FINAL

FIELD SAMPLING PLAN ADDENDUM
FOR THE
BACKGROUND GROUNDWATER CHARACTERIZATION AT MODERN LANDFILL
PREPARED IN SUPPORT OF THE REMEDIAL INVESTIGATION
NIAGARA FALLS STORAGE SITE

NIAGARA COUNTY, NEW YORK

Contract DACW-49-97-D-0001
Delivery Order 0012

Prepared For:

U.S. Army Corps of Engineers
Buffalo District
1776 Niagara Street
Buffalo, New York 14207-3199

February 2003
9905005

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Review Certification Sheet
For

Final Field Sampling Plan Addendum
For the
Background Groundwater Characterization at Modern Landfill Property
Prepared in Support of the Remedial Investigation
Niagara Falls Storage Site
Niagara County, New York

Prepared by:
Maxim Technologies, Inc.
St. Louis, Missouri

We, the undersigned, have reviewed and submitted our comments on the Draft Field Sampling Plan Addendum for the Background Groundwater Characterization. All internal comments have been resolved. We have reviewed and are in agreement with the resolution of external comments. We certify that this Final Document is ready for release to the Government.

Name	Date
Max Gricevich, Maxim Project Principal	2/14/03
Paul Smith, CHMM Maxim Analytical Services Coordinator	2/14/03
Thomas Lachajczyk, Maxim Project Manager	2/14/03

LIST OF ACRONYMS/ABBREVIATIONS

CRDL	Contract Required Detection Limit
DI	Deionized Water
FSP	Field Sampling and Analysis Plan
FUSRAP	Formerly Used Sites Remedial Action Program
IDL	Instrument Detection Limit
IDW	Investigation Derived Waste
L	Liters
Lpm	Liters/minute
MDL	Method Detection Limit
MSD	Matrix Spike Duplicate
NFSS	Niagara Falls Storage Site
NTU	Nephelormetric Turbidity Unit
ORP	Oxidation Reduction Potential
PID	Photo-Ionizing Detector
Q	Flow Rate
RI	Remedial Investigation
SAIC	Science Applications International Corporation
SM	Site Manager
SOW	Scope of Work
SVOC	Semi-Volatile Organic Compound
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
VOC	Volatile Organic Compound
WBZ	Water-Bearing Zone

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1.0 Introduction

This Field Sampling Plan (FSP) Addendum is a part of the ongoing Remedial Investigation (RI) being performed at the NFSS and is a supplement to the 1999 Field Sampling Plan. It describes the activities that will be performed to characterize background groundwater concentrations at the NFSS and is submitted in accordance with the statement of work for Delivery Order 12, Contract #: DACW49-97-D-0001.

The activities described in this document are based on the June 2002 Statement of Work (SOW), "*Background Groundwater Sampling",* issued by the Buffalo District, United States Army Corps of Engineers (USACE), and on decisions made during subsequent negotiations.

The following Data Quality Objectives were developed during Technical Planning Process meetings and were presented in the original Field Sampling Plan for this project:

- Obtain information of sufficient quantity and quality to meet the requirement of a site inspection as described in the directives entitled "Guidance for Performing Site Inspections Under CERCLA: USEPA Directives 93.151-05, September 1992";
- Obtain information of sufficient quantity and quality to meet the requirement for use in a risk assessment as described in the USEPA document, Guidance for Data Usability in Risk Assessment, April 1992;
- Obtain information of sufficient quantity and quality to meet the requirements for development of a Baseline Risk Assessment (BRA) based on USEPA Risk Assessment Guidance for Superfund (RAGS), 1989 and subsequent guidance documents;
- Obtain information of sufficient quantity and quality to identify sources of contamination and migration pathways to adequately characterize potential contamination at areas included in this investigation; and
- Install temporary well points and monitoring wells, and use the existing monitoring well network to collect groundwater samples and collect soil, sediment and surface water samples to obtain information of sufficient quantity and quality to determine if contaminants are migrating off-site or migrating on-site from off-site sources.

The above Data Quality Objectives were used to guide the development of this plan. In order to properly characterize the groundwater background conditions at the NFSS additional objectives were identified. Objectives for this task include:

- Determine the background concentrations of chemical and radiological parameters (described in Section 4) in both the upper and lower water-bearing zones. For each analytical parameter, two background data sets will be generated – one for the upper water-bearing zone and one for the lower water-bearing zone. Background concentrations for each parameter in each water-bearing zone will then be statistically determined. The methods of statistical analysis are presented under separate cover as a technical memorandum.

- Compare these background values to on-site groundwater results in order to determine which, if any, NFSS groundwater samples contain analytes at levels that exceed background. The methods of this comparison are presented under separate cover as a technical memorandum.

Background groundwater charachterization entails four primary activities. They are:

- Selection of representative background groundwater locations
- Groundwater sample collection and analysis,
- Statistical analysis of the analytical results and the preparation of a Comparative Memo, and
- Management of investigation derived waste (IDW).

The data and conclusions generated during the performance of this task will be an integral part of the site characterization and will be included in the Draft and Final Remedial Investigation Reports.

All background groundwater samples will be collected from existing wells on the portion of the Modern Landfill property described in the Right-of-Entry agreement between the USACE and Modern Landfill. The area covered by this agreement, and shown in Figure 1, is located adjacent to and southeast of the NFSS. Appendix A contains a copy of the agreement.

As required by the statement of work, Maxim and its subcontractor SAIC have supplied proof of insurance to the USACE for presentation to Modern Landfill in satisfaction of Right-of-Entry requirements.

The Site Manager for this task will be David Germeroth, P.E. During the field activities described in this plan, he may be reached at the site trailer at 716-754-9141.

2.0 Site Geology

The following is a summary of the geology and hydrogeology at the NFSS. The NFSS and the adjacent Modern Landfill site are located on the Ontario Lake Plain of the Erie-Ontario Lowland Physiographic Province, 3.5 miles east of the Niagara River and 4.0 miles south of Lake Ontario.

The following geological units are present at the NFSS and are described in order of depth from ground surface:

Surficial Soils and Fill - brown to yellowish silt with organic matter usually present in the root zone. Gravel and sands are generally encountered and are dispersed randomly throughout this unit. The thickness of surficial deposits range from zero to five feet.

Brown Clay Till - a silty clayey glacial till. Sandy gravel and gravelly sand lenses are common within the basal portion of the unit and the lateral extent and thickness of these lenses vary abruptly. The materials in the lenses are usually moist to saturated. The till varies in thickness from six to 23 feet. The upper (first) water-bearing zone is located in the Brown Clay Till (NFSS-084 and NFSS-302).

Glaciolacustrine Clay - gray clay of lacustrine origin that occasionally grades vertically to a silt and sand mixture. Post-depositional erosion of the unit is evident from channels along its upper surface, which are filled intermittently with the coarser grained sediments of the Brown Clay Till. Gravel is dispersed throughout the unit, as are lenses of fine to medium-grained sand. Sand and gravel become the primary constituents near the base of the unit. The clay is a fully saturated and competent semi-confining unit that is continuous across the vicinity of the NFSS. Thickness of the Glaciolacustrine Clay varies from less than five to 30 feet and is the thickest unconsolidated unit on site (NFSS-084 and NFSS-302).

Sand and Silt Outwash Unit - clean sand to mixtures of sand, gravel, and silt. The unit is thought to be glaciofluvial in origin and is normally wet to saturated. The Sand and Silt Outwash Unit contains the upper portion of the lower (second) water-bearing zone. The Sand and Silt Outwash Unit is approximately three to seven feet in thickness and occurs 15 to 28 feet below the ground surface (NFSS-084 and NFSS-302).

Basal Red Till - clayey gravelly silt with lesser amounts of sand. This unit is generally dry to moist, overconsolidated, and ranges from medium to very dense. The Basal Red Till varies in thickness and is absent in some locations at the site and is approximately zero to seven feet in thickness. Where present, it occurs 37 to 46 feet below the ground surface (NFSS-084 and NFSS-302).

Queenston Formation - brownish red and green shales, siltstone, and mudstone. The Queenston Formation is over 1,200 feet thick and the upper portion is slightly to moderately weathered and fractured. Calcite replacement and clays have been noted in some of the wider fractures. The Queenston Formation typically is encountered 32 to 49 feet below the ground surface. Because the Basal Red Till is discontinuous across the site, this unit is hydraulically connected to the Sand and Silt Outwash Unit (NFSS-084 and NFSS-302).

Two groundwater water-bearing zones have been identified at the NFSS, the upper water-bearing zone (in the Brown Clay Till) and a lower water-bearing zone (in the Sand and Silt Outwash Unit and the fractured and weathered upper portion of the Queenston Formation). The Glaciolacustrine Clay Unit separates the two zones, though wells screened in the Glaciolacustrine Clay Unit are considered to be in the upper water-bearing zone. These groundwater zones are not considered significant sources of groundwater, due to low well yield and/or high degree of mineralization. The natural principal groundwater flow direction in the lower water-bearing zone is north-northwest toward Lake Ontario, mimicking the gently sloping surface of the underlying strata. The upper water-bearing zone is found chiefly in discontinuous sand lenses and may be perched at many locations.

Some of the site documentation further divides the lower water-bearing zone into two subunits, separated by the Basal Red Till (NFSS-082 and NFSS-302). However, since the lateral extent and thickness of the Basal Red Till is highly variable across the NFSS and vicinity and water level responses in the weathered Queenston Formation and Sand and Silt Outwash Unit are similar, a hydraulic connection is evident between these two subunits.

Geochemical differences in the Sand and Silt Outwash Unit and the Queenston Formation (the two main water-bearing units within the lower water-bearing zone) may exist. In a personal communication between HydroGeoLogic, Inc. (HGL, the USACE groundwater contractor) and Maxim, HGL hypothesized that the groundwater in the deeper, unfractured portion of the Queenston Formation may be connate water and this deeper water could be released into the fractured portion of the Queenston Formation and, in turn, to the Basal Red Till and the Sand and Silt Outwash unit. However, the Sand and Silt Outwash Unit also derives a portion of its water as leakage through the overlying Glaciolacustrine Clay and from regional flow. The water resulting from the leakage and the regional flow is probably of meteoric origin. Thus, water in the Sand and Silt Outwash Unit, Basal Red Till and fractured Queenston Formation are mixtures of connate and meteoric water, although the proportion of connate water is probably highest in the Queenston Formation. Because the ratio of connate water to meteoric water may vary between the units, it is possible that geochemical differences exist in the groundwater in the different units. For this reason, wells and piezometers representative of all the component units of the lower water-bearing zone were selected.

The extent to which the Sand and Silt Outwash Unit is connected to the Queenston Formation will be determined by the three-dimensional regional numerical groundwater model currently being constructed for the NFSS and vicinity. This model may be useful for the Lake Ontario Ordnance Works investigation as well.

The current sampling plan will collect sufficient data to allow a characterization of the groundwater background conditions at the NFSS and vicinity, whether the groundwater system is considered to have two water-bearing zones or three.

As part of this RI, groundwater samples have been collected at the NFSS at approximately 150 locations. The samples were collected from both permanent wells and temporary well points and from both the upper and lower water-bearing zones. NFSS groundwater samples have been collected from:

- 30 wells, installed by the DOE, screened in the lower water-bearing zone
- 18 wells, installed by the DOE, screened in the upper water-bearing zone
- 15 wells, installed during the current RI, screened in the upper water-bearing zone
- 87 temporary well points, installed during the current RI, screened in the upper water-bearing zone.

3.0 Sample Locations

All background groundwater samples will be collected from the portion of the Modern Landfill site shown on Figure 1. Modern was selected because it was hydraulically upgradiant of the NFSS, within one mile of the site (assuring similar lithology), and had a sufficient number of available wells screened in the water-bearing zones of interest. Additionally, well construction and geology were documented for the Modern Landfill Site.

The feasibility of using other wells located further upgradiant from Modern was investigated. But all these other wells were installed for drinking or irrigation water purposes. Along with access issues (i.e. obtaining Right-of-Entry from various property owners), the well construction and geologic information was incomplete. The feasibility of installing new background wells was also investigated. However, there was a concern that installation of shallow wells would not supply adequate well volume for sampling.

All available analytical, well construction, and water level data for the wells located within the area covered by the Right-of-Entry were tabulated and evaluated. Twelve wells and piezometers are screened in the upper water-bearing zone. All of these wells were selected for sampling.

The selection process for wells within the area covered by the Right-of-Entry was as follows:

1. Wells GW-1A, GW-3A, GW-4A, W-14, W-1R2, and W-8R were screened across both water-bearing zones and were excluded from further consideration.
2. All wells/piezometers screened exclusively in the upper water-bearing zone were selected. Twelve wells in the upper water-bearing zone will be sampled.
3. For wells/piezometers screened in the lower water-bearing zone, the selection process consisted of the application of several criteria and then the selection of 18 wells/piezometers that best satisfied the criteria. The selection criteria were:

    A) Wells were favored over piezometers.
    B) Wells/piezometers with higher hydraulic conductivities were favored over those with lower hydraulic conductivities.
    C) The wells/piezometers were selected to provide a good spatial representation of the area covered by the Right-of-Entry.

D) The wells/piezometers were selected to provide a good representation of the geologic units that make up the lower water-bearing zone.
E) Preference was given to Modern wells/piezometers in which the screened lithology was similar to that encountered on the NFSS. Wells/piezometers on the Modern Landfill site that encountered the Sand and Silt Outwash Unit, the Basal Red Till or the Queenston formation at elevations substantially higher than the elevations those units were observed on the NFSS site were considered less suitable.

The wells and piezometers on the Modern Landfill site that are located within the area covered by the Right-of-Entry Agreement are listed on Table 1 and are shown on Figure 1. The sample designations are shown on Table 2.

4.0 Analytical Parameters, Methods, and Detection Limits

All groundwater samples collected for this task will be analyzed for the parameters shown in Table 3. Table 3 also shows method numbers, preservation requirements and holding times.

For this task, there are two modifications of the analytical protocols that have been in force for previous tasks:

- PAH concentrations will be determined using method 8310 in addition to 8270, and
- Organic compound data (volatile organic compounds, semi-volatile organic compounds, explosives, pesticides and PCBs) will be reported to the Method Detection Limit (MDL), rather than the Practical Quantitation Limit (PQL), to provide better comparability to screening criteria limits.

These two issues are discussed in greater detail in Appendix B.

The primary and Quality Control (QC) groundwater samples will be shipped to General Engineering Laboratories at the following address:

General Engineering Laboratories
Attn: Sample Custodian
3040 Savage Road
Charleston, SC 29407
Telephone: (843) 556-8171, Fax: (843) 766-1178

One Quality Assurance (QA) sample will be collected for this task and will be analyzed for the following parameters:

- VOA
- SVOA
- PEST/PCB
- Total Metals
- Uranium
- Thorium
- Radium 226/228

The QA laboratory for this task is:

Severn Trent Laboratories
c/o Diane Mueller
13715 Rider Trail North
Earth City, MO 63045
Phone: 314-298-8566

5.0 Groundwater Sample Collection

The low-flow procedure described below will be used to collect all groundwater samples for this task. The procedure is based on EPA/540/S-95/504, "*Low-Flow (Minimal Drawdown) Groundwater Sampling Procedures*" and EPA Region 2 "*Ground water Sampling Procedure, Low Stress (Low Flow) Purging and Sampling*" (Appendix C). Prior to purging and sampling, the field equipment will be calibrated in accordance with the manufacturer's instructions.

A schematic summary of this procedure is shown on Figure 2.

1) Using a PID, measure and record the well headspace VOC concentration. Using an electronic water-level indicator, measure and record the depth to groundwater, to the nearest 0.01 foot, relative to the top-of-casing elevation. After measuring the depth to groundwater, sound the total depth of the well with the water-level indicator.
2) Gently lower the pump into the well to approximately the elevation of the mid-point of the wetted portion of the screened interval. To the extent allowable by the project schedule, the pumps will be installed in wells 48 hours prior to pumping the well. This waiting period will allow any temporary increase in turbidity caused by the installation of the pumps to attenuate.
3) While monitoring the depth to groundwater, pump the well at a rate not exceeding 0.5 L/minute. Pump the well at the maximum allowable rate (not exceeding 0.5 L/minute) that causes little or no drawdown in the well. Ideally, the drawdown should be limited to no more than one foot. Notify the Site Manager if pump rates less than 0.1 L/minute cause a drawdown of more than one foot. This requirement may be difficult to achieve due to geologic heterogeneities within the screened interval, and may be relaxed in the field if the other sample collection method requirements can be satisfied. If the Site Manager believes that the recharge capacity of the subject well is too low to

allow sampling, sampling efforts at the subject well may be terminated and a different well may be substituted with approval of the USACE. Substitute wells are listed on Table 1. The substitute well with the most similar geohydraulic characteristics will be selected. Alternatively, the Site Manager may temporarily suspend pumping groundwater from the well. The pumps and/ or tubing will be left in the well and the well will be allowed to recover. After recovery, pumping will resume, with additional rest periods as necessary, until the well stabilizes and is sampled.

4) Continuously monitor in-line water quality indicator parameters (temperature, pH, conductivity, oxidation reduction potential (ORP), oxygen concentration, and turbidity). Record the values for these parameters every three to five minutes. Stabilization is defined as three successive readings for all parameters within the following ranges:

- pH: difference of no more than 0.1 units between the high and low readings,
- conductivity: relative percent difference between the high and low readings of no more than 3%,
- ORP: difference of no more than 10 mV between high and low readings,
- dissolved oxygen: relative percent difference between the high and low readings of no more than 10%, and
- turbidity: all readings less than 50 NTU and relative percent difference between the high and low readings of no more than 10%

Notify the Site Manager and Site Superintendent if the well does not stabilize within 3 hours. An inability to achieve stabilization may result in termination of pumping at the subject well and the selection of a different well for sampling, with the approval of the USACE. Substitute wells are listed on Table 1. The substitute well with the most similar geohydraulic characteristics will be selected.

An example calculation demonstrating the method by which relative percent difference will be determined is shown in Appendix D.

5) After the well has stabilized, disconnect the flow-through cell and fill sample containers directly from the pump in the following order:

- VOCs (3x40 ml vials)
- Radiological Parameters – Total (1 gallon)
- Gross Alpha/Beta –Total (1 L)
- Total Uranium (1L)
- Metals – Total (1 L)
- PAHs (1 L)

- Radiological Parameters – Dissolved (1 gallon)
- Gross Alpha/Beta – Dissolved (1 L)
- Total Uranium – Dissolved (1 L)
- Metals – Dissolved (1 L)
- SVOC (1 L)
- Pesticides/PCBs (2 L)
- Nitroaromatic Compounds (1 L)
- Radiological Parameters – Dissolved (1 gallon)*
- Radiological Parameters – Total (1 gallon)*
- SVOC (1 L)*

*These 'extra' containers provide additional sample volume in the event a sample container is damaged in transit or at the laboratory.

If the well offers a good response (i.e. rapid stability, minimal drawdown), and the response does not diminish through time, the order of the above list may be modified. If after filling the PAH container the well continues to show a good response, the Site Manager may instruct the field team to fill containers for SVOC, Pest/PCBs, and nitroaromatic compounds prior to filling the dissolved radiological and metals containers.

All dissolved samples will be filtered in the field using disposable, in-line 0.45-micron filters. If it is necessary to suspend sample collection while filling the PAH or SVOC bottles, the bottles will be capped. After all sample bottles are filled, the pumps will be removed from the well/piezometer.

While filling the sample containers, the pump rate should not be increased above that required to achieve well stabilization. Periodically measure the turbidity and recorded (i.e. at least once per sample container). If the turbidity exceeds 50 NTU, cease filling sample containers and continue to pump the well until the stabilization criteria are again satisfied.

The water level will be periodically measured and recorded (i.e. at least once per sample container) and if necessary the pump rate may be decreased to minimize the drawdown. Notify the Site Manager if it is necessary to decrease the pump rate to below 0.1 L/minute.

The date and time at which the first bottle of a given sample set is filled will be recorded on the chain-of-custody form and on all bottles of the sample set. Because of analytical laboratory's sample logging requirements, all bottles of a given sample set must have the same collection date and time. The times at which the individual sample containers are filled will be recorded in the field notes.

Electric submersible pumps (whale pumps) and an air bladder pump will be available for sampling wells. It is anticipated that most of the wells and piezometers will be sampled with electric submersible pumps. However, if the submersible pumps cannot maintain the necessary low flow, the wells may be sampled with the air bladder pump. In all cases, the pumps will be equipped with new Teflon tubing and the tubing will not be reused. When electric submersible pumps are used, new pumps will be dedicated to each well. The electric submersible pumps will not be reused in other wells.

A list of equipment required for the performance of the fieldwork for this task is shown in Appendix E. Table 2 shows the assigned sample names and quality control samples for this task.

6.0 Decontamination Procedures and Management of Investigation Derived Waste

To a large extent, only single-use and dedicated equipment will come in contact with the samples. New Teflon tubing will be used at each well. At wells sampled with submersible electric pumps, new dedicated pumps will be used at each well. All dissolved samples will be filtered using single-use in-line 0.45-micron filters.

The air bladder pump will be decontaminated after each use by pumping a mixture of Alconox soap and deionized (DI) water through the pump for five minutes. Afterwards, the pump will be rinsed by pumping DI water through it for five minutes. The pump will also be decontaminated at the site prior to any sampling activities. The PVC air delivery tubing will be replaced with new tubing prior to each use.

Water quality meter flow-through cells will be decontaminated after each use by washing the cells with an Alconox/DI mixture, followed by a DI rinse. The water quality probe will be decontaminated with a DI rinse.

During the sampling of background groundwater wells at the Modern Landfill Property, liquid IDW will be generated that consists of well purge and equipment decontamination water. As liquid IDW is generated at the groundwater monitoring well locations, it will be collected in portable plastic carboys. When a carboy is filled to capacity with liquid IDW, it will be transported back to the NFSS site and its contents poured into a dedicated heated plastic storage tank (approximately 1500 gallon capacity). The liquid IDW generated during the Modern Landfill groundwater sampling activities will remain in the dedicated storage tank until the City of Niagara Falls (CNF) Wastewater Treatment plant grants a temporary discharge permit. Once the temporary discharge permit is obtained, Maxim will have the liquid IDW transported by a vacuum/tanker truck to the treatment plant for discharge and subsequent treatment.

To receive a temporary discharge permit from the City of Niagara Falls (CNF) Wastewater Treatment plant, Maxim will characterize the IDW for wastewater discharge acceptance criteria parameters. The characterization will be based, in part, on analytical results from the Modern Landfill groundwater monitoring wells. This approach assumes that the collected groundwater will have the same chemical and radiological characteristics as the well purge and equipment decontamination water. Maxim contacted the CNF Industrial Monitoring coordinator and has received approval to use this approach for the characterization of the liquid IDW, with the following conditions:

1. A composite sample of the liquid IDW will be collected from the dedicated storage tank and will be analyzed for total organic carbon (TOC), total suspended solids (TSS), cyanides, and phosphorous. TOC and TSS will be analyzed since these parameters are the basis for the discharge fee charged by the CNF. Cyanides and phosphorous will be analyzed since they are on the local sewer ordinance parameter list.
2. The CNF has requested that the worst-case concentration for each parameter will be reported. Along with reporting concentrations for the acceptance criteria parameters, Maxim will report the wasteload for each parameter (#/discharge). In addition to reporting worst-case concentrations, Maxim will report the range and median of the concentrations to further characterize the liquid IDW generated at the Modern Landfill facility.

A summary of the groundwater chemical and radiological parameters/parameter groups that will be submitted to the CNF Industrial Monitoring coordinator for review is as follows:

1. Total Radionuclides
2. Total Uranium
3. Total Gross Alpha/Beta
4. VOCs
5. SVOCs
6. Total Metals
7. Pesticides/PCBs
8. Nitroaromatics
9. PAHs
10. TOC
11. TSS
12. Total Cyanides
13. Total Phosphorous

Approvals for discharge from both the CNF and NYSDEC are required before a discharge can be made to the CNF wastewater treatment plant. After all approvals are obtained, Maxim will contact a vacuum/tanker truck company to pump out the contents of the dedicated storage tank containing the Modern Landfill liquid IDW, transport the liquid IDW, and discharge it at the location specified by the CNF Industrial Monitoring Coordinator.

Based on past liquid IDW sampling events and the components of liquid IDW (primarily decontamination water), it is not anticipated that two phases will be encountered in the storage tank. However, if two phases are encountered, both will be sampled accordingly.

7.0 Subcontractor Activities

Sciences Applications International Corporation (SAIC) will provide health physics (HP) services for this task. SAIC will insure compliance with all regulations governing the shipment of potentially radioactive environmental samples. Also, SAIC will provide HP support, as necessary, for all sampling activities.

SAIC also provided an independent review of a pre-draft version of this document and will participate in the statistical determination of background concentrations. Appendix F contains SAIC's review comments.

8.0 Preparation of Comparative Memorandum

Maxim will evaluate the background groundwater analytical results and will compare the upper and lower water-bearing zone background groundwater results to the groundwater results for samples collected on the NFSS. The results of this comparison will be presented to the USACE as an interim deliverable, submitted no later than two weeks following the receipt of all analytical information.

8.1 Data Evaluation

As discussed in Section 1, the analytical results for each parameter, in both the upper and lower water-bearing zones, will be compiled into background data sets. Each data set will be evaluated separately. The evaluation will consist of two parts:

- An evaluation of site history, land use, and ownership, and
- An outlier test.

As part of the data evaluation, new information acquired after the submission of this FSP Addendum, along with the information used in the selection of the sample wells, will be reviewed. The analytical data generated by this task will be included in this review. This evaluation will include the development of data subsets, based on sample locations. Distribution parameters for these subsets, such as maximum, minimum, and median for will be evaluated to determine if the chemical results indicate that specific wells or areas of the site have been impacted by a previous land use and therefore are not suitable for background screening.

The available chemical data for wells on the Modern Landfill site does not indicate that the wells have been impacted by previous land uses. However, the available data is limited, both spatially and with respect to parameters of interest for the NFSS RI.

Inter-well variation will be evaluated by testing for outliers. An outlier is a value that is abnormally different than the other values in a given data set. Though there is no standard definition for "abnormally different", there are several standard statistical methods by which data that *may* be abnormally different can be identified. The following procedure will be used to identify potential outliers:

1) Histograms for each data set will be prepared and the data sets will be tested for normality and lognormality using the Shapiro-Wilk test with an alpha value of 0.05. Non-normal data sets will be log transformed prior to testing for lognormality using the Shapiro-Wilk test.
2) Grubbs' test will be used for normal and lognormal data sets to detect potential outliers at an alpha value of 0.01. For lognormal data sets, Grubbs' test will be performed on log-transformed data.
3) Box plots will be produced for data sets that are neither normal nor lognormal data sets and inner fence and outer fence values will be determined. Data points beyond the outer fences will be considered to be potential outliers.

The process of data evaluation will couple the consideration of site history with the determination of potential outliers in each data set. No data points will be excluded based solely on the results of any single part of the evaluation. Rather, specific data points will be proposed for exclusion only if the conclusions of the evaluation, taken as a whole, indicate that the specific data points are in fact "abnormally different" from the other members of the parent data set.

8.2 Data Comparisons

In support of the ongoing Remedial Investigation of the NFSS, NFSS groundwater data will be compared to background values for each analytical parameter. The purpose of this comparison, described in separate Technical Memorandum, is to help determine the magnitude of any contamination and to help delineate the extent of contamination at the NFSS.

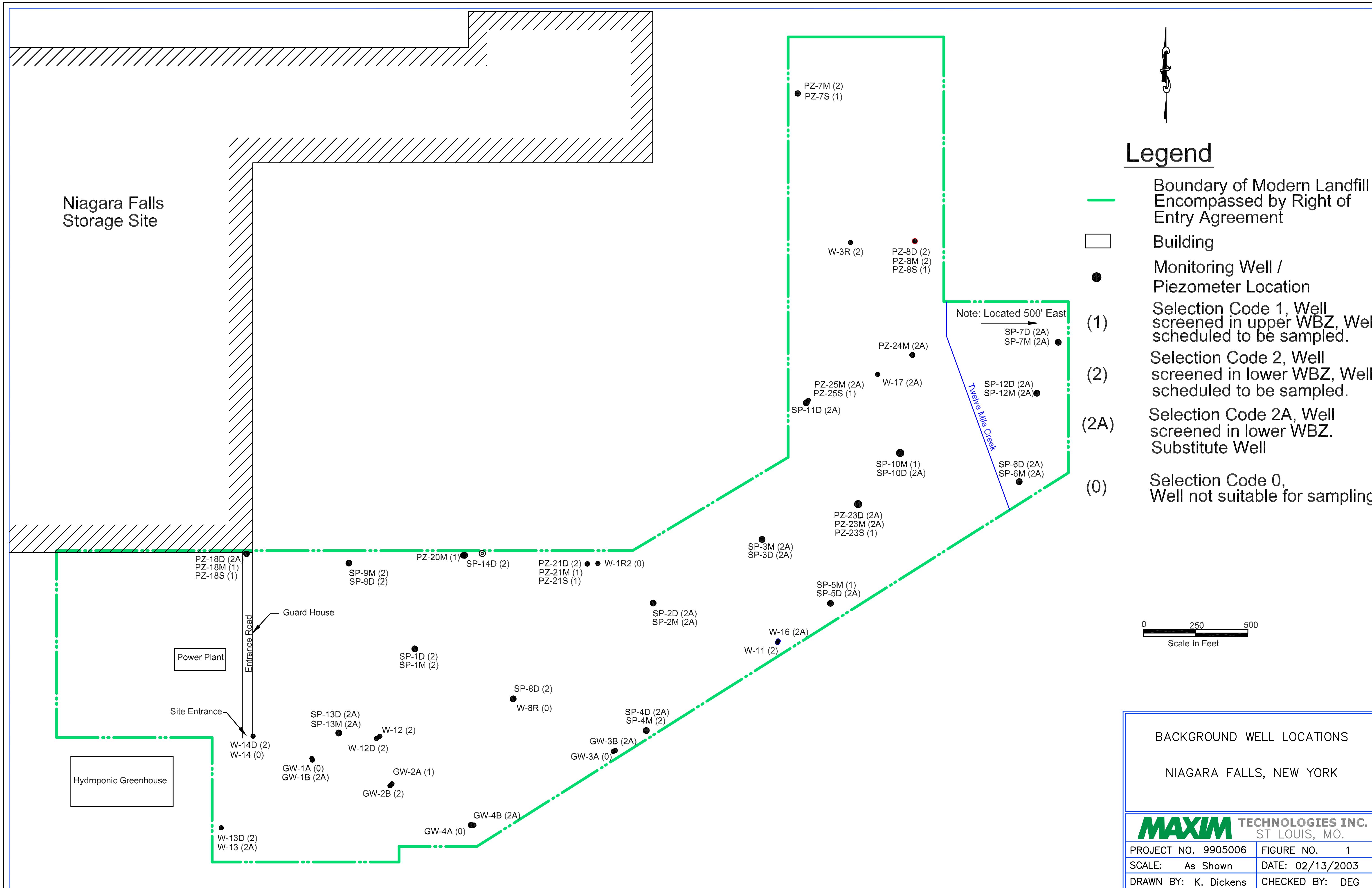

Niagara Falls
Storage Site
Legend
Boundary of Modern Landfill Encompassed by Right of Entry Agreement
Building
Monitoring Well / Piezometer Location
(1) Selection Code 1, Well screened in upper WBZ, Well scheduled to be sampled.
(2) Selection Code 2, Well screened in lower WBZ, Well scheduled to be sampled.
(2A) Selection Code 2A, Well screened in lower WBZ. Substitute Well
(0) Selection Code 0, Well not suitable for sampling.
0 250 500
Scale In Feet
Note: Located 500' East
PZ-7M (2)
PZ-7S (1)
W-3R (2)
PZ-8D (2)
PZ-8M (2)
PZ-8S (1)
SP-7D (2A)
SP-7M (2A)
PZ-24M (2A)
W-17 (2A)
PZ-25M (2A)
PZ-25S (1)
SP-11D (2A)
SP-12D (2A)
SP-12M (2A)
Twelve Mile Creek
SP-10M (1)
SP-10D (2A)
SP-6D (2A)
SP-6M (2A)
PZ-23D (2A)
PZ-23M (2A)
PZ-23S (1)
SP-3M (2A)
SP-3D (2A)
PZ-18D (2A)
PZ-18M (1)
PZ-18S (1)
SP-9M (2)
SP-9D (2)
PZ-20M (1)
SP-14D (2)
PZ-21D (2)
PZ-21M (1)
PZ-21S (1)
W-1R2 (0)
SP-5M (1)
SP-5D (2A)
SP-2D (2A)
SP-2M (2A)
Guard House
Entrance Road
W-16 (2A)
W-11 (2)
Power Plant
SP-1D (2)
SP-1M (2)
SP-8D (2)
W-8R (0)
Site Entrance
SP-13D (2A)
SP-13M (2A)
W-12 (2)
W-12D (2)
SP-4D (2A)
SP-4M (2)
GW-3B (2A)
GW-3A (0)
W-14D (2)
W-14 (0)
GW-1A (0)
GW-1B (2A)
GW-2A (1)
GW-2B (2)
Hydroponic Greenhouse
GW-4B (2A)
GW-4A (0)
W-13D (2)
W-13 (2A)
BACKGROUND WELL LOCATIONS
NIAGARA FALLS, NEW YORK
MAXIM TECHNOLOGIES INC.
ST LOUIS, MO.
PROJECT NO. 9905006
FIGURE NO. 1
SCALE: As Shown
DATE: 02/13/2003
DRAWN BY: K. Dickens
CHECKED BY: DEG

Figure 2
Decision Tree
Background Groundwater Sample Collection

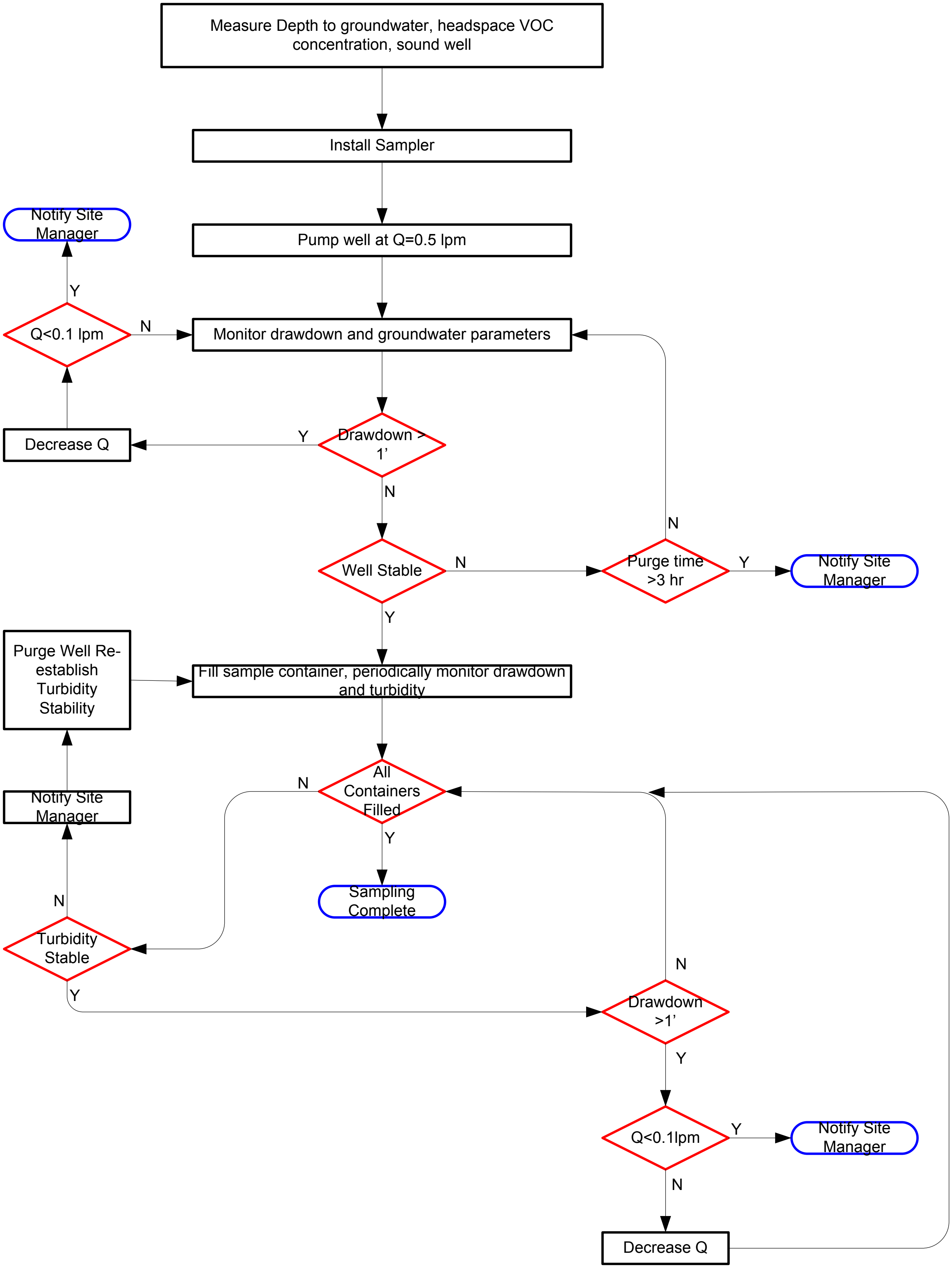


Table 1
Modern Landfill Wells

WELL	K (cm/sec)	DEPTH	Ground Elev.	Depth to Top of Screen	Depth to Btm of Screen	Elev. Top of Screen	Elev. Btm of Screen	Screen Length	Selection Code	Screened Units
GW-1A	1.1E-05	18.8	323.90	13.25	18.80	310.65	305.10	5.55	0	GLC, SSOW
GW-3A	msg	24.00	326.80	18.25	23.25	308.55	303.55	5.00	0	GLC, SSOW, BRT
W-1R2	msg	21.00	322.95	17.50	20.50	305.45	302.45	3.00	0	GLC, SSOW, BRC
W-14	msg	28.5	325.97	18.50	23.50	307.47	302.47	5.00	0	GLC, SSOW
W-8R	msg	20.0	322.33	14.00	19.00	308.33	303.33	5.00	0	GLC, SSOW
GW-4A	msg	24.5	326.80	19.00	24.50	307.80	302.30	5.50	0	GLC, BRT
SP-5M	msg	17.70	324.74	12.70	17.70	312.04	307.04	5.00	1	GLC, BCT
PZ-18M	4.7E-05	29.30	322.25	24.30	29.30	297.95	292.95	5.00	1	GLC
PZ-20M	1.3E-09	31.50	328.96	28.50	31.50	300.46	297.46	3.00	1	GLC
PZ-21M	8.7E-06	18.40	321.95	16.40	18.40	305.55	303.55	2.00	1	GLC
GW-2A	8.0E-05	18.4	324.30	13.35	18.35	310.95	305.95	5.00	1	GLC
SP-10M	msg	13.70	320.10	10.20	13.70	309.90	306.40	3.50	1	GLC
PZ-18S	4.5E-05	12.10	322.11	10.00	12.10	312.11	310.01	2.10	1	BCT
PZ-25S	1.7E-05	12.28	321.65	8.15	12.28	313.50	309.37	4.13	1	BCT
PZ-21S	2.7E-07	12.00	321.88	8.00	12.00	313.88	309.88	4.00	1	BCT
PZ-7S	msg	8.00	319.47	6.60	8.00	312.87	311.47	1.40	1	BCT
PZ-23S	1.3E-05	9.50	323.63	6.50	9.50	317.13	314.13	3.00	1	BCT
PZ-8S	9.8E-05	10.50	319.10	5.45	10.50	313.65	308.60	5.05	1	BCT
W-3R	msg	30.75	320.95	18.00	28.00	302.95	292.95	10.00	2	SSOW, BRT
W-12	msg	20.00	323.07	16.00	20.00	307.07	303.07	4.00	2	SSOW, BRT
PZ-7M	3.4E-03	40.90	319.27	35.85	40.90	283.42	278.37	5.05	2	SSOW
SP-9M	6.3E-04	29.90	322.73	25.10	29.90	297.63	292.83	4.80	2	SSOW
SP-1M	1.2E-04	24.70	323.11	21.70	24.70	301.41	298.41	3.00	2	SSOW
SP-4M	3.4E-05	19.40	322.29	18.30	19.40	303.99	302.89	1.10	2	SSOW
PZ-8M	9.2E-05	27.50	319.11	25.35	27.50	293.76	291.61	2.15	2	SSOW
SP-14D	msg	44.85	328.68	41.40	44.80	287.28	283.88	3.40	2	QFM
PZ-8D	1.3E-03	41.50	319.11	36.45	41.50	282.66	277.61	5.05	2	QFM
PZ-21D	2.7E-04	41.50	322.09	35.00	41.50	287.09	280.59	6.50	2	QFM
SP-9D	1.2E-03	44.20	322.67	34.80	44.20	287.87	278.47	9.40	2	QFM
SP-1D	2.5E-04	43.70	324.55	34.30	43.70	290.25	280.85	9.40	2	QFM
W-14D	msg	42.5	325.99	32.50	42.50	293.49	283.49	10.00	2	QFM
W-12D	msg	42.00	325.40	31.50	41.50	293.90	283.90	10.00	2	QFM
W-13D	msg	40.0	323.60	30.00	40.00	293.60	283.60	10.00	2	QFM
W-11	msg	33.0	323.81	27.50	32.32	296.31	291.49	4.82	2	QFM
SP-8D	1.6E-03	37.60	323.40	28.20	37.60	295.20	285.80	9.40	2	BRT
GW-2B	3.0E-03	29.6	326.12	23.90	29.60	302.22	296.52	5.70	2	BRT

Table 1
Modern Landfill Wells

WELL	K (cm/sec)	DEPTH	Ground Elev.	Depth to Top of Screen	Depth to Btm of Screen	Elev. Top of Screen	Elev. Btm of Screen	Screen Length	Selection Code	Screened Units
SP-12M	1.2E-06	13.90	321.87	10.20	13.90	311.67	307.97	3.70	2A	SSOW, BRT
W-13	msg	19.00	323.70	14.00	19.00	309.70	304.70	5.00	2A	SSOW, BRT
W-16	msg	18.5	323.83	12.33	16.33	311.50	307.50	4.00	2A	SSOW, BRT
PZ-23M	1.5E-07	13.10	323.94	12.10	13.80	311.84	310.14	1.70	2A	SSOW, BRT
W-17	msg	19.50	322.77	17.50	19.50	305.27	303.27	2.00	2A	SSOW
SP-2M	3.2E-04	18.90	324.78	16.70	18.90	308.08	305.88	2.20	2A	SSOW
SP-6M	1.4E-06	17.50	323.21	12.50	17.50	310.71	305.71	5.00	2A	SSOW
SP-3M	2.5E-05	14.50	325.68	12.50	14.50	313.18	311.18	2.00	2A	SSOW
PZ-18D	1.6E-04	50.60	321.93	43.60	50.60	278.33	271.33	7.00	2A	QFM
SP-11D	4.8E-05	44.20	322.54	35.60	44.20	286.94	278.34	8.60	2A	QFM
PZ-23D	1.4E-04	41.60	323.98	31.60	41.60	292.38	282.38	10.00	2A	QFM
SP-2D	1.0E-03	39.40	325.79	29.80	39.40	295.99	286.39	9.60	2A	QFM
SP-4D	msg	38.60	325.38	29.20	38.60	296.18	286.78	9.40	2A	QFM
SP-13D	3.0E-04	38.00	322.23	28.60	38.00	293.63	284.23	9.40	2A	QFM
SP-5D	msg	37.70	324.51	28.30	37.70	296.21	286.81	9.40	2A	QFM
GW-3B	5.1E-06	32.5	326.50	27.50	32.50	299.00	294.00	5.00	2A	QFM
SP-3D	1.9E-03	36.70	322.12	27.30	36.70	294.82	285.42	9.40	2A	QFM
GW-4B	msg	32.00	327.20	26.15	32.00	301.05	295.20	5.85	2A	QFM
SP-7D	3.6E-04	35.30	322.88	25.90	35.30	296.98	287.58	9.40	2A	QFM
SP-12D	3.9E-05	33.60	321.82	24.20	33.60	297.62	288.22	9.40	2A	QFM
SP-6D	6.3E-04	33.50	323.54	24.10	33.50	299.44	290.04	9.40	2A	QFM
SP-10D	6.0E-05	32.60	320.36	23.20	32.60	297.16	287.76	9.40	2A	QFM
SP-7M	msg	17.70	322.91	14.70	17.70	308.21	305.21	3.00	2A	QFM
GW-1B	9.1E-04	29.7	323.80	24.10	29.70	299.70	294.10	5.60	2A	BRT, QFM
PZ-25M	6.8E-07	21.50	321.94	19.40	21.50	302.54	300.44	2.10	2A	BRT
SP-13M	1.4E-06	20.00	322.55	16.50	20.00	306.05	302.55	3.50	2A	BRT
PZ-24M	3.4E-05	19.00	321.34	16.00	17.50	305.34	303.84	1.50	2A	BRT

BCT: Brown Clay Till, GLC: Glacio Lucustrine Clay, SSOW: Sand Silt Outwash, BRT: Basal Red Till, QFM: Queenston Formation

Selection Codes: 0) well not selected, 1) selected for upper water-bearing zone sample collection, 2) selected for lower water-bearing zone sample collection, 2A) substitute well, alternate selection for lower water-bearing zone sample collection

Table 2
Sample Designations

Sample ID	Well/ Piezometer	Water-Bearing Unit	Remarks
GW- PZ18M -U- 3100	PZ-18M	Upper	
GW- PZ18M -U- 9100	PZ-18M	Upper	QC Sample
GW- PZ20M -U- 3101	PZ-20M	Upper	
GW- PZ21M -U- 3102	PZ-21M	Upper	
GW- GW2A -U- 3103	GW-2A	Upper	
GW- SP10M -U- 3104	SP-10M	Upper	
GW- SP5M -U- 3105	SP-5M	Upper	
GW- PZ18S -U- 3106	PZ-18S	Upper	
GW- PZ25S -U- 3107	PZ-25S	Upper	
GW- PZ21S -U- 3108	PZ-21S	Upper	
GW- PZ7S -U- 3109	PZ-7S	Upper	
GW- PZ23S -U- 3110	PZ-23S	Upper	
GW- PZ8S -U- 3111	PZ-8S	Upper	
GW- W3R -L- 3112	W-3R	Lower	
GW- PZ7M -L- 3113	PZ-7M	Lower	
GW- PZ7M -L- 9113	PZ-7M	Lower	QC Sample
GW- SP9M -L- 3114	SP-9M	Lower	
GW- SP1M -L- 3115	SP-1M	Lower	
GW- PZ4M -L- 3116	PZ-4M	Lower	
GW- PZ8M -L- 3117	PZ-8M	Lower	
GW- W12 -L- 3118	W-12	Lower	
GW- SP14D -L- 3119	SP-14D	Lower	
GW- PZ8D -L- 3120	PZ-8D	Lower	MS/MSD
GW- PZ21D -L- 3121	PZ-21D	Lower	
GW- SP9D -L- 3122	SP-9D	Lower	MS/MSD
GW- SP1D -L- 3123	SP-1D	Lower	
GW- W14D -L- 3124	W-14D	Lower	
GW- W12D -L- 3125	W-12D	Lower	
GW- W13D -L- 3126	W-13D	Lower	
GW- W11 -L- 3127	W-11	Lower	
GW- SP8D -L- 3128	SP-8D	Lower	
GW- SP8D -L- 9128	SP-8D	Lower	QC Sample
GW- GW2B -L- 3129	GW2B	Lower	QA Sample
IDW-BCKGW-3130	--	--	Purge/Decon IDW sample

Table 3

SUMMARY OF PRESERVATION, STORAGE AND METHOD REQUIREMENTS FOR GROUNDWATER SAMPLES

Parameter	Preservative	Holding Time	Containers	Method
Volatile TCL Organics, Compounds (VOCs)	4C, No headspace, HCL, pH <2 and $Na_2S_2O_3$, if chlorinated	14 days	Three 40 ml glass vials, with Teflon-lined septum and screw caps	SW-846 5030B/8260B
Semi-Volatile TCL Organic Compounds (SVOCs)	4C	7 days until extraction, 40 days after extraction	1-liter amber with Teflon-lined lid	SW-846 3510C/8270C
Polycyclic Aromatic Hydrocarbons (PAHs)	4C	7 days until extraction, 40 days after extraction	1-liter amber with Teflon-lined lid	SW-846 8310
Total Metals	HNO_3, pH <2	6 months, except Hg 28 days	1-liter HDPE bottle with Teflon-lined lids	SW-846 3010A 6010B/6020/7470A
Dissolved Metals	Field filtered, HNO_3 pH <2	6 months, except Hg 28 days	1-liter HDPE bottle with Teflon-lined lids	SW-846 3005A 6010B/6020/7470A
Total Radionuclides (incl. Iso-U , Iso-Th, Ra-226, gamma spec (9 isotopes)	HNO_3, pH <2	6 months	1-gallon, HDPE bottle with Teflon-lined lids	HASL 300 (alpha; Th, U) HASL 300 (gamma) EPA 903.1 (Ra-226)
Diss. Radionuclides (incl. Iso-U , Iso-Th, Ra-226, gamma spec (9 isotopes)	Field Filtered, HNO_3, pH <2	6 months	1-gallon, HDPE bottle with Teflon-lined lids	HASL 300 (alpha; iso Th and U) HASL 300 (gamma) EPA 903.1 (Ra-226)
Gross alpha/beta (Total)	HNO_3, pH <2	6 months	1-liter, HDPE bottle with Teflon-lined lid	EPA 900 (gas-flow)
Gross alpha/beta (Dissolved)	Field Filtered, HNO_3, pH <2	6 months	1-liter, HDPE bottle with Teflon-lined lid	EPA 900 (gas-flow)
Total U	HNO_3, pH <2	6 months	1-liter, HDPE bottle with Teflon-lined lid	ASTM D5174
Total U (dissolved)	Field Filtered, HNO_3, pH <2	6 months	1-liter, high density polyethylene bottle with Teflon-lined lid	ASTM D5174
Pesticides/PCBs	4C	7 days until extraction, 40 days after extraction	Two 1-liter amber with Teflon-lined lids	SW-846 3510C/8081/8082
Nitroaromatics	4C	7 days until extraction, 40 days after extraction	1-liter amber with Teflon lids	SW-846/8330

Table 4
IDW Characterization Parameters

PARAMETER	ANALYTICAL METHOD	BOTTLE TYPE	PRESERVATION
Total Organic Carbon (TOC)	EPA 415.1	60-ml HDPE	pH<2; H_2SO_4; 4 ^{o} C
Total Suspended Solids (TSS)	EPA 160.2	250-ml HDPE	Cold; 4 ^{o} C
Cyanides	EPA 335.3	1-liter HDPE	pH>12; NaOH
Phosphorous	EPA 365.4	125-ml HDPE	pH<2; H_2SO_4; 4 ^{o} C

Note: TOC and phosphorous samples can be placed together in a 250-ml HDPE container.

Appendix A

Right-of-Entry Agreement

FAX TRANSMISSION

Corps of Engineers
Detroit District
Real Estate Division
BOX 1027
Detroit, MI 48231-1027
voice: (313)226-2510
fax: (313)226-2118
e-mail: don.c.erwin@LRE02.usace.army.mil

To:	Michelle Rhodes	**Date:**	December 2, 2002
Fax #:	716-879-4355 53	**Pages:**	4
From:	Don Erwin		
Subject:	Modem ROE		

COMMENTS:

Michelle,

ROE attached.

Don

DEPARTMENT OF THE ARMY
RIGHT-OF-ENTRY FOR SURVEY AND EXPLORATIONS
NO DACW35-9-03-

Niagara Falls Storage Site, NFSS FUSRAP

Modern Landfill, Inc.
Lewiston/Porter, New York

The undersigned, hereinafter called the "Owner," hereby grants to the UNITED STATES OF AMERICA hereinafter referred to as the "Government," a right-of-entry upon the following terms and conditions:

1. The Owner hereby grants to the Government and/or its contractors or authorized agents, an irrevocable right to enter upon the lands hereinafter described at any time within a period of one (1) year, beginning 25 November 2002 and ending 24 November 2003, to conduct sampling and other investigations of existing groundwater sampling locations on said lands as shown on figure 1, which is attached and incorporated herein by reference, and to carry out such other activities which may be necessary in regards to sampling and investigation of existing groundwater sampling locations; reserving to the landowner(s), their heirs, executors, administrators, successors and assigns, all such right, title, interest, and privilege as may be used and enjoyed without interfering with or abridging the rights and right-of-entry hereby acquired to complete the remedial investigation and feasibility study activities being made of said lands by the Government or its contractor under the Defense Environmental Restoration Program and Formerly Utilized Sites Remedial Action Programs.

2. This Right-of-entry may be revoked by either mutual consent of the Government and Owner or six months after the Owner gives written notice to the Government of its intent to revoke the Right-of-entry. The revocation is effective six months from the date the Government receives written notice of the revocation.

3. This right-of-entry includes the right of ingress and egress on other lands of the Owner not described below, provided such ingress and egress is necessary and not otherwise available to the Government.

4. All tools, equipment, and other property taken upon or placed upon the land by the Government shall remain the property of the Government and may be removed by the Government at any time within a reasonable period after the expiration of this right-of-entry.

5. If any action of the Government's employees and agents in the exercise of the right-of-entry results in damage to the real property, the Government will, at its option, either repair such damage or make an appropriate settlement with the Owner. In no event shall such repair or settlement exceed the fair market value of the fee interest of the real property at the time immediately preceding such damage. The Government's liability under this clause may not exceed appropriations available for such payment and nothing contained in this agreement may be considered as implying that Congress will at a later date appropriate funds sufficient to meet deficiencies. The provisions of this clause are without prejudice to any rights the Owner may have to make a claim under applicable laws for any other damages than provided herein.

6. If aircraft flights over said land, or entry upon the land by means of helicopter or other types of aircraft, are necessary, the Government shall inform the Owner, in advance, of each such flight or entry.

DACW35-9-03-

7. The land affected by this right-of-entry is located in the towns of Lewiston and Porter, county of Niagara, State of New York, and is described on attached Figure 1.

8. If the Government contractor proposes the sampling of "W" designated wells, no surging will be performed and low flow pumping techniques will be used that do not exceed flow rates of one (1) liter per minute.

9. A two-week minimum advance written notice will be provided to the Owner prior to conducting fieldwork on the Owner's property. Required site visits not involving fieldwork (i.e., site tours, etc.) will require telephonic notification to the Owner at (716)754-8226, prior to entry onto the Owner's property.

10. The Government's Contractor shall name the Owner as an additional insured on any insurance policies providing coverage for any claims for injury to persons or property as may be made related to the Government's Contractor's Activities under this Right-of-Entry and shall provide the Owner a copy of the Certificate of Insurance evidencing same.

11. The Government shall provide, if allowable under applicable laws, regulations, and policies, the Owner with the results of any and all studies, testing, analyses, samples and data of any kind generated during the performance, implementation and completion of the ground water sampling.

12. The Owner will be allowed access to and the use of the finalized regional numerical model under development for the Niagara Falls Storage Site project.

13. The Owner will review the Work Plan for any work to be conducted on their property prior to its execution. Revisions to Work Plans shall be based upon terms mutually agreeable to Government and the Owner.

14. Any notice, request, demand, or other communication made as required by this Right-of-Entry shall be deemed to have been received by the addressee at the earlier of such time as it is actually received or seven calendar days after it is mailed.

WITNESS MY HAND AND SEAL THIS 27 day of Nov. 2002.

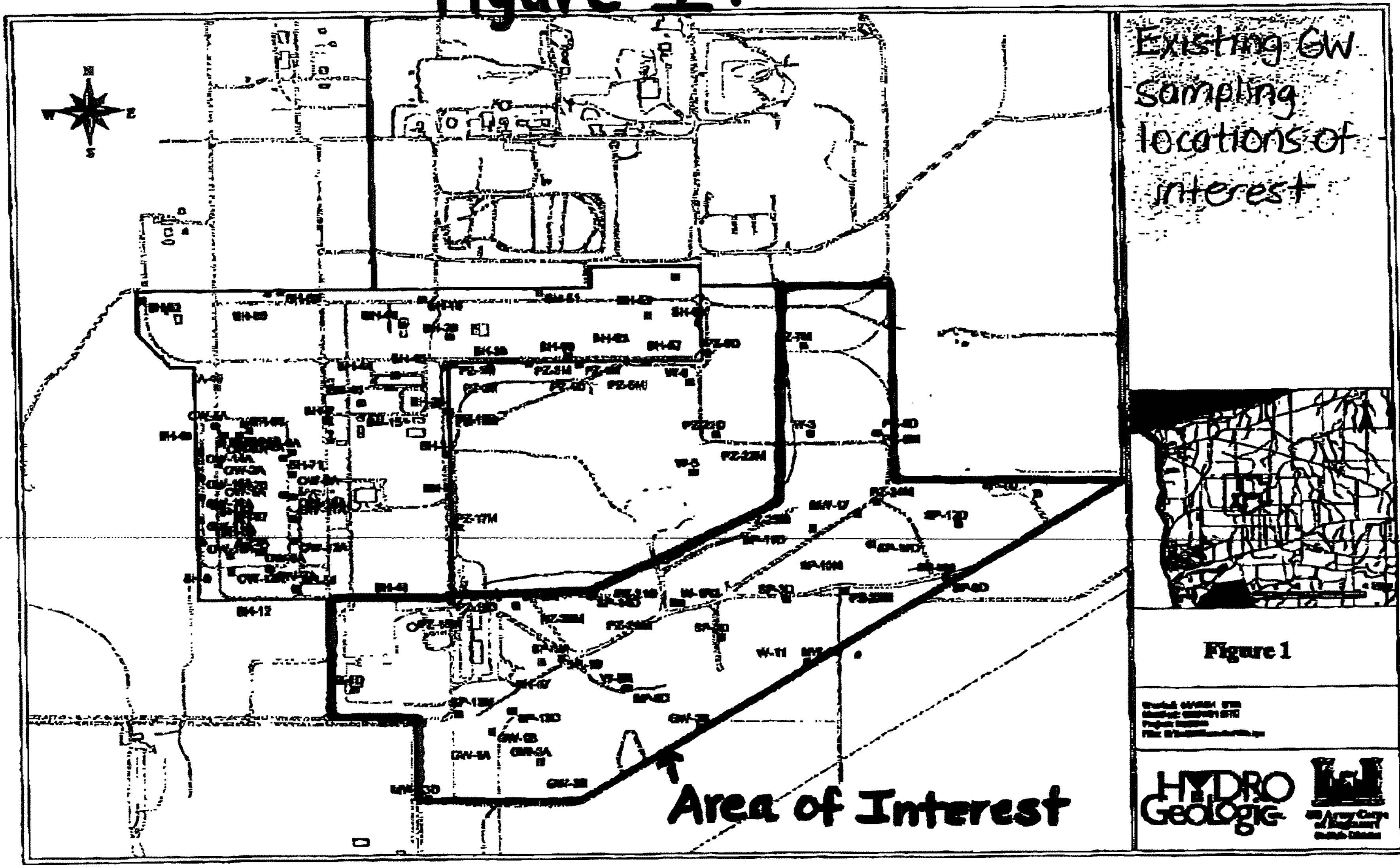
MODERN LANDFILL, INC

By: [signature]
GARY E. SMITH
~~President~~ COO

Accepted:
DEPARTMENT OF ARMY

By: [signature]
VICTOR L. KOTWICKI
Chief, Real Estate Division
Detroit District

Figure 1:


Existing GW sampling locations of interest
Figure 1
Area of Interest
HYDRO GeoLogic
N
S
E
W
SH-12
PZ-17M
W-11

NO DACW35-9-03-

NOTE: THE CERTIFICATE OF AUTHORITY must be executed by an individual <u>other</u> than by the person who signed the right-of-entry. The individual must certify that the official who signed the right-of-entry was authorized to act in that capacity.

CERTIFICATE OF AUTHORITY

I, Lorie L. Washuta, do hereby certify that I am the
(someone other than the person signing the agreement)

Secretary of Modern Landfill Inc. and
(my position of responsibility within the organization)

that Gary E. Smith,

who signed the right-of-entry on behalf of Modern Landfill Inc.,

was at the time of signature its COO,
(position held)

and that the person who executed the right-of-entry behalf of Modern Landfill Inc. acted within his/her authority.

IN WITNESS WHEREOF, I have made and executed this certification this 29th day of November, 2002.

[signature]
(Name)

Secretary
(Title)

Appendix B

Discussion of Additional Analytical Methods and Modified Detection Limits

1.0 PARAMETERS/METHODS

A listing of the analytical parameters for sample collection and analysis, preservation requirements, holding times, containers, and associated methodologies is presented in the table titled "Summary of Collection, Preservation, Method and Storage Requirements for Groundwater Samples".

1.1 PAH's by HPLC (8310)

In addition to sample fractions being collected for semi-volatile organic compounds by GC/MS methodology - 8270, additional fractions will also be collected for Polycyclic Aromatic Hydrocarbons (PAHs) analysis by method 8310. This inclusion of PAHs by 8310 will result in PAH data with reporting limits an order of magnitude lower than those generated by the formerly used method for PAHs - 8270. The PAH fractions will be reported for both sets of analyses with each of their respective reporting limits and sample results for the PAHs will be differentiated by both the method and fraction as follows:

Parameter	Fraction	Method
PAHs	SVOC	8270
PAHs	PAH	8310

1.2 REVISED REPORTING CRITERIA

In an effort to generate data more supportive of risk-based work based upon the evaluation of sample data to established screening criteria, a modification of the current reporting requirements were necessary. The current reporting requirements established Contract Required Detection Limits (CRDLs) based upon the Contract Laboratory Program (CLP) default values. These CRDLs or Practical Quantitation Limits (PQLs) were generated based upon a high level of confidence with the non-detect and reported values and were typically between the range of 4 to 10 times the statistically determined Method Detection Limits (MDLs) or Instrument Detection Limits (IDLs).

Commencing with this project will be the utilization of MDL or IDL data as the default reporting limits rather than the CRDLs. Therefore, non-detect data will be reported down to the MDL (or IDL) which will allow for better comparability with many of the established screening criteria regulatory limits. This modification essentially only effects the organic data fractions (i.e. Volatile Organic Compounds, Semi-Volatile Organic Compounds, PAHs, Pesticides, PCBs and Nitroaromatics) since the radiological and metals fractions will continue to be reported to the IDLs. Detected concentrations of organic compounds less than the RL (CRDL), utilizing the new reporting requirements, will be reported as estimated ("J" qualified). The reporting forms will be modified to allow for implementation of this reporting modification. Both hardcopy and electronic database data will utilize the MDL/IDL reporting criteria and be reflective of this reporting limit modification.

Appendix C
EPA Guidance, Low-Flow Sample Collection

United States Environmental Protection Agency | Office of Research and Development | Office of Solid Waste and Emergency Response | EPA/540/S-95/504 April 1996

Ground Water Issue

LOW-FLOW (MINIMAL DRAWDOWN) GROUND-WATER SAMPLING PROCEDURES

by Robert W. Puls[1] and Michael J. Barcelona[2]

Background

The Regional Superfund Ground Water Forum is a group of ground-water scientists, representing EPA's Regional Superfund Offices, organized to exchange information related to ground-water remediation at Superfund sites. One of the major concerns of the Forum is the sampling of ground water to support site assessment and remedial performance monitoring objectives. This paper is intended to provide background information on the development of low-flow sampling procedures and its application under a variety of hydrogeologic settings. It is hoped that the paper will support the production of standard operating procedures for use by EPA Regional personnel and other environmental professionals engaged in ground-water sampling.

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I. Introduction

The methods and objectives of ground-water sampling to assess water quality have evolved over time. Initially the emphasis was on the assessment of water quality of aquifers as sources of drinking water. Large water-bearing units were identified and sampled in keeping with that objective. These were highly productive aquifers that supplied drinking water via private wells or through public water supply systems. Gradually, with the increasing awareness of subsurface pollution of these water resources, the understanding of complex hydrogeochemical processes which govern the fate and transport of contaminants in the subsurface increased. This increase in understanding was also due to advances in a number of scientific disciplines and improvements in tools used for site characterization and ground-water sampling. Ground-water quality investigations where pollution was detected initially borrowed ideas, methods, and materials for site characterization from the water supply field and water analysis from public health practices. This included the materials and manner in which monitoring wells were installed and the way in which water was brought to the surface, treated, preserved and analyzed. The prevailing conceptual ideas included convenient generalizations of ground-water resources in terms of large and relatively homogeneous hydrologic *units*. With time it became apparent that conventional water supply generalizations of *homogeneity* did not adequately represent field data regarding pollution of these subsurface resources. The important role of *heterogeneity* became increasingly clear not only in geologic terms, but also in terms of complex physical,

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chemical and biological subsurface processes. With greater appreciation of the role of heterogeneity, it became evident that subsurface pollution was ubiquitous and encompassed the unsaturated zone to the deep subsurface and included unconsolidated sediments, fractured rock, and *aquitards* or low-yielding or impermeable formations. Small-scale processes and heterogeneities were shown to be important in identifying contaminant distributions and in controlling water and contaminant flow paths.

It is beyond the scope of this paper to summarize all the advances in the field of ground-water quality investigations and remediation, but two particular issues have bearing on ground-water sampling today: aquifer heterogeneity and colloidal transport. Aquifer heterogeneities affect contaminant flow paths and include variations in geology, geochemistry, hydrology and microbiology. As methods and the tools available for subsurface investigations have become increasingly sophisticated and understanding of the subsurface environment has advanced, there is an awareness that in most cases a primary concern for site investigations is characterization of contaminant flow paths rather than entire aquifers. In fact, in many cases, plume thickness can be less than well screen lengths (e.g., 3-6 m) typically installed at hazardous waste sites to detect and monitor plume movement over time. Small-scale differences have increasingly been shown to be important and there is a general trend toward smaller diameter wells and shorter screens.

The hydrogeochemical significance of colloidal-size particles in subsurface systems has been realized during the past several years (Gschwend and Reynolds, 1987; McCarthy and Zachara, 1989; Puls, 1990; Ryan and Gschwend, 1990). This realization resulted from both field and laboratory studies that showed faster contaminant migration over greater distances and at higher concentrations than flow and transport model predictions would suggest (Buddemeier and Hunt, 1988; Enfield and Bengtsson, 1988; Penrose et al., 1990). Such models typically account for interaction between the mobile aqueous and immobile solid phases, but do not allow for a mobile, reactive solid phase. It is recognition of this third *phase* as a possible means of contaminant transport that has brought increasing attention to the manner in which samples are collected and processed for analysis (Puls et al., 1990; McCarthy and Degueldre, 1993; Backhus et al., 1993; U. S. EPA, 1995). If such a phase is present in sufficient mass, possesses high sorption reactivity, large surface area, and remains stable in suspension, it can serve as an important mechanism to facilitate contaminant transport in many types of subsurface systems.

Colloids are particles that are sufficiently small so that the surface free energy of the particle dominates the bulk free energy. Typically, in ground water, this includes particles with diameters between 1 and 1000 nm. The most commonly observed mobile particles include: secondary clay minerals; hydrous iron, aluminum, and manganese oxides; dissolved and particulate organic materials, and viruses and bacteria. These reactive particles have been shown to be mobile under a variety of conditions in both field studies and laboratory column experiments, and as such need to be included in monitoring programs where identification of the *total* mobile contaminant loading (dissolved + naturally suspended particles) at a site is an objective. To that end, sampling methodologies must be used which do not artificially bias *naturally* suspended particle concentrations.

Currently the most common ground-water purging and sampling methodology is to purge a well using bailers or high speed pumps to remove 3 to 5 casing volumes followed by sample collection. This method can cause adverse impacts on sample quality through collection of samples with high levels of turbidity. This results in the inclusion of otherwise immobile artifactual particles which produce an overestimation of certain analytes of interest (e.g., metals or hydrophobic organic compounds). Numerous documented problems associated with filtration (Danielsson, 1982; Laxen and Chandler, 1982; Horowitz et al., 1992) make this an undesirable method of rectifying the turbidity problem, and include the removal of potentially mobile (contaminant-associated) particles during filtration, thus artificially biasing contaminant concentrations low. Sampling-induced turbidity problems can often be mitigated by using low-flow purging and sampling techniques.

Current subsurface conceptual models have undergone considerable refinement due to the recent development and increased use of field screening tools. So-called hydraulic *push* technologies (e.g., cone penetrometer, Geoprobe®, QED HydroPunch®) enable relatively fast screening site characterization which can then be used to design and install a monitoring well network. Indeed, alternatives to conventional monitoring wells are now being considered for some hydrogeologic settings. The ultimate design of any monitoring system should however be based upon adequate site characterization and be consistent with established monitoring objectives.

If the sampling program objectives include accurate assessment of the magnitude and extent of subsurface contamination over time and/or accurate assessment of subsequent remedial performance, then some information regarding plume delineation in three-dimensional space is necessary prior to monitoring well network design and installation. This can be accomplished with a variety of different tools and equipment ranging from hand-operated augers to screening tools mentioned above and large drilling rigs. Detailed information on ground-water flow velocity, direction, and horizontal and vertical variability are essential baseline data requirements. Detailed soil and geologic data are required prior to and during the installation of sampling points. This includes historical as well as detailed soil and geologic logs which accumulate during the site investigation. The use of borehole geophysical techniques is also recommended. With this information (together with other site characterization data) and a clear understanding of sampling objectives, then appropriate location, screen length, well diameter, slot size, etc. for the monitoring well network can be decided. This is especially critical for new in situ remedial approaches or natural attenuation assessments at hazardous waste sites.

In general, the overall goal of any ground-water sampling program is to collect water samples with no alteration in water chemistry; analytical data thus obtained may be used for a variety of specific monitoring programs depending on the regulatory requirements. The sampling methodology described in this paper assumes that the monitoring goal is to sample monitoring wells for the presence of contaminants and it is applicable whether mobile colloids are a concern or not and whether the analytes of concern are metals (and metalloids) or organic compounds.

II. Monitoring Objectives and Design Considerations

The following issues are important to consider prior to the design and implementation of any ground-water monitoring program, including those which anticipate using low-flow purging and sampling procedures.

A. Data Quality Objectives (DQOs)

Monitoring objectives include four main types: detection, assessment, corrective-action evaluation and resource evaluation, along with *hybrid* variations such as site-assessments for property transfers and water availability investigations. Monitoring objectives may change as contamination or water quality problems are discovered. However, there are a number of common components of monitoring programs which should be recognized as important regardless of initial objectives. These components include:

1) Development of a conceptual model that incorporates elements of the regional geology to the local geologic framework. The conceptual model development also includes initial site characterization efforts to identify hydrostratigraphic units and likely flow-paths using a minimum number of borings and well completions;

2) Cost-effective and well documented collection of high quality data utilizing simple, accurate, and reproducible techniques; and

3) Refinement of the conceptual model based on supplementary data collection and analysis.

These fundamental components serve many types of monitoring programs and provide a basis for future efforts that evolve in complexity and level of spatial detail as purposes and objectives expand. High quality, reproducible data collection is a common goal regardless of program objectives.

High quality data collection implies data of sufficient accuracy, precision, and completeness (i.e., ratio of valid analytical results to the minimum sample number called for by the program design) to meet the program objectives. Accuracy depends on the correct choice of monitoring tools and procedures to minimize sample and subsurface disturbance from collection to analysis. Precision depends on the repeatability of sampling and analytical protocols. It can be assured or improved by replication of sample analyses including blanks, field/lab standards and reference standards.

B. Sample Representativeness

An important goal of any monitoring program is collection of data that is truly representative of conditions at the site. The term *representativeness* applies to chemical and hydrogeologic data collected via wells, borings, piezometers, geophysical and soil gas measurements, lysimeters, and temporary sampling points. It involves a recognition of the statistical variability of individual subsurface physical properties, and contaminant or major ion concentration levels, while explaining extreme values. Subsurface temporal and spatial variability are facts. Good professional practice seeks to maximize representativeness by using proven accurate and reproducible techniques to define limits on the distribution of measurements collected at a site. However, measures of representativeness are dynamic and are controlled by evolving site characterization and monitoring objectives. An evolutionary site characterization model, as shown in Figure 1, provides a systematic approach to the goal of consistent data collection.

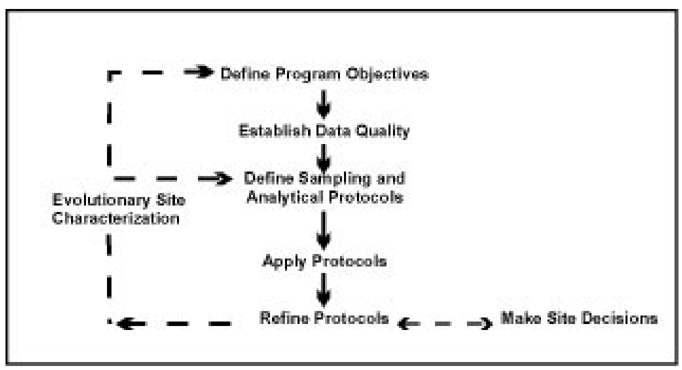

Figure 1. Evolutionary Site Characterization Model

The model emphasizes a recognition of the causes of the variability (e.g., use of inappropriate technology such as using bailers to purge wells; imprecise or operator-dependent methods) and the need to control avoidable errors.

1) Questions of Scale

A sampling plan designed to collect representative samples must take into account the potential scale of changes in site conditions through space and time as well as the chemical associations and behavior of the parameters that are targeted for investigation. In subsurface systems, physical (i.e., aquifer) and chemical properties over time or space are not statistically independent. In fact, samples taken in close proximity (i.e., within distances of a few meters) or within short time periods (i.e., more frequently than monthly) are highly auto-correlated. This means that designs employing high-sampling frequency (e.g., monthly) or dense spatial monitoring designs run the risk of redundant data collection and misleading inferences regarding trends in values that aren't statistically valid. In practice, contaminant detection and assessment monitoring programs rarely suffer these *over-sampling* concerns. In corrective-action evaluation programs, it is also possible that too little data may be collected over space or time. In these cases, false interpretation of the spatial extent of contamination or underestimation of temporal concentration variability may result.

2) Target Parameters

Parameter selection in monitoring program design is most often dictated by the regulatory status of the site. However, background water quality constituents, purging indicator parameters, and contaminants, all represent targets for data collection programs. The tools and procedures used in these programs should be equally rigorous and applicable to all categories of data, since all may be needed to determine or support regulatory action.

C. Sampling Point Design and Construction

Detailed site characterization is central to all decision-making purposes and the basis for this characterization resides in identification of the geologic framework and major hydro-stratigraphic units. Fundamental data for sample point location include: subsurface lithology, head-differences and background geochemical conditions. Each sampling point has a proper use or uses which should be documented at a level which is appropriate for the program's data quality objectives. Individual sampling points may not always be able to fulfill multiple monitoring objectives (e.g., detection, assessment, corrective action).

1) Compatibility with Monitoring Program and Data Quality Objectives

Specifics of sampling point location and design will be dictated by the complexity of subsurface lithology and variability in contaminant and/or geochemical conditions. It should be noted that, regardless of the ground-water sampling approach, few sampling points (e.g., wells, drive-points, screened augers) have zones of influence in excess of a few feet. Therefore, the spatial frequency of sampling points should be carefully selected and designed.

2) Flexibility of Sampling Point Design

In most cases *well-point* diameters in excess of 1 7/8 inches will permit the use of most types of submersible pumping devices for low-flow (minimal drawdown) sampling. It is suggested that *short* (e.g., less than 1.6 m) screens be incorporated into the monitoring design where possible so that comparable results from one device to another might be expected. *Short*, of course, is relative to the degree of vertical water quality variability expected at a site.

3) Equilibration of Sampling Point

Time should be allowed for equilibration of the well or sampling point with the formation after installation. Placement of well or sampling points in the subsurface produces some disturbance of ambient conditions. Drilling techniques (e.g., auger, rotary, etc.) are generally considered to cause more disturbance than *direct-push* technologies. In either case, there may be a period (i.e., days to months) during which water quality near the point may be distinctly different from that in the formation. Proper development of the sampling point and adjacent formation to remove fines created during emplacement will shorten this water quality *recovery* period.

III. Definition of Low-Flow Purging and Sampling

It is generally accepted that water in the well casing is non-representative of the formation water and needs to be purged prior to collection of ground-water samples. However, the water in the screened interval may indeed be representative of the formation, depending upon well construction and site hydrogeology. Wells are purged to some extent for the following reasons: the presence of the air interface at the top of the water column resulting in an oxygen concentration gradient with depth, loss of volatiles up the water column, leaching from or sorption to the casing or filter pack, chemical changes due to clay seals or backfill, and surface infiltration.

Low-flow purging, whether using portable or dedicated systems, should be done using pump-intake located in the middle or slightly above the middle of the screened interval. Placement of the pump too close to the bottom of the well will cause increased entrainment of solids which have collected in the well over time. These particles are present as a result of well development, prior purging and sampling events, and natural colloidal transport and deposition. Therefore, placement of the pump in the middle or toward the top of the screened interval is suggested. Placement of the pump at the top of the water column for sampling is only recommended in unconfined aquifers, screened across the water table, where this is the desired sampling point. Low-flow purging has the advantage of minimizing mixing between the overlying stagnant casing water and water within the screened interval.

A. Low-Flow Purging and Sampling

Low-flow refers to the velocity with which water enters the pump intake and that is imparted to the formation pore water in the immediate vicinity of the well screen. It does not necessarily refer to the flow rate of water discharged at the surface which can be affected by flow regulators or restrictions. Water level drawdown provides the best indication of the stress imparted by a given flow-rate for a given hydrological situation. The objective is to pump in a manner that minimizes stress (drawdown) to the system to the extent practical taking into account established site sampling objectives. Typically, flow rates on the order of 0.1 - 0.5 L/min are used, however this is dependent on site-specific hydrogeology. Some extremely coarse-textured formations have been successfully sampled in this manner at flow rates to 1 L/min. The effectiveness of using low-flow purging is intimately linked with proper screen location, screen length, and well construction and development techniques. The reestablishment of natural flow paths in both the vertical and horizontal directions is important for correct interpretation of the data. For high resolution sampling needs, screens less than 1 m should be used. Most of the need for purging has been found to be due to passing the sampling device through the overlying casing water which causes mixing of these stagnant waters and the dynamic waters within the screened interval. Additionally, there is disturbance to suspended sediment collected in the bottom of the casing and the displacement of water out into the formation immediately adjacent to the well screen. These disturbances and impacts can be avoided using dedicated sampling equipment, which precludes the need to insert the sampling device prior to purging and sampling.

Isolation of the screened interval water from the overlying stagnant casing water may be accomplished using low-flow minimal drawdown techniques. If the pump intake is located within the screened interval, most of the water pumped will be drawn in directly from the formation with little mixing of casing water or disturbance to the sampling zone. However, if the wells are not constructed and developed properly, zones other than those intended may be sampled. At some sites where geologic heterogeneities are sufficiently different within the screened interval, higher conductivity zones may be preferentially sampled. This is another reason to use shorter screened intervals, especially where high spatial resolution is a sampling objective.

B. Water Quality Indicator Parameters

It is recommended that water quality indicator parameters be used to determine purging needs prior to sample collection in each well. Stabilization of parameters such as pH, specific conductance, dissolved oxygen, oxidation-reduction potential, temperature and turbidity should be used to determine when formation water is accessed during purging. In general, the order of stabilization is pH, temperature, and specific conductance, followed by oxidation-reduction potential, dissolved oxygen and turbidity. Temperature and pH, while commonly used as purging indicators, are actually quite insensitive in distinguishing between formation water and stagnant casing water; nevertheless, these are important parameters for data interpretation purposes and should also be measured. Performance criteria for determination of stabilization should be based on water-level drawdown, pumping rate and equipment specifications for measuring indicator parameters. Instruments are available which utilize in-line flow cells to continuously measure the above parameters.

It is important to establish specific well stabilization criteria and then consistently follow the same methods thereafter, particularly with respect to drawdown, flow rate and sampling device. Generally, the time or purge volume required for parameter stabilization is independent of well depth or well volumes. Dependent variables are well diameter, sampling device, hydrogeochemistry, pump flow rate, and whether the devices are used in a portable or dedicated manner. If the sampling device is already in place (i.e., dedicated sampling systems), then the time and purge volume needed for stabilization is much shorter. Other advantages of dedicated equipment include less purge water for waste disposal, much less decontamination of equipment, less time spent in preparation of sampling as well as time in the field, and more consistency in the sampling approach which probably will translate into less variability in sampling results. The use of dedicated equipment is strongly recommended at wells which will undergo routine sampling over time.

If parameter stabilization criteria are too stringent, then minor oscillations in indicator parameters may cause purging operations to become unnecessarily protracted. It should also be noted that turbidity is a very conservative parameter in terms of stabilization. Turbidity is always the last parameter to stabilize. Excessive purge times are invariably related to the establishment of too stringent turbidity stabilization criteria. It should be noted that natural turbidity levels in ground water may exceed 10 nephelometric turbidity units (NTU).

C. Advantages and Disadvantages of Low-Flow (Minimum Drawdown) Purging

In general, the advantages of low-flow purging include:

- samples which are representative of the *mobile* load of contaminants present (dissolved and colloid-associated);
- minimal disturbance of the sampling point thereby minimizing sampling artifacts;
- less operator variability, greater operator control;

- reduced stress on the formation (minimal drawdown);
- less mixing of stagnant casing water with formation water;
- reduced need for filtration and, therefore, less time required for sampling;
- smaller purging volume which decreases waste disposal costs and sampling time;
- better sample consistency; reduced artificial sample variability.

Some disadvantages of low-flow purging are:

- higher initial capital costs,
- greater set-up time in the field,
- need to transport additional equipment to and from the site,
- increased training needs,
- resistance to change on the part of sampling practitioners,
- concern that new data will indicate a *change in conditions* and trigger an *action*.

IV. Low-Flow (Minimal Drawdown) Sampling Protocols

The following ground-water sampling procedure has evolved over many years of experience in ground-water sampling for organic and inorganic compound determinations and as such summarizes the authors' (and others) experiences to date (Barcelona et al., 1984, 1994; Barcelona and Helfrich, 1986; Puls and Barcelona, 1989; Puls et. al. 1990, 1992; Puls and Powell, 1992; Puls and Paul, 1995). High-quality chemical data collection is essential in ground-water monitoring and site characterization. The primary limitations to the collection of *representative* ground-water samples include: mixing of the stagnant casing and *fresh* screen waters during insertion of the sampling device or ground-water level measurement device; disturbance and resuspension of settled solids at the bottom of the well when using high pumping rates or raising and lowering a pump or bailer; introduction of atmospheric gases or degassing from the water during sample handling and transfer, or inappropriate use of vacuum sampling device, etc.

A. Sampling Recommendations

Water samples should not be taken immediately following well development. Sufficient time should be allowed for the ground-water flow regime in the vicinity of the monitoring well to stabilize and to approach chemical equilibrium with the well construction materials. This lag time will depend on site conditions and methods of installation but often exceeds one week.

Well purging is nearly always necessary to obtain samples of water flowing through the geologic formations in the screened interval. Rather than using a general but arbitrary guideline of purging three casing volumes prior to sampling, it is recommended that an in-line water quality measurement device (e.g., flow-through cell) be used to establish the stabilization time for several parameters (e.g. , pH, specific conductance, redox, dissolved oxygen, turbidity) on a well-specific basis. Data on pumping rate, drawdown, and volume required for parameter stabilization can be used as a guide for conducting subsequent sampling activities.

The following are recommendations to be considered before, during and after sampling:

- use low-flow rates (<0.5 L/min), during both purging and sampling to maintain minimal drawdown in the well;
- maximize tubing wall thickness, minimize tubing length;
- place the sampling device intake at the desired sampling point;
- minimize disturbances of the stagnant water column above the screened interval during water level measurement and sampling device insertion;
- make proper adjustments to stabilize the flow rate as soon as possible;
- monitor water quality indicators during purging;
- collect unfiltered samples to estimate contaminant loading and transport potential in the subsurface system.

B. Equipment Calibration

Prior to sampling, all sampling device and monitoring equipment should be calibrated according to manufacturer's recommendations and the site Quality Assurance Project Plan (QAPP) and Field Sampling Plan (FSP). Calibration of pH should be performed with at least two buffers which bracket the expected range. Dissolved oxygen calibration must be corrected for local barometric pressure readings and elevation.

C. Water Level Measurement and Monitoring

It is recommended that a device be used which will least disturb the water surface in the casing. Well depth should be obtained from the well logs. Measuring to the bottom of the well casing will only cause resuspension of settled solids from the formation and require longer purging times for turbidity equilibration. Measure well depth after sampling is completed. The water level measurement should be taken from a permanent reference point which is surveyed relative to ground elevation.

D. Pump Type

The use of low-flow (e.g., 0.1-0.5 L/min) pumps is suggested for purging and sampling all types of analytes. All pumps have some limitation and these should be investigated with respect to application at a particular site. Bailers are inappropriate devices for low-flow sampling.

1) General Considerations

There are no unusual requirements for ground-water sampling devices when using low-flow, minimal drawdown techniques. The major concern is that the device give consistent results and minimal disturbance of the sample across a range of *low* flow rates (i.e., < 0.5 L/min). Clearly, pumping rates that cause minimal to no drawdown in one well could easily cause *significant* drawdown in another well finished in a less transmissive formation. In this sense, the pump should not cause undue pressure or temperature changes or physical disturbance on the water sample over a reasonable sampling range. Consistency in operation is critical to meet accuracy and precision goals.

2) Advantages and Disadvantages of Sampling Devices

A variety of sampling devices are available for low-flow (minimal drawdown) purging and sampling and include peristaltic pumps, bladder pumps, electrical submersible pumps, and gas-driven pumps. Devices which lend themselves to both dedication and consistent operation at definable low-flow rates are preferred. It is desirable that the pump be easily adjustable and operate reliably at these lower flow rates. The peristaltic pump is limited to shallow applications and can cause degassing resulting in alteration of pH, alkalinity, and some volatiles loss. Gas-driven pumps should be of a type that does not allow the gas to be in direct contact with the sampled fluid.

Clearly, bailers and other *grab* type samplers are ill-suited for low-flow sampling since they will cause repeated disturbance and mixing of *stagnant* water in the casing and the *dynamic* water in the screened interval. Similarly, the use of inertial lift foot-valve type samplers may cause too much disturbance at the point of sampling. Use of these devices also tends to introduce uncontrolled and unacceptable operator variability.

Summaries of advantages and disadvantages of various sampling devices are listed in Herzog et al. (1991), U. S. EPA (1992), Parker (1994) and Thurnblad (1994).

E. Pump Installation

Dedicated sampling devices (left in the well) capable of pumping and sampling are preferred over <u>any</u> other type of device. Any portable sampling device should be slowly and carefully lowered to the middle of the screened interval or slightly above the middle (e.g., 1-1.5 m below the top of a 3 m screen). This is to minimize excessive mixing of the stagnant water in the casing above the screen with the screened interval zone water, and to minimize resuspension of solids which will have collected at the bottom of the well. These two disturbance effects have been shown to directly affect the time required for purging. There also appears to be a direct correlation between size of portable sampling devices relative to the well bore and resulting purge volumes and times. The key is to minimize disturbance of water and solids in the well casing.

F. Filtration

Decisions to filter samples should be dictated by sampling objectives rather than as a *fix* for poor sampling practices, and field-filtering of certain constituents should not be the default. Consideration should be given as to what the application of field-filtration is trying to accomplish. For assessment of truly dissolved (as opposed to operationally *dissolved* [i.e., samples filtered with 0.45 µm filters]) concentrations of major ions and trace metals, 0.1 µm filters are recommended although 0.45 µm filters are normally used for most regulatory programs. Alkalinity samples must also be filtered if significant particulate calcium carbonate is suspected, since this material is likely to impact alkalinity titration results (although filtration itself may alter the CO_2 composition of the sample and, therefore, affect the results).

Although filtration may be appropriate, filtration of a sample may cause a number of unintended changes to occur (e.g. oxidation, aeration) possibly leading to filtration-induced artifacts during sample analysis and uncertainty in the results. Some of these unintended changes may be unavoidable but the factors leading to them must be recognized. Deleterious effects can be minimized by consistent application of certain filtration guidelines. Guidelines should address selection of filter type, media, pore size, etc. in order to identify and minimize potential sources of uncertainty when filtering samples.

In-line filtration is recommended because it provides better consistency through less sample handling, and minimizes sample exposure to the atmosphere. In-line filters are available in both disposable (barrel filters) and non-disposable (in-line filter holder, flat membrane filters) formats and various filter pore sizes (0.1-5.0 µm). Disposable filter cartridges have the advantage of greater sediment handling capacity when compared to traditional membrane filters. Filters must be pre-rinsed following manufacturer's recommendations. If there are no recommendations for rinsing, pass through a minimum of 1 L of ground water following purging and prior to sampling. Once filtration has begun, a filter cake may develop as particles larger than the pore size accumulate on the filter membrane. The result is that the effective pore diameter of the membrane is reduced and particles smaller than the stated pore size are excluded from the filtrate. Possible corrective measures include prefiltering (with larger pore size filters), minimizing particle loads to begin with, and reducing sample volume.

G. Monitoring of Water Level and Water Quality Indicator Parameters

Check water level periodically to monitor drawdown in the well as a guide to flow rate adjustment. The goal is minimal drawdown (<0.1 m) during purging. This goal may be difficult to achieve under some circumstances due to geologic heterogeneities within the screened interval, and may require adjustment based on site-specific conditions and personal experience. In-line water quality indicator parameters should be continuously monitored during purging. The water quality indicator parameters monitored can include pH, redox potential, conductivity, dissolved oxygen (DO) and turbidity. The last three parameters are often most sensitive. Pumping rate, drawdown, and the time or volume required to obtain stabilization of parameter readings can be used as a future guide to purge the well. Measurements should be taken every three to five minutes if the above suggested rates are used. Stabilization is achieved after all parameters have stabilized for three successive readings. In lieu of measuring all five parameters, a minimum subset would include pH, conductivity, and turbidity or DO. Three successive readings should be within ± 0.1 for pH, ± 3% for conductivity, ± 10 mv for redox potential, and ± 10% for turbidity and DO. Stabilized purge indicator parameter trends are generally obvious and follow either an exponential or asymptotic change to stable values during purging. Dissolved oxygen and turbidity usually require the longest time for stabilization. The above stabilization guidelines are provided for rough estimates based on experience.

H. Sampling, Sample Containers, Preservation and Decontamination

Upon parameter stabilization, sampling can be initiated. If an in-line device is used to monitor water quality parameters, it should be disconnected or bypassed during sample collection. Sampling flow rate may remain at established purge rate or may be adjusted slightly to minimize aeration, bubble formation, turbulent filling of sample bottles, or loss of volatiles due to extended residence time in tubing. Typically, flow rates less than 0.5 L/min are appropriate. The same device should be used for sampling as was used for purging. Sampling should occur in a progression from least to most contaminated well, if this is known. Generally, volatile (e.g., solvents and fuel constituents) and gas sensitive (e.g., Fe^{2+}, CH_4, H_2S/HS^-, alkalinity) parameters should be sampled first. The sequence in which samples for most inorganic parameters are collected is immaterial unless filtered (dissolved) samples are desired. Filtering should be done last and in-line filters should be used as discussed above. During both well purging and sampling, proper protective clothing and equipment must be used based upon the type and level of contaminants present.

The appropriate sample container will be prepared in advance of actual sample collection for the analytes of interest and include sample preservative where necessary. Water samples should be collected directly into this container from the pump tubing.

Immediately after a sample bottle has been filled, it must be preserved as specified in the site (QAPP). Sample preservation requirements are based on the analyses being performed (use site QAPP, FSP, RCRA guidance document [U. S. EPA, 1992] or EPA SW-846 [U. S. EPA, 1982]). It may be advisable to add preservatives to sample bottles in a controlled setting prior to entering the field in order to reduce the chances of improperly preserving sample bottles or introducing field contaminants into a sample bottle while adding the preservatives.

The preservatives should be transferred from the chemical bottle to the sample container using a disposable polyethylene pipet and the disposable pipet should be used only once and then discarded.

After a sample container has been filled with ground water, a Teflon™ (or tin)-lined cap is screwed on tightly to prevent the container from leaking. A sample label is filled out as specified in the FSP. The samples should be stored inverted at 4°C.

Specific decontamination protocols for sampling devices are dependent to some extent on the type of device used and the type of contaminants encountered. Refer to the site QAPP and FSP for specific requirements.

I. Blanks

The following blanks should be collected:

(1) field blank: one field blank should be collected from each source water (distilled/deionized water) used for sampling equipment decontamination or for assisting well development procedures.

(2) equipment blank: one equipment blank should be taken prior to the commencement of field work, from each set of sampling equipment to be used for that day. Refer to site QAPP or FSP for specific requirements.

(3) trip blank: a trip blank is required to accompany each volatile sample shipment. These blanks are prepared in the laboratory by filling a 40-mL volatile organic analysis (VOA) bottle with distilled/deionized water.

V. Low-Permeability Formations and Fractured Rock

The overall sampling program goals or sampling objectives will drive how the sampling points are located, installed, and choice of sampling device. Likewise, site-specific hydrogeologic factors will affect these decisions. Sites with very low permeability formations or fractures causing discrete flow channels may require a unique monitoring approach. Unlike water supply wells, wells installed for ground-water quality assessment and restoration programs are often installed in low water-yielding settings (e.g., clays, silts). Alternative types of sampling points and sampling methods are often needed in these types of environments, because low-permeability settings may require extremely low-flow purging (<0.1 L/min) and may be technology-limited. Where devices are not readily available to pump at such low flow rates, the primary consideration is to avoid dewatering of the well screen. This may require repeated recovery of the water during purging while leaving the pump in place within the well screen.

Use of low-flow techniques may be impractical in these settings, depending upon the water recharge rates. The sampler and the end-user of data collected from such wells need to understand the limitations of the data collected; i.e., a strong potential for underestimation of actual contaminant concentrations for volatile organics, potential false negatives for filtered metals and potential false positives for unfiltered metals. It is suggested that comparisons be made between samples recovered using low-flow purging techniques and samples recovered using passive sampling techniques (i.e., two sets of samples). Passive sample collection would essentially entail acquisition of the sample with no or very little purging using a dedicated sampling system installed within the screened interval or a passive sample collection device.

A. Low-Permeability Formations (<0.1 L/min recharge)

1. Low-Flow Purging and Sampling with Pumps

a. "portable or non-dedicated mode" - Lower the pump (one capable of pumping at <0.1 L/min) to mid-screen or slightly above and set in place for minimum of 48 hours (to lessen purge volume requirements). After 48 hours, use procedures listed in Part IV above regarding monitoring water quality parameters for stabilization, etc., but do not dewater the screen. If excessive drawdown and slow recovery is a problem, then alternate approaches such as those listed below may be better.

b. "dedicated mode" - Set the pump as above at least a week prior to sampling; that is, operate in a dedicated pump mode. With this approach significant reductions in purge volume should be realized. Water quality parameters should stabilize quite rapidly due to less disturbance of the sampling zone.

2. Passive Sample Collection

Passive sampling collection requires insertion of the device into the screened interval for a sufficient time period to allow flow and sample equilibration before extraction for analysis. Conceptually, the extraction of water from low yielding formations seems more akin to the collection of water from the unsaturated zone and passive sampling techniques may be more appropriate in terms of obtaining "representative" samples. Satisfying usual sample volume requirements is typically a problem with this approach and some latitude will be needed on the part of regulatory entities to achieve sampling objectives.

B. Fractured Rock

In fractured rock formations, a low-flow to zero purging approach using pumps in conjunction with packers to isolate the sampling zone in the borehole is suggested. Passive multi-layer sampling devices may also provide the most "representative" samples. It is imperative in these settings to identify flow paths or water-producing fractures prior to sampling using tools such as borehole flowmeters and/or other geophysical tools.

After identification of water-bearing fractures, install packer(s) and pump assembly for sample collection using low-flow sampling in "dedicated mode" or use a passive sampling device which can isolate the identified water-bearing fractures.

VI. Documentation

The usual practices for documenting the sampling event should be used for low-flow purging and sampling techniques. This should include, at a minimum: information on the conduct of purging operations (flow-rate, drawdown, water-quality parameter values, volumes extracted and times for measurements), field instrument calibration data, water sampling forms and chain of custody forms. See Figures 2 and 3 and "Ground Water Sampling Workshop -- A Workshop Summary" (U. S. EPA, 1995) for example forms and other documentation suggestions and information. This information coupled with laboratory analytical data and validation data are needed to judge the "useability" of the sampling data.

VII. Notice

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Figure 2. **Ground Water Sampling Log**

Project _______________ **Site** _______________ **Well No.** _____________ **Date** _________________________

Well Depth ____________ **Screen Length** __________ **Well Diameter** _________ **Casing Type** ____________

Sampling Device _______________ **Tubing type** _____________________ **Water Level** __________________

Measuring Point ___________________ **Other Infor** ____

____

Sampling Personnel ____

Time	pH	Temp	Cond.	Dis.O_2	Turb.	[ ]Conc			Notes

Type of Samples Collected

____

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3\pi\ r^3$

Figure 3. **Ground Water Sampling Log** (with automatic data logging for most water quality parameters)

Project ______________ **Site** ______________ **Well No.** ____________ **Date** ______________________

Well Depth ___________ **Screen Length** _________ **Well Diameter** ________ **Casing Type** __________

Sampling Device ______________ **Tubing type** ___________________ **Water Level** ________________

Measuring Point __________________ **Other Infor** ____

____

Sampling Personnel ____

Time	Pump Rate	Turbidity	Alkalinity	[ ] Conc	Notes

Type of Samples Collected

____

Information: 2 in = 617 ml/ft, 4 in = 2470 ml/ft: $Vol_{cyl} = \pi r^2 h$, $Vol_{sphere} = 4/3\pi\ r^3$

STANDARD OPERATING PROCEDURE FOR LOW-STRESS (Low Flow) / MINIMAL DRAWDOWN GROUND-WATER SAMPLE COLLECTION

INTRODUCTION

The collection of "representative" water samples from wells is neither straightforward nor easily accomplished. Ground-water sample collection can be a source of variability through differences in sample personnel and their individual sampling procedures, the equipment used, and ambient temporal variability in subsurface and environmental conditions. Many site inspections and remedial investigations require the sampling at ground-water monitoring wells within a defined criterion of data confidence or data quality, which necessitates that the personnel collecting the samples are trained and aware of proper sample-collection procedures.

The purpose of this standard operating procedure (SOP) is to provide a method which minimize the amount of impact the purging process has on the ground water chemistry during sample collection and to minimize the volume of water that is being purged and disposed. This will take place by placing the pump intake within the screen interval and by keeping the drawdown at a minimal level (0.33 feet) (Puls and Barcelona, 1996) until the water quality parameters have stabilized and sample collection is complete. The flow rate at which the pump will be operating will be depended upon both hydraulic conductivity of the aquifer and the drawdown with the goal of minimizing the drawdown. The flow rate from the pump during purging and sampling will be at a rate that will not compromise the integrity of the analyte that is being sampled. This sampling procedure may or may not provide a discrete ground water sample at the location of the pump intake. The flow of ground-water to the pump intake will be dependent on the distribution of the hydraulic conductivity (K) of the aquifer within the screen interval. In order to minimize the drawdown in the monitoring well a low-flow rate must be utilized. Low-flow refers to the velocity with which water enters the pump intake from the surrounding formation in the immediate vicinity of the well screen. It does not necessarily refer to the flow rate of water discharged at the surface, which can be affected by flow regulators or restrictions (Puls and Barcelona, 1996). This SOP was developed by the Superfund/RCRA Ground Water Forum and draws from an USEPA's Ground Water Issue Paper, Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedure, by Robert W. Puls and Michael J. Barcelona. Also, available USEPA Regional SOPs regarding Low-Stress(Low Flow)Purging and Sampling were used for this SOP.

SCOPE AND APPLICATION

This SOP should be used primarily at monitoring wells which have a screen or an open interval with a length of ten feet or less and can accept a sampling device which minimizes the disturbance to the aquifer or the water column in the well casing. The screen or open interval should have been optimally located to intercept an existing contaminant plume(s) or along flowpaths of potential contaminant releases. Knowledge of the contaminant distribution within the screen interval is highly recommended and is essential for the success of this sampling procedure. The ground-water samples which are collected using this procedure are acceptable for the analyses of ground-water contaminants which may be found at Superfund and RCRA contamination sites. The analytes may be volatile, semi-volatile organic compounds, pesticides, PCBs, metals and other inorganic compounds. The screened interval should be located within the contaminant plume(s) and the pump intake should be placed at or near the known source of the contamination within the screened interval. It is critical to place the pump intake in the exact location or depth for each sampling event. This argues for the use of dedicated, permanently installed sampling devices whenever possible. If this is not possible then the placement of the pump intake should be positioned with a calibrated sampling pump hose sounded with a weighted-tape or using a pre-measured hose. The pump intake should not be placed near the bottom of the screened interval to avoid disturbing any sediment that may have settled at the bottom of the well.

Water-quality indicator parameters and water levels must be measured during purging, prior to sample collection. Stabilization of the water quality parameters as well as

monitoring water levels are a prerequisite to sample collection. The water-quality indicator parameters which are recommended include the following: specific electrical conductance, dissolved oxygen, turbidity, oxidation-reduction potential, pH, and temperature. The latter two parameters are useful data, but are generally insensitive as purging parameters. Oxidation-reduction potential may not always be appropriate stabilization parameter, and will depend on site-specific conditions. However, readings should be recorded because of its value as a double check for oxidation conditions, and for fate and transport issues.
Also, when samples are collected for metals, semi-volatile organic compounds, and pesticides every effort must be made to reduce turbidity to 10 NTUs or less (not just the stabilization of turbidity) prior to the collection of the water sample. In addition to the measurement of the above parameters, depth to water must be measured during purging (U.S. Environmental Protection Agency, 1995).

Proper well construction, development and maintenance are essential for any ground-water sampling procedure. Prior to conducting the field work, information on the construction of the well and well development should be obtained and that information factored into the site specific sampling procedure. The attached Sampling Checklist is an example of the type of information that is useful.

Stabilization of the water-quality indicator parameters is the criterion for sample collection. But if stabilization is not occurring and the procedure has been strictly followed, then sample collection can take place once three (minimum) to six (maximum) casing volumes have been removed (Schuller et al., 1981 and U.S. Environmental Protection Agency., 1986; Wilde et al., 1998; Gibs and Imbrigiotta., 1990). The specific information on what took place during purging must be recorded in the field notebook or in the ground-water sampling log.

This SOP is not to be used where non-aqueous phase liquids (immiscible fluids) are present in the monitoring well.

EQUIPMENT

- Depth-to-water measuring device - An electronic water-level indicator or steel tape and chalk, with marked intervals of

0.01 foot. Interface probe for determination of liquid products (NAPL) presence, if needed.

- Steel tape and weight - Used for measuring total depth of well. Lead weight should not be used.
- Sampling pump - Submersible or bladder pumps with adjustable rate controls are preferred. Pumps are to be constructed of inert materials, such as stainless steel and teflon®. Pump types that are acceptable include gear and helical driven, centrifugal (low-flow type) and air-activated piston. Adjustable rate, peristaltic pump can be used when the depth to water is 20 feet or less.
- Tubing - Teflon® or Teflon® lined polyethylene tubing is preferred when sampling for organic compounds. Polyethylene tubing can be used when sampling inorganics.
- Power Source - If a combustion type (gasoline or diesel-driven) generator is used, it must be placed downwind of the sampling area.
- Flow measurement supplies - flow meter, graduated cylinder and a stop watch.
- Multi-Parameter meter with flow-through-cell - This can be one instrument or more contained in a flow-through cell. The water-quality indicator parameters which must be monitored are pH, ORP/EH, dissolved oxygen (DO), turbidity, specific conductance, and temperature. Turbidity readings must be collected before the flow cell because of the potential for sediment buildup which can bias the turbidity measurements. Calibration fluids for all instruments should be NIST-traceable and there should be enough for daily calibration through-out the sampling event. The inlet of the flow cell must be located near the bottom of the flow cell and the outlet near the top. The size of the flow cell should be kept to a minimum and a closed cell is preferred. The flow cell must not contain any air or gas bubbles when monitoring for the water-quality indicator parameters.
- Decontamination Supplies - Including a reliable and documented source of distilled water and any solvents (if used). Pressure sprayers, buckets or decontamination tubes for pumps, brushes and non-phosphate soap will also be needed.
- Sample bottles, sample preservation supplies, sample tags or labels and chain of custody forms.
- Approved Field Sampling and Quality Assurance Project Plan.
- Well construction data, field and water quality data from the previous sampling event.
- Well keys and map of well locations.

- Field notebook, ground-water sampling logs and calculator. A suggested field data sheet (ground-water sampling record or ground-water sampling log) are provided in the attachment.
- Filtration equipment, if needed. An in-line disposable filter is recommended.
- Polyethylene sheeting which will be placed on ground around the well head.
- Personal protective equipment specified in the site Health and Safety Plan.
- Air monitoring equipment as specified in the Site Health and Safety Plan.
- Tool box -All needed tools for all site equipment used.
- A 55-gallon drum or container to contain the purged water.

Materials of construction of the sampling equipment (bladders, pumps, tubing, and other equipment that comes in contact with the sample) should be limited to stainless steel, Teflon®, glass and other inert material. This will reduce the chance of the sampling materials to alter the ground-water where concentrations of the site contaminants are expected to be near the detection limits. The sample tubing diameter thickness should be maximized and the tubing length should be minimized so that the loss of contaminants into and through the tubing walls may be reduced and the rate of stabilization of ground-water parameters is maximized. The tendency of organics to sorb into and out of material makes the appropriate selection of sample tubing material critical for trace analyses (Pohlmann and Alduino, 1992; Parker and Ranney, 1998).

PURGING AND SAMPLING PROCEDURES

The following describes the purging and sampling procedures for the Low-Stress (Low Flow)/ Minimal Drawdown method for the collection of ground-water samples. These procedures also describe steps for dedicated and non-dedicated systems.

<u>Pre-Sampling Activities</u> (Non-dedicated and dedicated system)

1. Sampling locations must begin at the monitoring well with the least contamination, generally up-gradient or furthest from the site or suspected source. Then proceed systematically to the monitoring wells with the most contaminated ground water.

2. Check and record the condition of the monitoring well for damage or evidence of tampering. Lay out polyethylene sheeting around the well to minimize the likelihood of contamination of sampling/purging equipment from the soil. Place monitoring, purging and sampling equipment on the sheeting.

3. Unlock well head. Record location, time, date and appropriate information in a field logbook or on the ground-water sampling log (See attached ground-water sampling record and ground-water sampling log as examples).

4. Remove inner casing cap.

5. Monitor the headspace of the monitoring well at the rim of the casing for volatile organic compounds (VOC) with a Photo-ionization detector (PID) or Flame ionization detector (FID), and record in the logbook. If the existing monitoring well has a history of positive readings of the headspace, then the sampling must be conducted in accordance with the Health and Safety Plan.

6. Measure the depth to water (water level must be measured to nearest 0.01 feet) relative to a reference measuring point on the well casing with an electronic water level indicator or steel tape and record in logbook or ground-water sampling log. If no reference point is found, measure relative to the top of the inner casing, then mark that reference point and note that location in the field logbook. Record information on depth to ground water in the field logbook or ground water sampling log. Measure the depth to water a second time to confirm initial measurement; measurement should agree within 0.01 feet or re-measure.

7. Check the available well information or field information for the total depth of the monitoring well. Use the information from the depth of water in step six and the total depth of the monitoring well to calculate the volume of the water in the monitoring well or the volume of one casing. Record information in field logbook or ground-water sampling log.

<u>Purging and Sampling Activities</u>

8A. Non-dedicated system - Place the pump and support equipment at the wellhead and slowly lower the pump and tubing down into the monitoring well until the location of the pump intake is set at a pre-determined location within the screen interval. The placement of the pump intake should be positioned with a calibrated sampling pump hose, sounded with a weighted-tape, or using a pre-measured hose. Refer to the available monitoring well information to determine the depth and length of the screen interval. Measure the depth of the pump intake while lowering the pump into location. Record pump location in field logbook or groundwater sampling log.

8B. Dedicated system - Pump has already been installed, refer to the available monitoring well information and record the depth of the pump intake in the field logbook or ground-water sampling log.

9. Non-dedicated system and dedicated system - Measure the water level (water level must be measured to nearest 0.01 feet) and record information on the ground-water sampling log, leave water level indicator probe in the monitoring well.

10. Non-dedicated and dedicated system - Connect the discharge line from the pump to a flow-through cell. A “T” connection is needed prior to the flow cell to allow for the collection of water for the turbidity measurements. The discharge line from the flow-through cell must be directed to a container to contain the purge water during the purging and sampling of the monitoring well.

11. Non-dedicated and dedicated system - Start pumping the well at a low flow rate (0.2 to 0.5 liter per minute) and slowly increase the speed. Check water level. Maintain a steady flow rate while maintaining a drawdown of less than 0.33 feet (Puls and Barcelona, 1996). If drawdown is greater than 0.33 feet lower the flow rate. 0.33 feet is a goal to help guide with the flow rate adjustment. It should be noted that this goal may be difficult to achieve under some circumstances due to geologic heterogeneities within the screened interval, and may require adjustment based on site-specific conditions and personal experience (Puls and Barcelona, 1996).

12. Non-dedicated and dedicated system - Measure the discharge rate of the pump with a graduated cylinder and a stop watch. Also, measure the water level and record both flow rate and water level on the groundwater sampling log. Continue purging, monitor and record water level and pump rate every three to five minutes during purging. Pumping rates should be kept at minimal flow to

ensure minimal drawdown in the monitoring well.

13. Non-dedicated and dedicated system - During the purging, a minimum of one tubing volume (including the volume of water in the pump and flow cell) must be purged prior to recording the water-quality indicator parameters. Then monitor and record the water-quality indicator parameters every three to five minutes. The water-quality indicator field parameters are turbidity, dissolved oxygen, specific electrical conductance, pH, redox-potential and temperature. Oxidation-reduction potential may not always be an appropriate stabilization parameter, and will depend on site-specific conditions. However, readings should be recorded because of its value as a double check for oxidizing conditions. Also, for the final dissolved oxygen measurement, if the readings are less than 1 milligram per liter, it should be collected and analyze with the spectrophotometric method (Wilde et al., 1998 Wilkin et al., 2001), colorimetric or Winkler titration (Wilkin et al., 2001). The stabilization criterion is based on three successive readings of the water quality field parameters; the following are the criteria which must be used:

Parameter	**Stabilization Criteria**	**Reference**
pH	± 0.1 pH units	Puls and Barcelona, 1996; Wilde et al.,
Specific electrical conductance (SEC)	± 3% FS/cm	Puls and Barcelona, 1996
oxidation-reduction potential (ORP)	± 10 millivolts	Puls and Barcelona 1996
turbidity	± 10 % NTUs (when turbidity is greater than 10 NTUs)	Puls and Barcelona, 1996 Wilde et al., 1998
dissolved oxygen	± 0.3 milligrams per liter	Wilde et al., 1998

Once the criteria have been successfully met indicating that the water quality indicator parameters have stabilized, then sample collection can take place.

14. If a stabilized drawdown in the well can't be maintained at 0.33 feet and the water level is approaching the top of the screened interval, reduce the flow rate or turn the pump off (for 15 minutes) and allow for recovery. It should be noted whether or not the pump has a check valve. A check valve is required if the pump is shut off. Under no circumstances should the well be

pumped dry. Begin pumping at a lower flow rate, if the water draws-down to the top of the screened interval again turn pump off and allow for recovery. If two tubing volumes (including the volume of water in the pump and flow cell) have been removed during purging then sampling can proceed next time the pump is turned on. This information should be noted in the field notebook or ground-water sampling log with a recommendation for a different purging and sampling procedure.

15. Non-dedicated and dedicated system - Maintain the same pumping rate or reduce slightly for sampling (0.2 to 0.5 liter per minute) in order to minimize disturbance of the water column. Samples should be collected directly from the discharge port of the pump tubing prior to passing through the flow-through cell. Disconnect the pump's tubing from the flow-through-cell so that the samples are collected from the pump's discharge tubing. For samples collected for dissolved gases or Volatile Organic Compounds (VOCs) analyses, the pump's tubing needs to be completely full of ground water to prevent the ground water from being aerated as the ground water flows through the tubing. The sequence of the samples is immaterial unless filtered (dissolved) samples are collected and they must be collected last (Puls and Barcelona, 1996). All sample containers should be filled with minimal turbulence by allowing the ground water to flow from the tubing gently down the inside of the container. When filling the VOC samples a meniscus must be formed over the mouth of the vial to eliminate the formation of air bubbles and head space prior to capping. In the event that the ground water is turbid,(greater then 10 NTUs), a filtered metal (dissolved) sample also should be collected.

If filtered metal sample is to be collected, then an in-line filter is fitted at the end of the discharge tubing and the sample is collected after the filter. The in-line filter must be pre-rinsed following manufacturer's recommendations and if there are no recommendations for rinsing, a minimum of 0.5 to 1 liter of ground water from the monitoring well must pass through the filter prior to sampling.

16A. Non-dedicated system - Remove the pump from the monitoring well. Decontaminate the pump and dispose of the tubing if it is non-dedicated.

16B Dedicated system - Disconnect the tubing that extends from the plate at the wellhead (or cap) and discard after use.

17. Non-dedicated system - Before locking the monitoring well, measure and record the well depth (to 0.1 feet).
Measure the total depth a second time to confirm initial measurement; measurement should agree within 0.01 feet or re-measure.

18. Non-dedicated and dedicated system - Close and lock the well.

DECONTAMINATION PROCEDURES

Decontamination procedures for the water level meter and the water quality field parameter sensors.
The electronic water level indicator probe/steel tape and the water-quality field parameter sensors will be decontaminated by the following procedures:

1. The water level meter will be hand washed with phosphate free detergent and a scrubber, then thoroughly rinsed with distilled water.

2. Water quality field parameter sensors and flow-through cell will be rinsed with distilled water between sampling locations. No other decontamination procedures are necessary or recommended for these probes since they are sensitive. After the sampling event, the flow cell and sensors must be cleaned and maintained per the manufacturer’s requirements.

Decontamination Procedure for the Sampling Pump

Upon completion of the ground water sample collection the sampling pump must be properly decontaminated between monitoring wells. The pump and discharge line including support cable and electrical wires which were in contact with the ground water in the well casing must be decontaminated by the following procedure:

1. The outside of the pump, tubing, support cable and electrical wires must be pressured sprayed with soapy water, tap water and distilled water. Spray outside of tubing and pump until water is flowing off of tubing after each rinse. Use bristle brush to help remove visible dirt and contaminants.
2.Place the sampling pump in a bucket or in a short PVC casing (4-in. diameter) with one end capped. The pump placed in this device must be completely submerged in the water. A small amount of phosphate free detergent must be added to the potable water

(tap water).
3. Remove the pump from the bucket or 4-in. casing and scrub the outside of the pump housing and cable.
4. Place pump and discharge line back in the 4-in. casing or bucket, start pump and re-circulate this soapy water for 2 minutes (wash).
5. Re-direct discharge line to a 55-gallon drum, continue to add 5 gallons of potable water (tap water)or until soapy water is no longer visible.
6. Turn pump off and place pump into a second bucket or 4-in. Casing which contains tap water, continue to add 5-gallons of tap water (rinse).
7. Turn pump off and place pump into a third bucket or 4-in. casing which contains distilled/deionized water, continue to add three to five gallons of distilled/deionized water (final rinse).
8. If a hydrophobic contaminant is present (such as separate phase, high levels of PCB’s, etc.) An additional decon step, or steps, may be added. For example, an organic solvent, such as reagent-grade isopropanol alcool may be added as a first spraying/bucket prior to the soapy water rinse/bucket.

FIELD QUALITY CONTROL

Quality control (QC) samples must be collected to verify that sample collection and handling procedures were performed adequately and that they have not compromised the quality of the ground water samples. The appropriate EPA program guidance must be consulted in preparing the field QC sample requirements for the site-specific Quality Assurance Project Plan (QAPP).

There are five primary areas of concern for quality assurance (QA) in the collection of representative ground-water samples:

1. Obtaining a ground-water sample that is representative of the aquifer or zone of interest in the aquifer. Verification is based on the field log documenting that the field water-quality parameters stabilized during the purging of the well, prior to sample collection.
2. Ensuring that the purging and sampling devices are made of materials, and utilized in a manner, which will not interact with or alter the analyses.
3. Ensuring that results generated by these procedures are reproducible; therefore, the sampling scheme should incorporate co-located samples (duplicates).

4. Preventing cross-contamination. Sampling should proceed from least to most contaminated wells, if known. Field equipment blanks should be incorporated for all sampling and purging equipment, and decontamination of the equipment is therefore required.
5. Properly preserving, packaging, and shipping samples.

All field quality control samples must be prepared the same as regular investigation samples with regard to sample volume, containers, and preservation. The chain of custody procedures for the QC samples will be identical to the field ground water samples. The following are quality control samples which must be collected during the sampling event:

	Sample Type	Frequency
●	Field duplicates	1 per 20 samples
●	Matrix spike	1 per 20 samples
●	Matrix spike duplicate	1 per 20 samples
●	Equipment blank	Per Regional requirements or policy
●	Trip blank (VOCs)	1 per sample cooler
●	Temperature blank	1 per sample cooler

HEALTH AND SAFETY CONSIDERATIONS

Depending on the site-specific contaminants, various protective programs must be implemented prior to sampling the first well. The site Health and Safety Plan should be reviewed with specific emphasis placed on the protection program planned for the sampling tasks. Standard safe operating practices should be followed, such as minimizing contact with potential contaminants in both the liquid and vapor phase through the use of appropriate personal protective equipment.

Depending on the type of contaminants expected or determined in previous sampling efforts, the following safe work practices will be employed:

Particulate or metals contaminants
1. Avoid skin contact with, and incidental ingestion of, purge water.
2. Use protective gloves and splash protection.

Volatile organic contaminants

1. Avoid breathing constituents venting from well.
2. Pre-survey the well head space with an appropriate device as specified in the Site Health and Safety Plan.
3. If monitoring results indicate elevated organic constituents, sampling activities may be conducted in level C protection. At a minimum, skin protection will be afforded by disposable protective clothing, such as Tyvek®.

General, common practices should include avoiding skin contact with water from preserved sample bottles, as this water will have pH less than 2 or greater than 10. Also, when filling pre-acidified VOA bottles, hydrochloric acid fumes may be released and should not be inhaled.

POST-SAMPLING ACTIVITIES

Several activities need to be completed and documented once ground-water sampling has been completed. These activities include, but are not limited to:

1. Ensure that all field equipment has been decontaminated and returned to proper storage location. Once the individual field equipment has been decontaminated, tag it with date of cleaning, site name, and name of individual responsible.
2. All sample paperwork should be processed, including copies provided to the Regional Laboratory, Sample Management Office, or other appropriate sample handling and tracking facility.
3. All field data should be complied for site records.
4. All analytical data when processed by the analytical laboratory, should be verified against field sheets to ensure all data has been returned to sampler.

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SAMPLING CHECKLIST

Well Identification:________________________

Map of Site Included: Y or N
Wells Clearly Identified w/ Roads: Y or N
Well Construction Diagram Attached: Y or N

Well Construction:

Diameter of Borehole:________ Diameter of Casing:__________
Casing Material:____________ Screen Material:______________

Screen Length:______________ Total Depth:_______________

Approximate Depth to Water:______________
Maximum Well Development Pumping Rate:__________________
Date of Last Well Development:______________

Previous Sampling Information:

Was the Well Sampled Previously: Y or N
(If Sampled, Fill Out Table Below)

Table of Previous Sampling Information

Parameter	Previously Sampled	Number of Times Sampled	Maximum Concentration	Notes (include previous purge rates)

Ground-Water Sampling Log

Site Name: **Well #:** **Date:**

Well Depth(Ft-BTOC[1]): **Screen Interval**(Ft):

Well Dia.: **Casing Material:** **Sampling Device:**

Pump placement(Ft from TOC[2]):

Measuring Point: **Water level (static)**(Ft):

Water level (pumping)(Ft): **Pump rate**(Liter/min):

Sampling Personnel:

Other info: (such as sample numbers, weather conditions and field notes)

Water Quality Indicator Parameters

Time	Pumping rates (L/min)	Water level (ft)	DO (mg/l)	ORP (mv)	Turb. (NTU)	SEC[3] (FS/cm)	pH	Temp. (C°)	Volume pumped (L)

Type of Sample collected:

1-casing volume was:

Total volume purged prior to sample collection:

Stabilization Criteria

DO	±	0.3 mg/l
Turb.	±	10%
SEC	±	3%
ORP	±	10 mv
pH	±	0.1 unit

[1]**BTOC-Below Top of Casing**
[2]**TOC-Top of Casing**
[3]**Specific electrical conductance**

Appendix D
Example Calculation,
Relative Percent Difference

For a given pair of numbers, relative percent difference (RPD) is defined as the difference between the two numbers divided by the average between the two numbers, expressed as a percentage. RPD can be calculated as follows:

$$RPD = 100 \times \{2 \times (X - Y)\} / (X + Y)$$

Where:

$X =$ The larger value of the pair
$Y =$ The lesser value of the pair

<u>Example Calculation:</u>

Given two numbers, 10 and 15, the RPD between this pair of numbers is:

RPD = 100X{2X(15-10)}/(15+10)
= 100X0.4
= 40%

Appendix E
Equipment List

Equipment List

Rheostat Pump Controllers (2)
Teflon Tubing (1000 ft)
Air Bladder Pump
Compressed Air Bottle
Water Quality Meter and In-line Flow-through Cell (2)
Turbidity Meter (2)
DC/AC Inverter (2)
Deionized Water (50 gallons)
Decontamination Kits (Alconox, sprayer, brushes, buckets, etc.) (2)
Water Level Indicators (2)
PID (2)
O_2/H_2S/Combination Gas Meter (2)
0.45-micron in-line filters

Appendix F

Review Comments and Responses

RESPONSE TO COMMENTS

Project Name: NFSS
Document: FSP Add for Background GW Sampling **Date:** 14 February, 2003

	PAGE OR SHEET	**COMMENT**	**RESPONSE**
The following comments were from: **Chris Hallam, USACE, Buffalo, Project HP**			
	Location	Comment	Response
	Intro	Please clearly state the <u>*Data Quality*</u> Objectives relevant to this FSP Addendum. General format of this document should follow that of the original, approved FSP, and should include appropriate discussion of plan elements relevant to the background GW, similar to that of the original FSP (including DQOs).	Format revised. DQOs are now included and discussion of plan elements and their relevance to this task are now addressed.
	Intro	It appears that a statistical analysis and preparation of a memo is included as part of the FSP. This is rather unusual. You may wish to consider addressing this aspect of the project somewhere other than the FSP.	This technical memorandum will be submitted as a separate document after the approval of this plan. This is now clarified in the FSP introduction.
	1.0, 1st bullet	Please clarify how background will be determined (i.e. what statistical analysis shall be used?)	This information will be submitted under separate cover as a technical memo. The referenced text will be revised to clarify this point.
	1.0 2nd bullet	Please clarify what the actual screening level is for project purposes (i.e. "background")	This information will be submitted under separate cover as a technical memo. The referenced text will be revised to clarify this point.
	3.0, First paragraph, last sentence (third paragraph in Final)	Sentence unclear. Please correct sentence structure/content.	Text revised. The referenced sentence now reads: "*All of these wells were selected for sampling.*"
	6.0	What is "Total Radiological parameters"? Please define this somewhere. Is this the same as "Total Radionuclides" as listed in Table 3? If so, please use the same terminology throughout the document (be consistent) and also reference Table 3 for the list. Otherwise, it is very confusing as this is not standard terminology.	The "Total Radiological Parameters" is equivalent to "Total Radionuclides". The suggested revision will be made.

RESPONSE TO COMMENTS

Project Name: NFSS
Document: FSP Add for Background GW Sampling **Date:** 14 February, 2003

	PAGE OR SHEET	COMMENT	RESPONSE
	App E	App E contains several responses to other reviewers which appear inadequate for resolution. Responses such as "Maxim does not understand the comment" or listing a commentor as "Unknown" are not acceptable. If you don't know what is being asked or who asked it, recommend you call and find out so you can give a sensible answer. Please clarify if resolution has been reached on these comments to the satisfaction of the commentor.	Concur. The comments have been clarified and the responses have been amended and reviewers are identified.
	App E	It is uncertain if Maxim "concurs", "non-concurs", or "partially concurs" in each response. Highly recommend stating this at the beginning of each response to minimize confusion. Also indicate what changes, if any, have been made in response. At this point I can't tell if/how the document was/will be revised.	The responses have been reworded as necessary to clarify Maxim's agreement (or disagreement) and the corrective actions made. Maxims level of concurrence is now noted.

Reviewer: Clyde Yancey, P.G., Maxim ITR member.

Comment 1: In the list of acronyms, “Field Sampling and Analysis Plan” is incorrectly presented as “Field Sampling Plan”.

Response 1: Text Revised.

Comment 2: On the table of contents, the title of Appendix E should be “Review Comments and Responses”, not “Review Comments”.

Response 2: Text revised.

Comment 3: Page 3, The Sand and Silt Outwash Unit is incorrectly called the “Sand and Gravel Unit” in the description of the Queenston Formation.

Response 3: Text revised.

Comment 4: Page 4, in the discussion of the two water-bearing zones, it is stated that the source of the groundwater in the Queenston Formation is ‘connate’ water. What is the source for this information? Also, what is the source of the groundwater in the Sand and Silt Outwash Unit?

Response 4: The USACE groundwater contractor, HydroGeoLogic, Inc., has provided additional clarification on this subject. The referenced text now reads:

> *Some of the site documentation further divides the lower water-bearing zone into two subunits, separated by the Basal Red Till (NFSS-082 and NFSS-302). However, since the lateral extent and thickness of the Basal Red Till is highly variable across the NFSS and vicinity and water level responses in the weathered Queenston Formation and Sand and Silt Outwash Unit are similar, a hydraulic connection is evident between these two subunits. However, geochemical differences in the Sand and Silt Outwash Unit and the Queenston Formation may exist. In a personal communication between HydroGeoLogic, Inc. (the USACE groundwater contractor) and Maxim, it was explained that the groundwater in the deeper, unfractured portion of the Queenston Formation may be connate water and this deeper water may be released into the fractured portion of the Queenston Formation and in turn to the Basal Red Till and the Sand and Silt Outwash unit. However the Sand and Silt Outwash Unit also derives a portion of its water as leakage through the overlying Glaciolacustrine Clay and from regional flow. The water resulting from the leakage and the regional flow is probably of meteoric origin. Thus, water in the Sand and Silt Outwash Unit, Basal Red Till and fractured Queenston Formation are probably mixtures of connate and meteoric water, although the proportions of connate water are probably highest in*

the Queenston Formation. Because the ratio of connate water to meteoric water may vary between the units, it is possible that geochemical differences exist in the groundwater in the different units. For this reason, wells and piezometers representative of all the component units of the lower water-bearing zone were selected.

Comment 5: Page 5, item 3B). Why was preference give to wells and piezometers with higher hydraulic conductivities?

Response 5: The analytical list is extensive and a large volume of sample will be required to satisfy the analytical requirements. It is believed that, in general, wells with higher hydraulic conductivities will be better able to satisfy these requirements.

Comment 6: Page 5, item 3E): Suggest defining a range of values for the phrase 'substantially higher'.

Response 6: Five criteria were used to select the wells and few of the selected wells perfectly satisfy all five criteria. In a somewhat subjective process, the wells that best satisfied the criteria were selected. As such, there was no hard and fast definition of 'substantially higher'.

Comment 7: Page 6. General Engineering Laboratories is incorrectly called "General Engineering Laboratory".

Response 7: Text revised.

Comment 8: Page 7, Item 1): Shouldn't you also state that you will 'sound' the total well depth.

Response 8: Yes. Sounding the wells will be added to the method.

Comment 9: Page 7: Couldn't find the substitute wells on Table 1.

Response 9: The footnote defining substitute wells has been clarified.

Comment 10: Page 12: What about QA/QC of lab data prior to the Data Evaluation (section 8.1).

Response 10: A QA/QC type of evaluation will be performed. Such activities are described in the project QCP.

Reviewer: Dennis Herzing, P.E., Maxim ITR member

Comment 1: Page 3, first paragraph, last sentence, 'water-bearing zone **in** located; should read 'water-bearing zone **is** located'.

Response 1: Text revised.

Comment 2: Page 4, second paragraph, is the acronym LOOW defined anywhere in the document.

Response 2: No. The acronym 'LOOW' stands for 'Lake Ontario Ordnance Works'. The acronym has been spelled out, negating the need for the acronym.

Comment 3: Page 4, last paragraph, second sentence, 'other wells installed' should read 'other wells **were** installed. . ."

Response 3: Text revised.

Comment 4: Page 12, penultimate paragraph, first sentence, 'indicate the wells have been' should read 'indicate **that** the wells have been'.

Response 4: Text revised.

Reviewer: Matthew J. Forcucci, NYDOH

Comment 1: Page 2, Section 2.0. The terminology used to describe the various geological units is inconsistent both within the descriptions and throughout the report, making review of the well selections somewhat confusing. For example, within the brown clay till description, there are references to the brown clay unit. Geologically, clay and till are two distinct features with varying water bearing and geotechnical characteristics.

Response 1: Concur. The nomenclature has been made consistent.

Comment 2: Page 5, Section 5.0. The sampling protocol needs to include several clarifications. It appears that sample collection starts immediately after water level measurements are collected, with well development occurring only as part of achieving stability of certain general parameters rather than removing a specific volume of water, or until the well is pumped dry. The low-flow sampling methodology is appropriate for low yield wells, especially those of the upper water-bearing unit, but enough development must occur to insure that the water sample being collected is from the water bearing unit and not static water around the well casing.

Response 2: The low-flow method accommodates the removal of stagnate water as described below.

The low-flow method does not specify a volume of water to be purged prior to sample collection. Instead, it relies on the measurement of several water qualities parameters to determine when water representative of the formation is being pumped. Prior to pumping a well, water in the well casing above the screen may be 'stagnant' and may not be representative of the groundwater in the formation. The low-flow method accommodates this problem two ways:

1) Drawdown is monitored and minimized, thereby reducing the mixing of the stagnant water above the screen with formation groundwater in the screened interval of the well.
2) Water quality parameters are measured every three to five minutes. Only after the water quality measurements indicate that the groundwater is stable (as specified in the plan) are samples collected. This insures that water that is chemically different from the formation water is not sampled.

Because of the drawdown requirement, wells will not be pumped dry.

Comment 3: Since well development or an attempt to achieve the parameters listed in item 4 can lead to a dry well, a criteria for what defines a dry well should be developed as well as how replacement wells will be selected. Using available slug test data where it exists, a determination can be made as to wells that may not sufficiently recharge, and replacement wells can be evaluated prior to field activities. Otherwise, a dry well can be defined as a well that does not recharge in sufficient volume to collect the needed samples after 3 days of the well being pumped dry. It is unclear in item 3 whether "recovery" and "additional rest periods" refers to the development of the well or the sampling of the well.

Response 3: The wells will be purged prior to sample collection, in accordance with EPA guidance for the low-flow method of groundwater sample collection. This is discussed in the response to Comment 2.

Wells will not be pumped dry. The sample teams are instructed to not allow the drawdown in a well to exceed one foot. If pump rates of less than 0.1 L/m cause an excessive drawdown, an alternate well may be selected. The alternate wells are presented in the plan.

Additional hydraulic conductivity data has become available since the submittal of the draft plan and this additional data has been incorporated into the selection of sample wells and replacement wells.

The ‘recovery’ and ‘additional rest periods’ refer to both the purging and the sampling of the well. This has been clarified in the text.

Comment 4: Table 1. Well SP-12M lists a screened unit as SL, yet that definition does not appear anywhere.

Response 4: The table has been revised. The information originally supplied to Maxim described the lithology of the screened unit of SP-12M as SL (‘sand lens’). This classification has since been clarified and the table has been revised accordingly. It is now reported as Sand Silt Outwash and Basal Red Till.

Comment 5: Table 1. While all wells within selection code 2 provide good aerial distribution across the site, sample data from wells in the Queenston formation should be used separate from the data collected from the 2 wells in the sand silt outwash unit and the well from the basal red till. This would address your (Michelle Rhodes’) initial comment number 10 concerning geochemical differences between the sand and silt outwash and the weathered upper Queenston. Additionally, the potentiometric surface map generated by focusing on the water level data from the Queenston formation only may be of greater relevance in determining true groundwater conditions and characteristics.

Response 5: As part of the preparation of the comparative memo, the analytical results for the Queenston formation will be compared to the results for the Sand and Silt Outwash Unit to determine if the analytical results for these two units are statistically different. The USACE groundwater contractor HydroGeoLogic, Inc will perform further evaluation of the degree to which these two units are hydraulically connected.

SUBMITTAL REVIEW
COMMENT SHEET

Compiled by:

Project: FUSRAP NFSS Background Groundwater SAP addendum, January 2003

Date: 14 February 2003

COMMENT NUMBER	PAGE OR SHEET	COMMENT	RESPONSE
USACE – Environmental Health Team – Fred Kozminski – Project Chemist			
1	Pg 1, sec 1.0 &	The text refers to statistical analysis of data. Section 8.1 identifies an outlier procedure. Is this the extent of the statistics? This procedure is not clearly stated regarding the “data set”. Does data set refer to replicate determinations for a result? And this test would recommend an outlier for that set relative to the other measurements? Please clarify.	Section 8.1 states: “a background groundwater data set for both the upper and lower water-bearing zones will be produced for each parameter”. This will be clarified to read: “The analytical results for each parameter, in both the upper and lower water-bearing zones, will be compiled into background data sets.”
2	Pg 5, sec 5.0	Please include EPA low-flow groundwater sampling guidance in the appendix.	Agreed. The guidance will be presented in Appendix C of the Final FSAP Addendum
3	Pg 5, Sec 5.0	Evaluation of stabilization parameters for groundwater low-flow sampling is based on the current measurement vs. the previous measurement. A confirmation of stability is indicated by a minimal specified acceptable change between these measurements. Confirmation will be apparent when the measurement is acceptably stable for three consecutive measurements. All parameters will not stabilize at the same rate, some will not stabilize. A default parameter should be identified indicating stabilization if the well is troublesome. What is contingency protocol for unacceptably slow recharge well? Note: I’m not sure if RPD will work for every scenario. Example, if one starts with a high conductivity reading and stabilization proceeds to a very low reading relative to the initial high reading, then the RPD test has the potential to fail, (>10%) and may continue to degrade until stabilization is encountered.	While it is true that all parameters will stabilize at different rates, it is equally true that in almost all cases there is a point in time when all parameters are stable. As discussed in Section 5, if stability cannot be achieved within three hours, either because of low recharge or unusually heterogeneity in the geochemistry of the groundwater, an alternate well will be selected. The use of a single ‘default’ parameter defeats the intent of the low-flow method in that it would allow sampling of a well when the collected groundwater is not demonstrably representative of the formation.
4	Pg 6, Sec 5	~~Please itemize rad parameters. Please provide all preparation and determinative analytical methods and sources for both chem and rad parameters. For gross alpha measurement, does NYSDEC reg exclude the radium?~~ Recommend collecting organic sampling material first and then non-filtered metals + rad and then filtered metals + rad. Last paragraph,	Portion of comment stricken at the request of the reviewer. The USACE has provided additional guidance on the issue of the sample collection order. The order of collection will be VOCs, total rad, total metals, PAHs,

SUBMITTAL REVIEW
COMMENT SHEET

Compiled by:

Project: FUSRAP NFSS Background Groundwater SAP addendum, January 2003

Date: 14 February 2003

COMMENT NUMBER	PAGE OR SHEET	COMMENT	RESPONSE
		ideally the well should not be allowed to draw down. Draw down may be minimized by purging and pumping at a rate not to exceed recharge. Recharge rate may be monitored with a depth sensor. If the well does not exhibit draw down the there should be no reason to intermittently check turbidity.	dissolved rad, dissolved metals, SVOCs, Pest/PCBs, nitroaromatics. However, if the field team is confident that the well will produce a sufficient quantity of water to satisfy all volume requirements, the order will be modified – the organics will be collected prior to the collection of the dissolved parameters. Concerning the comment concerning drawdown: Insuring stability of drawdown does not necessarily guarantee an acceptable degree of turbidity. A sample may become turbid for reasons completely independent of pumping rate (e.g. if the pump or tubing is disturbed during sampling it may temporarily suspend sediment lodged in the well screen). For this reason, it is useful to document the turbidity of each sample container. Each turbidity measurement will consume only 10 to 15 ml of water.
5	Pg 7, sec 5.0	Please provide the composition of the dedicated submersible pumps. Dedicated is preferred over decontamination. Recommend use of dedicated Teflon bladders.	The dedicated submersible pumps have plastic housing and a plastic impeller. They are of the same manufacture as the pumps used during earlier phases of the RI. The bladder pump is equipped with a Teflon bladder. However, the cost of dedicating bladders to wells would be substantial. The bladders cost $175 each.
6	Pg 8, sec 6	Please provide copy of CNF approval. Has a profile been prepared for the liquid IDW? Has this been submitted to CNF?	The CNF has approved acceptance of previous IDW waste on a case-by-case basis. Liquid IDW from the Modern Landfill site (NFSS Background Groundwater Samples) has not yet been generated or subsequently sampled. Therefore, a waste profile has not been prepared for the City of Niagara Falls WWTP and approval for the trucked

SUBMITTAL REVIEW
COMMENT SHEET

Compiled by:

Project: FUSRAP NFSS Background Groundwater SAP addendum, January 2003

Date: 14 February 2003

COMMENT NUMBER	PAGE OR SHEET	COMMENT	RESPONSE
			discharge has not been granted. After the NFSS background sampling effort is completed and resultant liquid IDW is generated and analyzed, the liquid IDW chemical characterization profile will be prepared for submittal to the City of Niagara Falls. Prior to submittal of the chemical characterization profile and accompanying request for discharge letter, Maxim will present the package to USACE-Buffalo for review and approval. After the discharge approval letter and approval number is obtained from the City of Niagara Falls for the proposed discharge, it will be provided to the USACE-Buffalo for the NFSS file.
7	Pg 8, sec 6.0	If CNF Issues a discharge permit why will NYSDEC be provided a copy? Some discharge detection limits are very low. Have the lab limits been compared and will they meet permit requirements? Are all the parameters accounted for? What is estimated IDW volume? If there are two phases will both phases be analyzed?	In the past, the CNF discharge approval letter and supporting wasteload calculations have been provided to the NYSDEC since they administer the CNF WWTP NPDES discharge permit. Maxim proposes to use the same analytical detection limitations for this round of liquid IDW analysis as have been used and acceptable to the CNF in the past. The same parameter list as has been used from the previous two liquid IDW sampling efforts will be used for the Modern Landfill sampling effort. This list accounts for all of the analytes requested by CNF except those analytes waived by the City during the first sampling effort (12/99). Waived analytes include – monochlorobenzotrifluoride, Monochlorotoluene, dichlorotoluene, trichlorotoluene, dichlorobenzotrifluoride, Mirex, and Declorane Plus.

SUBMITTAL REVIEW
COMMENT SHEET

Compiled by:

Project: FUSRAP NFSS Background Groundwater SAP addendum, January 2003

Date: 14 February 2003

COMMENT NUMBER	PAGE OR SHEET	COMMENT	RESPONSE
			The estimated volume of liquid IDW generated from the groundwater sampling at the Modern Landfill is less than 500 gallons. Based on past liquid IDW sampling events and the components of liquid IDW (primarily decontamination water), it is not anticipated that two phases will be encountered in the storage tank. However, if two phases are encountered, both will be sampled accordingly.
8	Pg 14, Appendix B	I recommend the 8310 result to be reported for a water matrix. This should be considered the primary, (definitive) number for PAHs. If both numbers are reported ambiguity will result.	Current plans were for the evaluation and reporting of PAHs by both methodologies, consistent with our January 10, 2003 teleconference. PAH data would be differentiated by both Fraction and Method and the 8270 data may be useful as comparative support to the primary data set (8310) for determination of potential outliers.
9	Pg 14, Appendix B	The IDL is a statistically based determination calculated at a confidence level. A lab may report to their IDLs/MDLs with appending a (J) qualifier to a positive identification < the lab reporting limit and > than zero.	Agreed. Since our discussion on this issue during the January 10, 2003 teleconference and reporting information supplied by the laboratory, Maxim is in agreement with this format for application of the (J) qualifier and Appendix B (Revised Reporting Criteria)will be reworded accordingly.
END OF COMMENTS			

Filename: SubXXX.doc

Reviewer: Jim Goehrig, Modern Landfill

Comment: I've read the documents and have no comments or additions.

Response: Comment noted.

Reviewer: John Mitchell, NYSDEC

Comment1: The 1 gallon of GW collected for the gamma spec analysis can be used for total U and Gross Alpha/Beta (thereby reducing the need for 4L of additional GW collection per well including filtered and unfiltered).

> Response 1: While it is technically feasible for the lab to perform the gamma spec analysis, total Uranium analysis and the gross Alpha/Beta analysis using a single 1-gallon sample container, there are laboratory operational concerns that discourage this practice. The laboratory would either have to split the sample into several subsamples after receipt, which would increase the chances for sample spillage, mislabeling of containers, sample contamination, etc. Or, the laboratory could perform the several analyses sequentially. But this could cause the laboratory to miss the contractually specified turn around time. Therefore, in the interests of quality assurance and schedule compliance, we feel that the collection of the additional sample volume, where practical, is warranted.

Reviewer: Judy Liethner, USACE

General Comment 1: This FSP Addendum is of improved quality compared to the general FSP addendums we have received throughout the project. This is appreciated.

> Response: Comment noted.

General Comment 2: The name and contact information for the site manager should be specified.

> Response 2: This information will be included in the revised FSP Addendum.

Comment 3: Page 3: Next to last Paragraph: Preference should be given to wells in the lower water bearing zone that most closely match the geochemistry (not topography) of the wells on NFSS.

> Response 3: Geochemical data exists for some "W" designated wells only. All other "wells" are not sampled by Modern, but used for water levels. All W wells (with available geochemical data) within the bounds of the Right of Entry except for W-8R (which is screened across both the lower and bedrock units) and W-13, W-16 and W-17 that are fairly shallow (less than 20' deep) and screened in the SSOW (which is not consistent with the lithology at NFSS). Since little geochemistry data existed, we used screened lithology as the next best substitute. The revised FSP Addendum will be changed to clarify this point. See Section 3.0, item 3.
>
> Based on additional guidance from the USACE, it has been decided to not contact the CX on this issue, at this time.

Comment 4: Page 5: Next to last bullet. Please add ORP (oxidation reduction potential) to the list of acronyms.

> Response 4: Text revised.

Comment 5: Page 6, item 5: In the event that insufficient volume is available to fill all sample containers, would recommend that Maxim consult the RI findings to date to determine which analytes appear to be potential contaminants. These are the essential background values that must be obtained, and this should help prioritize collection needs in the case of insufficient water volumes.

> Response 5: The USACE has provided additional guidance in resolving this issue. The collection order will be: VOCs, total rad, total metals, PAHs, dissolved rad, dissolved metals, SVOCs, Pest/PCBs, nitroaromatics. If the field team believes that the well will produce

sufficient volume to satisfy all parameters, The Site Manager may modify the order – the organic parameters will be collected prior to collecting the dissolved rad and metals samples.

Comment 6: Page 9, second paragraph. What assurances are provided that the vacuum/tanker truck provided to transport the IDW is clean? (i.e. contains no contaminants that would cause a treatment plant upset despite the fact that our IDW meets acceptance criteria)?

Response 6: The contractor selected to haul our IDW (the "Drain Doctor", 716-285-6383), is not permitted to haul hazardous waste. They have several trucks, each dedicated to the hauling of a specific waste. One truck hauls septic tank/sanitary wastewater only, one truck handles grease, one truck handles oil, etc. The truck used to haul the liquid IDW from the NFSS to the CNF-WWTP hauls sanitary/septic wastewater only. Between loads from customer to another, the truck is emptied but not washed out. Since the truck to be used at the NFSS only hauls sanitary/septic wastewater, the chances of carrying industrial sources of contamination are limited. In addition, the Drain Doctor was on a list of haulers recommended by the CNF-WWTP.

Comment 7: Page 10, first paragraph. This sounds like the wells will be selected based on available information, the samples will be taken and analyzed, and then the data used in well selection will be assessed to determine whether the wells have been previously impacted by previous land uses or ownership. Unless the sample data is to figure in to this assessment (it sounds like it will not from the text provided), this determination after the fact is too late. This paragraph needs further explanation to clarify at what point, and using what data, it will be determined that the wells have/have not been previously impacted.

Response 7: Section 8.1 has been revised to read:

As part of the data evaluation, new information acquired after the submission of this FSP Addendum, along with the information used in the selection of the sample wells, will be reviewed. The analytical data generated by this task will be included in this review. This evaluation will include the development of data subsets, based on sample locations. Distribution parameters for these subsets, such as maximum, minimum, and median for will be evaluated to determine if the chemical results indicate that specific wells or areas of the site have been impacted by a previous land use.

The available chemical data for wells on the Modern Landfill site *does not indicate the wells have been impacted by previous land uses. However, the available data is limited, both spatially and with respect to parameters of interest for the NFSS RI.*

COMMENT SHEET
PDT/ ITR Review

Complete and Return to: Michelle Rhodes, Project Engineer by 7 Feb. 2003

Project: NFSS FUSRAP **Work item/phase:** Remedial Investigation: Background Groundwater collection

Reviewer: Karen Keil, CELRB-TD-EH Risk Assessor **Date:** 03 February 2003

COMMENT NUMBER	PAGE / OR SHEET	COMMENT	RESPONSE

Reviewer: Karen Keil, USACE

		Comment	**Response**
1	Section 3.0	First paragraph, last sentence. Should the "and" be "all"? (note: referenced test in the Final FSP is now the third paragraph)	Text revised.
2	Section 6.0	Why is IDW discharged to City of Niagara Falls WWTP, rather than to the Town of Lewiston's facilities, which are located on Pletcher road?	On 12/1/99, Maxim communicated with Mr. Tim Lockhart – Superintendent of the Town of Lewiston WWTP regarding disposal of liquid IDW at their facility. At the time of the communication, Mr. Lockhart indicated that his plant could not accept the waste because their discharge permit from the NYSDEC was only for the receipt of sanitary and septic tank wastes. Mr. Lockhart indicated that he could probably apply for an exemption to the discharge permit, but it would take a significant amount of time to receive approval from the NYSDEC if acceptable. Knowing that the City of Lewiston could probably not accept the liquid IDW from the NFSS, Maxim contacted the City of Niagara Falls Wastewater Treatment Plant (Mr. Al Zaephel – Industrial Monitoring Coordinator) that had a trucked industrial wastewater discharge program and coordinated their discharge closely with the NYSDEC. Mr. Zaephel indicated he could accept our liquid IDW if it were analyzed for a specific list of acceptance analytes and submitted a

COMMENT SHEET
PDT/ ITR Review

Complete and Return to: Michelle Rhodes, Project Engineer by 7 Feb. 2003

Project: NFSS FUSRAP **Work item/phase:** Remedial Investigation: Background Groundwater collection

Reviewer: Karen Keil, CELRB-TD-EH Risk Assessor **Date:** 03 February 2003

COMMENT NUMBER	PAGE / OR SHEET	COMMENT	RESPONSE
			formal request for discharge. In addition to having the trucked waste program, the City of Niagara Falls has a treatment train (physical/chemical plant consisting of chemical precipitation/clarification; pH adjustment; activated carbon and chemical oxidation) that can manage most industrial discharges. Since 1999, Maxim has been discharging liquid IDW generated at the NFSS in close coordination with Al Zaephel and NYSDEC representatives (Mr. John Mitchell and Kent Johnson) with no problems.
3	Section 8.1	One of the assumptions for use of Grubb's test for outliers is that the data set is normally distributed. Also, recommend that this test be used at an alpha of 1% (otherwise, we may be "over" identifying "outliers").	Agreed. Grubbs' test is also valid for lognormally distributed data sets if the data set is log transformed prior to performing the test. Transformation of data sets will be described in more detail in the revised FSAP addendum. As recommended by the reviewer, an alpha value of 0.01 will be used for the Grubbs' test of normality and lognormality.

Reviewer: Kent Johnson, NYSDEC

Comment 1: -the use of "low flow" sampling: The shallow wells have very slow recharge. I can't imagine how slow purging will be if you want to minimize drawdown.

> Response 1: Partially concur. Maxim is aware of the fact that the purge rate for some of the wells will be very slow. However, since the submittal of the Draft FSAP Addendum, additional hydraulic conductivity data has been made available. This additional data was incorporated into the selection process. The field teams are instructed to notify the Site Manager if purge rates greater 0.1 L/m cause a drawdown of more than one foot. If a well is slow to recharge, the drawdown criteria may be relaxed or the sample point may be abandoned and an alternate sample point will be selected.

Comment 2: - the list of parameters and the associated volumes: I hope you have three days per well to collect the samples.

> Response 2: The list of parameters is extensive and the required sample volume is quite large – 21 L, including the ‘extra’ volume. However, at the minimum pumping rate of 0.1 L/m, all containers will be filled in about 3.5 hours, excluding any interruptions in the pumping of the sample. The plan specifies corrective actions for wells incapable of producing the required sample volume.

Reviewer: Liza Finley, USACE Baltimore District, (410) 962-2683

Comment 1: Section 1.0 – In the first paragraph that discusses the objectives, it states that two water-bearing zones will be evaluated to determine two separate sets of background concentrations, has it been determined that there actually are two separate distinct water bearing units? The document that established this should be cited, such as, the *Groundwater Flow Model Calibration Technical Memorandum, April 2002.* NYSDEC, based on discussions at the LOOW TPP August 2002 meeting, does not fully accept this concept, so additional information must be presented here to substantiate the investigation.

Response 1: The following text has been inserted into Section2.0:

Two groundwater water-bearing zones have been identified at the NFSS, the upper water-bearing zone (in the Brown Clay Till) and a lower water-bearing zone (in the Sand and Silt Outwash Unit and the fractured and weathered upper portion of the Queenston Formation). The Glaciolacustrine Clay Unit separates the two zones, though wells screened in the Glaciolacustrine Clay Unit are considered to be in the upper water-bearing zone. These groundwater zones are not considered significant sources of groundwater, due to low well yield and/or high degree of mineralization. The natural principal groundwater flow direction in the lower water-bearing zone is north-northwest toward Lake Ontario, mimicking the gently sloping surface of the underlying strata. The upper water-bearing zone is found chiefly in discontinuous sand lenses and may be perched at many locations.

Some of the site documentation further divides the lower water-bearing zone into two subunits, separated by the Basal Red Till (NFSS-082 and NFSS-302). However, since the lateral extent and thickness of the Basal Red Till is highly variable across the NFSS and vicinity and water level responses in the weathered Queenston Formation and Sand and Silt Outwash Unit are similar, a hydraulic connection is evident between these two subunits.

Geochemical differences in the Sand and Silt Outwash Unit and the Queenston Formation (the two main water-bearing units within the lower water-bearing zone) may exist. In a personal communication between HydroGeoLogic, Inc. (HGL, the USACE groundwater contractor) and Maxim, HGL hypothesized that the groundwater in the deeper, unfractured portion of the Queenston Formation may be connate water and this deeper water could be released into the fractured portion of the Queenston Formation and, in turn, to the Basal Red Till and the Sand and Silt Outwash unit. However, the

Sand and Silt Outwash Unit also derives a portion of its water as leakage through the overlying Glaciolacustrine Clay and from regional flow. The water resulting from the leakage and the regional flow is probably of meteoric origin. Thus, water in the Sand and Silt Outwash Unit, Basal Red Till and fractured Queenston Formation are mixtures of connate and meteoric water, although the proportion of connate water is probably highest in the Queenston Formation. Because the ratio of connate water to meteoric water may vary between the units, it is possible that geochemical differences exist in the groundwater in the different units. For this reason, wells and piezometers representative of all the component units of the lower water-bearing zone were selected.

The extent to which the Sand and Silt Outwash Unit is connected to the Queenston Formation will be determined by the three-dimensional regional numerical groundwater model currently being constructed for the NFSS and vicinity. This model may be useful for the Lake Ontario Ordnance Works investigation as well.

The current sampling plan will collect sufficient data to allow a characterization of the groundwater background conditions at the NFSS and vicinity, whether the groundwater system is considered to have two water-bearing zones or three.

Comment 2: Section 1.0 – The discussion of the location of the background wells should be expanded to include an explanation of why this location was chosen, i.e. similar geologic units, upgradiant of general groundwater flow (groundwater flow in the northwesterly direction), similar use of property, etc…There is no discussion of using any wells further upgradiant of Modern Landfill, why?

Response 2: The following text has been inserted into Section 3:

All background groundwater samples will be collected from the portion of the Modern Landfill site shown on Figure 1. Modern was selected because it was hydraulically upgradiant of the NFSS, within one mile of the site (assuring similar lithology), and had a sufficient number of available wells screened in the water-bearing zones of interest. Additionally, well construction and geology were documented for the Modern Landfill Site.

The feasibility of using other wells located further upgradiant from Modern was investigated. But all these other wells were installed for drinking or irrigation water purposes. Along with access issues *(i.e. obtaining Right-of-Entry from various property owners), the well construction and geologic information was incomplete. The feasibility of installing new background wells was also investigated. However, there was a concern that installation of shallow wells would not supply adequate well volume for sampling.*

Comment 3: Section 3.0 - Last sentence of first paragraph (note: third paragraph in Final FSP), please re-word. I think the use of <u>and</u> should be taken out of sentence.

Response 3: The referenced text has been revised. It now reads: "*All of these wells were selected for sampling".*

Comment 4: Section 3.0 – What is the definition of the upper vs. the lower water-bearing zones? For the upper will it be from 0 – 23 ft. bgs and the lower 23 to 49 ft. bgs, please define.

Response 4: The water-bearing zones are defined in Section 2 of the FSAP Addendum. The following text is excerpted from Section 2:

Two groundwater water-bearing zones have been identified at the NFSS, the upper water-bearing zone (in the Brown Clay Unit) and a lower water-bearing zone (in the Sand and Gravel Unit and Queenston Formation).

The definitions of the water-bearing zones are tied to lithology and not to any set elevations or depths.

Comment 5: Section 3.0 – In the second paragraph there is discussion of using the deeper wells in the lower units at Modern Landfill, are they located in similar geologic units as the NFSS wells, in order to achieve representativeness?

Response 5: This section, which discusses the process of selecting wells for sampling, has been significantly revised. Preference to wells at which the lithology occurs at elevations similar to the NFSS is only one of the selection criteria. Section 3 now reads:

All available analytical, well construction, and water level data for the wells located within the area covered by the Right-of-Entry were tabulated and evaluated. Fourteen wells and piezometers are screened in the upper water-bearing zone. All of these wells were selected for sampling.

Well log and construction data from Modern Landfill indicate that *the lower water-bearing zone occurs at elevations significantly higher than the corresponding zone on the NFSS. In order to ensure that groundwater samples collected from the lower water-bearing zone on the Modern Landfill site are comparable to the lower water-bearing zone samples collected from the NFSS, preference was given to the deeper wells screened in the lower water-bearing zone. The elevations and lithology of the screened intervals for these deeper Modern Landfill wells are comparable to the elevations and lithology of the screened intervals for the NFSS wells.*

In summary, the selection process for wells within the area covered by the right-of-entry was as follows:

1. *Wells GW-1A, GW-4A, W-14 and W-8R were screened across both water-bearing zones and were excluded from further consideration.*
2. *All wells/piezometers screened exclusively in the upper water-bearing zone were selected. Fourteen wells in the upper water-bearing zone will be sampled.*
3. *For wells/piezometers screened in the lower water-bearing zone, the selection process consisted of the application of several criteria and then selecting the 16 wells/piezometers which best satisfied the criteria. The selection criteria were:*

   A) *Wells were favored over piezometers.*
   B) *Wells/piezometers with higher hydraulic conductivities were favored over those with lower hydraulic conductivities.*
   C) *The selected wells/piezometers should provide a good spatial representation of the area covered by the right-of-entry.*
   D) *The selected wells/piezometers should provide a good representation of the geologic units that make up the lower water-bearing zone.*
   E) *Preference was given to Modern wells/piezometers in which the screened lithology was similar to that encountered on the NFSS. Wells/piezometers on the Modern Landfill site that encountered the Sand and Silt Outwash Unit, the Basal Red Till or the Queenston formation at elevations substantially higher than the elevations those units were observed on the NFSS site were considered less suitable.*

Comment 6: Section 5.0 – The low-flow groundwater sampling procedures cited should be included in an appendix to this SAP (sampling and analysis plan). In addition, the recommended groundwater flow is 100ml to 500ml, in order to reduce the amount of aeration and turbidity in the groundwater. The procedure used should strive to achieve the lowest rate possible that maintains a steady flow of groundwater.

> Response 6: In response to this comment and to the comments of others, the USEPA guidance will be included as Appendix C to the FSAP Addendum. The sample collection procedure is designed to produce a sample that is representative of the formation. As such, Maxim does not see the utility to biasing the procedure to exceptionally low flow rates. The maximum flow rate that satisfies all procedural requirements is also acceptable.

Comment 7: Section 5.0 – Step 4, the end point of 5 hours before any action is sought is not acceptable. The low-flow procedures are designed to achieve stabilization within 15 – 30 minutes at most. Some difficult wells may take up to an hour, however, at that point other problem sources must be investigated such as instrument problems, incorrect placement of pump within well screen, and improperly screened well. Contingency plans should be developed and incorporated into the decision tree (Figure 2).

> Response 7: In response to the comments of others, the time specified in Step 4 has been reduced to three hours. Maxim realizes that many wells will stabilize much faster. However, in the event that stabilization is problematic, Maxim believes the three-hour time period is warranted because the number of suitable wells at the site is limited. This, coupled with the time required to pull the pumps and move to a new well, which might not perform any better, lead Maxim to conclude that in this specific case it is better to be more patient with a problematic well. Also, one of the well selection criteria was hydraulic conductivity – Maxim biased the selection process towards wells that are more likely to produce usable quantities of water. The revised well selection procedure is discussed in the response to Comment 5. The reviewer's suggested corrective actions are along the lines of 'verification' of previous actions (is the meter working? Is the pump properly located? etc.). This type of troubleshooting is standard field procedure when problems arise. Figure 2 is designed to present the sample collection method that is specific to this project. Including information describing additional procedures would result in a very complex figure of questionable utility.

Comment 8: Section 5.0, Step 5 – Additional volume of groundwater for parameters other than radiological and SVOC should be collected, such as for metals analysis. The laboratory should be consulted to determine the total amounts necessary.

Response 8: The laboratory was consulted. The volumes specified in the FSP are adequate for laboratory analysis, absent a problem that results in the loss of a sample container (e.g. a contain is broken in shipment or at the laboratory). For this reason, additional sample containers will be filled and submitted to the laboratory. Two containers (a filtered sample and an unfiltered sample) will be acid preserved and an unfiltered sample will be cold preserved. Since the laboratories sample login protocols have no provision for containers which are ‘extra’, they will be submitted for radiological and SVOC analysis. However, these designations are provisional, made only to comply with login procedures, and the laboratory is aware of the fact that a cold preserved sample submitted for SVOC analysis is equally suitable for any other procedure that requires a cold preserved sample. The case is similar for the acid preserved samples.

Comment 9: Section 8.0 & 8.2 – A comparative memorandum will be prepared to discuss the background results to the NFSS groundwater results, however there is no discussion regarding how the comparison will be conducted. This should be discussed as part of the SAP or as a separate workplan for data comparison.

Response 9: The methods of statistical analysis will be presented in a technical memo.

Reviewer: Louise Lindsay, M. Sc., P. Ag., Environmental Solutions

Comment 1: Several of the wells that Maxim have chosen for your background sampling were installed to monitor the old Town of Lewiston Dump (an unlined municipal solid waste disposal site). These wells may be impacted by the old dump and would not reflect background water quality. I would suggest that they eliminate these wells from their sampling program.

Response: While it is agreed that these wells may be impacted by the old dump, these wells were included in the sampling plan for the following reasons:

- To increase the available dataset for background screening (due to limited availability of monitoring wells versus temporary well points), and
- These wells may provide true background values for non-landfill COCs (such as rad).

An outlier test will be performed on all data points. If the outlier test indicates that these wells may be impacted by past land use, they will be excluded from the background data sets.

Comment 2: I did spot checks on some of the information presented in Table 1 and found some errors. I will fax you that page with my corrections; however, based on the errors I found, I would suggest that the information in this table should be checked.

Response 2: The table will be corrected.

Comment 3: Table of Contents, Reference to Figure 2 "Decision Tree..." is missing and Table 4 is mislabeled as Table 3

Response 3: Text revised.

Comment 4: My copy of the document was missing both Table 3 and Table 4

Response 4: Though Tables 3 and 4 were presented in the hard copies of the plan submitted to the USACE, they were inadvertently omitted from the electronic submittal. The electronic file, with both Tables 3 and 4,will be resubmitted to the USACE.

Comment 5: Main text page 1, second last paragraph "The area covered by this agreement, and shown and". Shouldn't the second "and" be "in"?

Response 5: Text revised.

Comment 6: Page 3, first paragraph, last line in Section 3.0, shouldn't the "and" be "all"?

Response 6: Text revised.

Comment 7: Page 4, item 3. "Well W-11, the deepest well not initially selected, was then...". Shouldn't this say, "Well W-11, the deepest well was not initially selected, but was later substituted..."?

Response 7: Additional hydraulic conductivity data has become available since the submittal of the FSAP Addendum. With this additional data, the well selection method was modified. Item 3 now reads:

In summary, the selection process for wells within the area covered by the right-of-entry was as follows:

1. *Wells GW-1A, GW-3A, GW-4A, W-14, W-1R2, and W-8R were screened across both water-bearing zones and were excluded from further consideration.*
2. *All wells/piezometers screened exclusively in the upper water-bearing zone were selected. Fourteen wells in the upper water-bearing zone will be sampled.*
3. *For wells/piezometers screened in the lower water-bearing zone, the selection process consisted of the application of several criteria and then selecting the 16 wells/piezometers which best satisfied the criteria. The selection criteria were:*

   A) *Wells were favored over piezometers.*
   B) *Wells/piezometers with higher hydraulic conductivities were favored over those with lower hydraulic conductivities.*
   C) *The selected wells/piezometers should provide a good spatial representation of the area covered by the right-of-entry.*
   D) *The selected wells/piezometers should provide a good representation of the geologic units that make up the lower water-bearing zone.*
   E) *Preference was given to Modern wells/piezometers in which the screened lithology was similar to that encountered on*

the NFSS. Wells/piezometers on the Modern Landfill site that encountered the Sand and Silt Outwash Unit, the Basal Red Till or the Queenston formation at elevations substantially higher than the elevations those units were observed on the NFSS site were considered less suitable.

Comment 8: Page 8, second paragraph from the bottom of the page is indented when it shouldn't be.

Response 8: The margin stop on the page has been corrected.

Comment 9: Appendix B, third paragraph, "This delivery ordor..". Shouldn't it be "order"?

Response 9: Text revised.

Comments from Michelle Rhodes, USACE

Comment #1: Page 1, Line 4: Please reword to say, "...characterize *background groundwater* concentrations..."

Response #1: Text Revised.

Comment #2: Page 1, Ist Bullet, Last Line: Please reword to say, "...each water-bearing zone will then be *statistically* determined."

Response #2: Text Revised.

Comment #3: Page 1, Mid Page: The WP states that there are three primary objectives. Please change to *four* and bullet "*Selection of representative background GW locations*".

Response #3: Text Revised

Comment #4: Page 2, Line 1: Please reword to say, "...a summary of the *geology and* hydrogeology *at NFSS*."

Response #4: Text Revised.

Comment #5: Page 2, Line 5: Please reword to say, "..are present *at NFSS in order of depth from ground surface*."

Response #5: Text Revised.

Comment #6: Page 2, Glaciolacustrine Clay description: 1. Please change Glaciolucustine to *Glaciolacustrine*. 2. Instead of describing the gray clay layer as "generally wet", please change to "*The clay is a fully saturated and competent semi-confining unit that is continuous across the vicinity of NFSS*." This text has been approved by HydroGeoLogic.

Response #6: Text Revised.

Comment #7: Page 2: Sand and Gravel Outwash Unit description: Please reword to say, "The Sand and Gravel Unit contains the *upper portion of the lower water-bearing zone."*

Response #7: See response to Comment #10.

Comment #8: Page 2, General: Please reference all NFSS-XXX docs cited.

Response #8: Text Revised.

Comment #9: Page 2: Queenston Formation description: Please reword to say, "...upper portion is slightly to moderately weathered and fractured *and contains the upper bedrock water-bearing zone*."

Response #9: See Response to Comment #10.

Comment #10: Page 3, 1st complete sentence: Please reword to say, "*Since the lateral extent and thickness of the Red Silt Till Unit is highly variable across the NFSS and vicinity and water* *level responses in the weathered Queenston Formation and Sand and Silt Outwash Unit are similar, a hydraulic connection is evident between the two lower water-bearing zones. However, since the main recharge source of the weathered bedrock is connate water, geochemical differences in the Sand and Silt Outwash and weathered upper Queenston water-bearing zones may exist."*

Response #10: Text revised. The text describing the water-bearing units, their respective component units, and geochemistry has been expanded and clarified. The following text now appears in Section 2:

Two groundwater water-bearing zones have been identified at the NFSS, the upper water-bearing zone (in the Brown Clay Till) and a lower water-bearing zone (in the Sand and Silt Outwash Unit and the fractured and weathered upper portion of the Queenston Formation). The Glaciolacustrine Clay Unit separates the two zones, though wells screened in the Glaciolacustrine Clay Unit are considered to be in the upper water-bearing zone. These groundwater zones are not considered significant sources of groundwater, due to low well yield and/or high degree of mineralization. The natural principal groundwater flow direction in the lower water-bearing zone is north-northwest toward Lake Ontario, mimicking the gently sloping surface of the underlying strata. The upper water-bearing zone is found chiefly in discontinuous sand lenses and may be perched at many locations.

Some of the site documentation further divides the lower water-bearing zone into two subunits, separated by the Basal Red Till (NFSS-082 and NFSS-302). However, since the lateral extent and thickness of the Basal Red Till is highly variable across the NFSS and vicinity and water level responses in the weathered Queenston Formation and Sand and Silt Outwash Unit are similar, a hydraulic connection is evident between these two subunits.

Geochemical differences in the Sand and Silt Outwash Unit and the Queenston Formation (the two main water-bearing units within the lower water-bearing zone) may exist. In a personal communication between HydroGeoLogic, Inc. (HGL, the USACE groundwater contractor) and Maxim, HGL hypothesized that the groundwater in the deeper, unfractured portion of the Queenston Formation may be connate water and this deeper water could be released into the fractured portion of the Queenston Formation and, in turn, to the Basal Red Till and the Sand and Silt Outwash unit. However, the Sand and Silt Outwash Unit also derives a portion of its water as leakage through the overlying Glaciolacustrine Clay and from regional flow. The water resulting from the leakage and the regional flow is probably of meteoric origin. Thus, water in the Sand and Silt Outwash Unit, Basal Red Till and fractured Queenston Formation are mixtures of connate and meteoric water, although the proportion of connate water is probably highest in the Queenston Formation. Because the ratio of connate water to meteoric water may vary between the units, it is possible that geochemical differences exist in the groundwater in the different units. For this reason, wells and piezometers representative of all the component units of the lower water-bearing zone were selected.

The extent to which the Sand and Silt Outwash Unit is connected to the Queenston Formation will be determined by the three-dimensional regional numerical groundwater model currently being constructed for the NFSS and vicinity. This model may be useful for the Lake Ontario Ordnance Works investigation as well.

The current sampling plan will collect sufficient data to allow a characterization of the groundwater background conditions at the NFSS and vicinity, whether the groundwater system is considered to have two water-bearing zones or three.

Comment #11: Page 3, Line 11: Please reword to say, "The upper water-bearing unit is found chiefly in discontinuous sand lenses and *may be* perched at many locations." There is not enough hydraulic field data to support that perched zones actually exist. The variations in water levels and transmissive properties in the upper water-bearing zone could be caused by the discontinuous nature of the sand and gravel lenses.

Response #11: Text revised.

Comment #12: Page 3, Section 3.0, Line 1: Please specify what you mean by "all available data." Are you referring to analytical, well construction details, water levels, etc.?

Response #12: The reviewer correctly enumerated the types of data referenced in this sentence. The text will be revised accordingly.

Comment #13: Page 3, Section 3.0, Line 3: Please reword to say, "in the upper water-bearing zone was limited, *all* of these wells were selected for sampling."

Response #13: Text revised.

Comment #14: I'm not sure that I understand the logic behind selecting the deeper Modern wells screened in the lower water-bearing zone. Elevation of the hydrogeologic unit alone doesn't substantiate the selection of the deeper wells. Since no well on Modern is screened across both the weathered Queenston Formation and Sand and Silt Outwash Unit, Maxim shall use geochemical data on NFSS and Modern, along with well construction and screened geologic info to select representative "lower" WBZ background wells. Is the geochemistry in the weathered Queenston Formation similar enough to that in the Sand and Silt Outwash Unit to use the deeper data for background screening? Should a few shallower "lower" background wells be more representative of NFSS site conditions? NFSS has 25 upper, 10 intermediate (Alluvial Sand and Gravel) and 5 lower (weathered upper Queenston) wells (with 7 screened in both the intermediate and lower). Modern has 16 upper (only 4 of which are screened in sand), 37 intermediate and 26 lower (with none screened in both the intermediate and lower).

Response #14: Since the submittal of the FSAP Addendum, additional data has become available and the selection criteria have been significantly modified. The text describing the selection of wells has been revised to read:

The selection process for wells within the area covered by the Right-of-Entry was as follows:

1. *Wells GW-1A, GW-3A, GW-4A, W-14, W-1R2, and W-8R were screened across both water-bearing zones and were excluded from further consideration.*
2. *All wells/piezometers screened exclusively in the upper water-bearing zone were selected. Twelve wells in the upper water-bearing zone will be sampled.*
3. *For wells/piezometers screened in the lower water-bearing zone, the selection process consisted of the application of several criteria and then the selection of 18 wells/piezometers that best satisfied the criteria. The selection criteria were:*

A) Wells were favored over piezometers.
B) Wells/piezometers with higher hydraulic conductivities were favored over those with lower hydraulic conductivities.
C) The wells/piezometers were selected to provide a good spatial representation of the area covered by the Right-of-Entry.
D) The wells/piezometers were selected to provide a good representation of the geologic units that make up the lower water-bearing zone.
E) Preference was given to Modern wells/piezometers in which the screened lithology was similar to that encountered on the NFSS. Wells/piezometers on the Modern Landfill site that encountered the Sand and Silt Outwash Unit, the Basal Red Till or the Queenston formation at elevations substantially higher than the elevations those units were observed on the NFSS site were considered less suitable.

Comment #15: Page 5, Item 2), Line 2: Please state the advantage of installing pumps in wells 48 hours prior to pumping the well. Was this acceptable to Modern?

Response #15: It is advantageous to install pumps 48 hours prior to pumping because the installation of the pumps can cause sediments in the well to become suspended, thereby increasing the turbidity in the well. The 48-hour waiting period allows these suspended sediments to settle. This information will be included in the FSAP Addendum. During the development of the FSAP Addendum, Maxim submitted the sampling procedure to Modern Landfill for review and comment and they found the procedure to be acceptable.

Comment #16: Page 5, Item 3), Line 5: Please add as follows, "...efforts at the subject well may be terminated and a different well may be substituted *upon approval from USACE*". Also, please prioritize the list of preferred substitute wells to reduce the need for field decisions.

Response #16: Text Revised. The following text was inserted into Section 5:

Substitute wells are listed on Table 1. The substitute well with the most similar geohydraulic characteristics will be selected.

For each well/piezometer within the area at Modern Landfill covered by the Right-of-Entry, Table 1 will show the elevation of the screened interval, lithology of the screened interval, and the hydraulic permeability at the well/piezometer.

Comment #17. Page 6, Line 1 (not bulleted): NFSS wells typically stabilize within 1 hour. Since may Modern wells have not been developed, more time may be required to achieve the desired turbidity requirements. However, I would recommend that the Site Manager and USACE Site Superintendent are notified if the well does not stabilize within 3 hours. Suggestions, based upon filed conditions, may warrant an alternate approach that achieves stabilization sooner or abandoning the well for an alternate.

Response #17: As suggested, the field teams will be instructed to notify the Site Manager and Site Superintendent if a well does not stabilize within 3 hours.

Comment #18. General: If insufficient volume is available to fill all sample containers, what is the minimum total number of each parameter (i.e. VOC, sVOC, Rad, Metals, PAHs, Nitroaromatics, Total Uranium, Gross Alpha/Beta) that would provide an adequate dataset for background screening?

Response #18: In response to further guidance from the USACE, the various sample containers will be filled in the following order: VOCs, Total Rad., Total Metals, PAHs, Dissolved Rad, Dissolved Metals, SVOCs, Pest/PCBs, Nitroaromatics. This is the approximate order of the relative importance of the various parameters. If however, the field team is confident that a particular well will produce a sufficient volume of groundwater to satisfy all sample requirements, the Site Manager may modify the order of collection: the organic parameters will be collected prior to filling the containers for dissolved rad and dissolved metals.

Comment #19: Since Maxim has proposed collecting VOCs, unfiltered parameters, filtered parameters and then unfiltered parameters, the turbidity in the flow-through cell shall be monitored closely to insure that the pressure change from hooking up the in-line filter did not stir up sediments in the well.

Response #19: The order of parameter collection has been revised in order to minimize the number of times the filter is hooked up.

Comment #20: Page 6, Last paragraph: Why does Maxim recommend that the pump rate should not be increased above that to achieve well stabilization? As long as the pump rate is less than the Modern specified 0.5 L/min, the WL could be monitored closely to make sure that there is not a significant change and the water quality meter checked to make sure the water quality parameters are remain stable.

Response #20: Maxim will pump the wells at the maximum rate (not to exceed 0.5 l/m) that allows well stabilization and meets the drawdown criteria. The use of the maximum rate will be clarified in the FSP Addendum. After the well stabilizes and the field team begins to fill the sample bottles, there will be fewer opportunities to monitor the groundwater (this is especially true for lower producing wells). The flow-through cell used for groundwater monitoring requires approximately 100 ml of water for filling and additional groundwater will flow through the cell while the meters properly measure the various quantities and stabilize. All of this water would be unsuitable for sample collection and would effectively be ‘lost’. For this reason, the ability to accurately monitor well stabilization after the initiation of sample collection is greatly diminished (though turbidity, which requires only approximately 20 ml of water, will be closely monitored during sample collection). Since the field team will have only limited opportunities to verify well stability after the initiation of sample collection, they will not be allowed to increase flow rates above that which was demonstrated to result in a ‘stable’ well.

Comment #21: Page 7, Paragraph 2: Does Maxim plan to document collection times of all samples in the field log?

Response #21: Yes. This will be clarified in the revised FSAP Addendum.

Comment #22: Page 7, Paragraph 3: By electric submersible, does Maxim mean whale pumps? Please specify in the revised report. Since whale pumps were used to sample NFSS wells, they are preferred.

Response #22: Yes, Maxim will use Whale Pumps. This will be clarified in the revised FSAP Addendum.

Comment #23: There are 2 SAIC comments where the author is identified as "unknown". Please identify the author of these comments in the revised report.

Response #23: The comments are now attributed.

Reviewer: Phyllis Della Camera

Comment 1: Section 3.0 and Table 1: Many of the wells selected for inclusion in the background study are piezometers. Have the piezometer installation procedures/construction details been verified to ensure that they comply sufficiently with monitoring well construction requirements to give accurate/defensible data?

> Response 1: All suitable and available wells are scheduled to be sampled. However, the number of suitable and available wells is insufficient for the requirements of this task and for this reason several piezometers are also scheduled to be sampled

Comment 2: Section 6.0: The text in this section states that where submersible electric pumps are used, "new dedicated pumps" will be used at each well location. This is very expensive and not common practice. Is this an accurate statement, and if it is, why are new dedicated pumps necessary?

> Response 2: The statement is accurate. The use of new dedicated pumps is a project requirement specified by Modern Landfill.

Reviewer: Russ Marsh

Comment 1. Sec. 3.0, Para. 1, last sentence This sentence is incomplete.

Response 1: Text revised.

Comment 2. Sec. 3.0 This section does not clearly indicate which wells are to be sampled.

Response 2: In response to other's comments, this section has been significantly revised. The wells to be sampled are identified in Table 1.

Comment 3. Sec. 3.0 In general, utilizing piezometers for long term water quality sampling is not recommended due to installation/construction techniques. Please comment on the choice to use piezometers.

Response 3: Agreed. However the number of suitable wells was insufficient to satisfy all sampling needs. For this reason, piezometers will also be sampled.

Comment 4. Sec. 5.0, no. 3) Given the site geology and well/piezometer size, it is very likely that the water level will drawdown below 1 foot. The field team should prepare to implement the alternative actions.

Response 4: The referenced section has been revised and the following text has been inserted into the FSAP Addendum:

This requirement may be difficult to achieve due to geologic heterogeneities within the screened interval, and may be relaxed in the field if the other sample collection method requirements can be satisfied.

Comment 5. Sec. 5.0, pg. 7 Based on the information provided here and in Appendix D, the use of forty (40) dedicated electric submersible pumps is anticipated. If these pumps do not work, then the use of one (1) air bladder pump is proposed. There are several concerns with this approach. First, since the electric pumps will be used (in wells for at least 48 hours) at the point in time when it is decided that they are not appropriate, will the Government be responsible for these pumps? If so, then this needs to be discussed with the USACE project manager. **There is concern that the Government will pay for pumps that it will not use.** It is suggested that the use of portable pumps be considered. Secondly, if it is determined that the use of the one (1) air bladder pump is appropriate, then the sampling schedule will be increased significantly. This needs to be discussed with the USACE project manager.

Response 5: The use of dedicated pumps is a project requirement.

Comment 6. Sec. 6.0, para. 1   a. It is unclear whether the dedicated pumps will be left in the wells following sampling.

> Response 6: The pumps will be removed following sampling. This will be clarified in the revised FSAP Addendum.

Comment 7. Sec. 6.0, para. 1   b. This paragraph indicates that all samples will be filtered. This does not agree with information on page 6.

> Response 7: Text revised.

The Baltimore District POC for these comments is Russ marsh 410-962-2227.

Comments from William Frederick, USACE:

Comment 1: p. 2, par. 1: change to "Ontario Lake Plain of the Erie-Ontario Lowland Physiographic Province," The Central Lowland Physiographic Province of the US extends from southwest Ohio to northern Texas/Oklahoma to the Dakotas.

Response 1: Text Revised.

Comment 2: p. 2, throughout lithologic descriptions: Please maintain a standard naming convention between the underlined titles and text descriptions, i.e., the brown clay till becomes the brown clay unit, the GLC becomes the gray clay unit, the SSOW becomes the sand and gravel unit, pick a naming convention and stick with it.

Response 2: Text Revised

Comment 3: p. 2, GLC paragraph: "...origin that occasionally grades **vertically** to a silt and sand mixture." also "...which are filled **intermittently** with..." we are still determining the aerial continuity of the sand lenses at the base of the BCT.

Response 3: Text Revised

Comment 4: p. 2: "Sand and Silt Outwash" capitalize "silt" in title.

Response 4: Text Revised.

Comment 5: p. 3, first full paragraph, 2nd last sentence: The QFM does not dip to the NNW, the surface topography may slope that way but not the bedding. Please use "gently sloping surface of the underlying strata."

Response 5: Text Revised.

Comment 6: p. 3, section 3.0, 2nd para.: Reword the first sentence: "Well log and construction data from Modern Landfill indicate that the lower water-bearing zone occurs at elevations significantly higher than the corresponding zone on the NFSS." Revisit the remainder of the paragraph and convert general "deeper wells, lower water-bearing zone, etc." text to lithology-specific text. You're using too much jargon.

Response 6: Text Revised.

Comment 7: p. 4, section 3.0, last paragraph: edit: "...Right-of-Entry Agreement are listed in Table 1 and shown on Figure 1." then delete text not needed.

Response 7: Text Revised.

Comment 8: p. 6, number 5: Reorder list to first obtain non-filtered VOC and all radiologic samples, secondly non-filtered metals, then SVOCs, then Pest/PCBs, then Nitro Cs, then add filters for dissolved rads, metals, and finally "extra" samples at end. If the well production is generally good, the "extra" samples can be taken during the filtered or non-filtered timeframe. This will ensure we are getting our target analytes for low-yield wells.

> Response 8: In response to further guidance from the USACE, the various sample containers will be filled in the following order: VOCs, Total Rad., Total Metals, PAHs, Dissolved Rad, Dissolved Metals, SVOCs, Pest/PCBs, Nitroaromatics. This is the approximate order of the relative importance of the various parameters. If however, the field team is confident that a particular well will produce a sufficient volume of groundwater to satisfy all sample requirements, the order of collection will be modified: the organic parameters will be collected prior to filling the containers for dissolved rad and dissolved metals.

Comment 9: p.6, last paragraph: If a shut down occurs during SVOC or PAH sample collection, cover the container.

> Response 9: The suggested addition to the collection methods will be made.

Comment 10: p. 7, 3rd paragraph: What is the lower flow limit of the electric pumps that you intend to use? It's likely depth specific.

> Response 10: Most of the wells for this task will be sampled using Whale pumps. Past experience with these pumps has proven them suitable for use with the low flow method. Maxim realizes that the pressure head on the pump will affect the pumps ability to maintain the necessary low flow rate. In the past, while sampling at the NFSS, Maxim has used two pumps in series, especially for the deeper wells. For this task, Maxim will also have available an air-bladder pump for use when the Whale pumps are not suitable.

Comment 11: p. 7, section 6.0, 1st paragraph, last sentence, edit: "All **dissolved** samples..."

> Response 11: Text revised.

Comment 12: p10, section 8.1: What statistical analysis software will be used? How will nondetects be handled in the distribution statistics? Provide references for statistical tests.

> Response 12: A description of the statistical methods will be provided at a later date.

Comment 13: Table 1: Edit the darker separation row marker between 2 and 2A groupings. The mixing of BCT and GLC under selection code #1 is acceptable for our screening purposes.

Response 13: Table revised.

Background Groundwater FSAP Addendum, Pre-Draft Version, Comments and Responses

Reviewer	Page	Comment	Response
S.L. McBride	Pg. 1 2nd Bullet	Compare these. . .	Bullets reworded, word 'of' inserted.
S.L. McBride	Pg. 4, sec 4	Should the lab name and address for the ACE QA lab be listed (if known at this time)	The QA laboratory has not yet been identified.
S.L. McBride	Pg 5, last para.	Inability. . .	"An" inserted.
S.L. McBride	Pg 6, middle of page	Extra volume is also required for the samples selected for field QC.	Agreed. This issue is discussed in detail in other project documents.
S.L. McBride	Pg 9, Sec 8	Replace in with an: an interim. . .	Revised.
S.L. McBride	Pg. 16 App B	There is a statement in this explanation that is at odds with the 2nd bullet on pg 4, which states that organic data will be reported to the method detection limit. In appendix B expanded discussion of the Revised Reporting Criteria, it is stated that: Concentrations of target compounds detected at less than the MDL will be reported as estimated. Below the MDL labs should only reported target compounds as non-detect. The MDL is the accepted, statistically based, lowest concentration that a target compound can be reported at with a specified level of confidence.	This topic has been the subject of considerable discussion and since the reviewed document was produced the USACE has provided additional guidance. The relevant section of Appendix B has been revised to state: "Detected concentrations of organic compounds, reported utilizing the new reporting requirements, i.e. < CRDL but >MDL, will be reported as estimated (J). Non-detects will be reported as undetected to the MDL and flagged “U”."
S.L. McBride	pg 9-10, sec 8.1	The data evaluation should also conform with ACE guidance found in EM-200-1-6, Pg 1-5, letter h. Review of Primary Laboratory Data.	Though Maxim does review data as described in EM-200-1-6, P1-5, letter h, this type of review is a separate topic from the evaluation of data to be performed in support of this task. Section 8 of this FSAP Addendum addresses topics specific to this task.
S.L. McBride	Page 1	If Table 3 is integral to the document, so should Table 1-2.	The report, and the position of tables within the report, is in Maxim's standard format.
S.L. McBride	Page 9	(In reference to the phrase "Total Radiological Parameters") define this as in Table 3.	As is done elsewhere in the document, in the interests of brevity, lists of parameters are frequently referenced by name (e.g. total metals, VOC, etc.).
S.L. McBride	Page 9	(In reference to the phrase "Total Radiological Parameters", "Total Uranium", and "Total Gross Alpha/Beta") - are these filtered/unfiltered?	These are, as stated, total concentrations and thus are unfiltered. Filtered results are not relevant to the subject of IDW disposal.

Background Groundwater FSAP Addendum, Pre-Draft Version, Comments and Responses

Reviewer	Page	Comment	Response
S.L. McBride	Section 8.0	Are these other background sampling data from non-impacted area?	Maxim does not understand the reference to "other". If "other" is in reference to the groundwater samples collected on the NFSS, the purpose of this task is determine the magnitude of the degree to which the NFSS is 'impacted'.
S.L. McBride	Several Locations	The review made comments concerning the positioning of tables within the document.	The document is presented in Maxim's standard format.
Catherine Woehr	pg 3	2nd sentence: "The Glaciolacustrine *Clay* Unit separates. . . "	Text revised
Catherine Woehr	pg 3	Last Sentence: 'The natural principal groundwater flow direction. . . mimicking the gently dipping underlying bedrock strata.' Suggest rewording - not clear if intended meaning is that the flow direction is the same as the bedrock and or the potentiometric surface mimics the surface of the gently dipping underlying bedrock strata; or that the groundwater flow direction is the same as the groundwater flow direction in the bedrock. Also may want to clarify (if this is the intended meaning) that the groundwater flow direction is the same in both the upper and lower groundwater zones.	The section has been revised and additional text has been inserted. It now reads "The natural principal groundwater flow direction in the lower water-bearing unit is north-northwest toward Lake Ontario, mimicking the gently dipping underlying bedrock strata. The upper water-bearing unit is found chiefly in discontinuous sand lenses and is perched at many locations."
Catherine Woehr	4	Number 1: "wells for which elevation data or lithographic lithologic data. . . "	Since preparation of the reviewed version, lithologic data has been made available and the referenced sentence has been stricken.
Catherine Woehr	Table 1	Footnotes: BRT: basel basal red till, QFM: Queenstone Queenston Formation	Text revised
Catherine Woehr	Figure 1	Can't read this figure (bad fax) so can't comment much on it. Does it have different well symbols for wells completed in the upper and lower groundwater zones? May want to add note in legend that background wells are located within the Area of Interest.	The figure does contain the information the reviewer suggested.
Catherine Woehr	Page 7, sec 6	1st para, last sentence Sounds like all samples will be filtered. Revise to "All *dissolved* samples will be filtered. . . "	Revised as suggested.
Catherine Woehr	Page 11	Definition of parameters used in formula	Revised as suggested.

Background Groundwater FSAP Addendum, Pre-Draft Version, Comments and Responses

Reviewer	**Page**	**Comment**	**Response**
Catherine Woehr	Page 5 Sec 5	General: Should state up-front that purging and sampling will be performed using low flow methodology.	Revised as suggested.
Catherine Woehr	Page 5 Sec 5	Also should mention calibration requirements (something general, like "Prior to purging and sampling, the field equipment shall be calibrated in accordance with the manufacturer's instructions" would be OK.	Suggested text inserted into Section 5.
Catherine Woehr	Page 5 Sec 5	Should state when PID is used - something like "every time the casing cape is removed a PID will be used to Monitor for VOCs in the breathing zone at the well head. The results of this air monitoring will be recorded on the well sampling form."	Text revised. The use of the PID has been clarified. The VOC concentration in the well head space will be measured prior to intalling the pumps.
Catherine Woehr	Page 5 Sec 5	Under 1: add that the static water level measurements will be made using an electronic water-level indicator.	Text revised
Catherine Woehr	Page 5 Sec 5	Under 4: Need to state that the water-quality indicator parameters will be monitored during sampling using an in-line flow-through cell and add 'in-line flow-through cell' to the equipment list on page 15.	Equipment list modified as suggested.
Catherine Woehr	Page 5 Sec 5	May want to add reference to the following guidance, since it applies to EPA Region 2: USEPA Region 2, 1998, Ground Water Sampling Procedure Low Stress (Low Flow) Purging and Sampling, GW Sampling SOP Final.	Suggested reference will be made.
Giordano/Tucker	Page 10	Comment in reference to last sentence of the fourth complete paragraph. The comment is not legible on our fax copy.	In response to other reviewers, the referenced sentence has been stricken.
Giordono/Tucker	Page10	Comment in reference to the last sentence of the first paragraph of Sec. 8.2 The comment is not legible on our fax copy.	In response to other reviewers, the sentence has been revise to: "The purpose of this comparison is to help determine the magnitude of any contamination and to help delineate the extent of contamination at the NFSS."