**Draft Quality Assurance Project Plan**

# Gowanus Canal

Brooklyn, New York
AOC Index No.

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December 2005
982482-34-4401

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# Abbreviations and Acronyms

| | |
|---|---|
| ASTM | American Society for Testing and Materials |
| ASP | Analytical Service Protocols |
| CHMM | Certified Hazardous Materials Manager |
| CMS | Chip Measurement System |
| CLP | Contract Laboratory Protocol |
| COC | Chain Of Custody |
| CSO | Combined Sewer Outfall |
| DQO | Data Quality Objective |
| DUSR | Data Usability Summary Report |
| ELAP | Environmental Laboratory Approval Program |
| EPA | United States Environmental Protection Agency |
| FSP | Field Sampling Plan |
| GEI | GEI Consultants, Inc. |
| HASP | Health and Safety Plan |
| ID | Identification |
| LEL | Lower Explosive Limit |
| LEP | Licenced Environmental Professional (Connecticut) |
| MDL | Method Detection Limit |
| MGP | Manufactured Gas Plant |
| MPH | Master of Public Health |
| MS | Matrix Spike |
| MSD | Matrix Spike Duplicate |
| Newfields | Newfields-Environmental Fore |
| NYSDEC | New York State Department of Environmental Conservation |
| NYSDOH | New York State Department of Health |
| PAH | Polycyclic Aromatic Hydrocarbons |
| PCB | Polychlorinated Biphenyls |
| P.G. | Professional Geologist |
| PID | Photo Ionization Detector |
| PM | Project Manager |
| PQL | Practical Quantification Limit |
| QA | Quality Assurance |
| QAPP | Quality Assurance Project Plan |
| QC | Quality Control |
| RL | Reporting Limit |
| SOP | Standard Operating Procedures |
| STL | Severn Trent Laboratories |
| SVOC | Semivolatile Organic Compound |
| TAL | Target Analyte List |
| TCN | Total Cyanide |
| TOC | Total Organic Carbon |
| VOC | Volatile Organic Compound |

# Quality Assurance Glossary

**"Analytical Services Protocol" or "ASP"** means the NYSDEC's compendium of approved EPA and NYSDEC laboratory methods for sample preparation and analysis and data handling procedures.

**"Confirmatory Sample"** means a sample taken after remedial action is expected to be complete to verify that the cleanup requirements have been met. This term has the same meaning as "post remediation sample".

**"Contract laboratory program" or "CLP"** means a program of chemical analytical services developed by the EPA to support CERCLA.

**"Data Usability Summary Report, (DUSR)"** is a document that provides a thorough evaluation of the analytical data to determine whether or not the data, as presented, meets the site/project specific criteria for data quality and use.

**"Effective solubility"** means the theoretical aqueous solubility of an organic constituent in groundwater that is in chemical equilibrium with a separate phase mixed product (product containing several organic chemicals). The effective solubility of a particular organic chemical can be estimated by multiplying its mole fraction in the product mixture by its pure phase solubility.

**"Environmental Laboratory Accreditation Program" or "ELAP"** means a program conducted by the NYSDOH which certifies environmental laboratories through on-site inspections and evaluation of principles of credentials and proficiency testing.

**"Intermediate Sample"** means a sample taken during the investigation process that will be followed by another sampling event to confirm that remediation was successful or to confirm that the extent of contamination has been defined to below a level of concern.

**"Method detection limit" or "MDL"** means the minimum concentration of a substance that can be measured and reported with a 99 percent confidence that the analyte concentration is greater than zero and is determined from the analysis of a sample in a given matrix containing the analyte.

**"Non-targeted compound"** means a compound detected in a sample using a specific analytical method that is not a targeted compound, a surrogate compound, a system monitoring compound or an internal standard compound.

**"Practical quantitation level" or "PQL"** means the lowest quantitation level of a given analyte that can be reliably achieved among laboratories within the specified limits of precision and accuracy of a given analytical method during routine laboratory operating conditions.

**"PAH"** means polycyclic aromatic hydrocarbon as defined by USEPA Method 8270.

**"Quality assurance"** means the total integrated program for assuring the reliability of monitoring and measurement data which includes a system for integrating the quality planning, quality assessment and quality improvement efforts to meet data end-use requirements.

**"Quality assurance project plan" or "QAPP"** means a document which presents in specific terms the policies, organization, objectives, functional activities and specific quality assurance/quality control activities designed to achieve the data quality goals or objectives of a specific project or operation.

**"Quality control"** means the routine application of procedures for attaining prescribed standards of performance in the monitoring and measurement process.

**"Semivolatile organic compound"** means compounds amenable to analysis by extraction of the sample with an organic solvent. For the purposes of this section, semi-volatiles are those target compound list compounds identified in the statement of work in the current version of the EPA Contract Laboratory Program.

**"Target analyte list" or "TAL"** means the list of inorganic compounds/elements designated for analysis as contained in the version of the EPA Contract Laboratory Program Statement of Work for Inorganics Analysis,Multi-Media, Multi-Concentration in effect as of the date on which the laboratory is performing the analysis. For the purpose of this chapter, a Target Analyte List scan means the analysis of a sample for Target Analyte List compounds/elements.

**"Targeted compound"** means a hazardous substance, hazardous waste, or pollutant for which a specific analytical method is designed to detect that potential contaminant both qualitatively and quantitatively.

**"Target compound list plus 30" or "TCL+30"** means the list of organic compounds designated for analysis (TCL) as contained in the version of the EPA "Contract Laboratory Program Statement of Work for Organics Analysis, Multi-Media, Multi-Concentration" in effect as of the date on which the laboratory is performing the analysis, and up to 30 non-targeted organic compounds (plus 30) as detected by gas chromatography/mass spectroscopy

(GC/MS) analysis. For the purposes of this chapter, a Target Compound List+30 scan means the analysis of a sample for Target Compound List compounds and up to 10 non-targeted volatile organic compounds and up to 20 non-targeted semivolatile organic compounds using GC/MS analytical methods. Non-targeted compound criteria should be pursuant to the version of the EPA "Contract Laboratory Program Statement of Work for Organics Analysis, Multi-Media, Multi-Concentration" in effect as of the date on which the laboratory is performing the analysis.

"**Tentatively identified compound" or "TIC"** means a non-targeted compound detected in a sample using a GC/MS analytical method which has been tentatively identified using a mass spectral library search. An estimated concentration of the TIC is also determined.

**"Unknown compound"** means a non-targeted compound which cannot be tentatively identified. Based on the analytical method used, the estimated concentration of the unknown compound may or may not be determined.

**"Volatile organics"** means organic compounds amenable to analysis by the purge and trap technique. For the purposes of this chapter, analysis of volatile organics means the analysis of a sample for either those priority pollutants listed as amenable for analysis using EPA method 624 or those target compounds identified as volatiles in the version of the EPA "Contract Laboratory Program Statement of Work for Organics Analysis, Multi-Media, Multi-Concentration" in effect as of the date on which the laboratory is performing the analysis.

"**Waste oil"** means used and/or reprocessed engine lubricating oil and/or any other used oil, including but not limited to: fuel oil, engine oil, gear oil, cutting oil, transmission fluid, oil storage tank residue, animal oil and vegetable oil, which has not subsequently been refined.

# 1. Purpose

GEI Consultants, Inc. (GEI) has prepared this Draft Quality Assurance Project Plan (QAPP) to address the investigation of the Gowanus Canal located in Brooklyn, New York. The QAPP is a companion document to the *Gowanus Canal Sediment Investigation Work Plan* dated June 8, 2005 (Work Plan) that was prepared by KeySpan Corporation (KeySpan) and the Draft Field Sampling Plan (FSP) dated December 2005 that was prepared by GEI. The project location is shown on Figure 1 of the Work Plan. The New York State Department of Environmental Conservation (NYSDEC) has given its approval for the implementation of the scope of work detailed in the Work Plan. The QAPP presents the project scope and goals, organization, objectives, sample handling procedures and specific quality assurance/quality control (QA/QC) procedures associated with Gowanus Canal Sediment Investigation in and adjacent to the Gowanus Canal.

Furthermore, this QAPP identifies project responsibilities, prescribes guidance and specifications to make certain that:

- Samples are identified and controlled through sample tracking systems and chain-of – custody (COC) protocols
- Field and laboratory analytical results are valid and usable by adherence to established protocols and procedures
- Laboratory data are validated so they can be applied to developing a conceptual understanding of the nature and extent of contamination of sediments and surface waters of the Gowanus Canal and subsurface soils adjacent to the Gowanus Canal
- All aspects of the investigation, from field to laboratory are documented to provide data that are technically sound and legally defensible

The requirements of this QAPP apply to all contractor activities as appropriate for their respective tasks.

This QAPP was prepared based upon guidance provided by the United States Environmental Protection Agency (EPA) and New York State Department of Environmental Conservation (NYSDEC) including:

- *Draft DER-10, Technical Guidance for Site Investigation and Remediation.* New York State Department of Environmental Conservation. December 2002.

- *Methods for Collection, Storage, and Manipulation for Sediments for Chemical and Toxicological Analyses: Technical Manual* [EPA-823-B-01-002]. *United States* Environmental Protection Agency. October 2001.

# 2. Project Goals and Objectives

KeySpan is conducting a sediment-sampling program in the Gowanus Canal in association with the on-going characterization of the Carroll Gardens/Public Place [Former Citizens Gas Works MGP] site in the Carroll Gardens neighborhood of Brooklyn, New York. This sediment investigation was prepared to investigate the potential impacts to the Gowanus Canal and abutting properties from the Carroll Gardens/Public Place site, two other former MGP sites, and other current and former industrial/ commercial sites that have operated adjacent to the canal.

The scope of the sediment sampling program is presented in the Gowanus Canal Sediment Sampling Work Plan dated June 8, 2005. The sediment investigation will include the following tasks:

- Gowanus Canal Bulkhead and Outfall Reconnaissance
- Gowanus Canal Bathymetry Data Collection
- Gowanus Canal Surface Water Sample Collection
- Gowanus Canal Sediment Coring and Analytical Sample Collection
- Subsurface Soil Boring Installation and Soil Sample Collection [Parcels located adjacent to the Gowanus Canal].

The completion of these tasks will help meet the objectives of characterizing the geology of sediments and subsurface soils, characterizing the sediment and surface water quality with the ultimate goal of evaluating the nature and extent of environmental impacts within the Gowanus Canal.

# 3. Project Organization and Responsibility

GEI is responsible for the implementation of Work Plan scope of work, including the supervision of contractors, field activities, and the evaluation and interpretation of data. GEI will direct the sampling activities and coordinate submittal of samples to testing laboratories. The project organization and key personnel for GEI are listed below:

In-House Consultant: Dennis Unites, P.G., LEP
Project Manager: David Terry, P.G. LEP
Investigation Managers: Matt O'Neil/ Lynn Willey
Field Team Leader: Melissa Felter
Quality Assurance Officer: Lorie MacKinnon
GEI Corporate Health & Safety Officer: Robin B. Dehate, MPH, PhD(c), CHMM
Data Validators: Lorie Mackinnon, Lisa McDonough
Data Manager: Karen Swartz

The primary responsibilities of each of these personnel are described in the following table.

| Key Project Personnel and Responsibilities | | |
|---|---|---|
| **Position** | **GEI Personnel** | **Areas of Responsibilities** |
| In-House Consultant | Dennis Unites | ▪ Overall program oversight<br>▪ Client contact regarding strategic issues<br>▪ Review of project deliverables |
| Project Manager | David Terry | ▪ Project management<br>▪ Project schedule<br>▪ Client contact regarding project related issues<br>▪ Personnel and resource management<br>▪ Review of project submittals<br>▪ Budgeting |
| Investigation Managers<br><br>Field Team Leader | Matt O'Neil<br>Lynn Willey<br><br>Melissa Felter | ▪ Client contact regarding project related issues on day to day basis<br>▪ Coordination of contractors<br>▪ Technical development and implementation of Work Plan and FSP<br>▪ Personnel and resource management<br>▪ Preparation and review of project submittals<br>▪ Preparation of project submittals<br>▪ Budgeting |
| Quality Assurance Officer | Lorie Mackinnon | ▪ QA/QC for sampling and laboratory performance |
| Data Validators | Lorie MacKinnon<br>Lisa McDonaugh<br>Nancy Potak | ▪ Perform data validation activities<br>▪ Prepare data usability summary reports<br>▪ Evaluate data with regards to quality objectives |
| Data Managers | Karen Swartz | ▪ Manage raw data from the laboratory |

Severn Trent Laboratories (STL) Inc., located in Shelton, Connecticut, was selected to perform the following standard analytical chemistry parameters for surface water, outfall water, subsurface soil, and sediment samples including:

- Volatile Organic Compounds (VOCs) according to EPA Method 8260B
- Semi-Volatile Organic Compounds (SVOCs) according to EPA Method 8270C
- Polychlorinated Biphenyls (PCBs) according to EPA Method 8082A
- Pesticides according to EPA Method 8081A
- Herbicides according to EPA Method 8151A
- Target Analyte List (TAL) Metals according to EPA Method 6000/7000 series
- Total Cyanide (TCN) according to EPA Method 9012
- Total Organic Carbon (TOC) according to EPA Method 9060
- Nitrate/nitrite according to EPA Method 300.0
- Sulfate according to EPA Method 300.0
- Toxicity Characteristic Leaching Procedure (TCLP) VOCs, SVOCs, TAL metals, pesticides, herbicides
- Disposal Parameters (paint filter test, ignitability, corrosivity and reactivity)

In addition, sediment samples will also be analyzed bulk density, grain size, and percent water content according to ASTM methods. STL's laboratory in Burlington, Vermont will conduct analysis of sediments by ASTM testing methods. STL's relevant certifications are summarized in the following table.

| Severn Trent Laboratories (STL) Certifications | | |
|---|---|---|
| Location | Responsible Agency | Certification |
| New York | New York State Department of Health | Environmental Laboratory Approval Program (ELAP) for potable water/ non-potable water, solid and hazardous waste) Contract Laboratory Protocol (CLP) |
| | New York State Department of Conservation | Analytical Service Protocol (ASP) |
| United States | United States Environmental Protection Agency | CLP-Lab:10602 [VOCs/ SVOCs/ PCBs/Pesticides/ Inorganics] |

STL has subcontracted Ambient Group, Inc. to complete fecal coliform testing by SM9222D (modified for sediments).

| Ambient Group, Inc. Certifications | | |
|---|---|---|
| Location | Responsible Agency | Certification |
| New York | New York State Department of Health | Environmental Laboratory Approval Program (ELAP) for potable water/ non-potable water, solid and hazardous waste) Lab ID: 10865 |

Tables 1 through 3 provide a summary of analysis by media (sediment, subsurface soil, and surface water). Table 4 provides a summary of quality assurance samples, holding times and analysis for each media.

Newfields Environmental Forensic Practice, LLC (Newfields) located in Rockland, MA will perform the environmental forensics and geochronology evaluation. Newfields was chosen for their experience in the forensic analysis of polycyclic aromatic hydrocarbons (PAHs) in aquatic environments. Newfields has subcontracted the laboratory environmental forensic analysis of subsurface soils and sediments to Alpha Analytical Inc.- Woods Hole Group Laboratory, located in Raynham, Massachusetts. Standard operating procedures for these procedures are located in Appendix A. The geochronology analysis will be performed by Battelle-Pacific Northwest National Laboratory located in Richland, Washington. Standard operating procedures for these laboratory tests are located in Appendix A

Ocean Surveys Incorporated, located in Old Saybrook, Connecticut, was contracted to complete the sampling activities within the Gowanus Canal. Zebra Environmental, located in Lynbrook, New York, was contracted to complete subsurface soil boring installation and sampling activities.

# 4. Quality Assurance Objectives

This section establishes the QA objectives for measurements that are critical to the project. The QA objectives are developed for relevant data quality indicators. These indicators include the method detection limit, reporting limit, precision, accuracy, completeness, representativeness, and comparability. The data quality objectives (DQOs) are based on project requirements and ensure: (1) that the data generated during the project are of known quality and (2) that the quality is acceptable to achieve the project's technical objectives provided in the Work Plan. All analytical data will be provided by the laboratory using the New York State ASP Category B deliverable format.

Quantitation Limits are laboratory-specific and reflect those values achievable by the laboratory performing the analyses. However, in order to ensure that the analytical methodologies are capable of achieving the DQOs, measurement performance criteria have been set for the analytical measurements in terms of accuracy, precision, and completeness. The analytical methods to be used at this site will provide a level of data quality and can be used for purposes of risk assessment and used to evaluate remedial alternatives if remedial actions are required.

The overall QA objective is to develop and implement procedures for field sampling, chain-of-custody, laboratory analysis, and reporting which will provide results that are scientifically valid, and the levels of which are sufficient to meet DQOs. Specific procedures for sampling, chain of custody, laboratory instruments calibration, laboratory analysis, reporting of data, internal quality control, and corrective action are described in other sections of the QAPP.

The data quality indicators are presented in subsections 4.1 through 4.6. Procedures to assess the data quality indicators are given below in Section 13.0.

## 4.1 Required Quantification Limit

The required quantification limit is the quantitative analytical level for individual analytes needed to make decisions relative to the objectives of the project. Quantitative limits may be expressed as the method detection limit or some quantitative level defined in terms relative to the program. It should be noted that there is some ambiguity in the definitions and use of terms that define quantification limits. The method detection limit (MDL) presented herein is a well-defined and accepted entity, although attainable only under ideal laboratory conditions.

**Method Detection Limit**: The MDL is the minimum concentration of a substance that can be measured and reported with 99 percent confidence that the analyte concentration is greater than zero. MDL is determined from analysis of a sample in a given matrix type containing the analyte.

**Practical Quantitation Limit:** The practical quantitation limit (PQL) [also referred to as the reporting limit (RL)] is the concentration in the sample that corresponds to the lowest concentration standard of the calibration curve.

Laboratory MDLs and PQLs for sediments/ subsurface soils and surface waters are located on Table 5 and 6, respectively.

## 4.2 Accuracy

Accuracy is the closeness of agreement between an observed value and an accepted reference value. The difference between the observed value and the reference value includes components of both systematic error (bias) and random error.

Accuracy in the field is assessed through the adherence to all field instrument calibration procedures, sample handling, preservation, and holding time requirements, and through the collection of equipment blanks prior to the collection of samples for each type of equipment being used (e.g., sample liners, drilling shoe, or stainless –steel sampling implements).

The laboratory will assess the overall accuracy of their instruments and analytical methods (independent of sample or matrix effects) through the measurement of "standards," materials of accepted reference value. Accuracy will vary from analysis to analysis because of individual sample and matrix effects. In an individual analysis, accuracy will be measured in terms of blank results, the percent recovery (%R) of surrogate compounds in organic analyses, or %R of spiked compounds in matrix spikes (MSs), matrix spike duplicates (MSDs) and/or laboratory control samples (LCSs). This gives an indication of expected recovery for analytes tending to behave chemically like the spiked or surrogate compounds. The laboratory accuracy will be evaluated in accordance with laboratory quality assurance plan and standard operating procedures located in Appendix A and B.

## 4.3 Precision

Precision is the agreement among a set of replicate measurements without consideration of the "true" or accurate value: i.e., variability between measurements of the same material for the same analyte. In environmental sampling, precision is the result of field sampling and analytical factors. Precision in the laboratory is easier to measure and control than precision in the field. Replicate laboratory analyses of the same sample provide information on analytical precision; replicate field samples provide data on overall measurement precision.

The difference between the overall measurement precision and the analytical precision is attributed to sampling precision. Precision is measured in a variety of ways including statistically, such as calculating variance or standard deviation. The difference between the overall measurement precision and the analytical precision is attributed to sampling precision.

Precision in the field is assessed through the collection and measurement of field duplicates. Field duplicates will be collected at a frequency of one per twenty investigative samples per matrix per analytical parameter, with the exception of the waste characterization parameters. Precision will be measured through the calculation of relative percent differences (RPDs) as described below in Section 13.2. The resulting information will be used to assess sampling and analytical variability. Duplicate samples are described in below in Section 5.1.6. Table 4 summarizes the number of duplicates per media sampled.

Precision in the laboratory is assessed through the calculation of RPD for duplicate samples. For organic analyses, laboratory precision will be assessed through the analysis of MS/MSD samples and field duplicates. For the inorganic analyses, laboratory precision will be assessed through the analysis of matrix duplicate pairs and field duplicate pairs. MS/MSD samples or matrix duplicate pairs will be performed at a frequency of one per twenty primary samples per matrix. Duplicate samples are described in below in Section 5.1.6. Table 5 summarizes the number of duplicates per media sampled

## 4.4 Completeness

Completeness is a measure of the amount of valid data obtained from a measurement system compared to the amount that was expected to be obtained under normal conditions. "Normal conditions" are defined as the conditions expected if the sampling plan was implemented as planned. The objective for completeness is a sufficient amount of valid data to achieve a predetermined statistical level of confidence. Critical samples must be identified and plans must be formulated to secure requisite valid data for these samples.

Field completeness is a measure of the amount of (1) valid measurements obtained from all the measurements taken in the project and (2) valid samples collected. The field completeness objective is greater than 90 percent.

Laboratory completeness is a measure of the amount of valid measurements obtained from all valid samples submitted to the laboratory. The laboratory completeness objective is greater than 95 percent.

To ensure that these percentages are met, materials for crucial parameters will be retained if re-sampling is required and strict adherence to holding times will be required.

## 4.5 Representativeness

Representativeness is a qualitative parameter that expresses the degree to which data accurately and precisely represent either a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition within a defined spatial and/or temporal boundary. To ensure representativeness, the sampling locations have been selected to provide coverage over a wide area and to highlight potential trends in the data.

Representativeness is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the Work Plan and FSP are followed and that proper sampling, sample handling, and sample preservation techniques are used.

Representativeness in the laboratory is ensured by using the proper analytical procedures, appropriate methods, and meeting sample-holding times. These are provided in Table 4 and within Appendix A and B.

## 4.6 Comparability

Comparability is a qualitative parameter that expresses the confidence with which one data set can be compared to another. Comparability is dependent upon the proper design of the sampling program and will be satisfied by ensuring that the Work Plan and FSP are followed and that proper sampling techniques are used. Maximization of comparability with previous data sets is expected because the sampling design and field protocols are consistent with those previously used.

Comparability is dependent on the use of recognized EPA or equivalent analytical methods and the reporting of data in standardized units. To facilitate data comparison, the data-reporting format as presented below will be used:

- Conventions (units reported as): for solids (weight/unit weight [i.e., mg/kg]); for liquids (weight/unit volume [i.e., mg/L]); for air (weight/unit volume [i.e., mg/m3]).
- Use common chemical name with corresponding chemical abstract system (CAS) code.
- Report all data for soils on a dry-weight basis.

# 5. Sampling Plan

Environmental sampling will include subsurface soil, sediment, surface water, outfall sampling, and waste characterization sampling. Sediment samples will be collected primarily using ponar/ Shipek sampler and vibracore sampling methods. If necessary, sediments within outfalls to the Gowanus Canal will be collected utilizing a remote sampler or other appropriate methods. Direct push drilling (Georobe®) , hollow-stem auger, and rotosonic drilling methods will be the preferred methods for obtaining subsurface soil samples. Surface water and Gowanus Canal outfall water samples will be collected utilizing direct methods, remote samplers, Kemmerer bottle or Van Doren sampler. Performing grab or composite sampling by appropriate hand-held sampling equipment will be the preferred method for waste characterization sampling. Analytical samples and analysis methods are prescribed in the Work Plan. Sampling methods and procedures are described in FSP.

## 5.1 Sample Type, Location, and Frequency

### *5.1.1 Sediment samples*

One hundred and six (106) sediment sample locations will be drilled and sampled with a vibracore drill rig or ponar/shipek sampler. The borings will be drilled with a core barrel with a Lexan liner. The core will be advanced approximately 20 feet below the sediment water interface or vibracore refusal. Up to 3 sediment samples will be submitted from each core location. In addition, sediment samples may be submitted from outfalls which empty into the Gowanus Canal. The actual number of outfalls was unknown at the start of the investigation. The actual number and location of samples will vary based upon access and subsurface obstructions. Sediments will be evaluated through visual, olfactory, and field screening observations in accordance with the FSP. Sediment samples will be collected and submitted for laboratory analysis in general accordance with the Work Plan and the FSP. A summary of sediment samples and analysis are located on Table 1

### *5.1.2 Surface water samples*

Seventy (70) surface water locations will be sampled using direct method, peristaltic pump, Kemmerer bottle, and Van Doren sampler. Surface water samples will be collected near the surface and near the bottom of the canal at proposed sample locations. Surface water samples will be collected and submitted for laboratory analysis in general accordance with the FSP and Work Plan. Surface water discharges from the outfall locations along the Gowanus Canal. The actual number of the outfall sample locations is will be determined during the outfall reconnaissance phase of the Work Plan. Water quality parameters

including pH, specific conductance, temperature, turbidity, clarity, dissolved oxygen, and oxidation reduction potential will be collected prior to laboratory analysis in general accordance with the Work Plan and the FSP. A summary of surface water samples and analysis are located on Table 2.

### *5.1.3 Subsurface Soil Samples*

Forty-one (43) subsurface sample locations will be sampled using Geoprobe®, rotosonic or hollow stem auger drilling methods. The borings will be drilled to a maximum depth of 40 feet. The actual number of subsurface soil samples and their location may be modified based upon subsurface utilities and property access. The number and location of samples will vary based upon access and subsurface obstructions. Sediments will be evaluated through visual, olfactory, and field screening observations in accordance with the FSP. Sediment samples will be collected and submitted for laboratory analysis in general accordance with the Work Plan and the FSP. A summary of sediment samples and analysis are located on Table 3.

### *5.1.4 Geochronolgy Sample Collection*

At a minimum of ten sediment cores will be collected utilizing vibracore sampling equipment at six locations in the study area. Each of these boring will be advanced to native material up to a maximum depth of 20 feet below the sediment water interface. Sediment samples will be handled and sampled in general accordance with the FSP. Each sample location will be analyzed for geochronology parameters specified in the Work Plan. Sediment samples will be handled in accordance with procedures for age dating sediment cores located in Appendix B.

### *5.1.5 Investigation-Derived Waste Sample Collection*

Waste classification sampling will be conducted for sediments and subsurface soils and liquid wastes. The purpose of characterizing a waste for its proper off-site disposal. Sediment samples will be collected from at least three heavily impacted zones at separate sediment core locations for the purposes of waste characterization. These sediment samples will be collected with stainless steel samplers or similar equipment and will be handled in general accordance with soil handling procedures presented in the FSP. Investigation derived waste samples will be analyzed for parameters listed in Section 3.0.

If required, composite samples will be collected from the on-site waste storage vessels (drums or roll-off) for parameters required by the approved disposal facility. Sediment samples will be collected utilizing stainless steel sampling tools, shovel, or auger that had been decontaminated. Liquid samples will be collected utilizing disposable bailer, peristaltic pump, a pump with tubing, or other similar methods.

### *5.1.6 Field QC Sample Collection*

Field QC samples are used to monitor the reproducibility and representativeness of field sampling activities. The field QC samples are handled transported and analyzed in the same manner as the associated field samples. Field QC samples will include equipment blanks, trip blanks, field duplicates and MS/MSDs. The quantity, field QC sample type and analysis is detailed on Table 4.

***Equipment Blank Samples*** are used to monitor the adequacy of decontamination procedures and possible sources of contamination such as potential laboratory methodologies. Equipment blanks will consist of laboratory-supplied, distilled or de-ionized water and will be used to check for potential contamination of the equipment which may cause sample contamination. Equipment blanks will be collected by routing the distilled water through decontaminated piece of sampling equipment or disposable sampling equipment into laboratory supplied bottles. Non-dedicated field equipment will be decontaminated as specified below in Section 4.3. Field blank bottles will be stored and handled as Equipment blanks will be submitted to the laboratory at a frequency of one per 20 samples per matrix per type of equipment being used per parameter. Equipment blanks will not be completed for waste characterization sampling activities.

***Trip Blank Samples*** will consist of analyte free water and will be prepared by the laboratory. (Trip blanks are used to assess the potential for VOC contamination of samples due to contaminant migration during sample shipment and storage. Trip blanks will be transported to the project location unopened, stored with the sediment investigation samples, and kept closed until analyzed by the laboratory. Trip blanks will be submitted to the laboratory at a frequency of one per cooler which contains samples submitted for VOC analysis.

***Field Duplicate Samples***, also referred to as blind duplicate samples, are two samples that are submitted form the same interval using the same sample procedures. Field duplicates will be used to assess the sampling and analytical reproducibility. Both samples are collected utilizing the same methods and are submitted for the same laboratory analysis however different sample identification numbers are used. Field duplicates for surface water and outfall sampling locations will be collected by alternately filling sample bottles from the source being sampled. Field duplicates will be submitted at a frequency of one per 20 samples for all matrices and all parameters. Field duplicates will not be completed for waste characterization sampling activities.

***MS/ MSD Samples*** are two additional aliquots of the same sample submitted for the same parameters as the original sample. However, the additional aliquots are spiked with the compounds of concern. Matrix spikes provide information about the effect of the sample matrix on the measurement methodology. MS/MSDs will be submitted at a frequency of one per 20 investigative samples per matrix for organic parameters. MSs will be submitted at a

frequency of one per 20 investigative samples per matrix for inorganic parameters. Field duplicates will not be completed for waste characterization sampling activities.

Refer to Table 4 for a summary of QC sample preservation and container requirements.

## 5.2 Sample Preservation and Containerization

The analytical laboratory will supply the sample containers for the chemical samples. These containers will be cleaned by the manufacturer to meet or exceed all analyte specifications established in the latest United States EPA's Specifications and Guidance for Contaminant-Free Sample Containers. Certificates of analysis are provided with each bottle lot and maintained on file to document conformance to United States EPA specifications. The containers will be pre-preserved, where appropriate (See Table 4)

## 5.3 Equipment Decontamination

All non-dedicated sampling equipment shall be cleaned between each use in the following manner:

- Wash/scrub with a biodegradable degreaser ("Simple Green") if there is oily residue on equipment surface
- Tap water rinse
- Wash and scrub with Alconox (or non-phosphate soap) and water mixture
- Tap water rinse
- All equipment used to collect samples for VOCs and SVOC analysis will then receive a methanol rinse followed by a de-ionized water rinse.
- All equipment used to collect samples for metals analysis will then receive a 10% nitric acid solution rinse followed by a de-ionized water rinse.
- All equipment used to collect samples for fecal coliform analysis will be rinsed with a tap water rinse and 5% commercial grade bleach solution between sample locations. Sample equipment will be allowed to air dry.
- Equipment will be wrapped in polyethylene plastic or aluminum foil for storage or transportation from the designated decontamination area to the sampling location, where appropriate.

The drilling and coring equipment will be decontaminated in general accordance with methods described in the FSP.

Decontamination fluids will be containerized into USDOT-approved 55-gallon drums or containment vessels and will be characterized and disposed of by KeySpan at an approved disposal facility.

# 6. Documentation and Chain-of-Custody

## 6.1 Sample Collection Documentation

### *6.1.1 Field Notes*

Field notes documenting field activities will be maintained in a field notebook in general accordance with Section 2.2 of the FSP. Field logbooks will provide the means of recording the chronology of data collection activities performed during the investigation. The logbook will be a bound notebook with water-resistant pages. Logbook entries will be dated, legible, and contain accurate and inclusive documentation of the activity. Each page of the logbook will be signed in permanent ink and dated. No erasures or obliterations of field notes will be made. If an incorrect entry is made, the information will be crossed out with a single strike mark which is signed and dated by the sampler. The correction shall be written adjacent to the error.

Field logbooks will be reviewed at regular intervals by the field team leader, site manager and project manager for completeness and representativeness. Logbooks will be supported by daily reports as described in Section 2.3 of the FSP.

### *6.1.2 Chain-of-Custody Records*

Sample custody is discussed in detail below in Section 6.2. Chain-of-custody records are initiated by the samplers in the field. The field portion of the custody documentation should include:

- the project name
- signature(s) of sampler (s) responsible for sample custody
- sample ID number
- date and time of collection
- whether the sample is grab or composite
- names of individuals involved in sampling
- air bill or other shipping number (if applicable)

On a regular basis (daily or on such a basis that all holding times will be met), samples will be transferred to the custody of the respective laboratories, via third-party commercial carriers or via laboratory courier service. Sample packaging and shipping procedures, and field chain-of-custody procedures are described below in Section 6.2.1 of this Plan. Sample

receipt and log-in procedures at the laboratory are described below in Section 6.2.2 of this Plan.

### *6.1.3 Sample Labeling*

Each sample will be labeled with a pre-printed adhesive label using indelible ink. The label should include the date and time of collection, sampler's initials, tests to be performed, preservative (if applicable), and a unique identification. The following identification scheme will be used:

| PRIMARY SAMPLES TYPES | QA/QC SAMPLE TYPES |
|---|---|
| **SOIL SAMPLES**<br>Boring -ID (SAMPLE DEPTH-FEET)<br>GCGP-120 (10-15)<br>GCSB-120 (10-15)<br>**SEDIMENT SAMPLES**<br>Sediment-ID-(SAMPLE DEPTH-FEET)<br>GCSED-01 (10-15)<br>**SURFACE WATER SAMPLES**<br>Surface Water-ID [SURFACE OR BOTTOM]<br>GCSW-01S<br>GCSW-01B<br>**OUTFALL WATER SAMPLES**<br>Outfall-ID<br>GCOF-01 | **FIELD BLANKS**<br>SAMPLE-ID – [DATE]<br>GCGP-FB-091905 ( Subsurface soil field blank)<br>GCSB-FB-091905 (Sediment field blank)<br>GCSED-FB-091905 (Sediment field blank)<br>GCSW-FB-091905 (Surface water field blank)<br>GCOF-FB-091905 (Outfall water field blank)<br><br>**MATRIX SPIKE (MS)/ MATRIX SPIKE DUP (MSD)**<br>SAMPLE [ ID ] [DEPTH] [EITHER MS OR MSD]<br>GCSED-01 (10-15) MS/MSD<br>GCGP-01-(10-15) MS/MSD<br>GCSB-01-(10-15) MS/MSD<br>GCSW-01S MS/MSD<br>GCOF-01 MS/MSD<br>**TRIP BLANKS**<br>SAMPLE- ID [DATE]<br>GCTB-091905<br>**BLIND DUPLICATES**<br>SAMPLE -ID[XX][ DATE ]<br>GCGP-XX-091905<br>GCSB-XX-091905<br>GCSED-XX-091905<br>GCSW-XX-091905<br>GCOF-XX-091905 |

This sample label contains the authoritative information for the sample. Inconsistencies with other documents will be settled in favor of the vial or container label unless otherwise

corrected in writing from the field personnel collecting samples or the Data Manager and/or the GEI Project QA Officer.

### *6.1.4 Sample Handling*

Samples will be handled in general accordance with Section 8.0 of the FSP.

## 6.2 Sample Custody

The chain-of-custody provides a record of the custody of any environmental field sample from the time of collection to the delivery to the laboratory. Custody is one of several factors that are necessary for the admissibility of environmental data as evidence in a court of law. Custody procedures help to satisfy the two major requirements for admissibility: relevance and authenticity. Sample custody is addressed in three parts: field sample collection, laboratory analysis, and final evidence files.

A sample is considered to be under a person's custody if

- the item is in the actual possession of a person
- the item is in the view of the person after being in actual possession of the person
- the item was in the actual physical possession of the person but is locked up to prevent tampering
- the item is in a designated and identified secure area

### *6.2.1* Field Custody Procedures

Samples will be collected following the sampling procedures indicated in the Work Plan and the FSP. A summary of samples and collection methods are provided above in Section 5.0 of this QAPP. Documentation of sample collection is described above in Section 6.1. Sample chain-of-custody and packaging procedures are summarized below. These procedures will ensure that the samples will arrive at the laboratory with the chain-of-custody intact.

- The field sampler is personally responsible for the care and custody of the samples until they are transferred or dispatched properly. Field procedures have been designed such that as few people as possible will handle the samples.
- All bottles will be identified by the use of sample labels with sample numbers, sampling locations, date/time of collection, and type of analysis. The sample numbering system is presented above in Section 6.1.3.
- Sample labels will be completed for each sample using waterproof ink unless prohibited by weather conditions.
- Samples will be accompanied by a completed chain-of-custody form. The sample numbers and locations will be listed on the chain-of-custody form. When transferring the possession of samples, the individuals relinquishing and receiving will sign, date, and note the time on the record. This record documents the transfer of custody of

samples from the sampler to another person, to a mobile laboratory, and to the laboratory facility.

- All shipments will be accompanied by the chain-of-custody record identifying the contents. The original record will accompany the shipment, and copies will be retained by the sampler and placed in the project files.
- Samples will be properly packaged for shipment and dispatched to the appropriate laboratory for analysis, with a separate signed custody record enclosed in and secured to the inside top of each sample box or cooler. Shipping containers will be secured with strapping tape and custody seals for shipment to the laboratory. The custody seals will be attached to the cooler and covered with clear plastic tape after being signed by field personnel.
- If the samples are sent by common carrier, the air bill will be used. Air bills will be retained as part of the permanent documentation. Commercial carriers are not required to sign off on the custody forms since the custody forms will be sealed inside the sample cooler and the custody seals will remain intact.
- Samples remain in the custody of the sampler until transfer of custody is completed. This consists of delivery of samples to the laboratory sample custodian, and signature of the laboratory sample custodian on chain-of-custody document as receiving the samples and signature of sampler as relinquishing samples.

### *6.2.2* Laboratory Custody Procedures

After accepting custody of the shipping containers, the laboratory will document the receipt of the shipping containers by signing the chain-of-custody record. The laboratory will:

- Examine the shipping containers to verify that the custody tape is intact
- Examine all sample containers for damage
- Determine if the temperature required for the requested testing program has been maintained during shipment and document the temperature on the chain-of-custody records
- Compare samples received against those listed on the chain-of-custody
- Verify that sample holding times have not been exceeded
- Examine all shipping records for accuracy and completeness
- Determine sample pH (if applicable) and record on chain-of-custody forms
- Sign and date the chain-of-custody immediately (if shipment is accepted) and attach the air bill
- Note any problems associated with the coolers and/or samples on the cooler receipt form and notify the laboratory project manager, who will be responsible for contacting the GEI data manager
- Attach laboratory sample container labels with unique laboratory identification and test
- Place the samples in the proper laboratory storage.

Following receipt, samples will be logged in according to the following procedure:

- The samples will be entered into the laboratory tracking system. At a minimum, the following information will be entered: project name or identification, unique sample numbers (both client and internal laboratory), type of sample, required tests, date and time of laboratory receipt of samples, and field ID provided by field personnel.
- The completed chain-of-custody, air bills, and any additional documentation will be placed in the final evidence file.

# 7. Calibration Procedure

## 7.1 Field Instruments

Field instruments will be calibrated according to the manufacturer's specifications. Air monitoring instruments will be calibrated to a known reference gas standard and ambient air outside the work zone. Calibration will be completed daily. If concentrations of VOCs are encountered above the reference gas standard, the soil screening PIDs may be calibrated or re-checked against the reference gas standard. Water quality and soil pH meters will be calibrated with known reference solutions. All calibration procedures performed will be documented in the field logbook and will include the date/time of calibration, name of person performing the calibration, reference standard used, and the readings. The following equipment has been identified for use to implement the Work Plan.

Sediment Sampling Activities:

- RAE Systems MultiRAE Plus equipped with VOC (10.6 eV lamp), lower explosive limit (LEL), percent oxygen, hydrogen sulfide and hydrogen cyanide
- RAE Systems MiniRAE 2000 photo-ionization detector (PID) with 10.6 eV lamp.
- RAE Systems VRAE Surveying Monitor with LEL, hydrogen cyanide, hydrogen sulfide, carbon monoxide, and percent oxygen.
- Drager Chip Measurement System (CMS) and compound specific chips (including benzene, hydrogen sulfide, hydrogen cyanide, etc.).
- Hanna HI-99121 Soil pH meter

Subsurface Soil Sampling Activities:

- RAE Systems MultiRAE Plus equipped with VOC (10.6 eV lamp), LEL, percent oxygen, hydrogen sulfide and hydrogen cyanide
- RAE Systems MiniRAE 2000 photo-ionization detector (PID) with 10.6 eV lamp.
- RAE Systems VRAE Surveying Monitor with LEL, hydrogen cyanide, hydrogen sulfide, carbon monoxide, and percent oxygen.
- Drager Chip Measurement System (CMS) and compound specific chips (including benzene, hydrogen sulfide, hydrogen cyanide, etc.).
- MIE pDR 1200 with cyclonic pump [particulate monitor]
- MSA LC Pump or SKC 224-PCXR4 [air pump for dust monitoring]
- BIOS Dry Cal DC Lite Primary Flow Meter Model ML [air pump calibration]

Surface Water / Outfall Water Sampling Activities

- In-Situ Multi-Parameter Troll 9000
- YSI 6280 XLM water quality meter

Similar field equipment can be substituted that perform the same functions can be substituted if selected equipment is not available from equipment supplier.

## 7.2 Laboratory Instruments

Calibration procedures for a specific laboratory instrument will consist of initial calibrations, initial calibration verifications, and/or continuing calibration verification. Detailed descriptions of the calibration procedures for a specific laboratory instrument are included in the laboratory's quality assurance plan, which describe the calibration procedures, their frequency, acceptance criteria, and the conditions that will require recalibration. These procedures are as required in the respective analytical methodologies summarized in Table 1 through 4 of this QAPP.

# 8. Sample Preparation and Analytical Procedures

Analytical samples will be collected in general accordance with the Field Sampling Plan and as specified in the Work Plan. Table 1 through Table 3 provide a sample collection matrix that is separated by media. Analytical samples will be collected into laboratory-preserved sample containers and will be preserved as indicated in Table 4.

# 9. Data Reduction, Validation, and Reporting

Appropriate QC measures will be used to ensure the generation of reliable data from sampling and analysis activities. Proper collection and organization of accurate information followed by clear and concise reporting of the data is a primary goal in this project. Complete data packages suitable for data validation to support the generation of a Data Usability Summary Report (DUSR) according to NYSDEC requirements will be provided by the analytical laboratory.

## 9.1 Field Data Evaluation

Measurements and sample collection information will be transcribed directly into the field logbook or onto standardized forms. If errors are made, results will be legibly crossed out, initialed and dated by the person recording the data, and corrected in a space adjacent to the original (erroneous) entry. Reviews of the field records by the field team leader, site manager, and project manager will ensure that:

- Logbooks and standardized forms have been filled out completely and that the information recorded accurately reflects the activities that were performed.
- Records are legible and in accordance with good record keeping procedures, i.e., entries are signed and dated, data are not obliterated, changes are initialed, dated, and explained.
- Sample collection, handling, preservation, and storage procedures were conducted in accordance with the protocols described in the FSP and Work Plan, and that any deviations were documented and approved by the appropriate personnel.

## 9.2 Analytical Data Validation

GEI will be responsible for performing an independent validation of the analytical data. Project-specific procedures will be used to validate analytical laboratory data. The basis for the validation will be the USEPA CLP National Functional Guidelines for Organic Data Review (January 2005) and the USEPA CLP National Functional Guidelines for Inorganic Data Review (October 2004), modified to accommodate the criteria in the analytical methods used in this program, and Region II Standard Operating Procedures (SOPs) for CLP Organic Data review (Revision 11, June 1996) and Evaluation of Metals for the CLP Program (Revision 11, January 1992). Critical functions for determining the validity of generated data are: (1) strict adherence to the analytical methods, (2) assurance that the instrumentation employed was operated in accordance with defined operating procedures, (3) assurance that quality parameters built into the analytical procedures have been adhered to, and (4) confirmation that the DQOs have been met.

Table 4 highlight the QC criteria and holding time requirements for all analyses conducted under this program. These criteria will be used to evaluate and qualify the data during validation.

GEI or qualified contracted personnel will validate all analytical samples collected as part of the Gowanus Canal Sediment Investigation. Samples collected for waste classification will not be validated. Validation will include all technical holding times, as well as QC sample results (blanks, surrogate spikes, laboratory duplicates, MS/MSDs, and LCSs), tunes, internal standards, calibrations, target compound identification, and results calculations.

For all analyses, the laboratory will report results which are below the laboratory's reporting limit; these results will be qualified as estimated (J) by the laboratory. The laboratory may be required to report tentatively identified compounds (TICs) for the VOC and SVOC analyses; this will be requested by GEI on an as-needed basis

The overall completeness of the data package will also be evaluated by the data validator. Completeness checks will be administered on all data to determine whether full data deliverables were provided. The reviewer will determine whether all required items are present and request copies of missing deliverables.

Upon completion of the validation, a report will be prepared. This report will summarize the samples reviewed, elements reviewed, any nonconformance with the established criteria, and validation actions. Data qualifiers will be consistent with EPA National Functional Guidelines. This report will be in a format consistent with NYSDEC's Data Usability Summary Report (DUSR).

## 9.3 Analytical Data Validation

Laboratory deliverables will consist of a original hard copy data package that are in general accordance with New York State Analytical Service Protocol (NYSDEC) Category B data deliverable requirements.

# 10. Internal Quality Control

Laboratory and field quality internal control checks will be used to ensure the data quality objectives. At a minimum, this will include:

- Matrix spike and/or matrix spike duplicate samples
- Matrix duplicate analyses
- Laboratory control spike samples
- Instrument calibrations
- Instrument tunes for VOC 8260B and SVOC 8270C analyses
- Method and/or instrument blanks
- Surrogate spikes for organic analyses
- Internal standard spikes for VOC 8260B and SVOC 8270C analyses
- Detection limit determination and confirmation by analysis of low-level calibration standard

The laboratory quality plan for STL is located in Appendix A and forensic SOPs located in Appendix B.

Field quality control samples will include:

- Equipment blanks as outlined in Table 4
- Field duplicate samples as outlined in Table 4
- Trip blanks as outlined in Table 4
- MS/MSDs as outlined in Table 4

# 11. Performance and System Audits

Audits are an independent means of: 1) evaluating the operation or capability of a measurement system and 2) documenting the use of QC procedures designed to generate data of know and acceptable quality.

Field audits may be completed to assess sample collection protocols, determine the integrity of COC procedures, and evaluate sample documentation and data handling procedures. Field audits may be scheduled by the QA officer, PM, site manager or in-house consultant, at their discretion. Written records of audits and any recommendations for corrective action will be submitted to the PM.

The QA officer is the interface between management and project activities in matters of project quality. The QA officer will review the implementation of the QAPP. Reviews will be conducted at the completion of field activities and will include the results of any audits and an evaluation of the data quality.

# 12. Preventative Maintenance

Preventative maintenance will be performed on field equipment in accordance with the manufacturer's recommendations. Preventative maintenance to field will be provided by equipment vendor, U.S Environmental Rental Corporation, Pine Environmental Services, or other selected vendors. The following equipment has been identified for use to implement the Work Plan.

Sediment Sampling Activities:

- RAE Systems MultiRAE Plus equipped with VOC (10.6 eV lamp), LEL, percent oxygen, hydrogen sulfide and hydrogen cyanide
- RAE Systems MiniRAE 2000 photo-ionization detector (PID) with 10.6 eV lamp.
- RAE Systems VRAE Surveying Monitor with LEL, hydrogen cyanide, hydrogen sulfide, carbon monoxide, and percent oxygen.
- Drager Chip Measurement System (CMS) and compound specific chips.
- Hanna HI-99121 Soil pH meter.

Subsurface Soil Sampling Activities:

- RAE Systems MultiRAE Plus equipped with VOC (10.6 eV lamp), LEL, percent oxygen, hydrogen sulfide and hydrogen cyanide
- RAE Systems MiniRAE 2000 photo-ionization detector (PID) with 10.6 eV lamp.
- RAE Systems VRAE Surveying Monitor with LEL, hydrogen cyanide, hydrogen sulfide, carbon monoxide, and percent oxygen.
- Drager Chip Measurement System (CMS) and compound specific chips.
- MIE pDR 1200 with cyclonic pump
- MSA LC Pump
- BIOS DCL-5k pump calibrator
- Hanna 99121 pH meter

Surface Water Sampling Activities

- In-Situ Troll 9000
- YSI 600 XLM

Similar equipment will be substituted that perform the same functions can be substituted if selected equipment is not available from equipment supplier.

Laboratory equipment calibration and maintenance procedures are specified in STL's laboratory quality manual located in Appendix A and forensic and age dating SOPs located in Appendix B.

# 13. Specific Procedures to Assess Data Quality Indicators

QC analyses conducted as a part of the testing program will provide a quantitative quality assessment of the data generated and their adherence to the data quality indicators. The data quality indicators ensure that the quality assurance objectives for the project are met.

## 13.1 Detection Limits

### *13.1.1* Method Detection Limit

The MDL is defined as follows for all measurements:

MDL = (t[n-1,1-a=0.99]) x (s)

where: s = standard deviation of the replicate analysis,
t(n-1, 1-a=0.99) = student's t-value for a one-sided, 99 percent confidence level and a standard deviation estimate with n-1 degrees of freedom

The MDLs calculated by the laboratory are determined under ideal conditions. MDLs for environmental samples are dependent on the sample aliquot, the matrix, the concentration of analyte, and interference present in the matrix, the percent of moisture, dilution factor, etc. The MDL for each sample analysis will be adjusted accordingly.

### 13.1.2 Reporting Limit

The reporting limit (RL) is the concentration of an analyte in the sample that corresponds to the lowest concentration standard of the calibration curve. As with the MDLs, the RLs are dependent on the sample aliquot, the final sample volume, the percent of moisture, dilution factor, etc.

The RL is determined as follows:

$$RL = \frac{Lowest\ conc.\ std\ (ng)}{Volume\ injected\ (uL)} \ x \ \frac{Sample\ aliquot\ (mL\ or\ g)}{Final\ volume\ (mL)} \ x\ DF\ x \ \frac{100}{(100 - \%M)}$$

where: DF = dilution factor, including all dilutions or lost samples not accounted for in a sample aliquot/final volume ratio
%M = percent moisture for solid samples.

## 13.2 Precision

Variability will be expressed in terms of the relative percent difference (RPD) when only two data points exist. The RPD is calculated as:

$$RPD = \frac{(Larger\ Value - Smaller\ Value)}{[(Larger\ Value + Smaller\ Value)/2]} \ x\ 100\%$$

For data sets greater than two points, the percent relative standard deviation (percent RSD) is used as the precision measurement. It is defined by the equation:

$$Percent\ RSD = \frac{Standard\ Deviation}{Mean} \ x\ 100\%$$

Standard deviation (SD) is calculated as follows:

$$SD = \sqrt{\sum_{i=1}^{n} \frac{(y_i - y)^2}{n - 1}}$$

where: SD = standard deviation
yi = measured value of the ith replicate
y = mean of replicate measurements
n = number of replicates

For measurements such as pH, where the absolute variation is more appropriate, precision is usually reported as the absolute range (D) of duplicate measurements:

D = | first measurement - second measurement |

or as the absolute standard deviation previously given. RPD, %RSD, and D are independent of the error of the analyses and reflect only the degree to which the measurements agree with each other, not the degree to which they agree with the true value for the parameter measured.

## 13.3 Accuracy

Accuracy is related to the bias in a measurement system. Accuracy describes the degree of agreement of a measurement with a true value. Accuracy will be expressed as percent recovery for each matrix spike analyte by using the following equation:

$$\% \ Recovery = \frac{Css - Cus}{Csa} \ X \ 100\%$$

where: Css = measured concentration in spiked sample
Cus = measured concentration in unspiked sample
Csa = known concentration added to the sample

Accuracy for a measurement such as pH is expressed as bias in the analysis of a standard reference sample according to the equation:

$$Bias = pH_m - pH_t$$

where: $pH_m$ = measured pH
$pH_t$ = the true pH of the standard reference sample

## 13.4 Completeness

Data completeness is a measure of the amount of usable data resulting from a measurement effort. For this program, completeness will be defined as the percentage of valid data obtained compared to the total number of measurements necessary to achieve our required statistical level of confidence for each test. The confidence level is based on the total number of samples proposed in the Work Plan.

Data completeness is calculated as:

$$Completeness = \frac{Number\ of\ valid\ data\ points}{Number\ of\ data\ points\ necessary\ for\ confidence\ level} x\ 100\%$$

The completeness goal is to generate a sufficient amount of valid data. GEI anticipates that 95 percent of the data will be complete. Data validation criteria discussed in the work plan and Section 10.0 of this QAPP will be used to determine data completeness. Any data deficiencies and their effect on project goals will be evaluated in the New York State Data Usability Summary Report (DUSR).

## 13.4 Representativeness

Representativeness is a qualitative statement that expresses the extent to which the sample accurately and precisely represents the characteristics of interest of the study. Representativeness is primarily concerned with the proper design of the sampling program and is best ensured by proper selection of sampling locations and the taking of a sufficient number of samples. It is addressed by describing the sampling techniques, the matrices sampled, and the rationale for the selection of sampling locations, which are discussed in the field sampling plan and Work Plan

## 13.5 Comparability

Comparability is a qualitative parameter expressing the confidence that one set of data can be compared to another. Comparability is possible only when standardized sampling and analytical procedures are used.

# 14. Corrective Action

If unacceptable conditions are identified as a result of audits or are observed during field sampling and analysis, the PM, Field Team Leader, and QA officer will document the condition and initiate corrective procedures. The specific condition or problem will be identified, its cause will be determined, and appropriate action will be implemented.

The entire sampling program will be under the direction of the PM and QA officer. The emphasis in this program is on preventing problems by identifying potential errors, discrepancies, and gaps in the data collection, laboratory analysis, and interpretation process. Any problems identified will be promptly resolved. Likewise, follow-up corrective action is always an option in the event that preventative corrective actions are not effective.

The acceptance limits for the sampling and analyses to be conducted in this program will be those stated in the method or defined by other means in the Work Plan and FSP. Corrective actions are likely to be immediate in nature and most often will be implemented by the contracted laboratory analyst or the PM. The corrective action will usually involve recalculation, reanalysis, or repeating a sample run.

## 14.1 Immediate Corrective Action

Corrective action in the field may be needed when the sample requirements are changed (i.e., more/less samples, sampling locations other than those specified in the Work Plan), or when sampling procedures and/or field analytical procedures require modification, etc. due to unexpected conditions. The field team may identify the need for corrective action. The Field Team Leader, Site Manager and PM will approve the corrective action and notify the QA officer. The PM and QA officer will approve the corrective measure. The Field Team Leader and Site Manager will ensure that the corrective measure is implemented by the field team.

Corrective actions will be implemented and documented in the field record book. Documentation will include:

- A description of the circumstances that initiated the corrective action
- The action taken in response
- The final resolution
- Any necessary approvals

No staff member will initiate corrective action without prior communication of findings through the proper channels.

Corrective action in the laboratory will be completed in accordance with the quality assurance procedures located in the Appendix A. Any corrective actions completed by the laboratory will be documented in both the laboratory's corrective action files, and the narrative data report sent from the laboratory to the PM. If the corrective action does not rectify the situation, the laboratory will contact the PM, who will determine the action to be taken and inform the appropriate personnel.

If potential problems are not solved as an immediate corrective action, the contractor will apply formalized long-term corrective action if necessary.

# Tables

# Appendix A

## Severn-Trent Laboratory Quality Assurance Plan (Electronic Media)

# Appendix B

## Environmental Forensic and Geochronology Standard Operating Procedures (Electronic Media)