Appendix E:

Quality Assurance Project Plan

Quality Assurance Program Plan
Ebenezer Plaza 1
Brownfield Cleanup Program
NYSDEC Site No. C224240

94 New Lots Avenue
Brooklyn, Kings County, New York

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Prepared for:

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1.0 PROGRAM DESCRIPTION

This Quality Assurance Program Plan (QAPP) describes protocols and procedures necessary to ensure that specific tasks and actions undertaken by The Chazen Companies (Chazen) are planned and executed in a manner consistent with the Quality Assurance (QA) objectives. This QAPP also details responsibilities for compliance with these requirements.

The QAPP provides guidance and specifications for:

- Organizational structure within The Chazen Companies
- A method for determining Data Quality Objectives
- All routine calibration and sampling procedures conducted by The Chazen Companies
- Chain of Custody requirements and Analytical Procedures
- Data Reduction, Validation, and Reporting
- Internal Quality Control and Internal Auditing
- Specific Routines to Assess Data Quality
- Preventative Maintenance
- Performance Reporting

This document will support all applicable work performed by Chazen in the areas of Remedial Investigations, Interim Remedial Measures, Alternatives Analyses, Remedial Design (RD), and long-term environmental monitoring. We note that this QAPP describes numerous investigative techniques and methods, some of which may not be applicable to the Ebenezer Plaza 1 Brownfields Cleanup Project. However, the more expansive list of techniques is included to avoid the need for additional QAPP documentation, should another sampling method be deemed appropriate late in the investigation/remedy.

The format for this QAPP is based on "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA, Interim Final", 1988 (EPA/540/G-89/004), "Data Quality Objectives for Remedial Response Activities (Development Process)", 1987 (EPA/540/G-87/003), and DER-10 "Technical Guidance for Site Investigation and Remediation. The QAPP will also reference all portions of the Work Plan relevant to the particular site.

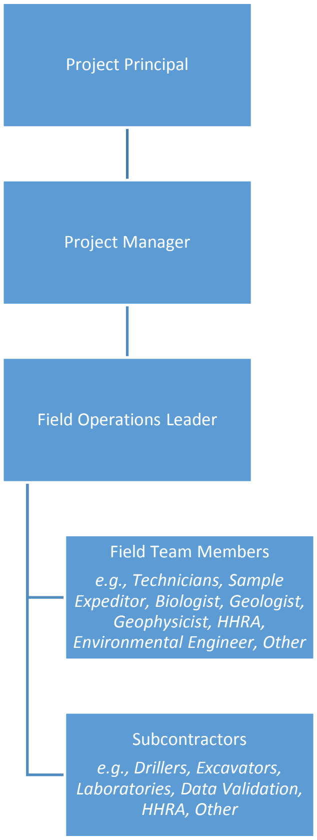
The QAPP is divided into 14 sections as described in the document "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final", 1988 (EPA/540/G-89/004).

2.0 PROGRAM ORGANIZATION

2.1 Company Organization

The Chazen Companies assigns a specialized team of experts to each project. These individuals act together to meet the needs of the project. Each project is assigned a Project Principal and Project Manager who oversee the components of the project. A typical organization chart is shown below.

Organization Plan



2.2 Specific Responsibilities

<u>Principals</u>: Principals of The Chazen Companies are responsible for establishing a contract for the services to be performed, for committing the corporate resources necessary to conduct the program work activities, and for supplying corporate-level input for problem resolution.

<u>Project Manager</u>: The Project Manager is responsible for the management and quality of the project. The Project Manager is named in the Site Investigation Work Plan and may be the Director of Environmental Services or his/her designee (e.g. Assistant Project Manager). The Project Manager will be responsible for establishing protocols to be used during the investigation and remedial activities, and establishing sampling methods. He/she will provide oversight and technical guidance during field activities and report preparation, maintain quality and consistency, and monitor the overall work progression.

The duties and responsibilities of the Project Manager include:

- General supervision of project execution to ensure that the project objectives are met on schedule and on budget.
- Assisting in project activities.
- Financial management.
- Identifying project staff, equipment, and other resource requirements.
- Conducting project progress meetings with the client and the technical reviewers.
- Final review of project deliverables prior to issue.
- Implementation of subcontracting, as required.

Field Operations Leader: The Field Operations Leader named in the Work Plan is usually an experienced member of the Environmental staff at The Chazen Companies and is responsible for the coordination and execution of the field activities, data reduction, and interpretation. Assigned responsibilities include:

- Organization of personnel, equipment, and materials to meet the objectives of the field tasks.
- Direction of field activities in accordance with the Work Plan and project QAPP.
- Coordination of subcontractor activities including verification and adequacy of subcontractor QA/QC programs.
- Assisting in project activities.
- On-going Quality Control (QC) during performance of work.
- Field and laboratory data reduction and interpretation.
- Execution of corrective actions for identified QA/QC problems.
- Supervision of field team.
- Supervision of deliverable preparation.

Technical Reviewer/Quality Assurance Manager: The Technical Reviewer(s) named in the Work Plan is (are) generally peer reviewers, the Director, or the managing Principal. Technical reviewers review field data and methodology and act as Quality Assurance Managers. The Technical Reviewer(s) will be responsible for the overview of tasks and procedures, which affect the quality of work performed during the investigation. The Technical Reviewer/Quality Assurance Manager is responsible for:

- Verification of the Quality Assurance Program through evaluation and overview of program tasks.
- Identification of problems affecting quality and recommending corrective actions.
- Reporting to the Project Manager on the status and adequacy of the overall QA program.
- Consultation on data analysis and interpretation.
- Technical review of the project.

Field Team Member: Field Team Members involved in the field investigation, geophysical survey, location and elevation survey, or other field activities are responsible for the on-site execution of planned field activities. Field team members named in the Work Plan are assigned responsibilities which may include:

- Completion of all field activities in accordance with the Work Plan.
- Field supervision of subcontractor activities.
- Monitoring of, and adherence to, health and safety requirements in accordance with the HASP during field activities.

2.3 Personnel Qualifications and Training

The Project Manager and the Quality Assurance Manager review the assignment of technical staff and the project management plan with regard to the appropriate qualifications in the technical areas relevant to the Project and any associated QC techniques. Training, if required, is specified and implemented prior to project start-up.

Site-specific training is provided to all members of the field team and includes:

- General briefings covering the QA program and Project plans;
- Detailed briefings on specific methods required by the Work Plan and QAPP;
- Specific briefings on individual QA and QC procedures and activities.

All employees of Chazen involved with hazardous waste investigations or investigations where the potential exists to contact hazardous wastes are required to attend an OSHA-approved 40-hour health and safety course prior to working on hazardous waste sites. In addition, these employees are required to annually attend an 8-hour refresher health and safety course and to participate in a medical surveillance program.

2.4 Analytical Laboratory and Other Support Services

The subcontractors for analytical services will be determined prior to the initiation of the field investigations. Data validation, if required, will be performed by The Chazen Companies or a qualified firm will also be identified.

The responsibility for implementing the laboratory QA Program resides with the laboratory subcontractor's Laboratory Analytical Task Manager. The Laboratory Analytical Task Manager is responsible for the following:

- Supporting the Chazen Project Manager and Quality Assurance Manager.
- Maintaining sufficient instruments, space resources, and personnel to perform the analyses as necessary.
- Handling/receiving samples in a manner consistent with New York State and Federal guidance as outlined in the Work Plan/QAPP.
- Implementing corrective action to account for analytical problems or QC deficiencies.
- Maintaining appropriate instrument controls/calibration.
- Reviewing all sampling and analyses, instrument blanks, sample blanks, and other QA/QC information to ensure that it meets the desired quality standards.
- Providing QA/QC checks at the proper frequency and maintaining an awareness of the laboratory condition to detect conditions which might jeopardize controls of the various analytical systems (e.g.
- improper calibration, improper sample storage conditions, and equipment maintenance intervals).
- Providing in-house QC audit documentation for sample storage, labeling, preservation, transportation, and disposal in accordance with Analytical Services Protocol (ASP).

Consistent with New York State Department of Health's (NYSDOH) discontinuance of the Contract Laboratory Protocol (CLP) accreditation process, dated January 28, 2009, the selected laboratory is not required to be CLP-accredited.

3.0 QUALITY ASSURANCE OBJECTIVES

Quality Assurance (QA) is a management system that ensures that all information, data, and decisions generated during a site investigation or feasibility study are technically sound and properly documented. Quality Control (QC) is the functional mechanism through which the quality assurance objectives are achieved. The overall objective of the QA/QC program is to establish procedures such that data obtained from the field and laboratory analyses are of adequate quality to satisfy the project objectives.

3.1 Data Quality Objectives

Data quality objectives (DQOs) are stated qualitatively and quantitatively, where applicable, in the Work Plan for a site investigation or feasibility study. DQOs specify the required quality of data necessary to support decisions related to the program including site screening, characterization, assessment of health risk, and ultimately, to the remedial actions that may take place on a site.

The basis of DQOs is that the quality of data is dependent upon the intended use of the collected data. DQOs are established based upon site-specific conditions and project objectives and are applicable to all data collection activities.

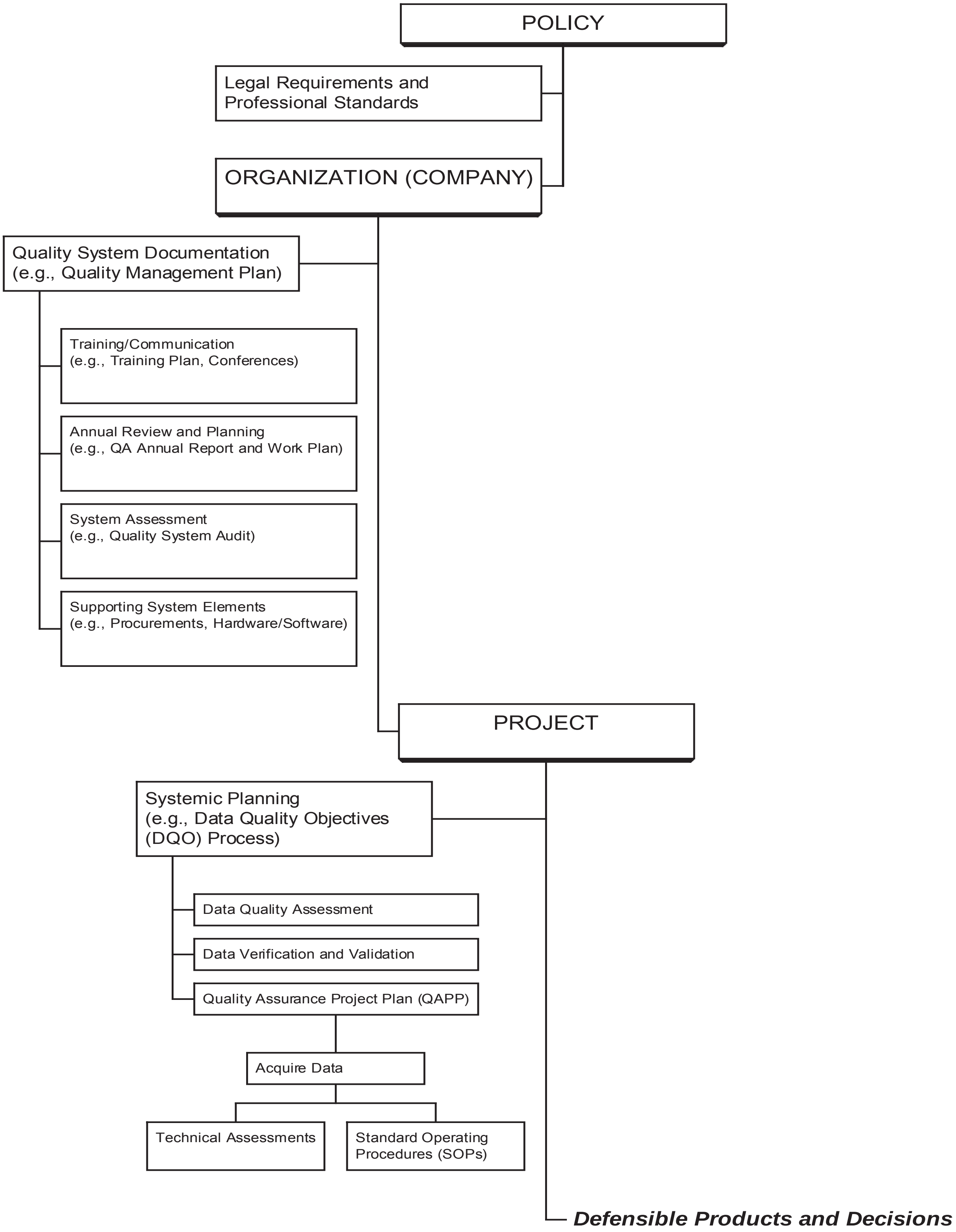
Data quality objectives are developed through an iterative process by which all the DQO elements are continually reviewed and re-evaluated to meet the overall project objectives. This process can be summarized as follows:

Stage 1: Defines the types of decisions which will be made during site remediation by identifying data users, evaluating available data, developing a conceptual model, and specifying goals for the project. Stage 1 results in a specific identification as to why new data are needed.

Stage 2: Identifies the data necessary to meet the objectives established in Stage 1. It also stipulates criteria for determining data adequacy. During Stage 2, sampling approaches and analytical options are evaluated to determine timely or cost-effective approaches.

Stage 3: Is the final design of the data collection program. The design of the data collection program results in the specification of the methods by which acceptable data will be obtained to make decisions.

QUALITY SYSTEM COMPONENTS AND TOOLS



3.2 Data Quality Characteristics

Data quality characteristics will be addressed as they pertain to a proposed investigation. Based on the DQOs selected, data will be assessed and evaluated for:

- Precision
- Accuracy
- Representativeness
- Completeness
- Comparability
- Reporting Limits

The manners in which these characteristics will be assessed and evaluated are described in the following sections.

3.2.1 Precision

Precision measures the reproducibility of measurements under a given set of conditions. Specifically, it is a quantitative measure of the variability of a group of measurements compared to their average value. The duplicate results for each precision check event will be compared to determine the range of the measurements as an indication of the precision associated with the measurement. In addition, the laboratory will analyze matrix spike/matrix spike duplicate samples to monitor the precision of the analytical methods.

Precision will be determined by calculating the relative percent differences (RPD) between the duplicate samples. The RPD for each sample will be calculated using the following equation:

$$\%RPD = \frac{D_1 - D_2}{(D_1 + D_2)/2} \times 100\%$$

where,
RPD Relative Percent Difference
D_1 First Sample Value
D_2 Second Sample Value (duplicate)

The RPD data will be used to evaluate the long term precision of the analytical/measurement methods. The laboratory will also calculate RPD values on the results of the matrix spike/matrix spike duplicate samples. These RPD values will be compared to RPD values provided in the current NYSDEC ASP protocols.

Procedures to be employed to maximize the precision of the data to be collected include:

- written methods and procedures documented in the project QAPP;
- multiple techniques will not be used to generate or collect the same data;
- all sampling and analytical personnel will be trained and required to follow the Work Plan and QAPP procedures;
- the Field Operations Leader will provide oversight during this investigation to monitor the adherence of project staff to these plans.

3.2.2 Accuracy

Accuracy measures the bias in a measurement system and is a determination of the closeness of the measurement to the true value. Sources of error include the physical sampling process, decontamination procedures, sample preservation and handling, homogeneity of the sample matrix, and sample preparation and analysis techniques used by the laboratory. Accuracy will be measured using blank and spike samples. The levels detected in the blanks and the difference between the reported and known concentrations for spikes will be used to assess the accuracy of the results.

The results of sample spiking will be used to calculate the Percent Recovery (%R), which will be used as the quality control Parameter for accuracy evaluation. Percent Recovery is calculated by the following equation:

$$\%R = \frac{ObservedValue}{TheoreticalValue} \times 100\%$$

Surrogate standard determinations will be performed on all samples and blanks. All samples and blanks will be fortified with surrogate spiking compounds before purging or extraction as specified in current USEPA SW-846 protocols.

Procedures employed to maximize the accuracy of the data to be collected include:

- written methods and procedures documented in the project FSP;
- all sampling and analytical personnel will be trained and required to follow the procedures specified in these plans, use of standard methods and known procedures to generate accurate data;
- adherence to strict decontamination procedures of sampling equipment;
- frequent calibration against known standards of field and laboratory equipment.

Calculations performed with analytical data are also checked for accuracy and precision by the Project Manager, Field Operations Leader or their designees, and reviewed by the QAM.

3.2.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represent an analytical result from the matrix being sampled. Representativeness is a qualitative parameter that is most concerned with the proper design of the sampling program.

Procedures employed to maximize the representativeness of the data to be collected include:

- written methods and procedures documented in the project FSP;
- avoiding use of multiple techniques to generate or collect the same data;
- all sampling and analytical personnel to be trained and required to follow the procedures specified in the project plans;
- Field Operations Leader to provide oversight during the investigation to monitor the adherence of project team members to these plans.

In addition, the sampling locations and number of samples to be collected (as specified in a Work Plan) will be selected to provide data representative of the media and potential contaminants of concern at locations where releases would be expected to be detected if present.

3.2.4 Completeness

Completeness is defined as the percentage of data collected judged to be valid and useful to the objectives of the project. Completeness is the amount of valid data obtained from a measurement system expressed as a percentage of the number of valid measurements that should have been (i.e., were planned to be) collected according to the Work Plan. The completeness objective will be 100% valid data for samples collected or analyzed. If this objective cannot be met due to unforeseeable problems, the problems will be addressed in the data usability report. Any data deficiencies will be evaluated in terms of their impact on project goals, and corrective action will be taken, if needed.

Procedures employed to maximize the usefulness and completeness of project data include:

- real-time field screening to focus on potential contaminant source regions;
- soils and groundwater samples for laboratory analysis for confirmation purposes;
- sample handling and shipping procedures which protect samples from breakage;
- communication with the laboratory to ensure their awareness of sample holding times;
- the availability of backup instruments or equipment for field measurements;
- collection of minimum-recommended sample volumes, which frequently include sufficient volume for re-analysis if a problem occurs in the laboratory;
- monitoring of field activities by the Field Operations Leader so as to allow for potential re-sampling or other measures to ensure that the required samples are collected.

3.2.5 Comparability

Comparability is a qualitative parameter expressing the confidence with which one data set can be compared with another. Methods will be employed during this investigation to ensure that the data generated can be compared to other relevant data sets of similar quality. The analytical results of QA/QC samples and internal laboratory QA/QC samples will be reported along with the results of field sample analyses. Standard sample analysis and reporting methods will follow NYSDEC ASP protocols.

3.2.6 Reporting Limits

Formulae for determining the reporting limits specific to each parameter analyzed are provided by the laboratory.

3.3 Quality Assurance Reports

The Quality Assurance Manager will prepare status reports to summarize QA/QC issues related to the collected data. The objective of the status report is to verify that the work being performed on the project adheres to all of the project plans, and that the collected data meet the previously described goals for precision, accuracy, and completeness.

3.4 Problem Resolution

The successful execution of a field investigation requires that a system be in place for reporting and responding to unexpected events as well as correcting problems or mistakes when they occur. The system described below includes internal systems for decreasing the risk of such occurrences and the procedures for reporting such events.

Procedures designed to minimize the possibility of problems throughout this project include:

- The use of standard methods
- Development of written project plans
- Team member supervision and training
- Project meetings
- Clear definition of the project objectives and team member responsibilities

To ensure that the approach to data collection is applied in a uniform manner, all project team members will be trained in the methodologies and procedures detailed in all project documents including the Work Plan, Field Sampling Plan (FSP), QAPP, and Health and Safety Plan (HASP). Copies of these plans will be available to all team members for individual use and reference. In addition, the Project Manager and Field Operations Leader will review these plans with the project team prior to the start of field activities.

Training in the use of the procedures required in the plans will be provided to all designated team members as determined necessary by the Quality Assurance Manager. The Project Manager and/or Field Operations Leader will hold regular project meetings with team members to communicate changes in procedures or scope; to discuss and assign upcoming tasks; to address potential problem areas in tasks yet to be conducted; and to communicate ways that past problems encountered in the project were remedied. These meetings will be scheduled by the Project Manager or Quality Assurance Manager, as necessary, during this investigation.

Should an event occur that cannot be readily resolved or appears to have gone unnoticed, the Project Manager will be notified. The project Quality Assurance Manager and the site owner may also be notified. The notification will include a completed Problem Resolution Form (PRF) (shown below).

PROBLEM RESOLUTION FORM NO.____________________________

Originator:____Date:____________

Contract/Task Involved:____

Description of Event:____
____

Sequence of Response Actions (Date, Person, Action Taken):__________________________
____

Description of Final Response:____
____

Final Response Approved By:____

Project Manager:____Date:____________

The PRF will be available for use by all project team members. The user of the form will provide a mechanism for reporting and responding to specific events which require a more formal quality control review to ensure proper resolution of the problem.

The Project Manager and/or Quality Assurance Manager will be responsible for ensuring that each issue identified in a PRF is resolved. The Project Manager, after a review of the issue with the Field Operations Leader and Quality Assurance Manager, will work with the Field Operations Leader to assign responsibility for remedying the problem and for establishing procedures, if necessary, to ensure that the problem is not repeated. The steps of the problem resolution process are:

1. Identify and describe the event or problem
2. Investigate and determine the cause
3. Determine a response action to remedy the situation
4. Implement the response action
5. Monitor the effectiveness of the action to verify that the situation has been remedied

The PRF form is designed to document and track the resolution of the event from its initial reporting to the final solution. The form is completed by the person reporting the problem and includes a description of the event, possible cause(s), and recommended solution(s). The form will then be used to document the sequence of events resulting in an effective resolution. Final approval of the response action as described on the PRF will be documented by the signature of the Project Manager and Quality Assurance Manager.

Completed PRFs and copies will be maintained in the field office and in Chazen's project file for future reference. Copies of PRFs (if utilized) will also be forwarded to the client and to any affected regulatory agency, if warranted.

The analytical laboratory will also use a system for on-the-spot and formal problem resolution procedures. The specific laboratory procedures will be consistent with the requirements of USEPA-SW-846 and are defined in the laboratory's Quality Assurance Program Plan.

3.5 Data Quality Requirements

Site specific data requirements are presented in the Work Plan, FSP, or associated documents for a particular project or investigation. There are five general analytical levels of data quality. These levels are described as follows:

Level I: Field screening utilizing portable instruments. These data may include pH, temperature, and specific conductance measurements of water samples, and ambient air and soil screening measurements with photoionization, flame-ionization, O_2, lower explosive limit (LEL), or other meters.

Level II: Field analyses utilizing more sophisticated portable analytical instruments such as gas chromatograph and x-ray fluorescence (XRF) analyzer. There is a wide range in the quality of data that can be generated. Data quality depends on the use of suitable calibration standards, reference materials, sample preparation equipment, as well as the training of the operator. Results from Level II data are available in real-time or within several hours of sample collection.

Level III: These data include analytical laboratory data utilizing USEPA-approved procedures. All analyses are performed in an off-site analytical laboratory following SW-846 protocols. Level III is characterized by rigorous QA/QC protocols and documentation.

Level IV: Analytical laboratory analysis supported by a rigorous QA program and documentation. These data are typically used for definitive site characterization, risk assessment, engineering alternative selection and design, and litigation activities. Level IV methods may include pre-approved non-standard methods for specific constituents or detection limits. All analyses are performed in an off-site analytical laboratory.

Level V: These data include physical property and engineering material analysis by approved standard or non-standard methods including analysis of non-standard sample matrices (e.g., wastes, biota). All analyses are performed in an off-site laboratory. The following table presents a summary of analytical levels appropriate to data uses.

Summary of Analytical Levels Appropriate to Data Uses

Data Uses	*Analytical Level*	*Type of Analysis*	*Limitations*	*Data Quality*
Site Characterization. Monitoring during implementation.	Level I	Total organic and inorganic vapor detection using portable instruments, Field test kits	Instruments respond to naturally occurring compounds	If instruments are calibrated and data are interpreted correctly, can provide indication of contamination
Site Characterization. Evaluation of alternatives. Engineering design. Monitoring during implementation.	Level II	Variety of organics by GC; Inorganics by AA; XRF Tentative ID; Analyte-specific; Detection limits vary from low ppm to low ppb	Tentative ID Techniques and instruments mostly limited to volatiles, metals	Dependent on QA/QC steps employed. Data typically reported in concentration ranges.
Risk assessment. PRP determination. Site characterization. Evaluation of alternatives. Engineering design. Monitoring during implementation.	Level III	Organics and inorganics using EPA Procedures can be analyte specific RCRA Characteristics tests	Tentative ID in some cases Can provide data of same quality as Levels IV, NS	Less rigorous QA/QC
Risk assessment. PRP determination. Evaluation of alternatives. Engineering design.	Level IV	HSL organics and inorganics by GC/MS; AA; ICP Low ppb detection limits	Tentative identification of non-HSL parameters. Some time may be required for validation of packages	Goal is data of known quality. Rigorous QA/QC.
Risk assessment. PRP determination.	Level V	Non-conventional parameters. Method specific detection limits. Modification of existing methods. Appendix 8 parameters	May require Method Development or Modification. Mechanism to obtain services requires special lead time.	Method specific

Reference: EPA Document No. 540 G-87 003, 1987, “Data Quality Objectives for Remedial Response Activities”

4.0 ENVIRONMENTAL SAMPLING / TESTING PROCEDURES

An essential aspect of any field investigation is assurance that sample collection is conducted in a manner that will provide high-quality, representative data. This section of the QAPP provides a description of sampling techniques, procedures, and equipment used during field sampling programs. These techniques and procedures conform to guidelines outlined in the EPA document “A Compendium of Superfund Field Operations Methods”, and with NYSDEC DER-10.

4.1 Site Specific Sampling and Testing Rationale

The Work Plan provides the sampling rationale for every investigation, including the rationale for the following tasks:

- sampling of environmental media,
- determination of constituents to be measured in each environmental media,
- sampling locations,
- sample depths and types,
- number and frequency of samples to be collected.

The specific details of a field investigation such as sampling locations, target depths, analytical methods, and a reference map are detailed in the project Work Plan.

4.2 Documentation

During the implementation of any investigation, field activities will be documented in field log books. The field log book is a controlled document, which records all major on-site activities during the investigation. The log book is a bound notebook with pages that cannot be removed without cutting or tearing pages. Each page of the log book will be numbered consecutively and signed at the bottom of the page with the signature or initials of the person who completed the page. All entries will be made in ink and errors crossed-out with a single line and initialed and dated.

Field data for all tasks completed during this field program, as well as general observations, pertinent conversations, and unexpected occurrences will be documented in field log books. At a minimum, the following information will be recorded:

- Names of personnel on-site (including all subcontractors);
- Date and time of arrival and departure;
- Daily objectives;
- Site name, location, and project number;
- Field observations;
- Weather conditions;
- Site sketch with description of sampling points;
- Health and Safety monitoring data;
- Field calibration, decontamination procedures, and performance frequency;
- Well bailing or pumping procedure and equipment;
- Well specifics including static water level, depth, and volume of water removed;
- Type and quantity of monitoring well construction materials used;
- Surveying data;
- Sample identification numbers;
- Sample point names and descriptions;
- Sample collection procedures and equipment;
- Sample preservation used;
- References to maps or sketches of the sampling site;
- Results of any field measurements, such as pH, water temperature, specific conductivity, and field screening results;
- Notes on conversations with site personnel, observers, or subcontractors;

- Problems encountered and the manner of their resolution;
- General observations that may support the data; and
- Summary of daily activities completed.

4.3 Pre-Sample Planning

The quality of sample collection is maintained by specifying the technique used for both the medium/matrix to be sampled and the analytes of interest. For example, groundwater samples intended for SVOC analyses are collected in amber glass containers; groundwater samples for VOC analyses are collected in Teflon-capped glass vials with “zero” headspace to minimize diffusive and evaporative losses; and groundwater samples for inorganic analyses are collected in polyethylene bottles. Sample containers provided by the analytical subcontractor are prepared in a manner consistent with USEPA protocol.

Acquisition of environmental samples also requires specialized techniques to preserve sample integrity and to ensure that a representative portion of the source is collected. Media-specific sample collection techniques and sample preservation are specified in the following sections. Field programs are designed and implemented using the EPA’s “Compendium of Superfund Methods”, NYSDEC Program Policy DER-10, Technical Guidance for Site Investigation and Remediation, and NYSDEC Regulations 6 NYCRR Part 375, Environmental Remediation Programs as primary references.

4.3.1 Sample Labels and Records

Sample labels will be prepared using a pre-determined labeling system. Each sample may require several containers depending on the intended analysis to be performed. At the time the sample is collected, a sample data record sheet and field logbook entries will be completed. The sample documentation may include:

- A plan of the site with the sample location and sample numbers indicated
- A description of the sample site
- Physical descriptors of the sample site, if appropriate (e.g., stream width, groundwater depth, etc.)
- Photographs of the sample site showing the sampling equipment and/or unusual conditions (orientation of photograph must be shown on sketch map, and photo number recorded in field notebook)
- Chain of Custody documentation (see Section 5)

Identification of samples collected during the field investigation may be accomplished using alphanumeric Sample Identification codes indicating sample type, sample identification, depth of sample (if applicable), and designation of duplicate samples. An explanation of a typical Sample Identification codes system for soil, groundwater, and sediment samples is shown below:

Sample Identification Code System

Digits	*Identification*	*Description*	*Code/Example*	
1, 2,3	Site Code	Three letter code to identify the site	LSS	Lower South Street
4,5	Sample Type	Two letter code to identify sample media	SB	Test Boring Soil Sample
			SS	Surface Soil
			BW	Screened-auger Groundwater Sample
			MW	Monitoring Well Groundwater Sample
			SW	Surface Water
			SD	Sediment Sample
			TB	Trip Blank
			EB	Sampler Blank
			SV	Sub-Slab Vapor Sample
			TP	Test Pit Soil
			PW	Test Pit Water
			WT	Waste Sample
			DL	Drum Liquid
			DS	Drum Solids or Sludge
			IA	Indoor Air Sample
			OA	Outdoor Air Sample
			GP	Geoprobe® Soil Sample
			CD	Septic System/Sump Sludge Sample
			CL	Septic System/Sump Catch Basin Liquid Sample
			CB	Catch Basin/Storm Drain Sediment Sample
6, 7, 8	Sample Locator	Three numbers to identify sample site name or location	MW22	Monitoring Well Groundwater Sample from Well 22
9, 10, 11	Depth of Sample Below Reference Surface		SB01(0-2’)	SB samples collected from 0 to 2 feet below ground surface (bgs)
			MW22(25)	MW sample depth is assumed to be the bottom of the well screen measured in feet bgs
			XXX	All samples obtained from drums or containers will be designated XXX
12, 13			XX	Duplicates will periodically be sent to the lab with the XX designation to preserve duplicate anonymity, according to Section 9.2.
			XF	Sample collected for field analysis or future reference
			XD	Duplicate sample (sample locator ID not used for blind field duplicates)
			MS	Matrix spike
			MD	Matrix spike duplicate
			XS	Laboratory split sample

4.3.2 Sample Container Requirements and Sample Preservation

Sample integrity will be maintained by using special containers and preservation methods keyed to both the medium/matrix to be sampled and the analytes. Sample containers and preservation methods specified in NYSDEC protocols are summarized in the table below. Any changes to these protocols required by a Specific project will be detailed in a site-specific Work Plan.

4.3.3 Preparation of Sample Containers

Sample containers will be provided by the laboratory and are prepared according to USEPA protocols. The bottles will be equivalent to I-Chem series 300. QC records for the bottles used will be maintained by the laboratory. The preparatory procedures typically used by the vendor providing the laboratory with sample containers are detailed below.

4.3.3.1 Volatile Organic Analyte (VOA) Containers

(40-mL glass vials and 2-oz or 4-oz glass jars)

1. Wash vials, septa, and closures in hot tap water with laboratory grade non-phosphate detergent.
2. Rinse three times with tap water.
3. Rinse three times with American Society for Testing and Materials (ASTM) Type II water.
4. Oven dry vials, septa, and closures.
5. Remove vials, septa, and closures from oven.
6. Place septa in closures, Teflon side down, and place on vials. The attendant must wear gloves and the vials cannot be removed from the preparation room until sealed.

If sampling for VOCs is needed and will use EPA Method 5035, the disposable transfer tool will be obtained from the laboratory.

4.3.3.2 Semi-Volatile Organic Analyte (SVOA) Containers

(1-liter amber glass bottles and 4-ounce glass jars)

1. Wash containers, closures, and Teflon® liners in hot tap water with laboratory grade non-phosphate detergent.
2. Rinse three times with tap water.
3. Rinse with 1:1 nitric acid.
4. Rinse three times with ASTM Type II water.
5. Rinse with pesticide-grade methylene chloride.
6. Oven dry.
7. Remove containers, closures, and Teflon® liners from oven.
8. Place Teflon liners in closures and place closures on containers. The attendant must wear gloves and the containers cannot be removed from the preparation room until sealed.

4.3.3.3 Metals, PCB, and Pesticide Containers

(1-liter, 500, 250, 120 and 60-milliliter (mL) clear and 1-liter amber polyethylene bottles)

1. Wash bottles, closures, and Teflon® liners with hot tap water and laboratory grade non-phosphate detergent.
2. Rinse three times with tap water.
3. Rinse with 1:1 nitric acid.
4. Rinse three times with ASTM Type II water.
5. Air dry in contaminant-free environment.
6. Place liners in closures and place closures on bottles. The attendant must wear gloves and the bottles cannot be removed from the preparation room until sealed.

4.3.3.4 Sample Preservation

Samples are preserved according to the protocol established for the selected analytical method. Unless the proper sample container preparation and sample preservation measures are taken in the field, sample composition can be altered by contamination, degradation, biological transformation, chemical interactions, and other factors during the time between sample collection and analysis.

Steps to maintain the in-situ characteristics required for analysis may include storage of samples at 4°C, pH adjustment, and chemical fixation. Specific sample and container preservation requirements are detailed in Table 3 above. Where pH adjustment is performed, the pH will be checked in the field with pH paper to ensure the required pH level is achieved. If pre-preserved sample containers are provided by the laboratory, extra preservation material should be available in the field in case it is needed to achieve the target pH.

Table 3 - Summary of Required Containers, Preservation Requirements and Holding Times

Parameter	*Matrix*	*Required Container*	*Minimum Volume Required for Analysis*	*Preservation Technique*	*Holding Time (2)*
Volatile Organics (3)	Water	Glass vials with Teflon faced septa and screw cap. (Two 40 ml vials per sample)	50 ml	Cool (4°C) Preserved with acid (HCl to pH<2)	7 days
	Soil	3 EnCore 5 gram samplers OR one set of 4 – 40 mL glass vials with Teflon faced septa. One unpreserved, one with 10 mL methanol and two with 5 mL deionized water and a magnetic stir bar. Each vial must be filled with at least 5 grams of soil.	10 grams	Cool (4°C). Freezing samples can extend holding time; 48 hours unfrozen holding time will be considered cumulative.	48 hours
Semi-Volatiles, Pesticides, PCBs (3), or Total Petroleum Hydrocarbons	Water	1-L Amber glass jar with Teflon lined screw cap.	1,000 ml (1 Liter)	Cool (4°C)	Extraction within 5 days of sampling. Analysis within 40 days of extraction
	Soil	8-oz wide mouth glass jar with Teflon-lined cover	50 grams	Cool (4°C)	Extraction within 5 days of sampling. Analysis within 40 days of extraction
Metals (Total and Dissolved) (1) (4)	Water	Polyethylene bottle (one 1 L bottle)	100 ml	(Dissolved metals only - field filtered using 0.45 micron filter) Cool (4°C) Preserved with acid (HNO_3 to pH<2)	180 days
	Soil	8-oz wide mouth glass jar with Teflon-lined cover	10 grams	Cool (4°C)	180 days
Total Petroleum Hydrocarbons Fingerprint Analysis	Water	Glass jar with Teflon lined screw cap (one 1 L bottle)	1,000 ml (1 Liter)	Cool (4°C)	28 days
	Soil	8-oz wide mouth glass jar with Teflon-lined cover	50 grams	Cool (4°C)	28 days
Total Cyanide	Water	Polyethylene bottle (one 1 L bottle)	100 ml	Cool (4°C) Preserved with base (NaOH to pH>12)	180 days
	Soil	8-oz wide mouth glass jar with Teflon-lined cover	10 grams	Cool (4°C)	12 days
Mercury (Total and Dissolved)	Water	Polyethylene bottle (one 1 L bottle)	100 ml	(Dissolved metals only - field filtered using 0.45 micron filter) Cool (4°C) Preserved with acid (HNO_3 to pH<2)	26 days
	Soil	8-oz wide mouth glass jar with Teflon-lined cover	10 grams	Cool (4°C)	26 days
Biochemical Oxygen Demand	Water	Polyethylene bottle (one 1 L bottle)	100 ml	Cool (4°C)	24 hours
Bicarbonate	Water	Polyethylene bottle (one 1 L bottle)	100 ml	Cool (4°C)	14 days
Carbonate	Water	Polyethylene bottle (one 1 L bottle)	100 ml	Cool (4°C)	14 days
Chemical Oxygen Demand	Water	Polyethylene bottle (one 1 L bottle)	100 ml	Cool (4°C) Preserved with acid (H_2SO_4 to pH<2)	26 days
Chloride	Water	Polyethylene bottle (one 1 L bottle)	100 ml	None Required	26 days
Sulfate	Water	Polyethylene bottle (one 1 L bottle)	100 ml	Cool (4°C)	28 days
Total Dissolved Solids (TDS)	Water	Polyethylene bottle (one 1 L bottle)	100 ml	Cool (4°C)	7 days
Total Suspended Solids (TSS)	Water	Polyethylene bottle (one 1 L bottle)	100 ml	Cool (4°C)	5 days

Reference: EPA Document No. 540 P-87 001, 1987, "A Compendium of Superfund Field Operations Methods"
NOTES: (1) Metals analysis will be conducted on unfiltered samples. If filtered samples are analyzed, unfiltered samples must also be collected and analyzed. If turbidity presents a problem, the samples will be handled according to NYSDEC "Guidelines for Handling Excessively Turbid Samples" following approval by the Division of Hazardous Waste Remediation (DHWR). (2) Holding times are calculated from VTSR (Verified Time at Sample Receipt). Samples must be received by the lab within 48 hours of collection. (3) TCL = Target Compound List. (4) TAL = Target Analyte List.

4.4 Decontamination Procedures

Standardized procedures for decontamination have been established to reduce the likelihood of cross-contamination between samples and sampling locations. Equipment to be decontaminated includes: backhoes, drilling equipment, and sampling equipment.

All decontamination procedures will comply with the personal protection requirements detailed in the site Health & Safety Plan (HASP). Personal protection levels will depend on the nature of the contamination and the specific decontamination method. Specific decontamination methods for exploratory and sampling equipment are described in the following sections.

4.4.1 Heavy Equipment

Heavy equipment such as drill rigs and backhoes may need to be steam cleaned with a portable high pressure steam cleaner upon arrival at the site and prior to demobilization. During the course of investigation activities, it is only necessary to decontaminate equipment that comes in contact with soils and/or groundwater (i.e., drill rods, bits, backhoe bucket, etc.).

Prior to initiation of drilling activities at the site, a temporary steam cleaning area will be established, if necessary, for the decontamination of the drill rig and associated tools and augers. When selecting the steam cleaning location, the following items will be considered:

- Free from traffic;
- Away from any proposed test boring or monitoring well locations;
- Readily accessible to the investigation area; and
- Free of known surficial contamination.

The decontamination area will consist of a controlled area or structure to contain all wash water and eliminate the possibility of drilling equipment coming in contact with the underlying surficial soils and/or pavement during steam cleaning. Site-specific decontamination area construction requirements may be detailed in the Work Plan.

All equipment will be placed on clean pallets or racks prior to and after steam cleaning. Potable water will be used for the steam cleaning activities. The equipment to be steam cleaned includes: drill rods, augers, bits, tools, and split-spoon samplers. Decontamination wastewater and soils will be initially drummed into 55 gallon steel containers or other appropriate holding vessels pending laboratory analyses.

4.4.2 Drilling Equipment

Drilling equipment that is exposed to soil and/or groundwater will be steam cleaned between sampling locations. The purpose of this decontamination is to ensure that potential contaminants are not transferred between sampling locations.

4.4.3 Sampling Equipment

Contaminated tools and sampling equipment will be placed in a plastic pail, tub, or other container with a Liquinox® (or equivalent) soap and water solution. The tools will be brushed off, rinsed, and transferred to a second soap and water solution bath. Tools will be rinsed with potable water and finally rinsed with de-ionized water. Tools such as wrenches, split-spoons, etc., may be decontaminated between exploration locations with a high-pressure steam cleaner instead of washing. Sampling equipment such as reusable bailers or submersible pumps will be wrapped in aluminum foil after cleaning to prevent contamination before their next use. Control and disposal of decontamination fluids are discussed in Section 4.4.4

4.4.4 Control and Disposal of Decontamination Materials

In general, The Chazen Companies is responsible for collecting, controlling, and staging hazardous material generated during field investigations. Disposal arrangements will be made for the client, if required, for particular work assignments. Specific procedures for handling contaminated environmental materials and contaminated personal protective equipment will be presented in the Work Plan and/or the HASP.

Contaminated soil and water will be handled according to NYSDEC DER-10 unless otherwise specified in the Work Plan. These documents describe alternatives for disposal of these materials and requirements for handling.

4.4.4.1 Soil Disposal

NYSDEC DER-10 will be used as guidance for on-site disposal of non-hazardous soils including:

- Backfill inside borehole to within 12 inches of the surface. Soil will not be returned to a boring if it contains free product, non-aqueous phase liquid, or grossly contaminated soil.
- Collect and dispose on-site following characterization and NYSDEC approval.
- Temporarily store on-site prior to off-site disposal.
- Transport from off-site areas that meet Unrestricted Use SCOs to site (without need to manifest or contract with licensed hauler).

Hazardous soils can be sent off site for disposal to a properly permitted treatment, storage, or disposal facility, and non-hazardous soils can be sent to a solid waste management facility. Representative samples of materials will be analyzed for proper classification, treatment, and disposal. Materials will be transported by a licensed hauler and accompanied by the proper manifests.

Disposal alternatives are subject to precautions listed in the NYSDEC DER-10 including the general requirement that the soils “be handled and disposed of in a manner that does not pose a threat to health and the environment”. Specific handling and disposal requirements for drill cuttings will be identified by the Field Operations Leader based on field screening and analytical results of drill cutting samples, if applicable.

4.4.4.2 Groundwater Disposal

The control of contaminated groundwater is important to prevent impacts to surficial soils. Alternatives for the disposal of groundwater generated during remedial investigations at hazardous or petroleum impacted sites are provided below:

- On-site disposal of non-impacted groundwater by allowing water to recharge and infiltrate into unpaved ground into the same groundwater unit in a manner which does not result in surface water runoff.
- Transportation off-site to an authorized Resource Conservation and Recovery Act (RCRA) treatment facility;
- Discharge to a sanitary sewer for treatment at a publicly-owned treatment works (POTW);
- On-site treatment and discharge to a storm sewer, receiving stream, or to the ground;
- Transport by truck to a POTW;

In order to determine the proper disposal option for groundwater generated during monitoring well development and purging, the water will be containerized pending the receipt of laboratory analysis. The preferred method of disposal of non-impacted groundwater is to the ground surface away from the well, or if allowed, to a storm sewer or a surface water body. Disposal of impacted or non-impacted water to a POTW or other disposal facility will require authorization from the receiving facility. Overall, handling and disposal of collected groundwater will be identified by the Field Operations Leader and approved by the DEC project manager based on field screening and analytical results of water samples.

4.4.5 Sample Handling/Shipping Areas

Sample containers will be wiped clean at the sample site, taken to the decontamination area to be further cleaned, as necessary, and transferred to a clean carrier. The sample identities will be checked off against the COC record. The samples will then be stored at approximately 4° C in a secure area prior to shipment.

Sample handling areas will be cleaned/wiped down daily. For final cleanup, all equipment will be disassembled and decontaminated. Equipment that cannot be satisfactorily decontaminated will be disposed of.

4.4.6 Monitoring Equipment

When monitoring equipment is used under conditions where contamination is possible, the equipment will be protected from contaminant sources by draping, masking, or otherwise covering as much of the instrument as possible with plastic without hindering the operation of the unit.

Any contaminated equipment will be taken from the source area and the protective coverings removed and disposed of in appropriate containers. Any direct or obvious contamination will be brushed or wiped with a disposable paper wipe. The units will then be dried, checked, and calibrated for subsequent operations.

4.5 Air Monitoring

The air monitoring program is designed to provide the necessary information to ensure the safety of on-site personnel and to evaluate potential increases to air contaminant levels and dispersion patterns during site activities. Air monitoring will be conducted during field activities as detailed in the site-specific HASP and/or Work Plan.

4.5.1 Site Safety Air Monitoring

The required level of personal protection equipment specified in the site-specific HASP will be verified by the results of air quality screening performed on-site during field activities. The screening will be performed using a photoionization detector (PID), which detects and measures concentration levels of total VOCs relative to a reference standard on a real-time basis. The PID lamp sensitivity will be specified in the site-specific HASP based on any information regarding identification of potential contaminants. Most sites will require a PID with a lamp of 10.2 or 11.7 electron volts (eV).

The HASP outlines the air monitoring procedures to be followed during the field investigation. Air monitoring equipment used on site may include a PID, chemical indicator tubes (e.g., Draeger® tubes), percent oxygen/lower explosive limit meter, respirable dust monitor, or a radiation detector.

4.6 Field Screening

Headspace vapor monitoring will be performed as a screening tool for determining the relative concentrations of VOCs in soil samples. A photoionization-detector (PID) will be used. The PID will be calibrated daily in accordance with manufacturer's specifications. Headspace readings will be collected using the static headspace analysis method detailed below:

- Approximately 2 oz. of soil will be collected from each open split-spoon and placed in a dedicated laboratory-cleaned glass jar. Alternatively, soil may be placed in a resealable plastic bag which will be immediately sealed. The mouth of the jar will then be immediately covered with aluminum foil prior to sealing the jar lid to minimize the loss of VOCs. Headspace samples will be collected for each split spoon sample.
- The jar will be shaken to break up the compacted soil or material, and will be placed in a specified location (e.g., field vehicle), out of direct sunlight, for a period of no less than 15 minutes to equilibrate prior to field monitoring.
- Where ambient temperatures are below 0^oC, headspace development should be within a heated vehicle or building. Ambient temperature during headspace analysis will be recorded and reported.
- The jar lid will be removed from the jar. Headspace will be monitored within the jar by piercing the aluminum foil with the PID probe. Care will be taken to prevent unnecessary mixing of jar headspace and outside air. Monitoring with the PID will continue for at least 1 minute or until a stable reading is shown. The highest PID concentration observed will be recorded along with the sample interval in the field notebook, and on the Soil Boring Log.

4.7 Test Pitting

Test pits are designed to explore and characterize shallow subsurface soils. Test pits allow observation of large sections of the subsurface and facilitate the collection of soil samples for field screening and laboratory analysis. The locations of test pits will be determined in advance and will be detailed in the Work Plan with the provision that site personnel may modify plans in response to site conditions.

Test pits are generally excavated using a hydraulic backhoe, excavator, or other mechanical equipment with dimensions and capabilities sufficient to complete test pits described in the Work Plan. The depths of test pits and collected soil samples will be determined using a weighted tape measure referenced to the ground surface. During test pitting, samples may be collected from the test pit for geologic characterization, field screening, and laboratory analyses. Samples from the test pits are generally collected from the backhoe bucket.

Field personnel may also enter the test pit to collect samples directly from the sidewalls or bottom of the excavation if the depth is less than four feet. Occupational Health and Safety Administration (OSHA) regulations prohibit entry into test pits greater than four feet deep without adequate shoring or benching of sidewalls. Before entry into any test pit, air monitoring will be conducted in accordance to the site HASP.

Soil samples collected from test pits may be screened with a photoionization detector. If a sample is required, it will be taken from the middle of the backhoe bucket and placed in appropriate containers according to soil sampling procedures outlined in Section 4.3.

Samples may also be placed in an airtight jar or a plastic zip-lock bag and field screened for headspace VOC concentrations as outlined in Section 4.6.1.

Excavated materials may be temporarily stockpiled on plastic sheeting. If hazardous conditions are encountered, the material will be stockpiled to one side, preferably downwind, and away from the edge of the pit to reduce pressure on the pit walls. Materials with different permeabilities (i.e., sand, silt, clay) will normally be segregated during stockpiling to allow for proper replacement during backfilling. Heavily contaminated soils will also be segregated and stockpiled pending laboratory analysis and possible alternative disposal.

In the event that it is necessary to excavate below the water table, groundwater will either be left in the excavation or containerized in a frac tank and evaluated for proper disposal. If drums or other obviously contaminated objects are uncovered, the excavation will be stabilized and further excavation terminated. The field geologist will contact the Project Manager and/or NYSDEC for further directions.

Upon completion of the excavation, the test pit will be backfilled to the ground surface. Prior to backfilling, each test pit may be photographed. During backfilling, materials will be compacted by tamping with the backhoe bucket. The surface will then be graded to the level of the ground surface. At locations where heavily contaminated materials are encountered, clean soil may be utilized for backfill.

The contractor operating the excavator will decontaminate the bucket of the backhoe between excavations using the procedures outlined in Section 4.4.1.

All pertinent information will be documented in a field notebook. A test pit log will also be prepared for each test pit. The test pit log may include a sketch of the test pit, geologic description, and a written summary. Information that may be noted in the log or field notebook includes the following:

- Site name and location;
- Date of excavation;
- Total depth and dimensions of excavation;

- Sample designations and methods of acquisition;
- Soil description;
- Air monitoring levels;
- Field screening results;
- Groundwater seeps or levels; List of photographs taken;
- Date and type of backfill;
- Other pertinent information (waste materials encountered, staining, odor, etc.).

4.7.1 Procedure for Obtaining Soil Samples using a Backhoe

In order to obtain relatively vertical samples from known depths, the backhoe technique is employed. Soil can be excavated and placed in a pile. Upon retrieval of subsurface soil from the backhoe bucket, the contents are examined. The use of the backhoe sampling method allows for direct observation of the stratigraphy.

1. Choose a location from which to obtain a soil sample. Solid covering such as concrete or asphalt must be removed using the backhoe. The operator can then proceed with the excavating.
2. Examine the contents of the backhoe bucket and log, noting the depth from which the sample came.
3. If an individual sample is to be saved for further observation or analyses, place it in a capped glass jar.
4. If the sample desired is a composite sample, place the individual sample in a clean bucket, on a clean piece of plastic or in a plastic zip-lock bag. Add additional samples to the bucket or plastic. After thoroughly mixing all individual samples together, obtain a composite sample and place in a capped glass jar.
5. Clean the bucket with soapy water prior to obtaining the next sample. If samples are to be analyzed for contaminants, properly decontaminate (steam clean) the bucket.
6. Repeat procedure at next location.

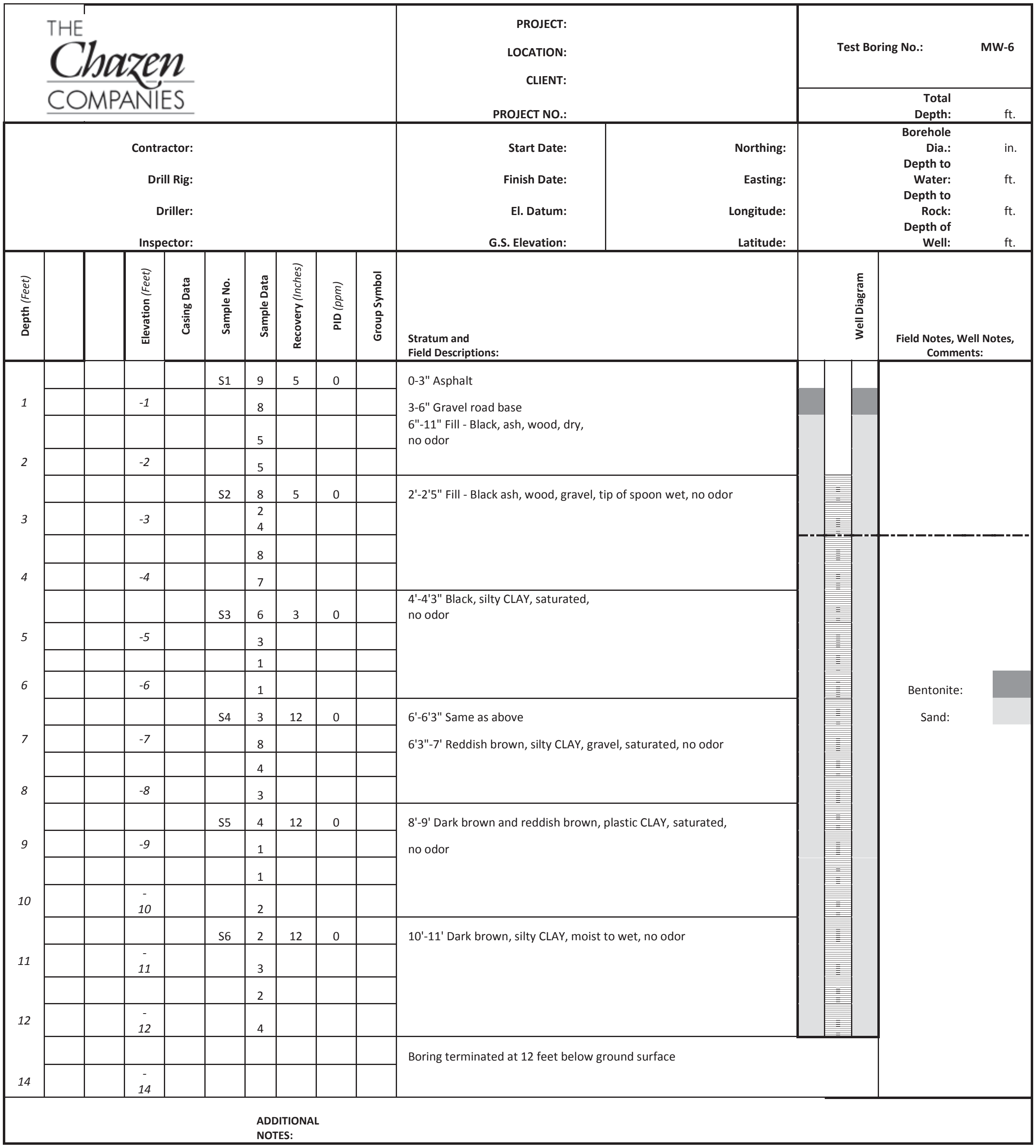
4.8 Borings and Environmental Wells

4.8.1 Drilling Methods

Soil borings may be drilled to facilitate collection of subsurface soil samples for geologic classification, chemical analyses, and physical testing. Drill rigs are utilized to advance the borings. The rigs are typically mounted on trucks, all-terrain vehicles, or skids. There are a variety of drilling methods that may be utilized including direct push (e.g. Geoprobe®), hollow-stem auger (HSA), drive and wash, and mud rotary. Each of these methods enables the collection of soil or groundwater samples. Drilling methods also facilitate the installation of monitoring wells to provide hydrogeologic data.

A geologist will observe drilling operations summarizing boring information in a field notebook, taking photographs when appropriate, and collecting samples in accordance with the Field Sampling Plan. A boring log will be prepared that includes: characterization of subsurface materials and geologic conditions, air monitoring readings, field screening readings, pertinent drilling information, and relevant observations (i.e., staining, odor, sheen, etc.). An example of a typical boring and monitor well log is presented below.

Typical Boring Log



THE Chazen COMPANIES	**PROJECT:** **LOCATION:** **CLIENT:** **PROJECT NO.:**	**Test Boring No.:** **MW-6** **Total Depth:** ft.
Contractor: **Drill Rig:** **Driller:** **Inspector:**	**Start Date:** **Finish Date:** **El. Datum:** **G.S. Elevation:**	**Northing:** **Easting:** **Longitude:** **Latitude:**

Borehole Dia.:	in.
Depth to Water:	ft.
Depth to Rock:	ft.
Depth of Well:	ft.

Depth *(Feet)*			**Elevation** *(Feet)*	**Casing Data**	**Sample No.**	**Sample Data**	**Recovery** *(Inches)*	**PID** *(ppm)*	**Group Symbol**	**Stratum and Field Descriptions:**	**Well Diagram**	**Field Notes, Well Notes, Comments:**
					S1	9	5	0		0-3" Asphalt		
1			*-1*			8				3-6" Gravel road base		
						5				6"-11" Fill - Black, ash, wood, dry, no odor		
2			*-2*			5						
					S2	8	5	0		2'-2'5" Fill - Black ash, wood, gravel, tip of spoon wet, no odor		
3			*-3*			2 4						
						8						
4			*-4*			7						
					S3	6	3	0		4'-4'3" Black, silty CLAY, saturated, no odor		
5			*-5*			3						
						1						
6			*-6*			1						Bentonite: ▨
					S4	3	12	0		6'-6'3" Same as above		Sand: ░
7			*-7*			8				6'3"-7' Reddish brown, silty CLAY, gravel, saturated, no odor		
						4						
8			*-8*			3						
					S5	4	12	0		8'-9' Dark brown and reddish brown, plastic CLAY, saturated,		
9			*-9*			1				no odor		
						1						
10			*-10*			2						
					S6	2	12	0		10'-11' Dark brown, silty CLAY, moist to wet, no odor		
11			*-11*			3						
						2						
12			*-12*			4						
										Boring terminated at 12 feet below ground surface		
14			*-14*									

ADDITIONAL NOTES:

Drilling methods used during an investigation will be determined in advance and will be detailed in the Work Plan with the provision that the drilling procedure may be modified in response to conditions encountered during drilling. A more detailed discussion of the various drilling methods, sampling procedures, and well installation procedures is provided below.

4.8.1.1 Hollow-Stem Augers

The Hollow Stem Auger (HSA) method utilizes coupled lengths of continuous-flight, hollow steel augers to advance through overburden materials. With this method, drill cuttings rise upward on the flights as the string of augers is rotated.

Typically, $4^1/_4$-inch or $6^1/_4$-inch inner diameter (ID) augers are used for hazardous waste investigations. These produce nominal 8-inch and 10-inch boreholes, respectively.

A center plug equipped with cutting teeth is attached to drilling rods and placed inside the augers to facilitate cutting and to prevent subsurface materials from entering the augers.

When the augers are advanced to the appropriate depth, the center plug is removed to allow for the collection of soil or in situ samples.

The advantage of the HSA method is that limited fluid use is required. In addition, 2-inch ID monitoring wells can be easily installed inside the augers. The limitations of HSA drilling include the inability to advance through very dense materials like rock, cobbles, rubble, etc., or drilling through loose saturated sands and silts which tend to flow around the plug and seize the tooling. Drilling depths are usually limited to the first dense rock layer encountered or by the torque of the machine.

4.8.1.2 Direct Push

Soil probing or "direct push" machines such as the Geoprobe® push tools and sensors into the ground without the use of rotation to remove soil and to make a path for the tool. A Geoprobe® relies on a relatively small amount of static (vehicle) weight combined with a hydraulic hammer as the energy for advancement of a tool string. Probing tools do not remove cuttings from the probe hole but depend on compression of soil or rearrangement of soil particles to permit advancement of the tool string.

Probing tools are advanced as far as possible using only the static weight of the carrier vehicle. Greater depth is achieved using the combined effect of the vehicle weight and hydraulic hammer. Hammering is often required when probing near the ground surface to penetrate hard-packed surface soil and other hard surfaces. The probe is then allowed to penetrate using only static force until refusal is again encountered, at which time the hammer is reapplied. The hammer is applied as required when probing through sands, gravels, high friction clays, tills, fill materials, and surface frost.

A Geoprobe® can be used to drive tools to obtain continuous soil cores or discrete soil samples; obtain groundwater samples or soil gas samples; install permanent sampling implants and air sparging points; set small diameter permanent monitoring wells; or drive a conductivity sensor probe to map subsurface lithology. Soil probing equipment is typically used for site investigations to depths of 30 to 60 feet.

The advantage of using a Geoprobe® versus conventional drilling techniques, are:

- Minimal cuttings are generated. This reduces handling, containing, storing, sampling, analyzing, and disposing of potentially hazardous and contaminated cuttings. This also reduces disposal costs and potential exposure of site workers, facility employees, residents, and surroundings to hazardous contaminants.

- Only a small diameter hole is created. Grouting is less expensive because a small volume of grouting material is required.

- Less obtrusive equipment required. Small, light, probing equipment is used for sample collection which allows the operator to reach many locations not accessible to larger and heavier conventional drilling equipment.

- Minimal physical and chemical disturbance of the sample materials occurs.

- Typical penetration rates are from 5 to 25 feet per minute, although probing time is highly dependent upon soil conditions.

- Sampling time is shorter; therefore, more sample locations can be sampled per day, depending upon soil conditions.

- The unit can sample all subsurface media including soil, groundwater, and soil gas; log soil conductivity and contaminants; grout probe holes; and inject remediation materials.

4.8.2 Subsurface Soil Sampling

4.8.2.1 Hand/Bucket Auger

A hand or bucket auger may be used for collecting shallow subsurface soil samples, usually no deeper than 3 to 4 feet below ground surface, although the achievable depth will be limited by soil type and conditions at the site. A hand or bucket auger may be used for collecting surface soil samples. The following procedure is used when collected soil samples with a hand auger:

1. Using a decontaminated stainless steel auger connected to an extension rod and handle, begin turning the auger clockwise until the auger is full. Remove the auger, empty the soil, and continue auguring until the desired depth is reached.

2. Using a decontaminated or second auger obtain soil from the specified depth interval (24-36”, 36-48”, etc.). The auger used to advance the hole is not suitable for sample collection, as it may be contaminated by the material above it.

3. When sampling at depths deeper than 12 inches, discard ½-inch of material at the top of the auger due to cave in.

4. Transfer soil to a stainless steel mixing bowl. Immediately transfer soil for VOC analysis into sample jar using a stainless steel spoon (unless State requirements specify methanol preservation of samples for VOC analysis).

5. Once a sufficient volume of soil is collected in the mixing bowl, thoroughly homogenize the sample and remove any vegetative material and stones.

6. Transfer the material to the labeled sample containers and place them in sample cooler on ice.

7. Either decontaminate the sampling equipment or place it in a plastic bag for later decontamination.

4.8.2.2 Split-Spoon Sampling

Split-spoon samplers are used to collect soil samples from the bottom of a borehole. The sampler consists of a thick-walled, steel tube that is split lengthwise. It has a cutting shoe attached at the lower end and a check valve at the upper end.

When needed, the split-spoon sampler is attached to drill rods with a threaded adapter. The split-spoon sampler is driven into the ground in accordance with the standard penetration test (ASTM D1586). The standard penetration test (SPT) consists of driving a $1^{3}/_{8}$-inch ID, 2-foot split-spoon 24 inches into the soil using a 140-pound hammer falling 30 inches. The number of blows required to drive the split-spoon each 6 inches is recorded to obtain the SPT-N value, which is defined as the total blows for the penetration from 6 to 18 inches. Often, larger split-spoons are used in order to provide sufficient soil volume when collecting samples for chemical analyses. The size of the split-spoon and the sampling interval are detailed in the FSP.

After the sampler has been retrieved, a field geologist will perform field screening, soil characterization, and sample collection according to the following procedures:

1. The split-spoon will be screened for VOCs immediately upon opening with a total VOC analyzer such as a PID. The instrument will be passed over the sample while slightly disturbing the soil with a sampling trowel or spoon.
2. The soil from the split spoon will be characterized in the field using Modified Burmeister Soil Classification System or the Unified Soil Classification. Physical characteristics such as color, grain size, soil type, texture, consistency, and moisture will be recorded in a field notebook or boring log form.
3. Representative soils will be placed into the appropriate jars for physical and chemical testing. The type and frequency of tests that will be performed are discussed in the FSP. Samples that may be submitted for laboratory analysis will be placed immediately into laboratory-supplied jars with a pre-cleaned stainless steel trowel or spoon. The samples will be labeled with the date and time of sampling, sample identification and site location, then packed for shipment to the laboratory in a cooler with ice. An 8-ounce jar and/or 40-ml vial will also be filled (if specified in the Work Plan) for soil jar headspace tests as detailed in Section 4.6.1.
4. The split-spoon and sampling utensils will be decontaminated between each sample according to the procedures outlined in Section 4.4.3.

4.8.2.3 Geoprobe® Sampling

Macro-Core Soil Samples

The MacroCore® Soil Sampler is a solid barrel, direct push device for collecting continuous core samples of unconsolidated materials at depth. The standard MacroCore® Sampler has an assembled length of approximately 52 inches (1,321 mm) with an outside diameter (OD) of 2.2 inches (56 mm). Collected samples measure up to 1,300 ml in volume in the form of a 1.5-inch by 45-inch (38-mm by 1,143-mm) core contained inside a removable liner. The MacroCore® Sampler may be used in an open-tube or closed-point configuration. It has a removable/replaceable, thin-walled liner tube inserted inside for the purpose of containing and storing soil samples. The standard MacroCore® liner is 1.75-inches OD by 46-inches long (44-mm by 1,169-mm). Liner materials include stainless steel, Teflon®, PVC, and PETG.

To obtain a soil sample, an assembled MacroCore® Soil Sampler is driven one sampling interval into the subsurface and then retrieved using a Geoprobe® soil probing machine. The collected soil core is removed from the sampler inside a liner.

The MacroCore® Soil Sampler is most commonly used as an open-tube sampler. In this configuration, coring starts at the ground surface with a sampler that is open at the leading end. The sampler is driven into the subsurface and then pulled from the ground to retrieve the soil core. In stable soils, an open-tube sampler is advanced back down the same hole to collect the next core.

In unstable soils, which tend to collapse into the core hole, the MacroCore® Sampler can be equipped with a piston rod point assembly. The point fits firmly into the cutting shoe and is held in place by a piston rod and stop-pin. The MacroCore® Piston Rod System prevents collapsed soil from entering the sampler as it is advanced to the bottom of an existing hole, thus ensuring collection of a representative sample.

Loose soils may fall from the bottom of the sampler as it is retrieved from depth. Better recovery is obtained when the core catcher is used with saturated sands and other non-cohesive soils. A core catcher should not be used with tight soils as it may actually inhibit sample recovery.

Large Bore Soil Sampler

The Large Bore (LB) Soil Sampler is a solid-barrel, piston-sealed, direct push device for collecting discrete interval samples of unconsolidated materials at depth. The assembled Large Bore Sampler is approximately 30-inches long with an OD of 1.5-inches. Collected samples measure up to 283-ml in volume in the form of a 1.0-inch by 22-inch core contained inside a removable liner. It has a 1.15-inch OD by 24-inch long removable/replaceable, thin-walled tube liner inserted inside for the purpose of containing and storing soil samples. Liner materials include brass, stainless steel, Teflon®, and clear plastic (cellulose acetate butyrate).

The Large Bore Sampler is used primarily as a discrete interval sampler; that is, for the recovery of a sample at a prescribed depth. In certain circumstances, it is also used for continuous coring.

To obtain a sample, the assembled Large Bore Sampler is connected to the leading end of a Geoprobe® rod and driven into the subsurface using a Geoprobe® Soil Probing Machine. Additional probe rods are connected in succession to advance the sampler to depth. The sampler remains sealed (closed) by a piston tip as it is being driven. The piston is held in place by a reverse-threaded stop-pin at the trailing end of the sampler. When the sampler tip has reached the top of the desired sampling interval, a series of extension rods, sufficient to reach depth, are coupled together and lowered down the inside diameter of the probe rods. The extension rods are then rotated clockwise using a handle. The male threads on the leading end of the extension rods engage the female threads on the top end of the stop-pin, and the pin is removed. After the extension rods and stop-pin have been removed, the tools string is advanced an additional 24 inches. The piston is displaced inside the sampler body by the soil as the sample is cut. To recover the sample, the sampler is retrieved from the hole and the liner containing the soil sample is removed.

4.8.3 Monitoring Well Installation

This section outlines the general procedures for monitoring well installation and typical materials utilized. The number, location, and construction details of monitoring wells will depend on the project objectives and will be discussed in the Work Plan.

4.8.3.1 Well Construction Materials

Well construction materials consist of well screen, riser pipe, sand pack, bentonite seal, cement grout, and protective casing. Specific monitoring well details may be outlined in the Work Plan. Typical well construction specifications are described below.

Well Screen and Riser Pipe

The most common materials used in the construction of monitoring wells are polyvinyl chloride (PVC) and stainless steel. Generally, PVC is used because it is less expensive and non-corrosive. However, PVC may deteriorate as a result of certain compounds. In such cases, stainless steel may be preferred. Riser pipe and well screen is typically 2-inch or 4-inch ID and has flush joint threads.

When PVC is used, wells constructed in unconsolidated materials less than 100 feet deep are constructed with Schedule 40 PVC.

Well screens are used in the construction of monitoring wells to limit sediment from entering the well. Generally, screens are machine slotted at slot sizes of 0.01 inches (10-slot) for fine materials or 0.02 inches (20-slot) for coarse materials such as coarse sand and gravel. The screen slot size should be selected to retain 90 percent of the filter pack material or native aquifer material.

Sand Pack

The sand pack consists of uniformly graded sand. A grade of sand is selected such that it will not to pass the well screen slot size and will exclude the fines from the formation. At least a 2-inch layer of sand will be placed at the bottom of the hole prior to the well installation. Sand will be placed around the well screen to a level of 2 feet above the top of the screen, site conditions permitting. In situations that require a well to straddle a shallow water table, it may be necessary to place less sand above the top of the screen to allow enough space for an adequate bentonite seal.

Bentonite Seal

The bentonite seal may consist of pure Wyoming sodium bentonite chips, pellets, or slurry. A bentonite seal expands by absorbing water, and due to its low permeability, serves to isolate the screened interval from the rest of the borehole. The bentonite seal should be at least 2 feet thick and be placed directly above the sand pack. It may be necessary to install less bentonite for shallow water table wells. Bentonite seals that are placed above the water table should be hydrated with potable water. NYSDEC guidelines specify that bentonite seals must be placed via tremie method. For deeper installations it is often more practical to tremie a bentonite slurry. In such cases, the bentonite slurry may be placed up to the ground surface in place of cement or cement-bentonite grout.

Cement-Bentonite Grout

Grout will be placed from the top of the bentonite seal to the ground surface via the tremie method. Generally, the grout consists of a cement-bentonite mixture. Cement is Portland Type 1, in conformance to ASTM specifications C150. The bentonite is powdered Wyoming sodium bentonite. Cement-bentonite grout typically consists of 94 pounds of cement mixed with 3 to 5 pounds of powdered bentonite and 7 gallons of water or a media approximating this mixture. The purpose of the grout seal is to replace material removed from the borehole during drilling and prevent collapse and subsidence around the well. Pure bentonite slurry may also be used in place of the cement-bentonite grout.

Protective Casings

Protective casings are placed around wells to prevent damage, provide security, and to provide a seal to prevent surface runoff from entering the well. They usually consist of a 4- or 6-inch diameter steel casing with a 2-3 foot stick up above the ground or a manhole road box installed flush to the ground surface (flush-mounted casing). The casings should be watertight and equipped with a locking cover. All protective casings should be labeled with the well identification. A concrete surface seal should be constructed around the protective casing at the ground surface to provide a seal and to divert surface runoff away from the well. All details of well installation will be recorded by the geologist.

4.8.4 Bedrock Monitor Well Installation

Monitor wells will be installed following National Water Well Association protocol and good engineering practices. The on-site geologist will be present during all drilling and monitor well installations to ensure that work progresses in a timely fashion. Continuous sampling of the unconsolidated sediments will be completed using split spoons. These samples will be examined to define the stratigraphy.

The on-site geologist shall log the borehole and provide an interpretation of cores, unconsolidated sediment samples, and drill cuttings. The on-site geologist shall also maintain a log of each boring including:

- Reference point for all depth measurements.
- The depth at which each change of formation occurs.
- Identification and classification of formation materials using Unified Soil Classification system for unconsolidated sediment samples.
- The number, interval, and time of sample collection.
- Identification of the bedrock type, rock quality density (RQD), fracture frequency and weathered zone by the examination of rock cores.
- Description of drilling progress.
- The number and time of each core run.
- Estimated water level, yield, and recovery rate.
- Field-screening PID readings in parts/million of each sample as logged at the time of drilling.

The bedrock monitor well will be installed using the air rotary method. A 4- to 6-inch steel casing will be sealed at least 1-foot into bedrock. The boring will be completed as an open rock well. The well will also be sealed with cement at the ground surface.

4.8.5 Well Development

Monitoring wells are developed in order to restore the natural permeability of the formation adjacent to the borehole; to permit water to flow through the screen easily. Well development removes fine sediment from the formation so, during sampling, water will not be turbid or contain suspended materials that can interfere with chemical analysis.

Shallow wells are generally developed with a bailer, a foot-valve pump, or a submersible pump. Pumping is usually a more efficient method for deeper wells. The selection of the well development methods and equipment will be determined on site by the field personnel based on drilling, well construction, and site-specific geologic information.

Well development will occur after a minimum of 24 hours following construction or after recovery is complete, whichever is later. All equipment that is introduced into the well will be decontaminated according to the procedures discussed in Section 4.4. The general procedures for well development are summarized below:

1. Measure the water level in the well with a water level indicator. The depth to the bottom of the well is measured with a weighted measuring tape.
2. A bailer or other pumping device is lowered to the bottom of the well. The well is surged by the bailer or the pump to agitate and loosen fines in the well screen and sand pack.
3. Groundwater is bailed or pumped from the well. If a pump is used, the pump intake will be periodically placed at different depths throughout the well and within the screen interval during development.
4. Readings of pH, temperature, specific conductance, and turbidity will be collected after each well volume removed or at other intervals depending upon well output and other factors pertinent to sampling.
5. Well development will continue until the field measurements stabilize. Ideally, the well should be developed to 50 Nephelometric Turbidity Units (NTU), if possible. The goal of 50 NTUs may not be practical in formations which contain a lot of silt and clay in which case the well will be developed until the turbidity readings appear to have stabilized.
6. The development tools will be removed from the well and the water level and well bottom will be measured following development.
7. The well will be covered and locked.
8. Purged water will be containerized pending subsequent sampling and handled according to the procedures outlined in Section 4.4.4.
9. All pertinent field data will be recorded on a Field Data Sheet (see Section 4.10).

4.9 Groundwater Sampling

Groundwater samples are collected from monitoring wells for laboratory analysis. The specific number and location of samples, rationale, and parameters to be tested are discussed in the Work Plan or Field Sampling Plan. The equipment and general procedures normally utilized for groundwater sampling are presented below.

4.9.1 Groundwater Sampling Equipment

Monitoring wells will be purged using one of the following pieces of equipment:

- Lubricant-free stainless steel submersible pump with polyethylene or Teflon discharge tubing.
- Peristaltic pump equipped with dedicated polyethylene tubing with or without a foot valve.
- Dedicated Teflon bailer connected to new solid-braid nylon rope.
- Inertial lift pump with dedicated polyethylene valve and tubing.

Project-specific purging methods are outlined in the Work Plan. The selection of a purging method is determined based on the following information:

1) Well depth
2) Static water level
3) Hydraulic conductivity
4) Well diameter
5) Well location

4.9.2 Procedures for Collecting Groundwater Samples

4.9.2.1 Pre-Sampling Activities

Before sampling, the following pre-sampling activities will occur:

- The well will be inspected for integrity and proper identification.
- A sheet of polyethylene will be laid out for placement of monitoring and sampling equipment, as needed.
- If site conditions are unknown, conditions warrant, or project requirements call for VOC monitoring, VOCs will be measured at the rim of the opened well with a PID and recorded in the field logbook.
- After removing the well cap, the water level will be allowed to equilibrate for a minimum of 5 minutes. The static water level in the well will be measured with a water level indicator to the nearest 0.01 feet referenced to a permanent mark on the PVC riser. The probe of the meter will be decontaminated according to the procedures detailed in Section 4.4.
- The volume of water in the well will calculated by the following equation:

  $$V = (\pi) r^2 l (7.48)$$

  where,
  V = volume, in gallons
  π = 3.14
  r = inside radius of well, in feet
  l = height of water in well, in feet
  7.48 = conversion factor for cubic feet to gallons

- If desired, the depth of any non-aqueous phase liquids (NAPLs) will be measured using an interface probe and recorded. If LNAPLs or DNAPLs are detected, the well will not be sampled. A sample of the LNAPLs or DNAPLs present may be obtained using a bailer, if appropriate.

4.9.2.2 Sampling Procedures

Low Flow Sampling:

- Install Pump: Slowly lower the pump, safety cable and tubing into the well to the depth specified for that well. The pump intake should be in the middle or slightly above the middle of the screened interval. Too close to the bottom increases the possibility that solids that have collected in the well over time will be collected in the sample. Too close to the top increases the possibility that water stored in the casing will be included in the sample. Record the depth to which the pump is lowered.

- Measure Water Level: Before starting the pump, measure the water level again with the pump in the well. Leave the water level measuring device in the well.

- Purge Well: Start pumping the well at 100 to 500 milliliters per minute (ml/min). The water level should be monitored approximately every 5 minutes. Ideally, a steady flow rate should be maintained that results in a stabilized water level (drawdown of 0.3 ft or less). Pumping rates should be reduced, if needed, to the minimum capabilities of the pump to ensure stabilization of the water level. Care should be taken to maintain pump suction and to avoid entrainment of air in the tubing. Record each adjustment made to the pumping rate and the water level measured immediately after each adjustment.

- Monitor Indicator Parameters: During purging of the well, monitor and record the field indicator parameters (temperature, specific conductance, and pH) approximately every 5 minutes. The well is considered stabilized and ready for sample collection when the indicator parameters have stabilized for three consecutive readings as follows:

  ±0.1 for pH

  ±3% for temperature

  ±3% for specific conductance (conductivity)

  The pump must not be removed from the well between purging and sampling.

- Sample collection should be directly from the dedicated or disposable tubing, not from the flow-through cell discharge hose.

- Remove pump and tubing: After collecting the samples, the tubing must be properly discarded or dedicated to the well for resampling by hanging the tubing inside the well.

- Close and lock the well.

Sample Collection

All laboratory samples will be placed in containers according to the procedures outlined in Section 4.3.3 of this document. Drums containing purge water will be handled in accordance with Section 4.4.4.

4.10 Sediment and Shallow Soil Sample Collection

Shallow soil samples and sediment samples provide information related to the presence of contamination caused by surface releases. These samples are typically collected utilizing one of the following tools:

- Split-spoon sampler
- Hand augur
- Sampling trowel

Depending on the objectives of the sampling program, either grab samples or composite samples may be collected. Samples can be composited over various depths from one location, or laterally from several locations of the same depth. Composite samples are homogenized in a stainless steel bowl using a stainless steel mixing spoon or trowel. Grab samples to be analyzed for VOCs are collected directly from the sampling implement and are not mixed. Soil samples are placed in the appropriate laboratory jars based on the proposed analytical methods, labeled, and packed for shipment to the laboratory in a cooler with ice.

All sampling equipment will be decontaminated between sample locations according to the procedures outlined in Section 4.4.

A detailed log for each sample will be recorded in a field notebook. This record will include: time and date of sample collection, depth, location, sampler's name, sampling procedures, soil types collected, and all other pertinent observations.

The various methods for obtaining shallow soil and sediment samples are described below. Site-specific sampling objectives and procedures are described in the Work Plan.

<u>Split-Spoon Sampling</u>: Split-spoon samples are collected in accordance with the procedures outlined in Section 4.8.2.2.

<u>Hand Auger Sample Collection</u>: A hand auger is twisted into the ground by hand. The auger is generally advanced in one-half to one-foot intervals to the target depth. Samples are collected by removing the device from the hole and emptying the sample from the bucket auger into a stainless steel bowl. The sample is then homogenized according to the procedure described above. Hand augers generally have a maximum depth range of about five feet, depending on soil type and density, frequency of cobbles, depth to water, and other natural or manmade conditions.

<u>Sampling Trowel</u>: The use of sampling trowels will follow the same procedures as described for hand augers. However, samples are collected by hand with a stainless steel shovel, trowel, or similar instrument. The maximum depth is generally about one to two feet.

4.11 Surface Water Sampling

The procedures for surface water sampling are dependent on the depth of water, flow rate, and analytical parameters of interest. Site-specific sampling locations and methods are presented in the FSP. In general, samples are collected according to the following procedures:

- A clean sample bottle is lowered into the surface water body. Care will be taken to avoid floating debris. Samples from streams are collected with the opening of the sampling vessel facing upstream.
- If a sample collection vessel is required due to depth or flow rate, the vessel will be filled as described above. The appropriate sample container can be filled from the sampling vessel.
- Depending on the parameters being sampled, collect measurements of pH, specific conductance, and temperature from the surface water body. Details of required surface water measurements will be shown in the FSP.
- All pertinent information will be recorded in a field notebook and on a Field Data Sheet.
- The sampling location will be staked and labeled for subsequent field survey, if required by the Work Plan.

4.12 Water Level Measurements

Groundwater level measurements are taken to calculate groundwater elevations so that groundwater contour maps can be constructed. Groundwater contour maps are used to assess flow directions and hydraulic gradients.

Water levels are measured with a water level indicator to the nearest hundredth (0.01) foot. Measurements collected from monitoring wells are taken from the top of well casing. The measurement point is notched or marked indelibly on the casing.

Water levels are measured according to the following procedures:

- Check the well for proper identification.
- Inspect the integrity of the protective casing and surface seal.
- If previous data warrant, or unknown conditions exist, then monitor the ambient air in the breathing zone and at the well head while unlocking and removing the well cover.
- Using a pre-cleaned water level indicator, measure the water level to the nearest hundredth (0.01) foot from the reference mark at the top of the well riser pipe.
- Record the water level measurements in a field notebook and/or on a field data sheet along with the date and time of measurement.
- Decontaminate the water level probe between locations by rinsing it with methanol and deionized water.
- Replace the well cover and lock.

4.13. Ground Penetrating Radar

Ground penetrating radar (GPR) uses high frequency radio waves to investigate shallow geologic features (e.g. depth to the water table or depth to bedrock) and for the detection of buried objects. GPR can provide subsurface information ranging in depth from several tens of feet to inches and is useful for locating subsurface objects, utilities, and geologic interfaces.

Ground penetrating radar operates by transmitting pulses of microwave-range (0.1- to 100-cm wavelength) electromagnetic energy into the ground through an antenna (a.k.a. transducer). Some of the energy is scattered where materials with different dielectric permitivity interface. The rest of the energy passes through the interface and on to the next interface where it may be reflected or pass through to deeper interfaces. The reflected signals are received by a control unit which registers the reflections against two-way travel time in nanoseconds. The control unit typically contains an output display on which the signals are plotted in profile (radargram).

The GPR antenna is pulled slowly along the ground surface radiating energy downward into the subsurface. Reflected energy is gathered at a receiving antenna and variations in the return signal are continuously recorded. These variations are caused by wave reflections from surfaces of materials having different electrical properties. These surfaces may be geologic features (e.g., soil interfaces, changes in moisture content, voids or fractures in bedrock) or indications of human activity (e.g., buried drums, utilities, tanks).

The depth of penetration is highly site-specific and is dependent on the soil types and properties. In general, dry, sandy soils provide better data, while moist, clayey or conductive soils provide poorer results.

4.13.1 Equipment/Instrumentation

The GPR system consists of a control unit, antenna, and a graphic recording device. The antenna transmits electromagnetic pulses of short duration into the ground. Pulses are reflected back to the antenna from the various interfaces within the subsurface. The receiver sends the signal to the control unit for processing and display.

Several manufacturers produce commercially-available GPR systems. For this reason, a detailed description of instrument operation is not practical. The operator should refer to the instrument setup and operations manual to prepare the instrument for a survey. The instrumentation should be selected based on the desired target and actual field conditions. The selection of a transducer frequency will need to balance the desired depth of penetration with resolution.

4.13.2 Field Procedures

The general field procedures for conducting GPR surveys are outlined below:

- Where possible, the instrument is calibrated by burying a metal object at known depth. The instrument is then adjusted so that the readings are consistent with the true depth.

- A grid of parallel lines is established across the investigation area. The size of the grid is dependent upon the project objectives and is detailed in the FSP.

- Data are collected by slowly pulling the antenna along the survey lines. The beginning and end points of each traverse should be surveyed from a known location, which can be recovered at a future date.

4.13.3 Data Analysis

Most modern GPR systems utilize portable digital processors operating on battery (DC) power. Digital processing allows the operator to utilize filtering, stacking, and gain controls as well as manipulate them in the field. Data is typically stored in an unfiltered (raw) form that can be reviewed and processed after the survey is complete.

GPR data are evaluated qualitatively in the field as the survey progresses. Data is displayed on the GPR system and observed in profile as it is collected. Estimates of depth are automatically made by utilizing a velocity conversion factor. The velocity conversion factor is a user-entered estimate of the radar wave propagation rate through the subsurface. It is used to determine distance (depth) from the GPR antenna.

4.13.4 Data Evaluation

The propagation velocity of the EM pulse depends upon the relative dielectric permittivity of the material (e_r) through which the pulse travels. The relative dielectric permittivity is a measure of the degree to which a medium can resist the flow of the EM pulse: the higher the relative permittivity, the lower the resistance to flow, and vice versa. For most earth materials and rocks, the relative dielectric permittivity does not exceed 10 and is always greater than unity, the value for a vacuum. The table below gives typical permittivity values for commonly encountered materials.

Approximate Electromagnetic Properties of Various Materials

Material	*Relative Dielectric Permittivity*	*Pulse Velocity (ns/ft)*
Air	1	1
Freshwater	81	9
Seawater	81	9
Sand (dry)	4 – 6	2.1 – 2.4
Sand (saturated)	30	5.5
Silt (saturated)	10	3.1
Clay (saturated)	8 – 12	2.8 – 3.3
Average “dirt”	16	4
Dry sandy coastal land	10	3.1
Marshy forested flat land	12	3.5
Rich agricultural land	15	3.9
Pastoral land, hilly, forested	13	3.6
Freshwater ice	4	2
Permafrost	4 – 8	2.0 – 2.9
Granite (dry)	5	2.2
Limestone	7 – 9	2.6
Concrete	6.4	2.5
Asphalt	3 – 5	1.7 – 2.5

The dielectric permittivity is related to the propagation velocity by the formula:

$$e_r = \left(\frac{c}{V_m}\right)^2$$

where, “c” is the propagation velocity in free space ($3\text{x}10^8$ meters per second or approximately 1 foot per nanosecond) and Vm is the propagation velocity through a material. It follows that

$$(e_r)^{1/2} = \frac{c}{V_m} \qquad \text{or} \qquad \frac{1}{V_m} = \frac{(e_r)^2}{c}$$

Since c is approximately equal to 1 ft/ns, then

$1/V_m \approx (e_r)^{1/2}$ (Formula 1)

Where units are in ns/ft (one-way travel time).

Formula 1 gives a method for estimating the propagation velocity for a medium (and therefore the depth to a reflecting horizon) if the soil conditions are known. If they are unknown or their properties cannot be estimated accurately enough, a reflector of known depth can often be used to calibrate the GPR recordings to site conditions.

Approximate Depth Ranges for Various Antenna Frequencies

Frequency (MHz)	**Minimum Target Size (m)**	**Approximate depth range (m)***
100	0.1-1	2-15
250	0.05-0.5	1-10
500	0.04	1-5
800	0.02	0.4-2

4.14 Soil Vapor Sampling

Soil vapor sampling will be conducted in accordance with the NYSDOH Guidance for Evaluating Soil Vapor Intrusion, Final October 2006.

Soil vapor samples are collected outside, and not beneath the foundation or slab of a building (addressed separately in section 4.15), to determine whether there is soil vapor contamination, to characterize the nature and extent of soil contamination, and to identify possible sources of contamination. The results are often used to evaluate the potential for current and future human exposures and to determine the effectiveness of measures implemented to remediate contaminated subsurface vapors.

4.14.1 Sample Probe Installation

Samples at depths less than 5 feet below the ground surface (bgs) are prone to negative bias from infiltration of outdoor air and should only be collected when deeper samples are not feasible.

Soil vapor probe installation can be permanent, semi-permanent, or temporary. Permanent probes are preferred for data consistency. Soil probes should be constructed in the same manner at all sampling locations to minimize possible discrepancies. The following procedures should be used when constructing and installing soil probes:

- Direct-push technology is the preferred method of installing sample probes. When necessary, an auger could be used.

- Porous backfill material (i.e. coarse sand, glass beads) should be used to create a sampling zone of 1 to 2 feet in length.
- Implants/probes should be fitted with VOC-inert tubing (i.e. polyethylene, stainless steel, or Teflon®) of the appropriate size (typically $^1/_8$-inch to $^1/_4$-inch diameter) that is of laboratory or food grade quality.
- The probes should be sealed above the sampling zone with bentonite slurry for a minimum distance of 3 feet to prevent outdoor air infiltration. The hole should be filled with clean material.
- For multiple probe depths, the borehole should be grouted with bentonite between probes to create discrete sampling zones.
- For permanent installations, a protective casing should be set around the top of the probe tubing and grouted in place to the top of the bentonite to minimize infiltration of outdoor air, as well as to prevent accidental damage to the probe.

4.14.2 Soil Vapor Sample Collection

Soil vapor samples should be collected in the same manner at all locations to minimize discrepancy and should include the following:

- Samples should be collected a minimum of 24 hours after the installation of permanent probes, and shortly after the installation of temporary probes.
- One to three implant volumes (volume of sample probe and tube) must be purged prior to sample collection.
- Flow rates for purging and collecting must NOT exceed 0.2 liters/minute to minimize outdoor air infiltration.
- Use conventional sampling methods, in an appropriate container that meets the requirements of the sampling and analytical methods and has been certified to be clean by the laboratory.
- Sample size is dependent on the volume needed for laboratory minimum reporting limits.
- Tracer gas (i.e. helium, butane, or sulfur hexafluoride) must be used to verify that outdoor air infiltration is not occurring. Once verified, continued use of the tracer gas may not be necessary. Two approaches can be selected when using a tracer gas:
    - Include the tracer gas in the list of laboratory analytes.
    - Use a portable field monitoring device to analyze the sample for the tracer gas.

4.15 Sub-Slab Vapor Sampling

Sub-slab vapor samples are collected to characterize the nature and extent of soil vapor contamination immediately beneath a building with a basement foundation and/or a slab-on grade. The sample results are used when evaluating current and potential for future human exposures, and site specific attenuation factors (i.e., the ratio of indoor air to sub-slab vapor concentrations). Sub-slab vapor samples are collected after soil vapor characterization and/or other environmental sampling (soil and groundwater characterization). Sub-slab samples are typically collected concurrently with indoor and outdoor samples. However, outside of the heating season, sub-slab vapor samples may be collected independently depending on the sampling objective.

Sub-slab vapor samples and, unless there is an immediate need for sampling, indoor air samples are typically collected during the heating season because soil vapor intrusion is more likely to occur when a building's heating system is in operation and air is being drawn into the building.

4.15.1 Investigation Considerations

Existing environmental data, site background information, and building construction details should be considered when selecting buildings and locations within buildings for sub-slab vapor sampling. At a minimum, these general guidelines should be followed:

- Buildings located above or directly adjacent to known or suspected areas of subsurface VOC contamination should be sampled;

- Buildings in which positive responses with field equipment were obtained should be sampled; and

- Buildings with known or suspected areas of subsurface VOC contamination that are used or occupied by sensitive population groups (i.e. daycares, schools, etc) should be given special consideration for sampling.

Investigations of sub-slab and/or indoor air contamination should proceed outward from known or suspected sources, as necessary, on an aerial basis until potential and human exposures have been adequately addressed. Samples should be collected in a central location away from the foundation footings, and from the soil or aggregate immediately below the basement or slab and the number of samples will depend on the number of slabs.

4.15.2 Sub-Slab Vapor Probe Installation and Sampling

Prior to the installation of the sub-slab vapor probes, the building floor will be inspected within 25 feet of the proposed sampling area and the location of any penetrations such as cracks, floor drains, utility perforations, or sumps will be noted and recorded. The probes will be installed at locations where the potential for ambient air infiltration via floor penetrations is minimal and may be adjusted from the proposed locations based on any floor inspection findings. Sub-slab vapor probe installation can be either permanent, semi-permanent, or temporary. Sub-slab probes should be constructed in the same manner at all sampling locations to minimize possible discrepancies and as described in section 4.14.1 above, Sample Probe Installation)

Sub-slab samples should be collected in the following manner:

- The probes will be purged of 1 to 3 volumes (i.e., the volume of the sample probe and tube) prior to collecting the samples;
- Environmental Protection Agency Method TO-15 will be followed when collecting and analyzing samples;
- The samples will be collected in a 6-liter Summa® canister over a 4- or 8-hour sampling period in order to achieve a detection limit of 0.25 micrograms per cubic meter (ug/m^3);
- The flow rates for both purging and collecting will not exceed 0.2 liters per minute; and
- The Summa® canisters will be certified as clean by the laboratory;
- If possible, samples will be collected over the same period of time as concurrent indoor and outdoor air samples.

The heating systems in each building, if functional, will have been in operation for at least 24-hours prior to and during the sample collection period at a normal indoor temperature typically between 65^0 and 75^0F. Additionally, a pre-sampling building inspection should be performed prior to each sampling event to identify and minimize conditions that may interfere with proposed testing.

4.16 Indoor Air Sampling

Indoor air samples are collected to characterize exposures to air within a building. Like sub-slab vapor sampling, indoor air sampling results are used when evaluating current and the potential for future human exposures, and site-specific attenuation factors. Indoor air samples are collected concurrently with sub-slab vapor and outdoor air samples. Some site-specific situations may warrant indoor air samples without concurrent sub-slab vapor and outdoor air samples. Additionally, Indoor and outdoor air samples may be collected without sub-slab vapor samples when confirming the effectiveness of a mitigation system.

4.16.1 Investigation Considerations

Similar to soil vapor and sub-slab vapor sampling, existing environmental data, site background information, and building construction details should be considered when selecting buildings and locations within buildings for sub-slab vapor sampling. At a minimum, these general guidelines should be followed:

- Where sub-slab vapor samples were collected without indoor air samples, buildings in which elevated concentrations of contaminants were measured in sub-slab vapor samples should be sampled;

- Buildings located above or directly adjacent to known or suspected areas of subsurface VOC contamination should be sampled;

- Buildings in which positive responses with field equipment were obtained should be samples; and

- Buildings with known or suspected areas of subsurface VOC contamination that are used or occupied by sensitive population groups (i.e. daycares, schools, etc) should be given special consideration for sampling.

To characterize contaminant concentration trends and potential exposures, indoor air samples should be collected from:

- The crawlspace area
- Basement (where vapor infiltration is suspected or in a central location) at a height approximately three feet above the floor
- The lowest level living space (in centrally-located, high activity-use areas) at a height of approximately three feet above the floor
- Or if in a commercial setting, from multiple tenant spaces at a height of approximately three feet above the floor

Investigations of indoor air contamination should proceed outward from known or suspected sources, as necessary, on an aerial basis until potential and human exposures have been adequately addressed.

4.16.2 Indoor Air Sampling

During colder months, the heating systems in each building will have been in operation for at least 24-hours, if operable, prior to and during the sample collection period at a normal indoor temperature typically between 65^0 and 75^0F. If possible, a pre-sampling inspection should be preformed.

In general, indoor air samples should be collected in the following manner:

- Sampling duration should reflect the exposure scenario without compromising the detection limit or sample flow collection rate (e.g. an 8 hour sample from a workplace with a single shift versus a 24 hour sample from a workplace with multiple shifts). Samples should be collected for at least one hour. If the goal is to represent an average concentration over a longer period of time, then longer duration sampling periods may be appropriate.

- Personnel should avoid lingering in the immediate area of the sampling device while the samples are being collected

- Sample flow rates must conform to the specifications in the sample collection method, and if possible, be consistent with the flow rates for concurrent outdoor and sub-slab samples;

- Samples must be collected using conventional sampling methods, in an appropriate container which meets the objective of the samples and one that is certified clean by the laboratory.

At sites with tetrachloroethene contamination, passive air monitors that are specifically analyzed for tetrachloroethene (i.e. perc badges) are commonly used to collect indoor and outdoor air samples.

4.17 Outdoor Air

Outdoor air samples are collected to characterize site-specific background outdoor air conditions. Outdoor air sampling results are primarily use when evaluating the extent to which outdoor sources may be influencing indoor air quality. They may also be used in the evaluation of soil vapor results.

Typically, outdoor air samples are collected at each location where an indoor air sample is collected (e.g. near each tenant space sampled). Outdoor samples should be collected in a representative upwind location, away from wind obstructions, and at a height of 3 to 5 feet. A representative sample is one that is not biased towards obvious sources of VOC.

4.17.2 Outdoor Air Sampling

Outdoor air samples must be collected simultaneously with indoor air samples, and may also be collected concurrently with soil vapor samples. Outdoor samples must be collected in the same manner as indoor air samples (see Section 4.16.2 above).

4.18 Vapor Intrusion Assessment Documentation/Considerations

The following should be considered during a soil vapor sampling event and may influence the interpretation of the results:

- If sampling near a building, uses of VOC-containing products during normal operations of the facility should be identified.
- Outdoor sketches, including site, streets, nearby facilities, and outdoor ambient air sample locations (if appropriate) should be drawn.
- Weather conditions should be noted for 24-48 hours prior to sampling events.
- Pertinent observations (odors, field screening readings) should be recorded.
- Use of HVAC systems during sampling (sub-slab and indoor air);
- A floor sketch of each building that includes the floor layout with sample locations, chemical storage areas, garages, doorways, stairways, location of basement sumps or subsurface drains and utility perforations through building foundations, HVAC system air supply and return registers, compass orientation (north), and any other pertinent information;

A sample log sheet should be maintained to include:

- Sample ID
- Sample date and time
- Sampler ID
- Sampling Methods/devices
- Purge volume
- Volume of vapor sample
- For canisters, the vacuum reading before and after sample collection
- Apparent moisture content of sampling zone
- Chain of Custody procedures used to track sample

4.19 Vapor Intrusion QA/QC Precautions and Laboratory Analytical Methods

On the day of sample collection activities, the person collecting the samples should avoid the following: fueling vehicles, use of permanent markers, wearing freshly dry-cleaned clothing, wearing perfumes, and any other activity where the use of VOCs could contaminate the samples. Proposed analytical procedures are identified in the Work Plan. TO-15 for VOCs is the preferred laboratory analytical method.

5.0 DOCUMENTATION / CHAIN OF CUSTODY PROCEDURES

5.1 Chain of Custody

Chain-of-Custody (COC) procedures are followed to insure that sample integrity is maintained throughout the sampling and analysis process and that all samples collected are accounted for at all times. The COC process begins when the sample is collected and carries on throughout the analytical laboratory operations. The field team member responsible for the collection of the samples acts as the initial sample custodian.

A sample is considered “in custody” of an individual if it is either in direct view of, or directly controlled by, that individual. Chain-of-Custody transfer is accomplished when the samples or sealed sample containers are directly transferred from one individual to the next. At the time of transfer, the first individual witnesses the signature of the receiver on the COC record. The objective of the COC program is to ensure that:

- Samples are protected from loss or damage.
- The correct samples are analyzed.
- All samples are uniquely identified.
- Samples are traceable to their records.
- Documentation of sample handling procedures including: sample location, sample number, number of sample containers, and the COC process.
- A signed COC record is included for each sample shipment, documenting contents of the shipment. The COC record indicates the following information:
  - Site name
  - Sample Identification Numbers
  - Date and time of collection
  - Sample type (e.g., groundwater, soil, etc.)
  - Number and type of containers per sampling location
  - Parameters requested for analysis for each container
  - Signature of person(s) involved in the chain-of-possession
  - Description of sample bottles and their condition
  - Problems associated with sample collection (i.e., breakage, no preservatives), if any.
  - Sample Delivery Group (SDG) ID (assigned by the laboratory on receipt of samples). The SDG is a group of up to 20 discrete samples (not including the QA/QC samples) of the same environmental media collected from the same project Site over not more than seven consecutive days and submitted for analysis by the same laboratory analytical methods and procedures. A separate chain-of-custody must be prepared for each day of sampling. If, at the end of a given day you do not have enough samples (20) to complete an SDG and will be returning within the next six days to collect more samples; place a note in the comment section of the COC that says: “Hold SDG open: Additional Samples Pending”. When the SDG is complete, in the comment section of the COC add note: “SDG complete”. If this SDG is the last set of samples from a specific sampling event, also add a note in the comment section that says: “Sampling Complete; no additional sample shipments pending at this time.”

The COC records are printed on triplicate forms. One copy is retained by The Chazen Companies when the samples are taken into custody by either a shipping agency or the lab. A second copy is kept by the analytical lab. The third copy is returned to Chazen with completed lab results.

5.1.1 Sample Tracking

A copy of all COC records is also maintained in a project file. Pertinent COC information is recorded in the file, as well as follow-up correspondence with the laboratory, via telephone or mail, indicating receipt of the samples, breakage, turnaround time, or any problems with the shipment. As analytical data are received, the file is updated to reflect the new information. Turnaround times are compared to protocols to ensure quality control. Missing data or invalid samples are addressed by the Field Operations Leader or the Project Manager.

5.1.2 Laboratory Operations

Specific laboratory Standard Operating Procedures used during the investigation are provided by the selected analytical laboratory. These procedures include sample tracking, methods for collection and handling of laboratory blanks, laboratory duplicates, matrix spikes, laboratory control samples, and surrogates. Maximum/minimum holding times and data reporting procedures are also defined by the laboratory.

5.2 Analytical Sample Shipping

Sample containers are packed in coolers. Bottles are packed tightly in materials such as Styrofoam, vermiculite, and/or “bubble pack” to minimize motion. Ice placed in zip-lock bags and can be added to the cooler to cool the samples to around 4° C. All paperwork is sealed in a separate zip-lock bag and placed in the cooler which is then taped shut. The samples are shipped to the laboratory together with the COC documents.

The standard procedure followed for shipping environmental samples to the analytical laboratory is:

1) Samples are shipped by courier or equivalent overnight delivery service.
2) Samples are shipped to the laboratory within 24 to 48 hours of collection.
3) Prior to leaving the field, the Analytical Lab is notified of the number, type, collection date, and shipment dates for samples. Notification to the Lab also occurs when sample shipments will arrive on a Saturday. This communication is critical to allow the laboratory enough time to prepare for the samples’ arrival.
4) If prompt shipping and laboratory receipt of the samples is not possible, (i.e., Sunday arrival), members of the Field Team are responsible for proper storage of the samples until adequate transportation arrangements can be made.
5) Field Operations Leader or his/her designee ensures that samples collected by the client are entered into the project sample log.

6.0 CALIBRATION PROCEDURES

This section details the calibration and operating procedures for the field and laboratory analytical instruments that will be used during this investigation.

6.1 Field Instruments

Field instrumentation is calibrated according to the manufacturer's instructions to ensure that accurate field data are collected. Each piece of equipment is calibrated daily prior to use or as specified by the manufacturer. More frequent calibration may be performed when accuracy of the equipment becomes suspect or under extreme field conditions. Calibration information is recorded in the same field notebook in which the field instrument readings will be recorded. The recorded calibration includes:

- Name of instrument
- Instrument serial number
- Date of calibration
- Observations and results of calibration
- Calibration gas used, if applicable
- Buffer solutions used, if applicable
- Specific calibration procedures and operating instructions are detailed below.

6.1.1 pH Meters

pH is the measure of the acidity or alkalinity of a solution. It is defined as the negative logarithm of the hydrogen ion activity. Hydrogen ion activity is related to the hydrogen ion concentrations, which in relatively weak solutions are nearly equal. For practical purposes, pH is the measure of the hydrogen ion concentration.

The operation of a pH meter relies on the same principal as many other ion-specific electrodes. Measurement relies on establishment of a potential difference in the response to hydrogen ion concentration across a membrane in the electrode. The membrane is conductive to ionic concentrations, which in combination with a reference electrode (which can be combined into a single "combination" electrode), can generate a potential difference proportional to the hydrogen ion concentration.

Variation in temperature will effect the association of hydrogen and hydroxide ions, which without proper compensation will affect the pH. pH meters have several controls to compensate for the variations between electrodes and the different responses to changes in temperature.

It is very important to obtain a pH measurement as soon as possible after sample collection, since temperature changes, precipitation/dissolution reactions, and sorption of carbon dioxide from the air all affect the pH of a solution.

Because of the great variety of pH meters available, operators should refer to the manufacturer's instruction manual for specific calibration, operation, and troubleshooting procedures for their instrument. The following general procedure is used for measuring pH in the field with a pH meter:

- The pH meter is calibrated at each sample site.
- The instrument and batteries are checked prior to the initiation of the field effort. pH electrodes are kept moist at all times.
- Buffer solutions used for calibration are checked since buffer solutions will degrade upon exposure to the atmosphere.
- Generally, 4.00 and 7.00 pH buffers are selected for calibration.
- All electrolyte solutions within the electrode(s) are filled to their proper levels and no air bubbles are present within the electrode(s).
- The electrodes are immersed in a pH-7 buffer solution.
- The temperature compensator is adjusted to the proper temperature (on models with automatic temperature adjustments, immerse the temperature probe into the buffer solution). Alternatively, the buffer solution may be immersed in the sample and allowed to reach temperature equilibrium before equipment calibration. It is best to maintain buffer solution at or near expected sample temperature before calibration.
- The pH meter is adjusted to read 7.0.
- The electrodes are removed from the buffer and rinsed well with deionized water. The electrodes are immersed in pH-4 (or pH-10 buffer solution) and the slope control is adjusted to read the appropriate pH. To check the calibration, three successive readings are taken, one minute apart, to see that readings are within ±0.1 pH unit.
- The electrodes are immersed in the unknown sample, slowly stirring the probe until the pH stabilizes. Stabilization may take several seconds to minutes. If the pH continues to drift, the sample temperature may not be stable, a chemical reaction (e.g., degassing) may be taking place in the sample, or the meter or electrode may be malfunctioning. This must be clearly noted in the logbook.
- The pH and temperature of the sample are read and recorded. pH is recorded to the nearest 0.1 pH unit.
- The electrodes are rinsed with deionized water.

6.1.2 Specific Conductance Meters

Conductivity is a numerical expression of the ability of a water sample to carry an electric current. This value depends on the total concentration of ionized substances dissolved in the water and the temperature at which the measurement is made. It is important to obtain a specific conductance measurement soon after sample collection since temperature changes, precipitation reactions, and sorption of carbon dioxide from the air affect the specific conductance.

Specific conductance can be used to identify the direction and extent of the migration of contaminants in groundwater and surface water. It can also be used as a measure of subsurface biodegradation or to indicate alternate sources of groundwater contamination.

A conductance cell and a Wheatstone Bridge (for the measurement of potential difference) may be used for measurement of electrical resistance. The ratio of current applied to voltage across the cell may also be used as a measure of conductance. Depending on ionic strength of the aqueous solution to be tested, a potential difference is developed across the cell which can be converted directly or indirectly (depending on instrument type) to a measurement of specific conductance.

Because many conductivity meters are available, operators should refer to the manufacturer's instruction manual for specific calibration, operation, and troubleshooting procedures. The following general procedure is used for obtaining specific conductance measurements:

- The conductivity meter is calibrated at the start of each sampling day or more frequently if deemed necessary.
- Batteries are checked before going into the field.
- The instrument is calibrated using a potassium chloride standard solution by completely immersing the electrode into the solution. The temperature of the calibration solution is checked and the temperature dial is adjusted on the meter (if not self-compensating). Calibration measurements and time are recorded in the field logbook.
- The umho value of the solution is checked in terms of the temperature. The Cell Constants dial is adjusted until the display reads the appropriate value.
- The electrode is rinsed with one or more portions of the sample to be tested.
- The electrode is immersed in the sample and the temperature and the conductivity are measured.
- The results are noted in the field logbook.
- If the specific conductance measurements become erratic, or inspection shows that any platinum black has flaked off the electrode, replatinization of the electrode is necessary. See the manufacturer's instructions for details.

6.1.3 Photoionization Detector

For monitoring total ambient air quality during field activities and for conducting static headspace testing, Chazen uses a MiniRae PID. This instrument measures total VOC concentrations. The operating and calibrating procedures for this instrument follow.

A MiniRAE Model 2000 or 3000 PID (hereafter simply MiniRAE) can be used to detect a variety of trace gases, particularly VOCs. The MiniRAE uses the principle of photoionization to detect and measure the VOC concentrations in the atmosphere or from a sample.

The MiniRAE operates using an electrodeless discharge ultraviolet (UV) lamp as the high-energy photon source. As organic vapors pass by the lamp, they are photo-ionized and the ejected electrons are detected as a current. The PID sensor with a standard 10.6 eV lamp detects a broad range of organic vapors. In principle, any compound with ionization energy lower than that of the lamp photons can be measured.

The following procedure is used for operating and calibrating the MiniRAE 2000:

- Press and hold the MODE key for one second and release to turn on the MiniRAE 2000. The audio buzzer will beep once and the air pump will turn on. The display will show "ON"
- To turn off the MiniRAE 2000, press and hold the MODE key for 5 seconds. The monitor will beep once per second during the power-down and the message "OFF" will flash and the screen will go blank.
- After the monitor is turned on, it runs through the start up menu and then a "READY…" message is displayed. At this point the user can either 1) step through the operation menu or 2) take a measurement.
- In the first menu of the programming mode, the user can calibrate the MiniRAE 2000. The calibration is a two-point process using "fresh air" and the calibration gas (Isobutylene)
- Calibration Process

  - Press and hold down both the [N/-] and MODE keys for three seconds to enter the programming mode; the first menu item is “Calibrate/select Gas”
  - The Fresh Air calibration determines the zero point of the sensor calibration curve. If a fresh air source from a cylinder or tedlar bag is not available, any clean ambient air without detectable contaminant or a charcoal filter can be used.
  - The first menu shows “Fresh Air Cal?”; make sure the instrument is connected to the fresh air source; press the [Y/+] key, the display will show “zero in progress”, flowed by “wait..” and a countdown timer; after a pause, the display will show the message “zeroed…reading= x.x. ppm…”; press any key or wait about 20 seconds, the monitor will return back to the submenu.
  - For the second point of the sensor calibration, a cylinder of span gas (Isobutylene) fitted with a 500 cc/min. flow limiting regulator is attached to the instrument.
  - Press the [Y/+] key at the “Span Cal?” to stat the calibration. The display shows the gas name and the span value of the corresponding gas; the display will show “Apply gas now” at which point the valve will be turned to open the gas supply.
  - The display with ask you to wait 30 seconds. When the count down timer reaches 0, the display will show the calibrated value. Turn off the flow to gas and disconnect the span gas. Press any key
- To record measurements
  - Press the [Y/+] key to start a measurement in survey mode
  - Instantaneous readings in ppm are updated every second
  - To stop measurements press the MODE key and the display shows STOP. Press [N/-] to continue measurement

Methods of operation and calibration for the MiniRAE 3000 are similar to those for the MiniRAE 2000. The MiniRAE is calibrated once per day or more frequently, if necessary. The MiniRAE is used to monitor the breathing zone for health and safety precautions or to screen samples by placing the probe near suspected sources of contaminants.

6.1.4 Airborne Particulate Matter Meters

For monitoring airborne particulate matter (i.e., dust) during field activities, Chazen uses an MIE, Inc. Personal Data-logging Real-time Aerosol Monitor (*personal*DataRAM). This instrument provides direct and continuous data measurements and is a high sensitivity nephelometric monitor optimized for the measurement of the respirable fraction of airborne dust emitted from ground intrusive work or work that has the potential to produce dust. The following procedures are used for calibrating and operating the *personal*DataRAM:

- Calibration/Zeroing Process
  - Conduct zeroing in a particle-free environment such as a *personal*DataRAM Z-Pouch, a clean room, a duct or area directly downstream of a HEPA filter, or the MINIRAM Z-Bag. The following instructions are for the Z-Pouch.
  - Wipe the outside surfaces of the instrument to remove as much dust as possible, then in a reasonably clean area, open the zipper of the Z-Pouch and place the unit inside.
  - Open the small nipple of the Z-Pouch and insert the fitting of the hand-pump/in-line filter unit into the nipple. Start pumping the hand-pump until the Z-Pouch begins to bulge slightly.
  - While continuing to pump, press ENTER and keep pumping slowly while ZEROING is displayed for 1.1 minutes followed by CALIBRATION: OK. If screen shows BACKGROUND HIGH or MALFUNCTION, consult instruction manual.

  - To set up a run and scroll logging/operating parameters, press NEXT when screen shows READY: NEXT.
  - After completing zeroing process, remove the *personal*DataRAM from the Z-Pouch, close the zipper and flatten the Z-Pouch while plugging its nipple to prevent dust contamination in the Z-Pouch.

- Operating Process
  - To enable the logging function, press ENTER when screen shows LOGGING DISABLED.
  - LOG INTRVL 600s indicates that logging is enabled (in this example for 10-minute log period). Press ENTER.
  - At ALARM: OFF press ENTER to toggle through alarm modes.
  - Press NEXT to move through the calibration factor screen and battery charge screen.
  - Press NEXT at CONNECT TO PC, then again to return to ready mode (this will enable data to be downloaded).
  - Press ENTER at LOG INTRVL with TAG # displayed. Concentration screen will be displayed after three seconds. Pressing NEXT will successively scroll to show various run values.
  - Press EXIT to terminate the current run, then ENTER to return to Ready mode.

6.1.5 XRF Analyzer

For field screening of select metals in soil, Chazen uses a Niton XL2 GOLDD, which utilizes a Thermo-Scientific x-ray tube. The operating and calibrating procedures for this instrument follow. See the HASP for information on safely using the XRF.

The following procedure is used for transporting, operating and calibrating the Niton XL2 GOLDD:

- For shipping, the battery pack is disconnected from the analyzer, and then the XRF is shipped in its carrying case and an over-pack to protect the sensitive measuring equipment inside the analyzer. There are no X-ray tube specific US Department of Transportation (DOT) or International Air Transport Association (IATA) radiation regulations regarding shipping the Niton XL2 analyzer.
- After turning on the XRF, wait five minutes for electronics to stabilize.
- From the Main Menu, select the System Check icon the Yes. This will calibrate the XRF and verify that it is operating to specifications.
- Select the Main Range filter which provides optimum sensitivity for manganese (atomic number 25) through bismuth (atomic number 83), which will also capture lead (atomic number 82).
- Set element ranges.
- Place soil sample in a sealable plastic bag to provide an approximately 2-inch-square section. Place the analyzer against the bag so the x-ray beam shutter is covered, then press and hold trigger, and release trigger after analysis. Log results.
- As a QC check, measure the supplied reference calibration check sample at least once per shift. If correct, continue work. If incorrect, redo System Check and re-take the previous two hours of readings.
- If the XRF is lost or stolen, immediately contact Matthew Williams (Chazen) at 518-266-7313 and Eco-Rental Solution (866-843-2165 or 914-400-0324), and the local police (911).

6.2 Laboratory Equipment Calibration

The Laboratory's Project Manager will be responsible for the operation and calibration of laboratory analytical instruments in accordance with the schedules and procedures specified by the NYSDEC ASP (Analytical Services Protocol).

The laboratory calibration procedures are addressed in the QA documents for the laboratory subcontractor.

7.0 ANALYTICAL PROCEDURES

Laboratory analyses will be scheduled based on historic information regarding potentially hazardous material disposal, previous site information, review of data objectives, and NYSDEC criteria. Specific parameters will be outlined in the Work Plan.

7.1 Analytical Laboratory

All sample analyses will be performed by a laboratory certified by the New York State Department of Health (NYSDOH). In order to provide legally defensible data, selected analytical procedures to be used will be in accordance with the most recent NYSDEC ASP. Laboratory analytical parameters will be based on previous site information, as well as data quality objectives and applicable NYSDEC criteria. The sampling program and related analytical methods are documented in the FSP. All samples will be received by the laboratory within 48 hours of collection.

8.0 DATA REDUCTION, VALIDATION, AND REPORTING

Independent third party data validation will be utilized. Data will be validated using the NYSDEC ASP Revision 12/91 and the USEPA Region II Functional Guidelines. The details supporting an independent validator's selection, describing how the individual is independent from the project, will be set forth in the Work Plan or other supplementary documentation.

8.1 Data Reduction

Data reduction is the conversion of raw data into a useful form from which conclusions can be made and presented. Raw data may consist of field data, which are real-time measurements, and technical data, which includes field and laboratory analytical data. Raw field data (e.g. PID readings) will be compared to laboratory analytical results which will be compared to site-specific criteria.

8.2 Data Validation

Data validation is the process of reviewing data and accepting it or rejecting it on the basis of sound criteria.

Records of all data will be maintained, even those judged to be "outlying" or spurious values.

The principle criteria that will be used to validate the integrity of the data during collection and reporting should be modeled from the following EPA guidance documents:

- "National Functional Guidelines for Organics Review", (USEPA, June, 1991)
- "Laboratory Data Validation, Functional Guidelines for Evaluating Inorganic Analyses", (USEPA, October, 1989)
- "NYSDEC ASP Revision 12/91"

8.2.1 Field Data Validation

Field data will be validated at the time of collection by following standard procedures and QC checks and after the data is reduced to review data sets for anomalous values. The objectives of field data validation are as follows:

- Adherence to approved site-specific plans.
- Standard operating procedures are followed.
- Sufficient sample volume is obtained, sample integrity is maintained, all required analyses are conducted, and all applicable field QC samples are provided with each sample set.
- Complete chain-of-custody documentation is maintained throughout the duration of the field effort.
- Maximize data consistency between field personnel by random checks of sampling and field conditions by supervisory personnel.

8.2.2 Laboratory Data Validation

Laboratory data verification will be performed by qualified individuals appointed by the analytical laboratory. Data verification will involve routine audits of the data collection and flow procedures and monitoring GC sample results. Results from the analysis of project and blind audit QC samples will be calculated and evaluated as reported. Immediate corrective action will be taken if these results indicate data quality problems.

An individual independent from the project (i.e., third party data validator) will conduct a data validation of the laboratory data and prepare a Data Usability Summary Report (DUSR). Independent validation will be according to criteria such as:

- Holding times
- Instrument tuning and performance
- Calibration
- Blanks
- Surrogate recoveries
- Matrix spike and matrix spike duplicate recoveries

8.3 Reporting

When required for a project, Category B Deliverables will be supplied for laboratory analysis. Validated field and laboratory data will be presented in a final report in the form of tables and/or figures. Figures may include planimetric maps, cross sections, and contour maps. All supporting data, such as raw field and laboratory analytical data, will be presented as an appendix to the final report. Electronic files may be provided in lieu of hardcopies.

9.0 INTERNAL QUALITY CONTROL PROCEDURES

Quality control (QC) checks will be performed to ensure the collection of representative and valid data. QC checks provide the mechanisms by which the quality assurance objectives are monitored.

9.1 Field Quality Control

Field quality control measures will be conducted in accordance with the NYSDEC RCRA Quality Assurance Project Plan Guidance dated March 29, 1991. The field QC checks that will be used are listed and described as follows.

9.1.1 Documentation

All activities must be properly documented including: sampling procedures, decontamination activities, chain-of-custody procedures, equipment calibration, and justification for all actions taken contrary to the approved QAPP, Work Plan, and FSP.

9.1.2 Blank and Duplicate Samples

Three types of blanks can used during sampling: trip blanks, field blanks and equipment blanks. These are discussed below.

<u>Trip Blanks</u>: Trip blanks are for assessing the potential for contaminating aqueous samples with VOCs during sample shipment. The trip blank consists of a VOC sample container shipped to the site with the other VOC sample containers either filled with reagent water at the lab or filled on-site with reagent water. Trip blanks will be used so as to maintain a 1:20 ratio of blanks to samples or with each shipment, whichever is greater. Non-aqueous samples do not require trip blanks.

<u>Field Duplicates (Replicates)</u>: When required, field duplicates of soil, sediment, and groundwater samples will be submitted for analysis of all site-specific parameters at a rate one every 20 samples collected for analyses. These duplicates are intended to assess the homogeneity of the sampled media and the precision of the sampling protocol. True duplicates of soil, sediment, and solid waste samples; however, are not possible because chemicals are typically not uniformly distributed.

<u>Equipment Blanks</u>: Equipment blanks, sometimes called rinsate blanks, are collected during each field event at a rate of one per day. VOC, SVOC, or inorganics present within or on the sampling apparatus where intimate contact with the sample occurs (i.e., split-spoon, trowel) are assessed by rinsing the sampling apparatus with ASTM Type II water following decontamination. Rinsate blanks are collected directly into the appropriate water container.

<u>Matrix Spike/Matrix Spike Duplicates (MS/MSD)</u>: For some projects, the NYSDEC ASP requires the laboratory to analyze MS/MSDs for organic analyses at a frequency of five percent. To meet this requirement, the Field Operations Leader will select samples for MS/MSD analyses and will provide additional sample volume to the laboratory.

<u>Temperature Blanks</u>: Temperature blanks are for ensuring that the samples have arrived at the lab at 4°C. The lab will check the temperature of the Temp Blank on arrival and write it on the COC when logging in the samples.

9.1.3 Completeness

Completeness of scheduled sample collection is controlled in the field by comparing a pre-sampling inventory with samples actually collected each day. Daily checking of field data sheets and comparison of transport and COC logs provides further control of documentation and completeness.

9.1.4 Field Analytical Quality Control

QC checks are performed on field measurement systems that emulate laboratory measurement systems (e.g., XRF analyzer).

9.2 Laboratory Analytical Quality Control

Data from QC samples (e.g., blanks, spiked samples) will be used as a measure of performance and as an indicator of potential sources of cross-contamination. In some cases, quality control data and records will be submitted to the data validator. Laboratory analytical quality control will be in accordance with the requirements outlined in the NYSDEC RCRA Quality Assurance Project Plan.

10.0 PERFORMANCE AND SYSTEM AUDITS

10.1 Systems Audit

System audits are performed to ensure that the QA/QC procedures are being followed. These audits include a careful evaluation of both field and laboratory control procedures.

Organization and Personnel: The project organization is reviewed for compliance with the proposed organization and for clarity of assigned responsibility. Personnel assigned to the project will be placed so that responsibility, skill, and training of the personnel are properly matched.

Facilities and Equipment: The audit will address whether field equipment and analytical instruments are meeting requirements specified by the project objectives stated in the Work Plan. Equipment and facilities provided for personnel health and safety may also be evaluated. Calibration and documentation procedures for instruments will also be verified.

Analytical Methodology: A review of analytical methodology with regard to the data requirements for the project will be performed. An on-site observation of analyst technique, data reduction, and record keeping may be performed if determined necessary. Periodic review of precision and accuracy of data will be performed.

Sampling and Sample Handling Procedure: An audit of scheduled samples versus samples collected versus samples received for analysis may be performed. Field documentation may be reviewed. If deemed necessary, a site visit will be made to document that designated control procedures are practiced during sampling activities.

Data Handling: During a system audit, the QAM will review data handling procedures with the TLs. Accuracy, consistency, documentation, and appropriate selection of methodologies will be discussed:

10.1.1 Field Systems Audit

Field systems audits are performed by QA personnel to compare field practices with standard procedures. These audits focus on such things as:

- Compliance with Work Plan
- Proper working order of field equipment
- Documentation procedures
- Field team efficiency
- Level of QA conducted by field members
- Proper sample packaging and shipping

10.1.2 Laboratory Systems Audit

Laboratory systems audit are conducted to ensure that measurement systems are properly maintained and used. Laboratory records and procedures may be reviewed for completeness, accuracy, precision, and adherence to prescribed methods.

10.1.3 Field Performance Audits

Field performance audits are conducted by QA personnel on an ongoing basis during a project as field data are generated, reduced, and analyzed. Field performance audits include review of numerical manipulations and review of blank and replicate samples.

10.1.4 Laboratory Performance Audits

Laboratory performance audits may be conducted and may include:

- Verification of written procedures, and analyst’s understanding
- Verification and documentation of procedures and documents
- Periodic unannounced inspections, if warranted
- Review of a portion of all analytical data and calculations

11.0 PREVENTATIVE MAINTENANCE

11.1 Analytical Instrumentation

Preventative maintenance of analytical instrumentation is outlined in the QA documents of the subcontract analytical laboratory.

11.2 Field Instrumentation and Equipment

Preventative maintenance of field instrumentation and equipment includes the following measures:

- The field operations leader shall ensure that all scheduled maintenance occurs as obligated.
- Critical spare parts will be kept in stock.
- Equipment will be cleaned on a daily basis after use.
- Field crews will report on the condition and performance of the equipment after each sampling event.

12.0 DATA MEASUREMENT ASSESSMENT PROCEDURES

The purpose of a data quality assessment is to document that data generated under the program are accurate and consistent with project objectives. The quality of data is assessed based on the precision, accuracy, representativeness, comparability, and completeness of the data that are generated. Data quality assessments are conducted in three phases.

<u>Phase I</u>: Prior to data collection, sampling, and analysis procedures are evaluated in regard to their ability to generate the appropriate, technically acceptable information required to achieve project objectives.

<u>Phase II</u>: During data collection, results will be assessed so that selected procedures are efficient and effective and that the data generated provide sufficient information to achieve project objectives. In general, evaluation of data are based on performance audits, results of duplicate and spiked sample analyses, and review of completeness objectives.

Documentation may include:

- Number and identity of duplicate samples collected
- Number and identity of duplicate, spike, and field blank samples analyzed
- Identification of statistical techniques, if used
- Use of historical data
- Identification of analytical method
- Data validation results

Procedures for assessing precision and accuracy for analytical data are outlined in Section 3.2. Precision is generally expressed as the relative percent difference (RPD) among duplicate analyses. Accuracy is generally expressed as percent recovery. Precision and accuracy of instrumental analysis is further addressed in the NYSDEC ASP and the Laboratory QAPP. It is the laboratory's responsibility to attempt to identify the source of substandard recoveries and take corrective action or document the cause as required by the NYSDEC ASP.

Phase III: Following completion of data collection activities, an assessment of the adequacy of the database generated in regard to completing project objectives is undertaken by the Project Manager and/or the Technical Reviewer. Recommendations for improved QC are developed, if appropriate. If data gaps are identified, additional raw data collection may be recommended to fully support the project findings and recommendations.

13.0 CORRECTIVE ACTIONS

Corrective actions are QA/QC problem-solving measures taken to rectify a laboratory or field measurement system that is out of control. Corrective action is required when potential or existing conditions are identified which may adversely affect the data quality. The need for corrective action may be identified by system or performance audits or by standard QC procedures. The corrective action system will include the following procedures:

The Project Manager is immediately notified of any potential problem with the data quality, and will then evaluate the need for changes in affected procedures and conduct appropriate corrective actions. Potential data quality problems may include:

- Loss of a sample or damaged sample containers.
- Analytical results that are substantially different from those expected.
- Laboratory QC samples that do not attain target performance objectives.
- Events that may require changes in specifications and sampling procedures.

Corrective action related to questionable analytical results or damaged sample containers may include re-sampling and re-analysis, if appropriate. Modification of procedures may be necessary to remedy problems related to unexpected conditions encountered in the field.

14.0 QUALITY ASSURANCE REPORTS TO MANAGEMENT

The Project Manager submits periodic QA reports for appraisal by management, appropriate to their level of responsibility. Reports to management include:

- Periodic assessment of measurement data accuracy, precision, and completeness.
- Results of performance and system audits.
- Significant QA/QC problems and recommended solutions.
- Resolutions of previously stated problems.

14.1 Field Quality Assurance Reports

Periodic status reports describing the progress of the project are submitted periodically to management. These reports include: copies of field notes or daily field progress reports, compiled field data sets, and corrective action documentation. The Project Manager is notified immediately of situations requiring corrective action measures.

14.2 Laboratory Quality Assurance Reports

A project QA report that summarizes QA activities and QC data is issued to the QA Manager and Project Manager. Any laboratory QA situations requiring immediate corrective action is reported to the Project Manager.

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