer, typically hydrogen peroxide or ozone, to chemically oxidize organic contaminants present in water. The oxidizer is added to the contaminated water and the mixture is passed through a unit lighted with UV bulbs. The combination of the intense UV light and oxidizer breaks down the complex organic molecules into a series of less complex molecules (i.e., water, carbon dioxide, and hydrogen chloride).

- **Effectiveness.** This technology may be moderately effective for treatment of VOCs, based on the relatively high concentrations of VOCs in the groundwater. The effectiveness of this technology in treating VOCs is sensitive to the amount of suspended solids in the groundwater, which impedes the penetration of ultraviolet light. As such, filtering for suspended solids may be required as a pretreatment step. In addition, this technology has a low tolerance for iron and manganese in the groundwater. At elevated iron and manganese levels precipitate tends to form on the lamps that supply the ultraviolet light, reducing effectiveness. As such, iron pretreatment may be required for this technology to be effective for operation.

- **Implementability.** The materials, labor, and equipment necessary to implement this technology are available. Treatability studies would be needed to evaluate the effectiveness of this process to treat the groundwater at the site to the required discharge limit. The process equipment required would include a shelter building, electrical power source, instrumentation and controls system equipment, equalization tank, bag filter for solids filtration (if necessary), potential metals (iron and manganese) removal system, a skid-mounted chemical oxidation unit, a hydrogen peroxide or ozone storage tank, a dose regulation system, and an effluent discharge line to the sanitary sewer. In addition, a sewer use permit will be required from the local POTW, which should be attainable.

- **Cost.** Costs for this process are anticipated to be moderate to high as compared with other treatment technologies when used in a pretreatment application, especially if filtration is a required pretreatment step.

In summary, UV oxidation may be effective in reducing concentrations of chlorinated VOCs in a pretreatment application. However, other technologies such as air stripping are likely to be more effective in achieving the pretreatment standards with less operation and maintenance. Based on the above, this treatment process will not be considered further in the detailed analysis of alternatives. However, if a pre-remedial design study indicates that the effectiveness of air stripping may be less than anticipated, the designer may wish to reconsider the use of the UV oxidation treatment process.

3.3.2 Soil

An evaluation of the analytical and field data for subsurface soils from the SRI indicates that VOC contamination above the SCGs is present in areas throughout the Frontier Chemical site. The most highly contaminated soils are located in the south/southwest central portion of the Frontier Chemical property, which may be associated with storage and/or spillage. The soil contamination extends down below the groundwater table (which is at about 5.5 feet bgs). Considering that the overburden groundwater at the site is highly contaminated it is assumed that soil below the water table will not be removed. Removal of contaminated soil below the water table would not be appropriate because the clean soil would become contaminated from the existing highly contaminated groundwater. As described previously, it is also assumed that the surface soil in the area of contaminated subsurface soil is also contaminated and will require removal.

The following sections discuss the preliminary screening of various general response actions and remedial technologies that were considered for remediation of site surface and subsurface soils.

3.3.2.1 No Action

The No Action alternative involves taking no further action to remedy the condition of contaminated soils. NYSDEC and EPA guidance requires that the No Action alternative automatically pass through the preliminary screening and be compared to other alternatives in the detailed analysis of alternatives (see Section 4).

3.3.2.2 Institutional Controls

Institutional controls include actions such as public notifications, deed restrictions on future use, and fencing and signs. These types of controls do not reduce contamination levels but can reduce potential exposure to the contaminated media by restricting access to the site and how the site will be used in the future. Institutional controls are most applicable to limited, restricted use remedial action alternatives or those alternatives that may leave some level of contamination in place.

3.3.2.3 Cover/Containment

A clean fill cover action could be used to reduce the potential for direct contact with contaminated materials and limit erosion and transport of contaminated surface soils. Clean fill cover is a 6-inch to 12-inch layer of soil (or other clean acceptable material) that can be graded and potentially vegetated.

A containment action provides a surface seal for use with technologies such as soil vapor extraction and reduces infiltration of precipitation through contaminated soils and into the groundwater. However, as discussed with NYSDEC and considering that a significant portion of the site is currently covered with asphalt or concrete at the surface (about 75%), the use of a containment action (low permeability cap) will not be considered further. Additionally, because the site is located in an industrial area, site access is restricted by fencing, and future use of the site is unknown (but will likely be restricted to industrial/commercial), the installation of a low permeability cap would not be needed. Contamination that would be flushed from the unsaturated soil to groundwater could be captured by groundwater remedial systems.

The following presents the preliminary screening of a clean soil cover action.

- **Effectiveness.** It appears that the placement of clean soil cover over the areas of the site currently lacking asphalt or concrete cover would be effective in helping to achieve the RAOs for soil, since it would reduce the potential for direct contact with the contaminated soils and limit erosion and transport of contaminated materials.

- **Implementability.** The materials, equipment, and labor for construction of a clean soil cover are available and can be readily implemented.

- **Cost.** Costs for an ordinary clean soil cover are expected to be low to moderate as compared with other cover system designs (not considered herein). Capital costs may include materials, labor, and equipment to construct the clean soil cover. Operation and maintenance costs would be minimal.

In summary, considering that a significant portion of the site is currently covered with asphalt or concrete, the use of a clean soil cover action in the remaining areas (where contaminated near-surface soils exist) appears to be an effective action to prevent the potential for direct contact with the contaminated soils and limit erosion and transport of contaminated materials.

3.3.2.4 In situ Treatment

The most common and proven in situ treatment technology to effectively reduce concentrations of VOCs in soil is soil vapor extraction (SVE). In this technology, a vacuum is applied to the contaminated soil through strategically located extraction wells screened through the contaminated zone, which creates a negative pressure gradient that causes movement of vapors toward these wells. Volatile constituents in the vapor phase are readily removed from the subsurface through the extraction wells. The extracted vapors are then treated (commonly with carbon adsorption) and discharged to the atmosphere. Because of the clayey nature of on-site soils and the perched groundwater conditions in some areas of the site, SVE would be ineffective in “flushing” the vapors to the extraction wells. In addition, SVE will not treat metal contamination and is ineffective in treating some SVOCs that are also present on-site.

In situ treatment technologies applicable to low-concentration, low-mobility, mixed-variety (i.e., metals and SVOCs) contaminants found at the site would be limited to in situ solidification technologies. These technologies are well developed and would further reduce the mobility of the soil contamination detected. Implementation of this technology requires in-place mixing of the contaminated soils with a binding agent such as Portland cement using augers or backhoes. The resulting product “captures” the contamination. Because a majority of the contaminants are primarily organic, the immobilization would not be as effective as it would with only metals contamination, where the metals react directly with the binder to reduce mobility. During the mixing process, the solidification process would generate heat, which could cause VOCs to volatize into the air and create potential exposure. Additionally, VOCs do not readily bond to the solidification agent and there would still be the potential for VOCs to leach from the solidified soil to groundwater. Therefore, in situ remediation is not considered an effective option for this site and is not discussed further.

3.3.2.5 Excavation and Ex situ Treatment

This action involves excavation of contaminated soils that exceed SCGs (i.e., unsaturated source soils). These soils may be excavated and removed for on-site or off-site treatment and/or disposal at a permitted solid waste disposal facility. Incineration (thermal destruction) done on-site or off-site, followed by disposal at a permitted landfill facility, would be an acceptable treatment alternative due to the high concentrations of VOCs. As discussed with NYSDEC, other ex situ treatments (e.g., bioventing and land farming) that would require staging the excavated contaminated soil will not be considered further due in part to the large area that would be required and the accompanying air issues associated with significant VOC concentrations in site soils.

- **Effectiveness.** Excavation and disposal of contaminated soil at a permitted landfill is an effective method of reducing potential for direct contact with contaminated soils. In addition, this action reduces the potential for future contamination of groundwater. Incineration would be effective in reducing the volume and mobility of soil contamination. Placing excavated or treated materials in a permitted solid waste facility reduces the risk to human health and the environment since the materials would be in a secure location with environmental monitoring.

- **Implementability.** Contractors, treatment facilities, and/or disposal facilities are available to implement this technology. However, this option alone would have limited application at the site due to the depth (below the groundwater table in some locations) of soil contamination. Treatability studies may be necessary to evaluate the effectiveness of the type of thermal treatment (low or high temperature) needed to treat the soil to acceptable levels for placement in a landfill or for placement back on-site.

- **Cost.** The cost of implementing excavation is expected to be moderate to high in comparison with the other technologies. Vapor suppression and/or soil containment structures would be necessary to limit off-site vapor migration, which will further increase costs associated with excavation activities. The cost for on-site or off-site treatment and disposal is high but may be cost-effective when considering the lifetime for treatment and operation/maintenance costs of other technologies.

In summary, excavation (with on-site or off-site treatment and disposal to a permitted solid waste facility) is applicable for removal of highly contaminated soil above the water table but is an ineffective technology for remediation of contaminated site soils below the water table. This technology with limited application will be maintained as a possible addition to the site-wide alternatives.

3.4 Development of Alternatives

In this section, the most effective technologies identified in the previous subsections have been combined into remedial alternatives to address soil and groundwater contamination at the Frontier Chemical site.

The remedial alternatives have been divided into three distinct operable units. The first operable unit (OU-1) contains the alternatives that address soil and groundwater contamination in the overburden. The second operable unit (OU-2) contains the remedial alternatives that address the groundwater contamination in bedrock zones A and B. The third operable unit (OU-3) includes groundwater contamination in bedrock zone C and potential lower bedrock groundwater zones that may have been impacted by site contamination. OU-3 will be further assessed as part of future remedial activities and is not included in this report. The remedial alternatives for OUs 1 and 2 are presented below.

OU-1 (Soil and Overburden Groundwater) Remedial Alternatives

In order to address overburden soil (OS) and overburden groundwater (OG) contamination detected at concentrations above the proposed cleanup criteria, the following alternatives (five for soil and three for overburden groundwater) have been developed.

Overburden Soil.

- Alternative No. OS-1: No action;
- Alternative No. OS-2: Institutional controls (i.e., access/use restrictions, deed restrictions);
- Alternative No. OS-3: Cover (existing asphalt pavement or concrete would remain as cover and clean soil cover would be placed in the remaining unpaved contaminated areas to limit potential for direct contact with impacted near surface soil; see Figure 3-1);
- Alternative No. OS-4: Excavation and on-site treatment of soils (soils generally containing greater than 10 ppm total VOCs; see Figure 3-2); and
- Alternative No. OS-5: Excavation and off-site treatment/disposal of soils (soils generally containing greater than 10 ppm total VOCs; see Figure 3-3).

Overburden Groundwater.

- Alternative No. OG-1: No action;
- Alternative No. OG-2: Institutional controls (i.e., access/use restrictions, deed restrictions, long term groundwater monitoring; see Figure 3-4); and
- Alternative No. OG-3: Hydraulic containment (collection trench with sand seam extraction well) with ex situ treatment of overburden groundwater with discharge to the POTW (see Figure 3-5).

OU-2 (Bedrock Groundwater) Remedial Alternatives

In order to address bedrock groundwater (BG) contamination detected at concentrations above the proposed cleanup criteria, the following three alternatives have been developed.

Bedrock Groundwater.

- Alternative No. BG-1: No action;
- Alternative No. BG-2: Institutional controls (i.e., access/use restrictions, deed restrictions, long term groundwater monitoring; see Figure 3-6)); and
- Alternative No. BG-3: Hydraulic containment (groundwater extraction from wells placed across the A and B bedrock fracture zones) and ex situ treatment of groundwater with discharge to the POTW (see Figure 3-7).

The remedial alternatives selected to address both soil and groundwater contamination will be further defined and evaluated in Sections 4 and 5.

The remedial action alternatives have been assembled using the general response actions and remedial technologies that have passed the preliminary screening. An expanded description of each of the alternatives is provided below.

Additional details associated with the alternatives are also presented in Appendix A.

3.4.1 Alternative No. OS-1, OG-1, and BG-1 – No Action

The No Action alternative involves taking no further action to remedy site conditions. NYSDEC and EPA guidance requires that the No Action alternative be considered in the detailed analysis of alternatives. However, the No Action alternative is considered an unacceptable alternative because the site would remain in its present condition and human health and the environment would not be adequately protected. Long-term groundwater monitoring is not included in this alternative.

3.4.2 Alternative No. OS-2, OG-2, and BG-2 – Institutional Controls

Institutional controls, which include access/use restrictions and deed restrictions, are viable options for controlling the potential for direct contact with contaminated media. They are often utilized on contaminated industrial sites (such as the Frontier Chemical site) where it may not be technically practical to achieve the proposed cleanup goals for soil or groundwater in a reasonable/predictable time frame (less than 30 years) due to the likely presence of DNAPL on-site.

Access/use restrictions for the Frontier Chemical site would include utilizing the existing fencing and posting signs. Deed restrictions would be filed to control future use/activities at the site. For the groundwater alternatives (OG-2 and BG-2), long-term groundwater monitoring would also be included as an institutional control. Alternatives OG-2 and BG-2 allow for natural attenuation of impacted groundwater. Additionally, these alternatives assume that semiannual groundwater monitoring would be conducted in on-site wells for five years, followed by annual sampling for 25 years. These wells are identified on Figures 3-4 and 3-6.

Conceptually, during each monitoring event, 17 existing monitoring wells would be purged and sampled. The 17 wells would include five in the overburden (as part of Alternative OG-2), five in the A bedrock zone (as part of Alternative BG-2), five in the B bedrock zone (as part of Alternative BG-2), and two in the C zone (as part of Alternative BG-2). Additionally, water levels would be measured in the 17 wells. Groundwater samples would be analyzed for VOCs and other compounds of concern consistent with the SRI. These alternatives do not include long-term soil monitoring because the on-site soils are also contaminated with compounds such as metals that are not expected to naturally attenuate significantly over time. It is assumed that the existing site fencing is adequate to restrict access and that long-term operation and maintenance (O&M) is not needed. Routine O&M would be required on the monitoring wells.

3.4.3 Alternative No. OS-3 – Cover

The soil cover alternative includes demolition of existing buildings and associated foundations (level with existing ground surface), removal of surface soil assumed to be contaminated, segregation and consolidation of on-site debris, and installation of surface water drainage piping. The alternative would also include site grading to fill low spots to the level of existing ground surface. Debris from existing site stockpiles and from demolition would be segregated and consolidated in two stockpiles (hard material suitable as backfill and debris). The hard material stockpile would include the remaining material not used to replace removed contaminated surface soil or to fill low spots and excavated soils associated with this alternative. The stockpile would be located in the northwest portion of the site out of the way of potential reuse of the main part of the site. The hard material would be stockpiled with as low a profile as possible and covered with 1 foot to 2 feet of clean imported soil, followed by a 6-inch cover of topsoil seeded to promote vegetative growth for erosion control. The debris pile would be located in the northeast part of the site for potential future disposal and recycling as appropriate.

The overall approach associated with this alternative is to provide a generally level (with the exception of the two stockpiles previously described), adequately drained site with about 1 foot of uncontaminated material at the surface. This would limit the potential for direct contact with contaminated media. Figure 3-1 presents this alternative.

This alternative would also include the actions described as part of Alternative OS-2 (institutional controls) as well as the following:

- Demolition, segregation, and consolidation (as described above) of existing on-site structural features. Crushed concrete from the building walls/foundations, concrete block/brick buildings, and similar material from existing debris piles would be segregated and would be used as fill on-site (as needed). It is assumed that about 10% of this existing on-site hard fill material can be used in excavated areas and to level the site. The remaining material would be stockpiled/graded in the northwest corner of the site and covered with 1 to 2 feet of clean soil, followed by seeded topsoil.

- Demolition and consolidation of other items such as old equipment, buildings (other than concrete block/brick), tanks (assumed to be RCRA-clean), and debris piles. This material would be stockpiled in the northeast corner of the site for future disposal as construction and debris (C&D).

- Excavation of about 1 foot of surface soil assumed to be contaminated (located proximate to subsurface soil contamination) and consolidation on-site in the hard fill stockpile. As previously stated, this stockpile would be covered with 1 foot to 2 feet of clean imported soil and seeded topsoil. The excavated area would be backfilled with hard fill (from the site).

- As part of excavation activities, it is assumed that approximately 13 monitoring wells and piezometers (which are now located in areas of proposed stockpiles) would be decommissioned along with the replacement of seven monitoring wells (overburden and bedrock) for future long-term monitoring programs. In addition, up to seven monitoring wells and piezometers would be decommissioned as part of the consolidation/stockpiling activities in the future long-term monitoring programs.

- Filling of low spots (including existing catch basins) with hard fill (from the site).

- Areas of existing asphalt pavement or concrete at the surface would remain without maintenance.

- Existing catch basins would be abandoned by backfilling basin openings with hard fill. Approximately five new catch basins, with approved connections to the POTW, would be installed as needed to facilitate proper drainage and minimize the potential for water to pond on-site.

Other than O&M associated with monitoring wells, it is assumed that long-term O&M would not be required for this alternative.

3.4.4 Alternative No. OS-4 – Excavation and On-site Treatment of Soil

The overall approach associated with this alternative is to excavate the contaminated source soils (greater than 10 ppm total VOCs) from above the groundwater table (about 5.5 feet bgs). The soil would be treated on-site by thermal desorption and returned to the excavation. This alternative would allow soil above the proposed cleanup goals to remain on-site in the saturated soil zone (about 5.5 feet to 16 feet bgs). Removal of the source soils could reduce the overall time required to clean up the site by reducing the overall mass of contamination. Figure 3-2 presents this alternative.

This alternative would include the actions described as part of Alternative OS-3 (cover) as well as the following:

Excavation

- Approximately 39,000 in-place cubic yards (surface area of 190,000 square feet to an average depth of 5.5 feet) of contaminated unsaturated zone soil (above 10 ppm total VOCs) would be removed by conventional excavation techniques. Vapor suppression may be necessary to limit migration of vapor off-site vapor from the excavation area. The proposed excavation is located in the central/south central part of the site.

- As part of excavation activities, it is assumed that approximately 33 monitoring wells and piezometers (which are now located in areas of proposed stockpiles) would be decommissioned and 13 monitoring wells (overburden and bedrock) replaced for future long-term monitoring.

- Building foundations would be removed and demolished as encountered during excavation. The removed foundations (assumed to be steel-reinforced concrete) would be broken up and reused as backfill or stockpiled on-site (as discussed in Section 3.4.3). Conduits, drains, and other piping that are encountered would be removed and the ends sealed or plugged with grout. Accumulated precipitation water in open excavation would be allowed to infiltrate to groundwater.

- Excavated soils may be staged in a containment structure to limit off-site vapor migration. The soil would then be mixed by mechanical means (typically a front-end loader) and fed to a blender or pug mill to ensure that the feed to the thermal desorption unit is relatively homogeneous. After blending, the soils would be screened for removal of objects/rocks greater than 1 inch that would be processed in a grinder to reduce their size and then returned for blending with the soil. The soils would then be fed to the thermal desorption unit (an inclined rotary dryer). Treated soil exiting the thermal desorption unit would be sprayed with water in an enclosed structure to allow for cooling without wind dispersion and used for backfilling the excavated areas. A conceptual design has been developed for this process; details are included in Appendix A.

- Visual observation, organic vapor meter field screening, and analytical testing would confirm the limits of the excavation.

On-site Treatment

- A trial burn would be completed to establish thermal desorption system parameters (such as temperature and feed rate) as well as effectiveness of the technology. Additionally, soil samples would be collected for testing to evaluate parameters such as organic content, density, moisture content, and particle size.

- Approximately 39,000 in-place cubic yards (60,000 tons) of contaminated unsaturated soil (with total VOCs greater than 10 ppm) would be treated using a mobile thermal desorption unit.

Long-term O&M (except for those associated with institutional controls) would not be required for this alternative.

3.4.5 Alternative No. OS-5 – Extraction and Off-site Treatment/Disposal of Soil

The overall approach associated with this alternative is to excavate contaminated source soils (greater than 10 ppm total VOCs) from above the groundwater table (about 5.5 feet bgs). Appropriate safety during the construction process will be maintained. The soil would be hauled off-site for treatment/disposal at a NYSDEC- approved facility. Usable on-site hard fill from demolished buildings/foundations and clean suitable fill would be used on-site to backfill the excavation. This alternative would allow soil above the proposed cleanup goals to remain on-site in the saturated soil zone (about 5.5 feet to 16 feet bgs). Removal of the source soils could reduce the overall time required to clean up the site by reducing the overall mass of contamination. Figure 3-3 presents this alternative.

This alternative would include the actions described as part of Alternative OS-3 (cover) as well as the following:

- Approximately 39,000 cubic yards (surface area of 190,000 square feet to an average depth of 5.5 feet) of contaminated unsaturated zone soil (above 10 ppm total VOCs) would be removed by conventional excavation techniques. Vapor suppression may be necessary to limit vapor migration off-site from the excavation area. The proposed excavation is located in the central/south central part of the site.

- As part of excavation activities, it is assumed that approximately 33 monitoring wells and piezometers (which are now located in areas of proposed stockpiles) would be decommissioned, with 13 monitoring wells (overburden and bedrock) replaced for future long-term monitoring programs.

- Building foundations would be removed and demolished as encountered during excavation. The removed foundations (assumed to be steel-reinforced concrete) would be broken up and reused as backfill or stockpiled on-site (as discussed in Section 3.4.3). Conduits, drains, and other piping that is encountered would be removed and the ends sealed or plugged with grout. Accumulated precipitation water in open excavation would be allowed to infiltrate to groundwater.

- The excavated material may be staged in a containment structure in attempt to limit off-site vapor migration before transportation off-site by dump truck to a NYSDEC-approved treatment/disposal facility. It is assumed that the contaminated soil would be pre-characterized to allow for direct loading and immediate off-site transport to the treatment/disposal facility (load-and-go technique).

- It is expected that about 25% of the excavated soil (about 9,750 cubic yards) would be characterized for disposal as hazardous waste with concentrations exceeding acceptable VOC levels.

- Clean suitable soil backfill would be brought on-site by truck and placed in lifts into the excavation. Additionally, it is assumed that about 50% of hard material currently staged on-site could be used as backfill in the excavation.

- Visual observation, organic vapor meter field screening, and analytical testing would be used to confirm the limits of the excavation and segregate hazardous from non-hazardous soil.

Long-term O&M would not be required for this alternative.

3.4.6 Alternative No. OG-3 – Hydraulic Containment (Overburden Groundwater)

The overall approach associated with this alternative is to intercept the overburden groundwater at the downgradient edge of the site (using a groundwater collection trench) to prevent off-site migration of contaminated overburden groundwater. Additionally, an extraction well would be installed in a hot spot area containing sandy soils that is deeper than other areas of the site. According to the SRI, this sandy soil area is located in the areas surrounding MW-7(R) and MW-01-1OB, indicating a groundwater depression. Installation of the extraction well in this area would be advantageous because it would allow more flexibility in design and performance of the overburden extraction system. Extracted groundwater would be conveyed by subsurface piping to an on-site treatment building, treated, and discharged to the POTW. Figure 3-5 presents this alternative.

This alternative would include the actions described as part of Alternatives OG-2 (institutional controls), as well as the following:

Groundwater Collection (Trench)

- Excavation of a collection trench (about 3 feet wide and 1,000 feet long) extending to bedrock (about 16 feet bgs) using conventional excavation equipment and maintaining appropriate side slopes along the trench. Installation of six manholes with 8-inch diameter perforated piping extending between manholes. Backfilling of the trench would consist of compacted open graded clean stone to ground surface.

- The extraction trench system would be operated for long-term groundwater control by extracting water at approximately 10 to 20 gallons per minute (gpm). More water is expected initially until water perched above the clay soils (in the fill) and in utilities drains to the trench.

- Consolidation of excavated materials on-site in the hard fill stockpile if Alternative OS-3 or OS-4 is selected. Otherwise, excavated materials would be characterized and disposed off-site if Alternative OS-5 is selected.

- Installation of a pump and controls.

- Installation of subsurface piping to convey the extracted groundwater from the trench manhole to the treatment building.

- Building foundations would be removed and demolished as encountered during excavation. The removed foundations (assumed to be steel-reinforced concrete) would be broken up and reused as backfill or stockpiled on-site (as discussed in Section 3.4.3). Conduits, drains, and other piping that is encountered would be removed and the ends sealed or plugged with grout. It is assumed that active utility laterals (i.e., water, gas) may be encountered and would be repaired if damaged during excavation work. Accumulated precipitation water in open excavations or accumulated groundwater would be discharged on-site, upgradient and allowed to infiltrate to groundwater.

Groundwater Extraction (Well)

- One-groundwater extraction well would be installed to capture contaminated overburden groundwater in the hot spot area (also the area of the groundwater depression) previously mentioned (see Figure 3-5). The extraction system would be operated long-term by extracting water at approximately 5 to 10 gpm. The extraction well would be constructed of 4-inch stainless steel casing. The wells would be screened from the top of the groundwater table (approximately 5 feet bgs) to approximately 12 feet bgs (about 1 foot to 2 feet into the clayey soils). Groundwater would be conveyed from the extraction well by underground piping to an on-site treatment system. Installation of the well would require the abandonment of monitoring wells MW -7(R) and MW-01-1OB for the most effective overburden groundwater remediation.

Groundwater Treatment and Discharge

Considering that the amount of total groundwater treatment associated with the overburden system (15 to 30 gpm) is minor compared to the bedrock groundwater system (105 to 175 gpm) and that it is expected that this alternative would not be implemented without Alternative BG-3 (due to the potential for contaminated overburden groundwater to migrate downward to bedrock through the collection trench), the groundwater treatment for this alternative is included as part of Alternative BG-3 (hydraulic containment of bedrock groundwater) (see Section 3.4.7).

- A treatability study should be performed on representative groundwater samples collected from monitoring wells in the area of the collection trench and extraction well. The treatment technologies should be assessed for applicability as part of the evaluation completed as part of Alternative BG-3.

- Groundwater monitoring would be performed to evaluate the extent to which the remedial action objectives are being met. It is assumed that semiannual groundwater monitoring would be conducted in years one through five and annually in years six through thirty. During each monitoring event, five existing site overburden wells (some wells may be new if replaced as a result of implementation of a soil excavation alternative) would be purged and sampled, and water levels would be measured. Groundwater samples would be analyzed for VOCs and other compounds of concern.

3.4.7 Alternative No. BG-3 – Hydraulic Containment (Bedrock Groundwater)

The overall approach associated with this alternative is to intercept the bedrock groundwater at the downgradient edge of the site (using a series of extraction wells) to prevent off-site migration of contaminated upper bedrock groundwater. Extracted groundwater would be conveyed by subsurface piping to an on-site treatment building, treated, and discharged to the POTW via the Southside interceptor tunnel. Figure 3-7 presents this alternative.

This alternative would include the actions described as part of Alternative BG-2 (institutional controls) as well as the following:

Groundwater Extraction (Well)

- Seven groundwater extraction wells would be installed to capture highly contaminated bedrock groundwater (see Figure 3-7). The extraction system would be operated long-term by extracting water at approximately 105 to 175 gpm, or 15 to 30 gpm at each well. Extraction wells would be constructed of 6-inch stainless steel casing. The wells would be screened from the top of the bedrock (approximately 16 feet bgs) to approximately 37 feet bgs (through the A and B fracture zones). The top of the extraction well screen would not extend above the top of weather bedrock. Groundwater would be conveyed from the extraction wells by underground piping to an on-site treatment system.

Groundwater Treatment and Discharge

- A pilot study should be performed on site in order to provide information to efficiently design the groundwater extraction system. The pilot study should consist of 24- or 48-hour pump tests. Results of the pump tests would be used to assess optimum pump rates and well layouts for the pumping wells.

- A treatability study should be performed on representative samples collected during the pump test. The treatment technologies should be assessed for applicability (e.g., metals removal, air stripping design, activated carbon design, etc.).

- A groundwater treatment system would be installed in a treatment building. Conceptually, the building would consist of a pre-engineered metal building with a slab-on-grade concrete foundation and would be approximately 50 feet by 50 feet in size in order to house the treatment system. The building would include a concrete floor and curbing to provide secondary containment. An internal sump would also be installed for liquid removal (if needed).

- The groundwater treatment system is expected to consist of an equalization tank, a metals removal system (for metals including iron and manganese), an air stripper, a granular activated carbon system (for polishing), and an effluent holding tank. The influent flow is expected to range from 120 to 205 gpm. It is assumed that the influent groundwater from the collection trench may have moderate turbidity, and thus filtration is assumed for that treatment stream only. Carbon would be used for destruction of organic air emissions from the air stripper. In addition, an instrumentation and controls system for the extraction trench and well and treatment system would be housed within the building. Treated water would be discharged to the POTW along Royal Avenue via the South Side interceptor tunnel.

- Pre- and post-treatment groundwater samples would be collected monthly to evaluate the performance of the treatment system. Air emissions would be monitored in accordance with applicable permits and requirements.

- Groundwater monitoring would be performed to evaluate the extent to which the remedial action objectives are being met. It is assumed that semiannual groundwater monitoring would be conducted in years one through five and annually in years six through thirty. During each monitoring event, twelve existing site bedrock wells (some wells may be new if replaced as a result of implementation of a soil excavation alternative) would be purged and sampled, and water levels would be measured. It is assumed that the twelve wells that would be monitored would include five wells in the A zone, five in the B zone, and two in the C zone. Groundwater samples would be analyzed for VOCs and other compounds of concern.

- O&M is necessary for the extraction and treatment systems. This work is necessary to maintain treatment performance and life span and would be performed monthly.

Table 3-1 POTW Local Discharge Limits, Niagara Falls Wastewater Facilities

	lbs/day
A. Volatile Compounds	
Vinyl Chloride	0.03
1,1 Dichloroethylene	0.065
Methylene Chloride	0.15
1,2 Dichloroethylene	0.065
Chloroform	0.055
1,1,1 Trichloroethane	0.02
Carbon Tetrachloride	0.046
Benzene	0.062
Dichloropropylene	NONE
Trichloroethylene	0.088
Dichlorobromomethane	0.011
Toluene	0.0344
1,1,2-Trichloroethane	0.02
Tetrachloroethylene	0.114
Dibromochloromethane	0.015
Monochlorobenzene	0.2
Monochlorobenzotrifluorides	0.2
Ethylbenzene	0.047
Bromoform	0.2
1,1,2,2-Tetrachlorethane	0.027
Monochlorotoluenes	1.4
Xylenes (M,P,O)	0.344
B. Acid Compounds	
Monochlorophenols	0.063
Dichlorophenols	0.038
Monochlorocresols	0.036
Trichlorophenols	0.102
Pentachlorophenol	0.038
C. Base/Neutral Compounds	
Dichlorobenzenes	0.016
Trichlorobenzene	0.076
Dichlorotoluene	0.016
Naphthalene	0.022
Hexachlorobutadiene	0.009
Hexachlorocyclopentadiene	0.088
Tetrachlorobenzenes	0.076
Trichlorotoluenes	0.076
Hexachlorobenzene	0.009
Dichlorobenzotrifluorides	0.2
Acenaphthene	0.024
Phenanthrene	0.017

Table 3-1 POTW Local Discharge Limits, Niagara Falls Wastewater Facilities

	lbs/day
Fluoranthene	0.009
Pyrene	0.009
Chrysene	0.009
Benzo(A)Anthracene	0.009
Dimethylphthalate	0.052
Butylbenzylphathalate	0.102
C. Base/Neutral Compounds	
Di-N-Butylphthalate	
Diethylphthalate	0.052
Di-N-Octylphthalate	0.204
Nitrosodiephenylamine	0.052
D. Pesticides/PCBs	
Hexachlorocylohexanes	0.025
PCBs (Aroclor 1248)	0.014
Endosulfan I + Ii + Endosulfan Sulfate	0.006
Mirex	0.002
Dechlorane Plus	0.006
Heptachlor + Heptachlor Epoxide	0.006
Conventionals, Metals, Cyanide	
Aluminum	0.002
Cadmium	19.4
Chromium	0.008
Copper	0.04
Lead	0.965
Mercury	0.32
Nickel	0.008
Zinc	0.4
Phenolics	1.38
Tss	0.474
Total Organic Carbon	200
Total Phosphorous	48.8
Soc	2
Total Cyanide	48.8
Flow	0.155
	0.025 MGD

General Notes:

1 The sewer use ordinance information listed above was obtained from City of Niagara Falls Wastewater Facility in 2003.

2 The actual allowable contaminant loading for discharge of treated groundwater from the site to the POTW will be based on existing and anticipated system loading at the time a discharge permit is requested. According to the Industrial Monitoring Coordinator for the POTW, it is expected that a higher limit (than list above) for some contaminants may be allowed. The treatment component of the groundwater alternatives were developed based on general anticipated limits described by the POTW for some contaminants as well as the more restrictive requirements for the others (as listed above).

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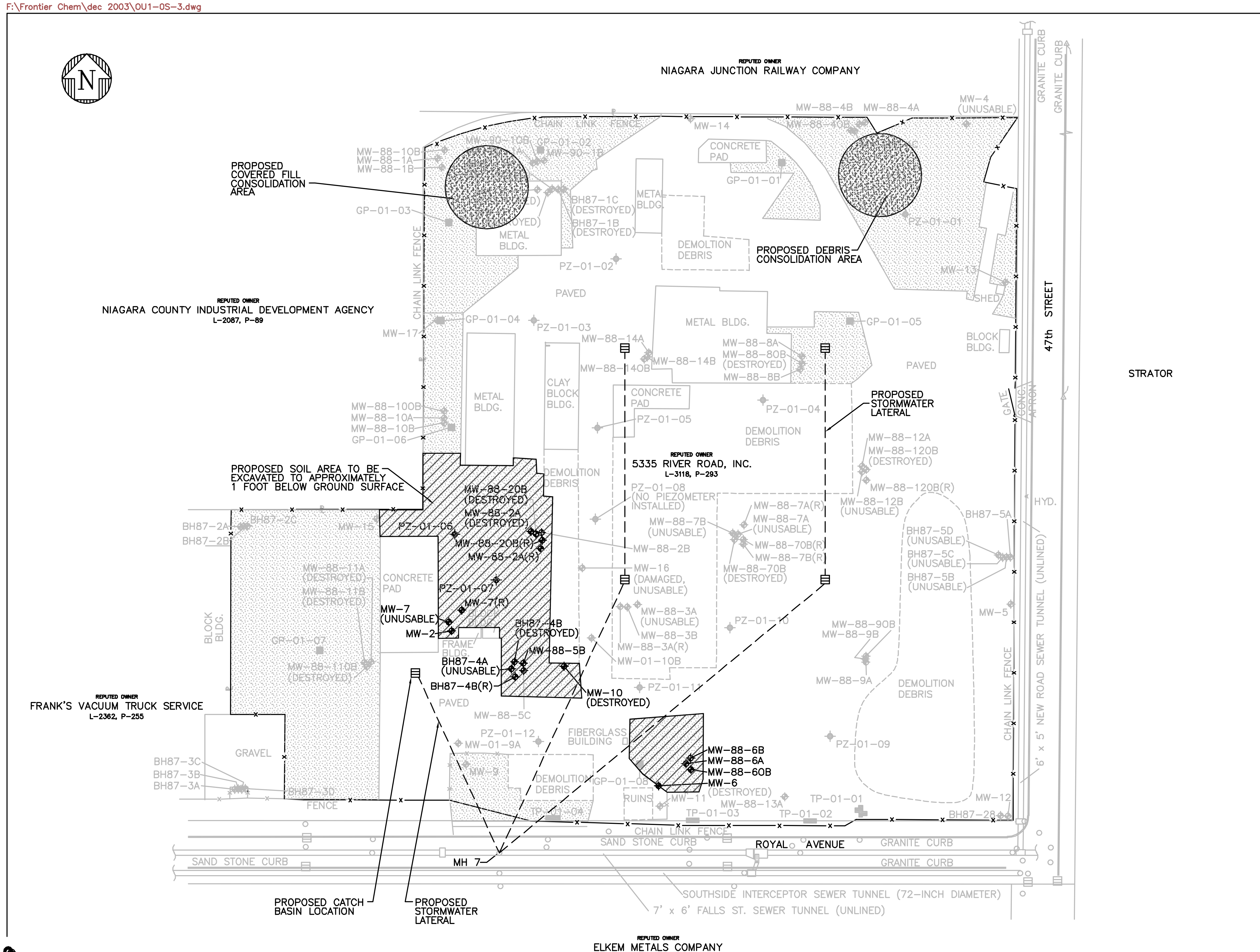

ecology and environment

LEGEND:

- UNPAVED AREAS
- PROPOSED SOIL AREA TO BE EXCAVATED TO APPROXIMATELY 1 FOOT BELOW GROUND SURFACE
- PROPERTY LINE
- MW-88-90B — EXISTING WELL
- MW-88-90B — PROPOSED MONITORING WELL TO BE DECOMMISSIONED
- PZ-01-01 — SRI PIEZOMETER LOCATION
- PZ-01-01 — PROPOSED PIEZOMETER TO BE DECOMMISSIONED
- GP-01-01 — SRI GEOPROBE SOIL BORING LOCATION
- TP-01-02 — SRI TEST PIT LOCATION
- EXISTING RECEIVER
- PROPOSED CATCH BASIN
- EXISTING MANHOLE
- OUTLINE OF DEMOLISHED BLDGS./ STRUCTURES OR DEBRIS PILE
- OUTLINE OF EXISTING BLDG. OR EXISTING CONCRETE PAD
- EXISTING FENCE

NOTES:

1) HORIZONTAL DATUM IS BASED ON THE NEW YORK STATE PLANE COORDINATE SYSTEM WEST ZONE NAD83/92HARN (FEET).

2) REFERENCE MAP – CITY OF NIAGARA FALLS TAX MAP NO. 160.09.

3) PROPERTY LINES SHOWN ARE APPROXIMATE IN LOCATION AND ARE BASED UPON THE ABOVE REFERENCED TAX MAP. PROPERTY OWNER INFORMATION IS BASED ON THE TAX MAP AND CITY OF NIAGARA FALLS WASTEWATER FACILITIES DRAWINGS.

4) NOT ALL PLANIMETRIC/TOPOGRAPHIC FEATURES WERE IDENTIFIED AS PART OF THIS PROJECT SCOPE.

5) SRI WELLS/PIEZOMETERS/GEOPROBE/TEST PIT LOCATIONS ARE SHOWN WITH BOLD TEXT.

6) SRI = SUPPLEMENTAL REMEDIAL INVESTIGATION.

7) SELECT UTILITY LINES AND SEWER TUNNELS LOCATIONS AND SIZES APPROXIMATE ARE BASED ON DRAWINGS PROVIDED BY CITY OF NIAGARA FALLS DEPT. OF WASTEWATER FACILITIES.

8) BASE MAP PROVIDED BY McINTOSH & McINTOSH, P.C. ON 3/11/02. ECOLOGY & ENVIRONMENT FIELD OBSERVATIONS ALSO INCLUDED.

9) FIELD OBSERVATIONS NOTED HEREON, REGARDING THE FUNCTIONING OF WELLS (e.g., UNUSABLE), WERE MADE ON OCTOBER 9, 2001.

10) FOR DELINEATION OF OVERBURDEN, A-FRACTURE ZONE, B-FRACTURE ZONE, C-FRACTURE ZONE, AND SRI MONITORING WELLS REFER TO SRI (E&E NOVEMBER 2002).

11) PRIOR TO CONSTRUCTION ACTIVITIES IT IS ASSUMED EXISTING BUILDINGS, FOUNDATIONS, ETC. TO BE DEMOLISHED TO GROUND SURFACE AND STOCKPILED IN NORTHEAST AND NORTHWEST CORNERS OF THE SITE; PERIMETER FENCE WILL REMAIN.

12) STOCKPILE SIZES AND LOCATIONS SHOWN AS APPROXIMATE; TO BE FIELD LOCATED.

SCALE IN FEET

0 100 200 300

FIGURE 3-1 OU1-ALTERNATIVE NO. OS-3- COVER
FORMER FRONTIER CHEMICAL WASTE PROCESS, INC. SITE
NIAGARA FALLS, NEW YORK

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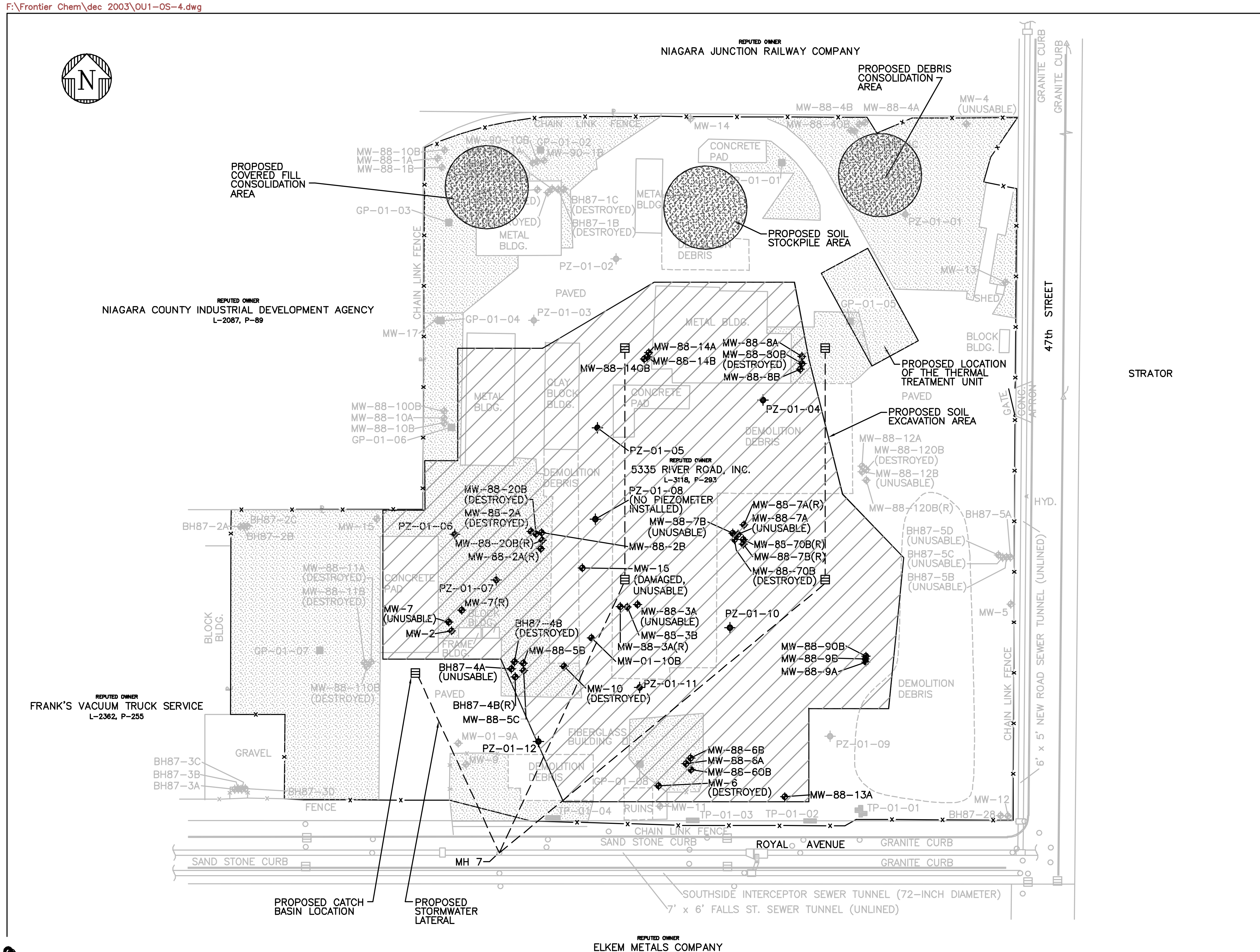

ecology and environment

LEGEND:

- UNPAVED AREAS
- PROPOSED SOIL EXCAVATION AREA TO BE TREATED ON-SITE
- PROPERTY LINE
- MW-88-4B — EXISTING WELL
- MW-88-140B — PROPOSED MONITORING WELL TO BE DECOMMISSIONED
- PZ-01-01 — SRI PIEZOMETER LOCATION
- PZ-01-05 — PROPOSED PIEZOMETER LOCATION TO BE DECOMMISSIONED
- GP-01-01 — SRI GEOPROBE SOIL BORING LOCATION
- TP-01-02 — SRI TEST PIT LOCATION
- EXISTING RECEIVER
- PROPOSED CATCH BASIN
- MANHOLE
- OUTLINE OF DEMOLISHED BLDGS./ STRUCTURES OR DEBRIS PILE
- OUTLINE OF EXISTING BLDG. OR EXISTING CONCRETE PAD
- EXISTING FENCE

NOTES:

1) HORIZONTAL DATUM IS BASED ON THE NEW YORK STATE PLANE COORDINATE SYSTEM WEST ZONE NAD83/92HARN (FEET).
2) REFERENCE MAP – CITY OF NIAGARA FALLS TAX MAP NO. 160.09.
3) PROPERTY LINES SHOWN ARE APPROXIMATE IN LOCATION AND ARE BASED UPON THE ABOVE REFERENCED TAX MAP. PROPERTY OWNER INFORMATION IS BASED ON THE TAX MAP AND CITY OF NIAGARA FALLS WASTEWATER FACILITIES DRAWINGS.
4) NOT ALL PLANIMETRIC/TOPOGRAPHIC FEATURES WERE IDENTIFIED AS PART OF THIS PROJECT SCOPE.
5) SRI WELLS/PIEZOMETERS/GEOPROBE/TEST PIT LOCATIONS ARE SHOWN WITH BOLD TEXT.
6) SRI = SUPPLEMENTAL REMEDIAL INVESTIGATION.
7) SELECT UTILITY LINES AND SEWER TUNNELS LOCATIONS AND SIZES APPROXIMATE ARE BASED ON DRAWINGS PROVIDED BY CITY OF NIAGARA FALLS DEPT. OF WASTEWATER FACILITIES.
8) BASE MAP PROVIDED BY McINTOSH & McINTOSH, P.C. ON 3/11/02. ECOLOGY & ENVIRONMENT FIELD OBSERVATIONS ALSO INCLUDED.
9) FIELD OBSERVATIONS NOTED HEREON, REGARDING THE FUNCTIONING OF WELLS (e.g., UNUSABLE), WERE MADE ON OCTOBER 9, 2001.
10) FOR DELINEATION OF OVERBURDEN, A-FRACTURE ZONE, B-FRACTURE ZONE, C-FRACTURE ZONE, AND SRI MONITORING WELLS REFER TO SRI (E&E NOVEMBER 2002).
11) PRIOR TO SOIL EXCAVATION ACTIVITIES IT IS ASSUMED EXISTING BUILDINGS, FOUNDATIONS, ETC. TO BE DEMOLISHED TO GROUND SURFACE AND STOCKPILED IN NORTHEAST AND NORTHWEST CORNERS OF THE SITE; PERIMETER FENCE WILL REMAIN.
12) LIMITS OF EXCAVATION ARE SHOWN AT GRADE; DEPTH OF EXCAVATION TO BE APPROXIMATELY 5.5 FEET.
13) STOCKPILE SIZES AND LOCATIONS SHOWN AS APPROXIMATE; TO BE FIELD LOCATED.

SCALE IN FEET

0 100 200 300

FIGURE 3-2 OU1-ALTERNATIVE NO. OS-4- EXCAVATION & ON-SITE TREATMENT OF OVERBURDEN SOURCE SOILS FORMER FRONTIER CHEMICAL WASTE PROCESS, INC. SITE NIAGARA FALLS, NEW YORK

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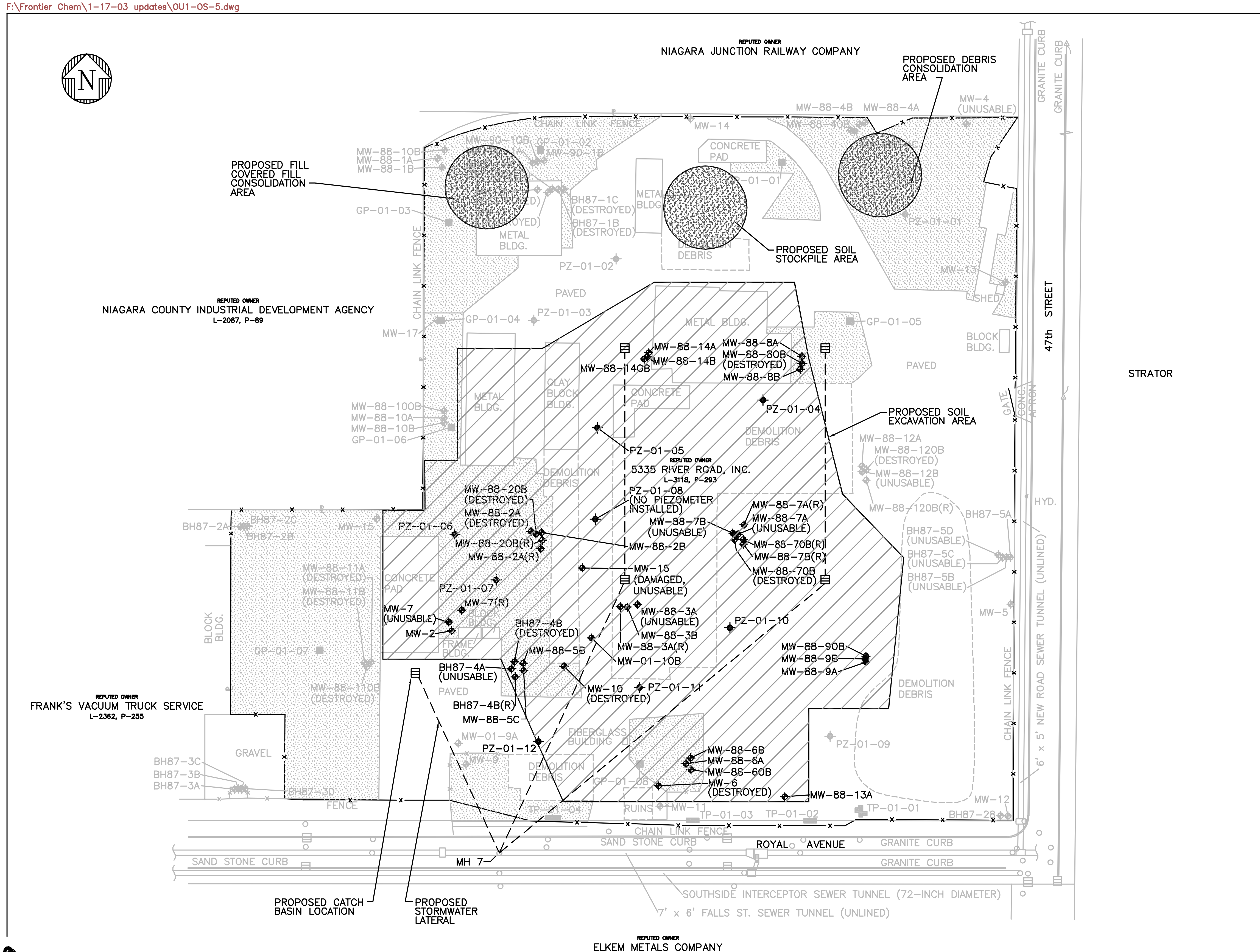


LEGEND:

	UNPAVED AREAS
	PROPOSED SOIL EXCAVATION AREA TO BE TREATED/DISPOSED OFF-SITE
	PROPERTY LINE
MW-88-4B	EXISTING WELL
MW-88-140B	PROPOSED MONITORING WELL TO BE DECOMMISSIONED
PZ-01-01	SRI PIEZOMETER LOCATION
PZ-01-05	PROPOSED PIEZOMETER LOCATION TO BE DECOMMISSIONED
GP-01-01	SRI GEOPROBE SOIL BORING LOCATION
TP-01-02	SRI TEST PIT LOCATION
	EXISTING RECEIVER
	PROPOSED CATCH BASIN
	MANHOLE
	OUTLINE OF DEMOLISHED BLDGS./ STRUCTURES OR DEBRIS PILE
	OUTLINE OF EXISTING BLDG. OR EXISTING CONCRETE PAD
	EXISTING FENCE

NOTES:

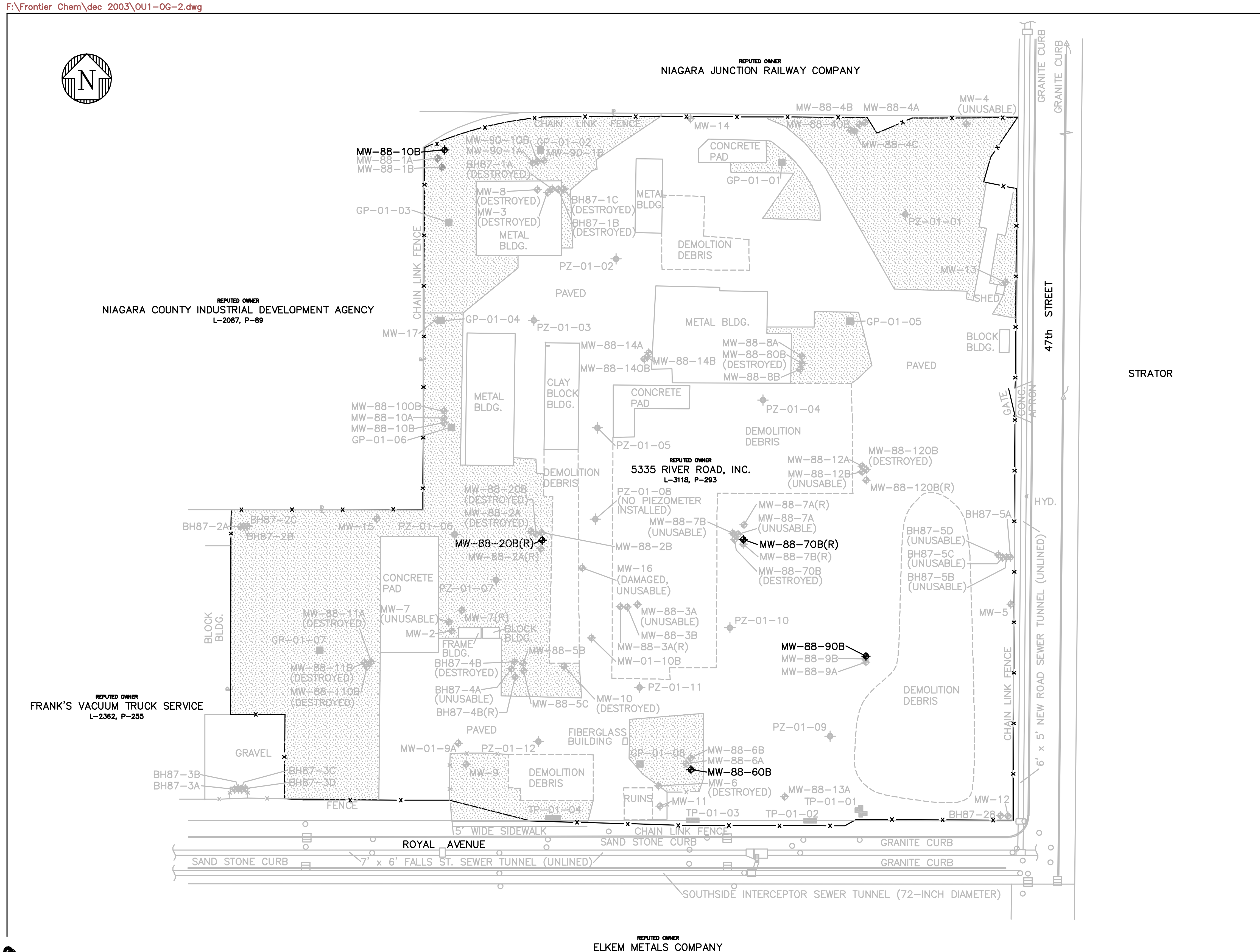
1) HORIZONTAL DATUM IS BASED ON THE NEW YORK STATE PLANE COORDINATE SYSTEM WEST ZONE NAD83/92HARN (FEET).
2) REFERENCE MAP – CITY OF NIAGARA FALLS TAX MAP NO. 160.09.
3) PROPERTY LINES SHOWN ARE APPROXIMATE IN LOCATION AND ARE BASED UPON THE ABOVE REFERENCED TAX MAP. PROPERTY OWNER INFORMATION IS BASED ON THE TAX MAP AND CITY OF NIAGARA FALLS WASTEWATER FACILITIES DRAWINGS.
4) NOT ALL PLANIMETRIC/TOPOGRAPHIC FEATURES WERE IDENTIFIED AS PART OF THIS PROJECT SCOPE.
5) SRI WELLS/PIEZOMETERS/GEOPROBE/TEST PIT LOCATIONS ARE SHOWN WITH BOLD TEXT.
6) SRI = SUPPLEMENTAL REMEDIAL INVESTIGATION.
7) SELECT UTILITY LINES AND SEWER TUNNELS LOCATIONS AND SIZES APPROXIMATE ARE BASED ON DRAWINGS PROVIDED BY CITY OF NIAGARA FALLS DEPT. OF WASTEWATER FACILITIES.
8) BASE MAP PROVIDED BY McINTOSH & McINTOSH, P.C. ON 3/11/02. ECOLOGY & ENVIRONMENT FIELD OBSERVATIONS ALSO INCLUDED.
9) FIELD OBSERVATIONS NOTED HEREON, REGARDING THE FUNCTIONING OF WELLS (e.g., UNUSABLE), WERE MADE ON OCTOBER 9, 2001.
10) FOR DELINEATION OF OVERBURDEN, A-FRACTURE ZONE, B-FRACTURE ZONE, C-FRACTURE ZONE, AND SRI MONITORING WELLS REFER TO SRI (E&E NOVEMBER 2002).
11) PRIOR TO SOIL EXCAVATION ACTIVITIES IT IS ASSUMED EXISTING BUILDINGS, FOUNDATIONS, ETC. TO BE DEMOLISHED TO GROUND SURFACE AND STOCKPILED IN NORTHEAST AND NORTHWEST CORNERS OF THE SITE; PERIMETER FENCE WILL REMAIN.
12) LIMITS OF EXCAVATION ARE SHOWN AT GRADE; DEPTH OF EXCAVATION TO BE APPROXIMATELY 5.5 FEET.
13) STOCKPILE SIZES AND LOCATIONS SHOWN AS APPROXIMATE; TO BE FIELD LOCATED.

SCALE IN FEET

0 100 200 300

ecology and environment

FIGURE 3-3 OU1-ALTERNATIVE NO. OS-5– EXCAVATION & OFF-SITE TREATMENT/ DISPOSAL OF OVERBURDEN SOURCE SOILS FORMER FRONTIER CHEMICAL WASTE PROCESS, INC. SITE NIAGARA FALLS, NEW YORK



LEGEND:

UNPAVED AREAS
PROPERTY LINE
MW-88-4C EXISTING WELL
MW-88-90B PROPOSED WELL TO BE SAMPLED DURING LONG-TERM MONITORING PROGRAM
PZ-01-01 SRI PIEZOMETER LOCATION
GP-01-01 SRI GEOPROBE SOIL BORING LOCATION
TP-01-02 SRI TEST PIT LOCATION
RECEIVER
MANHOLE
OUTLINE OF DEMOLISHED BLDGS./ STRUCTURES OR DEBRIS PILE
OUTLINE OF EXISTING BLDG. OR EXISTING CONCRETE PAD
EXISTING FENCE

NOTES:

1) HORIZONTAL DATUM IS BASED ON THE NEW YORK STATE PLANE COORDINATE SYSTEM WEST ZONE NAD83/92HARN (FEET).

2) REFERENCE MAP – CITY OF NIAGARA FALLS TAX MAP NO. 160.09.

3) PROPERTY LINES SHOWN ARE APPROXIMATE IN LOCATION AND ARE BASED UPON THE ABOVE REFERENCED TAX MAP. PROPERTY OWNER INFORMATION IS BASED ON THE TAX MAP AND CITY OF NIAGARA FALLS WASTEWATER FACILITIES DRAWINGS.

4) NOT ALL PLANIMETRIC/TOPOGRAPHIC FEATURES WERE IDENTIFIED AS PART OF THIS PROJECT SCOPE.

5) SRI WELLS/PIEZOMETERS/GEOPROBE/TEST PIT LOCATIONS ARE SHOWN WITH BOLD TEXT.

6) SRI = SUPPLEMENTAL REMEDIAL INVESTIGATION.

7) SELECT UTILITY LINES AND SEWER TUNNELS LOCATIONS AND SIZES APPROXIMATE ARE BASED ON DRAWINGS PROVIDED BY CITY OF NIAGARA FALLS DEPT. OF WASTEWATER FACILITIES.

8) BASE MAP PROVIDED BY McINTOSH & McINTOSH, P.C. ON 3/11/02. ECOLOGY & ENVIRONMENT FIELD OBSERVATIONS ALSO INCLUDED.

9) FIELD OBSERVATIONS NOTED HEREON, REGARDING THE FUNCTIONING OF WELLS (e.g., UNUSABLE), WERE MADE ON OCTOBER 9, 2001.

10) FOR DELINEATION OF OVERBURDEN, A-FRACTURE ZONE, B-FRACTURE ZONE, C-FRACTURE ZONE, AND SRI MONITORING WELLS REFER TO SRI (E&E NOVEMBER 2002).

SCALE IN FEET
0 100 200 300

ecology and environment

FIGURE 3-4 OU1-ALTERNATIVE NO. OG-2- INSTITUTIONAL CONTROLS FORMER FRONTIER CHEMICAL WASTE PROCESS, INC. SITE NIAGARA FALLS, NEW YORK

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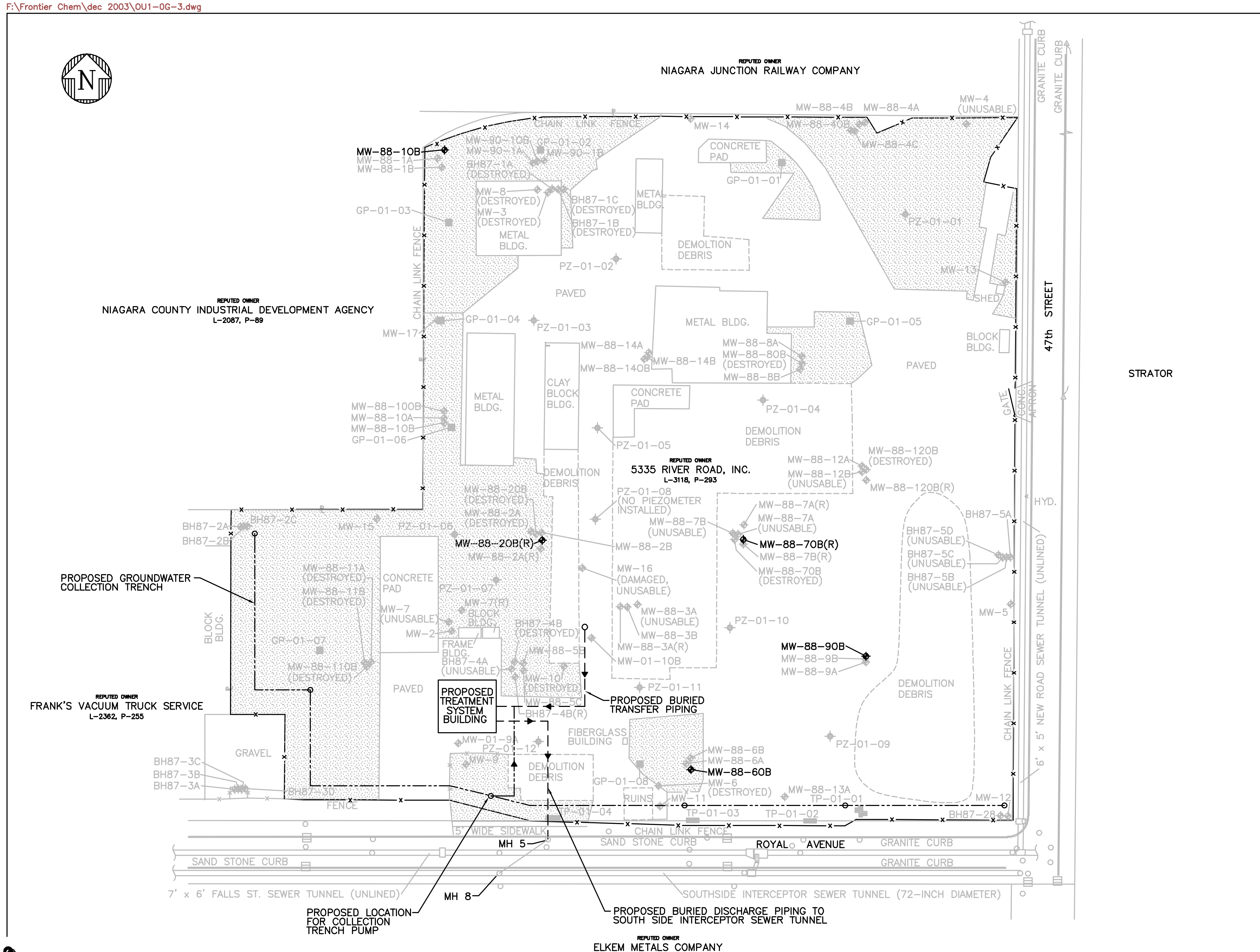

LEGEND:

- UNPAVED AREAS
- PROPERTY LINE
- MW-88-90B — EXISTING WELL
- PROPOSED OVERBURDEN EXTRACTION WELL
- MW-88-90B — PROPOSED WELL TO BE SAMPLED DURING LONG TERM MONITORING PROGRAM
- PZ-01-01 — SRI PIEZOMETER LOCATION
- GP-01-01 — SRI GEOPROBE SOIL BORING LOCATION
- TP-01-02 — SRI TEST PIT LOCATION
- RECEIVER
- EXISTING MANHOLE
- PROPOSED MANHOLE
- OUTLINE OF DEMOLISHED BLDGS./ STRUCTURES OR DEBRIS PILE
- OUTLINE OF EXISTING BLDG. OR EXISTING CONCRETE PAD
- EXISTING FENCE

NOTES:

1) HORIZONTAL DATUM IS BASED ON THE NEW YORK STATE PLANE COORDINATE SYSTEM WEST ZONE NAD83/92HARN (FEET).

2) REFERENCE MAP – CITY OF NIAGARA FALLS TAX MAP NO. 160.09.

3) PROPERTY LINES SHOWN ARE APPROXIMATE IN LOCATION AND ARE BASED UPON THE ABOVE REFERENCED TAX MAP. PROPERTY OWNER INFORMATION IS BASED ON THE TAX MAP AND CITY OF NIAGARA FALLS WASTEWATER FACILITIES DRAWINGS.

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9) FIELD OBSERVATIONS NOTED HEREON, REGARDING THE FUNCTIONING OF WELLS (e.g., UNUSABLE), WERE MADE ON OCTOBER 9, 2001.

10) FOR DELINEATION OF OVERBURDEN, A-FRACTURE ZONE, B-FRACTURE ZONE, C-FRACTURE ZONE, AND SRI MONITORING WELLS REFER TO SRI (E&E NOVEMBER 2002).

11) TREATMENT SYSTEM POWER SOURCE WILL BE PROVIDED THROUGH AN OVERHEAD WIRE CONNECTION ON ROYAL AVENUE OR 47TH STREET.

SCALE IN FEET

0 100 200 300

ecology and environment

FIGURE 3-5 OU1-ALTERNATIVE NO. OG-3- OVERBURDEN GROUNDWATER HYDRAULIC CONTAINMENT FORMER FRONTIER CHEMICAL WASTE PROCESS, INC. SITE NIAGARA FALLS, NEW YORK

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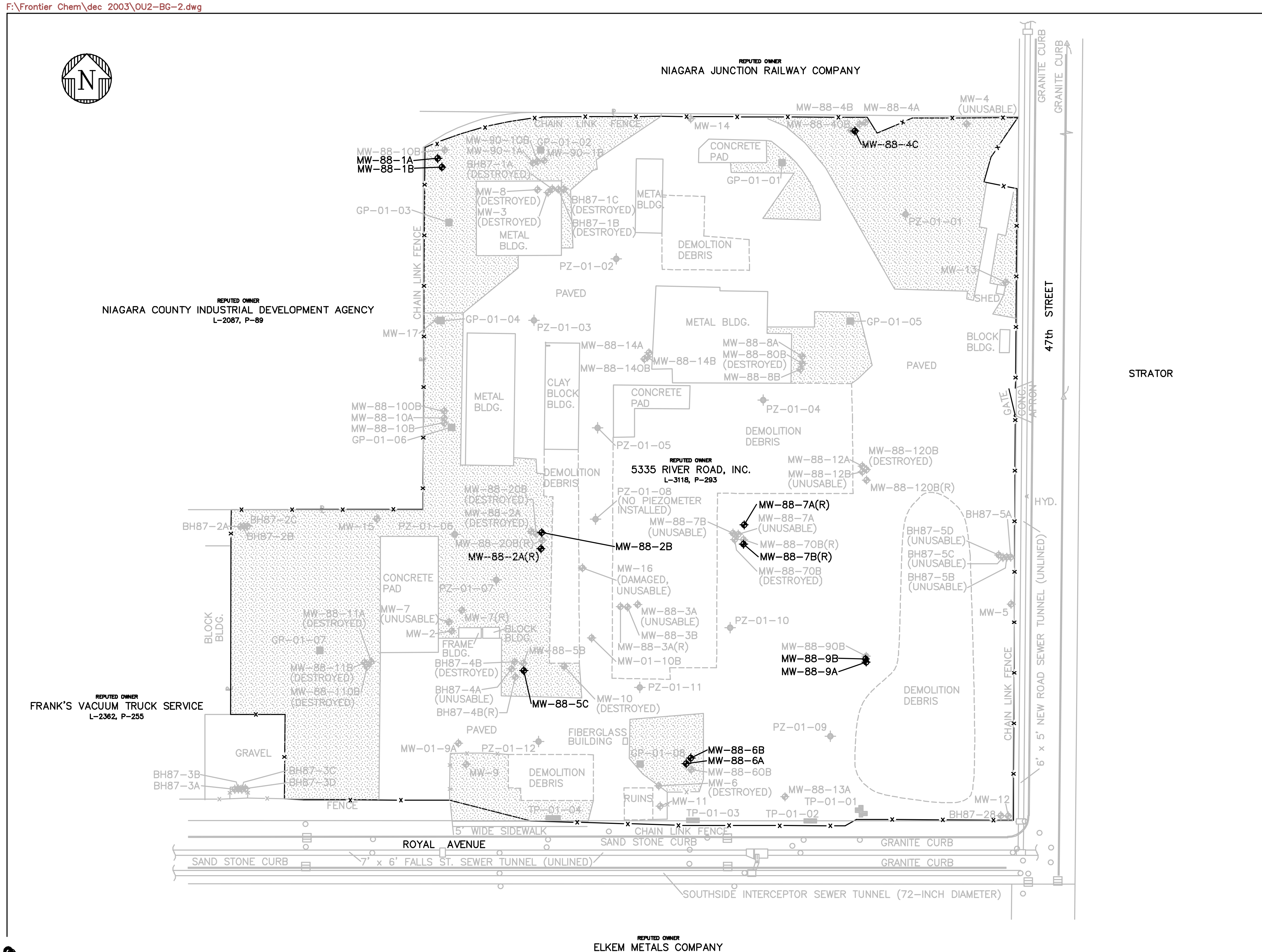

LEGEND:

	UNPAVED AREAS
	PROPERTY LINE
MW-88-90B	EXISTING WELL
MW-88-4C	PROPOSED WELL TO BE SAMPLED DURING LONG-TERM MONITORING PROGRAM
PZ-01-01	SRI PIEZOMETER LOCATION
GP-01-01	SRI GEOPROBE SOIL BORING LOCATION
TP-01-02	SRI TEST PIT LOCATION
	RECEIVER
	MANHOLE
	OUTLINE OF DEMOLISHED BLDGS./ STRUCTURES OR DEBRIS PILE
	OUTLINE OF EXISTING BLDG. OR EXISTING CONCRETE PAD
	EXISTING FENCE

NOTES:

1) HORIZONTAL DATUM IS BASED ON THE NEW YORK STATE PLANE COORDINATE SYSTEM WEST ZONE NAD83/92HARN (FEET).

2) REFERENCE MAP – CITY OF NIAGARA FALLS TAX MAP NO. 160.09.

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7) SELECT UTILITY LINES AND SEWER TUNNELS LOCATIONS AND SIZES APPROXIMATE ARE BASED ON DRAWINGS PROVIDED BY CITY OF NIAGARA FALLS DEPT. OF WASTEWATER FACILITIES.

8) BASE MAP PROVIDED BY McINTOSH & McINTOSH, P.C. ON 3/11/02. ECOLOGY & ENVIRONMENT FIELD OBSERVATIONS ALSO INCLUDED.

9) FIELD OBSERVATIONS NOTED HEREON, REGARDING THE FUNCTIONING OF WELLS (e.g., UNUSABLE), WERE MADE ON OCTOBER 9, 2001.

10) FOR DELINEATION OF OVERBURDEN, A-FRACTURE ZONE, B-FRACTURE ZONE, C-FRACTURE ZONE, AND SRI MONITORING WELLS REFER TO SRI (E&E NOVEMBER 2002).

SCALE IN FEET

0 100 200 300

ecology and environment

FIGURE 3-6 OU2-ALTERNATIVE NO. BG-2– INSTITUTIONAL CONTROLS FORMER FRONTIER CHEMICAL WASTE PROCESS, INC. SITE NIAGARA FALLS, NEW YORK

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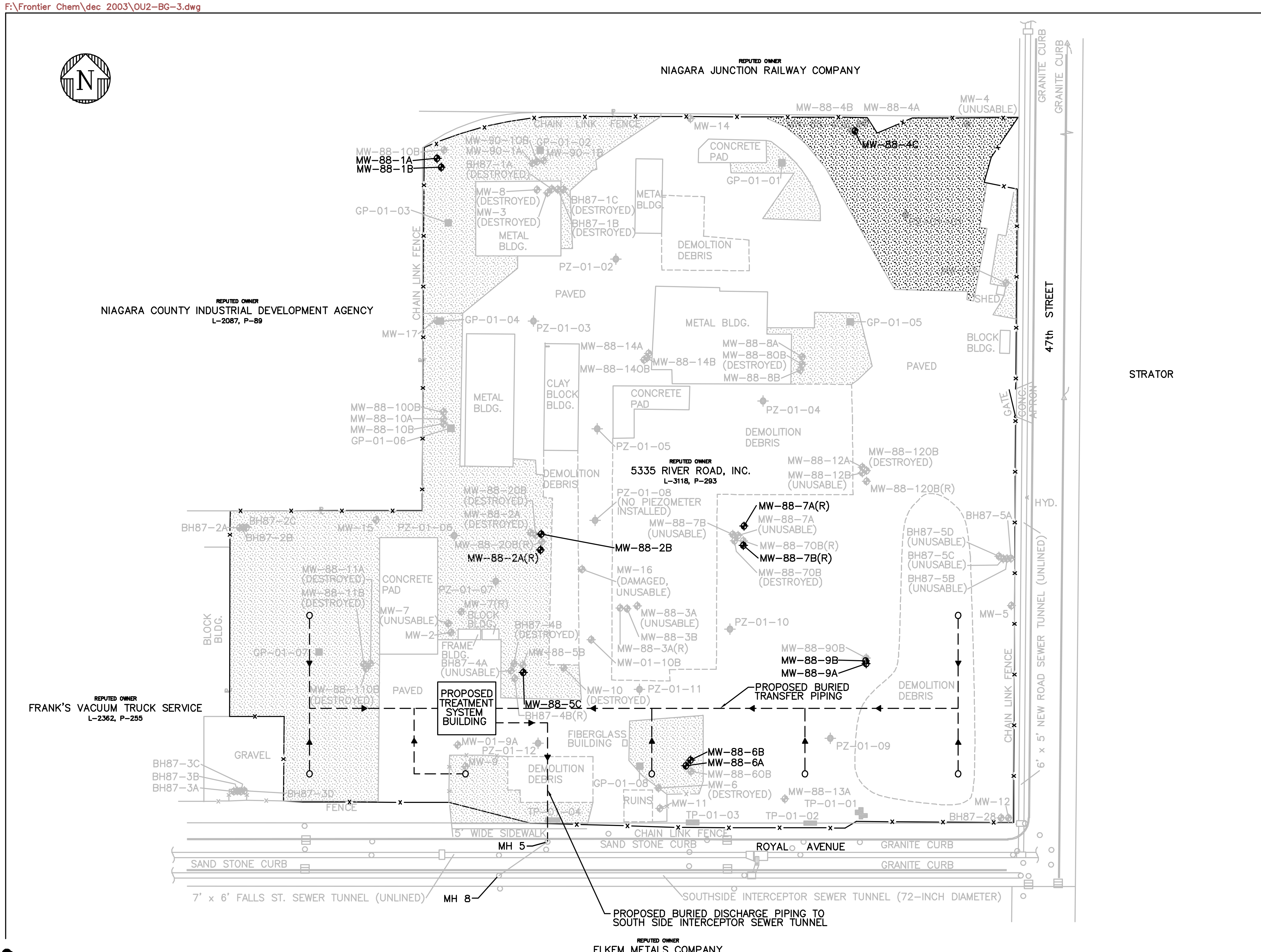

LEGEND:

- UNPAVED AREAS
- PROPERTY LINE
- MW-88-90B EXISTING WELL
- PROPOSED BEDROCK EXTRACTION WELL
- MW-88-90B PROPOSED WELL TO BE SAMPLED DURIN LONG TERM MONITORING PROGRAM
- PZ-01-01 SRI PIEZOMETER LOCATION
- GP-01-01 SRI GEOPROBE SOIL BORING LOCATION
- TP-01-02 SRI TEST PIT LOCATION
- RECEIVER
- MANHOLE
- OUTLINE OF DEMOLISHED BLDGS./ STRUCTURES OR DEBRIS PILE
- OUTLINE OF EXISTING BLDG. OR EXISTING CONCRETE PAD
- EXISTING FENCE

NOTES:

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5) SRI WELLS/PIEZOMETERS/GEOPROBE/TEST PIT LOCATIONS ARE SHOWN WITH BOLD TEXT.
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8) BASE MAP PROVIDED BY McINTOSH & McINTOSH, P.C. ON 3/11/02. ECOLOGY & ENVIRONMENT FIELD OBSERVATIONS ALSO INCLUDED.
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10) FOR DELINEATION OF OVERBURDEN, A-FRACTURE ZONE, B-FRACTURE ZONE, C-FRACTURE ZONE, AND SRI MONITORING WELLS REFER TO SRI (E&E NOVEMBER 2002).
11) TREATMENT SYSTEM POWER SOURCE WILL BE PROVIDED THROUGH AN OVERHEAD WIRE CONNECTION ON ROYAL AVENUE OR 47TH STREET.

SCALE IN FEET

0 100 200 300

ecology and environment

FIGURE 3-7 OU2-ALTERNATIVE NO. BG-3- BEDROCK GROUNDWATER HYDRAULIC CONTAINMENT FORMER FRONTIER CHEMICAL WASTE PROCESS, INC. SITE NIAGARA FALLS, NEW YORK

4 Detailed Analysis of Alternatives

4.1 Introduction

The purpose of the detailed analysis of remedial action alternatives is to present the relevant information for selecting an on-site remedy. In the detailed analysis the alternatives established in Section 3 are compared on the basis of environmental benefits and costs using criteria established by NYSDEC in TAGM 4030. This approach is intended to provide needed information to compare the merits of each alternative and select an appropriate remedy that satisfies the remedial action objectives for the site.

This section first presents a summary of the seven evaluation criteria (six environmental criteria in TAGM 4030 plus a cost criterion) that were used to evaluate the alternatives.

Overall Protection of Human Health and the Environment

This criterion provides an overall assessment of protection of human health and the environment and is based on a composite of factors assessed under the evaluation criteria, especially short-term effectiveness, long-term effectiveness and performance, and compliance with cleanup goals.

Compliance with SCGs

This criterion is used to evaluate the extent to which each alternative may achieve the proposed cleanup goals. The proposed cleanup goals were developed based on SCGs presented in Section 2.

Short-Term Impacts and Effectiveness

This criterion addresses the impacts of the alternative during the construction and implementation phase until the RAOs are met. Factors to be evaluated include protection of the community during the remedial actions; protection of workers during the remedial actions; and the time required to achieve the remedial action objectives. Several alternatives described within the following sections may not be effective in meeting remedial action objectives in less than 30 years. Therefore, references to short-term impacts and effectiveness may include discussions of impacts/effectiveness over a period of 30 years.

Long-Term Effectiveness and Permanence

This criterion addresses the long-term protection of human health and the environment after completion of the remedial action. An assessment is made of the effectiveness of the remedial action in managing the risk posed by untreated wastes and/or the residual contamination remaining after treatment and the long-term reliability of the remedial action.

Reduction of Toxicity, Mobility, and Volume

This criterion addresses NYSDEC's preference for selecting "remedial technologies that permanently and significantly reduce the toxicity, mobility and volume" of the contaminants of concern at the site. This evaluation consists of assessing the extent to which the treatment technology destroys toxic contaminants, reduces mobility of the contaminants using irreversible treatment processes, and/or reduces the total volume of contaminated media.

Implementability

This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of services and materials required during implementation. Technical feasibility refers to the ability to construct and operate a remedial action for the specific conditions at the site and the availability of necessary equipment and technical specialists. Technical feasibility also considers construction and operation and maintenance difficulties, reliability, ease of undertaking additional remedial action (if required), and the ability to monitor effectiveness. Administrative feasibility refers to compliance with applicable rules, regulations, and statutes and the ability to obtain permits or approvals from government agencies or offices.

Cost

The estimated capital costs, long-term operation and maintenance costs, and environmental monitoring costs are evaluated. The estimates included herein (unless otherwise noted) assume engineering costs would equal 15% of the capital costs and contingency/administrative costs would equal 10% of the capital costs. A present-worth analysis is made to compare the remedial alternatives on the basis of a single dollar amount for the base year. For the present-worth analysis, assumptions are made regarding the interest rate applicable to borrowed funds and the average inflation rate. It is also assumed that a 30-year operational period would be necessary for groundwater control systems and site monitoring. The comparative cost estimates are intended to reflect actual costs with an accuracy of +50% to –30%.

The detailed analysis (presented below) focuses on the contaminants of concern at the site (VOCs). However, it should be noted that other contaminants such as metals and SVOCs are present on-site above proposed cleanup goals. These other contaminants are generally located proximate to the soils containing high levels of VOCs. Some of these contaminants (such as metals) are not expected to naturally attenuate significantly over time. Therefore, considering the high levels of VOCs present and other contaminants that do not readily naturally attenuate, the natural attenuation processes are not considered a significant mechanism for contaminant reduction on-site.

RAOs (as described in Sections 2.3.1 and 2.3.2) are discussed (including in terms of the time required to meet RAOs) in the short-term impacts and effectiveness section for each alternative. Additionally, a brief summary of the detailed analysis is included at the end of each alternative.

The following alternatives are evaluated individually in terms of the six environmental criteria and the cost criterion described above.

4.2 OU-1 Soil Remedial Alternatives

4.2.1 Alternative No. OS-1: No Action

The No Action alternative is presented as a baseline for comparison with other alternatives. This alternative does not include remedial action, institutional or engineering controls, or long-term monitoring.

Overall Protection of Human Health and the Environment

This alternative is not protective of human health and the environment, because the site would remain in its present condition. Subsurface soils would serve as a continuing source of impact to groundwater. Uncontrolled excavations or entering subsurface structures could lead to risk to human health.

Compliance with SCGs

The contaminant levels in soil are not expected to decrease appreciably over time. Therefore, this alternative would not comply with the chemical-specific SCGs for the site.

Short-Term Impacts and Effectiveness

No short-term impacts (other than those existing) are anticipated during the implementation of this alternative since there are no remedial activities involved.

This alternative does not include source removal or treatment and would not meet any of the three RAOs (as defined in Section 2.3.1) in a reasonable or predictable timeframe.

Long-term Effectiveness and Permanence

This alternative would not be effective in the long-term because this alternative does not involve removal or treatment of the contaminated soil. The risks involved with direct contact with contaminants would remain the same.

Reduction in Toxicity, Mobility, or Volume

This alternative does not involve the removal or treatment of contaminated soil. Therefore, neither the toxicity, nor mobility, nor volume of contamination is expected to be reduced. Natural attenuation of contaminants may reduce the concentrations in soil over time. However, this reduction is not expected to be significant within a reasonable or predictable timeframe.

Implementability

This alternative is readily implementable on a technical basis in that it involves no actions.

Cost

There is no cost associated with this alternative.

Alternative OS-1 (No Action) is readily implementable with minimal short-term risks because no intrusive work would be done. However, this alternative leaves the soil contamination in place (unchanged) and does not reduce or eliminate existing risks.

4.2.2 Alternative No. OS-2: Institutional Controls

Institutional controls such as access/use and deed restrictions at the Frontier Chemical site would include utilizing the existing fencing and posting signs. Deed restrictions would be filed to control future use/activities at the site. It is assumed that the existing site fencing is adequate to restrict access and long- term O&M is not needed. Like Alternative OS-1, this alternative does not include remedial action or long-term monitoring.

Overall Protection of Human Health and the Environment

Because this alternative includes placement of institutional controls such as access and deed restrictions (that would control future use/activities at the site), it would provide some long-term protection of human health. It is difficult to ensure enforcement of institutional controls in the future. Fencing alone may not be adequate to prevent unauthorized access to the site by trespassers (who could potentially directly contact contaminants). Since subsurface soils would serve as a continuing source of impact to groundwater, this alternative may not be protective of the environment.

Compliance with SCGs

The contaminant levels in soil are not expected to decrease appreciably over time. Therefore, this alternative would not comply with the chemical-specific SCGs for the site. Action-specific SCGs (e.g., safety regulations) would be included in the institutional controls and complied with for site activities.

Short-Term Impacts and Effectiveness

No short-term impacts (other than those existing) are anticipated during the implementation of this alternative since there are no remedial activities involved. Controlling future use and activities on-site would protect workers' health. This alternative would provide some protection to the community by limiting site access.

This alternative meets one of the three soil RAOs. It reduces (to the extent practicable) the potential for direct contact with on-site contaminated soil. However, it does not significantly eliminate the potential for human exposure to organic vapors (due to the presence of existing on-site structures) and does not adequately reduce the risk of further contamination of groundwater.

Long-term Effectiveness and Permanence

This alternative would not be effective in the long term (in terms of protecting human health and the environment) because this alternative does not involve removal or treatment of the contaminated soil. The risks involved with direct contact with on-site contaminants would be limited to some extent. Deed or other restrictions would be effective in the long term as long as they are interpreted correctly and/or are not modified by future site users. Subsurface soils would serve as a continuing source of impact to groundwater.

Reduction in Toxicity, Mobility, or Volume

This alternative does not involve the removal or treatment of contaminated soil. Therefore, neither the toxicity, nor mobility, nor volume of contamination is expected to be reduced. Natural attenuation of contaminants may somewhat reduce the concentrations in soil over time. However, this reduction is not expected to be significant within a reasonable or predictable timeframe.

Implementability

This alternative can be readily implemented on a technical and administrative basis using typical institutional control practices and procedures. However, it may be difficult to ensure long-term enforcement.

Cost

The total present-worth cost of this alternative based on a 30-year period and a discount rate 5% is $3,000. Table 4-1 presents the quantities, unit costs, and subtotal costs for the various work items in this alternative. No O&M cost are anticipated with this alternative.

Alternative OS-2 (institutional controls) is readily implementable with minimal short-term risks because no intrusive work would be done. This alternative reduces risks associated with direct contact with on-site soil contamination. However, the effectiveness of this alternative in reducing risks would be based on enforcement of the restrictions/controls over an extended period of time (greater than 30 years).

4.2.3 Alternative No. OS-3: Cover

The overall approach associated with this alternative is to provide a generally level, adequately drained site with either existing concrete and asphalt or about 1 foot of uncontaminated material at the surface, which would limit the potential for direct contact with contaminated soil. This alternative would include the removal of the top 12 inches of soil from unpaved areas of the site; demolition of remaining site buildings and foundations to existing surface grade; grading the site using "clean" rubblized demolition debris from the site to fill low areas and to create a low-profile cover over excavated soils in the northwestern portion of the site; segregation and stockpiling of unuseable or recyclable demolition debris;

installation of surface water drainage as necessary; and implementation of institutional controls (described as part of Alternative OS-2). It is assumed that asbestos is not present in existing on-site buildings. Long-term O&M would not be required for this alternative.

Overall Protection of Human Health and the Environment

Because this alternative includes covering contaminated near-surface soil as well as institutional controls (that would control future use/activities at the site), it would provide some long-term protection of human health. Human health exposure risks from harmful vapors associated with existing on-site structures and subsurface utilities (where vapors could accumulate) would be reduced with the demolition of these structures. Replacement structures may be designed to prevent infiltration of vapors. Since subsurface soils would serve as a continuing source of impact to groundwater, this alternative is not protective of the environment.

Compliance with SCGs

This alternative includes the relocation of impacted near-surface soil to minimize the potential for direct contact with contaminated soil. However, since all soil will remain on-site, this alternative would not comply with the chemical-specific SCGs for the site. Action-specific SCGs (e.g., safety regulations) would be included in the institutional controls and complied with for site activities.

Short-Term Impacts and Effectiveness

Several limited short-term impacts to the community and workers may arise during demolition activities, installation of surface water drainage piping, and excavation of contaminated surface soils. These impacts are primarily associated with the potential for air emissions (dust and VOCs) and noise. To minimize short-term impacts, site access would be restricted during construction and remediation activities and mitigation measures would be implemented as needed. Health and safety measures, including air monitoring and use of appropriate personal protective equipment, would be in place to protect workers. Equipment leaving the site would be decontaminated and a community air monitoring plan/program established to protect the surrounding community. Action levels would be set prior to intrusive work, and an appropriate corrective action would be implemented if these action levels are exceeded.

This alternative meets two of the three soil RAOs. It eliminates (to the extent practicable) the potential for direct contact with on-site contaminated soil and eliminates (to the extent practicable) the potential for human exposure to on-site organic vapors (by the removal of on-site structures) but does not adequately reduce the risk of further contamination of groundwater. The potential for volatile vapor migration off-site would remain. This could pose a human exposure risk.

Demolition and construction of the cover system is estimated to be complete in approximately six months.

Long-term Effectiveness and Permanence

This alternative would provide some long-term effectiveness (in terms of protecting human health) because the risks associated with direct contact with contaminants would be reduced by covering the contaminated soil (which provides a physical barrier), removing structures, and implementing institutional controls. However, long-term effectiveness (in terms of protecting the environment) may not be met due to subsurface soils continuing to provide a source of impact to groundwater. The potential for contaminated surface water runoff from the site would be reduced by the placement of the soil cover and installation of catch basins and associated piping.

Reduction in Toxicity, Mobility, or Volume

Excavated, contaminated surface soils would be consolidated on-site without treatment. Other contaminated subsurface soil would remain on-site. Therefore the toxicity, mobility, and volume of contamination would not be reduced.

Implementability

This alternative can be readily implemented on a technical and administrative basis using standard construction means/methods and typical institutional control practices/procedures. No technical difficulties are anticipated during demolition and construction activities. No delay is anticipated in obtaining the necessary approvals/permits from the state and local agencies or in placing institutional controls for implementation of this alternative.

Cost

The total present-worth cost of this alternative based on a 30-year period and a discount rate of 5% is $1,100,000. Table 4-2 presents the quantities, unit costs, and subtotal costs for the various work items in this alternative. No O&M costs are anticipated with this alternative.

Alternative OS-3 (cover) is readily implementable with minimal short-term risks. This alternative reduces the risks associated with directly contacting surface soil (by creating a barrier) and the risks associated with the potential for vapor accumulation in on-site structures. However, this alternative leaves subsurface soil contamination (above SCGs) in place and does not prevent off-site migration of vapors. These risks would continue since this alternative does not result in a reduction in toxicity, mobility, or volume.

4.2.4 Alternative No. OS-4: Excavation and On-site Treatment of Soils

The overall approach associated with this alternative is to excavate the contaminated source soils (greater than 10 ppm total VOCs) from above the groundwater table (about 5.5 feet bgs), treat the contaminated soils on-site by thermal desorption, and return the treated soils to the excavation. Vapor suppression would be needed to limit off-site vapor migration from the excavation area. This alternative includes actions described as part of Alternative OS-3 (cover) as well as institutional controls. Long-term O&M would not be required for this alternative.

Overall Protection of Human Health and the Environment

Although the entire extent of contaminated soils would not be removed from the site, this alternative is considered protective of human health (with respect to soil exposure) since contaminated soils from the unsaturated zone (ground surface to the groundwater table) would be thermally treated on-site to meet site proposed cleanup goals for VOCs. Because the contaminants would be treated and destroyed, exposure risks associated with the soil contamination in the excavated area would be reduced. Some contaminants (such as metals) may remain above SCGs after treatment. Additionally, human health exposure risks to harmful vapors inside on-site existing structures and subsurface utilities (where vapors could accumulate) would be reduced with the demolition of these structures. Under existing conditions, there are currently no on-site human receptors impacted by the soil contamination. Potential human receptors are limited to site visitors, workers, and trespassers. However, since subsurface soils (below the water table) would serve as a continuing source of impact to groundwater, this alternative may not be considered fully protective of the environment.

In order to maintain long-term protection of human health, institutional controls such as access and activity restrictions, would be implemented to ensure risks to human health are minimized.

Compliance with SCGs

This alternative would comply with SCGs in the area of excavated and treated soil. However, since soil contamination above SCGs in the saturated zone (below the water table) and to a lesser degree in the unsaturated zone would remain on-site, this alternative would not comply with the chemical-specific SCGs for the site.

Applicable action-specific SCGs, including air discharge permits and requirements, noise limitations, and safety regulations would be complied with during treatment and implementation of the alternative.

Short-Term Impacts and Effectiveness

Several short-term impacts to the community and workers may arise during excavation and treatment of contaminated soil and demolition at the site. The primary impact of concern is the volatilization of VOCs from soil during excavation activities.

Appropriate measures such as proper protective equipment for the workers and vapor suppression (i.e., foam and/or covering material with tarps) to prevent off-site migration of vapors would be necessary to protect both workers and the surrounding community. With this alternative an increased risk to workers is imposed because they would be handling soils with high concentrations of VOCs. Community impacts include potential odors, dust, and noise from equipment operation. Continuous (24-hour) operation of the thermal desorption system may increase the potential for noise impacts on the surrounding community. These noise impacts can be reduced through proper design and the use of mitigation such as noise barriers. To minimize other short-tem impacts, site access would be restricted during construction and remediation activities. A community air monitoring plan/program would be established to protect the surrounding community. Action levels would be set prior to intrusive work, and an appropriate corrective action would be implemented if these action levels are exceeded.

This alternative (once complete) meets two of the three soil RAOs. It eliminates (to the extent practicable) the potential for direct contact with on-site contaminated soil and (to the extent practicable) the potential for human exposure to on-site organic vapors (by the excavation and treatment of contaminated soil and removal of on-site structures). It minimizes but does not adequately reduce the risk of further contamination of groundwater. The potential for volatile vapor migration off-site through the subsurface would also be reduced by this alternative.

Demolition, excavation, and thermal desorption of contaminated soils is estimated to be complete in approximately 15 months.

Long-term Effectiveness and Permanence

This alternative would provide some long-term effectiveness (in terms of protecting human health) because the risks associated with direct contact with contaminants would be minimized by the excavation and on-site treatment, removal of structures (where vapors could accumulate), and implementation of institutional controls. However, in the long-term this alternative would not be effective (in terms of protecting the environment) because the remaining subsurface soils (below the water table) would continue to provide a significant source of impact to groundwater. The potential for contaminated surface water runoff from the site would be reduced by the placement of the soil cover and installation of catch basins and associated piping.

Reduction in Toxicity, Mobility, or Volume

Because this alternative actively treats VOCs and, to a lesser degree, other contaminants of concern in the unsaturated soils, the volume of contamination would be reduced at the site. Consequently, the toxicity and mobility of the contaminants would also be reduced. However, some of the other contaminant concentrations such as metals are not expected to be reduced significantly by on-site treatment. Contaminants within soils in the saturated zone will not be reduced nor will contaminants within the groundwater.

Implementability

This alternative can be readily implemented on a technical and administrative basis using standard construction means/methods and typical institutional control practices/procedures. VOC emissions would be difficult to control because of the high concentration of VOCs and the large area requiring excavation. Engineering controls could be used as necessary in an effort to control such emissions. No other significant technical difficulties are anticipated during excavation and removal of contaminated soil and demolition. A contractor specializing in thermal desorption systems would likely be retained for installation and operation of the thermal desorption system. Engineers and contractors are readily available to design and operate such a treatment system. Although start-up problems may be encountered initially, technical difficulties are not anticipated once the thermal desorption system is fully operational. Due to the heterogeneity of some soils, adjustment in operational parameters may be required during treatment. This, however, should not affect the performance or implementability of the alternative. Monitoring and sampling of the thermal desorption system would be conducted during the treatment phase to ensure that proposed site cleanup goals are met for excavated soils and air discharge and noise standards are not exceeded. Finally, no delay is anticipated in obtaining the necessary approvals/permits from the state and local agencies for implementation of this alternative.

Cost

The total present-worth cost of this alternative based on a 30-year period and a discount rate of 5% is $11,600,000. Table 4-3 presents the quantities, unit costs, and subtotal costs for the various work items in this alternative. No O&M costs are anticipated with this alternative.

Alternative OS-4 (excavation and on-site treatment of soils) is readily implementable. The primary short-term risks are associated with controlling volatile vapors during excavation and handling of highly contaminated soil. This alternative reduces the risks associated with directly contacting highly contaminated subsurface soil by reducing toxicity, mobility, or volume. However, this alternative does not address the removal of highly contaminated soil below the water table or non-source soils that exceed SCGs.

4.2.5 Alternative No. OS-5: Excavation and Off-site Treatment/Disposal of Soils

The overall approach associated with this alternative is to excavate the contaminated source soils (greater than 10 ppm total VOCs) from above the groundwater table (about 5.5 feet bgs) and transport the material off-site for treatment/disposal at a NYSDEC-approved facility. Vapor suppression would be needed to limit off-site vapor migration from the excavation area. This alternative includes actions described as part of Alternative OS-3 (cover) as well as institutional controls. Long-term O&M would not be required for this alternative.

Because this alternative is similar to OS-4 (off-site treatment/disposal vs. on-site treatment), key points that are similar to both alternatives are minimally discussed.

Overall Protection of Human Health and the Environment

This alternative is considered protective of human health since contaminated soils from the unsaturated zone (ground surface to the groundwater table) would be treated/disposed off-site to meet site proposed cleanup goals. However, since subsurface soils (below the water table) would serve as a continuing source of impact to groundwater, this alternative is not considered protective of the environment. In order to maintain long-term protection of human health, institutional controls such as access and activity restrictions would be implemented to ensure risks to human health are minimized.

Compliance with SCGs

This alternative would comply with SCGs in the area of excavated and treated soil. However, since soil contamination above SCGs in the saturated zone (below the water table) and, to a lesser degree in the unsaturated zone, would remain on-site, this alternative would not comply with the chemical-specific SCGs for the site. Excavated soils would be tested prior to treatment/disposal to determine the waste profile (hazardous waste or non-hazardous waste) as per disposal facility requirements

Applicable action-specific SCGs, including noise limitations and safety regulations, would be complied with during implementation of the alternative.

Short-Term Effectiveness

Several short-term impacts to the community and workers may arise during excavation and demolition at the site. The primary impact of concern is the volatilization of VOCs from soil during excavation activities. Trucking material off-site may pose a temporary impact on the community from increased truck traffic, dust, and noise. The potential for spills during transport also exists. While there is a risk of spills due to accidents, this risk would be minimized by using covered and lined containers for transport and a licensed, experienced hauler.

Appropriate measures such as proper protective equipment for the workers, vapor suppression (i.e., foam and/or covering material with tarps) to prevent off-site migration of vapors, and covering of trucks to minimize vapor emissions would be necessary to protect both workers and the surrounding community. A community air monitoring plan/program would be established to protect the surrounding community. Action levels would be set prior to intrusive work, and an appropriate corrective action would be implemented if these action levels are exceeded.

This alternative (once complete) meets two of the three soil RAOs. It eliminates (to the extent practicable) the potential for direct contact with on-site contaminated soil and eliminates (to the extent practicable) the potential for human exposure to on-site organic vapors (by the excavation and off-site treatment/disposal of contaminated soil and removal of on-site structures). It minimizes but does not adequately reduce the risk of further contamination of groundwater. The potential for volatile vapor migration off-site through the subsurface would also be reduced by this alternative.

Demolition, excavation, and off-site treatment/disposal of contaminated soils is estimated to be complete in approximately 12 months.

Long-term Effectiveness and Permanence

This alternative would provide some long-term effectiveness (in terms of protecting human health) because the risks associated with direct contact with contaminants would be minimized by the excavation and off-site treatment/disposal, removal of structures (where vapors could accumulate), and implementation of institutional controls. However, in the long term this alternative may not be effective (in terms of protecting the environment) because the remaining subsurface soils (below the water table) would continue to provide a significant source of impact to groundwater.

Reduction in Toxicity, Mobility, or Volume

Because this alternative removes soil containing contaminants of concern in the unsaturated soil zone from the site, the toxicity, mobility, and volume of the contaminants at the site would be reduced. The degree of treatment would be based on the selected treatment/disposal facility. The highest concentrations of other contaminants (such as metals and semivolatile compounds) are expected to be proximate to source soil. However, the degree of reduction of these other contaminants would depend on the type of treatment and disposal facility selected. Contaminants in soils within saturated zones will not be reduced, nor will contamination in the groundwater.

Implementability

This alternative can be readily implemented on a technical and administrative basis using standard construction means/methods and typical institutional control practices/procedures. VOC emissions would be difficult to control because of the high concentration of VOCs and the large area requiring excavation. Engineering consultants and contractors are readily available to design and complete such an alternative. No other technical difficulties are anticipated during excavation and removal of contaminated soil and demolition. Disposal would be based on acceptance by a treatment/disposal facility.

No delay is anticipated in obtaining the necessary approvals/permits from the state and local agencies for implementation of this alternative.

Cost

The total present worth cost of this alternative based on a 30-year period and a discount rate of 5% is $11,000,000. Table 4-4 presents the quantities, unit costs, and subtotal costs for the various work items in this alternative. No O&M costs are anticipated with this alternative.

Alternative OS-5 (excavation and off-site treatment/disposal of soils) is readily implementable. The primary short-term risk is associated with controlling volatile vapors during excavation and handling of highly contaminated soil. This alternative reduces the risks associated with directly contacting highly contaminated subsurface soil by reducing toxicity, mobility, or volume. However, this alternative does not address the removal of highly contaminated soil below the water table or non-source soils that exceed SCGs. This alternative would result in a slightly greater amount of contaminant mass removal than Alternative OS-4 because the backfill replacement soil would be clean rather than contain residual contamination (such as metals) if treated on-site.

4.3 OU-1 Overburden Groundwater Remedial Alternatives

4.3.1 Alternative No. OG-1: No Action

The No Action alternative is presented as a baseline for comparison with other alternatives. This alternative does not include source removal or treatment or long-term monitoring of overburden groundwater. This alternative would allow the potential continued migration of overburden groundwater off-site and to the nearby sewer tunnels (Falls Street and New Road) for an indefinite period of time. It is expected that the majority of overburden groundwater leaving the site infiltrates the Falls Street tunnel. Groundwater infiltrating the New Road tunnel is conveyed into the Falls Street tunnel.

Overall Protection of Human Health and the Environment

Under existing site conditions, there are currently no on-site human or environmental receptors in direct contact with overburden groundwater contamination. However, vapors from volatile groundwater contaminants could diffuse to the surface or migrate to site structures or subsurface utilities, potentially exposing human receptors to these vapors. The site and surrounding area are serviced by the city water system; therefore potential use of on-site groundwater is not expected. Additionally, the use of overburden groundwater for industrial purposes is not expected due to low yield.

With no action, overburden groundwater contamination exceeding the groundwater standards would remain in place and be available for potential future exposure. Additionally, the migration of contaminated overburden groundwater off-site (although limited) and into the nearby sewer tunnels would remain a concern in terms of impacting the environment. Impact to the environment is associated with the potential (under high flow in the sewer tunnels) for site groundwater (that is mixed with other water in the sewer tunnel) to discharge to the Niagara River. This alternative is therefore not considered protective of human health and the environment.

Compliance with SCGs
The contaminant levels in overburden groundwater are not expected to decrease appreciably over time. Therefore, this alternative would not comply with the chemical-specific SCGs for the site.

Short-Term Impacts and Effectiveness
No short-term impacts (other than those existing) are anticipated during the implementation of this alternative since there are no remedial activities involved.

This alternative does not meet any of the three RAOs (as defined in Section 2.3.2) in a reasonable or predictable timeframe.

Long-term Effectiveness and Permanence
This alternative would not be effective in the long term because this alternative does not involve removal or treatment of the contaminated overburden groundwater.

Reduction in Toxicity, Mobility, or Volume
This alternative does not involve the removal or treatment of contaminated overburden groundwater. Therefore, neither the toxicity, nor mobility, nor volume of contamination is expected to be reduced. Natural attenuation of contaminants may reduce the concentrations in overburden groundwater over time. However, this reduction is not expected to be significant within a reasonable or predictable timeframe.

Implementability
This alternative is readily implementable on a technical basis in that it involves no actions.

Cost
There is no cost associated with this alternative.

Alternative OG-1 (No Action) is readily implementable with minimal short-term risks because no intrusive work would be done. However, this alternative leaves overburden groundwater contamination in place (unchanged) and does not reduce or eliminate existing risks (including those associated with off-site migration of contamination).

4.3.2 Alternative No. OG-2: Institutional Controls
Institutional controls such as access/use and deed restrictions and long-term monitoring at the site would include controlling excavation work that could result in encountering on-site groundwater. These controls are considered effective in minimizing the potential for direct contact with on-site contaminated overburden groundwater. Semiannual groundwater monitoring of on-site wells would be conducted as part of the long-term groundwater monitoring program for five years, followed by annual sampling for 25 years. Overburden groundwater samples would be analyzed for VOCs and other compounds of concern consistent with the SRI. Routine O&M would be required on the monitoring wells.

Overall Protection of Human Health and the Environment

Because this alternative includes placement of institutional controls such as access and deed restrictions (that would control future use/activities at the site), it would provide some on-site long-term protection of human health. However, this alternative would allow the potential continued migration of overburden groundwater off-site and to the nearby sewer tunnels. Accordingly, this alternative may not be fully protective of human health or the environment.

Compliance with SCGs

The contaminant levels in overburden groundwater are not expected to decrease appreciably over time. Therefore, this alternative would not comply with the chemical-specific SCGs for the site. Action-specific SCGs (e.g., safety regulations) would be included in the institutional controls and complied with during site activities.

Short-Term Impacts and Effectiveness

No short-term impacts (other than those existing) are anticipated during the implementation of this alternative since there are no remedial activities involved. Controlling future use and activities on-site would protect workers' health. This alternative would provide some protection for the community by limiting site access.

This alternative meets one of the three overburden groundwater RAOs. It eliminates (to the extent practicable) the potential for human exposure to contaminated overburden groundwater. It would not reduce, control, or eliminate groundwater contamination present in the overburden or prevent (to the extent practicable) further off-site migration of contaminated overburden groundwater.

Long-term Effectiveness and Permanence

Institutional controls are an effective mechanism to minimize future on-site exposure to contaminated overburden groundwater. Data collection during the groundwater monitoring program would be used to evaluate groundwater conditions over time.

This alternative would not be effective in the long term because this alternative does not prevent potential human health and environmental impacts associated with off-site migration of contaminated overburden groundwater.

Reduction in Toxicity, Mobility, or Volume

This alternative does not involve the removal or treatment of contaminated overburden groundwater. Therefore, neither the toxicity, nor mobility, nor volume of contamination is expected to be reduced. Natural attenuation of contaminants may reduce the concentrations in overburden groundwater. However, this reduction is not expected to be significant within a reasonable or predictable timeframe.

Implementability

This alternative can be readily implemented on a technical and administrative basis using typical institutional control practices/procedures and standard groundwater sampling methods.

Cost

The total present-worth cost of this alternative based on a 30-year period at a discount rate of 5% is $330,000. Table 4-5 presents the quantities, unit costs, and subtotal costs for the various work items in this alternative. Annual groundwater monitoring costs are assumed with this alternative.

Alternative OG-2 (institutional controls) is readily implementable with minimal short-term risks because no intrusive work would actually be done. This alternative reduces risks associated with direct contact with on-site overburden groundwater contamination. However, effectiveness of this alternative in reducing on-site risks would be based on enforcement of the restrictions/controls over an extended period of time (greater than 30 years). This alternative would not be effective at preventing off-site migration of contaminated overburden groundwater.

4.3.3 Alternative No. OG-3: Hydraulic Containment

The overall approach associated with this alternative is to intercept the overburden groundwater at the downgradient edge of the site to prevent off-site migration of contaminated overburden groundwater. This would be achieved by installation of a groundwater collection trench and an extraction well located in a hot spot area containing sandy soils (groundwater depression area). Extracted groundwater would be conveyed by subsurface piping to an on-site treatment building, treated, and discharged to the POTW via the Southside interceptor tunnel. This alternative would also include the actions described as part of Alternative OG-2 (institutional controls). Pre- and post-treatment groundwater sampling would be performed to ensure treatment effectiveness. O&M is necessary for the extraction and treatment systems.

Overall Protection of Human Health and the Environment

This alternative would limit the off-site migration of overburden groundwater. Therefore, this alternative would provide some additional protection of human health and the environment. However, contaminated overburden groundwater would remain on-site, and vertical migration of contaminated overburden groundwater to bedrock groundwater is expected to continue to occur.

Under existing site conditions, there are currently no on-site human or environmental receptors in direct contact with on-site groundwater contamination. The site and surrounding area are serviced by the city water system; therefore potential use of groundwater in the area is not expected. Additionally, because the overburden groundwater zone is expected to have limited yield, its use is unlikely.

Compliance with SCGs

The contaminant levels in overburden groundwater are expected to decrease over time. However, the decrease is not expected to result in compliance with SCGs due to the high concentration of contamination and likely presence of DNAPLs in the subsurface (which provide an ongoing source of groundwater contamination). Discharge of treated extracted overburden groundwater to the local POTW would comply with action-specific SCGs.

Short-Term Impacts and Effectiveness

Several limited short-term impacts to the community and workers may arise during construction of the collection trench and installation of the extraction well and treatment system. These limited impacts are primarily associated with the potential for air emissions (dust and VOCs) and noise. To minimize short-term impacts, site access would be restricted during construction and remediation activities and mitigation measures would be implemented as needed. Health and safety measures, including air monitoring and use of appropriate personal protective equipment, would be in place to protect workers. Equipment leaving the site would be decontaminated and a community air monitoring plan/program would be established to protect the surrounding community. Action levels would be set prior to intrusive work and an appropriate corrective action implemented if these action levels are exceeded.

Based on a 30-year time frame, this alternative meets the three overburden groundwater RAOs. It eliminates (to the extent practicable) the potential for human exposure to contaminated overburden groundwater; reduces and controls (to the extent practicable) groundwater contamination present in the overburden; and prevents (to the extent practicable) the further off-site migration of contaminated overburden groundwater.

Long-term Effectiveness and Permanence

This alternative, which includes collection/extraction and treatment of overburden groundwater, is considered to be effective in the long-term because it reduces contamination on-site and limits the potential for off-site migration. Overburden groundwater contaminants would be treated through operation of an on-site groundwater treatment system and discharge to the POTW for treatment. Groundwater monitoring data would provide information related to the reduction of contamination over time.

Considering the low hydraulic conductivity of the overburden soils and the possible presence of residual DNAPL in the subsurface, it is expected that contaminated groundwater above SCGs would exist on-site beyond the 30-year timeframe. The extraction and treatment of the contaminated overburden groundwater would be effective while the treatment system is in operation.

Reduction in Toxicity, Mobility, or Volume

Because this alternative involves the containment of contaminated overburden groundwater, the mobility of contamination would be controlled. Treatment of collected groundwater either on-site or by the POTW would reduce the toxicity and volume of overburden groundwater contamination. However, the volume of contamination is not expected to be significantly reduced over time due to the presence of highly contaminated areas (including the possible presence of DNAPLs) that provide an ongoing source of groundwater contamination. Groundwater in the overburden is expected to continue to migrate vertically downward into the bedrock zones.

Along with the primary contaminants of concern (VOCs) other contaminants (such as metals and SVOCs) would be present in the extracted overburden groundwater. The degree of reduction of these other contaminants through on-site or POTW treatment would depend on the treatment system used. The concentration (and associated mass loading) of contaminants in the discharge to the POTW would be based on the POTW's allowable limits.

Residual wastes may be generated through on-site groundwater treatment and would be treated/disposed of off-site as appropriate.

Implementability
This alternative is readily implemented on a technical and administrative basis using standard construction methods, typical institutional control practices/procedures, and standard groundwater sampling methods. Numerous engineering consultants and contractors are readily available to design and construct such a system. A pump test and a treatability study are recommended to determine optimal design parameters and treatment options prior to implementation of this alternative. It is anticipated there would be no issues associated with obtaining the necessary approvals/permits from the state and local agencies to discharge treated water to the local POTW or for air discharge permits (if needed) associated with groundwater treatment, thereby complying with action-specific SCGs. Since the collection trench would be constructed on the downgradient side of the site, outside the area of highly contaminated soil, volatile vapor emissions are not expected to create an implementability issue. The effectiveness of the containment/treatment system could be monitored through groundwater elevations and contaminant concentration monitoring

Cost
The total present-worth cost of this alternative based on a 30-year period at a discount rate of 5% is $800,000. Table 4-6 presents the quantities, unit costs, and subtotal costs for the various work items in this alternative. A considerable number of O&M activities associated with the collection trench, extraction well, and treatment system (see alternative BG-3) are anticipated with this alternative, resulting in significant annual costs. Annual groundwater monitoring costs are also assumed with this alternative.

Alternative OG-3 (hydraulic containment) is readily implementable with minimal short-term risks. It is not technically feasible to clean up the overburden groundwater in a predictable timeframe due to the high level of contamination present (including the possible presence of DNAPLs). However, this alternative minimizes risks associated with off-site migration of contaminated groundwater (including to the sewer tunnels) by containment and reduction of toxicity and volume through treatment (on-site and/or by the POTW). This alternative also reduces the risks associated with directly contacting contaminated on-site overburden groundwater.

4.4 OU-2 Bedrock Groundwater Remedial Alternatives

4.4.1 Alternative No. BG-1: No Action

The No Action alternative is presented as a baseline for comparison with other alternatives. This alternative does not include source removal or treatment or long-term monitoring of bedrock groundwater. This alternative would allow the potential continued migration of bedrock groundwater to the nearby sewer tunnels (Falls Street and New Road) for an indefinite period of time. It is expected that the majority of bedrock groundwater leaving the site infiltrates the Falls Street tunnel. Groundwater infiltrating the New Road tunnel is conveyed into the Falls Street tunnel.

Overall Protection of Human Health and the Environment

Under existing site conditions, there are currently no on-site human or environmental receptors in direct contact with bedrock groundwater contamination. However, vapors from volatile groundwater contaminants could enter subsurface utilities, potentially exposing human receptors to these vapors. The site and surrounding area are serviced by the city water system; therefore potential use of on-site groundwater is not expected. Additionally, there is no known use of bedrock groundwater for industrial purposes in the immediate area of the site.

Bedrock groundwater contamination exceeding the groundwater standards would remain on-site. The migration of contaminated bedrock groundwater into the nearby sewer tunnels would continue to pose a potential impact to the environment. Under high flow conditions in the sewer tunnels site contaminants may ultimately be discharged to the Niagara River.

Compliance with SCGs

The contaminant levels in bedrock groundwater are not expected to decrease appreciably over time. Therefore, this alternative would not comply with the chemical-specific SCGs for the site.

Short-Term Impacts and Effectiveness

No short-term impacts (other than those existing) are anticipated during the implementation of this alternative since there are no remedial activities involved. Controlling future use and activities on-site would protect workers' health.

This alternative would not meet any of the three RAOs (as defined in Section 2.3.2) in a reasonable or predictable timeframe.

Long-term Effectiveness and Permanence
This alternative would not be effective at preventing contaminated bedrock groundwater from leaving the site.

Reduction in Toxicity, Mobility, or Volume through Treatment
This alternative does not involve the removal or treatment of contaminated bedrock groundwater. Therefore, neither the toxicity, nor mobility, nor volume of contamination is expected to be reduced. Natural attenuation of contaminants may reduce the concentrations in bedrock groundwater over time. However, this reduction is not expected to be significant within a reasonable or predictable timeframe.

Implementability
This alternative is readily implementable on a technical basis in that it involves no actions.

Cost
There is no cost associated with this alternative.

Alternative BG-1 (No Action) is readily implementable with minimal short-term risks because no intrusive work would be done. However, this alternative leaves bedrock groundwater contamination in place (unchanged) and does not reduce or eliminate existing risks (including those associated with off-site migration of contamination).

4.4.2 Alternative No. BG-2: Institutional Controls
Institutional controls such as access/use and deed restrictions and long-term monitoring at the site would include placing restrictions on use the of on-site bedrock groundwater. These controls are considered effective in minimizing the potential for direct contact with on-site contaminated bedrock groundwater. Semiannual groundwater monitoring of on-site wells for five years followed by annual sampling for 25 years would be conducted as part of the long-term groundwater monitoring program. Bedrock groundwater samples would be analyzed for VOCs and other compounds of concern consistent with the SRI. Routine O&M would be required on the monitoring wells.

Overall Protection of Human Health and the Environment
Because this alternative includes placement of institutional controls such as access and deed restrictions (that would control future use/activities at the site), it would provide some on-site long-term protection of human health. However, this alternative would allow the potential continued migration of bedrock groundwater off-site to the nearby sewer tunnels, which may not be fully protective of off-site impacts to human health or the environment.

Compliance with SCGs
The contaminant levels in bedrock groundwater are not expected to decrease appreciably over time. Therefore, this alternative would not comply with the

chemical-specific SCGs for the site. Action-specific SCGs (e.g., safety regulations) would be included in the institutional controls and complied with for site activities.

Short-Term Impacts and Effectiveness

No short-term impacts (other than those existing) are anticipated during the implementation of this alternative since there are no remedial activities involved. Controlling future use and activities on-site would protect future workers' health. This alternative would provide some protection to the community by limiting site access.

This alternative meets one of the three bedrock groundwater RAOs. It eliminates (to the extent practicable) the potential for human exposure to contaminated bedrock groundwater. However, it does not reduce, control, or eliminate groundwater contamination present in the bedrock or prevent (to the extent practicable) the further off-site migration of contaminated bedrock groundwater.

Long-term Effectiveness and Permanence

Institutional controls are an effective mechanism to minimize the potential for future exposure to contaminated bedrock groundwater. Data collection during the groundwater monitoring program would be used to evaluate groundwater conditions over time.

This alternative would not be effective at preventing contaminated bedrock groundwater from leaving the site.

Reduction in Toxicity, Mobility, or Volume

This alternative does not involve the removal or treatment of contaminated bedrock groundwater. Therefore, neither the toxicity, nor mobility, nor volume of contamination is expected to be reduced. Natural attenuation of contaminants may reduce the concentrations in bedrock groundwater. However, this reduction is not expected to be significant within a reasonable or predictable timeframe.

Implementability

This alternative can be readily implemented on a technical and administrative basis using typical institutional control practices/procedures and standard groundwater sampling methods.

Cost

The total present worth cost of this alternative based on a 30-year period at a discount rate of 5% is $630,000. Table 4-7 presents the quantities, unit costs, and subtotal costs for the various work items in this alternative. Annual groundwater monitoring costs are assumed with this alternative.

Alternative BG-2 (institutional controls) is readily implementable with minimal short-term risks as no intrusive work would be done. This alternative reduces risks associated with direct contact with on-site bedrock groundwater contamination. However, the effectiveness of this alternative in reducing risks would be based on enforcement of the restrictions/controls over an extended period of time (greater than 30 years).

4.4.3 Alternative No. BG-3: Hydraulic Containment

The overall approach associated with this alternative is to intercept the bedrock groundwater at the downgradient edge of the site to prevent off-site migration of contaminated bedrock groundwater. This would be achieved by installing a series of groundwater extraction wells that intercept the upper two bedrock fracture zones (zones A and B). Extracted groundwater would be conveyed by subsurface piping to an on-site treatment building, treated, and discharged to the POTW via the Southside interceptor tunnel. This alternative would also include the actions described as part of Alternatives BG-2 (institutional controls). Pre- and post-treatment groundwater sampling would be performed monthly to ensure treatment effectiveness. O&M is necessary for the extraction and treatment systems.

Overall Protection of Human Health and the Environment

This alternative would limit the off-site migration of bedrock groundwater to the nearby sewer tunnels. Therefore, this alternative would provide some additional protection of human health and the environment. However, contaminated bedrock groundwater would remain on-site.

Under existing site conditions, there are currently no on-site human or environmental receptors in direct contact with on-site groundwater contamination. The site and surrounding area are serviced by the city water system; therefore potential use of bedrock groundwater in the area is not expected. Additionally, there is no known use of bedrock groundwater for industrial purposes in the area of the site.

Compliance with SCGs

The contaminant levels in bedrock groundwater are expected to decrease over time. However, the decrease is not expected to result in compliance with SCGs because of the high concentration of contamination and likely presence of DNAPLs in the subsurface (which provide an ongoing source of groundwater contamination). Discharge of treated extracted bedrock groundwater to the local POTW would comply with action-specific SCGs.

Short-Term Impacts and Effectiveness

Several limited short-term impacts to the community and workers may arise during construction of the extraction well and treatment system. These limited impacts would be primarily associated with the potential for air emissions (VOCs) and noise. To minimize short-term impacts, site access would be restricted during construction and remediation activities and mitigation measures implemented as needed. Health and safety measures, including air monitoring and use of appropriate personal protective equipment would be in place to protect workers. Equipment leaving the site would be decontaminated and a community air monitoring plan/program would be established to protect the surrounding community. Action levels would be set prior to intrusive work and appropriate corrective action implemented if these action levels are exceeded.

Based on a 30-year time frame, this alternative meets the three bedrock groundwater RAOs. It eliminates (to the extent practicable) the potential for human exposure to contaminated bedrock groundwater; reduces and controls (to the extent practicable) groundwater contamination present in the bedrock; and prevents (to the extent practicable) the further off-site migration of contaminated bedrock groundwater.

Vertical migration of contaminated bedrock groundwater downward into the C-fracture zone would continue but would be limited by this alternative (i.e., extraction from the A and B zones). The third operable unit (OU-3) includes groundwater contamination in bedrock zone C and potential lower bedrock groundwater zones, which may be impacted by site contamination. OU-3 would be further assessed as part of future remedial activities and is not included in this report.

Long-term Effectiveness and Permanence

This alternative, which includes extraction and treatment of bedrock groundwater, is considered effective in the long-term because it reduces contamination on-site and limits the potential for off-site migration. This alternative would reduce potential contaminant loading to the Niagara River. Bedrock groundwater contaminants would be treated through operation of an on-site groundwater treatment system and discharge to the POTW for treatment. Groundwater monitoring data would provide information related to the reduction of contamination over time and contaminant loading.

Considering the possible presence of residual DNAPLs in the subsurface, it is expected that contaminated bedrock groundwater would exist on-site beyond the 30-year timeframe. The extraction and treatment of the contaminated bedrock groundwater would be effective while the treatment system is in operation.

Reduction in Toxicity, Mobility, or Volume

Because this alternative involves the containment of contaminated bedrock groundwater, the mobility of contamination would be controlled. Treatment of collected groundwater either on-site or by the POTW would reduce the toxicity and volume of bedrock groundwater contamination. However, the volume of contamination is not expected to be significantly reduced over time due to the presence of highly contaminated areas (including the possible presence of DNAPLs) that provide an ongoing source of groundwater contamination. Vertical migration of upper bedrock groundwater downward into deeper bedrock zones (including zone C) would be minimized by this alternative.

Along with the primary contaminants of concern (VOCs), other contaminants (such as metals and SVOCs) would be present in the extracted bedrock groundwater. The degree of reduction of these other contaminants through on-site or POTW treatment would depend on the treatment system used. The concentration (and associated mass loading) of contaminants in the discharge to the POTW would be based on the POTW's allowable limits.

Residual wastes may be generated through on-site groundwater treatment and would be treated/disposed of off-site as appropriate.

Implementability

This alternative is readily implemented on a technical and administrative basis using standard construction methods, typical institutional control practices/procedures, and standard groundwater sampling methods. Numerous engineering consultants and contractors are readily available to design and construct such a system. A pump test and a treatability study are recommended to determine optimal design parameters and treatment options prior to implementation of this alternative. It is anticipated there would be no issues associated with obtaining the necessary approvals/permits from the state and local agencies to discharge treated water to the local POTW or for air discharge permits (if needed) associated with groundwater treatment, thereby complying with action-specific SCGs. The effectiveness of the containment/treatment system could be monitored through groundwater elevations and contaminant concentration monitoring.

Cost

The total present-worth cost of this alternative based on a 30-year period at a discount rate of 5% is $10,700,000. Table 4-8 presents the quantities, unit costs, and subtotal costs for the various work items in this alternative. Considerable O&M activities associated with the extraction well and treatment system are anticipated with this alternative, resulting in significant annual costs. Annual groundwater monitoring costs are also assumed with this alternative.

Alternative BG-3 (hydraulic containment) is readily implementable with minimal short-term risks. It is not technically feasible to clean up the bedrock groundwater in a predictable timeframe due to the high level of contamination present (including the possible presence of DNAPL). However, this alternative does minimize the risks associated with off-site migration of contaminated groundwater (including to the sewer tunnels) by containment and reduction of toxicity and volume through treatment (on-site and/or by the POTW).

Table 4-1
OU1 - Alternative No. OS-2 - Institutional Controls
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Capital Costs					
Institutional Controls		Each	1	$2,000	$2,000
Subtotal					$2,000
				Capital Cost Subtotal:	$2,000
				Adjusted Capital Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$2,056
				10% Legal, administrative, engineering fees, construction management:	$206
				15% Contingencies:	$339
				Total Capital Cost:	**$3,000**
Annual Costs					
Not Applicable					$0
Subtotal					$0
				Annual Cost Subtotal:	$0
				Adjusted Annual Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$0
				10% Legal, administrative, engineering fees:	$0
				15% Contingencies:	$0
				Annual Cost Total:	**$0**
				30-Year Present Worth of Annual Costs:	**$0**
				Total Present Worth Cost:	**$3,000**

Assumptions
1. Assume existing fence will remain and repairs are not needed.

Table 4-2
OU1 - Alternative No. OS-3 - Cover
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Capital Costs					
Construction Management (2.5% of total capital cost)	Includes submittals, reporting, meetings	LS	1	NA	$26,434
Institutional Controls		Each	1	$2,000	$2,000
Subtotal					$28,434
Site Preparation					
Surveying Crew	2-person crew @ $50/hr, 8hr/day	Day	10	$800.00	$8,000
Site Clearing	With dozer, light clearing; assume 25% of site area	Acre	2	$790.00	$1,904
Subtotal					$9,904
Health and Safety					
Construct Decontamination Pad & Containment	For equipment & personnel	Setups	1	$1,000.00	$1,000
Community/Exclusion Zone Air Monitoring	Photoionization detector (Qty 1) & particulate meter rental (Qty 3)	months	6	$3,300.00	$19,800
Site Safety Officer	8 hrs/day, 5days/wk, $55/hr	manweeks	24	$2,200.00	$52,800
Personal Protective Equipment	Includes disposable coveralls, hard hats, safety glasses, reusable boots, gloves; assume 10-persons on-site per day changing twice per day; includes PPE disposal	months	6	$4,500.00	$27,000
Subtotal					$100,600
Demolition					
Soil					
Soil Excavation	Dozer 105 horsepower, 150 ft haul; based on 28,425 ft2 x 1 ft depth unpaved areas	BCY	1,053	$3.70	$3,895
Transport Soil to Stockpile	300 Horsepower Front End Loader w/ 300' haul; based on 28% soil swell factor	LCY	1,348	$1.20	$1,617
Buildings					
Building Demolition (Metal)	see Appendix A; includes loading of dump trucks	CF	23,775	$0.20	$4,755
Building Demolition (Concrete)	see Appendix A; includes loading of dump trucks	CF	4,395	$0.30	$1,319
Building Demolition (Wood)	see Appendix A; includes loading of dump trucks	CF	192	$0.20	$38
Building Demolition (Asphalt Shingles)	see Appendix A; includes loading of dump trucks	CF	990	$0.23	$231
Transport Debris to Stockpile	300 Horsepower Front End Loader w/ 300' haul	LCY	1,087	$1.20	$1,305

Table 4-2
OU1 - Alternative No. OS-3 - Cover
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Tanks					
Tank Characterization	Includes TCLP, Pesticides/PCB, PAH, RCRA ignitability, RCRA corrosivity, RCRA reactivity analyses; Assume 24-hr turnaround	Each	1	$1,063.61	$1,064
Tank Demolition/Transportation to Stockpile (6,000-8,000 gal)		Each	3	$650.00	$1,950
Tank Demolition/Transportation to Stockpile (9,000-12,000 gal)		Each	7	$1,000.00	$7,000
Tank Demolition/Transportation to Stockpile (12,000+ gal)		Each	6	$1,000.00	$6,000
Walls/Foundations					
Wall Demolition	Assume 6" thick	SF	7,125	$1.70	$12,113
Foundation Demolition	Assume reinforced concrete	BCY	1,383	$109.00	$150,783
Transport Debris to Stockpile	300 Horsepower Front End Loader w/ 300' haul; based on 40% brick/concrete swell factor	LCY	2,121	$1.20	$2,546
Misc Debris					
Transport Debris to Stockpile	300 Horsepower Front End Loader w/ 300' haul	LCY	15,336	$1.20	$18,403
Development of Stockpiles					
Additional Debris Sorting	300 Horsepower Front End Loader w/ 300' haul; assume 50% of total cost to transport debris to stockpile	LS	1	NA	$11,935
Filter Fabric	Includes polypropylene fabric material and installation	SY	3,478	$1.60	$5,564
Common Earth Cover (Material Only)	2' of cover over fill stockpile; assume 31,300 ft2 area; based on 28% soil swell factor	LCY	2,968	$6.00	$17,806
Topsoil (Material Only)	6" of topsoil; add 10% for compaction	LCY	638	$12.00	$7,651
Seeding (w/ mulch and fertilizer)	Bluegrass 4#/MSF w/ mulch and fertilizer, hydroseeding	MSF	31	$45.00	$1,409
Placement/Grading of Cover Material	300 Horsepower Front End Loader w/ 300' haul; based on 28% soil swell factor	LCY	3,605	$1.20	$4,326
Compaction of Gravel / Backfill	Vibrating roller, 12" compacted lifts, 4 passes	LCY	3,605	$0.30	$1,082
Subtotal					$262,791

Table 4-2
OU1 - Alternative No. OS-3 - Cover
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Monitoring Well Decommissioning / Installation					
Monitoring Well Decommissioning	Excludes existing destroyed or unusable wells/piezometers; 13 within excavation limits + 7 in stockpile areas	Each	18	$150.00	$2,738
Drill Rig Mob/Demob		LS	NA	NA	$1,000
Monitoring Well Installation (Overburden)	2" SS overburden well; includes drilling, well construction; 2 within excavation limits + 3 in stockpile areas	Each	5	$2,340.00	$11,700
Monitoring Well Installation (Bedrock)	2" SS bedrock well for zones A, B, and C; includes drilling, well construction; 5 within excavation limits+ 4 in stockpile areas	Each	9	$8,100.00	$72,900
Subtotal					$88,338
Installation of Catch Basins					
Pavement Demolition	Assumes to 6" depth with hydraulic hammer; based on 1,050' of trench	SY	1,750	$10.00	$17,500
Stormwater Lateral Trenching	Excavate trench 4'-6' deep w/ 1-1/2 CY hydraulic backhoe; Assume 1,275 LF of trenching/5.5' deep/3'width	BCY	1,946	$2.70	$5,254
Transport Pavement/Soil to Stockpile	300 Horsepower Front End Loader w/ 300' haul; pavement/foundation w/ 40% and soil w/ 28% swell factor	LCY	2,899	$1.20	$3,479
Stormwater Laterals	8" fiberglass reinforced pipe and fittings; includes material and labor	LF	675	$65.00	$43,875
Lateral Connections	Includes fittings, reducers; assume 5% of total lateral cost	LS	1	NA	$5,194
Stormwater Laterals	12" fiberglass reinforced pipe and fittings; includes material and labor	LF	600	$100.00	$60,000
Gravel (Material Only)	Assume 4.5' gravel fill; 1.57 Ton/BCY and 13% swell factor	Ton	2,827	$20.00	$56,549
Filter Fabric	Includes polypropylene fabric material and installation above gravel layer	SY	1,842	$1.60	$2,947
Backfill (Material Only)	Assume 1' common earth backfill; based on 28% swell factor	LCY	846	$6.00	$5,077
Placement of Gravel / Backfill	Front End Loader w/ 100' haul; backfill trench	LCY	2,881	$3.80	$10,949
Compaction of Gravel / Backfill	Vibrating roller, 12" compacted lifts, 4 passes	LCY	2,881	$0.30	$864
Installation of Catch Basins	4' inner diameter, 6 ft deep, concrete, pre-cast catch basin; includes material, labor, equipment	Each	5	$2,000.00	$10,000
Subtotal					$221,689
Installation of Cover					
Placement of Fill (On-Site)	300 Horsepower Front End Loader w/ 300' haul; based on 10% of total on-site fill	LCY	1,939	$1.23	$2,385
Subtotal					$2,385

Table 4-2
OU1 - Alternative No. OS-3 - Cover
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
				Capital Cost Subtotal:	$714,141
				Adjusted Capital Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$734,137
				10% Legal, administrative, engineering fees, construction management:	$73,414
				15% Contingencies:	$121,133
				Total Capital Cost:	**$929,000**
Annual Costs					
Not Applicable					$0
Subtotal					$0
				Annual Cost Subtotal:	$0
				Adjusted Annual Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$0
				10% Legal, administrative, engineering fees:	$0
				15% Contingencies:	$0
				Annual Cost Total:	**$0**
				30-Year Present Worth of Annual Costs:	**$0**
				Total Present Worth Cost:	**$929,000**

Assumptions
1. Assume existing trees along site perimeter will remain on-site; site clearing/excavation activities will be performed as close to site perimeter as permissible.
2. Assume site surface area to be approximately 420,000 square feet.
3. Assume all building walls to be 6 inches thick.
4. Assume Bldg 70, 73, 56, and 18 to be 25 ft in height.
5. Assume Bldg 20/60 to be 15 ft in height.
6. Assume 16 on-site above-ground storage tanks; see Appendix A.
7. White poly tank located by gate in northeast corner of site is assumed to be removed by others and therefore, not considered in this cost estimate.
8. Assume any collected stormwater in tanks to be discharged on-site (assuming the tanks were cleaned previously and the accumulated water would be from preci
9. Assume 10% of total hard debris will remain on-site as fill to level site; remaining 90% will be stockpiled on-site.
10. Assume 25% of debris pile in the center of the site to have foundation existing to 3 ft above ground surface; remaining 75% assumed to be at ground surface.
11. Assume drums will be sorted out of debris piles.
12. Debris volume for walls/foundations assumes demolition to ground surface.
13. Assume common earth (moist) swell factor of 28% and 1.54 Tons/BCY; concrete swell factor of 40% and 1.86 tons/BCY; brick/concrete swell factor of 40% and 1.49 tons/BCY; gravel swell factor of 13% and 1.57 tons/BCY (Means Estimating Handbook. United States of America : Means Southern Construction Information Network, 1990).
14. Assume characterization samples to be collected for every 500 tons of soil.
15. Assume existing catch basins in pavement or concrete areas will be abandoned.
16. Assume new catch basins to extend 5.5' below ground surface and connect to Falls Street Tunnel.
17. Assume existing fence will remain and repairs are not needed.
18. Assume water main lines currently existing in Block Building located by gate in the northeast corner of site will remain as is (sticking up above the ground surfac
19. Assume existing monitoring wells will remain as is (with stickup above the ground surface).
20. Assume existing demolition debris will be removed and disposed off-site by site owner or others.

Abbreviations:
BCY = bank cubic yards
LCY = loose cubic yards
SY = square yards
LF = linear feet
SF = square feet
CF = cubic feet
LS = lump sum

Table 4-3
OU1 - Alternative No. OS-4 - Excavation & On-Site Treatment of Overburden Source Soils
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Capital Costs					
Construction Management (2.5% of total capital cost)	Includes submittals, reporting, meetings	LS	1	NA	$324,668
Institutional Controls		Each	1	$2,000	$2,000
Subtotal					$326,668
Site Preparation					
Surveying Crew	2-person crew @ $50/hr, 8hr/day	Day	10	$800.00	$8,000
Site Clearing	With dozer, light clearing; assume 25% of site area	Acre	2	$790.00	$1,904
Subtotal					$9,904
Health and Safety					
Construct Decontamination Pad & Containment	For equipment & personnel	Setups	1	$1,000.00	$1,000
Community/Exclusion Zone Air Monitoring	Photoionization detector (Qty 1) & particulate meter rental (Qty 3)	months	15	$3,300.00	$49,500
Site Safety Officer	8 hrs/day, 5days/wk, $55/hr	manweeks	60	$2,200.00	$132,000
Personal Protective Equipment	Includes coveralls, hard hats, safety glasses, reusable boots, gloves; assume 10-persons on-site per day changing twice per day	months	15	$4,500.00	$67,500
Subtotal					$250,000
Demolition					
Buildings					
Building Demolition (Metal)	see Appendix A; includes loading of dump trucks	CF	23,775	$0.20	$4,755
Building Demolition (Concrete)	see Appendix A; includes loading of dump trucks	CF	4,395	$0.30	$1,319
Building Demolition (Wood)	see Appendix A; includes loading of dump trucks	CF	192	$0.20	$38
Building Demolition (Asphalt Shingles)	see Appendix A; includes loading of dump trucks	CF	990	$0.23	$231
Transport Debris to Stockpile	300 Horsepower Front End Loader w/ 300' haul	LCY	1,087	$1.20	$1,305

Table 4-3
OU1 - Alternative No. OS-4 - Excavation & On-Site Treatment of Overburden Source Soils
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Tanks					
Tank Characterization	Includes TCLP, Pesticides/PCB, PAH, RCRA ignitability, RCRA corrosivity, RCRA reactivity analyses; Assume 24-hr turnaround	Each	1	$1,063.61	$1,064
Tank Demolition/Transportation to Stockpile (6,000-8,000 gal)		Each	3	$750.00	$2,250
Tank Demolition/Transportation to Stockpile (9,000-12,000 gal)		Each	7	$1,000.00	$7,000
Tank Demolition/Transportation to Stockpile (12,000+ gal)		Each	6	$1,000.00	$6,000
Walls/Foundations					
Wall Demolition	Assume 6" thick	SF	7,125	$1.70	$12,113
Foundation Demolition	Assume reinforced concrete	BCY	1,383	$109.00	$150,783
Transport Debris to Stockpile	300 Horsepower Front End Loader w/ 300' haul; based on 40% brick/concrete swell factor	LCY	2,121	$1.20	$2,546
Misc Debris					
Transport Debris to Stockpile	300 Horsepower Front End Loader w/ 300' haul	LCY	15,336	$1.20	$18,403
Development of Stockpiles					
Additional Debris Sorting	300 Horsepower Front End Loader w/ 300' haul; assume 50% of total cost to transport debris to stockpile	LS	1	NA	$11,127
Filter Fabric	Includes polypropylene fabric material and installation	SY	3,478	$1.60	$5,564
Common Earth Cover (Material Only)	2' of cover over fill stockpile; assume 31,300 ft2 area; based on 28% soil swell factor	LCY	2,968	$6.00	$17,806
Topsoil (Material Only)	6" of topsoil; add 10% for compaction	LCY	638	$12.00	$7,651
Seeding (w/ mulch and fertilizer)	Bluegrass 4#/MSF w/ mulch and fertilizer, hydroseeding	MSF	31	$45.00	$1,409
Placement/Grading of Cover Material	300 Horsepower Front End Loader w/ 300' haul; based on 28% soil swell factor	LCY	3,605	$1.20	$4,326
Compaction of Gravel / Backfill	Vibrating roller, 12" compacted lifts, 4 passes	LCY	3,605	$0.30	$1,082
Subtotal					$256,770

Table 4-3
OU1 - Alternative No. OS-4 - Excavation & On-Site Treatment of Overburden Source Soils
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Soil Excavation					
Utility Repair		Each	5	$5,000.00	$25,000
Pavement Demolition	Assumes to 6" depth with hydraulic hammer; based on 190,075 ft2 (excavation area) - 32,025 ft2 (unpaved area)	SY	17,561	$10.20	$179,123
Excavation	Hydraulic excavator w/2 CY bucket = 130 CY/hr; based on 38,718 BCY (excavated soil) + 1,036 BCY soil (cut-back)	BCY	39,754	$1.70	$67,582
Application of Foam	Includes rental of foam dispensing unit, foam (for excavation area and soil stockpile), on-site technician for 1 week	Day	90	$740.00	$69,600
Containment Building (for Soil Staging Area)	Rental of 24,000 ft2 structure for 6 mo; inlcudes delivery on- and off-site, structure erection, and dismantling	LS	1	NA	$272,506
Transport Soil & Pavement to Stockpile	300 Horsepower Front End Loader w/ 300' haul; based on 28% soil swell factor and 40% concrete swell factor	LCY	54,990	$1.20	$65,988
Stockpiling	300 Horsepower Bulldozer w/ 50' haul	LCY	54,990	$0.50	$27,495
VOC Screening	Immunoassay testing; assume 2 sample every 5 feet along perimeter of excavation only	Each	740	$100.00	$74,000
Confirmatory Sampling	Includes TCLP, Pesticides/PCB, PAH, RCRA ignitability, RCRA corrosivity, RCRA reactivity analyses; Assume 24-hr turnaround; one sample per 500 tons	Each	169	$1,063.61	$180,143
Disposal of Decon Drums	Waste decon water (<1% solids); price per 55 gal drum including transportation	Drum	50	$150.00	$7,500
Subtotal					$968,937

Table 4-3
OU1 - Alternative No. OS-4 - Excavation & On-Site Treatment of Overburden Source Soils
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Monitoring Well Decommissioning / Installation					
Monitoring Well Decommissioning	Excludes existing destroyed or unusable wells/piezometers; 33 in excavation limits + 7 in stockpile areas	Each	30	$150.00	$4,500
Drill Rig Mob/Demob		LS	NA	NA	$1,000
Monitoring Well Installation (Overburden)	2" SS overburden well; includes drilling, well construction; 4 in excavation limits + 3 in stockpile areas	Each	7	$2,340.00	$16,380
Monitoring Well Installation (Bedrock)	2" SS bedrock well for zones A, B, and C; includes drilling, well construction; 9 in excavation limits+ 4 in stockpile areas	Each	13	$8,100.00	$105,300
Subtotal					$127,180
Thermal Desorption Treatment					
Additional Soil Testing	Geotechnical testing includes organic content, density, moisture content, particle size	Each	3	$185.39	$556
Thermal Desorption System (Fixed Costs)	Includes equipment, mob/demob costs	LS	1	NA	$4,045,095
Thermal Desorption System (Treatment)	Includes labor, maintenance, utilities, and fuel costs; based on 38,718 BCY (excavated soil @ 1.54 tons/BCY)	Ton	59,630	$41.39	$2,468,086
Soil Mixing	300 Horsepower Front End Loader w/ 150' haul; based on 38,718 BCY (excavated soil @ 28% swell factor)	LCY	49,560	$0.85	$42,126
Loading Soil to Thermal Desorption Unit	Front End Loader, 2-1/2 to 3-1/2 CY, 130 horsepower	months	3	$3,800.00	$11,400
Unloading Soils from Thermal Desorption Unit	Front End Loader, 2-1/2 to 3-1/2 CY, 130 horsepower	months	3	$3,800.00	$11,400
Subtotal					$6,578,663

Table 4-3
OU1 - Alternative No. OS-4 - Excavation & On-Site Treatment of Overburden Source Soils
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Backfilling					
Placement of Fill (On-Site)	300 Horsepower Front End Loader w/ 300' haul; based on 10% of total on-site fill	LCY	1,939	$1.23	$2,385
Placement of Soil (Excavation)	300 Horsepower Front End Loader w/ 300' haul	LCY	54,990	$1.23	$67,638
Compaction	Vibrating roller, 12" compacted lifts, 4 passes	LCY	54,990	$0.33	$18,147
Subtotal					$88,169
Installation of Catch Basins					
Pavement Demolition	Assumes to 6" depth with hydraulic hammer; based on 375' of trench	SY	625	$10.00	$6,250
Stormwater Lateral Trenching	Excavate trench 4'-6' deep w/ 1-1/2 CY hydraulic backhoe; Assume 375 LF of trenching/5.5' deep/3'width	BCY	556	$2.70	$1,501
Transport Pavement/Soil to Stockpile	300 Horsepower Front End Loader w/ 300' haul; pavement/foundation w/ 40% and soil w/ 28% swell factor	LCY	858	$1.20	$1,029
Stormwater Laterals	8" fiberglass reinforced pipe and fittings; includes material and labor	LF	675	$65.00	$43,875
Lateral Connections	Includes fittings, reducers; assume 5% of total lateral cost	LS	1	NA	$5,674
Stormwater Laterals	12" fiberglass reinforced pipe and fittings; includes material and labor	LF	600	$116.00	$69,600
Placement of Backfill	Front End Loader w/ 100' haul; backfill trench	LCY	746	$3.80	$2,835
Compaction of Backfill	Vibrating roller, 12" compacted lifts, 4 passes	LCY	746	$0.33	$246
Installation of Catch Basins	4' inner diameter, 6 ft deep, concrete, pre-cast catch basin; includes material, labor, equipment	Each	5	$2,275.00	$11,375
Subtotal					$142,385

Table 4-3
OU1 - Alternative No. OS-4 - Excavation & On-Site Treatment of Overburden Source Soils
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
				Capital Cost Subtotal:	$8,748,676
				Adjusted Capital Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$8,993,639
				10% Legal, administrative, engineering fees, construction management:	$899,364
				15% Contingencies:	$1,483,950
				Total Capital Cost:	**$11,377,000**
Annual Costs					
Not Applicable					$0
Subtotal					$0
				Annual Cost Subtotal:	$0
				Adjusted Annual Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$0
				10% Legal, administrative, engineering fees:	$0
				15% Contingencies:	$0
				Annual Cost Total:	**$0**
				30-Year Present Worth of Annual Costs:	**$0**
				Total Present Worth Cost:	**$11,377,000**

Assumptions
1. Assume existing trees along site perimeter will remain on-site; site clearing/excavation activities will be performed as close to site perimeter as permissible.
2. Assume site surface area to be approximately 420,000 square feet.
3. Assume all building walls to be 6 inches thick.
4. Assume Bldg 70, 73, 56, and 18 to be 25 ft in height.
5. Assume Bldg 20/60 to be 15 ft in height.
6. Assume 16 on-site above-ground storage tanks; see Appendix A.
7. White poly tank located by gate in northeast corner of site is assumed to be removed by others and therefore, not considered in this cost estimate.
8. Assume any collected stormwater in tanks to be discharged on-site (assuming the tanks were cleaned previously and the accumulated water would be from prec
9. Assume 10% of total hard debris will remain on-site as fill to level site; remaining 90% will be stockpiled on-site.
10. Assume 25% of debris pile in the center of the site to have foundation existing to 3 ft above ground surface; remaining 75% assumed to be at ground surface.
11. Assume drums will be sorted out of debris piles.
12. Debris volume for walls/foundations assumes demolition to ground surface.
13. Assume common earth (moist) swell factor of 28% and 1.54 Tons/BCY; concrete swell factor of 40% and 1.86 tons/BCY; brick/concrete swell factor of 40% and 1.49 tons/BCY; gravel swell factor of 13% and 1.57 tons/BCY (Means Estimating Handbook. United States of America : Means Southern Construction Information Network, 1990).
14. Assume characterization samples to be collected for every 500 tons of soil.
15. Assume existing catch basins in pavement or concrete areas will be abandoned.

Abbreviations:
BCY = bank cubic yards
LCY = loose cubic yards
SY = square yards
LF = linear feet
SF = square feet
CF = cubic feet
LS = lump sum

Table 4-3
OU1 - Alternative No. OS-4 - Excavation & On-Site Treatment of Overburden Source Soils
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost

16. Assume new catch basins to extend 5.5' below ground surface and connect to Falls Street Tunnel.
17. Assume excavated soil for catch basin installation is considered non-hazardous and will be replaced as backfill.
18. Assume existing fence will remain and repairs are not needed.
19. Assume water main lines currently existing in Block Building located by gate in the northeast corner of site will remain as is (sticking up above the ground surfac
20. Assume existing monitoring wells will remain as is (with stickup above the ground surface).
21. Assume no site restoration (I.e. seeding).
22. Assume existing demolition debris will be removed and disposed off-site by site owner or others.

Table 4-4
OU1 - Alternative No. OS-5 - Excavation & Off-Site Treatment/Disposal of Overburden Source Soils
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Capital Costs					
Construction Management (2.5% of total capital cost)	Includes submittals, reporting, meetings	LS	1	NA	$305,630
Institutional Controls		Each	1	$2,000	$2,000
Subtotal					$307,630
Site Preparation					
Surveying Crew	2-person crew @ $50/hr, 8hr/day	Day	10	$800.00	$8,000
Site Clearing	With dozer, light clearing; assume 25% of site area	Acre	2	$790.00	$1,904
Subtotal					$9,904
Health and Safety					
Construct Decontamination Pad & Containment	For equipment & personnel	Setups	1	$1,000.00	$1,000
Community/Exclusion Zone Air Monitoring	Photoionization detector (Qty 1) & particulate meter rental (Qty 3)	months	12	$3,300.00	$39,600
Site Safety Officer	8 hrs/day, 5days/wk, $55/hr	manweeks	48	$2,200.00	$105,600
Personal Protective Equipment	Includes coveralls, hard hats, safety glasses, reusable boots, gloves; assume 10-persons on-site per day changing twice per day	months	12	$4,500.00	$54,000
Subtotal					$200,200
Demolition					
Buildings					
Building Demolition (Metal)	see Appendix A; includes loading of dump trucks	CF	23,775	$0.20	$4,755
Building Demolition (Concrete)	see Appendix A; includes loading of dump trucks	CF	4,395	$0.30	$1,319
Building Demolition (Wood)	see Appendix A; includes loading of dump trucks	CF	192	$0.20	$38
Building Demolition (Asphalt Shingles)	see Appendix A; includes loading of dump trucks	CF	990	$0.23	$231
Transport Debris to Stockpile	300 Horsepower Front End Loader w/ 300' haul	LCY	1,087	$1.20	$1,305
Tanks					
Tank Characterization	Includes TCLP, Pesticides/PCB, PAH, RCRA ignitability, RCRA corrosivity, RCRA reactivity analyses; Assume 24 hr turnaround	Each	1	$1,063.61	$1,064

Table 4-4
OU1 - Alternative No. OS-5 - Excavation & Off-Site Treatment/Disposal of Overburden Source Soils
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Tank Demolition/Transportation to Stockpile (6,000-8,000 gal)		Each	3	$650.00	$1,950
Tank Demolition/Transportation to Stockpile (9,000-12,000 gal)		Each	7	$1,000.00	$7,000
Tank Demolition/Transportation to Stockpile (12,000+ gal)		Each	6	$1,000.00	$6,000
Walls/Foundations					
Wall Demolition	Assume 6" thick with reinforcing	SF	7,125	$2.06	$14,706
Foundation Demolition	Assume reinforced concrete	BCY	1,383	$109.00	$150,783
Transport Debris to Stockpile	300 Horsepower Front End Loader w/ 300' haul; based on 40% brick/concrete swell factor	LCY	2,121	$1.20	$2,546
Misc Debris					
Transport Debris to Stockpile	300 Horsepower Front End Loader w/ 300' haul	LCY	15,336	$1.20	$18,403
Development of Stockpiles					
Additional Debris Sorting	300 Horsepower Front End Loader w/ 300' haul; assume 50% of total cost to transport debris to stockpile	LS	1	NA	$11,127
Filter Fabric	Includes polypropylene fabric material and installation	SY	2,611	$1.62	$4,230
Common Earth Cover (Material Only)	2' of cover over fill stockpile; assume 23,500 ft2 area; based on 28% soil swell factor	LCY	2,228	$6.00	$13,369
Topsoil (Material Only)	6" of topsoil; add 10% for compaction	LCY	479	$12.00	$5,744
Seeding (w/ mulch and fertilizer)	Bluegrass 4#/MSF w/ mulch and fertilizer, hydroseeding	MSF	24	$45.50	$1,069
Placement/Grading of Cover Material	300 Horsepower Front End Loader w/ 300' haul; based on 28% soil swell factor	LCY	2,707	$1.23	$3,329
Compaction of Gravel / Backfill	Vibrating roller, 12" compacted lifts, 4 passes	LCY	2,707	$0.33	$893
Subtotal					$249,861

Table 4-4
OU1 - Alternative No. OS-5 - Excavation & Off-Site Treatment/Disposal of Overburden Source Soils
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Soil Excavation					
Utility Repair		Each	5	$5,000.00	$25,000
Pavement Demolition	Assumes to 6" depth with hydraulic hammer; based on 190,075 ft2 (excavation area) - 32,025 ft2 (unpaved area)	SY	17,561	$10.20	$179,123
Excavation	Hydraulic excavator w/2 CY bucket = 130 CY/hr; based on 38,718 BCY (contaminated soil) + 1,036 BCY (cut-back)	BCY	39,754	$1.71	$67,979
Application of Foam	Includes rental of foam dispensing unit, foam (for excavation area and soil stockpile), on-site technician for 1 week	Day	90	$740.00	$69,600
Containment Building (for Soil Staging Area)	Rental of 24,000 ft2 structure for 6 mo; inlcudes delivery on- and off-site, structure erection, and dismantling	LS	1	NA	$272,506
Transport Soil & Pavement to Stockpile	300 Horsepower Front End Loader w/ 300' haul; based on 28% soil swell factor and 40% concrete swell factor	LCY	54,990	$1.23	$67,638
Stockpiling	300 Horsepower Bulldozer w/ 50' haul; excluding pavement	LCY	54,990	$0.53	$29,145
VOC Screening	Immunoassay testing; assume 2 sample every 5 feet along perimeter of excavation only	Each	740	$100.00	$74,000
Confirmatory Sampling	Includes TCLP, Pesticides/PCB, PAH, RCRA ignitability, RCRA corrosivity, RCRA reactivity analyses; Assume 24 hr turnaround; one sample per 500 tons	Each	169	$1,063.61	$180,143
Disposal of Decon Drums	Waste decon water (<1% solids); price per 55 gal drum including transportation	Drum	50	$150.00	$7,500
Loading Trucks	300 Horsepower Front End Loader w/ 150' haul; based on 28% soil swell factor	LCY	54,990	$0.85	$46,742
Dump Truck Transportation	16.5 CY Dump truck; 20 mi round trip	LCY	54,990	$15.90	$874,341
Off-Site Disposal (Non-Haz Soil)	Dump truck transport; soil @ 1.54 Tons/BCY; assume 75% of excavated soil	Ton	44,719	$60.00	$2,683,157
Off-Site Disposal (Haz Soil)	Dump truck transport; soil @ 1.54 Tons/BCY; assume 25% of excavated soil	Ton	14,906	$150.00	$2,235,965
Subtotal					$6,812,838

Table 4-4
OU1 - Alternative No. OS-5 - Excavation & Off-Site Treatment/Disposal of Overburden Source Soils
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Monitoring Well Decommissioning / Installation					
Monitoring Well Decommissioning	Excludes existing destroyed or unusable wells/piezometers; 33 in excavation limits + 7 in stockpile areas	Each	30	$150.00	$4,500
Drill Rig Mob/Demob		LS	NA	NA	$1,000
Monitoring Well Installation (Overburden)	2" SS overburden well; includes drilling, well construction; 4 in excavation limits + 3 in stockpile areas	Each	7	$2,340.00	$16,380
Monitoring Well Installation (Bedrock)	2" SS bedrock well for zones A, B, and C; includes drilling, well construction; 9 in excavation limits+ 4 in stockpile areas	Each	13	$8,100.00	$105,300
Subtotal					$127,180
Installation of Catch Basins					
Pavement Demolition	Assumes to 6" depth with hydraulic hammer; based on 375' of trench	SY	625	$10.20	$6,375
Stormwater Lateral Trenching	Excavate trench 4'-6' deep w/ 1-1/2 CY hydraulic backhoe; Assume 375 LF of trenching/5.5' deep/3'width	BCY	556	$2.76	$1,535
Transport Pavement/Soil to Stockpile	300 Horsepower Front End Loader w/ 300' haul; pavement/foundation w/ 40% and soil w/ 28% swell factor	LCY	858	$1.23	$1,055
Stormwater Laterals	8" fiberglass reinforced pipe and fittings; includes material and labor	LF	675	$71.00	$47,925
Lateral Connections	Includes fittings, reducers; assume 5% of total lateral cost	LS	1	NA	$5,876
Stormwater Laterals	12" fiberglass reinforced pipe and fittings; includes material and labor	LF	600	$116.00	$69,600
Placement of Backfill	Front End Loader w/ 100' haul; backfill trench	LCY	746	$3.80	$2,835
Compaction of Backfill	Vibrating roller, 12" compacted lifts, 4 passes	LCY	746	$0.33	$246
Installation of Catch Basins	4' inner diameter, 6 ft deep, concrete, pre-cast catch basin; includes material, labor, equipment	Each	5	$2,275.00	$11,375
Subtotal					$146,821
Backfilling					
Placement of Fill (On-Site)	300 Horsepower Front End Loader w/ 300' haul; based on 10% of total on-site fill	LCY	1,939	$1.23	$2,385

Table 4-4
OU1 - Alternative No. OS-5 - Excavation & Off-Site Treatment/Disposal of Overburden Source Soils
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Backfill (Material Only)	Based on total soil volume excavated - 50% of unused on-site fill; add 10% for compaction	LCY	48,863	$6.00	$293,178
Placement of Fill & Backfill (Excavation)	300 Horsepower Front End Loader w/ 300' haul; based on excavated soil area	LCY	54,990	$1.23	$67,638
Compaction	Vibrating roller, 12" compacted lifts, 4 passes	LCY	54,990	$0.33	$18,147
Subtotal					$381,348
				Capital Cost Subtotal:	$8,235,782
				Adjusted Capital Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$8,466,384
				10% Legal, administrative, engineering fees, construction management:	$846,638
				15% Contingencies:	$1,396,953
				Total Capital Cost:	**$10,710,000**
Annual Costs					
Not Applicable					$0
Subtotal					$0
				Annual Cost Subtotal:	$0
				Adjusted Annual Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$0
				10% Legal, administrative, engineering fees:	$0
				15% Contingencies:	$0
				Annual Cost Total:	**$0**
				30-Year Present Worth of Annual Costs:	**$0**
				Total Present Worth Cost:	**$10,710,000**

Table 4-4
OU1 - Alternative No. OS-5 - Excavation & Off-Site Treatment/Disposal of Overburden Source Soils
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost

Assumptions

1. Assume existing trees along site perimeter will remain on-site; site clearing/excavation activities will be performed as close to site perimeter as permissible.
2. Assume site surface area to be approximately 420,000 square feet.
3. Assume all building walls to be 6 inches thick.
4. Assume Bldg 70, 73, 56, and 18 to be 25 ft in height.
5. Assume Bldg 20/60 to be 15 ft in height.
6. Assume 16 on-site above-ground storage tanks; see Appendix A.
7. White poly tank located by gate in northeast corner of site is assumed to be removed by others and therefore, not considered in this cost estimate.
8. Assume any collected stormwater in tanks to be discharged on-site (assuming the tanks were cleaned previously and the accumulated water would be from precipitation).
9. Assume 10% of total hard debris will remain on-site as fill to level site; 50% of the remaining 90% will be used as backfill in the excavation; the remaining fill will be stockpiled on-site.
10. Assume 25% of debris pile in the center of the site to have foundation existing to 3 ft above ground surface; remaining 75% assumed to be at ground surface.
11. Assume drums will be sorted out of debris piles.
12. Debris volume for walls/foundations assumes demolition to ground surface.
13. Assume common earth (moist) swell factor of 28% and 1.54 Tons/BCY; concrete swell factor of 40% and 1.86 tons/BCY; brick/concrete swell factor of 40% and 1.49 tons/BCY; gravel swell factor of 13% and 1.57 tons/BCY (Means Estimating Handbook. United States of America : Means Southern Construction Information Network, 1990).
14. Assume characterization samples to be collected for every 500 tons of soil.
15. Assume existing catch basins in pavement or concrete areas will be abandoned.
16. Assume new catch basins to extend 5.5' below ground surface and connect to Falls Street Tunnel.
17. Assume excavated soil for catch basin installation is considered non-hazardous and will be replaced as backfill.
18. Assume existing fence will remain and repairs are not needed.
19. Assume water main lines currently existing in Block Building located by gate in the northeast corner of site will remain as is (sticking up above the ground surface).
20. Assume existing monitoring wells will remain as is (with stickup above the ground surface).
21. Assume no site restoration (I.e. seeding).
22. Assume existing demolition debris will be removed and disposed off-site by site owner or others.

Abbreviations:

BCY = bank cubic yards
LCY = loose cubic yards
SY = square yards
LF = linear feet
SF = square feet
CF = cubic feet
LS = lump sum

Table 4-5
OU1 - Alternative No. OG-2 - Institutional Controls
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Capital Costs					
Work Plan		LS	1	NA	$15,000
Institutional Controls		Each	1	$2,500.00	$2,500
Subtotal					$17,500
				Capital Cost Subtotal:	$17,500
				Adjusted Capital Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$17,990
				10% Legal, administrative, engineering fees, construction management:	$1,799
				15% Contingencies:	$2,968
				Total Capital Cost:	**$23,000**
Annual Costs (First 5 Years)					
Groundwater Monitoring					
Monitoring Well Sampling (Labor)	2-person @ $50/hr, 8hr/day; 5 total wells - assume 3 wells per day; twice per year	Day	4	$800.00	$3,200
Equipment Rental	Groundwater level indicator; twice per year	Day	4	$50.00	$200
Parameter Analyses	Includes TCL VOCs, TCL SVOCs, TCL PCB/Pesticides, TAL Metals, Cyanide, hardness; assume 1 sample per well; twice per year	Each	10	$1,093.44	$10,934
Data Evaluation and Reporting	Twice per year	HR	64	$90.00	$5,760
Monitoring Well Maintenance		LS	1	NA	$500
Subtotal					$20,594
				Annual Cost Subtotal:	$20,594
				Adjusted Annual Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$21,171
				10% Legal, administrative, engineering fees:	$2,117
				15% Contingencies:	$3,493
				Annual Cost Total:	**$26,781**
				30-Year Present Worth of Annual Costs:	**$116,000**

Table 4-5
OU1 - Alternative No. OG-2 - Institutional Controls
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Annual Costs					
Groundwater Monitoring					
Monitoring Well Sampling (Labor)	2-person @ $50/hr, 8hr/day; 5 total wells - assume 3 wells per day	Day	2	$800.00	$1,600
Equipment Rental	Groundwater level indicator	Day	2	$50.00	$100
Parameter Analyses	Includes TCL VOCs, TCL SVOCs, TCL PCB/Pesticides, TAL Metals, Cyanide, hardness; assume 1 sample per well	Each	5	$1,093.44	$5,467
Data Evaluation and Reporting		HR	32	$90.00	$2,880
Monitoring Well Maintenance		LS	1	NA	$500
Subtotal					$10,547
				Annual Cost Subtotal:	$10,547
				Adjusted Annual Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$10,843
				10% Legal, administrative, engineering fees:	$1,084
				15% Contingencies:	$1,789
				Annual Cost Total:	**$13,716**
				30-Year Present Worth of Annual Costs:	**$194,000**
				Total Present Worth Cost:	**$333,000**

Assumptions
1. 30-year present worth of costs assumes 5% annual interest rate.

Abbreviations:
LS = lump sum
HR = hour

Table 4-6
OU1 - Alternative No. OG-3 - Overburden Groundwater Hydraulic Containment
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Capital Costs					
Work Plan	Includes submittals, reporting, meetings	LS	1	NA	$13,925
Institutional Controls		Each	1	$2,500.00	$2,500
Subtotal					$16,425
Site Preparation					
Surveying Crew	2-person crew @ $50/hr, 8hr/day	Day	10	$800.00	$8,000
Subtotal					$8,000
Health and Safety					
Construct Decontamination Pad & Containment	For equipment & personnel	Setups	1	$1,000.00	$1,000
Community/Exclusion Zone Air Monitoring	Photoionization detector (Qty 1) & particulate meter rental (Qty 3)	months	3	$4,050.00	$12,150
Site Safety Officer	10 hrs/day, 5days/wk, $75/hr	manweeks	12	$2,200.00	$26,400
Personal Protective Equipment	Includes coveralls, hard hats, safety glasses, reusable boots, gloves; assume 10-persons on-site per day changing twice per day	LS	1	NA	$21,700.00
Subtotal					$61,250
Collection Trench Excavation					
Utility Repair		Each	5	$5,000.00	$25,000
Soil					
Soil Excavation	1-1/2 CY hydraulic backhoe; based on length of 530'; trench 16' deep	BCY	1,649	$3.11	$5,128
Transport Soil to Stockpile	300 Horsepower Front End Loader w/ 150' haul; based on 28% soil swell factor	LCY	2,111	$0.85	$1,794
Pavement					
Pavement Demolition	Assumes to 6" depth with hydraulic hammer; based on 440' trench	SY	733	$10.20	$7,480
Additional Soil Excavation (to 16')	1-1/2 CY hydraulic backhoe; based on 440' trench; 15.5' deep	BCY	1,251	$3.11	$3,890
Transport Debris to Stockpile	300 Horsepower Front End Loader w/ 150' haul; based on 40% pavement swell factor & 28% soil swell factor	LCY	1,772	$0.85	$1,506
Foundations					
Foundation Demolition	Assume reinforced concrete to maximum 1'; based on 30' trench	BCY	17	$109.00	$1,817
Additional Soil Excavation (to 16')	1-1/2 CY hydraulic backhoe; based on 30' trench; 15' deep	BCY	78	$3.11	$242

Table 4-6
OU1 - Alternative No. OG-3 - Overburden Groundwater Hydraulic Containment
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Transport Debris to Stockpile	300 Horsepower Front End Loader w/ 150' haul; based on 40% pavement swell factor & 28% soil swell factor	LCY	123	$0.85	$104
Subtotal					$46,961
Collection Trench Installation					
Trench Box	7' deep, 6' x 20', require approx 10 trench boxes	months	3	$15,500.00	$46,500
Pump (Dewatering)	Assume 3 pump rentals	months	3	$1,609.20	$4,828
Piping (Dewatering)	150' flexible hosing	Each	3	$500.00	$1,500
Drainage Piping	8" PVC perforated pipe material and labor	LF	1,000	$8.13	$8,125
Gravel (Material Only)	Assume 15' gravel fill; 1.57 Ton/BCY and 13% swell factor	Ton	4,600	$20.00	$91,990
Filter Fabric	Includes polypropylene fabric material and installation above gravel layer	SY	1,444	$1.62	$2,340
Backfill (Material Only)	Assume 1' common earth backfill; based on 28% swell factor	LCY	664	$6.00	$3,982
Placement of Gravel / Backfill	Front End Loader w/ 100' haul	LCY	3,593	$3.80	$13,655
Compaction of Gravel / Backfill	Vibrating roller, 12" compacted lifts, 4 passes	LCY	3,593	$0.33	$1,186
Installation of Manhole	4' inner diameter, 16 ft deep, concrete, pre-cast manhole; includes material, labor, equipment	Each	6	$7,200.00	$43,200
Pump and Controls	4" submersible pump; 1/3 HP; 0.3-7 gpm w/ controls; up to 140' head	Each	1	$1,953.60	$1,954
Subtotal					$219,259
Extraction Well Installation					
Monitoring Well Decommissioning		Each	2	$500.00	$1,000
Drill Rig Mob/Demob		LS	NA	NA	$1,000
4" Overburden Extraction Well	Includes drilling, well construction, and pump w/controls	Each	1	$9,490.00	$9,490
Subtotal					$11,490

Table 4-6
OU1 - Alternative No. OG-3 - Overburden Groundwater Hydraulic Containment
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Transfer Piping Installation					
Pavement Demolition (from Trench and Well to Treatment System)	Assumes to 6" depth with hydraulic hammer; based on 260' of trenching	SY	289	$10.20	$2,947
Transfer Pipe Trenching (from Trench and Well to Treatment System)	Excavate trench 1'-4' deep w/ 3/8 CY tractor/loader/backhoe; Assume 260 LF of trenching/4' deep/2'width	BCY	190	$5.75	$1,093
Transport Pavement/Soil to Stockpile	300 Horsepower Front End Loader w/ 300' haul; pavement/foundation w/ 40% and soil w/ 28% swell factor	LCY	311	$1.23	$382
Transfer Pipe (Laterals)	4" PVC, Schedule 80 connection piping; includes material and installation; from collection trench and well to manifold	LF	175	$9.26	$1,621
Discharge Pipe (Manifold to Treatment System)	8" PVC, Schedule 80 manifold piping (based on BG hydraulic containment alternative)	LF	85	$18.46	$1,569
Gravel (Material only)	Gravel @ 1.57 Ton/BCY and 13% swell factor	Ton	256	$20.00	$5,125
Filter Fabric	Includes polypropylene fabric material and installation above gravel layer	SY	231	$1.62	$374
Backfill (Material Only)	Assume 1' common earth backfill; based on 28% swell factor	LCY	37	$6.00	$222
Placement of Gravel / Backfill	Front End Loader w/ 100' haul	LCY	221	$3.80	$841
Compaction	Vibrating roller, 12" compacted lifts, 4 passes	LCY	221	$0.33	$73
Subtotal					$14,247
				Capital Cost Subtotal:	$377,632
				Adjusted Capital Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$388,206
				10% Legal, administrative, engineering fees, construction management:	$38,821
				15% Contingencies:	$64,054
				Total Capital Cost:	**$492,000**

Table 4-6
OU1 - Alternative No. OG-3 - Overburden Groundwater Hydraulic Containment
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Annual Costs (First 5 Years)					
Groundwater Monitoring					
Monitoring Well Sampling (Labor)	2-person @ $50/hr, 8hr/day; 5 total wells - assume 3 wells per day; twice per year	Day	4	$800.00	$3,200
Equipment Rental	Groundwater level indicator; twice per year	Day	4	$50.00	$200
Parameter Analyses	Includes TCL VOCs, TCL SVOCs, TCL PCB/Pesticides, TAL Metals, Cyanide, hardness; assume 1 sample per well	Each	10	$1,093.44	$10,934
Data Evaluation and Reporting	Twice per year	HR	64	$90.00	$5,760
Monitoring Well Maintenance		LS	1	NA	$500
Subtotal					$20,594
				Annual Cost Subtotal:	$20,594
				Adjusted Annual Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$21,171
				10% Legal, administrative, engineering fees:	$2,117
				15% Contingencies:	$3,493
				Annual Cost Total:	**$26,781**
				30-Year Present Worth of Annual Costs:	**$116,000**

Table 4-6
OU1 - Alternative No. OG-3 - Overburden Groundwater Hydraulic Containment
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Annual Costs					
Groundwater Monitoring					
Monitoring Well Sampling (Labor)	2-person @ $50/hr, 8hr/day; 5 total wells - assume 3 wells per day	Day	2	$800.00	$1,600
Equipment Rental	Groundwater level indicator	Day	2	$50.00	$100
Parameter Analyses	Includes TCL VOCs, TCL SVOCs, TCL PCB/Pesticides, TAL Metals, Cyanide, hardness; assume 1 sample per well	Each	5	$1,093.44	$5,467
Data Evaluation and Reporting		HR	32	$90.00	$2,880
Monitoring Well Maintenance		LS	1	NA	$500
Subtotal					$10,547
				Annual Cost Subtotal:	$10,547
				Adjusted Annual Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$10,843
				10% Legal, administrative, engineering fees:	$1,084
				15% Contingencies:	$1,789
				Annual Cost Total:	**$13,716**
				30-Year Present Worth of Annual Costs:	**$194,000**
				Total Present Worth Cost:	**$802,000**

Assumptions
1. Assume survey crew will be on-site 50% total project duration.
2. Assume 1,000 ft length / 16 ft depth / 3 ft width collection trench along southern and part of western perimeter of site; trench to follow contour of fenceline at a distance of approx 15'.
3. Assume no site clearing necessary.
4. Assume trench excavation to encounter 530 ft of unpaved soil, 440 ft of existing pavement, and 30 ft of existing foundation.
5. Assume common earth (moist) swell factor of 28% and 1.54 Tons/BCY; concrete swell factor of 40% and 1.86 tons/BCY; gravel swell factor of 13% and 1.57 tons/BCY (Means Estimating Handbook. United States of America : Means Southern Construction Information Network, 1990).
6. Assume reinforced concrete foundation depth to 1 ft.
7. Overburden groundwater treatment system and associated costs included in Table 4-8 OU2 - Alternative No. BG-3 - Hydraulic Containment.
8. 30-year present worth of costs assumes 5% annual interest rate.

Abbreviations:
BCY = bank cubic yards
LCY = loose cubic yards
LS = lump sum
LF = linear foot
SY = square yard

Notes
"2002 Means" = RS Means Site Work & Landscape Cost Data, 21st Annual Edition
"2002 ECHOS" = RS Means Environmental Remediation Cost Data - Unit Price, 8th Annual Edition
Costs from 2002 ECHOS include 10% O&P for equipment/material only and 25% O&P for services

Table 4-7
OU2 - Alternative No. BG-2 - Institutional Controls
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Capital Costs					
Work Plan		LS	1	NA	$15,000
Institutional Controls		Each	1	$2,000.00	$2,000
Subtotal					$17,000
				Capital Cost Subtotal:	$17,000
				Adjusted Capital Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$17,476
				10% Legal, administrative, engineering fees, construction management:	$1,748
				15% Contingencies:	$2,884
				Total Capital Cost:	**$23,000**
Annual Costs (First 5 Years)					
Groundwater Monitoring					
Monitoring Well Sampling (Labor)	2-person @ $50/hr, 8hr/day; 12 total wells - assume 3 wells per day; twice per year	Day	8	$800.00	$6,400
Equipment Rental	Groundwater level indicator; twice per year	Day	8	$50.00	$400
Parameter Analyses	Includes TCL VOCs, TCL SVOCs, TCL PCB/Pesticides, TAL Metals, Cyanide, hardness; assume 1 sample per well; twice per year	Each	24	$1,093.44	$26,243
Data Evaluation and Reporting	Twice per year	HR	80	$90.00	$7,200
Monitoring Well Maintenance		LS	1	NA	$500
Subtotal					$40,743
				Annual Cost Subtotal:	$40,743
				Adjusted Annual Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$41,883
				10% Legal, administrative, engineering fees:	$4,188
				15% Contingencies:	$6,911
				Annual Cost Total:	**$52,982**
				30-Year Present Worth of Annual Costs:	**$230,000**

Table 4-7
OU2 - Alternative No. BG-2 - Institutional Controls
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Annual Costs					
Groundwater Monitoring					
Monitoring Well Sampling (Labor)	2-person @ $50/hr, 8hr/day; 12 total wells - assume 3 wells per day	Day	4	$800.00	$3,200
Equipment Rental	Groundwater level indicator	Day	4	$50.00	$200
Parameter Analyses	Includes TCL VOCs, TCL SVOCs, TCL PCB/Pesticides, TAL Metals, Cyanide, hardness	Each	12	$1,093.44	$13,121
Data Evaluation and Reporting		HR	40	$90.00	$3,600
Monitoring Well Maintenance		LS	1	NA	$500
Subtotal					$20,621
				Annual Cost Subtotal:	$20,621
				Adjusted Annual Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$21,199
				10% Legal, administrative, engineering fees:	$2,120
				15% Contingencies:	$3,498
				Annual Cost Total:	**$26,816**
				30-Year Present Worth of Annual Costs:	**$378,000**
				Total Present Worth Cost:	**$631,000**

Assumptions
1. 30-year present worth of costs assumes 5% annual interest rate.

Abbreviations:
LS = lump sum
HR = hour

Table 4-8
OU2 - Alternative No. BG-3 - Bedrock Groundwater Hydraulic Containment
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Capital Costs					
Construction Management (2.5% of total capital cost)	Includes submittals, reporting, meetings	LS	1	NA	$29,488
Institutional Controls		Each	1	$2,000.00	$2,000
Subtotal					$31,488
Site Preparation					
Surveying Crew	2-person crew @ $50/hr, 8hr/day	Day	30	$800.00	$24,000
Subtotal					$24,000
Health and Safety					
Construct Decontamination Pad & Containment	For equipment & personnel	Setups	1	$1,000.00	$1,000
Community/Exclusion Zone Air Monitoring	Photoionization detector (Qty 1) & particulate meter rental (Qty 3)	months	3	$3,300.00	$9,900
Site Safety Officer	8 hrs/day, 5days/wk, $55/hr	manweeks	12	$2,200.00	$26,400
Personal Protective Equipment	Includes coveralls, hard hats, safety glasses, reusable boots, gloves; assume 10-persons on-site per day changing twice per day	LS	1	NA	$21,700.00
Subtotal					$59,000
Extraction Well Installation					
Pump Tests	Per well	Each	3	$9,170.00	$27,510
Treatibility Study		LS	1	NA	$10,000
Drill Rig Mob/Demob		LS	1	NA	$1,000
6" Bedrock Extraction Well	Includes drilling and well construction	Each	7	$18,500.00	$129,500
Pump and Controls (Bedrock Wells)	4" submersible pump; 2 HP; 21-32 gpm w/ controls; 201' to 280' head	Each	4	$2,599.30	$10,397
Pump and Controls (Bedrock Wells)	4" submersible pump; 5 HP; 21-32 gpm w/ controls; 341' to 600' head	Each	3	$4,643.10	$13,929
Subtotal					$192,337
Transfer / Discharge Piping					
Pavement Demolition (from Trench and Well to Treatment System)	Assumes to 6" depth with hydraulic hammer; based on 1,030' of trenching	SY	1,144	$10.20	$11,673
Transfer Pipe Trenching (from Wells to Treatment System)	Excavate trench 1'-4' deep w/ 3/8 CY tractor/loader/backhoe; Assume 1,180 LF of trenching/4' deep/2'width	BCY	870	$5.75	$5,003

Table 4-8
OU2 - Alternative No. BG-3 - Bedrock Groundwater Hydraulic Containment
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Transport Pavement/Soil to Stockpile	300 Horsepower Front End Loader w/ 300' haul; pavement/foundation w/ 40% and soil w/ 28% swell factor	LCY	1,381	$1.23	$1,698
Transfer Pipe (Laterals)	6" PVC, Schedule 80 connection piping; includes material and installation; from wells to manifold	LF	480	$15.83	$7,596
Transfer Pipe (Manifold to Treatment System)	8" PVC, Schedule 80 manifold piping; includes material and installation	LF	550	$18.46	$10,154
Discharge Pipe (Treatment System to POTW)	8" PVC, Schedule 80 connection piping; includes material and installation	LF	150	$20.66	$3,099
Gravel (Material only)	Gravel @ 1.57 Ton/BCY and 13% swell factor	Ton	1,163	$20.00	$23,260
Filter Fabric	Includes polypropylene fabric material and installation above gravel layer	SY	1,049	$1.62	$1,699
Backfill (Material Only)	Assume 1' common earth backfill; based on 28% swell factor	LCY	168	$6.00	$1,007
Placement of Gravel / Backfill	Front End Loader w/ 100' haul	LCY	909	$3.80	$3,453
Compaction of Gravel / Backfill	Vibrating roller, 12" compacted lifts, 4 passes	LCY	909	$0.33	$300
Electrical Distribution					
Electrical Pole and Overhead Wire Installation	Assume power source is overhead electric from Royal Ave or 47th Street	Each	2	$1,500.00	$3,000
Panel Board		Each	1	$2,000.00	$2,000
Electrical & Telephone Connection Fee and Meter		LS	1	NA	$1,500
Subtotal					$75,443
Treatment System					
Delivery of Systems	Assume 5 deliveries	Each	5	$1,000.00	$5,000
Pre-Fabricated Enclosure (Approx 2,500 SF)	Includes installation, insulation, piping, etc.	LS	1	NA	$20,000
Carbon Drums & Accessories	For collection trench; includes 2-55 gal carbon-filled drums, associated piping, and pre/post filter (bag-type)	LS	1	NA	$2,000
Equalization Tank	10,000 gal double walled fiberglass tank includes fittings and piping	Each	1	$49,599.90	$49,600
Oil Water Seperator		LS	1	$50,000.00	$50,000
Air Stripper and GAC treatment system		LS	1	$200,000.00	$200,000

Table 4-8
OU2 - Alternative No. BG-3 - Bedrock Groundwater Hydraulic Containment
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Settling Tank	10,000 gal double walled steel tank includes fittings	Each	1	$16,407.20	$16,407
Effluent Holding Tank	10,000 gal double walled fiberglass tank includes fittings	Each	1	$49,589.70	$49,590
Installation of Treatment Systems and Piping	3-man crew @ $50/hr, 8hr/day, 10 days	HR	120	$150.00	$18,000
Connection to POTW		LS	1	NA	$2,500
Discharge to POTW	Maximum discharge flow = 205 gpm	MG	1	$2,000.00	$1,051
Subtotal					$414,148
				Capital Cost Subtotal:	$796,416
				Adjusted Capital Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$818,715
				10% Legal, administrative, engineering fees, construction management:	$81,872
				25% Contingencies:	$225,147
				Total Capital Cost:	**$1,126,000**
Annual Costs (First 5 Years)					
Groundwater Monitoring					
Monitoring Well Sampling (Labor)	2-person @ $50/hr, 8hr/day; 12 total wells - assume 3 wells per day; twice per year	Day	8	$800.00	$6,400
Equipment Rental	Groundwater level indicator; twice per year	Day	8	$50.00	$400
Parameter Analyses	Includes TCL VOCs, TCL SVOCs, TCL PCB/Pesticides, TAL Metals, Cyanide, hardness; assume 1 sample per well	Each	24	$1,093.44	$26,243
Data Evaluation and Reporting	Twice per year	HR	80	$90.00	$7,200
Monitoring Well Maintenance		LS	1	NA	$500
Groundwater Treatment System Monitoring	2-person crew @ $50/hr, 8 hr/day, 12 times per year	Day	12	$800.00	$9,600

Table 4-8
OU2 - Alternative No. BG-3 - Bedrock Groundwater Hydraulic Containment
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Groundwater Treatment System Sampling	Includes TCL VOCs, TCL SVOCs, TCL PCB/Pesticides, TAL Metals, Cyanide, hardness; influent and effluent; once per month	Each	24	$1,093.44	$26,243
Groundwater Treatment System Maintenance	Assume 12 per year	Each	12	$500.00	$6,000
Carbon Replacement	Assume replacement of carbon once per 12 months; Includes removal of spent carbon and refill of new	LB	400	$2.00	$800
Electricity Charge	Based on pump usage	Each	12	$1,099.84	$13,198
Telephone Charge	Assume $50/month	LS	1	NA	$600
Subtotal					$97,183
				Annual Cost Subtotal:	$97,183
				Adjusted Annual Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$99,904
				10% Legal, administrative, engineering fees:	$9,990
				25% Contingencies:	$27,474
				Annual Cost Total:	**$137,368**
				30-Year Present Worth of Annual Costs:	**$595,000**
Annual Costs					
Groundwater Monitoring					
Monitoring Well Sampling (Labor)	2-person @ $50/hr, 8hr/day; 12 total wells - assume 3 wells per day	Day	4	$800.00	$3,200
Equipment Rental	Groundwater level indicator; twice per year	Day	4	$50.00	$200
Parameter Analyses	Includes TCL VOCs, TCL SVOCs, TCL PCB/Pesticides, TAL Metals, Cyanide, hardness; assume 1 sample per well	Each	12	$1,093.44	$13,121
Data Evaluation and Reporting		HR	40	$90.00	$3,600
Monitoring Well Maintenance		LS	1	NA	$500
Groundwater Treatment System Monitoring	2-person crew @ $50/hr, 8 hr/day, 12 times per year	Day	12	$800.00	$9,600
Groundwater Treatment System Sampling	Includes TCL VOCs, TCL SVOCs, TCL PCB/Pesticides, TAL Metals, Cyanide, hardness; influent and effluent; once per month	Each	24	$1,093.44	$26,243

Table 4-8
OU2 - Alternative No. BG-3 - Bedrock Groundwater Hydraulic Containment
Former Frontier Chemical Waste Process Inc. Site

Item Description	Comment	Unit	Quantity	Unit Cost	Cost
Groundwater Treatment System Maintenance	Assume 12 per year	Each	12	$500.00	$6,000
Carbon Replacement	Assume replacement of carbon once per 12 months; Includes removal of spent carbon and refill of new	LB	400	$2.00	$800
Electricity Charge	Based on pump usage	Each	12	$1,099.84	$13,198
Telephone Charge	Assume $50/month	LS	1	NA	$600
Subtotal					$77,062
				Annual Cost Subtotal:	$77,062
				Adjusted Annual Cost Subtotal for Niagara Falls, New York Location Factor (1.028):	$79,220
				10% Legal, administrative, engineering fees:	$7,922
				25% Contingencies:	$21,785
				Annual Cost Total:	**$108,927**
				30-Year Present Worth of Annual Costs:	**$1,536,000**
				Total Present Worth Cost:	**$3,257,000**

Assumptions

1. Assume survey crew will be on-site 50% total project duration.
2. Assume no site clearing necessary.
3. Assume common earth (moist) swell factor of 28% and 1.54 Tons/BCY; concrete swell factor of 40% and 1.86 tons/BCY; gravel swell factor of 13% and 1.57 tons/BCY (Means Estimating Handbook. United States of America : Means Southern Construction Information Network, 1990).
4. 30-year present worth of costs assumes 5% annual interest rate.
5. Assume metals treatment will be done in the equilization tank (if needed).

Abbreviations:

BCY = bank cubic yards
LCY = loose cubic yards
LS = lump sum
LF = linear foot
SY = square yard
MGD=million gallons per day

5 Comparative Evaluation of Alternatives

5.1 Introduction

This section presents a comparative analysis of remedial alternatives. The alternatives for each operable unit (by medium) are based on the seven evaluation criteria. The comparative analysis is based on the evaluations provided in Section 4. Section 6 discusses the alternatives relative to a site-wide remedy.

5.2 OU-1 Overburden Soil Remedial Alternatives

OU-1 overburden soil remedial alternatives consist of the following:

- Alternative No. OS –1: No action.
- Alternative No. OS-2: Institutional controls (i.e., access restrictions, deed restrictions).
- Alternative No. OS-3: Cover (existing asphalt pavement or concrete would remain as cover and clean soil cover would be placed in the remaining unpaved contaminated areas to limit the potential for direct contact with impacted near-surface soil).
- Alternative No. OS-4: Excavation and on-site treatment of soils (soils generally containing greater than 10 ppm total VOCs).
- Alternative No. OS-5: Excavation and off-site treatment/disposal of soils (soils generally containing greater than 10 ppm total VOCs).

Overall Protection of Human Health and the Environment

Alternatives OS-2, OS-3, OS-4, and OS-5 provide varying degrees of long-term protection of human health and the environment. These alternatives depend on institutional controls as the primary method of protection of human health and the environment. Alternatives OS-3, OS-4, and OS-5 provide some additional protection because near-surface soils would be relocated and covered (OS-3) or treated (OS-4 and OS-5) and on-site structures (where vapor could accumulate) would be demolished, thereby further limiting the potential for direct contact with contaminated soil or vapors. Excavation and treatment/disposal (OS-4 and OS-5) of source subsurface soils (above the water table) would result in a lower potential for direct contact with highly contaminated soil and would therefore be more protective than the other soil alternatives. OS-1 is not protective.

Compliance with SCGs

None of the alternatives would achieve complete compliance with the chemical-specific SCGs. Alternatives OS-4 and OS-5 would comply with SCGs in the excavated and treated soil areas (OS-4) or the replaced (OS-5) soil areas. However, other contaminated soil would remain on-site above SCGs (but below 10 ppm total VOCs) in areas outside the excavation areas. Additionally, no soil above SCGs (including source soils) would be removed below the water table for any of the alternatives.

Alternatives OS-2, OS-3, OS-4, and OS-5 would comply with action-specific SCGs.

Short-Term Impact and Effectiveness

Alternatives OS-3, OS-4, and OS-5 involve intrusive work, which could cause releases of contamination during remedial activities. VOC emissions may be difficult to control during excavation activities in Alternatives OS-4 and OS-5 and could result in potential impact on workers and the surrounding community. Alternative OS-4 (on-site treatment) would pose a slightly greater potential for impact on on-site workers and the surrounding community than would Alternative OS-5 (off-site treatment/disposal). Alternative OS-1 would not have any short-term impacts.

Once complete, alternatives OS-2, OS-3, OS-4, and OS-5 would meet the RAO to limit (to the extent practicable) direct contact with on-site contaminated soil. Alternatives OS-3, OS-4, and OS-5 also meet the RAO to eliminate (to the extent practicable) the potential for human exposure to on-site organic vapors. Considering that source soils below the water table would not be removed or treated, none of the alternatives completely meets the RAO to reduce the risk of further contamination of groundwater by leaching of contaminants. Alternative OS-1 is not expected to be effective in meeting the RAOs.

Each alternative that includes remedial action (OS-3, OS-4, and OS-5) can be completed in the same general timeframe of approximately 6 to 15 months.

Long-term Effectiveness and Permanence

Alternatives OS-3, OS-4, and OS-5 would provide some long-term effectiveness (in protecting human health) because the risk associated with directly contacting the contamination would be minimized through relocation and covering of contaminated soil (OS-3), removing structures where vapors could accumulate (OS-3, OS-4, and OS-5), and excavation and treatment/disposal of contaminated soil (OS-4 and OS-5). Alternatives OS-4 and OS-5 are the most effective and are the most permanent alternatives (in the long-term). Alternative OS-2 provides long-term effectiveness through institutional controls only. Alternative OS-1 is not considered an adequate, reliable, or permanent long-term soil remedy.

In the long-term, OS-2, OS-3, OS-4, and OS-5 would offer some limited protection of human health and the environment. Since subsurface contamination below the water table would remain in each of these alternatives, potential impacts on human health and the environment would be managed through some form of institutional control.

Reduction in Toxicity, Mobility, or Volume

Alternatives OS-4 and OS-5 provide for reduction of toxicity, mobility, and volume of site contaminants, as the alternatives would reduce contaminant concentrations in unsaturated soil. Alternatives OS-1, OS-2, and OS-3 would not reduce the toxicity, mobility, and volume of site contaminants, except as would occur through natural attenuation.

Implementability

Alternatives OS-1, OS-2, OS-3, OS-4, and OS-5 are technically implementable (with readily available methods, equipment, materials and services) and administratively implementable. However, OS-4 is more difficult to implement than the other alternative because of issues associated with on-site treatment.

Cost

Alternative OS-1 calls for no action and thus incurs no cost. Institutional controls are the only actions that would be implemented for Alternative OS-2; therefore its total present cost of $3,000 is the least expensive of the remaining alternatives. Although the cost for on-site demolition activities remains constant for Alternatives OS-3, OS-4, and OS-5, Alternative OS-3 has a lower total present cost of $1,100,00 because less soil excavation is required for this alternative. Alternatives OS-4 and OS-5 are the most expensive alternatives, with Alternative OS-4 being slightly more expensive ($11,600,000 versus $11,000,000), due to the lower cost of trucking and disposal compared with on-site treatment.

5.3 OU-1 Overburden Groundwater Remedial Alternatives

OU-1 overburden groundwater remedial alternatives consist of the following:

- Alternative No. OG-1: No action.
- Alternative No. OG-2: Institutional controls (i.e., access restrictions, deed restrictions, long-term groundwater monitoring).
- Alternative No. OG-3: Hydraulic containment (collection trench with sand seam extraction well) and ex situ treatment of overburden groundwater with discharge to POTW.

Overall Protection of Human Health and the Environment

Although on-site overburden groundwater is not currently used, Alternative OG-1 does not prevent potential future on-site exposures. Alternative OG-2 includes institutional controls and a monitoring program to help ensure that there are no future exposures to on-site contaminants; therefore, this alternative is considered protective of human health and the environment. Alternative OG-3 employs active treatment to reduce overburden groundwater contamination and contain the remaining contamination on-site, providing the highest level of protection for the alternatives developed.

Because overburden groundwater may be migrating off-site to the Falls Street tunnel, there is potential for off-site impacts on utility workers and the environment with Alternatives OG-1 and OG-2. Alternative OG-3 would both reduce and contain on-site overburden groundwater contamination, therefore reducing the potential for impacts to human health and the environment.

Compliance with SCGs

Alternatives OG-1 and OG-2 do not comply with chemical-specific SCGs since overburden groundwater contamination would remain as is. Alternative OG-3 also does not comply with chemical-specific SCGs because it would not reduce overburden groundwater contamination to concentration levels below the groundwater standards in a reasonable and predicable timeframe (i.e., less than 30 years) due to the presence of high concentrations of contamination and possible DNAPLs. Alternative OG-3 would comply with action-specific SCGs by obtaining the necessary approvals/permits to discharge treated water to the local POTW.

Short-Term Impacts and Effectiveness

No short-term impacts are anticipated during implementation of Alternatives OG-1 and OG-2. Alternative OG-2 involves institutional controls and long-term monitoring of on-site wells. Short-term impacts associated with Alternative OG-3 such as possible VOC emissions, dust, and noise would be similar to those encountered during soil remedial construction activities.

Long-term Effectiveness and Permanence

Because Alternatives OG-1 and OG-2 do not involve the removal or treatment of contaminated overburden groundwater, contamination would remain essentially the same. Institutional controls combined with long-term monitoring in Alternative OG-2 provide an effective long-term on-site mechanism in a 30-year timeframe to protect human health and the environment. However, Alternative OG-3 provides an established technology to extract and treat the contaminated overburden groundwater that is known to control groundwater migration, thus increasing protection. It is noted that OG-2 and OG-3 must be continued beyond the 30-year timeframe since contaminated groundwater is expected to exist on-site for an extended timeframe due to the low hydraulic conductivity of overburden soils, high levels of contamination and the possible presence of residual DNAPLs.

Reduction in Toxicity, Mobility, or Volume

Alternatives OG-1 and OG-2 do not involve removal or treatment of contaminated overburden groundwater, and therefore the toxicity, mobility, and volume of contamination would not be reduced. Alternative OG-3 would reduce the volume of contaminated overburden groundwater through extraction and treatment, thus reducing the toxicity and mobility of the groundwater.

Implementability

There are no actions to implement under Alternative OG-1. Alternative OG-2 is readily implementable. Although further groundwater investigations (i.e., pump tests and a treatability study) are needed before finalizing the extraction scheme for Alternative OG-3, no issues are anticipated with implementation of this alternative. Additionally, no issues are anticipated related to acquiring approvals to discharge treated groundwater to the POTW or to discharge treated air.

Cost

Alternative OG-1 calls for no action and thus incurs no costs. Alternative OG-2 is significantly less expensive than Alternative OG-3 at an estimated present worth cost of $330,000 for an assumed 30-year long-term monitoring program at the site and placement of institutional controls. For extraction and treatment of contaminated overburden groundwater, Alternative OG-3 is estimated with a present worth cost of $800,000, most of which is due to the present worth of an assumed 30-year O & M cost.

5.4 OU-2 Bedrock Groundwater Remedial Alternatives

OU-2 (bedrock groundwater) remedial alternatives consist of the following:

- Alternative No. BG-1: No action.
- Alternative No. BG-2: Institutional controls (i.e., access restrictions, deed restrictions, long term monitoring).
- Alternative No. BG-3: Hydraulic containment (groundwater extraction from wells placed across the A and B bedrock fracture zones) and ex situ treatment of groundwater with discharge to the POTW.

The C-zone bedrock groundwater (OU-3) would be further assessed as part of future remedial activities and is not included in this report.

Overall Protection of Human Health and the Environment

Although on-site bedrock groundwater is not currently used, Alternative BG-1 does not prevent potential future exposures to on-site bedrock groundwater and is therefore not protective. Alternative BG-2 includes institutional controls and a monitoring program to limit the potential for future exposures to on-site contaminants; therefore, this alternative provides some protection of human health and the environment. Alternative BG-3 employs active treatment to reduce bedrock groundwater contamination, providing the highest level of protection of the three alternatives developed.

Because bedrock groundwater is expected to migrate off-site and to the Falls Street tunnel, there is a potential for off-site impacts on utility workers and the environment with Alternatives BG-1 and BG-2. Alternative BG-3 would both reduce and contain on-site bedrock groundwater contamination, therefore reducing the potential for impacts on human health and the environment.

Compliance with SCGs

Alternatives BG-1 and BG-2 do not comply with chemical-specific SCGs since bedrock groundwater contamination would remain as is. Alternative BG-3 does not comply with chemical-specific SCGs because it would not reduce bedrock groundwater contamination to concentration levels below the groundwater standards in a reasonable and predictable timeframe (i.e., less than 30 years). Alternative BG-3 would comply with action-specific SCGs by obtaining the necessary approvals/permits to discharge treated water to the local POTW.

Short-Term Effectiveness

No short-term impacts are anticipated during implementation of Alternatives BG-1 and BG-2. Alternative BG-2 involves institutional controls and long-term monitoring of on-site wells. Minimal short-term impacts are anticipated for BG-3 during the installation of the bedrock extraction wells, treatment system, and associated piping.

Long-term Effectiveness and Permanence

Because Alternatives BG-1 and BG-2 do not involve the removal or treatment of contaminated bedrock groundwater, contamination would remain essentially the same. Institutional controls combined with long-term monitoring in Alternative BG-2 provide some on-site long-term protection of human health. However, Alternative BG-3 provides an established technology to extract and treat the contaminated bedrock groundwater, which is known to control groundwater migration, thus increasing protection. It is noted that BG-1 and BG-2 would likely be required beyond the 30-year timeframe of evaluation because contaminated groundwater is expected to exist on-site for an extended period of time due to the possible presence of residual DNAPLs.

Reduction in Toxicity, Mobility, or Volume

Alternatives BG-1 and BG-2 do not involve removal or treatment of contaminated bedrock groundwater, and therefore the toxicity, mobility, and volume of contamination would not be reduced. Alternative BG-3 would somewhat reduce the volume of contaminated bedrock groundwater through extraction and treatment, thus reducing the toxicity and mobility groundwater. However, because of the DNAPLs and high contaminant concentrations, significant reductions are not likely.

Implementability

There are no actions to implement under Alternative BG-1. Alternative BG-2 is readily implementable. Although further groundwater investigations (i.e., pump tests and a treatability study) are needed before finalizing the extraction scheme, no issues are anticipated with implementation of Alternative BG-3. Additionally, no issues are anticipated related to acquiring approvals to discharge treated groundwater to the POTW or to discharge treated air.

Cost

Alternative BG-1 calls for no action and thus incurs no costs. Alternative BG-2 is significantly less expensive than Alternative BG-3 at an estimated present worth cost of $630,000 for an assumed 30-year long-term monitoring program at the site and placement of institutional controls. For extraction and treatment of contaminated bedrock groundwater, Alternative BG-3 is estimated with a present worth cost of $10,700,000, most of which is due to the present worth of an assumed 30- year O & M cost.

6 Summary

This report presents the results of the Frontier Chemical site feasibility study for OU-1 (overburden soil and groundwater) and OU-2 (bedrock groundwater zones A and B). The third operable unit (OU-3) includes groundwater contamination in bedrock zone C and possible lower bedrock groundwater zones that may be impacted by site contamination. OU-3 will be further assessed as part of future remedial activities and is not included in this report. This report is a companion document to the Supplemental Remedial Investigation Report (E & E February 2003). The SRI, along with the previous site investigations, characterized the nature and extent of on-site contamination and provided data to complete this FS. The history of industrial activities has revealed a variety of contamination in on-site soil and groundwater. Although various contaminants are present on-site (including metals and SVOCs) the primary contaminants of concern are VOCs: VOCs were found most frequently and in the highest concentrations and present the greatest risk to human health and the environment. VOCs also pose the greatest risk of off-site migration due to their mobility. The highest levels of contamination were found in the central and southwest parts of the site.

6.1 Key Factors

The following are key factors and/or unique conditions that exist on or near the site that required careful consideration during the completion of the FS.

- Nearby sewer tunnels intercept most of the on-site overburden groundwater and the majority of the bedrock groundwater at the nearby and downgradient side of the site.

- Water in the sewer tunnels is treated by the POTW before discharge to the Niagara River, except during certain high flow conditions.

- Complete cleanup of the site is not considered feasible due to the high concentration of contamination and suspected presence of DNAPLs. Complete DNAPL remediation is generally not considered practical in a reasonable or predictable timeframe and is further complicated by the unproven nature of remediating DNAPLs in fractured bedrock.

6.2 Remedial Action Objectives

The RAOs were developed for contaminated on-site media (soil and groundwater). The RAOs are described in Section 2.3.1 (Soils) and Section 2.3.2 (Groundwater):

The RAOs for site subsurface soils are:

- Eliminate to the extent practicable the potential for direct human or animal contact with the contaminated subsurface soils;
- Reduce the risk of further contamination of the groundwater by reducing the potential for leaching of contaminants into the groundwater; and
- Eliminate to the extent practicable the potential for human exposures to organic vapors in site buildings, structures, and subsurface utilities.

The RAOs for on-site groundwater are:

- Prevent to the extent practicable the further off-site migration of contaminated groundwater;
- Reduce, control, or eliminate to the extent practicable the groundwater contamination present within the overburden;
- Reduce, control, or eliminate to the extent practicable the groundwater contamination present within the bedrock groundwater zones of concern; and
- Eliminate to the extent practicable the potential for human exposures to contaminated groundwater.

An overall cleanup goal for soil of 10 ppm total VOCs was established based upon NYSDEC soil cleanup guidance.

6.3 Summary of Remedial Alternatives

The following is a brief summary of the on-site remedial alternatives developed for soil and groundwater, followed by a discussion of the alternatives as they relate to an overall site remediation approach. A detailed discussion of alternatives is included in Section 4 and each of the alternatives is discussed comparatively (by operable unit and medium) in Section 5.

OU-1 Soil

- Alternative No. OS-1: No action.
- Alternative No. OS-2: Institutional controls (i.e., access/use restrictions, deed restrictions).

- Alternative No. OS-3: Cover (existing asphalt pavement or concrete would remain as cover and clean soil cover would be placed in the remaining unpaved contaminated areas to limit potential for direct contact with impacted near-surface soil).

- Alternative No. OS-4: Excavation and on-site treatment of soils (soils generally containing greater than 10 ppm total VOCs).

- Alternative No. OS-5: Excavation and off-site treatment/disposal of soils (soils generally containing greater than 10 ppm total VOCs).

OU-1 Overburden Groundwater

- Alternative No. OG-1: No action.

- Alternative No. OG-2: Institutional controls (i.e., access/use restrictions, deed restrictions, long-term groundwater monitoring).

- Alternative No. OG-3: Hydraulic containment (collection trench with sand seam extraction well) and on-site ex situ treatment of overburden groundwater with discharge to a POTW.

OU-2 Bedrock Groundwater

- Alternative No. BG-1: No action.

- Alternative No. BG-2: Institutional controls (i.e., access/use restrictions, deed restrictions, long-term groundwater monitoring).

- Alternative No. BG-3: Hydraulic containment (groundwater extraction from wells placed across the A and B bedrock fracture zones) and ex situ treatment of groundwater with discharge to the POTW.

6.4 Overall Site Remediation Approaches

6.4.1 No Action

Because soil and groundwater Alternatives OS-1, OG-1, and BG-1 employ no action, on-site contamination would remain essentially the same and the RAOs for the site would not be achieved in a reasonable or predictable timeframe.

6.4.2 Institutional Controls

Institutional controls of soil and groundwater (Alternatives OS-2, OG-2, and OG-3) are effective in protecting on-site human health over a 30-year time period but do not prevent off-site contaminant migration and as such do not fully prevent potential exposure to human health or the environment. Only some of the RAOs would be achieved if institutional controls were used to mitigate/remedy soil and groundwater contamination.

6.4.3 Soil Remedial Alternatives

Alternative OS-3 (which includes the excavation of near surface contaminated soil in unpaved areas) is the most cost-effective of the three soil remedial alternatives. The cover alternative and excavation and treatment alternatives would require additional institutional controls in order to limit potential direct human exposure pathways. Alternatives OS-4 and OS-5 would eliminate contaminated source soils in the unsaturated zone by on-site treatment/off-site disposal and achieve some soil RAOs, but contamination would remain in the saturated zone and, to a lesser degree in the unsaturated zone outside the excavation area. In addition, the difficulty of controlling VOC emissions and potential worker and community risks associated with the areas to be excavated make OS-4 and OS-5 more problematic alternatives. The cost of Alternatives OS-4 and OS-5 are an order of magnitude greater than Alternative OS-3 and do not provide a significant change in the overall time (in terms of a 30-year time frame) required to clean up the site.

6.4.4 Groundwater Remedial Alternatives

Overburden Groundwater

Alternative OG-3 would provide on-site containment of contaminated overburden groundwater, which would limit uncontrolled overburden groundwater migrating to the sewer tunnel, thus providing a higher degree of overall protection of human health and the environment. However, uncontrolled overburden groundwater migration is likely limited due to the strong downward influence of the Falls Street tunnel.

Bedrock Groundwater

Alternative BG-3 would provide on-site containment of contaminated bedrock groundwater, which would limit uncontrolled bedrock B zone contaminated groundwater migrating to the sewer tunnel, thus providing a high degree of protection of human health and the environment. However, considering that the current natural groundwater migration is to the sewer tunnel and an on-site containment system would only provide pretreatment before discharge to the same sewer tunnel, this alternative primarily only limits the potential for occasional discharge of untreated groundwater to the Niagara River (under high flow conditions) and the potential for a worker in the tunnel to contact the untreated contaminated groundwater.

7 References

Ecco, Inc., 1991, *Interim Remedial Measure Report, Frontier Chemical Waste Process, Inc., Niagara Falls, New York,* Buffalo, New York.

Ecology and Environment Engineering, P.C., September 2002, *Work Plan for the Supplemental Remedial Investigation/Feasibility Study at the Former Frontier Chemical Waste Process, Inc., Site*, Lancaster, New York.

__________, February 2003, *Final Supplemental Remedial Investigation for the Former Frontier Chemical Waste Process, Inc., Site*, Lancaster, New York.

New York State Department of Environmental Conservation (NYSDEC) Division of Hazardous Waste Remediation, March 1989, Technical and Administrative Guidance Memorandum (TAGM) No. 4025, *Guidelines for Remedial Investigation/Feasibility Studies,* Albany, New York.

__________, May 1990, Technical and Administrative Guidance Memorandum (TAGM) No. 4030, *Selection of Remedial Actions at Inactive Hazardous Waste Sites,* Albany, New York.

______, 1994, Technical and Administrative Guidance Memorandum (TAGM) No. 4046, *Determination Of Soil Cleanup Objectives And Cleanup Levels,* Albany, New York.

NYSDEC Division of Water Technical and Operational Guidance Series (TOGS) (1.1.1), 1998, *Ambient Water Quality Standards and Guidance Values and Groundwater Effluent Limitations,* Albany, New York.

United States Environmental Protection Agency (EPA), October 1988, *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA,* Washington, D.C.

A Supporting Documentation for Alternatives

Appendix A - Building Demolition Calculations
Former Frontier Chemical Waste Process Inc. Site

Building No./ Description	Type	LF	Height (ft)	Area (SF)	Thickness (ft)	Debris Volume (ft3)	Debris Weight (Ton)
73	metal	304	25	-	0.5	3,800	
Roof	metal	-	-	5600	0.5	2,800	
70	metal	340	25	-	0.5	4,250	
Roof	metal	-	-	5625	0.5	2,813	
56	metal	190	25	-	0.5	2,375	
Roof	metal	-	-	1750	0.5	875	
21/60	metal/wood	420	15	-	0.5	3,150	
Roof	metal	-	-	7425	0.5	3,713	
18	concrete block	270	25	-	0.5	3,375	
Roof	asphalt	-	-	3500	0.167	583	
Structure Immediately South of Bldg 18	brick	75	8	-	0.5	300	
Roof	asphalt	-	-	1750	0.167	292	
Block Bldg (NE)	brick	70	8	-	0.5	280	
Roof	asphalt	-	-	250	0.167	42	
Shed	wood	32	8	-	0.5	128	
Roof	asphalt	-	-	64	0.167	11	
Frame Bldg	brick	60	8	-	0.5	240	
Roof	asphalt	-	-	200	0.167	33	
Block Bldg (SW)	brick	50	8	-	0.5	200	
Roof	asphalt	-	-	150	0.167	25	
Fiberglass Bldg	fiberglass	16	8	-	0.5	64	
Roof	asphalt	-	-	25	0.167	4	
					Total Metal:	**23,775**	5,439
					Total Brick/Concrete:	**4,395**	242
					Total Wood/Fiberglass:	**192**	3
					Total Asphalt Shingles:	**990**	9

Notes:

1. Take-offs approximated from Figure 2-1 of RI (E&E 2002).
2. Assume approximate debris weight (*Means Estimating Handbook*. United States of America : Means Southern Construction Information Network, 1990).

metal (steel)	490 lb/ft3
metal (aluminum)	165 lb/ft3
brick/concrete	110 lb/ft3
wood/fiberglass	35 lb/ft3
asphalt (shingles)	3 lb/ft2

Appendix A - Tank Demolition Calculations
Former Frontier Chemical Waste Process Inc. Site

Tank No.	Type	Tank Capacity (gal)	Tank Diameter (ft)	Tank Height (ft)	Tank Thickness (ft)	Debris Volume (ft3)	Reference
R-101	FRP	13,800	11.75	17	0.25	157	1
R-102	FRP	13,750	11.67	17.17	0.25	157	1
T-103	FRP	20,300	12	24	0.25	226	1
T-104	Unknown	19,742				225	2
T-307	FRP	10,000	10	17	0.25	134	1
T-106	Steel	5,860	10	10	0.08	26	1
T-301	FRP	9,500	12.67	10	0.25	99	1
T-302	FRP	9,500	12.67	10	0.25	99	1
T-303	FRP	10,000	10	17	0.25	134	1
T-304	FRP	11,980	10	19.92	0.25	156	1
T-305	FRP	11,980	10	19.92	0.25	156	1
T-306	FRP	10,000	10	17	0.25	134	1
T-107	Unknown	16,120				190	2
200	Unknown	19,000	5	50	0.25	196	See Notes No. 2
R-301	FRP	5,943	10	10	0.25	79	1
R-302	FRP	5,943	10	10	0.25	79	1
					Total:	**2,247**	

Notes:
1. Assume 16 on-site above-ground storage tanks.
2. Engineer's estimate based on historical drawings.

References:

1. Blasland, Bouch & Lee, Inc., 1994, Removal Action Plan, Frontier Chemical-Royal Avenue Site, Niagara Falls, New York, Rochester, New York.
2. Planning Research Corporation (PRC), 1986, Preliminary Assessment, Draft Final Report, Frontier Chemical Waste Process, Inc., Chicago, Illinois.

Appendix A - Existing Wall/Foundation Demolition Calculations
Former Frontier Chemical Waste Process Inc. Site

Location Description of Wall	LF	Height (ft)	Thickness (ft)	Debris Volume (ft3)	Associated Foundation Above Ground	Area Footprint (ft2)	Foundation Height (ft)	Debris Volume (ft3)	Total Debris Volume (ft3)	Total Debris Volume (BCY)	Total Debris Volume (LCY)	Total Debris Weight (Ton)
Northeast												
Retaining Wall (Concrete Pad)	170	2	0.5	170	No				170	6		
Secondary Containment associated with Bldg 21/60 ASTs	240	3	0.5	360	No				360	13		
Northwest												
Curbing	150	0.5	0.5	38	No				38	1		
Immediately South of Bldg 18	40	8	0.5	160	No				160	6		
Immediately South of Bldg 18	40	3	0.5	60	No				60	2		
Retaining Wall (Concrete Pad)	250	3	0.5	375	No				375	14		
Debris Pile in Center of Site	875	3	0.5	1,313	Yes, in some areas	8,850	3	26,550	27,863	1,032		
Southwest												
Retaining Wall (Concrete Pad)	330	3	0.5	495	No				495	18		
Retaining Walls Surrounding Frame/Block Bldg	75	1	0.5	38	No				38	1		
Demolition Debris	250	3	0.5	375	Yes	3,600	3	10,800	11,175	414		
Ruins	120	3	0.5	180	No				180	7		
			Total:	**3,563**				**37,350**	**40,913**	**1,515**	**2,121**	**2,250**

Notes:

1. Existing walls/concrete pads approximated by field observations during RI.
2. Debris volume for walls/foundations assumes demolition to ground surface.
3. Assume 25% of debris pile in the center of the site to have foundation existing to 3 ft above ground surface; remaining 75% assumed to be at ground surface; total area of debris pile in the center of the site to be approximately 35,400 ft2.
4. Assume approximate debris swell factor of 40% and weight (*Means Estimating Handbook*. United States of America : Means Southern Construction Information Network, 1990).

brick/concrete 110 lb/ft3

Appendix A - Miscellaneous Debris
Former Frontier Chemical Waste Process Inc. Site

Type	Approx Quantity	Unit	Approx Total Debris Volume	Unit	Approx Weight Per Unit	Unit	Approx Total Weight	Unit	Comments
1,500 gal Poly Tanks	2	Each	302		150	lb/tank	300	lb	Assume 4' dia x 4' height
Northeast									
Steel Cylinders	2	Each	1200	ft3	100	lb/cylinder	200	lb	Approx. 8 ft dia x 10 ft height
Tires	15	Each	120	ft3	20	lb/tire	300	lb	
Piping/Tubing	108	ft3	108	ft3	NA		100	lb	
Northwest									
55-gal Drums	11	Each	99	ft3	50	lb/drum	550	lb	
Debris Pile in Center of Site	53,100	ft3	53,100	ft3	130	lb/ft3	6,903,000	lb	50% of approx. 35,400 ft2 surface area; 3 ft height
Southwest									
Ruins	2,700	ft3	2,700	ft3	130	lb/ft3	351,000	lb	Approx. 900 ft2 surface area; 3 ft height
Southeast									
Demolition Debris	402,750	ft3	402,750	ft3	130	lb/ft3	52,357,500	lb	Approx 26,850 ft2 surface area; 15 ft height
		Total:	**460,077** **17,040**	**ft3** **LCY**			**7,255,450** **3,628**	**lb** **Ton**	

Notes:

1. Assume approximate debris weight (*Means Estimating Handbook*. United States of America : Means Southern Construction Information Network, 1990).
   brick/concrete 130 lb/ft3

Former Frontier Chemical Waste Process Inc. Site

Photo 1

Misc. debris pile primarily consisting of building demolition material. Approx. 15' in height.

Photo 2

Misc. debris pile primarily consisting of building demolition material. On left side of photo is example of existing **walls,** here, approx. 3' in height.

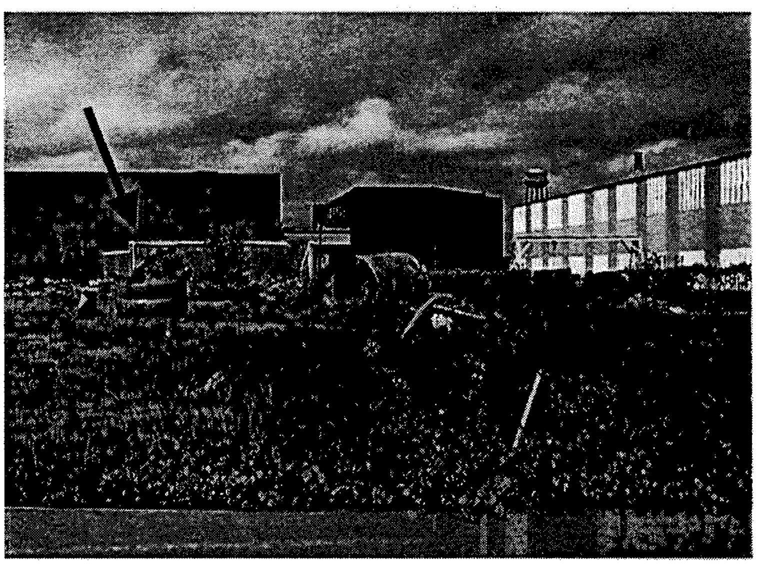

Photo 3

Misc. debris consisting of steel cylinders, tires, piping/tubing. Arrow pointing to one of the **metal buildings**.

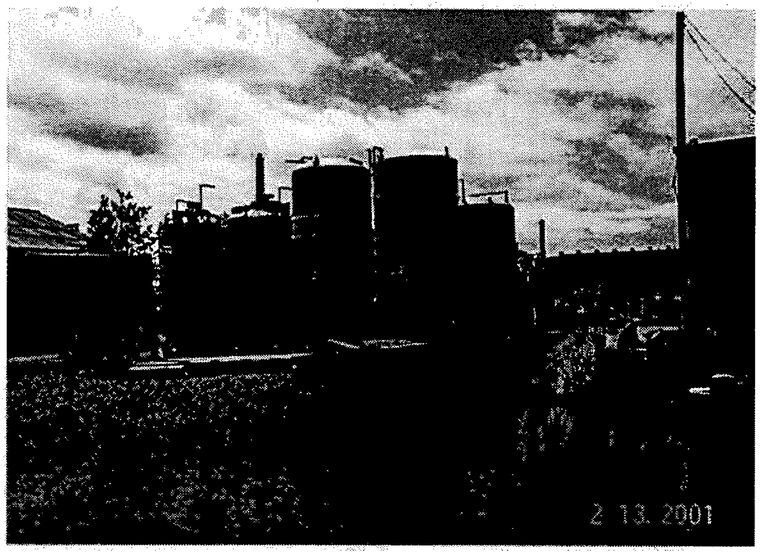

Photo 4

FRP **tanks** > 12,000 gal.

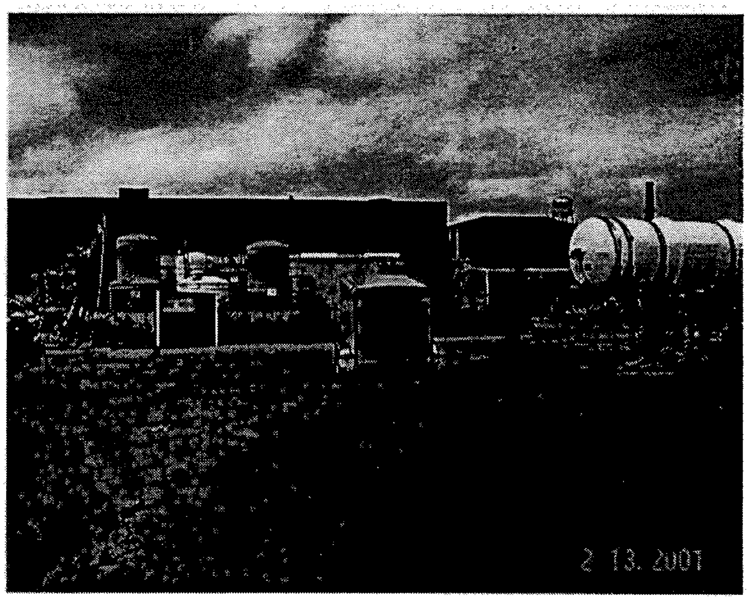

Photo 5

Majority of FRP **tanks** < 12,000 gal.

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Computation Sheet

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Project Name: Frontier Chemical FS
Subject: HTTD Study

Rev.	Completed By: JLT	Checked By: KMP
X	Initials: 1/16/03	Initials: 1/17/03
	Initials: / /	Initials: / /

Contaminants

VOC's

1, 2-dichlorobenzene (BP= 357°F)
1,3-dichlorobenzene
1,4-dichlorobenzen (BP= 345°F)
benzene (BP= 176°F)
Chlorobenzene (BP= 270°F)
monochlorotoluene

SVOC

phenol (BP= 359°F)

Quantity

~~38,000~~ 39,000 KMP yd^3

Soil Density = 1.54 ~~tons~~ tons/yd^3

Tons = 38,000 yd^3 × 1.54 tons/yd^3 = ~~58,520~~ 60,060 KMP tons

Contaminant Concentration

VOC = 2,089 ppm

Cleanup Goal = 10 ppm

Calculation of Soil Retention Time

Contaminant Reduction Ratio = $\frac{10 \text{ ppm}}{2089 \text{ ppm}} = 4.78 \times 10^{-3}$

Use $\approx 5.0 \times 10^{-3}$

$\Rightarrow$ Retention Time $\approx$ 20 minutes (see attached figure)

Assume T = 20 minutes @ 700 °F For PCBs

This is conservation since it is based on PCB removal data In actuality, T = 15 minutes would probably be more accurate since PCB boiling point is ~ 320 °C or 608 °F. Therefore, T = 15 minutes would be more realistic.

Calculation of Soil Feed Rate

$$\text{Time} = \frac{a\left(\frac{d^2 \cdot \pi}{4}\right) \cdot L \cdot R}{C} \quad (\text{minutes})$$

$$C\,(\text{lbs/min}) = \frac{a\left(\frac{d^2 \cdot \pi}{4}\right) \cdot L \cdot R}{T\,(\text{minutes})}$$

L = length of rotary kiln (ft) = 52 feet

R = material ~~bulk~~ 10k (density) (lbs/ft³) = 114 lbs/ft³

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	Initials: / /	Initials: / /

d = internal diameter of kiln (feet) = 9.5 ft

a = % loading of kiln (as fraction)

Can vary between 3-15% 8 to 12% normal

⇒ use 10% = 0.10

$$C\ (\text{lbs/min}) = \frac{(0.1)\left[\frac{(9.5)^2 \cdot \pi}{4}\right] \cdot (52) \cdot (114)}{(15)}$$

$$= \frac{(0.1)(70.88)\cdot(52)\cdot(114)}{15} = 2801.3 \text{ lbs/min}$$

$$= 2{,}801.3 \frac{\text{lbs}}{\text{min}} \times 60 \frac{\text{min}}{\text{hr}} \times \frac{\text{ton}}{2000 \text{ lbs}} = 84 \text{ ton/hr}$$

⇒ Use 80 tons/hour for design

Calculation of Clean up Time

$$\text{Production Rate} = 80 \text{ ton/hr} \times 24 \frac{\text{hr}}{\text{day}} \times (0.75)$$

$$= 1440 \text{ tons/day}$$

$$\frac{\cancel{58{,}520}\ 60{,}000^{\text{KMP}} \text{ tons}}{1440 \text{ tons/day}} = \cancel{41}\ 42^{\text{KMP}} \text{ days}$$

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Computation Sheet

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	Initials: / /	Initials: / /

Project Name: Frontier Chemical FS

Subject: HTTD Study

1. Calculation of Mass and Thermal Balance

Assumptions

Soil Temperature = 700°F

Fuel Oil Burners = No. 2 Fuel @ 25% excess air

Soil Moisture Content = 10% by weight

Rotary Dryer Exhaust Gas Discharge Temperature = 400°F

Soil Inlet Temperature = 60°F

Air Inlet Temperature = 60°F

Soil Feed Rate = 80 tons/hour (72 ton/hr dry)

Rotary Dryer Soil Retention Time = 15 minutes

Heat Loss From Rotary Dryer = 10%

Air Leakage Into Rotary Dryer = 20%

A. Rotary Dryer Mass and Thermal Balance

(1) Thermal Balance (Energy Required)

a) Soil Energy Requirement

$$\Delta\ BTU/hr = 72\ \frac{ton}{hr} \times 2000\ \frac{lb}{ton} \times (700-60)\ °F \times 0.22\ \frac{BTU}{lb\ °F}$$

$$= \underline{20.3 \times 10^6}\ BTU/hr$$

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b) Moisture Energy Requirement

Mass of H_2O in Soil $= 80 \frac{ton}{hr} \times 2000 \frac{lb}{ton} \times (0.10)$

$= 16{,}000 \text{ lb/hr}$

Δ BTU/hr Required $= 16{,}000 \frac{lb}{hr} \times (1211.82)$ BTU/lb

$= \underline{19.4 \times 10^6}$ BTU/hr

Δ Enthalpy 60°F → 400°F

c) Total Soil and Moisture Energy Requirement

Total Energy $: 20.3 \times 10^6 + 19.4 \times 10^6 = \underline{39.7 \times 10^6}$ BTU/hr

d) Fuel Oil Required (Rotary Dryer)

Assume that at 25% excess burner air and 20% leakage into the dryer is equivalent to 50% burner excess air.

For No. 2 Fuel Oil @ 400°F and 50% excess air (Total Air Ratio = 1.5) from Brunner Table 9-4

lb dry gas / gal of fuel = 156.8

lb H_2O / gal of fuel = 9.16

Net Heat Available = 115,716 BTU/gal

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Subject

Assuming 10% heat loss, the fuel oil required is as follows:

$$\text{Fuel Oil Required} = \frac{(39.7 \times 10^6)\ \frac{BTU}{hr} \times (1.10)}{(115,716)\ BTU/gal}$$

$$= \underline{377}\ gal/hr$$

(2) <u>Mass Balance</u> (Rotary Dryer)

(a) <u>Mass of Dry Gas</u>

Rotary Dryer Dry Gas Rate = 377 gal/hr

$\times$ 156.8 $\frac{lb\ dry\ gas}{gal}$ = $\underline{59,\cancel{175}}$ 114 cmp lb/hr

(b) <u>Mass of Wet Gas</u>

Wet gas from soil moisture = 16,000 lb/hr

Wet gas from fuel combustion = 377 gal/hr

$\times$ 9.16 $lb\ H_2O/gal$ = 3,453 lb/hr

Total Mass of Wet Gas = (16,000 + 3,453)

= $\underline{19,453}$ lb/hr

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c) Volume of Dry Gas

For Dry Gas (from Table 4-4 in Brunner) Specific Volume = 21.7 ft^3/lb @ 400°F

$\Rightarrow$ Volume Flowrate of Dry Gas = 59,~~175~~ 114 KMP lbs/hr

$\times$ 21.7 $\frac{ft^3}{lb}$ $\times$ $\frac{1\ hr}{60\ min}$ = 21,402 ft^3/min

~~21,402~~ 21,379 KMP dcfm @ 400°F (12,940 dsfm)

d) Volume of Wet Gas

For Wet Gas from Table 4-4 in Brunner, Specific Volume = 34.9 ft^3/lb @ 400°F

$\Rightarrow$ Volume Flowrate of Wet Gas =

19,453 lb/hr $\times$ 34.9 ft^3/lb $\times$ $\frac{1\ hr}{60\ min}$

= 11,315 wcfm @ 400°F

e) Total Volume Flowrate From Rotary Dryer

= ~~21,402~~ 21,379 KMP + 11,315 = ~~32,717~~ 32,694 KMP acfm @ 400°F

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Project Name

Subject

B. Thermal Oxidizer Mass and Energy Balance

Assumptions

Thermal Oxidizer Exit Temperature = 2000 °F

Fuel = No 2 Fuel @ 10% Excess Air

Thermal Oxidizer Heat Loss = 5%

(1) Thermal/Energy Balance

a) Dry Gas Energy Required

$$\Delta BTU/hr = \underbrace{\overset{59,114\ KNP}{\cancel{59,175}}}_{\text{dry gas}} \frac{lb}{hr} \times (510.07 - 82.19)\ \Delta\text{Enthalpy } 400° \rightarrow 2000°F\ BTU/lb$$

$$= \underline{25.3 \times 10^6}\ BTU/hr$$

b) Wet Gas Energy Required

$$\Delta BTU/hr = \underbrace{19,453}_{\text{wet gas}} \frac{lb}{hr} \times (2067.42 - 1211.82)\ \Delta\text{Enthalpy } 400° \rightarrow 2000°F\ BTU/lb$$

$$= \underline{16.6 \times 10^6}\ BTU/hr$$

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Computation Sheet

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Project Name

Subject

c) Total Dry Gas and Wet Gas Energy Requirement

$$\text{Total Energy Required} = 25.3 \times 10^6 + 16.6 \times 10^6$$

$$= \underline{41.9 \times 10^6} \ BTU/hr$$

d) Fuel Oil Required (Thermal Oxidizer)

For No. 2 Fuel Oil @ 2000°F and 10% excess air (Total Air Ratio = 1.1) from Brunner Table 9-4

lb dry gas / gal of fuel = 115.115

lb H_2O / gal of fuel = 8.615

Net Heat Available = 63,175 BTU/gal

Assume 5% heat loss, the fuel oil required is as follows:

$$\text{Fuel Oil Required} = \frac{41.9 \times 10^6 \frac{BTU}{hr} \times (1.05)}{(63,175) \ BTU/gal}$$

$$= \underline{696.4} \ \frac{gal}{hr}$$

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Computation Sheet

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Project Name

Subject

(2) Mass Balance

a) Mass of Dry Gas

Mass Flowrate of Dry Gas = Dry Gas From Rotary Dryer + Dry Gas From Fuel Combustion

Dry Gas From Rotary Dryer = ~~59,175~~ 59,114 KMP lb/hr

Dry Gas From Fuel Combustion = (115.115) lb dry gas / gal of fuel

× 696.4 gal/hr = 80,166 lb/hr

Total Dry Gas Mass Flowrate = ~~59,175~~ 59,114 KMP + 80,166

= ~~139,341~~ 139,280 KMP lb/hr

b) Mass of Wet Gas

Mass Flowrate of Wet Gas = Wet Gas From Rotary Dryer + Wet Gas from Fuel Combustion

Wet Gas From Rotary Dryer = 19,453 lb/hr

Wet Gas From Fuel Combustion = 8.615 lb H_2O/gal Fuel

× 696.4 gal/hr = 6000 lb/hr

Total Wet Gas Mass Flowrate = 19,453 + 6,000

= 25,453 lb/hr

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Project Name

Subject

c) Volume of Dry Gas

For Dry Gas (from Table 4-4 in Brunner)

Specific Volume = 61.9 ft³/lb @ 2000°F

$\Rightarrow$ Volume Flowrate of Dry Gas =

139,280 kmr ~~139,341~~ lb/hr × 61.9 ft³/lb × 1 hr/60 min

= 143,690 kmp ~~143,753~~ dcfm @ 2000°F (30,387 dscfm)

d) Volume of Wet Gas

For Wet Gas (from Table 4-4 in Brunner)

Specific Volume = 99.7 ft³/lb @ 2000°F

$\Rightarrow$ Volume Flowrate of Wet Gas =

25,453 lb/hr × 99.7 ft³/lb × 1 hr/60 min

= 42,294 wcfm @ 2000°F

e) Total Thermal Oxidizer Gas flow Volume

= 143,753 + 42,294 = 185,984 kmp ~~186,047~~ acfm

@ 2000°F

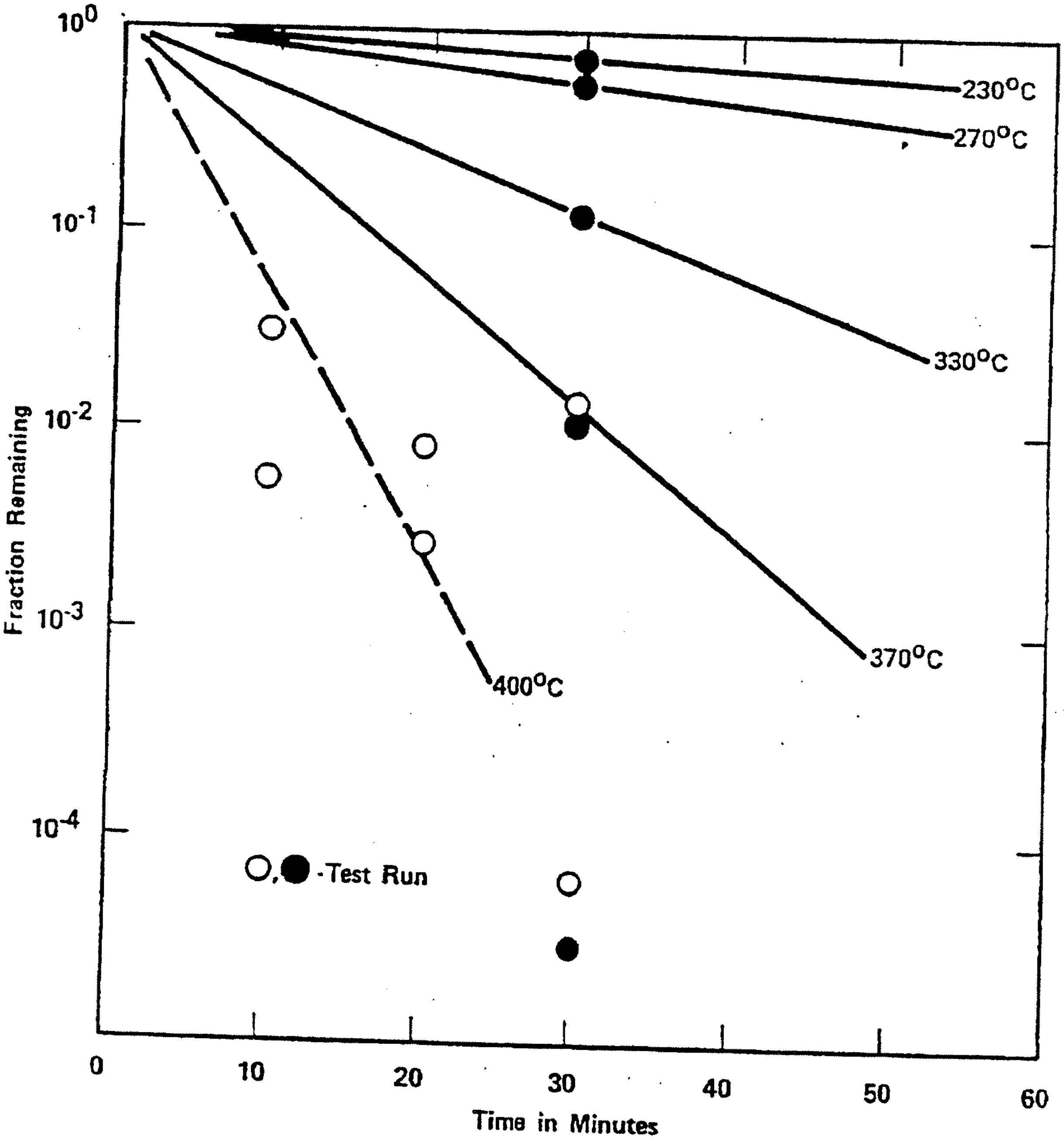

Figure D-1. Relationship Between Temperature, Time and PCB Concentration in a Solid Sample

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General Computation Sheet

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Rev.	Completed By		Checked By
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	Initials: / /		Initials: / /

Name of Project FRONTIER CHEMICALS [illegible] System

Subject EXCAVATED SOIL VOLUME - > 10 ppm VOC

OBJECTIVE - CALCULATE CONTAMINATED SOIL VOLUME GREATER THAN 10 ppm VOC.

ASSUMPTIONS -

- DEPTH OF EXCAVATION [illegible] 5.5' IN PROPOSED EXCAVATION AREA [illegible] THE EXCEPTION OF DEPRESSION AREA WHICH IS 13' (SEE PAGE 3 FOR ADDITIONAL INFORMATION)

CALCULATIONS -

BASED ON ATTACHED FIGURE, SURFACE AREA OF CONTAMINATED SOIL:

$A_1 = \frac{1}{2}(120')(65') = 3{,}900\ ft^2$

$A_2 = (140')(65') = 9{,}100\ ft^2$

$A_3 = (350')(110') = 38{,}500\ ft^2$

$A_4 = (405')(50') = 20{,}250\ ft^2$

$A_5 = ([illegible]50')(150') = [illegible]7{,}500\ ft^2$

$A_6 = \frac{1}{2}(100')(65') = [illegible]\ ft^2$

$A_7 = (60')(100') = [illegible]\ ft^2$

$A_8 = (340')(50') = 17{,}000\ ft^2$

$A_9 = (250')(90') = 22{,}500\ ft^2$

$A_{10} = \frac{1}{2}([illegible])([illegible]) = 3{,}375\ ft^2$

$A_T = \sum_{n=1}^{10} A_n = (3{,}900 + [illegible] + [illegible] + [illegible] + [illegible]7{,}500 + [illegible] + [illegible] + [illegible] + [illegible] + 3{,}375)\ ft^2$

$A_T = [illegible],375\ ft^2$

ASSUMING AN AVERAGE DEPTH OF 5.5', SOIL VOLUME:

$V = A \cdot D = 19[illegible],375 \times 5.5 = [illegible]\ ft^3 \left(\frac{1\ cy}{27\ ft^3}\right)$

$V = [illegible],[illegible]18$ CY (CONTAMINATED SOIL VOLUME [illegible])

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Computation Sheet

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Project Name FRONTIER CHEMICAL FS

Subject DETERMINATION OF EXCAVATION DEPTH

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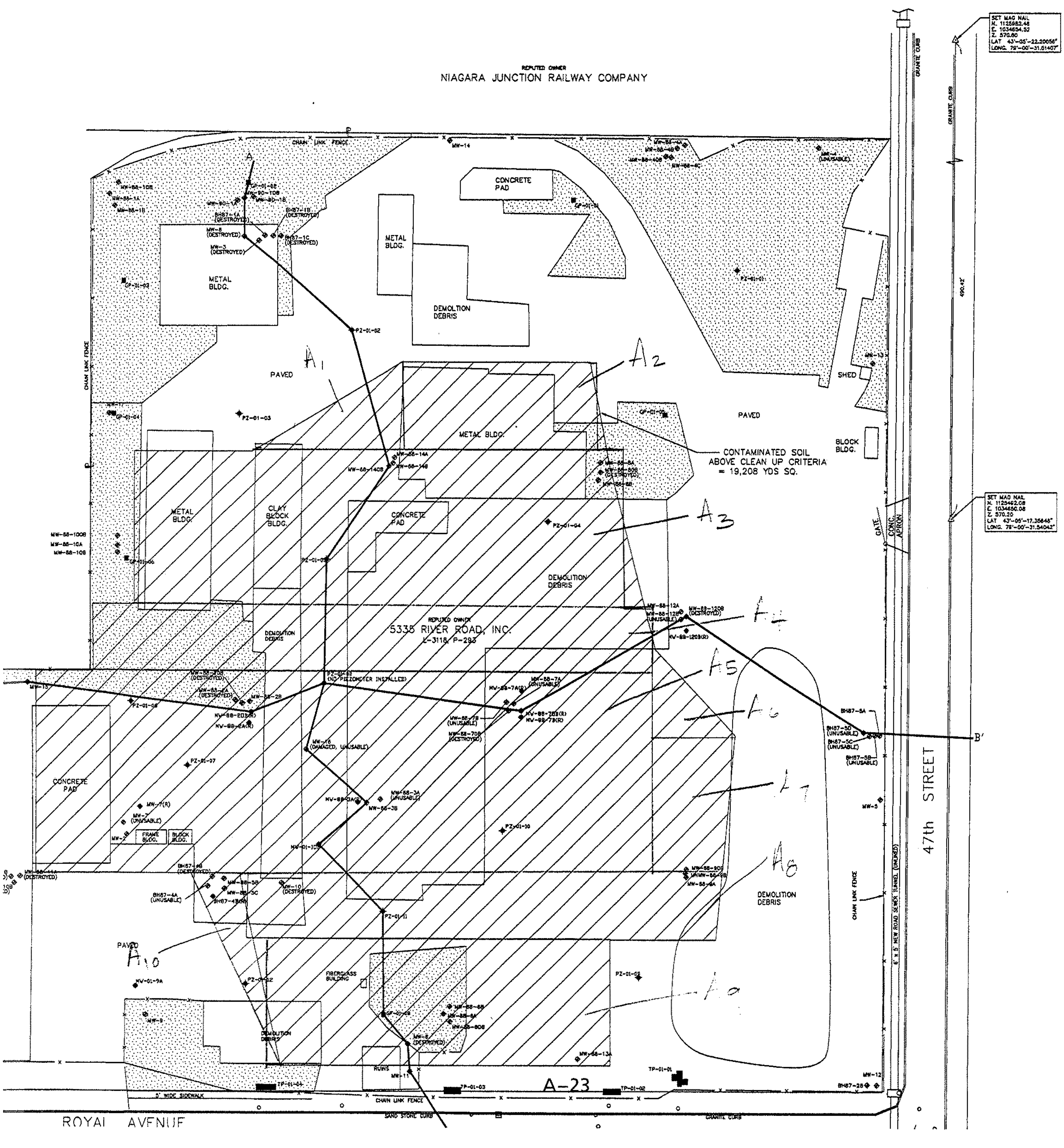
☒	Initials: 1/13/03	Initials: / /
	Initials: / /	Initials: / /

AVERAGE DEPTH TO WATER OF MONITORING WELLS LOCATED [illegible] (BASED [illegible] TAKEN ON 5/10/2002 FROM [illegible] (E&E 2002); AND EXCLUDING MW-01-10B & MW-7(2) [illegible] NOT REPRESENTATIVE OF [illegible]).

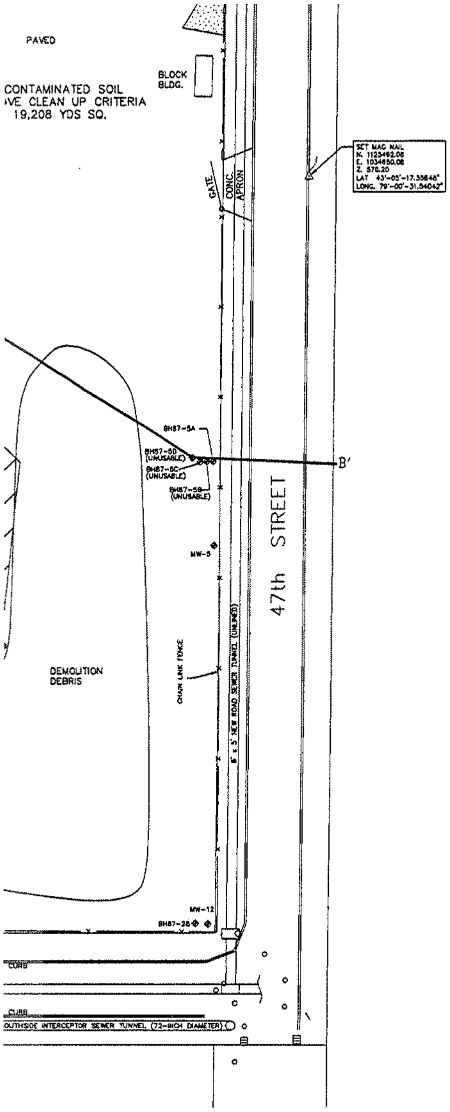
WELL ID	[illegible]
3?57-2? [illegible]	7
[illegible]	5
[illegible]	[illegible]
MW-88-6CB	10.1
MW-88-7.3(2)	3.3
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
MW-88-[illegible]	[illegible]
[illegible]	3.8
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
	Σ 93.52

AVERAGE DEPTH OF EXCAVATION = $\frac{93.52}{17}$ = 5.5 [illegible]

FRONTIER CHEMICALS
PAGE 3 OF 4



FRONTIER CHEMICAL FS
PAGE 1 OF 4



LEGEND

- UNPAVED AREAS
- PROPERTY LINE
- OVERBURDEN MONITORING WELL
- A-FRACTURE ZONE BEDROCK WELL
- B-FRACTURE ZONE BEDROCK WELL
- C-FRACTURE ZONE BEDROCK WELL
- SRI WELLS
- SRI PIEZOMETER LOCATION
- SRI GEOPROBE SOIL BORING LOCATION
- SRI TEST PIT LOCATION
- A—A' CROSS SECTION LINE
- RECEIVER
- MANHOLE
- OUTLINE OF DEMOLISHED BLDGS./STRUCTURES OR DEBRIS PILE
- OUTLINE OF BLDG. OR CONCRETE PAD
- — x — FENCE

BENCHMARK

1) PROJECT ELEVATIONS BASED UPON EXISTING BENCHMARK TBM 3 AS OBSERVED IN CONTROL PLACED FOR THE CITY OF NIAGARA FALLS GIS CONTROL PROJECT AS FOLLOWS: A SQUARE CUT ON THE NORTHWEST CORNER OF THE CONCRETE FOOTING AT THE NORTHWEST LEG OF TRANSMISSION TOWER #LN 32 TWR 97. LOCATED AT THE SOUTHWEST CORNER OF THE INTERSECTION OF PACKARD ROAD AND NIAGARA FALLS BOULEVARD. ELEV. 581.24 (NGVD 1929)

2) SITE TBM CUT 'X' ON THE N.-N.E. BONNET BOLT OF HYDRANT LOCATED ON WEST SIDE OF 47th STREET (ELEV. 572.86).

NOTES

1) HORIZONTAL DATUM IS BASED ON THE NEW YORK STATE PLANE COORDINATE SYSTEM WEST ZONE NAD83/92HARN (FEET).

2) REFERENCE MAP – CITY OF NIAGARA FALLS TAX MAP NO. 160.09.

3) PROPERTY LINES SHOWN ARE APPROXIMATE IN LOCATION AND ARE BASED UPON THE ABOVE REFERENCED TAX MAP. PROPERTY OWNER INFORMATION IS BASED ON THE TAX MAP AND CITY OF NIAGARA FALLS WASTEWATER FACILITIES DRAWINGS.

4) NOT ALL PLANIMETRIC/TOPOGRAPHIC FEATURES WERE IDENTIFIED AS PART OF THIS PROJECT SCOPE.

5) SRI WELLS/PIEZOMETERS/GEOPROBE/TEST PIT LOCATIONS ARE SHOWN WITH BOLD TEXT.

6) SRI = SUPPLEMENTAL REMEDIAL INVESTIGATION.

7) SELECT UTILITY LINES AND SEWER TUNNELS LOCATIONS AND SIZES ARE APPROXIMATE BASED ON DRAWINGS PROVIDED BY CITY OF NIAGARA FALLS DEPT. OF WASTEWATER FACILITIES.

8) BASE MAP PROVIDED BY McINTOSH & McINTOSH, P.C. ON 3/11/02. ECOLOGY & ENVIRONMENT FIELD OBSERVATIONS ALSO INCLUDED.

9) FIELD OBSERVATIONS NOTED HEREON, REGARDING THE FUNCTIONING OF WELLS (e.g., UNUSABLE), WERE MADE ON OCTOBER 9, 2001.

SCALE IN FEET
0 40 80 120

FORMER FRONTIER CHEMICAL
WASTE PROCESS, INC. SITE

NIAGARA FALLS NEW YORK

CONTAMINED SOIL
ABOVE CLEAN UP CRITERIA

SCALE	DATE ISSUED	C.A.D. FILE NO.	DRAWING NO.	REV.
1"=40'-0"	12/2/02	CONTAMINATED SOIL	Figure – 2–2	

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Computation Sheet

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Rev.	Completed By: [illegible]	Checked By:
☒	Initials: 1/5/03	Initials: GSR / /
	Initials: / /	Initials: / /

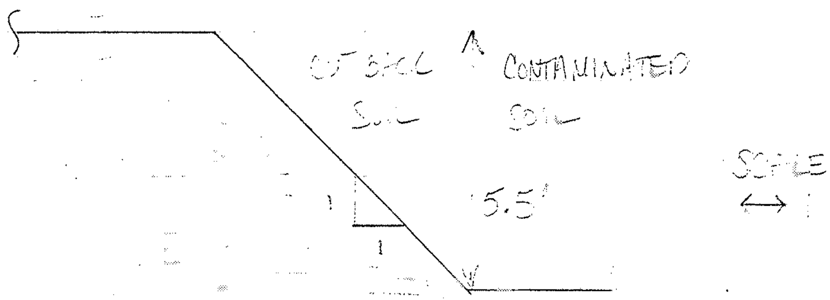
Project Name [illegible] FS

Subject EXCAVATED SOIL VOLUME - CUT BACK

OBJECTIVE: [illegible] THE CUT-BACK SOIL VOLUME ASSOCIATED WITH EXCAVATION

ASSUMPTIONS: [illegible]

1. ASSUME 1H:1V SLOPE TO DEPTH OF 6' BGS; [illegible] SLOPE ASSUMED AT EXCAVATION GREATER THAN 6'
2. EXCAVATION DEPTH APPROXIMATELY 5.5'; THEREFORE ASSUME 1H:1V SLOPE ENTIRE DEPTH ALONG EXCAVATION LIMITS.



CALCULATIONS:

$V = A \cdot L$

$A = \frac{1}{2}(5.5')(5.5') = 15.125\ ft^2$

L = PERIMETER OF EXCAVATION ≈ 1,850'

$V = (15.125\ ft^2)(1,850') = 2,7[illegible]\ ft^3 \left(\frac{1\ CY}{27\ ft^3}\right)$

V = 1036 CY (CUT BACK VOLUME)

TOTAL VOLUME TO BE EXCAVATED = CONTAMINATED SOIL VOLUME + CUT-BACK VOLUME

= [illegible]

= [illegible] CY

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General Computation Sheet

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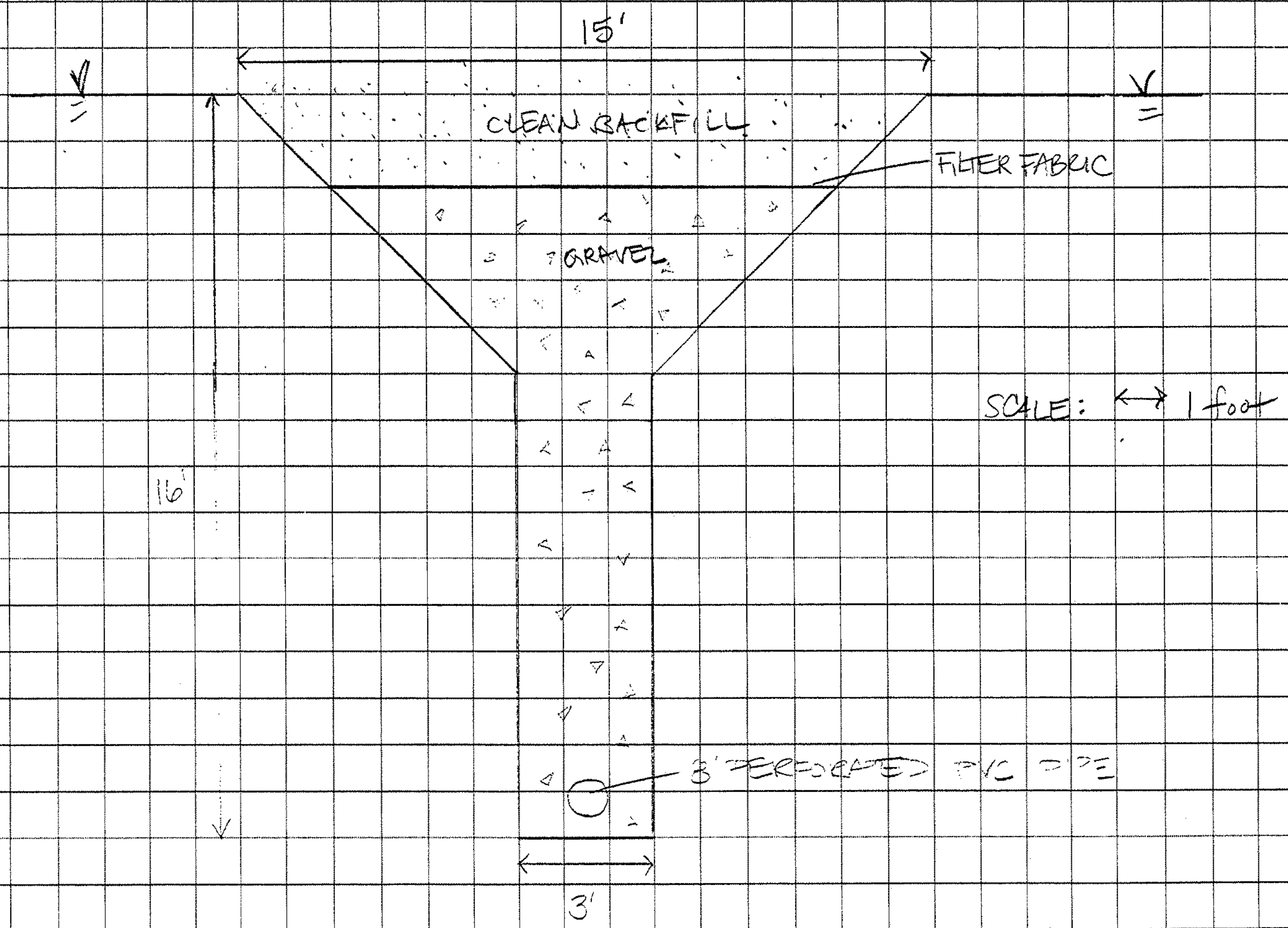
	Initials: KMY 1/12/03	Initials: GJ?2 / /
	Initials: / /	Initials: / /

Name of Project Frontier Chemical System

Subject Collection Trench Cross-section



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General Computation Sheet

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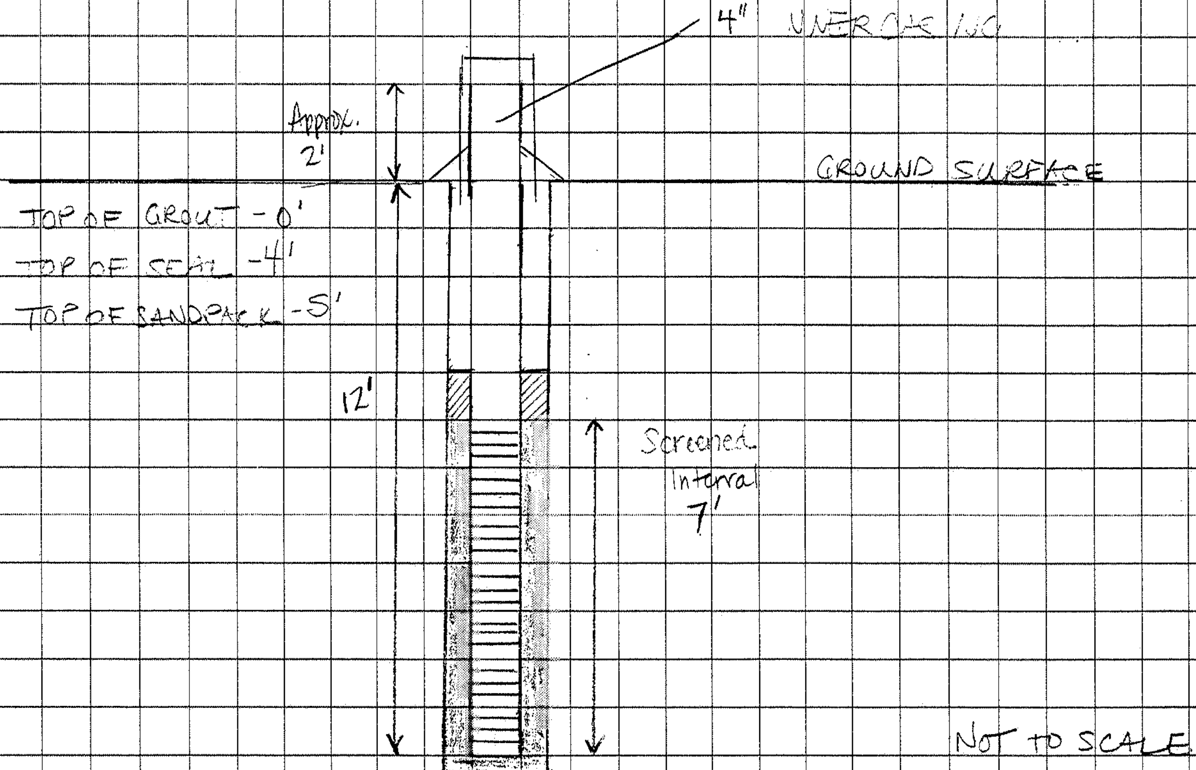
Name of Project FRONTIER CHEM. OXL FS System

Subject OVERBURDEN GROUNDWATER EXTRACTION WELL CROSS-SECTION TYP.



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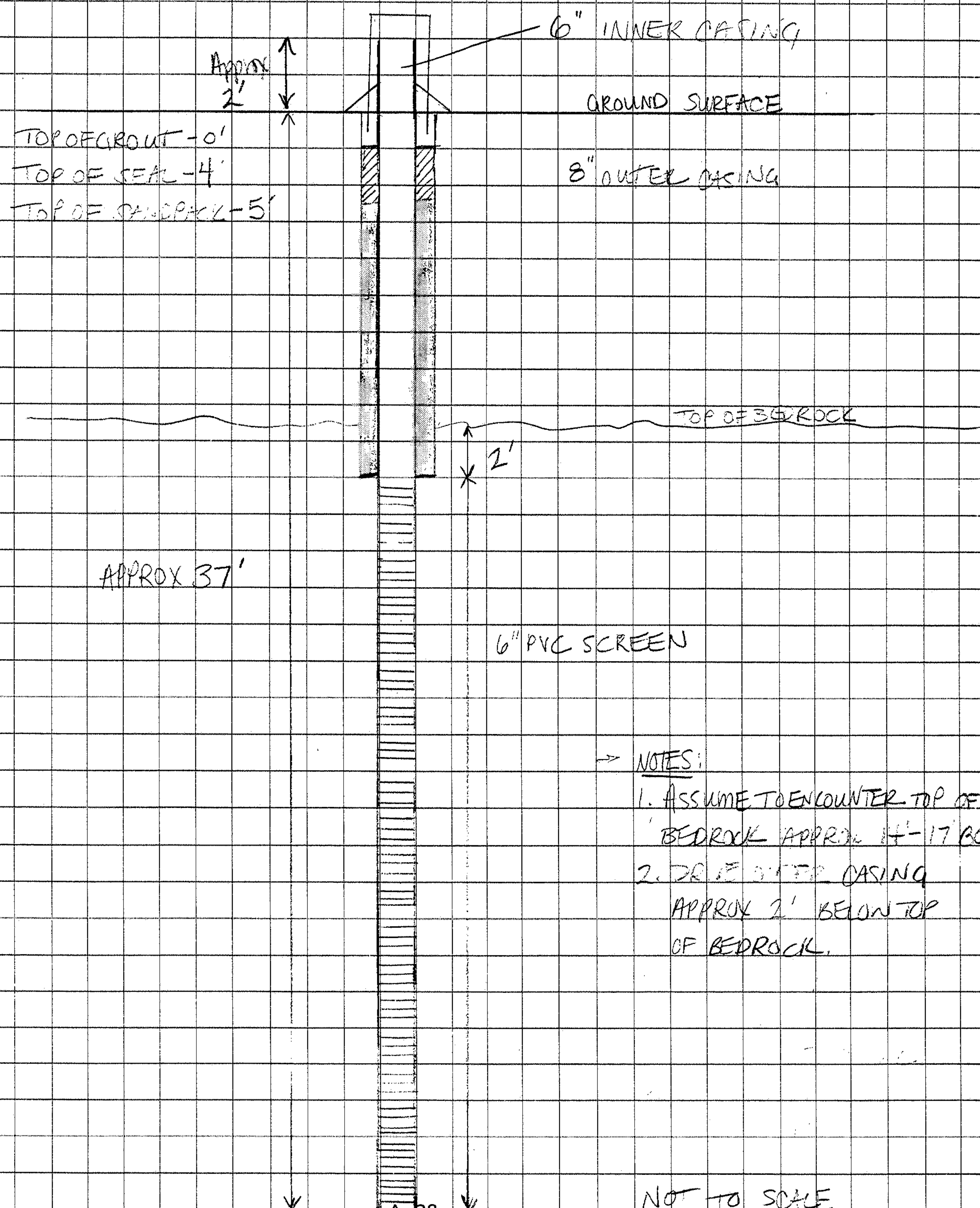
	Initials: KMP 1/8/03	Initials: GJR / /
	Initials: / /	Initials: / /

Name of Project FRONTIER CHEMICAL FS System

Subject BEDROCK GROUNDWATER EXTRACTION WELL CROSS-SECTION TYP.



NOTES:

1. ASSUME TO ENCOUNTER TOP OF BEDROCK APPROX 14'-17' BGS.
2. DRIVE OUTER CASING APPROX 2' BELOW TOP OF BEDROCK.

NOT TO SCALE

Thermal Desorption Conceptual Design
Former Frontier Chemical Waste Process Inc. Site

This appendix is supplemental to, Alternative No. OS-4 – Extraction and On-Site Treatment of Soil. E&E completed a conceptual design for a representative thermal desorption system at the Frontier Chemical Site to size system components, establish preliminary operating parameters, and costs. This conceptual design is based on the use of a theoretical mass and thermal balance to define overall system quantities, followed by proven empirical design criteria to establish system layout and performance. Included in the conceptual design are assumed maximum VOC concentrations for soils. However, if higher VOC concentrations are encountered in the field, the system is designed for flexibility of feed rate and retention time to achieve site cleanup goals.

Design Parameters

The design parameters used in the conceptual design process are as follows:

(1) Mass and Thermal Balance:

- Maximum VOC Concentration for:
  - Soil = 2,089 mg/kg

  (based on analytical data (E&E, 2002)).

- Soil Feed Rate = 80 tons per hour

- Soil Moisture Content = The soil moisture content is assumed to be 10 percent (based on engineer's estimate).

- Soil Energy Content = Negligible energy content in soil.

- Cleanup Criteria = 10 mg/kg for soil.

- System Temperatures
  - Soil Inlet Temperature = 60° Fahrenheit
  - Soil Exit Temperature = 700° Fahrenheit
  - Air Inlet Temperature = 60° Fahrenheit
  - Rotary Dry Exhaust Gas Temperature = 400° Fahrenheit
  - Thermal Oxidizer Inlet Temperature = 400° Fahrenheit
  - Thermal Oxidizer Exhaust Gas Temperature = 2,000° Fahrenheit
  - Heat Loss from System = 10 percent

- System Losses
  - 10 percent Heat Loss from Rotary Dryer and Thermal Oxidizer
  - 20 percent Air Leakage in Rotary Dryer
  - Negligible heat loss from thermal oxidizer

- Fuel
  - Number 2 Diesel Fuel at 25 percent Excess Air

(2) Equipment Design Assumptions:

- Rotary Dryer
  - Soil Retention Time = 15 minutes
  - Length to Diameter Ratio = 4.0 to 6.0
  - Rotary Dryer Fuel = Number 2 (diesel)
  - Rotary Dryer Excess Air = 25 percent
  - Dryer Gas Flow Velocity <500 feet per minute
  - Maximum Soil Temperature = 700° Fahrenheit
  - Rotary Dryer Leakage = 20 percent

- Thermal Oxidizer
  - Gas Flow Retention Time >3.0 seconds
  - Length to Diameter Ratio = 3.0 to 4.0
  - Thermal Oxidizer Excess Air = 10 percent

- Mechanical Cyclone
  - High-Temperature Stainless Steel
  - Removal Efficiency = More than 75 percent for particles more than 10 microns

- Baghouse
  - Nomex Bags with Temperature Capability of 450° Fahrenheit
  - Air to Cloth Ratio = 4.0 to 6.0

Based on these conditions, a theoretical mass and energy balance was conducted, and the results are presented in the following tables. Using the gas flows and energy requirements defined by this mass and energy balance, and the design parameters as previously presented, an empirical design was conducted for each system component.

Cost Estimate

Based on the conceptual design and operating parameters described above, E & E developed a cost estimate for thermal treatment of contaminated soils. The cost estimate was separated into fixed costs and per-ton unit treatment cost. Fixed costs include equipment and installation cost, start-up cost, and demobilization cost. Equipment cost was obtained from Tarmak Inc., a leading vendor specializing in thermal treatment equipment supply. Additional fixed costs and (piping, instrumentation, foundations) and operating costs were estimated based on the value of major purchased equipment cost, using guidance published by the United States Environmental Protection Agency ("Engineering Handbook for Hazardous Waste Incineration" Chapter 6 "Estimating Incineration Costs"). The following basic parameters were established, for the purpose of developing the cost estimate:

- Thermal desorption unit will have a capacity to process 80 tons of contaminated soil at a moisture content of 10 percent or less;

- Each unit will operate 24 hours per day, seven days per week;

- Each unit will be off-line 25 percent of the total time, due to maintenance and holidays;

Additional assumptions for developing the cost estimate are presented in the cost tables. The table below presents a description of the tables used to develop the thermal desorption cost estimate.

Table	Description
Table C-1	Cost for Thermal Desorption Treatment: Summary
Table C-2	Cost for Thermal Desorption Treatment of Soils: Production Calculation
Table C-3	Cost for Thermal Desorption Treatment of Soils: Labor Cost Calculation
Table C-4	Cost for Thermal Desorption Treatment of Soils: Maintenance Cost Calculation
Table C-5	Cost for Thermal Desorption Treatment of Soils: Utility Cost Calculation
Table C-6	Cost for Thermal Desorption Treatment of Soils: Capital and Interest Cost Calculation
Table C-7	Cost for Thermal Desorption Treatment of Soils: Startup Cost Calculation
Table C-8	Cost for Thermal Desorption Treatment of Soils: Fuel Cost Calculation

References

Brunner, Calvin R., P.E., 1988, Incineration Systems: Selection and Design, Incineration Consultants, Inc., Reston, Virginia.

Rock Talk Manual, 3rd Revised Printing, 1982, Wichita, Kansas.

Table C-1: Lump Sum and Unit Costs for Thermal Desorption Treatment

Production Rate Summary		
	Reference	
Production Rate (tons/hr)	Table C-2	80
Total throughput (annual) tons/yr	Table C-2	524,160

Cost per Ton of Contaminated Soil				
Item	Reference	Unit Cost ($) per Ton	Unit Cost Subtotals	Lump Sum Cost ($)
Labor	Table C-3	$10.85		
Maintenance	Table C-4	$3.27		
Utility	Table C-5	$1.30		
Captial Cost	Table C-6			$894,305
Interest Cost	Table C-6	$0.33		
Startup	Table C-7			$1,853,332
Fuel	Table C-8	$19.86		
Subtotal			$35.61	
Soil Pretreatment	Note 1	$1.60		
Monitoring, Sampling, Analysis	Note 2	$0.40		
Subtotal			$2.00	
Generated Waste	Note 3	$1.00		
Demobilization	Note 4			$929,723
Subtotal			$1.00	
Subtotal of the above items			$38.61	$3,677,359
Mark Up (excluding labor)	10%		$2.78	$367,736
Total			**$41.39**	**$4,045,095**

Notes:

1. Cost was based on 1996 vendor survey estimate of $0.80 per US ton. Because of potentia varying soil concentrations and soil type, sufficient blending and screening will be required. Therefore, a soil pretreatment cost of $1.60 per ton was assumed.
2. Based on the 1996 vendor survey of $0.40 per ton and adjusted for variation in on-site VOC concentrations.
3. Based on the 1996 vendor survey cost of $1.00 per ton.
4. Demobilization cost was assumed equal to cost of equipment, piping, and building installation cost.

Table C-2 : Cost for Thermal Desorption Treatment of Soils: Production Calculation

	Unit	Quantity
Throughput	tons/hour	**80**
Online System Avalability	%	75%
Hours Offline/Year	hours	2,184
Annual Production	tons/year	**524,160**

Froniter FS_TD_012102.xls

Table C-3: Cost for Thermal Desorption Treatment of Soils: Labor Cost Calculation

Labor Classification	Quantity	Hourly Rate ($/hour)	Quantity Costed	Total ($)
Site Manager/Project Director	1	$114.48	0.33	$37.78
Resident Engineer	1	$71.00	1	$71.00
Assistant Resident Engineer	1	$71.00	1	$71.00
Project Engineer (O&M)	1	$56.58	1	$56.58
Safety Engineer	4	$56.58	0.33	$74.69
Skilled Laborer				
Mechanical	1	$48.35	1	$48.35
Electrical	1	$52.90	1	$52.90
Common Laborer	2	$36.50	1	$73.00
Equipment Operators	3			
Control Panel	1	$47.15	1	$47.15
Front End Loader	2	$47.15	1	$94.30
Administrative	1	$35.83	0.33	$11.82
Clerk	1	$31.93	0.33	$10.54
Total Hourly Labor Cost ($)				$649.10
Total Annual Working Hours	8,760			
Total Annual Labor Cost				$5,686,158
Per Ton Cost (annual)	524,160			**$10.85**

References:

1. RS Means 2002 Environmental Remediation Cost Data- Assemblies 8th Annual Edition, Kingston, MA (Rates include 2.5 multiplier for overhead and profit).
2. RS Means 2002 Heavy Construction Data, 16th Annual Edition, Kingston MA (Rates include overhead and profit).

Table C-4: Cost for Thermal Desorption Treatment of Soils: Maintenance Cost Calculation

Cost per Ton ($)	Factor	Source
$1.50		1991 ThermoTech System Corporation
$1.64	1.09	Escalation factor for 2002 vs. 1991 (138.2/126.7)
$3.27	2.0	Engineer's Estimate

Notes:
ThermoTech Systems Corporation, *Operating Cost and Commercial Aspects of Contracting*, Remediation America 1991 Seminar.

Table C-5: Cost for Thermal Desorption Treatment of Soils: Utility Cost Calculation

Thermal Desorption Utility Costs			
Moisture to be added to treated soil	5%		Added for Dust Control
Production Rate	80	tons/hour	E & E Estimate and Tarmack Inc., 2002
Water Usage for Soil Additive	1,000	gal/hr	
Factor for loss to overspray and evaporation	2.50		Engineer's Estimate
Subtotal	2,500	gal/hr	
Plant Use	1000	gal/hr	ThermTec, 2002
Total Water Use	3,500	gal/hr	
Contingency - 100%	7,000	gal/hr	
Total Annual Water Usage	61,320,000	gal/yr	
Unit Cost of water	0.0047	$/gallon	
Annual Cost of Water	$288,204	$/year	
Total Water Cost	***$0.55***	$/ton	
Plant Electricity Usage	800	KWH	
Yearly Electricity Usage (w/ 25% contingency)	6,570,000		Engineer's Estimate
Unit Cost of Electricity	$0.06	$/KWH	
Annual Cost of Electricity	$394,200	$/year	
Electricity Cost	***$0.75***	$/ton	
Total Utility Cost	**$1.30**	$/ton	

Table C-6: Cost for Thermal Desorption Treatment of Soils: Capital and Interest Cost Calculation

Cost Item Description	Capital Cost Factor*	Factor of	Total Cost ($)
Purchased Equipment Cost (PEI)			$3,541,800
Installed Equipment Cost (IEC)	0.15	PEI	$531,270
Cost of Piping	0.4	IEC	$212,508
Buildings, Tanks, Structures, and Foundations	0.35	IEC	$185,945
Total Physical Plant Cost (TPPC)			$4,471,523
Engineering, Permitting	0.1	TPPC	$447,152
Total Capital Cost (TCC)			$4,918,675
Assume thermal desorption equipment has lifetime of 5 yrs, and will be on-site for 6 mo, =>Equivalent TCC**			**$894,305**
Interest/Year	7.0%	TCC	$344,307
Assume thermal desorption Unit On-Site for 6 mo			**$172,154**
Tons Treated per Year	524,160	tons/year	
Interest Cost per Ton of Production			**$0.33**

Notes:

*Cost factors were based on USEPA "Engineering Handbook for Hazardous Waste Incineration" Chapter 6 "Estimating Incineration Costs" September, 1981

** Equivalent TCC is the cost that would be charged to the job for the time the thermal desorption unit is actually on-site

Purchased Equipment Cost (PEI)		
Description	**Cost ($)**	**Reference**
In Feed Hopper/Weigh Scale	$95,000	Tarmack, Inc
Infeed Belt Conveyor	$35,000	Tarmack, Inc
Rotary Dryer	$1,150,000	Tarmack, Inc
Soil Conditioner	$65,000	Tarmack, Inc
Stacking Conveyor	$50,000	Tarmack, Inc
Cyclone Collectors	$60,000	Tarmack, Inc
Baghouse	$175,000	Tarmack, Inc
Baghouse ID Fan	$41,000	Tarmack, Inc
Thermal Oxidizer	$325,000	Tarmack, Inc
Draft Stack	$52,000	Tarmack, Inc
Collection Auger	$75,000	Tarmack, Inc
Transfer Duct Work	$75,000	Tarmack, Inc
Compressor/Tank	$65,000	Tarmack, Inc
Control House/Controls and Motor Control Center	$147,000	Tarmack, Inc
1000 KW Generator Set	$255,000	Caterpillar
Subtotal	*$2,665,000*	
Onsite Equipment Prep	$350,000	ThermTec, Inc
Electrical and Instrumentation	$400,000	ThermTec, Inc
System Total	***$3,415,000***	
Auxiliary Equipment		
Soil Blending System (Pug Mill with Hopper and Screen)	$126,800	ThermTec, Inc
Total Auxiliary Equipment	*$126,800*	
Total w/ Auxiliary Equipment	**$3,541,800**	

Notes:

1. Capital costs were obtained from indicated vendors in August, 2002

Table C-7: Cost for Thermal Desorption Treatment of Soils: Startup Cost Calculation

Startup Time	25	days
	600	hours

Description	Cost per Ton ($)	Startup Factor[1]	Startup Cost Per Ton ($)
Labor	$10.85	1	$10.85
Fuel	$19.86	1	$19.86
Utility	$1.30	1	$1.30
Maintenance	$3.27	1	$3.27
Interest	$0.33	1	$0.33
Soil Pretreatment[1]	$1.60	1	$1.60
Monitoring[2]	$0.40	1	$0.40
Generated Waste[3]	$1.00	1	$1.00
Total			$38.61
Total Hourly Cost (80 tons/hr)			$3,089
Total Startup Cost			$1,853,332
Cost per Ton ($)			**$0.39**

Notes:
1. Refer to Table C-1 for cost per ton.
2. Refer to Table C-1 for cost per ton.
3. Refer to Table C-1 for cost per ton.

Table C-8: Cost for Thermal Desorption Treatment of Soils: Fuel Cost Calculation

Fuel Cost Summary		
Item	Quantity	Units
Thermal Desorption	7,032,917	gal/yr
Material Handling	550,368	gal/yr
Standby Generator	72,000	gal/yr
Total Yearly Fuel Consumption	7.66E+06	gal/yr
Gallons per Ton (80 ton/hr)	14.60	gal/ton
Fuel Cost per Gallon	$1.36	
Cost Fuel per Ton	**$19.86**	

Thermal Desorption Fuel Consumption

Production Rate	80	tons/hr
Moisture Content	10%	
Mean BTU Content of Soil (In Situ)	0	Btu/lb

Energy Consumption of Thermal Desorption

Based on mass and energy balances, total thermal desorption fuel consumption: 1,073 gal/hr
This assumes no energy content in soil and 10% moisture content.

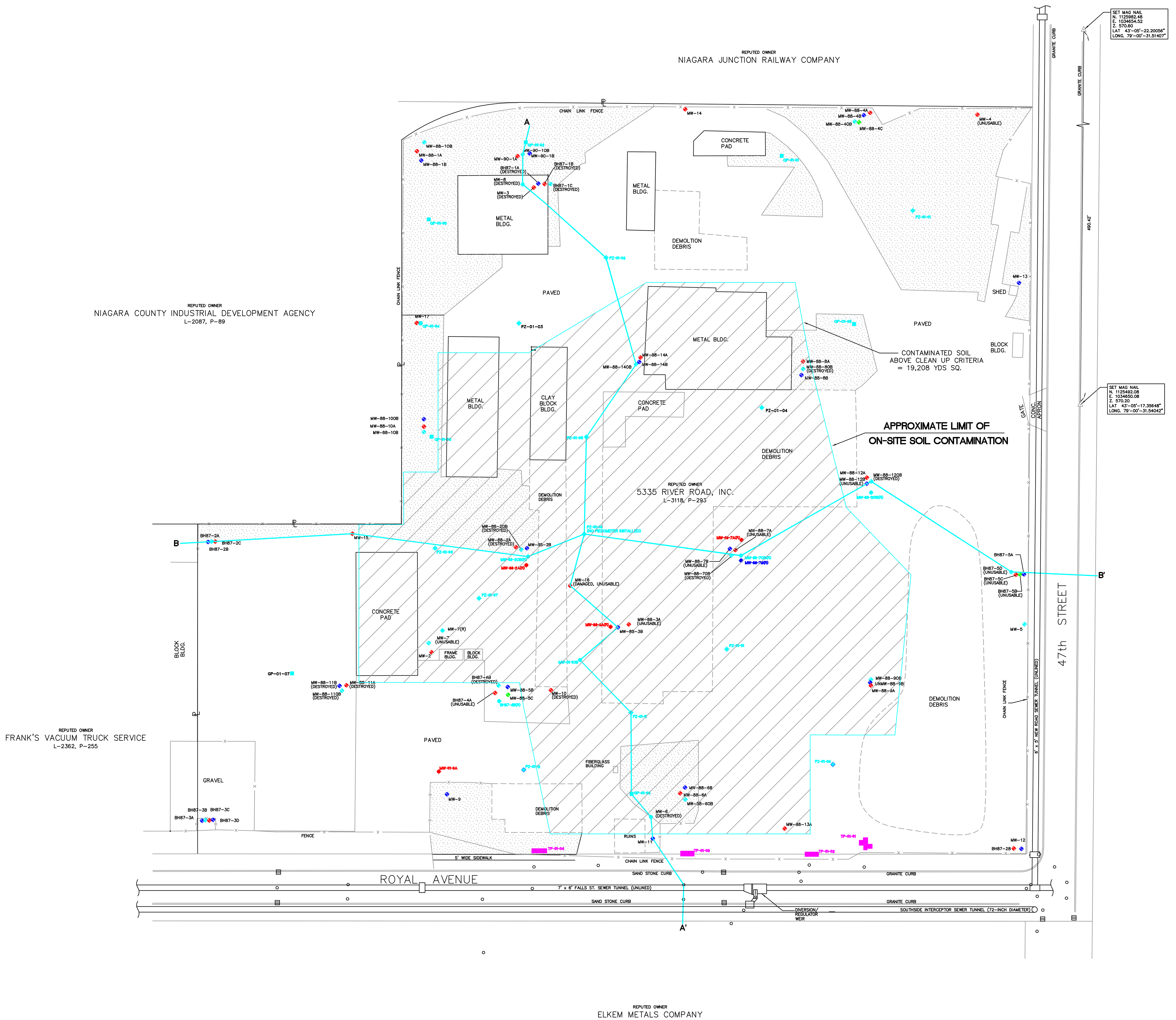
Total Fuel Consumption	1,073	gal/hr
Annual Fuel Consumption	**7,032,917**	gal/yr

Material Handling Fuel Consumption

From Caterpillar Performance Handbook;		
Front End Loader Fuel Usage	42	gal/hr
For 2 Front End Loaders		
Annual Fuel Consumption	**550,368**	gal/yr

Standby Generator 1000 KW Fuel Consumption

From Caterpillar Performance Handbook;		
Hourly Fuel Usage	72	gal/hr
Assume Generator Use	1000	hrs/yr
Annual Fuel Consumption	**72,000**	gal/yr



LEGEND

	UNPAVED AREAS
	PROPERTY LINE
MW-88-90B	OVERBURDEN MONITORING WELL
MW-88-9A	A-FRACTURE ZONE BEDROCK WELL
UNMW-88-9B	B-FRACTURE ZONE BEDROCK WELL
BH87-5B	C-FRACTURE ZONE BEDROCK WELL
MW-88-3A(R)	SRI WELLS
PZ-01-01	SRI PIEZOMETER LOCATION
GP-01-01	SRI GEOPROBE SOIL BORING LOCATION
TP-01-02	SRI TEST PIT LOCATION
A — A'	CROSS SECTION LINE
	RECEIVER
	MANHOLE
	OUTLINE OF DEMOLISHED BLDGS./ STRUCTURES OR DEBRIS PILE
	OUTLINE OF BLDG. OR CONCRETE PAD
	FENCE

BENCHMARK

1) PROJECT ELEVATIONS BASED UPON EXISTING BENCHMARK TBM 3 AS OBSERVED IN CONTROL PLACED FOR THE CITY OF NIAGARA FALLS GIS CONTROL PROJECT AS FOLLOWS: A SQUARE CUT ON THE NORTHWEST CORNER OF THE CONCRETE FOOTING AT THE NORTHWEST LEG OF TRANSMISSION TOWER #LN 32 TWR 97. LOCATED AT THE SOUTHWEST CORNER OF THE INTERSECTION OF PACKARD ROAD AND NIAGARA FALLS BOULEVARD. ELEV. 581.24 (NGVD 1929)

2) SITE TBM CUT 'X' ON THE N.-N.E. BONNET BOLT OF HYDRANT LOCATED ON WEST SIDE OF 47th STREET (ELEV. 572.86).

NOTES

1) HORIZONTAL DATUM IS BASED ON THE NEW YORK STATE PLANE COORDINATE SYSTEM WEST ZONE NAD83/92HARN (FEET).
2) REFERENCE MAP – CITY OF NIAGARA FALLS TAX MAP NO. 160.09.
3) PROPERTY LINES SHOWN ARE APPROXIMATE IN LOCATION AND ARE BASED UPON THE ABOVE REFERENCED TAX MAP. PROPERTY OWNER INFORMATION IS BASED ON THE TAX MAP AND CITY OF NIAGARA FALLS WASTEWATER FACILITIES DRAWINGS.
4) NOT ALL PLANIMETRIC/TOPOGRAPHIC FEATURES WERE IDENTIFIED AS PART OF THIS PROJECT SCOPE.
5) SRI WELLS/PIEZOMETERS/GEOPROBE/TEST PIT LOCATIONS ARE SHOWN WITH BOLD TEXT.
6) SRI = SUPPLEMENTAL REMEDIAL INVESTIGATION.
7) SELECT UTILITY LINES AND SEWER TUNNELS LOCATIONS AND SIZES ARE APPROXIMATE BASED ON DRAWINGS PROVIDED BY CITY OF NIAGARA FALLS DEPT. OF WASTEWATER FACILITIES.
8) BASE MAP PROVIDED BY McINTOSH & McINTOSH, P.C. ON 3/11/02. ECOLOGY & ENVIRONMENT FIELD OBSERVATIONS ALSO INCLUDED.
9) FIELD OBSERVATIONS NOTED HEREON, REGARDING THE FUNCTIONING OF WELLS (e.g., UNUSABLE), WERE MADE ON OCTOBER 9, 2001.

SCALE IN FEET
0 50 100 150

FORMER FRONTIER CHEMICAL WASTE PROCESS, INC. SITE

NIAGARA FALLS — NEW YORK

CONTAMINATED SOIL ABOVE CLEAN UP CRITERIA

SCALE	DATE ISSUED	C.A.D. FILE NO.	DRAWING NO.	REV.
1"=40'-0"	12/2/02	CONTAMINATED SOIL	Figure – 2-1	

F:\Frontier Chem\Fig 2-1.dwg
BUFF PLOTTED 8/16/04 JGL

ecology and environment engineering, p.c.