HYDROGEOLOGIC INVESTIGATION
PHASE III

FRONTIER CHEMICAL WASTE PROCESS, INC.
NIAGARA FALLS, NEW YORK

APRIL 1990

ecco INC.
THE ENVIRONMENTAL CONSULTING COMPANY

VOLUME 1

FRONTIER
CHEMICAL WASTE PROCESS INC.
4626 Royal Avenue, Niagara Falls, New York 14303

April 30, 1990

New York State Department of
Environmental Conservation
600 Delaware Avenue
Buffalo, New York 14202

Re: Phase III Hydrogeologic Investigation,
Frontier Chemical Waste Process, Inc.
Niagara Falls, New York 14303

Attn: Peter Beuchi, P.E.

Dear Mr. Beuchi:

Enclosed are 2 copies of the final report on the Phase III Hydrogeologic Investigations at the Frontier Chemical Plant site in Niagara Falls, New York; prepared by ECCO, Inc.

The report fulfills the items covered in the Order of Consent 85-136.

Sincerely,

FRONTIER CHEMICAL WASTE PROCESS, INC.

Rudolph F. Scarpelli

Rudolph F. Scarpelli
Laboratory/Technical Director

RFS/bp

Enclosures

cc: G. Brown
D. Gowland
R. Crouch

[redacted]

ecco INC.
The
Environmental
Consulting
Company

HYDROGEOLOGIC INVESTIGATION
PHASE III

Frontier Chemical Waste Process, Inc.
Niagara Falls, New York

Prepared for:

Frontier Chemical Waste Process, Inc.
47th Street and Royal Avenue
Niagara Falls, New York 14303

Prepared by:

ECCO, Inc.
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Date: April 30, 1990

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1.0 INTRODUCTION

ECCO, Inc., (Buffalo, New York) was retained by Frontier Chemical Waste Process, Inc., (Frontier) for the purpose of conducting a hydrogeological investigation at Frontier's facility located at the intersection of 47th Street and Royal Avenue in Niagara Falls, New York (See Figure 1). [illegible]

Previous investigations conducted at the Frontier facility by Wehran Engineers, Thomsen Associates, Earth Dimensions, Inc., and Golder Associates were directed at determining the geologic stratigraphy beneath the site and the presence and direction of ground water flow in the overburden soils and in the fractured bedrock. A drawing indicating the location of the on-site Frontier facilities and the location of the previous and current test borings and monitoring wells is presented on Drawing 1.

The Wehran investigation established initial ground water flow directions for the overburden soils and the top of the fractured bedrock. Thomsen Associates expanded upon the Wehran investigation by installing additional monitoring wells and collecting ground water samples for analysis. Compounds detected in the ground water samples of downgradient wells were noted to be at elevated concentrations when compared to the concentrations encountered in the upgradient wells. Earth Dimensions performed auger sampling at the location of a former sludge settling lagoon for the purpose of obtaining soil samples for subsequent analysis.

Golder Associates was first retained by Frontier in October 1985. Golder's investigation consisted of a four (4) point program comprising of: (1) a historical review of the on-site facility, (2) a regional review, (3) continued routine ground water monitoring and sampling and (4) the installation of additional borings and monitoring wells. The results of Golder's investigation were presented in a draft report prepared in April 1988, along with recommendations for an additional investigation to determine the source(s) of the detected ground water contamination and to further investigate the nature of the bedrock fracture zones. These recommendations were subsequently approved by the NYSDEC. At this point, ECCO, Inc., was retained by Frontier to complete this additional investigation.

The purpose of the ECCO, Inc., investigation was to conduct an additional hydrogeologic evaluation of the overburden and bedrock stratigraphy, provide an indication of the aerial and vertical extent of ground water contamination, and define the source(s) of the ground water contamination encountered on-site. In addition, based on the existing and newly acquired data, potential migration pathways, off-site loading, a baseline cancer risk assessment and an outline of potential remedial measures were addressed.

This report presents the results of the ECCO, Inc., investigation and comprises the installation of additional bedrock and overburden monitoring wells, collection and analysis of ground water samples, the evaluation of the data and the preparation of this report. The ECCO, Inc., investigation and this submission were executed in accordance with the conditions set forth by the New York State Department of Environmental Conservation (NYSDEC) Order on Consent File No. 85-136, Section V.

2.0 PREVIOUS INVESTIGATIONS

Several investigations have been conducted at the Frontier site, beginning in 1981 and extending to the present.

WEHRAN ENGINEERING (December 1981)

The initial hydrogeological investigation performed in December 1981, was conducted by Wehran Engineering Corporation of Middletown, New York. The purpose of the Wehran investigation was: to define the nature of the subsurface geologic materials at the site; to determine the existence, direction, and rate of flow of ground water; and establish a ground water monitoring system for the Frontier facility. The scope of the investigation included the drilling of eight (8) boreholes and the subsequent installation of monitoring wells in each of the boreholes. These wells were installed in one of two configurations: (1) as a top of clay/silt well or (2) as a top of bedrock well.

Ground water was encountered in the overburden lacustrine soils (i.e., clays and silts) and is generally perched. Ground water was also encountered in the upper fractured bedrock unit under semi-confined conditions. This fractured bedrock unit was encountered below the confining, overlying glacial till unit, directly below the overburden lacustrine silts and clays.

Water levels were monitored for a period of six (6) months after the well installations. Water level measurements indicated that the direction of ground water flow, encountered in the fill and lacustrine silts, was primarily to the northwest. Ground water flow encountered in the semi-confined bedrock exhibited a general flow direction to the southeast.

Chemical analysis of ground water samples was not performed during the Wehran investigation. Additional monitoring wells were recommended by Wehran Engineers to provide for an adequate ground water monitoring system.

THOMSEN ASSOCIATES (June 1985)

Thomsen Associates was retained by Frontier to conduct a hydrogeological investigation at the project site. Thomsen proposed and installed nine (9) monitoring wells at strategic locations across the site. All nine (9) wells were installed at top of rock wells. Ground water was encountered in the upper fractured bedrock aquifer. Water level measurements indicated that the ground water flow direction in the upper bedrock unit is from the northwest to the southeast. Monitoring wells MW-9, MW-11, MW-12, and MW-13 required redrilling and installation at greater depths due to insufficient ground water being encountered in the initial installations.

A concerted weekly monitoring program was instituted which involved measurements of pH, specific conductance, TOC, phenol and water elevations in all installed wells for a four (4) week period. During the fourth weekly sampling event, a volatile organic scan was added to the above noted parameter list. The ground water samples were submitted to Ecology and Environment, Inc., (E & E) for the volatile analysis. Problems were encountered with the quantification of certain chemical species which necessitated the resampling of the wells. The ground water samples from the resampling event were submitted to Zenon Environmental for analysis.

The findings of the investigation indicated that water quality in downgradient wells was elevated in concentrations of volatile organics, phenols, TOC (total organic carbon), and pH and specific conductance as compared to upgradient wells MW-14 and MW-17. Analytical results of ground water samples obtained from monitoring wells installed near the former sludge settler indicated that the settler was apparently not the source of elevated concentrations of organics in the remaining downgradient wells (i.e., MW-9, MW-11, MW-12, MW-15, and MW-16). Continued monitoring of the wells for a one-year period was recommended by Thomsen Associates. No investigation of the overburden ground water system was performed during this investigation.

GOLDER ASSOCIATES (NOVEMBER 1985)

Golder Associates of Mississauga, Ontario, was retained by Frontier Chemical Waste Process to continue the hydrogeological investigation of the site.

Golder reviewed the previous investigations performed by Wehran and Thomsen and proposed a four (4) point investigation as follows:

- An on-site historical review
- A regional review
- On-going routine monitoring
- Additional boreholes and monitoring wells

The report made a preliminary review of the historical aspects of the Frontier Chemical Waste Process site. This review presented information about the site usage and of the previous hydrogeological investigations conducted by Wehran and Thomsen. Golder reiterated the discrepancies encountered in the analytical data presented by Thomsen Associates (i.e., from E & E and Zenon).

Surrounding sites and utilities were also briefly examined as possible sources of part of the contamination encountered at the Frontier Chemical Waste Process site. Possible contamination was attributed to be originating from surcharging of the Falls Street Tunnel, situated on Royal Avenue, immediately south of the Frontier plant site. An ongoing ground water monitoring plan, consisting of analysis via a Gas Chromatography/Mass Spectrophotometer (GC/MS) scan, was recommended to be performed on samples obtained from each well. The sampling was to be completed after the drilling and installation of additional borings and monitoring wells.

GOLDER ASSOCIATES (AUGUST 1986)

The technical specifications of the proposed Golder hydrogeologic investigation are presented in this August 1986 report. The drilling methodologies, well development and acceptance criteria were established and the locations of the proposed monitoring wells, as recommended in the November 1985 Golder report, were presented.

GOLDER ASSOCIATES (SEPTEMBER 1986)

This report presented the Health and Safety program to be utilized during the installation of the monitoring wells recommended in the November 1985 Golder report.

GOLDER ASSOCIATES (OCTOBER 1986)

This report presented a detailed historical review of the Frontier Chemical Waste Process site and the surrounding facilities. The Falls Street and New Road sewer tunnels were examined as potential sources of contaminants in the vicinity of the Frontier Chemical Waste Process site. It was noted that, of the contaminants encountered in the ground water at the Frontier site, many are present upgradient of the site as discharges to the Falls Street and New Road sewer system.

Potential on-site sources were also examined. It was indicated that certain storage tanks, leased to various off-site facilities such as Hooker Chemical (now Occidental Chemical Corporation) and Solvent Chemical Corporation, Sobin Chemicals and the IMC Chemical Group (the latter three now defunct), may have impacted the ground water of several of the monitoring wells. No data was presented to substantiate any leaks from the former storage tanks. Little information was available for the on-site practices prior to ownership by Frontier.

EARTH DIMENSIONS, INC. (FEBRUARY AND NOVEMBER 1986)

Earth Dimensions of East Aurora, New York, was contracted by Frontier Chemical Waste Process in November 1985 to obtain soil samples from borings located around the perimeter and a boring in the center of a former sludge settler lagoon. Five borings were advanced to auger refusal on presumed bedrock at approximately eleven (11) and thirteen (13) feet. The remaining four borings were advanced by a hand auger to a depth of 8.5 feet to 9.5 feet. All borings were continuously sampled and logged. Subsequently, selected samples were submitted for analysis via EP Toxicity Leachate Test procedure and EPA Methods 624 and 625. The purpose of the February report was to identify the geology underlying the site and submit final boring logs.

In October 1986, Earth Dimensions were again retained to advance eight borings located in the area of the former lagoon. The borings were hand augered to a maximum depth of 8.5 feet below the bottom of the former lagoon. Two composite samples were prepared from each boring for subsequent analysis. One composite represented the two (2) to three (3) foot depth interval below the base of the former lagoon. The second composite represented the bottom one (1) foot of each boring.

As was noted in Earth Dimension's November 1986 report both within the text and on the boring logs, a dark-brown oily-type film was observed on the soil samples from five (5) to six (6) feet below the bottom of the lagoon in the borings located in the northern half of the former lagoon area. This oily-type film was not observed in the upper five (5) feet below the base of the lagoon nor at depth in the southern half of the lagoon. It should be noted that this observation of an oily film was not observed during the February 1986 sampling.

No evaluation of the analytical data was presented in the text of this report.

GOLDER ASSOCIATES (DECEMBER 1986)

The December 1986 Golder report presented the results of the interim ground water monitoring program conducted at the Frontier Chemical Waste Process site in October 1986. Ground water samples were jointly collected by Golder and Frontier and submitted to Zenon Laboratory for analysis. The ground water samples were analyzed for EPA Method 624 priority pollutants, chlorotoluene, dichlorobenzene, total halogenated organics (TOX), and phenol. A dense non-aqueous phase liquid (DNAPL) was encountered in well MW-11 and was analyzed for EPA Method 625 extractable compounds. The analysis of the DNAPL from well MW-11 revealed the presence of fifteen (15) organic compounds, the most salient being dichlorobenzene, 1,1,1, trichlorobenzene, tetrachloroethylene, and chlorotoluene. It was concluded that the analysis from the October 1986 sampling event was found to be similar in the range of concentrations to the sampling and analysis performed in April 1985.

Water levels were also measured in the monitoring wells and, according to Golder, ground water flow directions are influenced by the Falls Street Tunnel and New Road Tunnel on Royal Avenue and 47th Street, respectively.

GOLDER ASSOCIATES (APRIL 1988)

A draft report detailing the geology and hydrogeology of the Frontier site was prepared by Golder in April 1988 which encompassed the results of the advancement of 28 overburden organic vapor analysis (OVA) boreholes (Phase I study) and six (6) clustered bedrock monitoring wells (Phase II Study). The bedrock wells were advanced to depths that range from 22 feet to 55 feet below the ground surface. The draft report also included the analytical results obtained from ground water sampling performed in March 1988, on wells installed by Golder in the summer of 1987 and other existing wells. Based on the results of the Phase I and II investigations, Golder provided recommendations for an additional investigation to define the source(s) of the contamination.

Golder recommended that bedrock wells be installed to monitor the "A" and "B" fractures of the Lockport Dolostone. All bedrock wells were to be constructed as open rock hole wells drilled into the respective zone of the Lockport. All "A" and "B" fracture wells were to provide a 4-inch inside diameter (ID) steel casing grouted into the bedrock surface, above the intended monitoring zone. The monitoring zone was to be core drilled below the 4-inch I.D. casing to complete the well installation.

Golder also recommended the advancement of a deep exploratory boring to determine additional bedrock stratigraphy and the depth of the next bedding plane fracture zone (i.e., "C" fracture). The presence of the "C" fracture was to be established from in-situ permeability test results. Subsequently, these recommendations were submitted and approved by the NYSDEC and thus, form the basis for the ECCO, Inc., investigation.

3.0 INVESTIGATIVE METHODOLOGY

3.1 Decontamination Procedures

Prior to commencement of the hydrogeological investigation, a CME-75 truck mounted drill rig and a CME-750 all-terrain vehicle (ATV) drill rig from CATOH Environmental Company were mobilized to the site on August 15, 1988. A Mobile B-61 drill rig was also mobilized to the Frontier site on September 6, 1988. The CME-750 ATV was subsequently demobilized for maintenance and repair on September 13, 1988.

3.1.1 Decontamination Site

A decontamination area was designated by Frontier at the truck staging area, west of the former settler, at location C-102 (see Drawing 1). This area consists of a concrete pad, sloped to a surface sewer drain, where trucks are kept prior to leaving or being accepted at the facility. Water and electric supply lines are located at the decontamination area.

All solid (i.e., soil) waste generated by the drilling contractor was retained in 55-gallon New York State Department of Transportation (NYSDOT) drains located adjacent to the decontamination area. All liquid wastes entered the sewer system via the surface drain for on-site treatment prior to discharge into the main sewer. It should be noted that the use of the decontamination area was not exclusive to the drilling contractor. Normal facility use of the truck area was also maintained by Frontier. All drums, whether new or reconditioned, were provided by Frontier. Clean gloves were utilized between successive decontamination operations and were disposed of in the 55-gallon waste drum located adjacent to the decontamination area. Upon completion of all drilling operations, the decontamination area was cleaned of all loose debris generated by the drilling contractor, and steam cleaned prior to demobilization.

3.1.2 Drill Rig and Equipment

All equipment and tools utilized in the drilling operations were decontaminated with a high-pressure, steam cleaner prior to use. The back end of the drill rig was also cleaned between successive activities and individual boreholes. The back end of each support vehicle (i.e., pickup) was also steam cleaned between activities and individual boreholes.

3.1.3 Well Materials

All steel casings, 3-inch, 4-inch, 6-inch, and 8-inch inside diameter and all 2-inch inside diameter stainless steel riser and well screen materials were steam cleaned prior to installation. Multiple lengths of steel casing, which were welded together, were steam cleaned after welding was complete. All pre-cleaned well materials were wrapped and kept in polyethylene sheeting prior to installation.

well

3.1.4 Equipment and Material Storage

All steel casings and well riser/screen materials delivered to the site were maintained in their respective shipping crates until needed and were placed on wooden pallets to the east of the decontamination area. When not in use, the well materials were covered with polyethylene sheeting. Sand, cement, bentonite powder and pellets, and concrete mix bags were also stored off the ground surface on wooden pallets and covered with polyethylene sheeting at one of two locations. The first location was adjacent to the west property line; the second area was located within the interior of Building 8-garage facility (see Drawing 1).

3.2 Overburden Drilling Procedures

3.2.1 Hollow Stem Augers

All borings were advanced to the top of the bedrock surface, through the overburden fills and soils, by means of hollow-stem augers (HSA). The HSA were utilized to create a stable borehole below which split-spoon soil sampling and well installation could be performed. The HSA also served on a temporary casing prior to installation of the permanent steel casings for the bedrock wells. The drilling contractor, CATOH Environmental Company, provided all steel casings and HSA.

Borings to be completed as bedrock monitoring wells utilized 6 1/4-inch ID HSAs. The overburden wells, however, were installed through the center of 4 1/4-inch ID HSAs. Upon completion of all soil sampling and permanent casing and monitoring well installations, the HSA were withdrawn from the overburden materials.

3.2.2 Soil Sampling

The nature of the overburden fill and soil materials were investigated by means of split-spoon samplers advanced to the top of the bedrock. The purpose of the sampling was to provide information on the geologic stratigraphy encountered beneath the site and to establish the presence of the ground water table within the overburden.

The soil sampling was performed in accordance with American Society for Testing and Material Standard ASTM D-1586. Blow counts obtained during the sampling provided Standard Penetration Test (SPT) results, and are presented on the boring logs in Appendix A. All recovered soil samples were placed in 8-ounce glass jars and were properly labeled according to borehole number, date, sample depth, sample number, and blow counts. The sample jar openings were then covered with a layer of aluminum foil prior to sealing with the jar lids. The soil samples were scanned the following day with an HNu Model PI-101 Photoionization Detector by means of piercing the aluminum foil cover and obtaining the readings. The results of the scanning are presented on the boring logs in Appendix A and are summarized in Table 1 presented in Section 4.3.2.

Soil sampling was performed at one (1) location of each well cluster. Sampling of the remaining borings of each respective cluster was not deemed necessary, since all borings were advanced within close proximity to one another.

3.2.3 Abandoned Boreholes

All boreholes not completed as monitoring wells were abandoned by means of pressure grouting. Four (4) borings were abandoned during the ECCO, Inc., investigation: three at well cluster MW-88-3; and MW-88-13B. The borings were abandoned at a depth of four (4) to six (6) feet due to fill and other obstructions. The entire length of each borehole was backfilled with a cement-bentonite grout, injected under pressure, through a tremie pipe lowered to the base of each borehole. Upon completion of the grouting operations, the tremie pipe was removed and each borehole was considered properly abandoned.

3.3 Monitoring Well Installation

3.3.1 Bedrock Fracture Type "A"

As stated in Section 1.0 of this report, one of the purposes of our investigation was to define the source(s) of the contamination encountered at the Frontier site. To accomplish this goal, additional monitoring wells were installed in the bedrock at depth intervals which correspond to fractures previously encountered on site (Thomsen, Golder). Upon completion of the well installation and development operations, ground water samples were obtained from each well for chemical analysis.

The first zone to be further investigated was the "A" fracture. The "A" fracture is located within Zone 1 tentatively associated with the lower Salina Formation, as previously noted by Golder Associates. Greater detail regarding the regional and site geology will be presented in Section 4.0 of this report.

The following procedure was utilized for the installation of all "A" fracture bedrock wells:

- Overburden drilling was accomplished in accordance with Section 3.2 of this report. All "A" fracture borings were advanced to auger refusal at the top of the bedrock unit.

- With the HSA in-place, a length of 6-inch inside diameter black steel casing was lowered through the center of the HSA to the top of the bedrock surface. The purpose of the 6-inch casing was to provide separation of the overburden soils from the bedrock surface upon withdrawal of the HSA. This overburden casing was then pressure grouted via a tremie pipe lowered into the casing. Upon completion of the pressure grouting operations, the HSA were removed from the overburden soils and decontaminated in accordance with Section 3.1 of this report. The grout was allowed to cure for a minimum of 24 hours prior to continuation of the drilling operations.

- A 6-inch ID steel "tee" was then temporarily welded to the casing to provide for recirculation of drilling fluids (supplied potable water).

- After at least 24 hours had elapsed, the grout within the 6-inch casing was reamed out, utilizing a 5 7/8-inch tricone bit, to the top of rock. All fluids utilized during the reaming operations were recirculated to the surface and diverted, via the "tee," to a water tank. Upon completion, all fluids were contained in 55 gallon drums supplied by Frontier and labeled as to contents, boring location, and date.

- Upon completion of the reaming, a nominal one (1) foot deep socket was drilled into the bedrock to facilitate the installation of a length of 4-inch ID steel casing. The purpose of the 4-inch casing is to serve as the riser pipe for the completed monitoring well. The bedrock socket was advanced by means of reaming with a 5 7/8-inch tricone bit. Drilling fluids were recirculated and contained as noted above.

- The 4-inch casing was installed within the 6-inch casing and was pressure-grouted via a tremie pipe. The grouting was considered complete when grout was noted at the ground surface. The grout was allowed to cure for a minimum of 24 hours prior to continuation of the drilling operations.

- After a minimum of 24 hours, one of two methods was utilized to complete the monitoring well installation:

  Method A

  An HQ size (4-inch outside diameter by 3-inch core diameter) core barrel was utilized to core a nominal 5 feet into the bedrock, below the base of the 4-inch casing, to the borehole completion depth.

Method B

An NQ size (3-inch outside diameter by 2-inch core diameter) core barrel was utilized to core a nominal 5 feet into bedrock, below the base of the 4-inch casing. Then, the corehole was enlarged, by means of reaming with a 3 7/8-inch tricone bit, to the borehole completion depth.

The "A" fracture monitoring wells are generally situated within the top 6 feet of the bedrock surface and are effectively isolated from the overburden soil conditions by means of a 6-inch casing, grouted in-place, and a 4-inch casing, grouted in-place, which also serves as the riser pipe for the open rock well. See Figure 2 for typical "A" fracture monitoring well details.

3.3.2 Bedrock Fracture Type "B"

The "B" fracture is located below the "A" fracture, at the base of Zone 2 (Golder designation). Since ground water contamination was encountered in the "A" fracture wells (Thomsen, June 1985; and Golder, April 1988), monitoring of the next permeable zone, the "B" fracture, was recommended (Golder, November 1985). Greater detail regarding the local and regional geology is presented in Section 4.0 of this report.

The following procedure was utilized for the installation of all "B" fracture bedrock wells:

- Overburden drilling was accomplished in accordance with Section 3.2 of this report. All "B" fracture borings were advanced to auger refusal at the top of the bedrock unit.

- Hollow-stem augers (HSA) were utilized to advance the borings to the top of the rock unit. A length of 6-inch inside diameter steel casing was pressure grouted in place, via a tremie pipe. Grouting was considered complete when grout was noted at the ground surface. The HSAs were then removed and decontaminated in accordance with Section 3.1 of this report. The grout was allowed to cure for a minimum of 24 hours prior to continuation of the drilling operations.

- A 6-inch inside diameter steel casing "tee" was then temporarily welded to the casing to provide for recirculation of all drilling fluids (supplied potable water). After at least 24 hours had elapsed, the grout within the 6-inch steel casing was reamed out, utilizing a 5 7/8-inch tricone bit to the top of rock. All drilling fluids utilized during the reaming operation were recirculated to the surface and diverted, via the "tee", to a water tank. Upon completion of the reaming operation, all fluids were contained in 55-gallon drums supplied by Frontier and labeled as to content, boring location, and date.

- Upon completion of the reaming operations, a nominal 9-foot deep socket was drilled into the bedrock to facilitate the installation of a length of 4-inch ID diameter steel casing. The 4-inch casing serves as the rise pipe for the completed monitoring well. The rock socket was drilled in accordance with one of the two following methods:

  Method A

  A 5.5-inch outside diameter (O.D.) by 4-inch core diameter core barrel was utilized to core the bedrock, 9 feet below the top of rock and the base of the 6-inch steel casing.

  Method B

  An NQ core barrel was utilized to core the bedrock, 9 feet below the top of rock and the base of the 6-inch casing. Upon completion of the NQ coring, the bedrock borehole was reamed by means of a 5 7/8-inch tricone bit, to the appropriate depth. All drilling fluids were recirculated to the surface via the casing "tee" and contained as previously noted.

- Upon completion of the coring operations, a length of 4-inch steel casing was installed into the 9 foot rock socket and pressure grouted via a tremie pipe till grout was noted at the ground surface. The grout was allowed to cure for a minimum of 24 hours prior to continuation of the drilling operations.

- After a minimum of 24 hours had elapsed, the grout within the 4-inch casing was reamed out utilizing a 3 7/8-inch tricone bit. All drilling fluids (supplied potable water) were recirculated and contained as previously noted. Upon completion of the reaming operations, the monitoring well was completed by coring the bedrock, 6 feet below the base of the 4-inch casing. This coring was accomplished by utilizing either an HQ core barrel or an NQ core barrel in combination with reaming with a 3 7/8-inch tricone bit, as similarly described for the "A" fracture wells.

- The "B" fracture wells are completed as open rock holes at a depth interval of 9 feet to 15 feet below the top of the bedrock/overburden interface. The "B" fracture well is isolated from the overburden soil conditions by means of the 6-inch steel casing and from the "A" fracture zone by means of the 4-inch steel casing telescoped through the 6-inch casing. All casing and reaming drilling fluids were recirculated to the surface via the 6-inch "tee" and contained as previously noted. See Figure 3 for typical "B" fracture monitoring well details.

3.3.3 Bedrock Fracture Type "C"

The purpose of the "C" fracture monitoring wells is twofold: first, to better define the bedrock geology along the north property line and beneath the former sludge settler area; and, second to establish the preliminary ground water quality of the fracture zone underlying the "B" fracture. Two (2) "C" fracture monitoring wells were, therefore, installed at the Frontier site. One (1) "C" fracture well, MW-88-4C, was advanced to a depth of 76 feet below the ground surface, along the north property line, and also served as a deep exploratory borehole. The second "C" fracture well, MW-88-5C, was advanced south of the former sludge settler area to a depth that was determined from permeability testing performed in MW-88-4C (See Section 3.4)

Exploratory borehole/well MW-88-4C was advanced in the following manner:

- 6 1/4-inch ID HSAs were advanced to auger refusal at the top of rock in accordance with Section 3.2 of this report. A length of 8-inch ID steel casing was pressure grouted, via a tremie pipe, at the top of rock. The HSAs were removed upon completion of the grouting operations. The grout was allowed to cure for a minimum of 24 hours prior to continuation of drilling operations. The 8-inch casing provides isolation from the overburden soil materials.

- The grout within the 8-inch casing was reamed out utilizing a 7 7/8-inch tricone bit, after at least 24 hours had elapsed after grouting of the 8-inch casing. Rock coring and/or reaming to an inside diameter of 7 7/8-inches continued to a depth of 9 feet below the base of the 8-inch casing. At this point, a length of 6-inch ID steel casing was installed, using pressure grouting procedures, at a depth of 20 feet below ground surface. The grout was allowed to cure for a minimum of 24 hours prior to completion of drilling operations. The 6-inch casing provides isolation from the "A" fracture zone.

- The grout within the 6-inch casing was reamed utilizing a 5 7/8-inch tricone bit, after at least 24 hours had elapsed. Rock coring continued to a depth of 26.5 feet below the ground surface. A length of 4-inch ID steel casing was then installed and pressure grouted, at a depth of 26.5 feet.

- The grout within the 4-inch casing was reamed out utilizing a 3 7/8-inch tricone bit, after at least 24 hours had elapsed. Rock coring then continued, utilizing an HQ core barrel, from a depth of 26 to 76 feet below the ground surface. Coring was alternated with in-situ permeability tests, in accordance with Section 3.4 of this report, until boring completion at a depth of 76 feet below the ground surface. The permeability tests were utilized to estimate the depth of the "C" fracture zone (see Section 3.4 and 4.2 of this report).

- The core hole was backfilled with a dense bentonite grout from a depth of 57 to 76 feet below ground surface. A cushioning layer of silica sand was tremied into the borehole from 56.5 feet to 57.0 feet. A length of 2-inch ID stainless steel well screen and rise (0.010-inches per slot) was then installed into the borehole and the well annulus was backfilled with silica sandup to a depth of 44 feet. The remainder of the well annulus was backfilled, via pressure injected grout, to the ground surface.

Monitoring well, MW-88-5C, was installed in a similar fashion with the exception of the installation of the 2-inch stainless steel well. The drilling procedures are similar and are summarized as follows:

- 6 1/4-inch HSA advanced to top of rock @ 16 feet
- Install (pressure grout) 8-inch ID steel casing at top of rock
- Reaming with a 7 7/8-inch tricone bit from 16 feet to 25 feet
- Install (pressure grout) 6-inch ID steel casing at 25 feet
- Core below 6-inch casing from 25 feet to 37.3 feet
- Install (pressure grout) 4-inch ID steel casing at 37.5 feet
- Core below 4-inch casing from 37.5 feet to 47.3 feet
- Install (pressure grout) 3-inch ID steel casing at 47.3 feet
- Complete the well by coring from 47.3 feet to 58.0 feet

A typical installation of the C fracture well is presented on Figure 4.

3.3.4 Overburden Wells

A 2-inch ID stainless steel riser and screen were installed at each well cluster, with the exception of MW-88-3, MW-88-5, and MW-88-13. Due to subsurface fill conditions at locations MW-88-3 and MW-88-13, an overburden well was not installed. It should be noted that well cluster MW-88-5 was installed in the immediate vicinity of Golder well MW-87-4A and MW-87-4B. It was agreed upon by Frontier, ECCO, Inc., and NYSDEC to utilize Golder well MW-87-4B as the overburden well for cluster MW-88-5.

Four 1/4-inch HSAs were utilized to advance the borehole to the top of the bedrock unit. Upon completion of the drilling procedures, but prior to removal of the HSAs, the 2-inch ID stainless steel riser and screen were installed as follows:

- A blanket of silica sand was tremied through the HSAs to the top of rock.

- The 2-inch well was then installed through the HSAs and the remainder of the well annulus was backfilled with the silica sand.

- A nominal 2-foot thick pelletonized bentonite seal was backfilled in the remaining well annulus.

- A second cushioning blanket of silica sand, approximately 0.5 foot to 1 foot thick was placed atop the bentonite seal prior to grouting operations (utilizing a cement-bentonite grout).

- It should be noted that the HSA were gradually withdrawn from the borehole in a manner which allowed for the auger tip to remain below the respective backfill operation. This method provides for a temporary "casing" while the well is being constructed and prevents collapse of the borehole wall into the well environment.

- A 6-inch steel protective casing with a locking cap was then installed over the 2-inch well riser so that it is embedded approximately 2 feet to 3 feet below the ground surface.

See Figure 5 for typical overburden monitoring well details.

3.4 In-Situ Bedrock Permeability Testing

3.4.1 Purpose

In-situ bedrock permeability tests were performed in deep exploratory boring, MW-88-4C, for the purpose of establishing the depth of the "C" fracture zone. The actual permeability of the bedrock is not determined by direct methods. Rock formations, such as the Lockport Dolostone, are structurally composed of joints, fractures, solution cavities, and bedding planes which are capable of transmitting ground water. Therefore, it is the "joint permeability" which is actually determined. The permeability of the bedrock itself, or the "matrix permeability" is normally several magnitudes lower than the "joint permeability" (USACE).

A series of variable head permeability tests were performed in the open rock core hole of boring MW-88-4C. This method involved measuring the falling head of the water level in a standpipe and double-packer assembly inserted into the core hole. The individual test zones were isolated by locating inflatable packers above and below the test interval. The typical equipment set-up is presented on Figure 6. After the permeability test apparatus was installed, silt-free, potable water, supplied from an accepted on-site source, was utilized to raise the water level within the packer standpipe. As the water dissipated into the bedrock joints or matrix, the falling head was recorded as a function of time.

Each test was performed over a nominal ten foot length of the bedrock core hole. The first test was performed at a depth of 26.5 feet to 36.5 feet below the ground surface or 15.5 feet to 25.5 feet below the top of the bedrock surface, below the 4-inch casing installed at 26.5 feet ("B" fracture casing).

Successive tests were performed until the bottom of the corehole was reached at 76.0 feet. A total of five (5) packer (permeability) tests, noted as Permeability Test No. 1 through No. 5, were performed in the borehole of well MW-88-4C. Permeability Test No. 5 was conducted over a 9.5 foot interval from 66.5 feet to 76.0 feet below the ground surface. The data obtained from the permeability tests were analyzed in accordance with the methodology described by Cedergren and the U.S. Army Corps of Engineers (USACE) and are presented in Appendix B (i.e., Figures 7 through 11 and Table 2).

As previously stated, the purpose of the permeability testing was to provide field data for the identification of the "C" fracture zone and an estimate of its relative depth. Based upon the results of the permeability testing, the open rock well of boring MW-88-4C was installed at a depth of 46.0 feet to 56.5 feet below the ground surface. The test data obtained from well MW-88-4C was compared to the preliminary data presented by Golder for well BH-87-5B, which was advanced to a total depth of 54.9 feet below grade. It should be noted that the screened interval for well BH-87-5B is at a depth of 41.0 feet to 54.9 feet, which corresponds with the placement of well MW-88-4C and MW-88-5C (ECCO, Inc.,).

3.5 Survey

On October 19, 1988, surveying was conducted by ECCO, Inc., personnel. The objective of the surveying activities was to obtain ground surface and top of casing/riser elevations for each of the newly installed monitoring wells. Elevations were established using standard acceptable surveying techniques. The bench mark elevation data was provided by the Frontier Engineering Department. The bench mark used for the survey was the west lug of the manhole cover known as Bench Mark No. 4, located east of Building No. 55 (see Drawing 1), with a reported elevation of 569.57 feet (USGS Datum).

3.6 Well Development and Sampling

3.6.1 Well Development

Development of the wells installed during this investigative program was performed by EFS Environmental Field Services personnel in conjunction with ECCO personnel. Well development activities were performed between October 17, 1988, and November 2, 1988. Well development methodology, procedure and field data are presented in EFS's report entitled "Ground water Monitoring, Well Development and Sampling, Frontier Chemical Waste Process, Inc.," (see Appendix C).

3.6.2 Sampling

From November 9 to November 22, 1988, sampling was conducted on on-site wells screened in the overburden, "A" fracture, "B" fracture and "C" fracture underlying the site. A total of 66 wells were sampled during this event, including 27 existing wells previously installed in 1981, 1984 and 1987, and the 39 newly installed wells constructed in 1988. The sampling activities were performed by EFS and ECCO personnel. Sampling methodology, procedure and field data, inclusive of chain of custody forms, are presented in EFS's report entitled "Ground water Monitoring, Well Development and Sampling, Frontier Chemical Waste Process, Inc.," (see Appendix C).

3.7 Laboratory Analysis

The ground water samples obtained during the above sampling event were submitted daily under chain-of-custody to BLT Technical Services, Inc., Niagara Falls, New York. The approved analytical program for the ground water samples was:

- EPA Method 8240-Priority Pollutant Volatile Organics plus Acetone, 2-Butanone, 4-Methyl-2-Pentanone, Total Xylenes, Total Monochlorotoluenes
- Soluble Organic Carbon
- Phenolics
- pH and Specific Conductance (field determined)

At those wells where a non-aqueous phase liquid (NAPL) was encountered, a sample of the NAPL was obtained and analyzed via the aforementioned EPA Method 8240 plus additional constituents and EPA Method 8270-Semivolatile Organics. In addition, the chromatograph output associated with the EPA Method 8270 analysis was reviewed for identification of any peaks above 10 ppm for a "clean" sample to 100 ppm for a dirty sample.

All analysis followed U.S. Environmental Protection Agency reference:

- U.S. Environmental Protection Agency "Test Method for Evaluating Solid Waste" Office of Solid Waste and Emergency Response. November 1986, SW-846, Third Edition.

4.0 RESULTS OF THE INVESTIGATION

4.1 Geology

4.1.1 Regional Geology

Information regarding the regional overburden geology was obtained from various references (Muller, 1977; Miller, 1988; and Kindler and Taylor, 1913; and others). The project site is located within the Erie-Ontario Lowland physiographic province of the State of New York (Broughton, 1976) and more specifically, within the Lake Ontario drainage basin (OMOE, 1973). The general overburden stratigraphy consists of a glacial basal till, overlain by glacial lacustrine deposits of silt and clay. Ground moraine deposits predominate throughout the City of Niagara Falls, generally to the north and west of Packard Road. These deposits are composed of silty clay and sandy tills which were transported by and lodged beneath flowing Pleistocene glaciers about 12,000 years before present (B.P.). To the south and east of Packard Road, glaciolacustrine deposits, consisting of silts, sands, and clays, are generally encountered. These glacial lacustrine deposits originated as offshore deposits of former glacial Lake Tonawanda. With the eventual drainage of Lake Tonawanda, the flow of receding waters was to the northwest, toward the ancestral Niagara River. The project site is located at the western edge of the former Lake Tonawanda basin where the greatest thickness of overburden deposits is to the southeast, toward the axis of the former lake basin.

Bedrock was encountered below the overburden materials in all borings advanced on-site during the ECCO, Inc., investigation. Structurally, the bedrock units found in Niagara Falls are part of a southerly sloping homocline with an average dip of 29 feet per mile to the south (Zenger, 1965). The bedrock is described by the following units:

Salina Group

This bedrock unit consists of the late Silurian age (400 million years old), basal Camillus Shale. The exact contact between the Salina and the underlying Lockport Formation has not been adequately defined, but its presence has been tentatively proposed by Golder. Based solely upon the April 1988 draft report prepared by Golder, this rock unit consists of a fine-grained, thick bedded to laminated, dolostone rock with numerous argillaceous and gypsum partings.

Golder has identified this unit of the Salina Group as Zone 1. A ground water transmitting bedding plane, also identified by Golder as the "A" Fracture, exists within Zone 1.

Lockport Formation

The principal water bearing bedrock unit in Niagara Falls is the Lockport Formation. Its upper contact with the Salina has not been clearly defined, but it appears that it may be a gradational one. The total thickness of the Lockport Formation has been estimated to range from 150 feet (Johnston, 1964) to more than 180 feet (Zenger, 1965). Furthermore, the Lockport Formation can be divided into five (5) members: (1) Oak Orchard, (2) Eramosa, (3) Goat Island, (4) Gasport, and (5) DeCew, from top to bottom, as follows:

(1) Oak Orchard Member

The Oak Orchard is a brown to gray brown, fine grained thin to thick bedded dolostone (Zenger, 1965; Woodward-Clyde Consultants, (WCC), 1983). The Oak Orchard constitutes the greatest thickness of the Lockport Formation, with more than 120 feet being measured at Niagara Falls.

(2) Eramosa Member

The contact between the Oak Orchard and the Eramosa is conformable (i.e., without discontinuities) (WCC, 1983, Tesmer, 1981). The Eramosa is a gray to dark gray, fine-grained, dolostone and contains numerous argillaceous and carbonaceous partings. Stylolites and fossils are not common in the Eramosa, but mineralized vugs and chert nodules are noted throughout the unit (Tesmer, 1981). The average thickness of this member is 18 feet.

(3) Goat Island Member

This member is a fine-grained, thick bedded dolostone with chert nodules in the upper portion and mineral filled vugs throughout. Also noted are stylolites and carbonaceous partings. The range of thickness for the Goat Island member varies between 20 feet and 25 feet.

(4) Gasport Member

The Gasport is a fossiliferous, medium to thick bedded dolostone with discontinuous shale partings. It is light gray to brown-gray and has a general coarse-grained, crystalline texture (Zenger, 1965; WWC, 1983). The reported thickness for the Gasport is generally between 15 and 44 feet (Zenger, 1965; Tesmer, 1981).

(5) DeCew Member

The DeCew is about eight feet thick in the Niagara Falls area and overlies the Rochester Shale of the Clinton Group. The transition between the DeCew and the Rochester Shale is generally gradational but is often marked by concretions and interbedded shales. The DeCew is finely crystalline and thin to medium bedded. Styolities and enterolithic structure are very noticeable (Tesmer, 1981).

4.1.2 Site Geology

The overburden stratigraphy can be divided into three (3) geologic units: fill, glaciolacustrine deposits and glacial basal tills. All three units are encountered overlying the bedrock surface of the Lockport Dolostone and were noted throughout the site. A schematic of the generalized geologic conditions is presented in Figure 8. The site stratigraphy is described as follows:

Fill

The most recent deposits encountered on site are of anthropogenic origin and consist of fill materials composed of clayey silt, topsoil, silt, sand, gravel, wood, cinders, slag, bricks, crushed stone, and concrete, lime, and asphaltic concrete. The fill encountered across the site ranges in thickness from one foot to eight feet. No fill materials were noted in well cluster MW-88-1, at the northwest corner of the project site. The greatest fill thickness, based on continuous split-spoon sampling, was noted at well location MW-88-10 (i.e., 8 feet).

As noted in Section 3.2.2 of this report, all soil samples recovered during the SPT sampling operations were scanned with an HNu Photoionization Detector (PID). The results of the PID scanning of the fill materials are presented in Table 1. As indicated in Table 1, the greatest concentration of total ionizable compounds (i.e., volatiles) was detected in the fill materials encountered in boring MW-88-8B at a depth of 0 feet to 2 feet (100-160 ppm) and at 6 feet to 8 feet (80-110 ppm). Maximum concentration were also recorded in MW-88-2A and 20B at 10 ppm and 30 ppm to 75 ppm, respectively. Concentrations of generally less than 1 ppm to 2 ppm were detected in the fill material of the remaining borings.

Glaciolacustrine Deposits

As noted in the regional geology section of this report (i.e., Section 4.1.1), glaciolacustrine deposits were encountered during the ECCO, Inc., investigation, beneath the fill materials. These lacustrine deposits were also encountered during previous investigations conducted by Wehran, Thomsen, and Golder.

The glaciolacustrine deposits consist of interbedded clays, silts, and sands. The gray to red-brown clayey silts and silty clays noted in the borings are generally laminated with silt and clay partings, and contain various percentages of sand and gravel. Glacial deposits composed of mottled gray and tan to brown sand, silt and clayey silt are generally encountered below the fills and above the laminated silty clay. The lacustrine deposits range in thickness from five feet to ten feet.

Basal Glacial Till

A red-brown sandy, silt till was generally encountered below the glaciolacustrine deposits. This till contains varying proportions of sand, gravel and fractured rock fragments. Occasional glacial erratics (i.e., cobbles and/or boulders) were encountered in boring MW-88-7A and MW-88-8A, atop the bedrock surface. The size of the erratics, based on the length of coring and reaming necessary to penetrate them, ranges from 4 inches to 12 inches.

Bedrock

The majority of the bedrock encountered in the borings advanced on-site consists of the Lockport Formation dolostone. As previously and tentatively identified by Golder Associates (Golder, April 1988) bedrock belonging to the Salina Group was encountered in the 1987 Golder borings. While the contact between the Salina and the Lockport is not well defined,

the Salina has not otherwise been encountered in the Niagara Falls area. Investigations by others (Zenger, 1965; Johnston, 1964; and WWC, 1983) did not encounter the Salina Group in the City of Niagara Falls. The Salina, however, has been encountered in northern Erie county in deep test borings (Kindle & Taylor, 1913).

The most predominant rock encountered during the ECCO, Inc., investigation, as previously stated, is the Lockport Dolostone. The upper unit of the Lockport, the Oak Orchard member, was generally encountered in all borings. The Oak Orchard consists of thin to thick bedded dolostone rock with several highly fractured zones throughout. It is these highly fractured zones that are the major water bearing features of the Lockport. The fracture zones, or bedding plane joints, are just one of three features present in the Lockport. The other two are vertical joints and solution cavities. While the latter two are important for ground water movement, it is the bedding plane joints which have been extensively studied by Johnston (1964) and offer the major avenue for ground water movement.

These joints have been divided by Johnston and Woodward-Clyde into seven zones with two differing nomenclatures. Johnston numbered his zones, "1" through "7", in ascending order above the Rochester Shale. Woodward-Clyde (WWC) designated the zones, in descending order from the top of the Lockport. In the investigations conducted by Golder, Golder adopted the WWC nomenclature. The WWC system for bedding plane joints was similarly adopted during the ECCO, Inc., investigation to maintain uniformity throughout the project.

The various zonations in the Lockport were determined from core recoveries, RQD's (i.e., Rock Quality Designation), degree of fracturing, lithology, and core water return. Based on these parameters, Zone 1 has been estimated to be the top portion of the Oak Orchard Member of the Lockport Dolostone.

The average thickness of Zone 1 has been estimated to be two feet to five feet. A highly fractured layer, designated as the "A" fracture was encountered in Zone 1. This "A" fracture is estimated to be approximately 0.5 to 1 feet thick and is generally encountered 1.5 to 2.0 feet below the top of Zone 1. The "A" fracture is marked by thin to laminated bedding, very poor RQDs and near total loss of coring fluids. The depth of the "A" fracture is presented in Figure 8.

Below Zone 1, lies Zone 2, a more thick bedded dolostone approximately 8 feet thick. The upper one-third of Zone 2 is vuggy and contains numerous gypsum partings and nodules. The top two feet to three feet of Zone 2 is medium to thick bedded and contains occasional voids. The lower five feet to six feet of Zone 2 is thick bedded and exhibits minor solution pitting. Zone 2 is considered to be an aquitard (Golder, 1987) in the eastern portion of Niagara County.

The next major bedding plane joint is the marker bed at the base of Zone 2. This marker bed, also known as the "B" fracture varies in thickness from one to four feet and overlies the medium to thick bedded and fossiliferous Zone 3. Zone 3 is distinguished from other zones by its saccaroidal (sugary) texture, stylolites, fossil assemblage and gypsum nodules in the top eight to nine feet of the zone. Below the top nine feet of Zone 3, the dolostone becomes more thick bedded. No zonal designations were interpreted by ECCO, Inc., for the remaining vertical extent of the Oak Orchard member since only two (2) borings (MW-88-4C and MW-88-5C) were advanced through this member into Zone 3.

4.1.3 Geologic Sections

Based upon the results of the ECCO, Inc., subsurface investigation program, information regarding the geologic stratigraphy was obtained and is presented in the boring logs in Appendix A. The data presented in the logs was utilized in conjunction with previous subsurface data (i.e., Wehran, Thomsen, and Golder boring logs) to prepare geologic cross sections. These cross sections are presented as Figure 9 through 17. Drawing 3A indicates the location of the geologic cross sections. Figures 9 through 13 (i.e., Cross Sections "A" through "E") were drawn subparallel to the assumed general bedrock ground water flow direction, in a northwest to southeast trend. Figures 13 through 17 (i.e., Cross Sections "1" through "4") were drawn perpendicular to the assumed bedrock ground water flow directions, in a southwest to northeast trend. The geologic details of each cross section are presented as follows:

Section A

Section A is located at the northeast end of the project site and indicates the southeasterly slope of the overburden and bedrock surface. As previously stated in Section 4.1.1, there is a regional thickening of the overburden to the southeast, toward the basin axis of ancestral Lake Tonawanda. While bedrock zonation and bedding plane fractures are presented for well MW-88-4B, there was insufficient detailed data to extrapolate the fracture zones for the entire section.

Section B

Section B is subparallel to Section A and indicates a similar sloping direction (i.e., to the south) for the top of the bedrock. Also indicated is the slope of the "A" and "B" fractures. It should be noted that the "A" fracture thins to the northwest of well MW-88-8B and according to the data presented in the 1988 Golder draft report, is not encountered in well BH-87-1A. Considering the regional slope of the bedrock units (i.e., to the south), it should be noted that the "A" and "B" fractures generally parallel the slope of the bedrock unit (Lockport Dolostone). It should also be noted that the reason for the thinning of the "A" fracture is because it may have been eroded away prior to deposition of the overburden soils at the end of the last glaciation, and, therefore, more basal Zone 1 rock has been exposed.

Section C

not on x-section

A similar condition is indicated in Section C (i.e., Figure 11). A thin, discontinuous layer of the "A" fracture was encountered in wells MW-88-9B and MW-88-1B. The lack of presence of the "A" fracture at well MW-88-7B may be due to its previous erosion at this location.

Section D

Section D is also subparallel to the bedrock ground water flow direction. It should be noted that the "A" fracture has been thinned out and was not found in the vicinity of well MW-88-10B. The general slope of the top of the bedrock is to the south-southeast.

Section E

This section indicates a thickening of the basal till toward the south-southeast. The slope of the top of the bedrock surface is also toward the south-southeast. It should be noted that Zone 1 was not encountered in the vicinity of well MW-88-11B. The cause for the reversal in slope of the "B" fracture zone can not be determined from the geologic data obtained during our investigation but its source may be structurally below Zone 3.

Section 1

Section 1 was drawn perpendicular to the general bedrock ground water flow direction. The top of the bedrock surface has sloping components to the east and the west direction in the vicinity of well MW-88-9B. The "A" and "B" fractures slope to the west-southwest in the vicinity of MW-88-9B. No fracture data was available from Golder log BH-87-5A and, therefore, the "A" and the "B" fractures are not represented on the section.

Section 2

As can be seen in Section 2, the "A" fracture has been eroded away in the vicinity of well MW-88-7B. The elevations of the "B" fracture, at a more shallow depth in well MW-88-7B and in wells MW-88-3B and MW-88-12B, were utilized, along with relatively uniform zone thicknesses, to establish the absence of the "A" fracture at MW-88-7B. It should be noted that there was insufficient fracture data in the Thomsen wells to establish the presence of the "A" or "B" fracture at MW-84-9 and MW-84-13.

Section 3

The undulatory nature of the "B" fracture is clearly presented in this geologic section. The presence of the "A" fracture was established only in well clusters MW-88-2 and MW-88-4. As noted on this section, the "A" fracture was not encountered at well cluster MW-88-14 but may have been eroded away prior to deposition of the overburden soils.

Section 4

The "B" fracture appears to be relatively level in this geologic cross section. The "A" fracture was encountered by Golder in well BH-87-2A. A thin layer of Zone 1 bedrock was encountered in BH-87-1 and BH-87-2A. The remainder of Zone 1 appears to have been eroded away at the other well locations. It should also be noted that considerable fill operations have occurred in the past at well cluster MW-88-10.

In summary, the greatest lateral extent of all combined overburden materials occurs at the southeast end of the project site. The depth to bedrock, is therefore similarly, the greatest at the southeast corner of the site. The shallowest depth to bedrock, and therefore the thinnest overburden, is at the northwest corner of the site.

The elevation of the top of the Lockport Dolostone bedrock, and similarly the top of Zone 1, varies between 555.4 feet (at MW-88-6) and 559.3 feet (at MW-88-4). The "A" fracture, located in Zone 1, varies in elevation from 550.8 feet (estimated for MW-88-13A) and 555.5 feet (MW-88-2B). Based upon the results of our subsurface investigation, the "A" fracture is generally not encountered above elevation 556. The top of the "A" fracture zone has been contoured and is presented on Drawing 2. As noted on Drawing 2, the "A" fracture generally dips to the south and east. Two (2) fracture sets have been previously identified by Yager and Kappel (1987) at the intersection of the Falls Street Tunnel and the Power Authority of the State of New York (PASNY) intake conduits, to the west of the Frontier Site. These fractures trend N 75^{o} E and N 80^{o} W and have dips of approximately 90^{o} and 30^{o} southwest, respectively. Johnston (1964) also identified two (2) fractures in the Niagara Falls area which are oriented N 65^{o} E and N 30^{o} W. It should be noted that the orientation of the top of the "A" fracture as it outcrops at the erosional surface of the Lockport trends approximately N 30^{o} E and N 30^{o} W. While there is insufficient data to conclude that these erosional trends are fractures or joints, they do correlate fairly well with the previously documented fractures of Yager, Kappel, and Johnston.

The orientation of the "B" fracture "mirrors" that of the "A" fracture, where present. Where the "A" fracture is not encountered, the orientation of the "B" fracture represents the regional trends of the Lockport Dolostone bedrock at the Frontier site.

4.2 Hydrogeology

4.2.1 Regional Hydrogeology

Several investigations have been conducted to determine the water bearing characteristics of the Lockport Dolostone in the Niagara Falls area and in the Niagara County. These investigations include projects conducted by the U.S. Geological Survey (Johnston, 1964; Yager and Kappel, 1987; Miller and Kappel, 1987; Miller, 1988; and Kindle and Taylor, 1913), New York State Geological Survey (Zenger, 1965) and private consultants (WWC, 1983; Golder, 1988; Tesmer, 1981).

Specifically in the Niagara Falls area, ground water is transmitted in both the glacial lacustrine and basal till deposits and in the fractured Lockport Dolostone bedrock. Ground water is also encountered in the overburden fill materials as seasonally perched zones above the ground water table during spring or excessively wet periods. The relatively more impermeable nature of the underlying lacustrine soils reduces the ease with which the infiltrating water drains downward through the fill creating the isolated perched water zones.

As previously stated in Section 4.1 of this report, the general overburden stratigraphy consists of glacial lacustrine silts, sands, and clays deposited during the waning stages of ancestral Lake Tonawanda. These deposits are the result of cyclic deposition of silt and clay laminations in relatively calm waters. Due to the alternation of clay and silt laminae, the transport of ground water is essentially along permeable bedding surfaces composed of silts and sands (Muller, 1977). Typical yields, from potable water wells drilled into these lacustrine deposits, are generally less than three gallons per minute (GPM) (OMOE, 1973). It should be noted that there are no major unconsolidated (overburden) aquifers in the City of Niagara Falls (Miller, 1988). Also, there are no primary potable water aquifers within the unconsolidated material in Niagara County (Serell, 1981).

Ground water flow direction in the overburden soils is generally controlled by the regional topography, dip of the bedrock surface and the proximity of local, natural and man-made discharge/recharge sources (i.e., streams, rivers, sewers, utility lines, etc.) within the overburden deposits. The most permeable overburden deposits encountered in the Niagara Falls area are the lacustrine sands deposited during the waning stages of ancestral Lake Tonawanda. The transmission of ground water through these deposits is greatest along the horizontal bedding planes of the glaciolacustrine deposits (Muller, 1977). The underlying basal glacial tills are more heterogeneous in composition and more compact. Therefore, the tills are generally less permeable.

As stated in Section 4.1, the most predominant rock type or formation encountered in the Niagara Falls area is the Lockport Dolostone. The transmission of ground water through the Lockport is governed by the interconnectivity of the various solution features and bedding plane fractures and joints. A joint is defined as a fracture in the rock which is more or less vertical or transverse to the bedding plane, along which no appreciable movement has occurred (American Geological Institute, 1974). Bedding plane fractures are defined as broken, interconnected cracks parallel to the bedding plane (AGI, 1974). The majority of the movement of ground water in the Lockport is through the fractured bedding planes. Johnston proposed that ground water recharge to the fractured bedding planes occurs where the bedding planes outcrop at the bedrock surface. Once ground water has infiltrated these fractured bedding planes at the bedrock surface, it continues down-dip, along the fractures, with a relatively constant loss of head (Johnston, 1964).

It should be noted that multiple fracture bedding planes have been identified in the Lockport Formation (WWC, 1983; Johnston, 1964; Golder, 1988). Due to the depositional nature of the Lockport Dolostone, that is, its horizontal bedding, fractured bedding planes encountered in the Lockport are essentially parallel to each other.

Typical yields from wells advanced into various members of the Lockport generally range from 55 to 550 GPM (OMOE, 1973). Often yields of more than 1000 GPM have been noted in a narrow band which trends in a northeasterly direction, approximately two miles east of Niagara Falls

(Johnston, 1964). According to Johnston, this narrow band of relatively higher permeability parallels one of two major joint sets encountered in Niagara County. While individual joints may or may not transmit ground water, when interconnected they could be very water bearing (Johnston, 1964). This narrow, higher permeability band has been tentatively and laterally extended by Yager and Kappel, farther into Niagara County to the southeast of the PASNY storage reservoir.

Regional ground water flow in the upper portion of the bedrock is controlled by the dip of the bedrock units and the extent of horizontal and vertical fracturing or bedding planes. Prior to the construction of the PASNY storage reservoir in Lewiston, New York, the general flow of ground water was down-dip, in the bedrock, and toward the Niagara River (Johnston, 1964). Yager and Kappel inferred the existence of a former ground water divide which approximately paralleled the Niagara River, east of the Niagara Gorge. West of the ground water divide, ground water previously flowed toward the Niagara Gorge (to the west). East of the divide, ground water previously flowed to the south, toward the Niagara River.

After the construction of the PASNY reservoir and the water intake conduits (which run north and south from the reservoir/power plant to the Niagara River) and industrial pumping wells at sites off of Buffalo Avenue, the flow of ground water within the Lockport Dolostone appears to have been altered (Johnston, 1964; Yager and Kappel, 1987). According to Johnston and Yager and Kappel, ground water flow in the upper portion of the Lockport now appears to be toward the (covered) PASNY conduits and towards the Falls Street Tunnel (see Figure 18). The current water divide, postulated by Yager and Kappel, is also indicated on Figure 18 and is based on short term ground water monitoring data.

4.2.2. Site Hydrogeology

The site hydrogeology was established based upon the results of the ECCO, Inc., investigation conducted in accordance with the NYSDEC approved investigation plan. Monitoring wells were installed in the overburden deposits and in various bedrock zones.

As part of the ECCO, Inc., hydrogeologic investigation, overburden monitoring wells were installed at eleven (11) of the total of fourteen (14) well clusters. As stated in Section 3.3.4 of this report, the boreholes

drilled through the overburden soils were advanced to the top of the bedrock surface. As noted in Section 4.1.2 of this report, the overburden is divided into three (3) geologic units: fill, glaciolacustrine deposits, and glacial basal till. Each unit exhibits its own unique hydrogeologic characteristics and is described as follows:

Fill

The fill unit consists of a heterogenous mixture of deposits ranging from clayey silts to cinders, bricks, slag, lime, and wood. While the horizontal hydraulic conductivity (permeability) of the fill has not been previously investigated, the permeability may be several orders of magnitude greater than that of the underlying glaciolacustrine (i.e., clay and silt) deposits. Also, due to its heterogenous nature, isolated "pockets" of water may be encountered in a "perched" condition during periods of seasonal high water tables. During periods of heavy precipitation or snow melt, water percolating downward through the fill encounters isolated deposits of relatively lesser permeability (i.e., clayey silt fill) or the underlying glaciolacustrine deposits which reduces the ease with which the water can infiltrate downward into the underlying soils. Infiltrating waters, for the most part, remain isolated above these lesser permeable deposits creating the perched water table conditions.

Fill thicknesses encountered across the site generally range from one to eight feet. Based on continuous split-spoon sampling, the greatest fill thickness was encountered at well cluster MW-88-10. No fill was encountered at well cluster MW-88-1. General fill thicknesses are indicated on the geologic cross sections presented as Figures 9 to 17.

Glaciolacustrine Deposits

Glaciolacustrine deposits were encountered during the ECCO, Inc., investigation beneath the fills. These lacustrine clays, silts, and sands were deposited at the waning stages of ancestral Lake Tonawanda. As Lake Tonawanda began draining, a gradual thinning of the lacustrine deposits to the northwest occurred.

The glaciolacustrine deposits encountered on the Frontier site are composed of generally fine-grained materials such as fine sands, silts, and clays. Deposition of these fine-grained materials occurred with the cyclic alternation of silts and clays. The clays were deposited in the relatively more calm waters of the post-glacial winters. The silts were deposited at a time of seasonal high waters during the post-glacial springs and summers. The resulting permeability of each of these deposits is generally a function of the size of the individual particles and the spacing between the particles or its porosity. Clays are known to be more impermeable than silts, sands, or gravels. Therefore, the interbedded silt laminations or layers encountered at the Frontier site are relatively more permeable than the clays. Ground water transmission is greatest along the bedding planes between the lacustrine silt and the clay. Typical permeabilities for these deposits (i.e., clays and silts) range from 10^{-5} cm/sec to 10^{-7} cm/sec (Bureau of Reclamations (BR) 1985).

Typical glaciolacustrine deposits encountered on-site are composed of sandy clays, silty clays, clayey silts, sandy silts, silts, clays, and fine sands with varying amounts of gravel. The vertical distribution of the glaciolacustrine deposits are presented on the geologic cross sections (Figures 9 to 17) and the boring logs in Appendix A. The cross sections indicate only general trends encountered during the ECCO, Inc., hydrogeologic investigation. It should be noted that the slope of the top of the glaciolacustrine unit is generally controlled by the slope of the top of the underlying basal till and ultimately, the bedrock.

Basal Glacial Till

Underlying the glaciolacustrine deposits is a relatively thin veneer of compact, glacial till. A till is defined (AGI, 1974) as a non-sorted, non-stratified sediment deposited or carried by a glacier. The till was left behind by the retreating glaciers as they receded to the north, over the eroded surface of the Lockport Dolostone bedrock. It should be noted that surficial ground moraine or lodgement till deposits are encountered to the north and west of the project site. These tills are also encountered at the site underlying the previously noted glaciolacustrine deposit. Due to the compact and non-sorted nature of the tills, these deposits are relatively impermeable.

A maximum till thickness was encountered at well cluster MW-88-11 (6 feet) and minimum till thicknesses (1 foot or less) were noted at well clusters MW-88-1, MW-88-2, MW-88-3, MW-88-8, and MW-88-10, and BH-87-2 (Golder).

As a result of investigations to date, the overburden at the project site contains two distinct zone through which water may be transmitted. The first zone is a seasonally perched water table zone encountered in the fill materials. Ground water within the fill is essentially controlled by the presence (top) of the underlying glaciolacustrine (clay) deposits. As previously stated, the glaciolacustrine deposits represent a relatively more impermeable unit than the overlying fill materials. A contour map was prepared which depicts the elevation of the top of the glaciolacustrine (clay) deposits (see Drawing 3), and thus, indicates the interface between the fill and the clay deposits where ground water may be anticipated to be seasonally perched. It should be noted that top of clay wells were not a part of the ECCO, Inc., investigation and therefore, a determination of the ground water flow within this hydrogeologic zone cannot be established. However, horizontal flow within this upper zone would be anticipated to mirror the slope of the underlying clay deposits.

The second zone within the overburden, below the fills, is the combined glaciolacustrine and basal till units. The overburden monitoring wells installed during the ECCO, Inc., investigation were installed within the second zone, above the top of bedrock, and screened across both the glaciolacustrine and till deposits. Therefore, ground water level measurements obtained during our investigation represent a combined contribution of the ground water being monitored from the glaciolacustrine and till deposits. The ground water elevations of the second zone are presented on the geologic cross sections (Figure 9 through 17) and on the overburden ground water contour maps (Drawing 4 through 6). Horizontal ground water flow direction within this zone is generally controlled by the slope of the bedrock surface (Drawing 6A) which is to the south. Due to the heterogeneity of the glaciolacustrine and basal till units, ground water flow direction can and will vary locally across the site. This variation can be observed in the anomalies depicted on Drawings 4 through 6. Therefore, the potentiometric surface configuration and subsequent flow direction shown on these drawings may not be the actual site conditions from a micro view.

The vertical component of flow, based on historical water level elevation from wells MW-81-2, 3, 7 and 8, through the glaciolacustrine and basal till units from the overlying seasonally perched water bearing zone to bedrock is in a downward direction.

Also as a result of the investigations to date, three (3) distinct hydrogeologic zones were encountered in the Lockport Dolostone bedrock. These hydrogeologic zones correspond to the previously (Golder) and currently (ECCO, Inc.,) investigated "A", "B", and "C" fractures.

As previously noted, the "A" fracture is encountered in Zone 1 of the Oak Orchard member of the Lockport Dolostone. As stated in Section 4.1.3 of this report, the "A" fracture is not encountered above elevation 556.0. It should be noted, that the dip of the "A" fracture and consequently the dip of the investigated portion of the Lockport Dolostone, is to the south and east. As previously stated, the "A" fracture outcrops at the erosional surface of the Lockport Dolostone. Recharge of ground water to the "A" fracture may, as postulated by Johnston, be occurring at the outcropping of the "A" fracture zone at the erosional surface of the Lockport. Ground water may then infiltrate down-dip along the fractured and thin bedded planes of the dolostone.

Water level measurements were obtained from the "A" fracture wells by EFS and ECCO, Inc., and are summarized in Appendix D. Water levels were also plotted for the three (3) monitoring dates for well clusters where overburden, "A" fracture, and "B" fracture wells were installed. The interrelationship of the water levels between the three (3) monitoring zones is indicated in Appendix E. Water levels were measured for a total of seventy-seven (77) wells. The water level data obtained by EFS was recorded between November 9 and November 18, 1988, and therefore represents a non-distinct monitoring event. The water level elevations, thus obtained by EFS, were contoured and are presented on Drawing 7. While the data does not reflect a single monitoring event, it is evident from Drawing 7 that the ground water flow direction within the "A" fracture has a general southeast trend.

Water level measurements were subsequently obtained by ECCO, Inc., on November 23, 1988, and are also presented in Appendix D. This water level elevation data was also contoured and is presented on Drawing 8. It is evident from the contour data presented on Drawing 8 that the ground water flow direction within the "A" fracture exhibits a similar trend as that presented on Drawing 7, that is, to the southeast. An anomalous high water level was record at well MW-88-9A. It should be noted that there is no "A" fracture at this well location. Therefore, the water level recorded by ECCO, Inc., for November 23, 1988, may indicate mounding of ground water at the overburden-bedrock interface.

On March 27, 1988, ECCO, Inc., once again measured water levels in all 77 monitoring wells. The water level elevations are presented in Appendix D and the contoured data is shown on Drawing 9. The ground water flow direction still exhibits a southeast trend. It should be noted, however, that two (2) anomalously high water levels were recorded for well MW-3 and MW-88-2A. It should also be noted that water levels for the southeast half of the site are nearly the same as those recorded by ECCO, Inc., for November 23, 1988.

As previously stated, Johnston (1964) postulated that ground water is recharging the fractured bedding planes of the Lockport when these fracture outcrop at the bedrock surface (See Drawing 2 for the contour map of the top of the "A" fracture). Ground water infiltrating the "A" fracture travels down-dip (down-fracture) and stabilizes at an elevation within the "A" fracture or within Zone 1, reflecting, what appears to be true ground water conditions with minor seasonal variations. Meanwhile, water elevations northeast of the outcropping "A" fracture appear to fluctuate widely with seasonal precipitation and thus may produce temporal and isolated ground water anomalies.

The "B" fracture is encountered at the base of Zone 2 of the Lockport Dolostone and constitutes a marker bed which has been noted farther to the east in Niagara County (Golder, 1987). The dip of the Lockport and consequently the dip of the "B" fracture is to the south-southeast. Therefore, ground water encountered within the "B" fracture may also be presumed to flow in a south-southeast direction.

Water level measurements of the "B" fracture wells were obtained by EFS during November 9 through November 18, 1988. As with the water level measurements for the "A" fracture, the EFS data represents a non-specific monitoring event. The EFS water elevation was contoured and indicates that the general ground water flow direction in the "B" fracture is to the south and east. The contour map of the ground water data

obtained by EFS for the "B" fracture is presented on Drawing 10. Water levels were measured by ECCO, Inc., on November 23, 1988 and the ground water elevations data was contoured and is presented on Drawing 11. As noted on Drawing 11, the general ground flow direction is to the south and east. It should be noted that an anomalous high water level was recorded at well MW-88-10B as compared to the water level measurements obtained by EFS, on November 15, 1988, for this same well. This water level anomaly was again noted from water level measurements obtained by ECCO, Inc., on March 27, 1989, and is presented on Drawing 12 as a contour map of water level elevations. Drawing 12 indicates a general south and east trend for the ground water flow direction. The graph for well MW-88-10 in Appendix E also indicates the high water levels recorded for this well and also indicates that for the March 27, 1989, monitoring data, the water level for the "A" fracture is equivalent to the water level for the "B" fracture. It should be noted that Zone 1 of the Lockport was not encountered at this location, only Zone 2. Therefore, the well designated MW-88-10A is monitoring the top of Zone 2. These water level measurements suggest minimal flow in the vertical direction between the top of Zone 2 and the "B" fracture at this location.

Geologic information regarding the "C" fracture is limited to a total of three (3) borings/wells: BH-87-5B (Golder) and MW-88-4C and MW-88-5C (ECCO, Inc.,). The "C" fracture was not previously investigated at the Frontier site. The presence of the "C" fracture was established during the ECCO, Inc., investigation through rock coring methods and in-situ permeability tests results (See Section 3.3 and 3.4, respectively, of this report). Water level measurements for the "C" fracture wells are presented in Appendix D and graphically in Appendix E. The data was contoured for each of three (3) monitoring dates and is presented on Drawing 13, 14, and 15, respectively. As indicated on these drawings, there is a general southeast trend for the direction of ground water flow. It should be noted that the water levels for the "C" fracture wells are consistently above the water levels for the "B" fracture wells. This observation indicates that there is a strong vertical (upward) gradient in the "C" fracture zone. This relationship of the "C" fracture water levels to the "B" fracture wells is also indicated in Appendix E for the three (3) "C" fracture wells. This upward gradient indicates that the "C" fracture is a confined zone.

As previously noted, a summary of the three (3) dates when water levels measurements were obtained, are presented in Appendix E. Appendix E represents data for well clusters where water levels in the overburden, "A" fracture, "B" fracture, and "C" fracture wells, where encountered, can be compared. By comparing water levels at the well clusters, certain hydraulic interrelationships or anomalies can be observed. The first observation is that water level elevations are consistently the highest for the overburden wells. The exception to this observation is the overburden well at cluster MW-88-2. During the November 1988 monitoring dates, EFS recorded a water level for the overburden well below the water level of the "A" fracture well. Water level measurements obtained by ECCO, Inc., for November 23, 1988, indicate that the water level in the overburden well is the same as the level recorded for the "A" fracture well. In March 1989, the water level elevation was greater for the overburden well as compared to the "A" fracture well. General ground water head differences between the overburden well levels and the "A" fracture well levels range from 2 feet to 19 feet. The smallest head difference was recorded at well MW-88-1 (2 feet) and the greatest head difference was recorded at well BH-87-4 and BH-87-5. The average recorded head difference between the overburden and "A" fracture wells for the three (3) previously noted monitoring dates is 10 feet.

The second observation is that the elevation of the ground water in the "A" fracture wells is generally greater than the ground water elevation of the "B" fracture wells. Two (2) exceptions are well clusters MW-88-10 and MW-88-11. It is interesting that a similarity exists between these two well clusters. Both "A" fracture wells appear to be monitoring the top of Zone 2. Ground water head differences were recorded between the "A" fracture and the "B" fracture wells and range from less than one foot, at well MW-88-10, to ten feet. The average recorded head difference between the "A" and "B" fracture water levels is eight feet.

4.3 ANALYTICAL RESULTS

All laboratory analytical results and quality control data for the November 1988 sampling event are presented in Appendix F. The field test results for pH and Specific Conductance are presented in the EFS report in Appendix C. The analytical data to date, inclusive of field pH and Specific Conductance and static water levels, for all wells and sampling events has been tabulated and is presented in Appendix G. Additionally, to facilitate the following discussion, the analytical data is presented graphically on Drawings 16 through 40, Appendix H.

4.3.1 HNu Photoionization Survey

As noted in Section 3.2.2 of this report, all soil samples were scanned with a HNu Photoionization Detector for the presence of total volatile compounds. The results of our scanning are summarized in Table 1. As noted in Table 1, scanning was performed on individual soil samples and also, during the soil augering, when possible. HNu readings of 0 ppm were recorded in the soils samples of borings MW-88-1A, MW-88-4B, MWW-88-9B, MW-88-9OB, and MW-88-13A. HNu readings of 0 ppm were also generally recorded for boring MW-88-10 OB, except at a depth of 6 feet to 8 feet, where a reading of 0.1 ppm was recorded.

The highest HNu readings were recorded in borings MW-88-20B (300 ppm at approximately 10 foot depth and 120 ppm to 135 ppm at 13 foot depth), MW-88-3 a (50 ppm to 200 ppm at 8 feet to 10 feet depth), MW-88-8A (100 ppm at 5 feet depth), and MW-88-8B (100 ppm to 160 ppm at 0 feet to 2 feet depth). HNu readings obtained for the remaining soil samples and boreholes are also summarized in Table 1.

4.3.2 Non-Aqueous Phase Liquid

During the November 1988 sampling event NAPL was observed and sampled in three (3) wells. Two (2) of the wells, BH-87-4B and MW-88-2 OB are screened in the overburden. The remaining well, MW-84-11, although screened in what may be extrapolated to be the "B" fracture zone, is sand packed above the screen to approximately one (1) foot above the top of rock. In both wells MW-84-11 and MW-88-2 OB, 1,3-Dichlorobenzene, 1,4-Dichlorobenzene,1,2-Dichlorobenzene and

TABLE 1
FRONTIER CHEMICAL WASTE PROCESS, INC.
PHOTOIONIZATION DETECTOR RESULTS OBTAINED FROM SOIL SAMPLING

MW-88-1A

DEPTH (ft)	HNu (ppm)
0-1	0
1-4	0
4-6	0
6-8	0
8-10	0
10-11.5	0

MW-88-2A

DEPTH (ft)	HNu (ppm)
0-2	10
2-4	0.5
6-8	19
8-10	0.4
14-15	0.4

MW-88-3A

DEPTH (ft)	HNu (ppm)
0-2	0
2-4	2-4
4-6	10-20
6-8	50
8-10	50-200
10-12	11-24
12-14	1-27

MW-88-4B

DEPTH (ft)	HNu (ppm)
0-1	0
1-4	0
4-6	0
6-8	0
8-10	0
10-11	0

MW-88-5C

DEPTH (ft)	HNu (ppm)
@0-5	0
@5-7	0.4
@10-12	10-45
@13-15	6
@15-16	30-50

MW-88-6A

DEPTH (ft)	HNu (ppm)
0-2	0.1
2-4	2
4-6	1.4
6-8	3
8-10	1.2
12-14	1.1
14-16.4	0.8

MW-88-7B

DEPTH (ft)	HNu (ppm)
@ 5	12.2
@ 10	32

MW-88-20B

DEPTH (ft)	HNu (ppm)
@ 2	30
@ 4	75
@ 6	8
@ 9	70-80
@ 10	300
@ 13	120-135

MW-88-4C

DEPTH (ft)	HNu (ppm)
@1.5-5	0.8
@5-11	0.2

MW-88-6B

DEPTH (ft)	HNu (ppm)
@2-6	1.5
@6-9	22.5
@9-12	3.8
@12-17	95

MW-88-60B

DEPTH (ft)	HNu (ppm)
@3-5	10.8
@5-9	2.6
@9-15.5	1.8

TABLE 1
FRONTIER CHEMICAL WASTE PROCESS, INC.
PHOTOIONIZATION DETECTOR RESULTS OBTAINED FROM SOIL SAMPLING
(continued)

MW-88-8A		MW-88-9A		MW-88-10A		MW-88-11A		MW-88-12A		MW-88-13A		MW-88-14B	
DEPTH (ft)	HNu (ppm)	DEPTH (ft)	HNu (ppm)	DEPTH (ft)	HNu (ppm)	DEPTH (ft)	HNu (ppm)	DEPTH (ft)	HNu (ppm)	DEPTH (ft)	HNu (ppm)	DEPTH (ft)	HNu (ppm)
@ 2	70	@5-10	0.4	@0-6	1	0-2	0.1	2-4	0.5	@0-5	0	@2-5	1.6
@ 5	100	@10-15	0.3	@6-8	0.6	2-4	0.6	4-6	0	@5-10	0	@5-8	1
@ 12	50			@8-10	0.8	4-6	0.7	6-8	0.4			@8-11	1.2
				@10-12	1.6	6-8	0.9	8-10	0.1			@11-14.4	1.6-5.8
				@12-15	0.2	8-10	1.3-9.8	10-12	0.2				
						10-12	0.8	12-14	0.3				
						12-14	1.8	14-15	3.4				

MW-88-8B		MW-88-9B		MW-88-100B		MW-88-11B		MW-88-12B		MW-88-140B	
DEPTH (ft)	HNu (ppm)	DEPTH (ft)	HNu (ppm)	DEPTH (ft)	HNu (ppm)	DEPTH (ft)	HNu (ppm)	DEPTH (ft)	HNu (ppm)	DEPTH (ft)	HNu (ppm)
0-2	100-160	@0-5	0	0-2	0	@0-5	0.3	@ 2	2.2	4-6	0.2
6-8	80-110	@5-10	0	2-4	0	@5-10	0.3	@ 4	1.6	6-8	0.3
8-10	20	@10 15	0	4 6	0	@10 15	4.1	6-8	0.8	8 10	0.1
10-12	70			6-8	0.1			8-10	0.6	10-12	1.8
				8-10	0			10-12	1	12-13	3.8
				10-12	0			12-14	2		
				12-12.7	0						

MW-88-80B		MW-88-90B		MW-88-12B	
DEPTH (ft)	HNu (ppm)	DEPTH (ft)	HNu (ppm)	DEPTH (ft)	HNu (ppm)
@0-12	60 (max.)	2-4	0	@ 2	1.8
@12-13	1.1	4-6	0	@ 5	2.4
		6-8	0	@ 10	1
		10-12	0	@ 14.5	0.6
		14-15	0		

NOTE: HNu readings preceded by an "@" were obtained during soil augering/drilling operations

1,2,4-Trichlorobenzene were detected via EPA 8270 in the NAPL samples at elevated values. However, analysis of the NAPL sample from BH-87-4B via the same method did not detect the above constituents. The only constituent detected was phenol. The analytical results via Method 8240 detected Monochlorotoluene in all three NAPL samples. Tetrachloroethylene, 1,1,1-Trichloroethane and Trichloroethylene were detected in only MW-84-11 NAPL.

4.3.3 Groundwater

The ground water was found to contain elevated concentrations of chlorinated solvents, benzene, toluene, chlorobenzene species and monochlorotoluene in the overburden, "A" fracture and "B" fracture underlying the central and southern portions of the site and to a lesser degree in the eastern and northern portions of the site. Within the "C" fracture, chemical analysis of samples from the three (3) wells monitoring this zone, detected four (4) constituents at approximately the same slightly elevated concentration in all three (3) wells (Drawing 16). These constituents were: 1,1-Dichlorolethylene; Trans-1,2-Dichloroethylene; Trichloroethylene; and Vinyl Chloride.

In order to illustrate the distribution of the detected constituents, concentration contour maps in units of ppm have been prepared and are presented in Appendix H. The concentration contour maps reflect the concentration pattern for the following constituents or group of constituents as a result of the November 1988 analysis. The constituents or group of constituents are:

- Total Volatile Organics
- Total Monochlorotoluene
- Total Volatile Organics minus Total Monochlorotoluene
- Group I (includes: Chloroform; Carbon Tetrachloride; 1,1-Dichloroethane; 1,1-Dichloroethene; Chloroethane)
- Group II (includes: Methylene Chloride; Trans-1,2-Dichloroethylene; 1,1,1-Trichloroethane; Trichloroethylene; Tetrachloroethylene; 1,1,2,2-Tetrachloroethylene)
- Group III (includes: Benzene; Chlorobenzene; Total Dichlorobenzene)
- Group IV (includes: Toluene; Xylene; Total Monochlorotoluene)

- Group V (includes : Acetone; 2-Butanone; 4-Methy-2-Pentanone)
- Phenolics

The constituents in the above groups were placed in each group based on their chemical similarity and/or constituents in common commercial solvents. The concentration contour maps were constructed using standard acceptable practices and the data available. The maps may not reflect the exact distribution of chemical constituents in the subsurface.

4.3.3.1 Total Volatile Organics

The concentration patterns depicted on Drawings 17, 18, and 19 are for the sum of the total volatile organics (TVO's) detected via EPA Method 8240 plus the five additional parameters, Section 3.7, for three (3) of the monitored water bearing zones (i.e., overburden, "A" fracture and "B" fracture). Within the overburden, Drawing 17, the concentration pattern for TVO's detected in the overburden wells shows an elevated concentration, 1000^{+} ppm, in the vicinity of well MW-88-2 OB radiating outward away from this well and elongated toward the southeast. An anomaly to this general pattern occurs in the vicinity of well MW-88-8 OB. Due to the concentration at this location, the 100 ppm concentration contour is elongated to the northeast.

Drawing 18 depicts the TVO's concentration pattern within the "A" fracture water bearing zone. Within this zone, the highest concentration, 450^{+} ppm, occurs in the vicinity of well MW-88-3A. The concentration in the "A" fracture zone in the vicinity of well MW-88-2A is 150^{+} ppm as compared to TVO's concentration detected in the overlying overburden of 1000^{+} ppm. The concentration contours radiating away from well MW-88-3A are elongated in a southeast and east direction. In addition, the elevated detected values at wells MW-88-10A, MW-84-17, MW-88-1A, and MW-84-14 force the 50 ppm contour to the northwest and northern property lines.

Within the "B" fracture zone, Drawing 19, the ground water in the vicinity of well 88-3B had the highest concentration of 200^{+} ppm with the concentration contour lines elongated to the south. An anomaly to this pattern due to the concentration detected at well MW-88-1B is the 25^{+} ppm contour is elongated to the northeast corner of the property.

4.3.3.2 Total Monochlorotoluene

Drawings 20, 21 and 22 present the concentration pattern for detected Total Monochlorotoluene in the overburden, "A" fracture and "B" fracture wells. Within the overburden, Total Monochlorotoluene was detected at an elevated concentration, 300 ppm, at well MW-88-2OB. The concentration pattern radiates away from this location with an elongation to the east towards well MW-88-7 OB. Total Monochlorotoluene was only detected in four (4) overburden wells. It was detected at elevated concentration in wells BH-87-4B, MW-88-2OB and MW-88-7 OB and at a slightly elevated concentration, 36 ppb, in well BH-87-1C.

Within the underlying "A" fracture, a different concentration pattern is observed. Elevated concentrations were detected in wells MW-88-10A, MW-84-17, MW-88-1A and MW-84-14. These wells are located adjacent to the northwest and northern property line. The concentration of monochlorotoluene decreases across the site towards the southern property line.

4.3.3.3 TVO's minus Total Monochlorotoluene

Drawings 23 and 24 show the concentration pattern within the "A" fracture and "B" fracture zones, respectively, for the TVO's concentration minus the concentration of total monochlorotoluene. These two (2) drawings were prepared to evaluate the distribution of TVO's underlying the site without the contribution of total monochlorotoluene which was detected in upgradient "A" fracture wells. As can be observed from both drawings, the overall patterns and concentrations are similar for both zones when compared to the TVO's drawing for each zone. The only change is within the northern part of the site where the TVO's minus total monochlorotoluene concentrations are less.

4.3.3.4 Group I

Group I is a summation of the concentration of the following constituents: Chloroform; Carbon Tetrachloride; 1,1-Dichloroethane; 1,1-Dichloroethene; and, Chloroethane. The Group I concentration patterns for the overburden, "A" fracture and "B" fracture zones are presented on Drawings 25, 26 and 27, respectively. Within the overburden, elevated concentrations of this group of constituents are in the vicinity of well MW-88-8 OB. Within the underlying "A" fracture, the concentration pattern is centered in the vicinity of well MW-88-3A. In the "B" fracture, the concentration pattern is centered in the southern half of the property in the vicinity of well MW-88-6B

4.3.3.5 Group II

Group II is a summation of the concentration of the following constituents: Methylene Chloride; Trans-1,2-Dichloroethylene; 1,1,1-Trichloroethane; Trichloroethylene; Tetrachloroethylene; and, 1,1,2,2-Tetrachloroethylene. The Group II concentration patterns for the overburden, "A" fracture and "B" fracture zones are presented on Drawings 28, 29 and 30, respectively. The pattern depicted for the overburden zone is again centered in the vicinity of well MW-88-8 OB. Within the "A" fracture and "B" fracture zone, the concentration pattern is centered in the vicinity of well MW-88-3A.

4.3.3.6 Group III

Group III is a summation of the concentration of the following constituents: Benzene; Chlorobenzene; and, Total Dichlorobenzene. The Group III concentration patterns for the overburden, "A" fracture and "B" fracture zones are presented on Drawings 31, 32 and 33, respectively. In both the overburden zone and the underlying "A" fracture zone, elevated concentrations of this group were detected in the vicinity of well MW-88-2OB. However, within the "B" fracture zone, elevated concentrations were detected in the vicinity of wells MW- 88-3B, MW- 88-5B and MW- 88-6B.

4.3.3.7 Group IV

Group IV is a summation of the concentration of the following constituents: Toluene; Xylene; and, Total Monochlorotoluene. The Group IV concentration patterns for the overburden, "A" fracture and "B" fracture zones are presented on Drawings 34, 35 and 36, respectively. Because of the contribution of Total Monochlorotoluene to the sum of this group, the concentration pattern for the overburden zone is similar to the pattern for Total Monochlorotoluene discussed previously. However with the addition of Toluene and Xylene concentrations, the radiating pattern away from the vicinity of well MW-88-2 OB is spread over a larger area within the central portion of the site. Also a similarity in patterns between Group IV and Total Monochlorotoluene is observed in the "A" fracture and "B" fracture.

4.3.3.8 Group V

Group V is a summation of the concentration of the following constituents: Acetone; 2-Butanone;and, 4-Methy-2-Pentanone. The Group V concentration patterns for the overburden, "A" fracture and "B" fracture zones are presented on Drawings 37, 38 and 39, respectively. In the overburden zone, two isolated highs are seen in the vicinity of wells MW-88-2 OB and MW-88-6OB. Within the "A" fracture zone, again two isolated highs are observed, however, the two highs are in the vicinity of wells MW-88-4A , MW-88-7A and MW-88-12A and at higher concentrations than detected in the overburden. The "B" fracture zone configuration depicts an elevated concentration in the vicinity of well MW-88-6B.

4.3.3.9 Phenolics

Drawing 40 presents the concentration pattern for phenolics in the overburden, "A" fracture and "B" fracture zones. As can be noted from the drawing the concentration of phenolics remains the same in all three zones. Within the overburden, the center is located in the vicinity of well MW-88-2 OB. However, within the "A" fracture zone, the center is located in the vicinity of well MW-87-4A. In the "B" fracture, The center of elevated concentration is in the area around well MW-88-3B.

5.0 SUMMARY AND CONCLUSIONS

5.1 Nature and Extent of Contamination √(8)

Four water bearing zones are presently being monitored on site. The four zones are: the lower portion of the unconsolidated material, "A" fracture, "B" fracture and "C" fracture. Groundwater flow within the unconsolidated material is difficult to ascertain since the material is heterogeneous across the site. In general, however, the flow parallels the top of rock flowing from the north of the site towards Royal Avenue. Groundwater flow within the "A" fracture is generally in a south to southeast direction. In the "B" fracture zone, ground water flows from the northwest to the southeast. Flow within the "C" fracture based on three wells is in a southeast direction. The vertical hydraulic relationship between the upper zones(i.e., overburden, "A" fracture and "B" fracture) is vertically downward. However, the hydraulic relationship between the "B" fracture and the underlying "C" fracture is upward. "C" fracture appears to be under confined conditions.

Elevated concentration of chlorinated solvents, benzene, toluene, chlorobenzene species and monochlorotoluene were detected in the overburden and "A" fracture underlying the central and southern portions of the site and to a lesser degree in the eastern and northern portions of the site. Although the same constituents are present in the "B" fracture zone, they were detected at a lower concentration.

Within the "C" fracture zone, the same four constituents were detected at approximately the same concentration in all three wells. The detection of the four constituents in the hydraulically upgradient well, MW-88-4C, at levels equal to or slightly above the downgradient suggests an off site source for the detectable constituents. This would suggest that this zone has not been affected by past activities on site. The vertical hydraulic relationship between the "C" fracture zone and the above zones also suggests this possibility.

Based on the analytical data and the HNu readings there appears to be several sources existing on site which have impacted the ground water in the overburden and the underlying "A" fracture and "B" fracture. The areas are: in the vicinity of the former settling basin; between Building 12A and 22; east of Building 60 in the area of well cluster MW-88-8; and,

yet no sources are mentioned in Risk assessment to a minor extent in the area of well cluster MW-88-6. Based on the analytical data, the greatest impact to water quality within the "A" fracture occurs beneath the area between Building 12A and 22 and east of Building 60 in the area of well cluster MW-88-8. Beside potential on site sources, the data indicates a possible off site source for total monochlorotoluene. The source appears to be northwest and north of the property line.

Non-aqueous phase liquid was observed in three wells and analyzed. Two of the wells were screened in the overburden and the third well, although screened in the "B" fracture zone, was sand packed to above top of rock. This method of construction can provide a conduit for contaminates to enter the borehole above the "B" fracture and migrate down the annulus between the borehole wall and the well casing and enter the well through the screened interval. Similarities and dissimilarities existed between the analytical results of the three NAPL samples. Monochlorotoluene, methylene chloride and chloroform were detected in all three NAPL samples from wells MW-88-2OB NAPL, MW-84-11 NAPL and MW-87-4B NAPL. Dichlorobenzene, chlorobenzene, benzene and trichlorobenzene were detected in MW-88-2OB NAPL and MW-84-11 NAPL. Tetrachloroethylene, 1,1,1-trichloroethane and trichloroethylene were detected in only MW-84-11 NAPL. The similarities and dissimilarities suggest the possibility of several sources for the NAPL analytical figure print in the downgradient well MW-84-11.

The data to date suggest several on site sources and a possible off site source(s) have impacted the waters within the overburden and the ground water quality in the underlying "A" and "B" fracture zones. The "C" fracture ground water quality appears to be reflective of off site source(s). The presence of the unlined sewer tunnels at an elevation coinciding with the "B" fracture zone downgradient of the site and along the southern and eastern property line would intercept the flow with this zone. A report prepared by Camp Dresser & McKee for the City of Niagara Falls dated December 1982 and entitled "Report on Falls Street Tunnel Visual Inspection and Infiltration, Air and Sediment Evaluation" noted ground water infiltration along the ceiling of the tunnel. This strongly suggests that ground water within the "A" fracture is percolating down and into the unlined tunnels.

In summary, four (4) areas have been identified as potential on-site source areas. These areas are the result of past activities at the site and are not the result of on-going operations. In addition to the on-site source areas, the data suggests off-site sources contributing to the ground water quality. Contamination has been identified in the water contained within the overburden fill and glaciolacustrine deposits.
The water within these deposits are recharging the underlying "A" and "B" fracture zones. In turn, the water quality in the "A" fracture zone and to a lesser extent the "B" fracture zone has been impacted. Due to the artesian conditions encountered within the "C" zone underlying the site, the vertical extent of the contaminant plume within ground water is limited to the "A" and "B" fracture zone. The south to southeast horizontal ground water flow direction within both fracture zones and the presence of the adjacent unlined tunnel systems downgradient and parallel to the downgradient property lines creates a boundary condition which limits the areal extent of the ground water plume from migrating downgradient beyond the tunnel systems.

The investigative approach to date has focused on the underlying ground water system as the primary route of migration of contaminates. This investigative approach was developed with input from the New York State Department of Environmental Conservation (NYSDEC) and subsequently approved by the NYSDEC. The rationale for this emphasis on ground water as the primary migration pathway is based in part on the physical character of the site.

Migration of contaminates via surface water and/or sediment is negated by the fact that the majority of the facility is paved or occupied by buildings. Surface runoff within these areas are collected within the storm water lines. The topography at the site is flat which minimizes surface runoff exiting the site from the unpaved areas. Hence, contaminant transport via surface water and/or sediment is not occuring. These same physical conditions also preclude contaminant transport via air or airborne particulates.

In order to further evaluate the environmental conditions as the ground water exits the site and enters the adjoining tunnel system, an off-site total contaminant loading determination and a baseline cancer risk assessment were performed. The report discussing the total contaminant loading determination is presented in Appendix I of this document. The baseline cancer risk assessment report is presented in Appendix J. The following sections summarize the findings of both studies.

5.2 Off-Site Total Contaminant Loading

The total contaminant loading exiting the Frontier facility of 0.62 lbs/day is an estimate. The calculations were performed assuming that the analytical results of the November 1988 sampling event were characteristic of the water quality underlying the site. The reliability of the assumption that the results of one sampling event is characteristic of the water quality beneath the site cannot be quantified.

Understanding that the total loading calculations are estimates and may be conservative, the loading calculations appear to suggest several important site conditions. Based on the loading calculations performed for the eastern and southern property lines, ninety-four percent (94%) of the total off-site loading is exiting the site along the Royal Avenue property line. This off-site loading is weighted more towards the "A" fracture zone than the"B" fracture zones(i.e., 0.4 lbs/day versus 0.2 lbs/day). Of the total off-site loading exiting the site, fifty percent (50%) is diverted into the South Side Interceptor upstream of Regulatory 8 during dry weather flow and treated at the Niagara Falls Waste Water Treatment Plant prior to discharge into the river. The estimated loading rate downstream of Regulatory 8 of approximately 0.32 pounds per day is less than the dry weather loading rate of five (5) pounds per day reported in the previously referenced O'Brien and Gere (October 1987) report at Drop Shaft 13A. This fact suggests that although past activities on the Frontier site are contributing to the detected total organics at Drop Shaft 13A, other off-site sources are also contributing.

In order to evaluate the present potential concern associated with that portion of the loading which is west of Regulator 8 in the absence of any remedial measures, further calculations were performed based on Frontier's loading rates for specific compounds identified as known and probable human carcinogen compounds. These calculations entailed the determination of an estimated concentration for each of the compounds at two locations hydraulically downstream of the Frontier site.

The estimated concentrations at the two locations were:

- Rainbow Bridge - benzene - 8.2 x 10^{-8} mg/l
  chloroform - 9.0 x 10^{-10} mg/l
  dichorobenzene - 2.6 x 10^{-7} mg/l
  trichloroethylene - 6.0 x 10^{-8} mg/l
- Niagara on the Lake - benzene - 2.2 x 10^{-8} mg/l
  chloroform - 2.5 x 10^{-10} mg/l
  dichorobenzene - 7.1 x 10^{-8} mg/l
  trichloroethylene - 1.6 x 10^{-8} mg/l

These projected concentrations were subsequently used in the baseline cancer risk assessment. The conclusions of which are discussed in the following section.

5.3 Baseline Cancer Risk Assessment

The baseline cancer risk assessment was performed by Health and Environmental Sciences Group, Washington, D.C.. The report entitled "Baseline Cancer Risk Assessment, Frontier Chemical Waste Process, Inc., Niagara Falls, New York" is presented in Appendix J. The report discusses the methodology used and the results. The conclusions drawn from the report suggests that the concentrations of chemicals contaminating the ground water and discharging into the Falls Street Tunnel west of Regulator 8 do not pose an undo risk of cancer to the public at the potential points of contact.

5.4 Conclusions

The information generated during the performance of the investigations to date at the Frontier site has identified degradation to subsurface soils and the ground water quality underlying the site. This impact on soils and ground water quality is due to past activities on-site. Presently, no ongoing activities are sources for future impact.

Two important site characteristics are presently limiting the areal and vertical extent of the contaminant plume in ground water. The existence of water within the "C" fracture zone under confining or artesian conditions have limited the vertical extent of the contaminant plume to the uppermost water bearing zones beneath the site. The water bearing zones of concern are the "A" and "B" fracture zones. Overlying these two zones is water contained within the overburden. Water within this zone is available to recharge the underlying fracture zones. The areal extent of the ground water plume is limited to the eastern and southern property lines. These two property lines are hydraulically downgradient of the site and are bordered by two unlined tunnels which receive ground water discharge from the "A" and "B" fracture zones underlying the site.

Approximately fifty (50) percent of the total organic loading exiting the site via ground water is diverted during dry weather flow to the Niagara Falls Wastewater Treatment plant. The remaining fifty (50) percent enters the Falls Street Tunnel. Of the total flow in the Falls Street Tunnel downstream of the site, seventy (70) percent is diverted into the treatment plant prior to discharge into the Niagara River. The remaining thirty (30) percent discharges into the Niagara River near the Rainbow Bridge.

Besides limiting the areal extent of the ground water contamination plume, the presence of the Falls Street Tunnel extends the point of possible human contact away from the site. The first point of possible human contact is in the Niagara River at the tunnel outfall. For this reason, a baseline cancer risk assessment conducted for the site suggests that the concentrations of chemicals contaminating the ground water do not pose an undue risk of cancer to the public.

The detected elevated concentration in ground water of chlorinated solvents, benzene, toluene, chlorobenzene species and monochlorotoluene in the overburden and "A" fracture and to a lesser degree in the "B" fracture underlying the central and southern portions of the site does require the performance of a feasibility study to ultimately select the most appropriate remedial measure program for the site.

Following is an outline of remedial technology measures which will be evaluate in the feasibility study. The data has identified two environmental media which are of concern at the site. One media is contaminated soil/NAPL underlying identified areas on site. This media is of concern because it potentially can act as a source for subsequent ground water contamination. The second media is ground water.

TABLE 2

OUTLINE
REMEDIAL TECHNOLOGY MEASURES

Environmental Media	General Response Action	Remedial Technology Types
soils/NAPL	no action	limit access
	institutional action	deed restriction
	containment action	capping
		vertical barriers
		horizontal barriers
	excavation/treatment action	removal-excavation
		treatment-
		solidification,fixation, stablization, immobilization
		physical treatment
		chemical treatment
		biological treatment
		in-situ treatment
		thermal treatment
		disposal-
		on-site
		off-site
ground water	no action	limit access
	institutional action	deed restriction
		monitoring-
		hydraulic
		chemical
	containment action	capping
		vertical barriers
		horizontal barriers
	collection/treatment actions	extraction-pumping
		collection-
		interceptor drains
		47th and Falls Street tunnels
		treatment-
		off-site
		on-site:
		physical
		chemical
		discharge-POTW

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APPENDIX A: SUBSURFACE BORING LOGS

DATE
STARTED 10-11-88
FINISHED 10-11-88
SHEET 1 OF 1

ecco Inc.

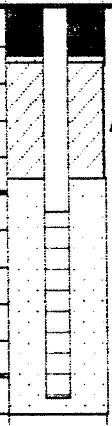
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. **MW-88-1 OB**
SUFACE ELEV. **570.03**
G.W. ELEV. --------
CASING ELEV. **572.62**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0/6 6/12 12/18 18/24	DESCRIPTION	NOTES
		Aug			Overburden Fill/Soils	Auger to top of rock w/o split spoon sampling
5					(wet)	HNu = 0.1 ppm
						For subsurface soil description see boring log MW-88-1A
10						HNu = 0.0 ppm
					Boring Complete with Auger Refusal at 11.0'	Installed 2" I.D. stainless steel well at 10.5'
15						
20						
25						
30						
35						

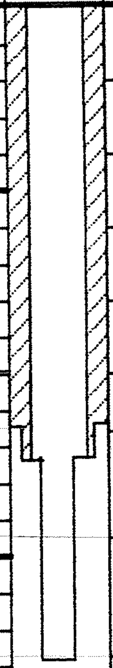
CLASSIFICATION **Visual-Manual Identification**
as per ASTM D-2488
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company**
Truck Mounted Drill Rig
(Mobile B-61) w/Hollow Stem
Augers (HSA), ASTM D-1586

DATE STARTED 8-16-88 FINISHED 8-30-88 SHEET 1 OF 1	**ecco Inc.** The Environmental Consulting Company SUBSURFACE LOG	HOLE NO. **MW-88-1A** SUFACE ELEV. **569.86** G.W. ELEV. ------- CASING ELEV. **572.35**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY



DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0/6 12/18	BLOWS ON SAMPLER 6/12 18/24	DESCRIPTION	NOTES
		SS	1	4 5	6 3	Tan Clayey SILT, trace topsoil, roots Mottled gray and tan f-m SAND (moist)	HNu = 0 ppm HNu = 0 ppm
		SS	2	4 4	6 6	Contains trace gravel, becomes brown	
5		SS	3	4 3	3 4	Gray-brown Sandy CLAY/Clayey SAND occ. Clay lenses, occ. shell fragments (wet)	HNu = 0 ppm
		SS	4	3 2	2 2	Becomes red-brown w/occ. gray staining (moist)	HNu = 0 ppm
		SS	5	17 24	23 25	Dark gray and brown Silty CLAY, trace gravel	HNu = 0 ppm
10		SS	6	20 100/0.6'	12	Becomes sandy, red-brown, contains occ. angular gravel (moist-wet)	HNu = 0 ppm
		HQ	RUN 1			Hard, gray, thin bedded, fractured, Dolostone ROCK	REC - 37% RQD - 0% Lost Core Water @ 13'
15		HQ	RUN 2			Contains verticle fractures @ 14.5'-14.9'	REC - 24% RQD - 12%
20						Boring Complete at 17.8'	Borehole open to 17.8' Roller bit (5-7/8") from 11.5' to 12.5' 4" Dia. casing installed (grouted) at 12.5'
25							
30							
35							

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Richard L. Crouch

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (CME-75) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE STARTED 8-16-88 FINISHED 8-23-88 SHEET 1 OF 1	**ecco Inc.** The Environmental Consulting Company	HOLE NO.	**MW-88-1B**
	SUBSURFACE LOG	SUFACE ELEV.	**569.98**
		G.W. ELEV.	———
		CASING ELEV.	**572.34**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0-6 / 6-12 / 12-18 / 18-24	DESCRIPTION	NOTES
0–10.8				**Overburden Fill/Soils**	**Auger to top of rock w/o split spoon sampling** **For subsurface conditions, see boring log MW-88-1A**
	6" Core	**RUN 1**		**Hard, gray, thin bedded Dolostone ROCK, bedding plane fractures at 11.0', 11.9' - 12.7', vertical fractures at 11.9' - 12.7', 12.7' - 13.3'**	**REC - 100%** **RQD - 70%**
15	**6" Core**	**RUN 2**		**Becomes thick-bedded, contains minor fractures at 15.3' - 15.8', occasional stylolites**	**REC - 83%** **RQD - 83%** **BOH - 0.1'** **VOIDS - 0.2'**
20	**6" Core**	**RUN 3**			**REC - 100%** **RQD - 100%**
	HQ	**RUN 4**		**Becomes more crystalline at 20', occ. gypsum nodules at 19'** **Becomes fractured at 20.9' and 21.5'**	**REC - 90%** **RQD - 79%** **BOH - 0.3'**
25	**HQ**	**RUN 5**		**Contains gypsum nodules and partings at 23.8', 24.2', and 24.9'**	**REC - 90%** **RQD - 87%**
30–35				**Boring Complete at 26.1'**	**Roller bit (5-7/8") from 10.8' to 20.1'** **4" Dia. casing installed (grouted) at 20.1'** **0% Corewater return at 18.5' - 20.0'**

fracture no description for 18.5-20

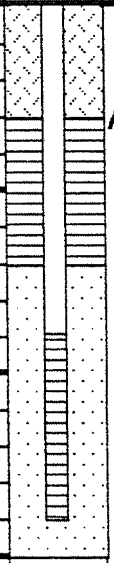
CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Richard L. Crouch

METHOD OF INVESTIGATION **Catoh Environmental Company**
Truck Mounted Drill Rig
(CME-75) w/Hollow Stem
Augers (HSA), ASTM D-1586

DATE STARTED 9-22-88 FINISHED 9-22-88 SHEET 1 OF 1	**ecco Inc.** The Environmental Consulting Company SUBSURFACE LOG	HOLE NO. MW-88-2 OB SUFACE ELEV. 570.34 G.W. ELEV. ------- CASING ELEV. 572.88

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0/6 6/12 12/18 18/24	DESCRIPTION	NOTES
					**Black Clayey SILT (moist-wet, FILL)**	**HNU (2') = 30 ppm** **Chemical odors noted between 0' - 5'**
		Aug				
5						**HNU (4') = 75 ppm**
					Red-brown Clayey SILT (moist)	**HNU (6') = 8 ppm** **HNU (9') = 70-80 ppm**
10						**HNU (10') = 300 ppm (12 sec.)** **HNU (13') = 120-135 ppm**
15					**(moist-wet)**	
20					**Boring Complete with Auger Refusal at 15.0'**	**Auger to top of rock w/o split spoon sampling** **For subsurface conditions, see boring log MW-88-2A**
25						
30						
35						

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (Mobile B-61) w/Hollow Stem Augers (HSA), ASTM D-1586**

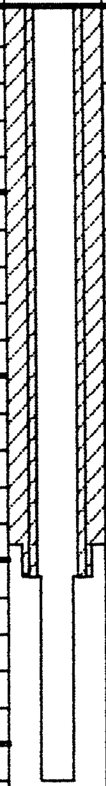
DATE
STARTED **8-17-88**
FINISHED **8-26-88**
SHEET **1** OF **1**

ecco Inc.
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. **MW-88-2A**
SUFACE ELEV. **570.44**
G.W. ELEV. **------**
CASING ELEV. **572.82**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC
LOCATION **47th Street**
Niagara Falls, NY



DEPTH-FT	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0/6	6/12	12/18	18/24	DESCRIPTION	NOTES
	SS	1	9	25	9	9	Brown-black Gravelly CINDER (damp-moist, FILL)	HNU = 10 ppm Sample No. 1 - odors noted
	SS	2	3	4	7	9	Brown, greenish-gray and yellow coarse SAND and fine-coarse Gravel w/Clay inclusions (moist)	HNU = 0.5 ppm
5	SS	3	7	7	19	20	Red-brown CLAY (moist)	
	SS	4	21	22	25	20	Gray and brown Silty CLAY and fine Sand (moist)	HNU = 19 ppm
10	SS	5	10	7	6	7	Contains some Rock Fragments, trace roots trace fossils (moist-wet)	HNU = 0.4 ppm
	SS	6	4	5	6	10		
	SS	7	15	20	21	20	Contains fine to coarse sand	HNU = 0.4 ppm
15	SS	8	15	100/0				
	5-7/8"RB						Hard, gray, thin bedded, fractured, Dolostone ROCK	Roller bit (5-7/8")
	HQ	RUN 1						REC - 63% RQD - 30%
20	HQ	RUN 2					Becomes laminated to thin bedded	REC - 27% RQD - 0%
							Boring Complete at 21.0'	4" Dia. casing installed (grouted) at 15.5'
25								
30								
35								

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Richard L. Crouch

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (CME-75) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE
STARTED 8-18-88
FINISHED 8-26-88
SHEET 1 OF 1

ecco Inc.

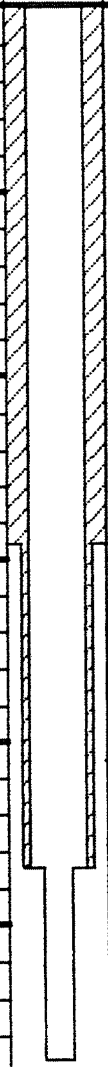
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO.	MW-88-2B
SUFACE ELEV.	570.46
G.W. ELEV.	-------
CASING ELEV.	573.06

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0/6	6/12	12/18	18/24	DESCRIPTION	NOTES
5 10								**Overburden Fills/Soils**	**Auger to top of rock w/o split spoon sampling** **For subsurface conditions, see boring log MW-88-2A**
15		6" Core	RUN 1					**Hard, gray, thin bedded Dolostone ROCK, occasionally vertically fractured**	**REC - 90%** **RQD - 40%**
20		6" Core	RUN 2					**Becomes bedded to thick bedded. minor soln. cavities at 17.9', thin bedded at 18.9'-19.4', sandy texture at 19.4'**	**REC - 78%** **RQD - 66%** **BOH - 0.7'**
		6" Core	RUN 3					**Slightly fractured at 20.8' - 21.9'**	**REC - 70%** **RQD - 66%** **BOH - 0.1%**
25		HQ	RUN 4					**Becomes thin bedded, weathered, occ. stylolitic partings, brown staining at 26'**	**REC - 66%** **RQD - 25%** **BOH - 0.3'** **Core water lost @ 25.9' Partial return at 27'**
30 35								**Boring Complete at 29.6'**	**Roller bit (5-7/8") from 14.5' to 23.5'** **4" Dia. casing installed (grouted) at 23.5'**

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Richard L. Crouch

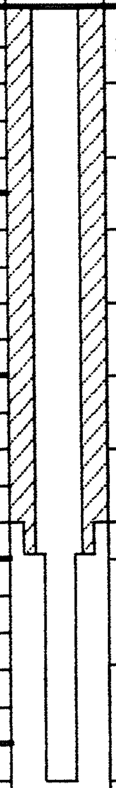
METHOD OF INVESTIGATION **Catoh Environmental Company**
Truck Mounted Drill Rig
(CME-75) w/Hollow Stem
Augers (HSA), ASTM D-1586

DATE STARTED 8-18-88 FINISHED 8-29-88 SHEET 1 OF 1	ecco Inc. The Environmental Consulting Company SUBSURFACE LOG	HOLE NO. SUFACE ELEV. G.W. ELEV. CASING ELEV.	MW-88-3A 570.95 ------ 573.44

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

LOG



DEPTH-FT	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0-6 / 12-18	BLOWS ON SAMPLER 6-12 / 18-24	DESCRIPTION	NOTES
	SS	1	2 5	6 7	Brown Brick Fragments w/intermixed brown-gray Clay (moist, FILL)	HNu = 0 ppm
	SS	2	23 50/.1'	32 -	Yellow-brown CLAY and Brick Fragments (moist, FILL)	HNu = 2-4 ppm
5	SS	3	53 29	58 28	Brown-gray clayey SILT and fine- coarse Sand some Rock Fragments (moist)	HNu = 10-20 ppm
	SS	4	120/0.9'			HNu = 50 ppm
10	SS	5	20 58	29 70	Gray and yellow-brown Silty CLAY (damp-moist)	HNu = 50-200 ppm
	SS	6	23 55	50 67		HNu = 11-24 ppm
	SS	7	75 100/0.1'	110	Becomes gray and red-brown, contains some Rock Fragments	HNu = 1-27 ppm
15	5-7/8 RB				Hard, gray, thin bedded Dolostone ROCK, cemented vertical fracture at 15'-16'	Roller bit (5-7/8")
	HQ	RUN 1				REC - 47% RQD - 15%
20	HQ	RUN 2			Becomes bedded, occ. styloilitic partings, chemical odors noted at 20.3', minor mineral deposits	REC - 100% RQD - 100%
					Boring Complete at 21.0'	
25						
30						
35						

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Richard L. Crouch

METHOD OF INVESTIGATION **Catoh Environmental Company**
Truck Mounted Drill Rig (CME-75) w/Hollow Stem Augers (HSA), ASTM D-1586

DATE			
STARTED	8-19-88		
FINISHED	8-30-88		
SHEET	1	OF	1

ecco Inc.

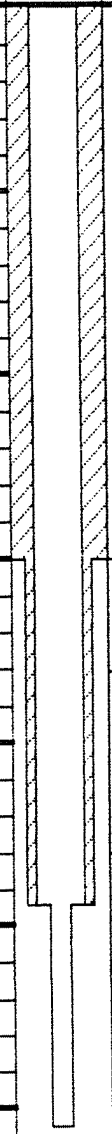
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. **MW-88-3B**
SUFACE ELEV. **570.97**
G.W. ELEV. **------**
CASING ELEV. **573.83**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY



DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0-6 / 6-12 / 12-18 / 18-24	DESCRIPTION	NOTES
0–15 5 10					Overburden Fill/Soils	Auger to top of rock w/o split spoon sampling For subsurface conditions, see boring log MW-88-3A
15		6" Core	RUN 1		Hard, gray, thin bedded Dolostone ROCK, vertical fractures at 16.4'-16.8', 17.4'-17.8' Becomes bedded, brown staining at 20.9', sandy texture at 22'	REC - 93% RQD - 27% BOH - 0.2'
20		6" Core	RUN 2		Becomes thin bedded Becomes bedded, sound	REC - 88% RQD - 79% BOH - 1.0'
25		6" Core	RUN 3			REC - 70% RQD - 66%
		HQ	RUN 4		Becomes bedded to thin bedded, occ. enterolithic structure	REC - 85% RQD - 50% VOIDS - 3% Core water lost @ 28'
30 35					Boring Complete at 30.5"	4" Dia. casing installed (grouted) at 24.5'

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Richard L. Crouch

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (CME-75) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE
STARTED 9-7-88
FINISHED 9-7-88
SHEET 1 OF 1

ecco Inc.

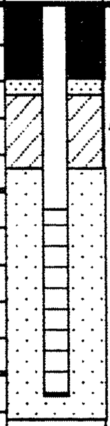
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. **MW-88-4 OB**
SUFACE ELEV. **570.60**
G.W. ELEV. --------
CASING ELEV. **572.54**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0/6, 6/12, 12/18, 18/24	DESCRIPTION	NOTES
0–11.2		Aug			**Overburden Fills/Soils**	**Auger to top of rock w/o split spoon sampling** **For subsurface soil description see boring log MW-88-4B**
5, 10, 15, 20, 25, 30, 35					**Boring Complete with Auger Refusal at 11.2'**	**Installed 2" I.D. stainless steel well at 10.5'**

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (CME-75) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE
STARTED 9-7-88
FINISHED 9-15-88
SHEET 1 OF 1

ecco Inc.

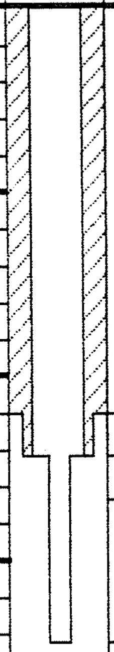
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. **MW-88-4A**
SUFACE ELEV. **570.26**
G.W. ELEV. **------**
CASING ELEV. **572.81**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER		DESCRIPTION	NOTES
				0 / 6 12 / 18	6 / 12 18 / 24		
						**Overburden Fill/Soil**	**Auger to top of rock w/o split spoon sampling**
5							**For subsurface conditions, see boring log MW-88-4B**
10							
		5-7/8" RB					**Roller bit (5-7/8")**
		HQ	**RUN 1**			**Hard, gray, thin bedded Dolostone ROCK**	**REC - 100%** **RQD - 35%**
15		**HQ**	**RUN 2**			**Thin bedded at 13.3' - 14.8'** **Becomes bedded**	**REC - 98%** **RQD - 55%**
						Boring Complete at 17.3"	
20							**4" Dia. casing installed (grouted) at 12.3'**
25							
30							
35							

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (CME-75) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE STARTED 9-7-88 FINISHED 9-15-88 SHEET 1 OF 1	**ecco Inc.** The Environmental Consulting Company SUBSURFACE LOG	HOLE NO. SUFACE ELEV. G.W. ELEV. CASING ELEV.	MW-88-4B 570.29 ------- 572.75

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0-6 / 12-18	BLOWS ON SAMPLER 6-12 / 18-24	DESCRIPTION	NOTES
		SS	1	6 6	7 3	Black SILT and Cinders, little fine-coarse sand, trace gravel (moist, FILL)	HNu = 0.0 ppm
		SS	2	3 4	3 5	Tan-brown SILT, little fine sand, trace clay (moist, wet)	HNu = 0.0 ppm
5		SS	3	3 3	4 3	Contains occ. fine Sand Partings	HNu = 0.0 ppm
		SS	4	3 3	3 3	Gray-brown mottled Clayey SILT, trace sand, trace roots, trace shells (moist)	HNu = 0.0 ppm
		SS	5	2 1	3 1	Gray and brown f-m SAND, some Silt, trace clay (wet) Red-brown Clayey SILT, some f-c Sand, little	HNu = 0.0 ppm HNu = 0.0 ppm
10		SS	6	1	1	f-c Gravel (wet)	
		NQ	RUN 1			Hard fractured, gray Dolostone ROCK	REC - 75% RQD - 0%
15		NQ	RUN 2			Becomes sound, thin bedded from 11.4'-14.8', vuggy at 17.3'-17.4' and 17.8'-17.9', black silty parting at 17.1' Occ. mineral partings at 19.1', 19.8' Becomes thick bedded at 20.0'-23.8'	REC - 98% RQD - 74% BOH - 0.2'
20							
25		NQ	RUN 3			Becomes thin bedded at 23.8'-25.5'	REC - 92% RQD - 78% Core Water lost at 25'
						Boring Complete at 26.0'	6" Dia. steel casing installed (grout) at 11.0'
30							Roller bit (5-7/8") from 11.0'-20.0'
35							4" Dia. steel casing installed (grout) at 20.0'

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (CME-75) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE STARTED 8-18-88 FINISHED 9-15-88 SHEET 1 OF 3	ecco Inc. The Environmental Consulting Company SUBSURFACE LOG	HOLE NO. SUFACE ELEV. G.W. ELEV. CASING ELEV.	MW-88-4C 570.39 ------ 572.71

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0-6 / 12-18	BLOWS ON SAMPLER 6-12 / 18-24	DESCRIPTION	NOTES
5 10						Cinder (FILL) Tan Silty CLAY (moist) (wet)	Auger to top of rock w/o split spoon sampling HNu = 0.8 ppm Roller bit (7-7/8") to from 11.0'-20.0' 8" Dia. casing installed (grouted) at 11.0' HNu = 0.2 ppm Auger refusal at 11.0'
		NQ	RUN 1			Hard, thin bedded, gray Dolostone ROCK, vertical fractures at 11.0'-11.4' and occ. bedding plane fractures	REC - 90% RQD - 12%
15		NQ	RUN 2			Highly fractured; occ. gypsum partings and vugs; void at 16.5'-17.0'	REC - 27% RQD - 0%
20		NQ	RUN 3			Void at 19.0' - 19.4'	REC - 44% RQD - 22% 6" Dia. casing installed (grouted) at 20.0'
		6" Core	RUN 4			Becomes sound, bedded	REC - 100% RQD - 100%
		6"Core	RUN 5				REC - 67% RQD - 0%
25		6" Core	RUN 6			Slightly fractured at 25.7'	REC - 100% RQD - 100% 4" Dia. casing installed (grouted) at 26.5'
30 35		HQ	RUN 7			Contains minor mineral inclusions	REC - 90% RQD - 79% BOH - 2.1' Packer Test No. 1 performed from 26.5'-36.5'

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (CME-750 ATV) w/Hollow Stem Augers (HSA), ASTM D-1586**

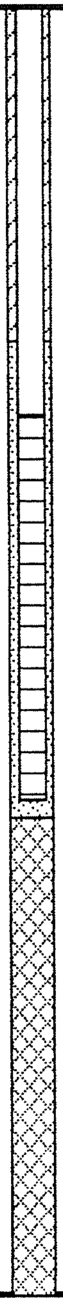
DATE
STARTED 8-18-88
FINISHED 9-15-88
SHEET 2 OF 3

ecco Inc.
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. MW-88-4C
SUFACE ELEV. 570.39
G.W. ELEV. -------
CASING ELEV. 572.71

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC
LOCATION **47th Street**
Niagara Falls, NY



DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0/6	6/12	12/18	18/24	DESCRIPTION	NOTES
		HQ	RUN 8					Contain gypsum nodules at 34.0'-34.3'	REC - 100+% RQD - 100+% Recovered from Run 7
40 45		HQ	RUN 9					Contains occ. stylolites and minor mineral inclusions at 45'	REC - 97% RQD - 83% Packer Test No. 2 performed from 36.5'-46.5'
50		HQ	RUN 10					Contains occ. fossils and mineral nodules/ inclusions Becomes thin bedded at 52.5'-53.4', contains occ. stylolites	REC - 97% RQD - 80% Packer Test No. 3 performed from 46.5'-56.5'
55		HQ	RUN 11					Becomes bedded at 53.4'-56.0' Becomes thin bedded at 56.0'-56.5' Contains occ. mineral inclusions	REC - 100% RQD - 95%
60 65		HQ	RUN 12					Becomes bedded Fractured at 60.2'-60.4', contains occ. solution cavities and minot pitting at 61' Contains occ. stylolites	REC - 94% RQD - 93% Core water lost at 60' Packer Test No. 4 performed from 56.5'-66.5'
70		HQ	RUN 13					Minor surface pitting at 67.5'-73.3'	REC - 100% RQD - 92%

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (CME-750 ATV) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE
STARTED 8-18-88
FINISHED 9-15-88
SHEET 3 OF 3

ecco Inc.
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. **MW-88-4C**
SUFACE ELEV. **570.39**
G.W. ELEV. --------
CASING ELEV. **572.71**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC
LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0/6 6/12 12/18 18/24	DESCRIPTION	NOTES
	▨				**Contains occ. stylolites**	**Packer Test No. 5 performed from 66.5'-76.0'**
75	▨				**Contains occ. shaley partings at 75.8'**	
					Boring Complete at 76.0'	
80						
85						
90						
95						
100						
105						

CLASSIFICATION **Visual-Manual Identification**
as per ASTM D-2488
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company**
Truck Mounted Drill Rig
(CME-750 ATV) w/Hollow Stem
Augers (HSA), ADTM D-1586

DATE
STARTED 9-14-88
FINISHED 10-11-88
SHEET 1 OF 1

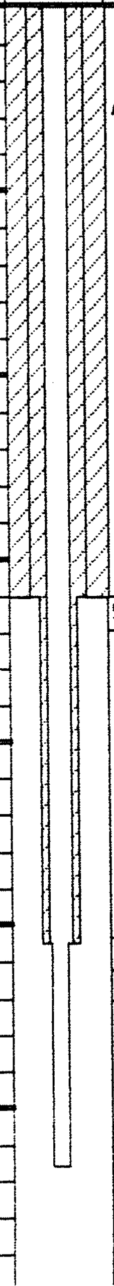
ecco Inc.
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. **MW-88-5B**
SUFACE ELEV. **570.82**
G.W. ELEV. **------**
CASING ELEV. **573.32**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0 6 12 18	6 12 18 24	DESCRIPTION	NOTES
5 10 15		**Aug**				**Overburden Fill/Soils**	**Auger to top of rock w/o split spoon sampling** **Auger refusal at 16.0'** **6" Dia. casing installed (grouted) at 16.0'**
		5-7/8" RB				**Hard, gray, thin bedded Dolostone ROCK, fractures at 18.5'-18.8', 19.6'-19.9', 21.3'-21.8'** **Void at 19.0' - 19.5'**	**Roller bit (5-7/8") from 16.0' to 16.5'**
20 25		**NQ**	**RUN 1**				**REC - 64%** **RQD - 29%** **Roller bit (5-7/8") from 16.5' to 25.5'** **4" Dia. casing installed (grouted) at 25.3'**
		HQ	**2**				**REC - 57%** **RQD - 0%**
		HQ	**3**			**Contains minor solution cavities**	**REC - 100%** **RQD - 92%**
30		**HQ**	**RUN 4**			**Contains minor surface pitting at 27.8'-28.2', occ. gypsum nodules and fossils**	**REC - 67%** **RQD - 57%**
35						**Boring Complete at 31.6'**	

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (CME-75) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE STARTED 8-23-88 FINISHED 9-28-8 SHEET 1 OF 2	ecco Inc. The Environmental Consulting Company SUBSURFACE LOG	HOLE NO. SUFACE ELEV. G.W. ELEV. CASING ELEV.	MW-88-5C 571.00 ------ 573.10

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0-6	6-12	12-18	18-24	DESCRIPTION	NOTES
								Crushed Stone and Cinder (fill)	HNu = 0.0 ppm
		Aug	1					Gray Clayey SILT, trace sand (wet)	
5		Aug	2						HNu = 0.4 ppm
10									
		Aug	3					Red-brown SILT, some f-c Sand, trace clay, trace gravel (moist)	HNu = 10-45 ppm HNu = 6 ppm
15		Aug	4					(wet)	HNu = 30-50 ppm
		Aug	5						
20		7-7/8"RB						Bedrock	Auger refusal at 16.0' Note: brown-black oily liquid noted on augers upon withdrawl Temporary 8" Dia. casing installed (grouted) at 16.0' Roller bit (7-7/8") to from 16.0'-25.0' and install (grout) 6" dia. casing at 25.0'
25		6"Core	RUN 1					Hard, gray, thin bedded, fractured Dolostone ROCK Voids at 27.5'-27.9' and 28.5'-29.4'	REC - 80% RQD - 40%
30		6" Core	RUN 2					Becomes thick bedded at 31.4'-35.0', saccharoidal, contains occ. gypsum nodules and seams, occ. fossils	REC - 90% RQD - 79% Core water "lost" at 27.5'
35									

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company**
Truck Mounted Drill Rig
(CME-750ATV) w/Hollow Stem
Augers (HSA), ASTM D-1586

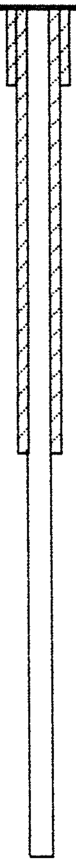
DATE
STARTED **8-23-88**
FINISHED **9-28-8**
SHEET **2** OF **2**

ecco Inc.
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. **MW-88-5C**
SUFACE ELEV. **571.00**
G.W. ELEV. **-------**
CASING ELEV. **573.10**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC
LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0-6	6-12	12-18	18-24	DESCRIPTION	NOTES
		6" Core	RUN 3					**Contains minor solution cavities, occ. gypsum filled fractures**	**REC - 83%** **RQD - 83%** **Core water: 0% return**
40		HQ	RUN 4					**Becomes bedded to thick bedded, contains occ. stylolites**	**4" Dia. casing installed (grouted) at 37.3'** **REC - 99.5%** **RQD - 98%** **Core water: 80% return**
45									**3" I.D. steel casing installed (pressure grouted) at 47.3'**
50		NQ	RUN 5					**Becomes thin bedded to bedded, contains occ. gypsum and calcite nodules, occ. fossils** **Highly fractured at 54.2'-57.2'**	**REC - 69%** **RQD - 33%**
55									
60								**Boring complete at 58.0'**	
65									
70									

CLASSIFICATION **Visual-Manual Identification**
as per ASTM D-2488
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company**
Truck Mounted Drill Rig
(CME-750ATV) w/Hollow Stem
Augers (HSA), ASTM D-1586

DATE	
STARTED	9-6-88
FINISHED	9-7-88
SHEET	1 OF 1

ecco Inc.

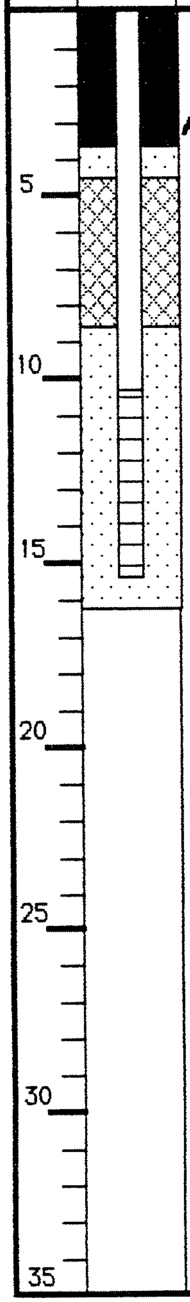
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO.	**MW-88-6 OB**
SUFACE ELEV.	**570.99**
G.W. ELEV.	--------
CASING ELEV.	**573.20**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY



DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0-6 / 12-18	BLOWS ON SAMPLER 6-12 / 18-24	DESCRIPTION	NOTES
		Aug				**Overburden Fills/Soils**	**Auger to top of rock w/o split spoon sampling** **For subsurface soil description see boring log MW-88-6A** **HNu = 10.8 ppm** **Note: black "liquid" noted on auger soil cuttings at 3' to 5'** **HNu = 2.6 ppm** **HNu = 1.8 ppm**
						Boring Complete with Auger Refusal at 16.2'	**Installed 2" I.D. stainless steel well at 15.5'**

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company**
Truck Mounted Drill Rig
(Mobile B-61) w/Hollow Stem
Augers (HSA), ASTM D-1586

DATE
STARTED 8-24-88
FINISHED 9-1-88
SHEET 1 OF 1

ecco Inc.

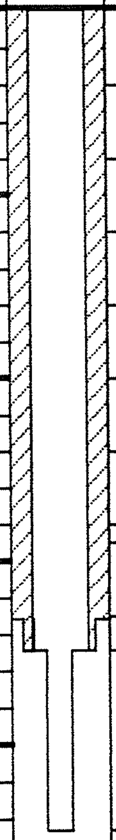
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. **MW-88-6A**
SUFACE ELEV. **570.89**
G.W. ELEV. **-------**
CASING ELEV. **573.44**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY



DEPTH-FT	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0-6 / 12-18	BLOWS ON SAMPLER 6-12 / 18-24	DESCRIPTION	NOTES
	AG	-	- -	- -	Gray-brown Crushed Stone, Slag (moist, FILL)	HNu = 0.1 ppm
	SS	1	6 5	4 5	Gray Clayey SILT, trace sand, trace gravel (moist, FILL)	HNu = 2.0 ppm Chemical odors noted
5	SS	2	4 6	5 8	Becomes gray-brown, contains little f-c Gravel (wet)	HNu = 1.4 ppm
	SS	3	8 15	14 16	Gray Clayey SILT, Gravel	SS sample #3, no recoverv. HNu = 3.0 ppm, LEL = 2%
	SS	4	9 12	10 15		
10	SS	5	5 8	6 10	Red-brown laminated SILT, occ. Clay partings (moist)	HNu = 1.2 ppm SS#5 no recovery WOH = Weight of Hammer
	SS	6	WOH 3	1 14	Red-brown Clayey SILT, some f-c Sand, little f-c Gravel (moist-wet)	HNu = 1.1 ppm
15	SS	7	WOH 6	6 50/.4	Red-brown SILT and f-c Sand, some f-c Gravel (moist-wet)	HNu = 0.8 ppm
	5-7/8"RB				Weathered Bedrock	Roller bit (5-7/8")
20	HQ	RUN 1			Hard, gray, Dolostone ROCK, bedded to thin bedded	REC - 60% RQD - 28% Core water return 0% at 19'
					Boring Complete at 22.4'	Temporary 6" dia. steel casing installed at 16.4'.
25						
30						4" dia. casing installed (grouted) at 17.4'
35						

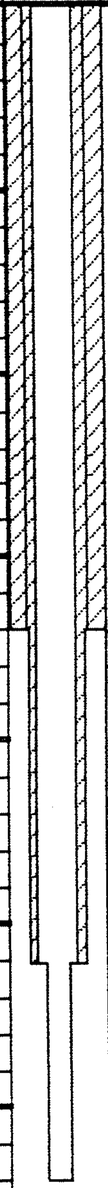
CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (CME-750ATV) w/Hollow Stem Augers (HSA). ASTM D-1586**

DATE STARTED 8-24-88 FINISHED 9-16-88 SHEET 1 OF 1	ecco Inc. The Environmental Consulting Company SUBSURFACE LOG	HOLE NO. SUFACE ELEV. G.W. ELEV. CASING ELEV.	MW-88-6B 571.35 ------ 573.98

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0/6 6/12 12/18 18/24	DESCRIPTION	NOTES
5 10 15		Aug			Overburden Fill/Soils	For description of subsurface see boring log MW-88-6A HNu = 1.5 ppm HNu = 22.5 ppm 6" Dia. casing installed (grouted) at 17.0' HNu = 3.8 ppm HNu = 95 ppm Auger refusal at 17.0'
		6"	1		Hard, gray, Dolostone ROCK, thin bedded to bedded, minor solution pitting at 19.8'-20.3', minor vertical fracturing	REC - 100% RQD - 0%
20 25		6" Core	RUN 2		Becomes thick-bedded at 26.0' - 29.2'	REC - 48% RQD - 41% BOH - 3.8' Core barrel lost in hole on 9/1/88, recovered 9/9/88 Roller bit (5-7/8") at 22.6' to 26.0'
30		HQ	RUN 5		Becomes bedded to thin bedded at 29.2-32.0, black staining and chemical odor noted at 29.1'	REC - 80% RQD - 63% Core water return 0% at 27'
35					Boring Complete at 32.0'	4" Dia. casing installed (grouted) at 26.0'

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (CME-750ATV) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE
STARTED 9-12-88
FINISHED 9-12-88
SHEET 1 OF 1

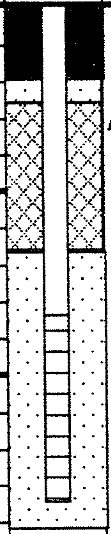
ecco Inc.
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. MW-88-7 OB
SUFACE ELEV. 569.95
G.W. ELEV. -------
CASING ELEV. 571.82

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY



DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0/6	6/12	DESCRIPTION	NOTES
				12/18	18/24		
		Aug				**Overburden Fills/Soils**	**Auger to top of rock w/o split spoon sampling** **For subsurface soil description see boring log MW-88-7A**
5							
10							
15						**Boring Complete with Auger Refusal at 14.2'**	**Installed 2" I.D. stainless steel well at 13.5'**
20							
25							
30							
35							

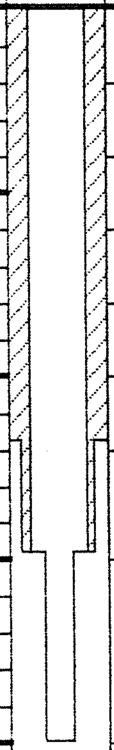
CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (Mobile B-61) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE STARTED 8-29-88 FINISHED 9-2-88 SHEET 1 OF 1	**ecco Inc.** The Environmental Consulting Company SUBSURFACE LOG	HOLE NO. SUFACE ELEV. G.W. ELEV. CASING ELEV.	MW-88-7A 570.03 ------- 572.45

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0 6 12 18	BLOWS ON SAMPLER 6 12 18 24	DESCRIPTION	NOTES
		AG	-	- -	- -	Crushed Stone (FILL) Gray-black SILT and f-c Sand, little Cinders (moist-wet, FILL)	
		SS	1	2 10	8 10	Gray-brown Clayey SILT, trace sand (moist)	HNu = 1.6 ppm
5		SS	2	8 10	7 10	Gray SILT, trace sand, trace clay (moist)	HNu = 15.0 ppm Installed (grouted) 6" I.D. steel casing at 11.8' due to cobbles and gravel
		SS	3	3 3	3 4	Contains occ. Clay partings and roots	
10		SS	4	3 11	5 13	Contains some f-m Sand (wet)	HNu(6-8') = 16 ppm
		SS	5	12 12	17 50/2	Red-brown SILT and f-c Sand, little - some f-c Gravel (moist)	HNu(8-10') = 30 ppm - 50 ppm
		5-7/8"RB				Cobbles/Gravel Till/Gravel	4" dia. casing installed (grouted) at 14.7'
15		NQ	RUN 1			Hard, sound, thin bedded Dolostone ROCK, minor pitting and mineral modules at 16.7'-19.7', inclined bedding noted at 16.3'-19.7'	REC - 94% RQD - 46% Roller bit (3-7/8") from 14.7-19.7 after coring
20						Boring complete at 19.7'	
25							
30							
35							

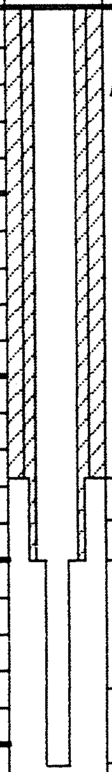
CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (CME-750ATV) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE STARTED 8-31-88 FINISHED 9-8-88 SHEET 1 OF 1	ecco Inc. The Environmental Consulting Company SUBSURFACE LOG	HOLE NO. SUFACE ELEV. G.W. ELEV. CASING ELEV.	MW-88-8A 571.19 ------- 573.46

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY



DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0/6 6/12 12/18 18/24	DESCRIPTION	NOTES
0–13 5 10		Aug			Overburden Fill/Soils (wet) Possible Concrete/Cobbles at 7'	For description of subsurface see boring log MW-88-8B HNu (2') = 70 ppm HNu (5') = 100 ppm 6" Dia. casing installed (grouted) at 12.9' Auger refusal at 12.9' HNu (12') = 50 ppm 4" Dia. casing installed (grouted) at 14.9'
		5-7/8"RB			Cobbles/Gravel	
15		5-7/8"RB			Bedrock	
		NQ	RUN 1		Hard, gray, thin bedded, fractured Dolostone ROCK Contains minor solution cavities Voids noted at 19.9' - 20.6'	REC - 58% RQD - 12%
20		NQ	RUN 2			REC - 95% RQD - 25%
25 30 35					Boring Complete at 20.6'	Roller bit (3-7/8") at 14.9' to 20.6'

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (Mobile B-61) w/Hollow Stem Augers (HSA), ASTM D-1586**

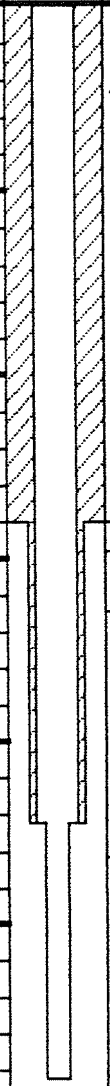
DATE
STARTED 8-29-88
FINISHED 9-9-88
SHEET 1 OF 1

ecco Inc.
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. MW-88-7B
SUFACE ELEV. 570.07
G.W. ELEV. -------
CASING ELEV. 572.58

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC
LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0-6	BLOWS ON SAMPLER 6-12	DESCRIPTION	NOTES
				12-18	18-24		
5 10		Aug				Overburden Fill/Soils	For description of subsurface see boring log MW-88-7A HNu (5') = 12.2 ppm Auger to top of rock w/o split spoon sampling HNu (10') = 32 ppm (max.) 0-5 ppm Auger refusal at 14.0' 6" Dia. casing installed (grouted) at 14.0'
		5-7/8" RB					Roller bit (3-7/8") at 13.7' to 14.5'
15		NQ	RUN 1			Hard, gray, Dolostone ROCK	REC - 75% RQD - 0%
20		NQ	RUN 2			Becomes sound, bedded, contains minor vertical fractures at 17' Inclined bedding noted at 17.2'-17.5' Becomes granular w/pitting at 19.5'-19.9'	REC - 99% RQD - 87% Roller bit (5-7/8") at 14.5' to 23.2' and install 4" dia. steel casing at 23.2'
25		NQ	RUN 3			Becomes thick-bedded, inclined bedding noted at 25.5' - 26.0'	REC - 94% RQD - 79% Roller bit (3-7/8") at 23.2' to 29.3'
30 35						Boring Complete at 29.3'	

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (CME-750ATV) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE
STARTED 9-13-88
FINISHED 9-13-88
SHEET 1 OF 1

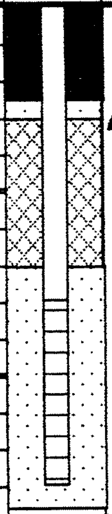
ecco Inc.
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. **MW-88-8 OB**
SUFACE ELEV. **571.30**
G.W. ELEV. **--------**
CASING ELEV. **573.67**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0/6	BLOWS ON SAMPLER 6/12	BLOWS ON SAMPLER 12/18	BLOWS ON SAMPLER 18/24	DESCRIPTION	NOTES
5 10		**Aug**						**Overburden Fills/Soils**	**Auger to top of rock w/o split spoon sampling** **For subsurface soil description see boring log MW-88-8B** **HNu = 60 ppm (max.)** **HNu = 1.1 ppm**
15 20 25 30 35								**Boring Complete with Auger Refusal at 13.6'**	**Installed 2" I.D. stainless steel well at 13.0'**

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (Mobile B-61) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE STARTED 8-31-88 FINISHED 9-13-88 SHEET 1 OF 1	**ecco Inc.** The Environmental Consulting Company SUBSURFACE LOG	HOLE NO. **MW-88-8B** SUFACE ELEV. **571.29** G.W. ELEV. ------- CASING ELEV. **573.49**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0 / 6 12 / 18	BLOWS ON SAMPLER 6 / 12 18 / 24	DESCRIPTION	NOTES
		SS	1	9	26	**Crushed Stone and Slag (moist, FILL)**	
				19	15	**Concrete and/or cobbles noted at 1'**	
		SS	2	15	6	**Contains some black Silt, trace bricks**	HNU = 100-160 ppm
				6	7		
5		SS	3	7	6		
				5	6		HNU = 80-110 ppm
		SS	4	10	11		HNU = 20 ppm, HNu in auger hole at 10' = 100 ppm
				10	10	Gray-green SILT, trace sand, trace clay (wet)	
		SS	5	4	5	**Gray and brown Clayey SILT and f-c Sand, trace gravel (moist-wet)**	
10				5	6		HNU = 3.4 ppm, HNu in auger hole at 12' = 70 ppm
		SS	6	6	19		
				6	3		6" Dia. casing installed (grouted) ● 14.9'
		SS	7	3	3		
				5	17	**Red-brown clayey SILT and f-c Sand, little f-c Gravel (moist)**	
15		SS	8	17	25/.1'		
		NQ	1			**Hard, gray, thin bedded Dolostone ROCK**	REC - 70% RQD - 0%
		NQ	RUN 2			**Inclined bedding noted at 17' and 19'** **vug noted at 18.6'** **Contains occ. stylolites**	REC - 93% RQD - 30%
20							
		NQ	RUN 3			**Becomes sound, bedded, contains occ. mineral nodules and parting**	REC - 100% RQD - 100%
25		HQ	RUN 4			**Becomes thick bedded from 24.0'-26.6'** **Void at 26.5'-27.0'** **Becomes thin bedded from 26.6'-30.3'** **Contains occ. stylolites**	REC - 73% RQD - 55% Core water return: 0% at 26.5'
30							
						Boring complete at 30.3'	4" Dia. casing installed (grouted) ● 23.9'
35							

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (Mobile B-61) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE STARTED	10-13-88	HOLE NO.	MW-88-9 OB
FINISHED	10-13-88	SUFACE ELEV.	570.35
SHEET 1 OF 1		G.W. ELEV.	--------
		CASING ELEV.	572.72

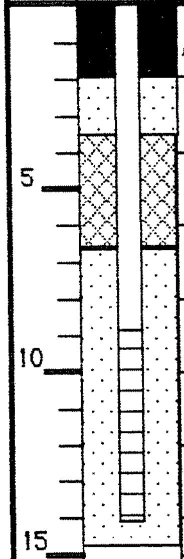
ecco Inc.

The Environmental Consulting Company

SUBSURFACE LOG

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY



SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0-6	6-12	12-18	18-24	DESCRIPTION	NOTES
AG	-	-	-	-	-	Asphaltic Concrete Crushed Stone (FILL)	
SS	1	24	21	12	18	Concrete (FILL)	HNu = 0.0 ppm
SS	2	8	8	3	10	Gray-brown SILT, trace clay, trace sand (moist)	HNu = 0.0 ppm
SS	3	10	12	12	13	Red-brown laminated SILT w/occ. Clay partings and seams (moist)	HNu = 0.0 ppm SS#4: No Recovery
SS	4	8	8	15	12		HNu = 0.0 ppm
SS	5	5	3	3	5	Red-brown SILT, trace sand (wet)	
SS	6	6	3	23	40		SS#6: No Recovery HNu = 0.0 ppm
SS	7	30	100/2"				
						Boring Complete with Auger Refusal at 14.7'	Installed 2" I.D. stainless steel well at 14.0'

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (Mobile B-61) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE
STARTED 10-3-88
FINISHED 10-11-88
SHEET 1 OF 1

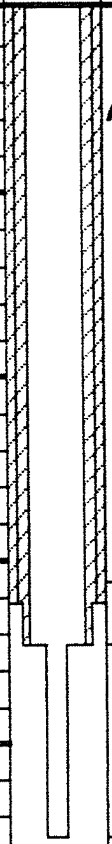
ecco Inc.
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. **MW-88-9A**
SUFACE ELEV. **570.41**
G.W. ELEV. -------
CASING ELEV. **572.94**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY



DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0-6 / 12-18	BLOWS ON SAMPLER 6-12 / 18-24	DESCRIPTION	NOTES
		Aug				**Asphaltic concrete and concrete**	**Auger to top of rock w/o split spoon sampling**
5						**Tan brown Clayey SILT, trace sand**	**For subsurface information, see boring log MW-88-90B**
10 15						**Becomes red-brown**	**HNu = 0.4 ppm** **6" Dia. casing installed (grouted) at 15.3'** **HNu = 0.3 ppm** **Auger refusal at 15.6'**
		5-7/8" RB				**Weathered Bedrock**	
20		HQ	RUN 1			**Hard, gray, thin bedded Dolostone ROCK, fractured at 18.5'-20.0'**	**4" Dia. casing installed (grouted) at 17.2'** **REC - 27%** **RQD - 6%**
25 30 35						**Boring Complete at 22.7"**	

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company**
Truck Mounted Drill Rig
(Mobile B-61) w/Hollow Stem
Augers (HSA), ASTM D-1586

DATE
STARTED 10-3-88
FINISHED 10-12-88
SHEET 1 OF 1

ecco Inc.

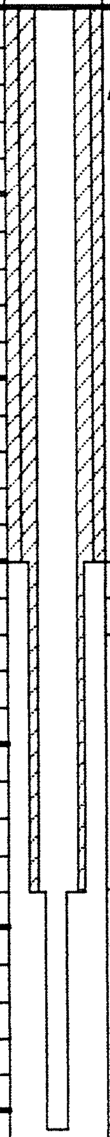
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. **MW-88-9B**
SUFACE ELEV. **570.40**
G.W. ELEV. **-------**
CASING ELEV. **572.98**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY



DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0-6 / 12-18	BLOWS ON SAMPLER 6-12 / 18-24	DESCRIPTION	NOTES
5 10		Aug				Overburden Fill/Soil	Auger to top of rock w/o split spoon sampling For subsurface information, see boring log MW-88-90B HNu = 0.0 ppm HNu = 0.0 ppm 6" Dia. casing installed (grouted) at 15.0' HNu = 0.0 ppm
15		NQ	1			Hard, gray, thin bedded Dolostone ROCK	REC - 85% RQD - 0%
		NQ	2				REC - 90% RQD - 0%
20		NQ	RUN 3			Contains minor pitting at 18.8'-19.4' Contains occ. mineral inclusions at 20' Becomes sandy, fractured at 21.3'-22.0'	Roller bit (5-7/8") from 15.0'-24.0' REC - 77% RQD - 0%
25 30		HQ	RUN 4			Becomes bedded, sound Becomes fractured at 26.6'-27.8'	4" Dia. casing installed (grouted) at 23.9' REC - 81% RQD - 43%
35						Boring Complete at 30.3'	

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (Mobile B-61) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE		HOLE NO.	**MW-88-10 OB**
STARTED	**10-7-88**	SUFACE ELEV.	**571.55**
FINISHED	**10-7-88**	G.W. ELEV.	-------
SHEET 1 OF 1		CASING ELEV.	**573.83**

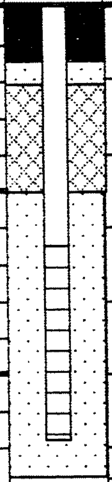
ecco Inc.

The Environmental Consulting Company

SUBSURFACE LOG

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0/6 12/18	BLOWS ON SAMPLER 6/12 18/24	DESCRIPTION	NOTES
		SS	1	10	15	**Brown and gray SILT and f-c Sand, trace gravel, trace wood (wet, FILL)**	**HNu = 0.0 ppm**
				18	12		
		SS	2	14	12	**Brown f-c SAND, trace silt, trace wood (wet, FILL)**	**HNu = 0.0 ppm**
				3	3	**Tan-brown and green Clayey SILT, little f-c sand (wet)**	**HNu = 0.0 ppm**
5		SS	3	16	15		
				12	18		
		SS	4	29	14	**Contains some f-c Sand**	**HNu = 0.1 ppm**
				18	14		
		SS	5	12	14	**Green-tan SILT w/occ. Clay partings, trace sand (wet)**	**HNu = 0.0 ppm**
10				12	13		
		SS	6	6	6		**HNu = 0.0 ppm**
				6	30	**Green-gray Clayey SILT (moist-wet)**	
		SS	7	100/.4'		**Green-gray f-c SAND, little Silt, trace fossils (wet)**	**HNu = 0.0 ppm**
						Red-brown Silt and Rock Fragments, little f-c Sand (moist)	**Installed 2" I.D. stainless steel well at 11.5'**
15						**Boring Complete with Auger Refusal at 12.8'**	
20							
25							
30							
35							

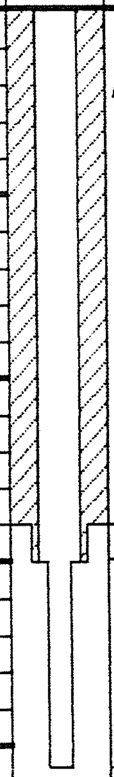
CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (Mobile B-61) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE STARTED 9-21-88 FINISHED SHEET 1 OF 1	**ecco Inc.** The Environmental Consulting Company SUBSURFACE LOG	HOLE NO. **MW-88-10A** SUFACE ELEV. **571.75** G.W. ELEV. ------ CASING ELEV. **572.58**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY



DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0–6	BLOWS ON SAMPLER 6–12	BLOWS ON SAMPLER 12–18	BLOWS ON SAMPLER 18–24	DESCRIPTION	NOTES
5 10		Aug						**Overburden Fill/Soils** **Becomes wet at 4'-5'**	**Auger to top of rock w/o split spoon sampling** **HNu = 1.0 ppm** **For description of subsurface see boring log MW-88-10 OB** **HNu = 0.6 ppm** **HNu = 0.8 ppm** **HNu = 1.6 ppm** **HNu = 0.2 ppm**
15		5-7/8"RB						**Fractured bedrock**	**Roller bit (5-7/8")**
20		HQ	RUN 1					**Hard, sound, gray, Dolostone ROCK, thin bedded, pitted at 15.0'-16.9'** **Void at 16.9' - 17.2'** **Chaotic structure at 17.2' - 17.5'**	**REC - 73%** **RQD - 21%** **VOIDS - 0.3'** **Core water return - 40 - 50%**
25 30 35								**Boring Complete at 20.6'**	**4" Dia. casing installed (grouted) at 15.0'**

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (Mobile B-61) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE	**ecco Inc.**	HOLE NO.	MW-88-10B
STARTED 9-7-88	The Environmental Consulting Company	SUFACE ELEV.	571.66
FINISHED 9-21-88		G.W. ELEV.	———
SHEET 1 OF 1	SUBSURFACE LOG	CASING ELEV.	573.86

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0/6, 12/18	BLOWS ON SAMPLER 6/12, 18/24	DESCRIPTION	NOTES
5		Aug				Overburden Fill/Soils Black Cinders Becomes wet at 4'	Auger to top of rock w/o split spoon sampling For subsurface conditions see boring log MW-88-10 0B
10						Gray-brown Clayey SILT (wet)	6" Dia. casing installed (grouted) at 15.1'
15		NQ	RUN 1			Hard, gray, thin bedded Dolostone ROCK, with inclined bedding at 15.0' - 15.3'	REC - 50% RQD - 18% BOH - 0.1'
20		NQ	RUN 2			Void at 17.5' - 18.0' Contains chaotic structure at 18.2'-18.5' Inclined bedding at 18.8', sandy texture at 19.0' - 19.4'	REC - 50% RQD - 33% BOH - 1.0' VOIDS - 0.5' Core water return: 0% at 17.5'
		NQ	RUN 3			Becomes bedded to thick bedded, contains occ. stylolites	REC - 100+% RQD - 100+%
25		HQ	RUN 4			Void at 25.0' - 25.6' Becomes sound, bedded	REC - 67% RQD - 57% VOIDS - 0.6' Core water return: 0% at 26.0'
30						Boring Complete at 30.0'	Roller bit (5-7/8") from 15.1' to 24.0' 4" Dia. casing installed (grouted) at 23.5'
35							

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (Mobile B-61) w/Hollow Stem Augers (HSA), ASTM D-1586**

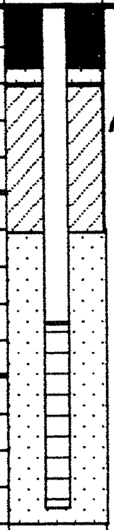
DATE
STARTED 9-29-88
FINISHED 9-29-88
SHEET 1 OF 1

ecco Inc.
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. **MW-88-11 OB**
SUFACE ELEV. **570.35**
G.W. ELEV. --------
CASING ELEV. **572.71**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC
LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0/6	BLOWS ON SAMPLER 6/12	DESCRIPTION	NOTES
				12/18	18/24		
		**Aug**				**Overburden Fills/Soils**	**Auger to top of rock w/o split spoon sampling** **For subsurface soil description see boring log MW-88-11A**
5							
10						**Becomes wet at 10'-14'**	
15						**Boring Complete with Auger Refusal at 14.0'**	**Installed 2" I.D. stainless steel well at 13.5'**
20							
25							
30							
35							

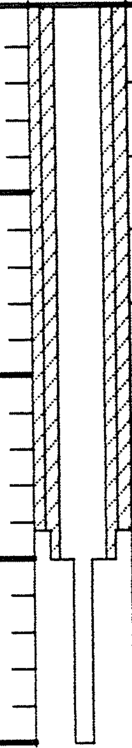
CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (Mobile B-61) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE		**ecco Inc.** The Environmental Consulting Company	HOLE NO.	MW-88-11A
STARTED	9-13-88		SUFACE ELEV.	570.39
FINISHED	9-29-88		G.W. ELEV.	------
SHEET 1 OF 1		SUBSURFACE LOG	CASING ELEV.	572.97

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY



DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0-6 / 12-18	BLOWS ON SAMPLER 6-12 / 18-24	DESCRIPTION	NOTES
		SS	1	12	30	Black-gray f-c GRAVEL and f-c Sand, trace silt (moist, FILL)	
				33	46		
		SS	2	3	10	Gray SILT, trace clay, trace sand (moist)	HNU = 0.1 ppm
				15	18		HNU = 0.6 ppm
5		SS	3	5	8	Becomes gray-brown (mottled), contains little fine Sand	HNU = 0.7 ppm
				8	9		
		SS	4	8	10	Contains occasional fine Sand and Clay partings and seams (moist-wet)	HNU = 0.9 ppm Slight chemical odor noted
				15	18		
		SS	5	20	15	Becomes green-gray	
10				12	19	Red-brown SILT and fractured Rock Fragments, little f-c Sand (moist)	HNU = 1.3-9.8 ppm
		SS	6	30	15	Contains some f-c Gravel, some f-c Sand, little Clay (wet)	Chemical odors noted
				5	4		
		SS	7	8	12	Red-brown and gray fractured ROCK FRAGMENTS and f-c Sand, some Silt (wet)	HNU = 0.8 ppm
				18	100/.5		HNU = 1.8 ppm
15		— 5-7/8" RB	RET.				REC - 38% RQD - 9%
		HQ	RUN 1			Hard, gray, thin bedded, fractured Dolostone ROCK	6" Dia. casing installed (grouted) at 14.3' Core Water Return = 60%
20						Boring Complete at 20.0'	Roller bit (5-7/8") at 8.0'-15.0'
25							4" Dia. casing installed (grouted) @ 15.0'
30							
35							

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (Mobile B-61) w/Hollow Stem Augers (HSA), ASTM D-1586**

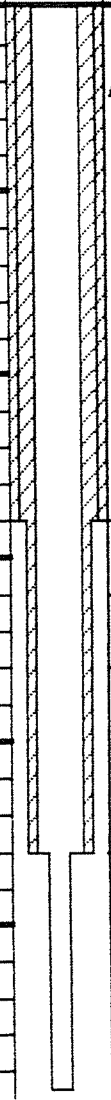
DATE
STARTED 9-13-88
FINISHED 9-29-88
SHEET 1 OF 1

ecco Inc.
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. **MW-88-11B**
SUFACE ELEV. **570.71**
G.W. ELEV. **------**
CASING ELEV. **573.30**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC
LOCATION **47th Street**
Niagara Falls, NY



DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0-6 / 12-18	BLOWS ON SAMPLER 6-12 / 18-24	DESCRIPTION	NOTES
5 10		Aug				Overburden Fill/Soils	Auger to top of rock w/o split spoon sampling HNu = 0.3 ppm HNu = 0.3 ppm For subsurface conditions, see log MW-88-11A HNu = 4.1 ppm 6" Dia. casing installed (grouted) at 14.0'
15		NQ	RUN 1			Hard, medium gray, thin bedded, weathered Dolostone ROCK	REC - 40% RQD - 0% Core Water Return = 10-30%
		NQ	RUN 2				REC - 60% RQD - 20% Core Water Return = 10-30%
20		5-7/8" RB					Roller bit (5-7/8") from 14.0'-23.3'
25		HQ	RUN 3			Becomes sound, bedded, contains gypsum nodules at 25.7' and 28.1'; occasional fossils, occasional vugs, thin bedded at 24.1'-24.4', 26.7-26.9', 27.9'-29.5' Void at 28.4'-29.0'	REC - 87% RQD - 65% BOH - 0.1' Core Water Return 0% at 28.4'
30 35						Boring complete at 29.5'	4" Dia. casing installed (grouted) at 23.3'

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (Mobile B-61) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE
STARTED 10-12-88
FINISHED 10-12-88
SHEET 1 OF 1

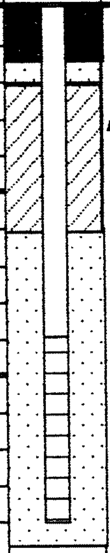
ecco Inc.
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. MW-88-12 OB
SUFACE ELEV. 570.39
G.W. ELEV. -------
CASING ELEV. 572.66

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0/6 6/12 12/18 18/24	DESCRIPTION	NOTES
5 10		Aug			**Overburden Fills/Soils**	**Auger to top of rock w/o split spoon sampling** **For subsurface conditions see boring log MW-88-12A** **Depth HNu** 2' 1.8 ppm 5' 2.4 ppm 10' 1.0 ppm 14.5 0.6 ppm
15 20 25 30 35					**Boring Complete with Auger Refusal at 14.5'**	**Installed 2" I.D. stainless steel well at 14.2'**

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (Mobile B-61) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE
STARTED 9-15-88
FINISHED 10-11-88
SHEET 1 OF 1

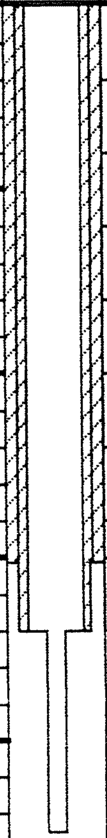
ecco Inc.
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. MW-88-12A
SUFACE ELEV. 570.45
G.W. ELEV. ------
CASING ELEV. 572.93

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0/6	BLOWS ON SAMPLER 6/12	BLOWS ON SAMPLER 12/18	BLOWS ON SAMPLER 18/24	DESCRIPTION	NOTES
		Aug	-					Asphaltic Conctete (pavement) and black-gray f-c Sand, f-c Gravel, little Cinders (FILL)	6" Dia. casing installed (grouted) ● 14.7'
		SS	1	3	4	8	12	Gray-brown SILT, trace fine sand, trace clay (moist-wet)	HNU = 0.3 ppm
5		SS	2	12	9	7	6		HNU = 0.0 ppm
		SS	3	4	5	5	5	Contains little Clay	HNU = 0.4 ppm
		SS	4	8	2	2	2	(wet)	
10		SS	5	1	1	1	2	Red-brown Clayey SILT, little-some f-c Sand, trace gravel (wet)	HNU = 0.1 ppm HNU = 0.2 ppm
		SS	6	7	15	61	97	Red-brown and gray f-m SAND, some Silt, some f-c Gravel, trace clay (moist-wet)	HNU = 0.3 ppm HNU(15') = 3.4 ppm
15				100/.1	REF.				
		5-7/8"RB						Bedrock	Roller bit (5-7/8")
20		HQ	RUN 1					Hard, sound, med. gray, bedded Dolostone ROCK, filled fractures (with calcite) at 18.0' - 18.6'	REC - 27% RQD - 0% Core Water Return = 70%
25								Boring/Coring complete at 22.6'	4" Dia. casing installed (grouted) ● 17.0'
30									
35									

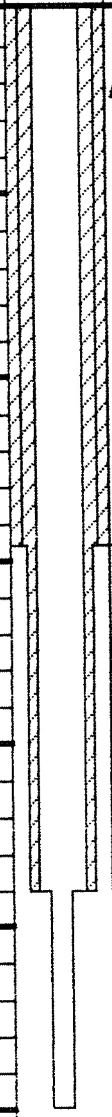
CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (Mobile B-61) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE		**ecco Inc.** The Environmental Consulting Company	HOLE NO. **MW-88-12B**
STARTED	**9-15-88**		SUFACE ELEV. **570.31**
FINISHED	**10-12-88**		G.W. ELEV. -------
SHEET **1**	OF **1**	SUBSURFACE LOG	CASING ELEV. **572.79**

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0-6	6-12	12-18	18-24	DESCRIPTION	NOTES
5 10		Aug						Overburden Fill/Soil	Auger to top of rock w/o split spoon sampling HNu(2') = 2.2 ppm HNu(4') = 1.6 ppm For description of subsurface see log MW-88-12A HNu = 0.8 ppm 6" Dia. casing installed (grouted) at 14.6' HNu = 0.6 ppm HNu = 1.0 ppm HNu = 2.0 ppm
15		NQ	RUN 1					Hard, gray, thin bedded to bedded Dolostone ROCK, occasional stylolites; surface pitting at 17.9'-18.9' Becomes thick bedded at 21.6'-23.9'	REC - 100% RQD - 56% Core Water Return = 60%
20		NQ	RUN 2					Becomes bedded to thick bedded, contains occasional stylolites	REC - 100% RQD - 80% Core Water Return = 70-80%
25		HQ	RUN 3					Becomes thin bedded at 29.3'-30.0'	REC - 90% RQD - 75% Core Water Return 0% at 27'
30 35								Boring Complete at 30.0'	Roller bit (5-7/8") from 14.6'-24.0' 4" Dia. casing installed (grouted) at 24.0'

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (Mobile B-61) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE
STARTED 10-3-88
FINISHED 10-13-88
SHEET 1 OF 1

ecco Inc.

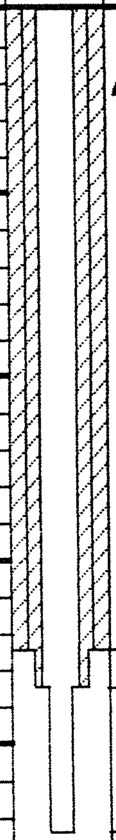
The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. MW-88-13A
SUFACE ELEV. 570.84
G.W. ELEV. ------
CASING ELEV. 573.27

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	LOG	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0 / 6 12 / 18	6 / 12 18 / 24	DESCRIPTION	NOTES
		Aug				Overburden Fill	Auger through fill to top of rock w/o split spoon soil sampling HNu = 0.0 ppm
5						Reinforcing steel bars noted at 6'-7'	HNu = 0.0 ppm
10							Driller notes difficult augering at 7' - 10'
15							6" Dia. casing installed (grouted) at 17.5'
		5-7/8" RB				Bedrock	Roller bit (5-7/8") at 17.5' to 18.6'
20		HQ	RUN 1			Hard, gray, thin bedded, Dolostone Rock, occasional gypsum nodules; surface pitting at 21.0' - 21.2'	REC - 92% RQD - 38% Core Water Return = 50%
25						Boring Complete at 23.6'	4" Dia. casing installed (grouted) at 18.6'
30							
35							

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company**
Truck Mounted Drill Rig
(Mobile B-61) w/Hollow Stem
Augers (HSA), ASTM D-1586

DATE
STARTED 10-12-88
FINISHED 10-12-88
SHEET 1 OF 1

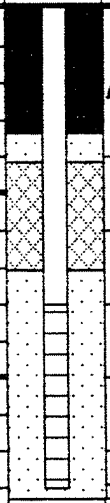
ecco Inc.

The Environmental Consulting Company

SUBSURFACE LOG

HOLE NO. MW-88-14 OB
SUFACE ELEV. 570.36
G.W. ELEV. -------
CASING ELEV. 572.43

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC
LOCATION **47th Street**
Niagara Falls, NY



DEPTH-FT	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0-6	6-12	12-18	18-24	DESCRIPTION	NOTES
	AUG	-	- - - -	- - - -			Asphaltic Concrete (0.2') Concrete (0.4') Crushed Stone (Fill) Brown SILT and f-c Sand	
5	SS	1	5	6	11	11	Green-gray SILT w/occ. clay partings, trace sand, trace gravel (moist)	HNu = 0.2 ppm
	SS	2	6	6	7	7	Contains trace clay (moist-wet)	HNu = 0.3 ppm
10	SS	3	2	4	4	5	Gray Clayey SILT w/occ. clay partings (moist-wet)	HNu = 0.1 ppm
	SS	4	2	2	13	13	Red-brown SILT and f-c Sand, trace gravel (wet)	HNu = 1.8 ppm
	SS	5	7	50/2				HNu = 3.8 ppm
15							Boring Complete with Auger Refusal at 13.5'	Installed 2" I.D. stainless steel well at 13.0'
20								
25								
30								
35								

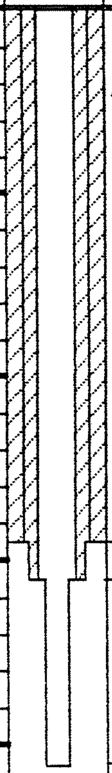
CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (Mobile B-61) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE		**ecco Inc.** The Environmental Consulting Company	HOLE NO.	**MW-88-14A**	
STARTED	**9-30-88**		SUFACE ELEV.	**570.57**	
FINISHED	**10-11-88**		G.W. ELEV.	------	
SHEET 1 OF 1		SUBSURFACE LOG	CASING ELEV.	**573.30**	

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY



DEPTH-FT	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0/6	6/12	12/18	18/24	DESCRIPTION	NOTES
							Concrete	**Auger to top of rock w/o split spoon sampling**
5 10	**Aug**						**Gray-Black Clayey SILT**	**For subsurface conditions, see boring log MW-88-14 OB** **6" Dia. casing installed (grouted) at 14.5'** **4" Dia. casing installed (grouted) at 15.6'**
15	5-7/8"RB						**Bedrock**	**Roller bit (5-7/8") at 14.5' to 15.7'**
20	**HQ**	**RUN 1**					**Hard, gray, thin bedded, Dolostone ROCK, fractured at 15.7-16.5'; pitted at 17.6'-18.0'**	**REC - 50%** **RQD - 27%** **BOH - 0.1'** **Core Water Return = 0%**
25 30 35							**Boring Complete at 20.6'**	

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (Mobile B-61) w/Hollow Stem Augers (HSA), ASTM D-1586**

DATE STARTED	9-30-88	**ecco Inc.** The Environmental Consulting Company SUBSURFACE LOG	HOLE NO. MW-88-14B
FINISHED	10-12-88		SUFACE ELEV. 570.41
SHEET 1 OF 1			G.W. ELEV. ------
			CASING ELEV. 573.26

PROJECT **Frontier Chemical Waste Process, Inc.**
Project No. 88-041SC

LOCATION **47th Street**
Niagara Falls, NY

DEPTH-FT	SAMPLE TYPE	SAMPLE NO	BLOWS ON SAMPLER 0-6	6-12	12-18	18-24	DESCRIPTION	NOTES
0	Aug						Concrete Crushed Stone (Fill)	Auger to top of rock w/o split spoon sampling
							Gray Clayey Silt	
5								HNu = 1.6 ppm
								HNu = 1.0 ppm
10								HNu = 1.2 ppm
							(moist-wet)	6" Dia. casing installed (grouted) at 14.4'
							Becomes brown (wet)	HNu = 1.6-5.8 ppm
15	NQ	RUN 1					Hard, gray, thin bedded Dolostone ROCK	REC - 93% RQD - 23% Core Water Return = 70%
20	NQ	RUN 2					Becomes thin bedded to bedded	REC - 63% RQD - 42% Core Water Return = 50-70% Roller bit (5-7/8") from 14.5'-23.5'
25	HQ	RUN 3					Contains occasional gypsum nodules Void at 26.0' - 26.5'	REC - 74% RQD - 43% Core Water Return 0% at 26'
30							Boring Complete at 29.5'	4" Dia. casing installed (grouted) at 23.1' For description of subsurface see log no. MW-88-14OB
35								

CLASSIFICATION **Visual-Manual Identification as per ASTM D-2488**
Andrew J. Kucserik

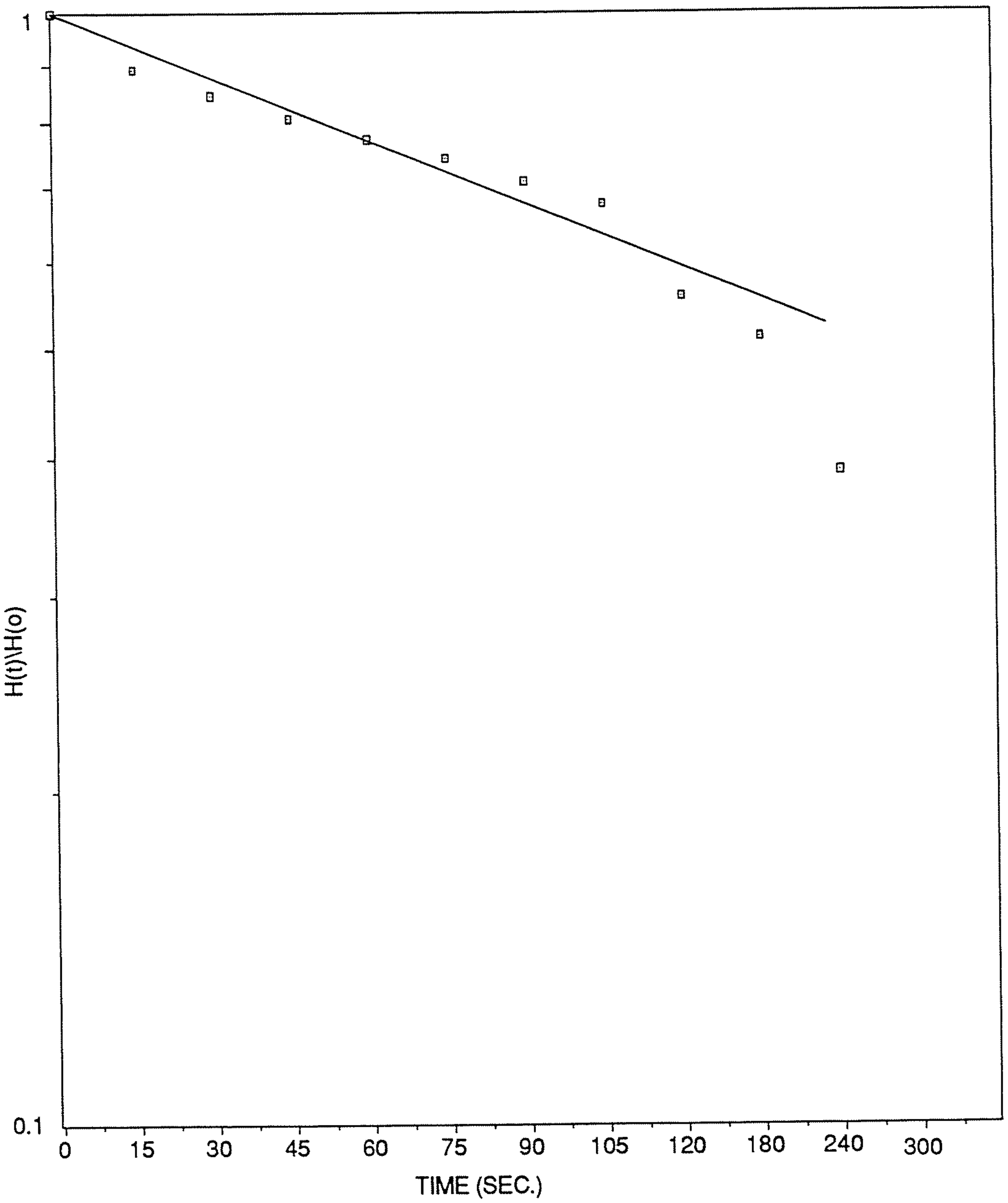
METHOD OF INVESTIGATION **Catoh Environmental Company Truck Mounted Drill Rig (Mobile B-61) w/Hollow Stem Augers (HSA), ASTM D-1586**

APPENDIX B: PERMEABILITY TEST RESULTS

TABLE 2

BORE HOLE MW-88-4C
PERMEABILITY TEST RESULTS

DEPTH INTERVAL (feet below grade)	JOINT PERMEABILITY (as "k" in cm/sec)
26.5 - 36.5	6.8×10^{-4}
36.5 - 46.5	1.4×10^{-3}
46.5 - 56.5	1.1×10^{-3}
56.5 - 66.5	8.0×10^{-4}
66.5 - 76.0	6.1×10^{-4}



THE ENVIRONMENTAL CONSULTING COMPANY

FIGURE 7A
BORING MW-88-4C
PERMEABILITY TEST NO. 1
DEPTH INTERVAL:26.5' - 36.5'

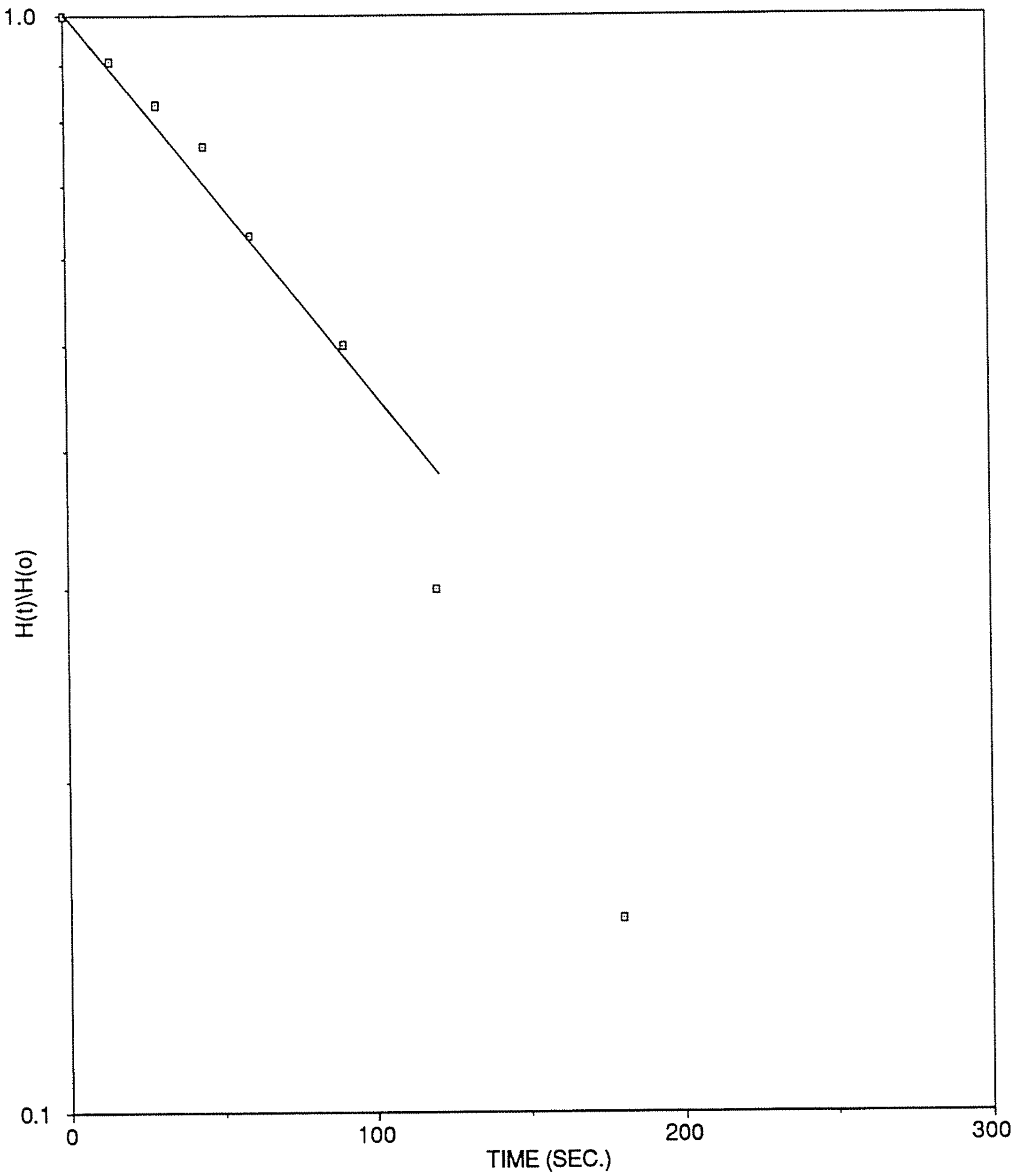


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FIGURE 7B
BORING MW-88-4C
PERMEABILITY TEST NO. 2
DEPTH INTERVAL:36.5' - 46.5'

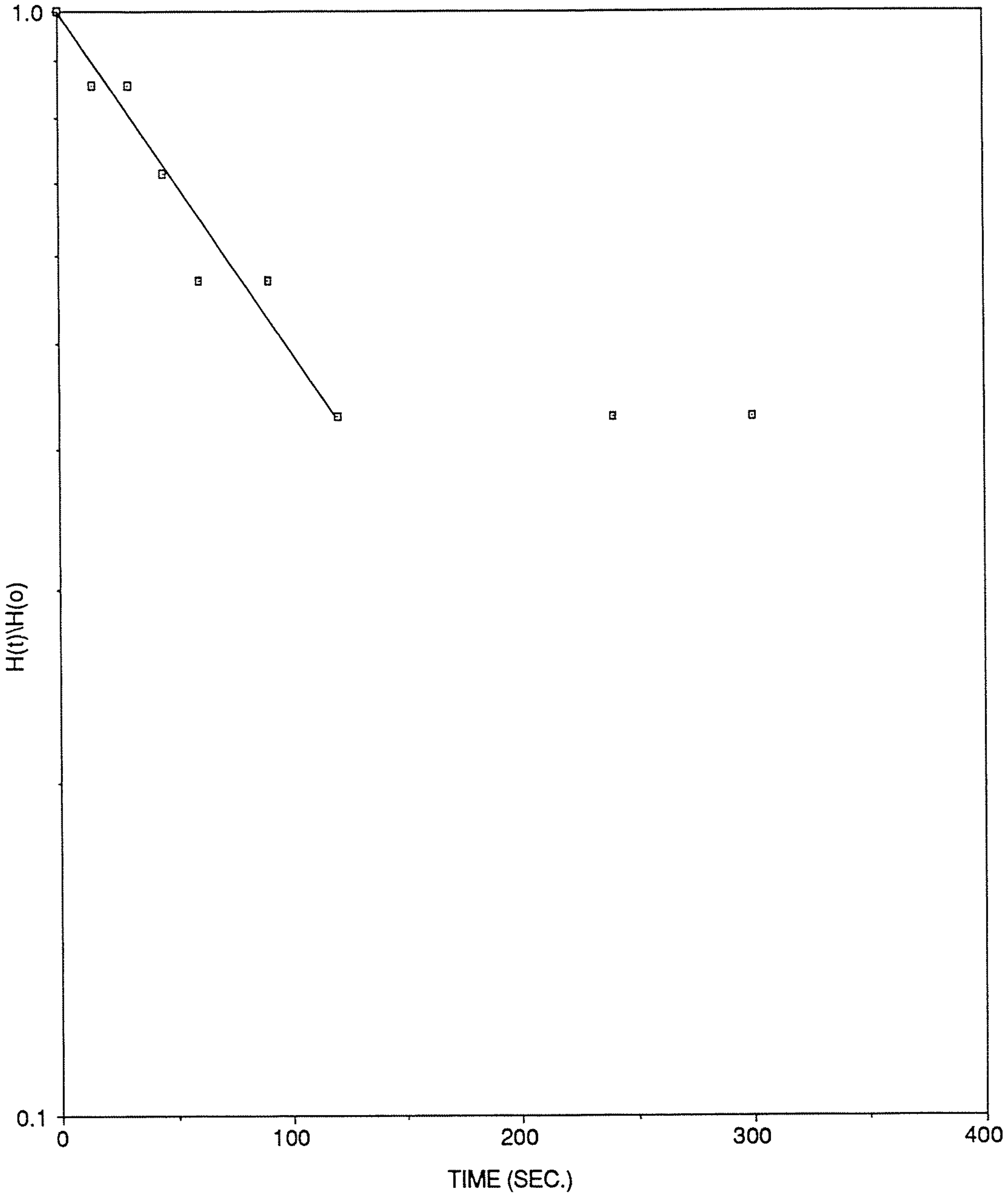

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FIGURE 7C
BORING MW-88-4C
PERMEABILITY TEST NO. 3
DEPTH INTERVAL:46.5' - 56.5'

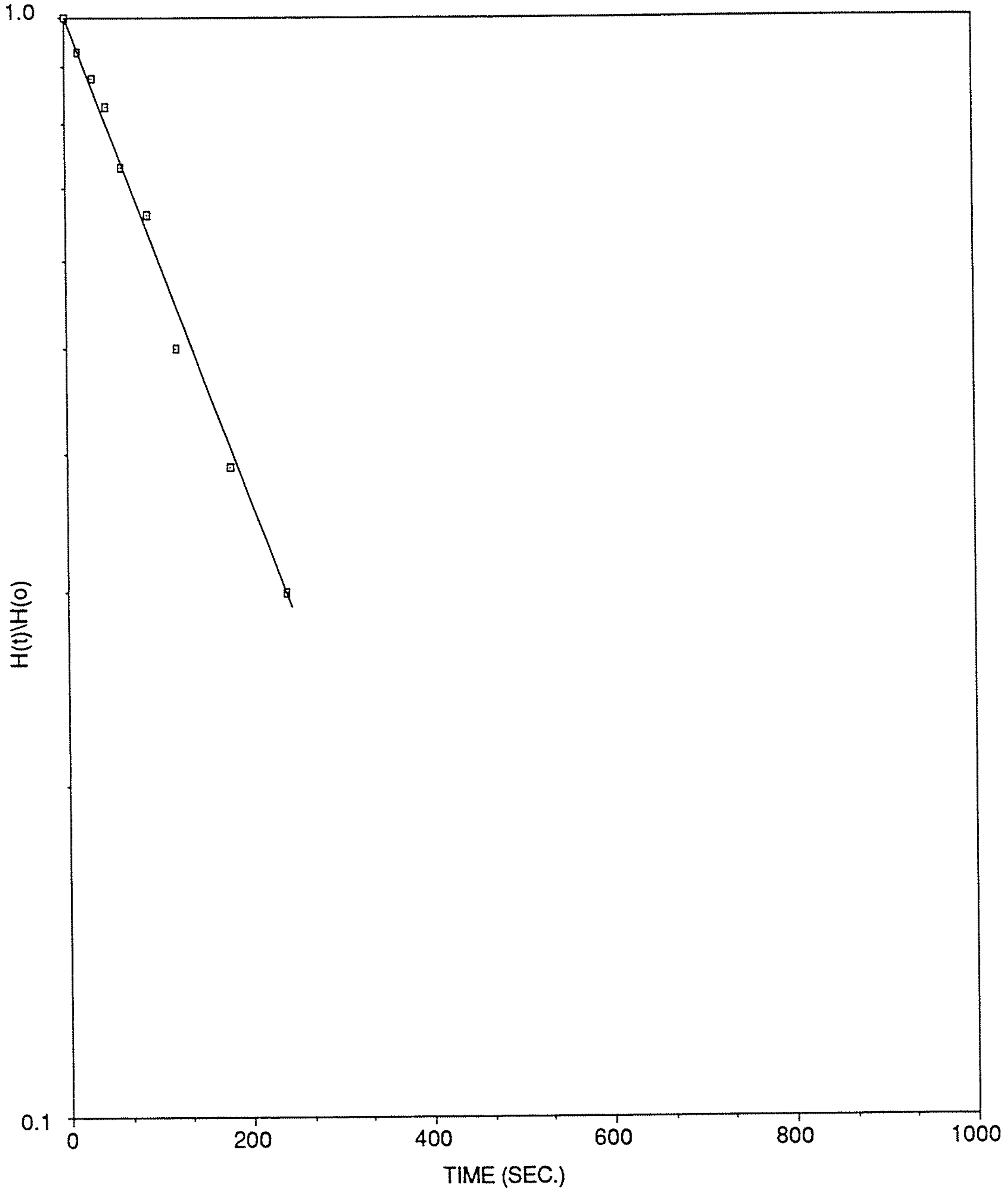

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FIGURE 7D
BORING MW-88-4C
PERMEABILITY TEST NO. 4
DEPTH INTERVAL:56.5' - 66.5'

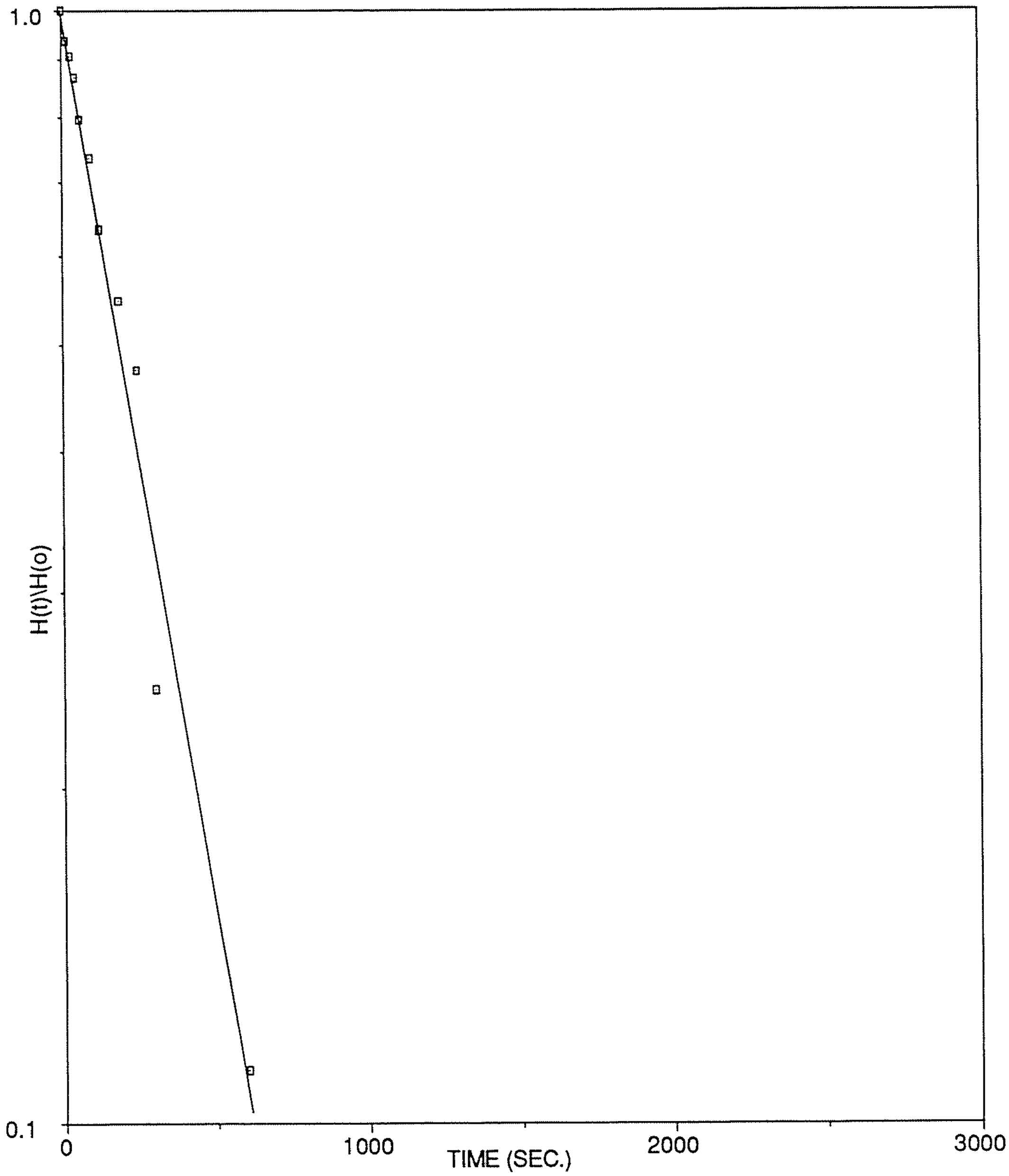

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FIGURE 7E
BORING MW-88-4C
PERMEABILITY TEST NO. 5
DEPTH INTERVAL:66.5' - 76.0'