Quality Assurance Project Plan

Flow/Solids Monitoring and Sediment Thickness Characterization

Tittabawassee River, Michigan

Revised: October, 2003

Adopted by: _____ Date: _____

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Limno-Tech, Inc.

Environmental Engineering

Ann Arbor, Michigan

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DISTRIBUTION LIST

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1 Project Management (Group A)

The purpose of the Quality Assurance Project Plan (QAPP) is to document the necessary procedures required to assure that the project is executed in a manner consistent with applicable United States Environmental Protection Agency (U.S. EPA) guidance documents and with generally accepted and approved quality assurance objectives. This QAPP is organized in accordance with the basic groups and subgroup elements discussed in the U.S. EPA guidance for QAPPs. The four basic groups include project management (Group A); data generation and acquisition (Group B); assessment and oversight (Group C); and data validation and usability activities (Group D). The groups are subdivided into elements covering specific topics related to each group. The Section and Subsection headings of this QAPP include references to the U.S. EPA QAPP Guidance group letters and element numbers to facilitate cross-reference with the Guidance. For example, Section 1 of this QAPP presents Group A (project management) requirements and Subsection 1.1 discusses the group element A4 (Project Organization) requirements.

This QAPP was prepared in conjunction with the Work Plan and Health and Safety Plan (HASP) for use in conducting the water quality sampling activities in accordance with the *Work Plan for Flow/Solids Monitoring and Sediment Thickness Characterization, Tittabawassee River*.

This QAPP provides guidance and specifications to assure that:

- proper preventive maintenance, equipment calibration, and approved analytical protocols will be implemented so that all field measurements and sampling analytical results will be valid;
- sampling is conducted using sample tracking systems and chain-of-custody procedures which properly identify samples being collected and insure the control of those samples from field collection through analysis and data reduction;
- records are produced and retained to document the quality of samples collected and analyzed, the validity of applied procedures, and the completeness of the investigation in relation to the approved scope of the project;
- generated data is validated; and
- calculations, evaluations, and decisions completed or deduced during the execution of the study are accurate, appropriate, and consistent with the objectives of the work plans.

The requirements of this QAPP are applicable to the activities of all participants in the investigation. This QAPP will address all anticipated activities necessary to execute the investigation. Section 1 of this QAPP summarizes project management activities and Section 2 presents QA/QC elements pertaining specifically to monitoring activities for the project.

1.1 Project Organization (A4)

Limno-Tech, Inc. (LTI), has been contracted by The Dow Chemical Company of Midland, Michigan to conduct activities which will build on previous studies to further quantify the modes of solids transport through the Tittabawassee River, and determine the current

inventory and distribution of sediment in the river. LTI will maintain the technical responsibility for implementing the water quality sampling activities. The analytical laboratory services for this project will be provided by Ann Arbor Technical Services, Inc. in Ann Arbor, Michigan.

LTI staff members report to their team leader and the project manager for technical and administrative direction. Each staff member has responsibility for performance of assigned quality control duties in the course of accomplishing identified sub-tasks. The quality control duties include:

- completing the assigned task on or before schedule and in a quality manner in accordance with established procedures.
- ascertaining that the work performed is technically correct and meets all aspects of the QAPP.

1.2 Project Team Responsibilities

LTI is responsible for development and implementation of the *Work Plan for Flow/Solids Monitoring and Sediment Thickness Characterization, Tittabawassee River* and this QAPP. Ann Arbor Technical Services, Inc. is responsible for all laboratory analytical testing associated with the monitoring program.

The roles and responsibilities of LTI personnel that will work on this project are as follows:

Role	Personnel	General Responsibilities
Project Administrator	Greg Peterson	General oversight; Review/approval of all work products
Project Manager	John Wolfe	Project management; Direct all field, data evaluation, and reporting activities
Project Engineer/Scientist	Robert Betz Tim Dekker Richard McCulloch Cathy Whiting *(Field Manager)*	Supervise all field sampling, quality assurance, data evaluation, and reporting activities
Assistant Project Engineer/Scientist	Chris Behnke Chris Cieciek Brian Lord	Field and technical support

Responsibilities and duties of the analytical laboratory include the following:

- Perform analytical procedures;
- Supply sampling containers and shipping cartons;
- Maintain laboratory custody of samples;
- Strictly adhere to all protocols in the QAPP;
- Notify LTI project manager in advance of any deviations to QA protocols.

1.2.1 Project Administrator

The project administrator is responsible for the overall administration and staffing of the project. As part of the QA/QC responsibilities, the project administrator will:

- Provide for overall direction of project objectives and activities as defined in the work plans;
- Provide for QA/QC management of all aspects of the project within the responsibility scope of LTI;
- Approve reports and other materials for release to members of the project team and other external organizations.

1.2.2 Project Manager

The project manager is responsible for maintaining a clear definition of and adherence to the scope, schedule, and budget of the project. As a part of this responsibility, the project manager will:

- Serve as the communication link with the project team members and client(s);
- Direct all work performed by LTI and its subcontractors;
- Perform final review of field data reductions, reports submittals, and presentations;
- Assure corrective actions are taken for deficiencies noted during project activities;
- Maintain budgetary and schedule surveillance of the work.

1.2.3 Project Engineer/Scientist

The project engineer/scientist is responsible for the implementation of field activities, initial data acquisition, health and safety aspects of field activities, and for the proper selection and execution of procedures that have been accepted for use in the investigation. As part of the QA/QC responsibilities, the project engineer/scientist will:

- Supervise assistant project engineers/scientists, technicians, or subcontractors executing data gathering tasks;
- Supervise the collection of samples so that sampling remains representative of actual field conditions;
- Supervise the regular maintenance of equipment to prevent unnecessary equipment failures and project delays caused thereby;
- Review the effectiveness of procedures and suggest changes that will enhance or more efficiently accomplish the objectives of the Work Plan;
- Prepare and review field data reductions, reports, submittals, and presentations to assure that data and conclusions accurately reflect observed conditions in the field;
- Assist in the maintenance of budgetary and scheduling surveillance.

1.2.4 Assistant Project Engineer/Scientist

The assistant project engineer/scientist is responsible for assisting in the implementation of field activities, initial data acquisition, health and safety aspects of field activities, and for the proper selection and execution of procedures that have been accepted for use in the investigation. As part of the QA/QC responsibilities, the assistant project engineer/scientist will:

- Perform data gathering and compilation tasks;
- Assist in supervising technicians and subcontractors;
- Assist in reviewing the effectiveness of procedures and suggest changes that will enhance or more efficiently accomplish the objectives of the Work Plan;
- Assist in the collection of samples so that sampling remains representative of actual field conditions;
- Perform regular maintenance and calibration of equipment to prevent unnecessary equipment failures and project delays caused thereby;
- Assist in the preparation and review of field data reductions, reports, submittals, and presentations to assure that data and conclusions accurately reflect observed conditions in the field.

1.3 Problem Definition/Background (A5)

The project background information is presented in the *Work Plan for Flow/Solids Monitoring and Sediment Thickness Characterization, Tittabawassee River* (Limno-Tech, 2003). This QAPP was developed to address necessary monitoring activities identified in this workplan.

1.4 Project/Task Description (A6) and Schedule

The *Work Plan for Flow/Solids Monitoring and Sediment Thickness Characterization, Tittabawassee River* identifies the major tasks involved in the study, together with sub-tasks required for the completion of each major task. The work plan defines the methodology to be employed by the project staff in satisfying the defined objectives of the study and describes the monitoring program to collect new data for this project, including identifying sampling locations, measurements and analyses to be conducted, number of samples to be collected, and equipment requirements. The work plan also identifies specific work products, including deliverable items such as reports. This QAPP addresses monitoring activities defined in the work plans.

The work plans contain project schedules for the study that identify the approximate start time, duration, and the approximate end time of each task. The schedule will be updated as necessary and will be used by the Project Manager to review overall progress on the project.

1.5 Quality Objectives and Criteria (A7)

The monitoring information that will be collected will meet the quality assurance objectives outlined in this section. Data quality will be measured in terms of accuracy, precision, completeness, representativeness, comparability, and the required detection limits for the analytical methods.

1.5.1 Accuracy

Accuracy is the measure of the agreement between an observed value and an accepted reference value or true value.

Laboratory Accuracy Objectives

Laboratory accuracy will be assessed through the analysis of matrix spikes and/or laboratory control samples, as and if required by the analytical methods, to determine percent recoveries (%R). Table 1 provides a summary of the laboratory accuracy objectives. The %R utilizing matrix spikes is calculated as follows:

$$\%R = \frac{(C_S - C_U)}{C_A} \; x \; 100$$

where C_S = measured concentration of spiked sample
C_U = measured concentration of unspiked sample
C_A = actual concentration of spike added

The %R utilizing laboratory control samples is calculated as follows:

$$\%R = \frac{(C_M)}{(C_A)} \; x \; 100$$

where C_M = measured concentration of control sample
C_A = actual concentration of control sample

Dilution blank samples and method blank samples will be generated by the contract laboratory, as and if required by the analytical method, for use in assessing contamination resulting from laboratory procedures. Duplicate analyses will be performed as required to check for sampling and analytical reproducibility. Matrix spikes provide information concerning the effect of the sample matrix on the measurement methodology.

Table 1 Data Accuracy Objectives

Parameter	Estimated by	Objective
Total Suspended Solids (TSS)	NA	NA
Total Organic Carbon (TOC)	Control/Matrix Spike	80-120%

NA = not applicable or not conducted

Field Accuracy Objectives

Field accuracy will be assessed through the use of field blanks. In order for the accuracy assessment to be relevant, all appropriate protocols concerning sample collection, handling, preservation, and hold times must be maintained.

For grab sampling, field blanks will be used to determine if samples collected have been contaminated. Field blanks consisting of reagent grade deionized water will be submitted to the analytical laboratory to assess the quality of the data resulting from the field monitoring program. Field blanks will be analyzed to check for procedural contamination at the

laboratory that may cause sample contamination.

Similarly, equipment that is used to collect samples for analysis may become contaminated through the normal course of monitoring. If not properly cleaned and rinsed, samples obtained subsequently may be contaminated from previous locations. Equipment and field blanks will be used to assess cross-contamination of samples by the equipment or method utilized.

1.5.2 Precision

Precision is a measure of the agreement between two or more measurements. Table 2 provides a summary of the data precision objectives for field and laboratory measurements. Table 2 applies if the average result of the duplicate/replicate samples is greater than five times the analysis detection limit. If the average result of the duplicate/replicate samples is less than five times the analysis detection limit, the precision test will not be utilized.

Table 2 Data Precision Objectives

Parameter	Field Precision – RPD		Analytical Precision - RPD	
	Estimated By	Objective	Estimated By	Objective
Total Suspended Solids (TSS)	Field Duplicates	30%	Lab Replicates	30%
Total Organic Carbon (TSS)	Field Duplicates	30%	MS/MSD	20%

Field Precision Objectives

Field precision tests are conducted for grab samples and physical parameter readings. The precision of grab samples is assessed by the comparison of field duplicates. The relative percent difference (RPD) between the analyte levels measured in the field duplicates is calculated as follows:

$$RPD = \frac{|C_A - C_B|}{0.5(C_A + C_B)} \times 100$$

where C_A = measured concentration of sample
C_B = measured concentration of duplicate sample

The precision of physical parameter readings may be assessed by the comparison of each instrument's calibration readings versus the post check readings. The RPD between the readings is calculated as follows:

$$RPD = \frac{|R_X - R_Y|}{0.5(R_X + R_Y)} \times 100$$

where R_X = calibration reading
R_Y = post check reading

Laboratory Precision Objectives

The precision of the laboratory analysis is assessed by the comparison of matrix spikes (MS) and matrix spike duplicates (MSD), if required by the analytical method. The RPD between the analyte levels measured in the MS sample and the MSD sample is calculated as follows:

$$RPD = \frac{|C_{MS} - C_{MSD}|}{0.5(C_{MS} + C_{MSD})} \times 100$$

where C_{MS} = measured concentration of the matrix spike
C_{MSD} = measured concentration of the matrix spike duplicate

In situations where spiked samples are not practicable (such as bacteria, $CBOD_5$, and TSS) to assess laboratory precision, a comparison of laboratory replicate analyses may be performed in order to calculate the RPD.

1.5.3 Completeness

Completeness is a measure of the amount of valid data obtained from the monitoring program compared to the amount of data that were expected. Events that may contribute to reduction in measurement completeness include sample container breakage, inaccessibility to proposed sampling locations, automatic sampler failure, and laboratory equipment failures.

The percent completeness (%C) is determined as follows:

$$\%C = \frac{(M_V)}{(M_P)} \times 100$$

where M_V = number of valid measurements
M_P = number of planned measurements

If the completeness objectives are not achieved for any particular category of data, the Project Manager will provide documentation why the objective was not met and how the lower percentage impacted the overall study objectives. If the objectives of the study are compromised, re-sampling or re-measurement may be necessary.

Field Completeness Objective

Field completeness is determined by the number of measurements collected versus the number of measurements planned for collection. The details concerning the actual number of field measurements and samples to be collected are discussed in the work plans. The number of measurements collected are validated by the Field Manager. The completeness criterion for all measurements and sample collection is 90 percent, but will be influenced by environmental situations that may alter monitoring schedules.

Laboratory Completeness Objective

Laboratory completeness is a measure of the amount of valid measurements obtained from all samples submitted for each sampling activity. The laboratory Technical Director assures the validity of the measurements reported and the Project Manager or designee validates the numbers of valid measurements. The completeness criterion for all measurements is 95 percent.

1.5.4 Representativeness

Representativeness is the degree to which data accurately and precisely represent a characteristic of a population, parameter variations at a sampling point, a process condition, or an environmental condition. Representative data of dry weather and wet weather conditions are required to support evaluation and modeling efforts.

For sample collection, representativeness will be assured by following the work plans and applying proper collection techniques including the proper sample sizes and volumes, sampling times, and sampling locations. The volumes of the samples depend on the analytical methods and should allow for QC sample analysis and reanalysis, if required. In the laboratory, representativeness will be ensured by using the appropriate sample preparation techniques, by following appropriate analytical procedures, and by meeting the recommended sample holding times.

1.5.5 Comparability

The objective for data comparability is to generate data for each parameter that are comparable between sampling locations and comparable over time. Data comparability will be promoted by:

- using standard approved methods, where possible;
- consistently following the sampling methods detailed in the SOPs;
- consistently following the analytical methods detailed in the QAPP;
- achieving the required detection limits detailed in the QAPP.

All sample collection and analytical methods will be specified, and any deviations from the methods will be documented. All results will be reported in the standard units shown in Table 3. All field and laboratory calibrations will be performed using standards traceable to National Institute of Science and Technology (NIST) or other U.S. EPA approved sources.

1.5.6 Required Detection Limits

The required detection limits (RDL) and methodology for the study are provided in Table 3. The RDLs were set to meet project requirements and are based on the Project Team's experience in having environmental samples analyzed similar to those to be collected. For the analytes specified for this study, all the RDLs are at the usual contract laboratory detection limits.

Table 3 Required Detection Limits

Parameter	Reference or Methodology	Method Detection Limit
Total Suspended Solids (TSS)	U.S. EPA 160.2 (2)	5.0 mg/L
Total Organic Carbon (TOC)	U.S. EPA 415.1 (2)	1.0 mg/L

Notes:
1. SM - Standard Methods for the Examination of Water and Wastewater, 20th Edition
2. U.S. EPA - EPA Methods for Chemical Analysis of Water and Wastes, March 1983

1.6 Special Training/Certification (A8)

Special training/certification needed for project, field, and laboratory staff to successfully complete project work is discussed in this section.

1.6.1 Project Staff

A variety of professional staff (engineers, scientists and others) will be involved in this monitoring program. Project staff will be assigned duties based on their qualifications to accomplish the task. The Project Manager will determine the appropriateness of an individual to undertake a task.

1.6.2 Field Staff

Training sessions will be carried out for all field staff on proper sampling, sample handling and shipping, and general field procedures prior to conducting the first sampling event. Specific emphasis will be placed on QA/QC issues as well as on health and safety. Field staff will receive a safety briefing conducted by the QA/QC Manager and/or Field Manager. Emphasis will be on field hazards and materials handling. The *Health and Safety Plan* outlines safety issues.

Field crews will receive training involving the operation, maintenance and calibration of field equipment including multi-parameter probes, velocity meters, and all other on-site equipment used throughout the field program.

SOPs for program elements will be distributed to appropriate staff and available at all times.

1.6.3 Laboratory Staff

The laboratory Technical Director will be the main point of contact for coordinating all sample drop-offs, pick-ups, etc. The laboratory Technical Director will be assisted by the laboratory QA/QC Manager in performing review and validation of all data generated to assure all data quality objectives have been met. The Technical Director or QA/QC Manager will contact the Project Manager or Field Manager immediately regarding any problems with samples that are noted during log in or with analysis. Prior to conducting the first sampling event, the Project Manager and/or Field Manager will communicate with the laboratory

Technical Director to review details of the planned progression of sampling events.

Laboratory staff may include Biologists, Microbiologists, Chemists, and Technicians with specific experience in sampling analysis. The laboratory staff will be on call 24 hours a day and 7 days a week for wet weather events, including weekends and holidays.

All laboratory personnel receive training and have proven proficiency in their designated analytical procedures. Laboratory personnel have been provided copies of the appropriate SAPs, which will be available at all times.

1.7 Documents and Records (A9)

The Project Manager will ensure that the project team has the most current approved version of the QAPP. The project manager is responsible for initiating project files and for overseeing maintenance of the files during the course of the project. All project files will be properly identified by client, project name, project number, file description, and file number for all appropriate correspondence, memoranda, calculations, technical work products, and other project-related data. In addition, a quality assurance file will be maintained containing all QA/QC related information. A back up of all computer files containing important project information will also be maintained.

Documents generated by field activities may include staff notes, field logs, equipment logs, field on-site measurement data sheets, field audit reports, chain of custody forms. Documents generated by laboratory activities may include QA/QC documentation, laboratory bench sheets, laboratory results, and laboratory audit reports. These documents will be maintained in the project files.

At the conclusion of the project, all relevant information from the project files and computer disks will be archived. Documents will be retained for a minimum period of three years following archiving.

2 Data Generation and Acquisition (Group B)

The U.S. EPA QAPP Guidance Group B Data Generation and Acquisition elements (B1-B10) are addressed below.

2.1 Sampling Process Design (B1)

The sampling process design is presented in the work plans, including sampling rationale, strategies, locations, media, frequencies, and schedules.

2.2 Sampling Methods (B2)

Standard operating procedures (SOPs) will be employed to provide consistency and reproducibility to the sampling methods used by field personnel. The following sections present or reference the detailed methods for performing sampling activities including related support procedures for equipment cleaning, field measurements, and calibration and maintenance of field instruments. Sample custody procedures are presented in the Sample Handling and Custody Section of this QAPP. For all sampling related procedures, personnel will use personal protective equipment as required by the HASP.

2.2.1 Surface Water Sample Collection

Surface water grab samples will be collected as specified in the Water Quality Monitoring Plan and/or according to the procedures presented in Appendix A.

2.2.2 Stream Discharge Monitoring

Stream discharge monitoring will be conducted as specified in the Water Quality Monitoring Plan and/or according to the procedures presented in Appendix A.

2.2.3 Cleaning of Equipment and Materials

All reusable equipment and materials used during the field activities will be cleaned prior to use at the site and at specified intervals during the field activities. Cleaning will be performed according to the procedures specified in the work plans and/or as presented in Appendix A to avoid the introduction of any chemical constituents or cross-contamination to the soils or groundwater. Equipment and materials that may be used during the investigation include water and/or sediment sample collection devices.

Equipment cleaning will be performed using water from a source approved by the project manager or engineer. A designated cleaning or decontamination area will be used or constructed, if necessary, so that all water generated during cleaning operations will be contained for proper disposal.

2.3 Sample Handling and Custody (B3)

Sample handling will be performed so as to collect, store, submit to the laboratory and analyze representative samples using methods as specified in the work plans and/or according to the procedures presented in Appendix A. Sample containers, volumes, preservatives and holding times are summarized in Table 4. Proper sample handling and custody procedures will be employed as discussed in the following subsections of this QAPP.

2.3.1 Field Sample Custody

The objective of field sample custody is to assure that samples are traceable and are not tampered with between sample collection and receipt by the analytical laboratory. A person will have custody of a sample when the samples are:

- In their physical possession;
- In their view after being in their possession;
- In their personal possession and secured to present tampering;
- In a restricted area accessible only to authorized personnel and;
- The person is one of the authorized personnel

Field custody documentation will consist of both field log books and chain of custody forms.

Chain-of-Custody Forms. Completed chain-of-custody forms will be required for all samples to be analyzed. Chain-of-custody forms will be filled-out by the field sampling crew during the sample collection events. The chain-of-custody form will contain the samples:

- Unique identification number;
- Sample date and time;
- Sample description;
- Sample type
- Sample preservation (if any) and;
- Analyses required.

The original chain-of-custody form will accompany the samples to the laboratory. Copies will be made prior to shipment for separate field documentation. A chain-of-custody form is included in Appendix A. The chain-of-custody forms will remain with the samples at all times. The samples and signed chain-of-custody form will remain in the possession of the sampling crew until the samples are delivered to the express carrier (e.g., Federal Express).

Sample Packing and Shipping Requirements. Sample packaging and shipping procedures are designed to ensure that the samples and the chain-of-custody forms will arrive at the laboratory intact and together. Samples will be properly packaged for shipment according to the procedures presented in Appendix A and submitted to the appropriate laboratory for analysis. Shipping containers will be secured with strapping tape and custody seals, if required, for shipment to the laboratory. The preferred procedure includes use of a custody seal attached to the front right and back left of the cooler. The custody seals are covered with clear plastic tape. The cooler is strapped shut with strapping tape in at least two locations.

All shipments will be accompanied by the chain-of-custody form identifying the contents. It is preferred that a separate chain-of-custody form be complete for and placed in each shipping container. The original form will accompany the shipment and copies will be retained by the sampler for the sampling office records.

If sample containers are sent by common carrier (i.e., by Federal Express or United Parcel Service), The carrier need not sign the chain-of-custody form. In such cases, the chain-of-custody form should be sealed inside the sample container. The bill of lading (i.e., Federal Express label) serves as the custody documentation for the shipment so long as the container

remains unopened until arrival at the laboratory. Copies of the bill of lading should be retained as part of the permanent documentation of the project.

2.3.2 Laboratory Sample Custody

Laboratory sample custody will be performed in accordance with the laboratory's Quality Assurance Manual and will be consistent with the guidelines set forth in this section of the QAPP.

The laboratory must have written standard operating procedures (SOPs) for sample custody including:

- Sample receipt and maintenance of custody;
- Sample storage; and
- Sample tracking.

In addition, the laboratory shall have written SOPs for laboratory safety, cleaning of analytical glassware, and traceability of standards used in sample analysis QA/QC.

A SOP is defined as a written narrative step-wise description of laboratory operating procedures including examples of laboratory documentation. The SOPs must accurately describe the actual procedures used in the laboratory, and copies of the written SOPs shall be available to the appropriate laboratory personnel. These procedures are necessary to ensure that analytical data produced are acceptable for use. The laboratory SOPs shall provide mechanisms and documentation to meet the specification of the following sections.

Sample Receipt and Maintenance of Custody. The laboratory shall have a designated sample custodian responsible for receipt of samples and have written SOPs describing duties and responsibilities.

The laboratory shall have written SOPs for receiving and logging in of the samples. The procedures shall include but not be limited to documenting the following information:

- Presence or absence of chain-of-custody forms,
- Presence of absence of bills of lading
- Presence or absence of custody seals on shipping and/or sample containers and their conditions,
- Presence or absence of sample labels,
- Sample label ID numbers if not recorded on the chain-of-custody record(s) or packing list(s),
- Condition of the shipping container,
- Condition of the sample bottles,
- Verification of agreement or nonagreement of information on receiving documents,
- Resolution of problems or discrepancies.

Sample Storage. After samples are received, they are placed in secure storage (e.g., locked refrigerators) where they are maintained at 4 degrees Celcius. Samples to be analyzed for volatile compounds are stored separately to minimize the risk of contamination.

The laboratory shall have written SOPs for maintenance of the security of samples after log-in and shall demonstrate security of the sample storage and laboratory areas. The SOPs shall specifically include descriptions of all storage areas for samples in the laboratory, and steps taken to prevent sample contamination. Only authorized personnel should have access or keys to secure storage areas.

Sample Tracking. The laboratory shall have written SOPs for tracking the work performed on any particular sample. Documentation of sample receipt, sample storage, sample transfers, sample preparations, sample analyses, instrument calibration and other QA/QC activities shall be performed.

2.4 Analytical Methods (B4)

The following section details aspects of the analytical requirements, ensuring that appropriate analytical methods are employed. Appendix B contains the Laboratory Quality Assurance Program (QAP). Table 3 summarizes the analytical methods to be used by the contract laboratory.

2.4.1 Parameter Specific Information

Table 4 displays the required container type, sample volume, preservation, and holding time for each parameter according to the previously referenced methods. The laboratory will provide sample containers from a commercial supplier. All sample containers will be new and/or pre-cleaned (and sterilized for bacteria sample containers). In addition, the laboratory will provide sample labels for each bottle and provide the required preservative for each parameter, where specified.

Table 4 Guidelines for Sample Container Preparation and Preservation

Parameter	Container	Recommended Sample Volume	Preservation	Holding Time
TSS	Polyethylene or Glass	1000 ml	Refrigerate to 4°C	28 days
TOC	Polyethylene or Glass	1000 ml	Refrigerate to 4°C	28 days

2.4.2 Laboratory Chain of Custody Procedures

Use of the chain-of-custody form may terminate when laboratory personnel receive the samples, sign the form and enter the samples into the laboratory tracking system. The laboratory custodian will open the sample coolers and carefully check the contents for evidence of leakage and to verify that samples were kept on ice. The laboratory will then verify that all information on the sample container label is correct and consistent with the chain-of-custody form. Any discrepancy between the sample bottle and the chain-of-custody form, any leaking sample containers, or any other abnormal situation will be reported to the laboratory Technical Director. The laboratory Technical Director will inform the Field Manager of any such problem, and corrective actions will be discussed and implemented.

2.4.3 Analytical Records

The analytical data results and intra-laboratory QA/QC results will be submitted by the contract laboratory to the Field Manager or other designated contact person within a specified time frame from the completion of each sampling event.

2.5 Quality Control (B5)

Analytical quality control will be performed in accordance with the specified analytical methods and as discussed under the Quality Objectives and Criteria Section of this QAPP.

2.6 Instrument/Equipment Testing, Inspection, and Maintenance (B6)

Field analytical equipment that may be used in this project include instruments for measuring conductivity, pH, temperature, dissolved oxygen and turbidity. Testing, inspection and maintenance will be conducted in accordance with manufacturer instructions. Calibration frequency and preventive maintenance procedures are provided in Appendix A.

Laboratory instrumentation and equipment will follow manufacturer instructions and accepted procedures associated with the selected analytical methods, the laboratory's QAP and SAPs.

2.7 Instrument/Equipment Calibration and Frequency (B7)

Field analytical equipment that may be used in this project include instruments for measuring conductivity, pH, temperature, dissolved oxygen and turbidity. Calibration procedures for the equipment will follow manufacturer instructions. In order to maintain field precision and accuracy, the water quality instruments will be calibrated to known standards. Field analysis and operation procedures, including calibration and sample analysis, are provided in Appendix A.

Laboratory instrument calibration will follow manufacturer instructions and accepted procedures associated with the selected analytical methods, the laboratory's QAP and SAPs.

2.8 Non-direct Measurements (B9)

Non-direct measurements will not be used in implementation of the monitoring program.

2.9 Data Management (B10)

Data generated through field and laboratory activities will be used for developing models and reports. Reporting formats will vary depending on the purpose for which the data has been assembled. The Field Manager, Project Manager or designee has the responsibility of maintaining documents and data associated with field programs. The Laboratory Technical Director has the same responsibility for laboratory data and information.

2.9.1 Field Data and Information Management

Field data reporting shall be conducted principally through the transmission of data sheets containing tabulated results of all measurements taken in the field, and documentation of all

field calibration activities. Field logs, equipment logs, and/or field data sheets will be turned over to the Field Manager following each monitored event. Following review by the Field Manager, the field sheets will be transmitted to the Project Manager and/or project files. Examples of standard field forms are provided in the standard operating procedures (SOPs) in Appendix A.

Field log books serve as a daily record of events, observations, and measurements during field activities. All information pertinent to sampling activities is recorded in the log books. The log books may be bound with the pages sequentially numbered or include separate sheets for field notes and method specific data logs. These separate logs will be secured in a binder at the end of the day and numbered sequentially. Entries in the log book will include:

- Name and title of author
- Name(s) of field crew
- Name(s) of site visitors
- Date and time of site entry
- Location of sampling activity
- Description of sample location
- Number and volume of samples taken
- Date and time of collection
- Sample identification numbers
- Sampling method
- Preservatives used
- Field measurements (pH, etc.)
- Date and time of shipment
- Shipment method
- Field Observations

2.9.2 Laboratory Data and Information Management

The reporting of laboratory data will begin after the laboratory Technical Director or designee has concluded the verification review. The laboratory will prepare and submit analytical and QC reports to the Project Manager or designee that will include the following, as appropriate and agreed upon:

- hard copy report for all sample results;
- hard copy QC summary report for each parameter by batch including the results of any replicates, matrix spikes, matrix spike duplicates, controls, dilution blanks, method blanks, verification tests, etc.;
- copies of all laboratory bench sheets (if requested);
- copies of all chain-of-custody forms (if requested).

Following receipt of laboratory data by the Project Manager or designee, the data will be reviewed and validated following the procedures outlined in Section 2.4. Data will be stored in a database developed for the project.

2.9.3 Electronic Data Management

All electronic files will be backed up on a regular basis. At the conclusion of the project all relevant information, project files and electronic data will be turned over to the Project Manager. Electronic files will be retained for a minimum period of three years following archiving.

Electronic data also refers to information that is electronically recorded using data loggers. Data logging equipment, such as the continuous water quality meters, will be downloaded as described in the work plans. The data will be backed up immediately after an instrument is downloaded and the download procedure will be logged in field notes as well as on equipment log sheets.

3 Assessment and Oversight (Group C)

The U.S. EPA QAPP Guidance Group C Assessment and Oversight elements are addressed in this section.

3.1 Assessment and Response Actions (C1)

Internal quality control checks are performed to ensure that the field and laboratory generated measurements meet the project quality assurance objectives. In addition, the quality control checks are intended to identify any need for corrective action.

3.1.1 Field Measurements

Field quality control checks will consist of QA/QC samples that will be collected or prepared by the field crews to be submitted for laboratory analysis. These samples will consist of duplicates, field blanks, and/or equipment blanks. The acceptable control limits are discussed in Section 2.1.1. Upon receipt of the data from the monitored event, the Field Manager will assess the adequacy of the quality control checks and identify any problems.

In addition, quality control checks of multi-parameter meters will involve the review of the calibration sheets. Any problems with sensors will be addressed immediately. The result of each review will be recorded on the instrument calibration sheet or field log. At the conclusion of each monitored event, all calibration sheets will be reviewed by the Field Manager to assess the adequacy of the quality control checks and to review instrument performance to identify any problems.

The Field Manager will inform the Project Manager of any quality control check issues and to discuss corrective actions. All quality control documents will be retained in the project files.

3.1.2 Laboratory Measurements

The contract laboratory will perform quality control checks on all sample analyses. These will include replicates, matrix spikes, matrix spike duplicates, control samples, and method blanks as appropriate. Quality control procedures for analytical services will be conducted by the contract laboratory in accordance with their standard operation procedures and the individual method requirements. The acceptable control limits are discussed in Section 2.1.1. The laboratory Technical Director will inform the Project Manager immediately of any quality control check issues and to discuss corrective actions.

At the conclusion of each monitored event, the laboratory will provide a summary of all appropriate QA/QC results. The QA/QC summary will be reviewed by the laboratory Technical Director and the Field or Project Manager to assess the adequacy of the quality control checks and to identify any potential problems. Table 5 summarizes laboratory quality control check frequencies.

Table 5 Laboratory Quality Control Check Frequencies

Parameter	Batch Size	QC Check	Frequency
TSS	10 Samples	Replicate	1 each per analytical batch
TOC	10 Samples	Replicate	1 each per analytical batch

3.1.3 System Audits and Technical Reviews

All project team members are committed to providing quality services. The primary responsibility for the quality of work products rests with the individuals doing the work and with their immediate supervisors.

For certain project components, it may be necessary for an independent technical reviewer to audit or review the study products. This reviewer may be a team member not directly involved with the work being audited. The independent technical reviewer performs a critical, written evaluation of the work product, and the independent technical audit or review is then incorporated in the project record.

The Project Manager is responsible for identifying the work products to be audited/reviewed and the scope of the audit/review, for scheduling independent technical audits/reviews, for assigning competent, qualified independent technical auditors/reviewers, and for making sure that appropriate follow-up actions are taken to correct reported deficiencies.

Field System Audits. Field system audits may be completed to ensure that the actual field procedures conform to those documented in the work plans and associated SOPs. The Field Manager or designee performs the field system audits. The audit includes a check of all field records and a review of all activities to document if procedures were conducted in compliance with the specified documentation.

Laboratory System Audits. Independent auditors may complete a laboratory audit during the monitoring program. If necessary, the audit will be scheduled, preferably, during analysis of project samples. The audits include an assessment of all quality system documents (e.g., the laboratory QAP (Appendix B) and SAPs), a laboratory site visit and discussions with the laboratory Technical Director and QA/QC Manager. Also, spot checks may be performed to interview individual analysts with regard to methods used, knowledge of quality systems, training, and competency.

3.1.4 Corrective Action

Corrective actions will be implemented as required to rectify problems identified during the course of normal field and laboratory operations. Possible problems requiring corrective action include:

- equipment malfunctions,
- analytical methodology errors, and
- non-compliance with quality control systems.

Equipment and analytical problems that require corrective action may occur during sampling

and sample handling, sample preparation, and laboratory analysis.

For non-compliance problems, steps for corrective action will be developed and implemented at the time the problem is identified. The individual who identifies the problem is responsible for notifying the Project Manager of the problem immediately.

Field Measurements and Sample Collection. Project staff will be responsible for reporting any suspected QA non-conformance to the Field Manager. The Field Manager will be responsible for assessing the suspected problems in consultation with the Project Manager to review the sampling protocols and provide additional training if necessary.

The Field Manager will be responsible for ensuring that the corrective action for non-conformance takes place by:

- evaluating all reported incidences of non-conformance,
- controlling additional work on nonconforming items,
- determining what corrective action is needed,
- implementing and documenting the corrective action.

Laboratory Analyses

Corrective actions are required whenever laboratory conditions, instrument malfunction or personnel situations have led or could potentially lead to errors in the analytical data. The corrective action taken will be dependent on the analysis and the event.

Laboratory personnel are alerted that corrective actions may be necessary if:

- QC data are outside the acceptable range for precision and accuracy,
- blanks contain target analyses above acceptable levels,
- undesirable trends are detected in spike recoveries or RPD between duplicates,
- excessive interference is noted, or
- deficiencies are detected by the QA staff during laboratory system audits.

Corrective action procedures are often handled at the bench level by the analyst, who reviews the preparation or extraction procedure for possible errors, checks the instrument calibration, spike and calibration mixes, instrument sensitivity, and etc.

Corrective action taken within the laboratory is the responsibility of the laboratory Technical Director who informs the Field or Project Manager when a problem occurs and of the steps taken to resolve. Once resolved, full documentation of the corrective action procedure will be filed with the Field or Project Manager.

3.2 Reports to Management (C2)

Periodic summary reports will be prepared by the Project Engineer in charge of Quality Assurance, if necessary, to inform the Project Manager of the project status. The reports will include:

- Periodic assessment of measurement data accuracy, precision, and completeness;
- Results of performance audits and/or systems audits;

- Significant Quality Assurance/Quality Control problems and recommended corrective action;
- Status of corrective action implementation to any problems previously identified.

4 Data Validation and Usability (Group D)

The U.S. EPA QAPP Guidance Group D Data Validation and Usability elements are addressed in this section. The purpose of these elements are to determine if the data meet the project's Data Quality Objectives (validation) and to evaluate the data against the method, procedural and/or contractual requirements (verification). Data validation, verification, and usability assessment will be conducted as outlined in this QAPP.

The data generated from the sampling program will be subjected to a multi-tiered review process described below. This process includes:

- A review of the data at the bench and field levels;
- A secondary review of field records by the Field Manager and analytical results within the laboratory by the lab QA/QC Manager to verify the data against method and SOP requirements;
- A review of the verified data by the Project Manager or designee for reasonableness and to identify obvious data anomalies;
- A validation by an objective third party, if necessary; and
- An assessment of the data by project team members for its usability to meet the project goals.

4.1 Data Review, Verification and Validation (D1)

All environmental measurement data collected by project staff will be subjected to quality control checks before being utilized in the interpretive reporting. A data generation system that incorporates reviews at several steps in the process is designed to protect the integrity of the data and reduce the number of data that do not meet the Data Quality Objectives (DQOs) or the project goals. This section describes the requirements of each review step that will be used in this project.

4.1.1 Data Verification Requirements

The definition of data verification, as described in the EPA's "Guidance on Environmental Data Verification and Data Validation" (EPA QA/G-8) is:

> "…the process of evaluating the completeness, correctness, and conformance/compliance of a specific dataset against the method, procedural or contractual requirements."

Data verification will occur at the field and laboratory level. This section describes the requirements of the data verification.

Field Activities Data Verification. The Field Manager will be responsible for ensuring that the samples are collected and handled according to the procedures specified in the work plans. Sample collection verification will include confirming that the samples were collected with the proper equipment at the appropriate locations with the appropriate frequency. Sample handling verification will include confirming that the samples were stored in the appropriate containers (see Table 4) with the correct preservative, that the samples were

stored at the proper temperature during transport from the field to the laboratory, and that all of the appropriate information is logged on the chain-of-custody records.

Lab Activities Data Verification. The laboratory QA/QC Manager will be responsible for verification of laboratory-generated data, although the laboratory SAPs for each method may require some components of the verification to also be conducted at the bench level. Laboratory verification will include assessing that the procedures used to generate the data are consistent with the method requirements as specified in the laboratory's SOPs and that the QA/QC requirements for each method are met. Examples of method requirements include verifying the calibration and data reduction procedures. However, these requirements vary by analyte and are presented in more detail in the laboratory's QAP and SAPs.

4.1.2 Data Review Requirements

The Field Manager will perform data reviews that consist of screening the field data sheets and laboratory data sheets according to established criteria listed in this section. If the established screening criteria are not met, an additional review of available laboratory data (e.g., quality control checks, relevant laboratory bench sheets) may be conducted. Investigation of the issue will be documented and the data will be discarded or flagged appropriately, identifying the limitations of the data.

Field Data Sheet Reviews. The following criteria may be used to screen the physical parameter measurements recorded by the field crews:

- temperature readings – check for reasonableness of values
- pH readings – check for reasonableness of values
- dissolved oxygen readings –compare concentrations to percent saturation
- conductivity readings – check for reasonableness of values

Laboratory Data Sheet Reviews. The following criteria will be used to screen the analytical measurements performed by the contract laboratory:

- equipment blanks –values should be less than detection limits
- method blanks –values should be less than detection limits
- field blanks – are values less than detection limits
- review of all analytical results – check for reasonableness of values
- TKN / ammonia ratios – TKN should be greater than NH_3

4.1.3 Data Validation Requirements

The purpose of data validation, as described in the EPA's "Guidance on Environmental Data Verification and Data Validation" (EPA QA/G-8) is:

> "…an analyte- and sample-specific process that extends the evaluation of data beyond method, procedural, or contractual compliance to determine the analytical quality of a specific data set."

According to EPA guidance, the data validation is typically performed by someone independent of the project activity and not associated with the organization responsible for

producing the dataset. However, the data validator needs to be familiar with both the data validation requirements and the project objectives. A scientist/engineer not directly involved in the field or laboratory operations will conduct the data validation. There are four requirements in the data validation process as follows:

- Inspect the data verification and review records to ensure that no oversights were made during that process.
- Evaluate the data against the project DQOs. If data do not meet one or more of the DQOs, the data validation process will include an investigation into causes and an assessment of the impact of the noncompliant data on project objectives.
- Evaluate the data in the context of the project's overall objectives.
- Communicate the data validation results to the rest of the project team.

4.2 Verification and Validation Methods (D2)

All environmental measurement data and samples collected by project staff will be subjected to quality control prior to being entered into the project database. This is a multi-step process where the laboratory QA/QC Manager will have primary responsibility for verifying the data and a third party, preferably on who is not involved in data collection or analysis, conducts the data validation. These steps are described in more detail in the following sections.

4.2.1 Data Verification

This section describes the procedures that will be utilized in this project for verifying the data against method, procedural and/or contractual requirements.

Field Activities Data Verification. Individual crew leaders will verify the completion of their field data sheets and chain-of-custody forms. In addition, crew leaders will also verify the proper calibration and operation of their multi-parameter instruments. At the completion of each monitored event, the Field Manager will review all field data sheets, calibration sheets, and chain-of-custody forms for accuracy and completeness. The Field Manager will also verify that monitoring QA objectives for all accuracy, precision, completeness, and adherence to the required collection techniques are being met.

Laboratory Analytical Results Verification. Individual analysts will verify the completion of the appropriate analytical test and required bench sheets. The laboratory Technical Director or designee will review calculations and inspect laboratory bench sheets and log books daily to verify their accuracy, completeness, and adherence to the specified analytical method protocols. Calibration and QC data will be examined daily by the individual analyst. The laboratory Technical Director or designee will verify that all instrument systems are under control and that QA objectives for accuracy, precision, completeness, and adherence to the required detection limits are being met.

A summary of reportable QA/QC results and any non-conformance issues will be included in the laboratory deliverable to the Field or Project Manager.

4.2.2 Data Validation

This section describes the process that may be used to validate the data generated for this project. The first requirement is to inspect the data, verification and review records to ensure that no oversights were made during that process. A complete set of field and laboratory information will be provided to the data validator for this task.

The primary objective of the data validation in this project is to evaluate the data conformance with the project DQOs. These DQOs include criteria for accuracy, precision, completeness, representativeness, comparability and compliance with required detection limits. The components described under the Data Management Section of this QAPP will provide the necessary information to make this evaluation. The following must be reviewed as part of the measurement data and analytical data validation activities:

- field measurement data,
- field sample collection information,
- sample custody records,
- laboratory analytical results,
- data review information and/or laboratory case narrative,
- quality control data.

The data validator will conduct a systematic review of the data for compliance with the established quality control criteria based on duplicate, replicate, spiked, control, and blank data results provided by the laboratory. In addition, quality assurance evaluations of data accuracy, precision, and completeness will be performed on the field measurement data and the laboratory analytical results for each monitored event. The data validation qualifiers listed in Table 6 will be used when validating the data:

Table 6 Data Validation Qualifiers

Qualifier	Definition
U	The material was analyzed for, but was not detected above the level of the associated value. The associated value is either the sample quantitation limit or the sample detection limit.
J	The associated value is an estimated quantity.
R	The data are unusable (note: analyte may or may not be present)
UJ	The material was analyzed for, but was not detected. The associated value is an estimated level.

If quality control checks or objectives were not met, an investigation of the non-conformance may be initiated by the data validator with the project team personnel, such as the Field Manager, the laboratory QA/QC Manager, and the Project Manager. The non-conformance will be documented and the affected data set will be flagged appropriately, identifying any limitations.

Another objective of the data validation is to evaluate the data within the context of the project goals. These goals include providing datasets that can be used to develop model inputs, to calibrate and validate the models, and to ensure consistency among different sources of data. Suitable datasets for the modeling portion of this project will be based on the data quality assessment described above as well as an assessment of the spatial and temporal extent of the sample collection. Comparability with other sources of data will be evaluated by comparing and, if necessary, plotting the data with previously collected data to identify outliers or anomalous values.

The data validation results will be communicated to the project team in the form of a summary table that lists the validation tasks and the associated results and conclusions. If the validated dataset includes non-compliant data, this data will be addressed in a memo that accompanies the summary table. Data qualifiers assigned to the data during validation will be maintained in the project database to ensure communication of validation results with current and future data users.

4.3 Reconciliation with User Requirements (D3)

Once all field measurements and analytical data have been reviewed, quality control measures assessed, and any problems addressed, the measurement and analytical data will be assessed.

The assessment of the information generated from the monitoring program will be initiated by entering all analytical data and field measurement data into the project database. Other data (such as precipitation, flow data, velocity data, stage data, field notes, and information on any sampling anomalies) may be appended. All of these data will be evaluated and any relationships or correlations will be noted. The compilation of all information surrounding a sampling and/or monitoring event will be available to facilitate reconciliation with user requirements.

5 References

Limno-Tech, Inc. 2003. Water Quality Study Work Plan for Toledo Waterways Initiative, March 25.

United States Environmental Protection Agency (EPA), 1998. *EPA Guidance for Quality Assurance Project Plans*, EPA QA/G-5. Washington , DC.

United States Environmental Protection Agency (EPA), 2002. *Guidance on Environmental Verification and Data Validation*. EPA QA/G-8. Washington, DC.

Appendix A

Standard Operating Procedures for Field Activities

1. Introduction

This standard operating procedure (SOP) is applicable to the collection of representative liquid samples, both aqueous and non-aqueous, from streams, rivers, lakes, ponds, lagoons, and surface impoundments. It includes samples collected from depth, as well as samples collected from the surface. These typically applicable procedures have been adapted from the U.S. EPA Surface Water Sampling SOP No. 2013, dated 11/17/94 and may be varied or changed as required, dependent upon site conditions or equipment and procedural limitiations. The actual procedures used should be documented in the field notes, especially if changes are made.

There are two primary interferences or potential problems with representative surface water sampling. These include cross contamination of samples and improper sample collection. Following proper decontamination procedures and minimizing disturbance of the sample site will eliminate these problems as follows:

- Cross contamination problems can be eliminated or minimized through the use of dedicated sampling equipment. If this is not possible or practical, then decontamination of sampling equipment is necessary. Refer to the Equipment Cleaning SOP.
- Improper sample collection can involve using contaminated equipment, disturbance of the stream or impoundment substrate, and sampling in an obviously disturbed area.

In order to collect a representative sample, the hydrology and morphometrics of a stream or impoundment should be determined prior to sampling. This will aid in determining the presence of phases or layers in lagoons or impoundments, flow patterns in streams, and appropriate sampling locations and depths. In addition, water quality indicator data may be collected, if necessary, in impoundments and to determine if stratification is present. Measurements such as dissolved oxygen, pH, temperature, and redox potential can indicate if strata exist which would effect analytical results. Measurements should be collected at sufficiently sized intervals (e.g., 1 meter) from the substrate to the surface using the appropriate instrument (e.g, Hydrolab).

2. Materials

The following materials shall be available, as required, during surface water sampling. Back-up field instruments/equipment should be available, if required.

- Personal protective equipment (as required by the Health and Safety Plan);
- Cleaning equipment (as required in the Standard Operating Procedure for Equipment Cleaning);
- Appropriate sampling apparatus and accessories (e.g., Kemmerer bottles, Bacon bomb sampler, Dip sampler, Overland flow sampler, line and messengers);
- Appropriate sample bottles, preservatives (if required) and sample bottle labels;
- Zip-closure type bags;
- Insulated coolers, ice, and appropriate packing material;
- Chain of Custody records and custody seals;
- Field data sheets, field log book, waterproof pen, camera and film;
- Decontamination equipment;
- Maps/plot plan, survey stakes/flags/buoys and anchors;

3. Preparations

- Determine the extent of the sampling effort, the sampling methods to be employed, and the types and amounts of equipment and supplies needed.
- Obtain the necessary sampling and monitoring equipment to suit the task. Consider sample volume, depth, deployment circumstances (shore, wading, boat, currents), type of sample, sampler composition materials, and analyses to be conducted.
- Decontaminate or pre-clean equipment and ensure that it is in working order.
- Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
- Perform a general site survey prior to site entry, in accordance with the site specific Health and Safety Plan.
- Use stakes, flagging, or buoys to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. If also collecting sediment samples, this procedure may disturb the bottom and cause interferences with collection of representative water samples.

4. General Sample Collection Procedures

1. Record pertinent data on the field log (see attached Surface Water Sampling Field Log, or equivalent).

2. Label all sample containers with the date, time, well number, site location, sampling personnel, and other requested information.

3. Don appropriate personal protective equipment (as required by the Health and Safety Plan).

4. Clean all sampling equipment prior to sample collection according to the procedures in the Standard Operating Procedure for Equipment Cleaning.

5. For samples requiring field filtering, use a pump and in-line disposable filter, if possible to collect the sample directly into the sample container.

6. If field preservation is required, place appropriate preservative into the sample container prior to sample collection. Note the preservative and preservative column on the sample container and sampling log.

7. If any quality control samples are specified in the work plan, they will be collected in the following manner:

- Duplicate samples should be collected at the same time or immediately following one another in accordance with the above procedures. If blind duplicate samples are specified in the work plan, one of the duplicate samples should be labelled so that it does not identify the other sample of the duplicate pair to the laboratory on the chain-of-custody (COC). For example, one sample of the duplicate pair would be labelled following the normal protocol, while the second would be labelled with a sample ID of "DUPLICATE" and a blank line placed in the location, date and time boxes of the

sample label. It is important that the duplicate pair samples are identified separately in the field notes with information including location, sample ID (as entered on the sample container label and COC), sample date and time so that analytical results can be paired after received from the laboratory.

- Trip blanks should be prepared by the laboratory and shipped with the sample bottles. Trip blanks are not to be opened at any time, except by the laboratory for analysis, and must accompany the other samples/sample bottles at all times. Be sure to log the trip blank samples on the COC before shipping samples back to the laboratory.
- Rinse (or equipment) blanks should be collected from a final distilled/deionized water rinse of the specified sampling equipment after that piece of equipment has been cleaned in accordance with appropriate specified cleaning procedures.
- Field blanks, such as samples of water or reagents used to clean sampling equipment, should be collected directly into the sample bottle from the appropriate source container.

8. Record sample collection information on the field log and store the samples in an iced cooler as described in the Standard Operating Procedure for the Shipping and Handling of Samples.

9. Handle, pack, and ship samples according to the procedures in Standard Operating Procedure for the Shipping and Handling of Samples.

5. Equipment-Specific Sample Collection Procedures

5.1 Kemmerer Bottle

A Kemmerer bottle may be used in most situations where site access is from a boat or structure such as a bridge or pier, and where samples at depth are required. Sampling procedures are as follows:

1. Use a properly cleaned Kemmerer bottle. Set the sampling device so that the sampling end pieces (upper and lower stoppers) are pulled away from the sampling tube (body), allowing he substance to be sampled to pass through this tube.

2. Lower the pre-set sampling device to the pre-determined depth. Avoid bottom disturbance.

3. When the Kemmerer bottle is at the required depth, send down the messenger, closing the sampling device.

4. Retrieve the sampler and discharge from the bottom drain the first 10-20 mL to clear any potential contamination of the valve.

5. Transfer the sample to the appropriate sample container.

5.2 Bacon Bomb Sampler

A bacon bomb sampler may be used in situations similar to those outlined for the Kemmerer bottle. Sampling procedures are as follows:

1. Lower the bacon bomb sampler carefully to the desired depth, allowing the line for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line until taut. This will allow the sampler to fill.

2. Release the trigger line and retrieve the sampler.

3. Transfer the sample to the appropriate sample container by pulling up on the trigger.

5.3 Dip Sampler

A dip sampler is useful in situations where a sample is to be recovered from locations (e.g., outfall pipe, sump manhole, along a pond or lagoon bank) where direct access is limited. The long handle (or line if sampling from a bridge or other structure directly above the water body) on such a device allows access from a safe location. Sampling procedures are as follows:

1. Assemble the device in accordance with the manufacturer's instructions.

2. Extend the device to the sample location and collect the sample by dipping the sampler into the substance.

3. Retrieve the sampler and transfer the sample to the appropriate sample container.

5.4 Direct Method

For streams, rivers, lakes, and other surface waters, the direct method may be used to collect water samples from the surface directly into the sample bottle. This method may not be appropriate for sampling lagoons or other impoundments where contact with contaminants is a concern. When using the direct method, do not use pre-preserved sample bottles as the collection method may dilute the concentration of preservative necessary for proper sample preservation. The procedures are as follows:

1. Using adequate protective clothing, access the sampling station by appropriate means.

2. For shallow stream stations, collect the sample under the water surface while pointing the sample container upstream. The container must be upstream of the collector. Avoid disturbing the substrate.

3. For lakes and other impoundments, collect the sample under the water surface avoiding surface debris and boat wakes.

E. GKY Associates First Flush Sampler (Overland Flow Sampler for Stormwater Runoff)

The First Flush Sampler (FFS) is designed and installed at a location so that sheet flows from stormwater runoff can be collected directly into the sample device. The container in the FFS device may be retrieved, capped and used as a sample container for submittal to the analytical laboratory, or a sample may be aliquoted from the FFS container directly into another specified sample bottle. If the later method is used, care should be taken to obtain a representative sample by first thoroughly mixing the sample (taking care to suspend settled sediments) in the FFS before decanting to another container.

6. Disposal Methods

If required, all water generated during equipment cleaning procedures will be collected and contained on site for determination of proper treatment or disposal. In addition, personal protective equipment (e.g., gloves, disposable clothing) and other disposable equipment resulting from cleaning and sampling procedures will be placed in plastic bags and appropriately contained for proper disposal.

SURFACE WATER SAMPLING FIELD LOG

Project Name: Project Code: Page __ of __

Date	Time	Sample ID	Sample Location	Equipment Used	Samplers	Comments

Notes:

I. Introduction

This standard operating procedure (SOP) is applicable to the collection of representative data (stream dimensions and water velocity) for use in determining discharge in streams and open channels. These typically applicable procedures have been adapted from the USGS *Techniques in Water Resources Investigations*, Book 3, Chapter A8: Discharge Measurements at Gaging Stations (http://water.usgs.gov/pubs/twri/twri3a8/pdf/TWRI_3-A8.pdf) and the *Open Channel Profiling Handbook*, January 1989 (Rev. May 1, 1990), Marsh-McBirney, Inc. The procedures herein may be varied or changed as required, dependent upon site conditions or equipment and procedural limitiations. The actual procedures used should be employed in consultation of the more detailed procedures found in the USGS discharge measurement guidance document and the actual procedures used should be documented in the field notes, especially any changes made.

II. Materials

The following materials shall be available, as required, during collection of surface water flow data. Back-up field instruments/equipment should be available, if required.

- Personal protective equipment (as required by the Health and Safety Plan);
- Boat and/or waders;
- Cleaning equipment (see the Standard Operating Procedure for Equipment Cleaning);
- Flowmeter/velocimeter and appropriate accessories (e.g., Marsh-McBirney Flo-Mate 2000, Pigmy-Gurly velocimeter, profiling/wading rod, boat/bridge board with suspension cable and weight, operation manuals);
- Protractor and compass;
- Measuring tape and/or measuring wheel;
- Field data sheets, field log book, waterproof pen, camera and film;
- Maps/plot plan, survey stakes/flags/buoys and anchors;

III. Preparations

- Determine the extent of the sampling effort, the methods to be employed, and the types and amounts of equipment and supplies needed.
- Obtain the necessary sampling and monitoring equipment to suit the task. Consider stream morphometrics (width, depths, channels) and deployment circumstances (bridges, shoreline, wading, boats, obstructions, currents).
- Decontaminate or pre-clean equipment and ensure that it is in working order.
- Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate.
- Perform a general site survey prior to site entry, in accordance with the site specific Health and Safety Plan.
- Use stakes, flagging, or buoys to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

IV. Flow Measurement Procedures

The methods of determining cross-sectional area and velocity must be selected prior to the field event. Data required for use in calculation of stream flow includes measurements of cross-sectional area (water depth and transect segment width), water velocity, flow angle, and transect angle. The mid-section method of computing cross-sectional area for discharge measurements is recommended by USGS and there are a number of different methods for measuring velocity. The two methods of velocity measurement that follow are frequently used for normal stream conditions:

- Six tenths Depth Method (0.6 depth below the water surface) uses observed velocity at this depth as the mean velocity in the vertical. This method gives extremely reliable results whenever the water depth is between 0.3 and 2.5 feet. It is also quicker to measure so is good for times of rapidly changing water level (stage).
- Two Point Method (0.2 and 0.8 depth below the water surface) averages velocities observed at these relative depths at each location and this average is used as the same mean velocity in the vertical. This method gives more consistent and accurate results than any of the other methods except the vertical-velocity curve method. The two point method is generally not used at depths less than 2.5 feet because the current meter settings would be too close to the water surface and stream bed for dependable results.

Flow measurement data collection using wading techniques are preferred by USGS, if conditions permit. Wading measurements offer the advantage over measurements from bridges (or other techniques such as cableways, not discussed herein) in that it is usually possible to select the best of several available cross-sections for the measurement.
When a stream cannot be waded, bridges may be used to obtain flow measurements (though cableway measurements are usually better, if available). No set rule can be given for choosing between the upstream or downstream side of the bridge to collect flow data.
The advantages of using the upstream side of the bridge are:

- Hydraulic characteristics at the upstream side of bridge openings usually are more favorable.
- Approaching drift can be seen and be more easily avoided.
- The streambed at the upstream side of the bridge is not likely to scour as badly as at the downstream side.

The advantages of using the downstream side of the bridge are:

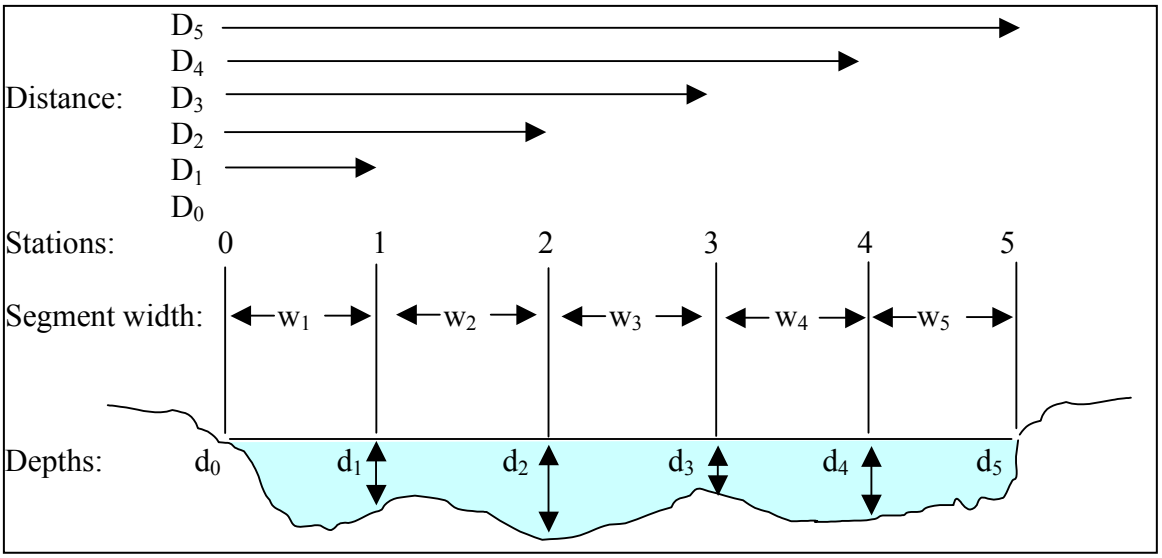
- Vertical angles are more easily measured because the sounding line will move away from the bridge.
- The flow lines of the stream may be straightened out by passing through a bridge opening with piers (see points under step 2 below).

To accomplish flow data collection using the methods selected, a transect of measurement stations across a stream is setup and marked before collecting section depth, width, and velocity data using the following steps:

1. Follow appropriate safety procedures and use personal protective equipment as required by the Health and Safety Plan.
2. Select the transect site location following as many of the following considerations as possible:

- The channel should have as much straight run as possible – at least such that the length upstream from the profile should be twice the downstream length.
- The channel should be free of flow disturbances. Look for protruding pipe joints, sudden changes in diameter, contributing sidestreams, outgoing sidestreams, or obstructions.
- The flow should be free of swirls, eddies, vortices, backward flow, or dead zones.
- Avoid areas immediately downstream from sharp bends or obstructions
- Avoid converging or diverging flow (approach to a flume) and vertical drops.
- Avoid areas immediately downstream from a sluice gate or where the channel empties into a body of stationary water.

2. Determine the width of the stream starting and ending at the stream's edges. Use a measuring wheel on a bridge or string a measuring tape between stakes if wading or in a boat.
3. Record the angle of the transect with respect to the stream channel and direction of flow.The transect should most preferably be at right angles to the direction of flow to avoid having to correct for the angle of the transect when calculating discharge.
4. Mark/record the partial section locations (measurement recording stations) of the measurement transect. These should be spaced so that no partial section contains more than 10 percent of the total flow. The ideal measurement would have less than 5 percent of the flow in any one partial section. Equal width partial sections across the transect are not recommended. Make the width of the partial sections less as depths and velocities become greater.
5. Assemble the appropriate equipment for the velocity and depth measurements.
6. Prepare the measurement note sheets to include the following information:
   - Name of stream and exact location of transect site.
   - Date, party, type of meter suspension, type of meter.
   - Measurement data (depth, width, position location, velocity, flow angle, time measurements were started and ended).
   - Bank of stream that was the starting point. Identify the stream bank by either LEW or REW (left edge of water or right edge of water, respectively) when facing downstream.
   - Gage height measurement and corresponding times.
   - Other pertinent information regarding site conditions and accuracy of the measurement.
7. Begin recording depth, width (transect distance) and velocity measurements at each station of the transect, successively, according to the remaining steps below and in reference to the figure that follows.



w = width of segment
D = distance from stream's edge
d = depth of water

8. Record distance (D1, D2, D3 …) from steam's edge at initial station (measurement point 0) to each successive station (1, 2, 3, …).
9. Record the water depth (d0, d1, d2, d3, …) at each measurement point, including the edge of the water at each end of the transect.
10. Measure velocity (0.2 depth & 0.8 depth – or – 0.6 depth below water surface) at each station and record the reading and associated meter depth position (0.2, 0.6, 0.8). Follow manufacturer instructions for operation of the meter.

    Note: If wading, stand in a position that least affects the velocity of the water passing the meter sensor (sufficiently downstream or to the side of the sensor – approximately an arm's lengh). Avoid standing in the water if feet and legs would occupy a considerable percentage of the cross section of a narrow stream (use a plank or other support). Keep the wading rod in a vertical position and the velocity sensor parallel to the direction of flow.
11. Measure and record the angle of flow with respect to the transect and direction of flow, especially if the flow is not at right angles to the transect.

V. Discharge Calculation

The USGS-preferred midpoint method of determining discharge uses the products of the partial areas of the stream cross-section (segment) and their respective average velocities (Q = A * V). It is assumed that the velocity measurement at each station represents the mean velocity in a partial rectangular area. The area extends laterally from half the distance from the preceding station to half the distance to the next and vertically from the water surface to the sounded depth. The cross-section is defined by depths at the station locations (d_1, d_2, …, d_n). There are two cases in the calculation, as follows:

For segments in the middle of the transect:

$$Q_{middle\text{-}segment} = (D_{n-1} - D_{n+1})/2 * d_n * V_n$$

For segments at the end of the transect:

$$Q_{first\text{-}end\text{-}segment} = (D_{n+1} - D_n)/2 * d_n * V_n$$

$Q_{last\text{-}end\text{-}segment} = (D_n - D_{n-1})/2 * d_n * V_n$

- $Q = A * V$ (discharge = area * velocity; where)
- $A = w * d$ (area = width * depth; where)
- $w = D_{n-1} - D_{n+1}$ or $D_{n+1} - D_n$ or $D_n - D_{n-1}$
  (segment width = distance between alternate or adjacent stations; and)

Another method used by USGS prior to 1950 and considered slightly less accurate is the mean-section method. Partial discharges are computed for partial sections between successive locations. The velocities and depths at successive locations are each average and the section extends laterally from one observation point to the next. Discharge is the product of the average of two mean velocities, the average of two depths, and the distance between locations, as follows:

$Q_{segment} = [D_n - D_{n-1}] * [(d_n - d_{n-1})/2] * [(V_n + V_{n-1})/2]$

- $Q = V * A$ (discharge = velocity * area; where)
- $V = (V_n + V_{n-1})/2$ (velocity = average velocity in segment; and)
- $A = w * d$ (area = width * depth; where)
- $w = D_n - D_{n-1}$ (segment width = distance between stations; and)
- $d = (d_n + d_{n-1})/2$ (depth = average depth in segment)

Sum the segment discharges to get the total discharge for the river at a particular location

VI. Other considerations for less than ideal site conditions:

Non-perpendicularity:

Ideally, the cross-section is perpendicular to the stream channel, which has a straight run of sufficient length, and the sream flow is perpendicular to the cross-section. However, this is not always possible in the real world.

Angle of flow measurements should be collected and incorporated into the discharge calculation when flow is not perpendicular to the stream cross-section (insufficient straight run length of channel, presence of swirls, eddies, etc.).

Calculation of discharge should consider only the velocity component vector that is parallel to the stream channel (perpendicular to the ideal cross-section). This can be obtained by multiplying the velocity reading by the cosine of the flow angle (V * cos(a)).

If the cross-section measurements are taken from a bridge that is not perpendicular to the stream channel, then correction for the angle of the bridge is also necessary.

Backwater and reverse flow:

Backwater areas or areas too shallow to measure are usually assigned a velocity of zero. Velocity values in areas of flow reversal (from eddies, or lake seiche effects near river mouths) must be assigned the opposite sign (if downstream velocities are positive, upstream velocities are negative).

Flow Monitoring Datasheet

Site: _____

Crew: _____ Date: _____

Staff Gage Reading (ft): _____ Begin Time: _____

Tape Down (ft): _____ End Time: _____

Equipment Used:

Transect Starting Point is on (circle one): left bank facing downstream right bank facing downstream

Bridge measurements are from (circle one): upstream side downstream side

Distance Starting Point to Nearest Edge of Water (ft): _____

Distance Ending Point to Nearest Edge of Water (ft): _____

Depth at Left Edge of Water (facing downstream): _____

Depth at Right Edge of Water (facing downstream): _____

Observations:

Transect Point No.	Transect Tape Reading (ft)	Water Depth (ft)	0.8D Velocity (ft/s) (if Depth >2.5 ft)	0.2D Velocity (ft/s) (if Depth >2.5 ft)	0.6D Velocity (ft/s) (if Depth <2.5 ft)	Angle coeff.	Notes

I. Introduction

Water quality parameters, such as turbidity, specific conductance, pH, and temperature, are usually measured in the field during groundwater monitoring well development and purging or surface water sampling activities. These parameters may be measured using individual or multi-sensor probes, as available and appropriate for each situation. Flow-through chambers are preferred when characterizing purge water from well development or prior to well sampling. The calibration and maintenance log for the above referenced meters is included as an attachment to this Standard Operating Procedure.

II. Materials

The following materials, as required, shall be available during field measurement of water quality:

- Personal protective equipment (as specified in the Health and Safety Plan);
- Clean container or flow-through chamber;
- Temperature, pH, conductivity, and turbidity meters, as required;
- Manufacturer's operating manuals for each instrument;
- Calibration solutions appropriate for each instrument;
- Tools necessary for field maintanence of instruments;
- Extra batteries for the meters;
- Nephelometric sample tubes;
- Cleaning materials (as required in the Standard Operating Procedure for Equipment Cleaning);Distilled/deionized water; and
- Appropriate forms and field notebook.

III. Procedures for Field Water Quality Measurements

1. Calibrate and operate all meters in accordance with manufacturer's operating manuals.
2. Setup instruments and collect water sample(s):
   - If purging a well with a pump, install individual meters or multiple sensor data sonde into flow-through chamber and connect to well pump tubing.
   - If purging a well with a bailer or collecting ex-situ surface water measurements, fill a suitably sized container with water from the well or surface water sample.
   - If taking in-situ surface water measurements place meter probes at the designated location in the water body.
3. Measure and record the meter readings for each parameter:
   - Allow instrument readings to stabilize before recording, as appropriate.
   - If measuring ex-situ samples, insert probes into container and record temperature and pH readings as soon as possible after collecting the sample to minimize inaccuracies

from the changing temperature of the sample as it equilibrates to ambient temperature.

4. Rinse probes off in distilled/deionized water, if required.
5. Log results and observations in field notebook.

FIELD INSTRUMENT CALIBRATION AND MAINTENANCE LOG
Temperature, pH, Conductivity, Dissolved Oxygen And Turbidity Meters

Instrument	Temperature	pH	Conductivity	D.O.	Turbidity
Manufacturer					
Model					
Identification No.					

Date	Time	Initials	Temp	pH			Conductivity	D.O.	Turbidity	Battery	Comments
			°C	4	7	10	Std: ______ umohs/cm		Std: ______ NTU	Check	

I. Introduction

The equipment cleaning procedures described in this document include pre-field, in-field, and post-field cleaning of sampling equipment. The sampling equipment may consist of surface water, groundwater or soil sampling devices; water testing instruments; well construction materials; or other activity-specific sampling equipment. All non-disposable sampling equipment will be cleaned after completion of each sampling event. If appropriate, cleaning procedures will be monitored through the analysis of rinse blank samples as described in the project work plan or QAPP. Equipment cleaning areas will be located within or adjacent to specific work areas as necessary or as specified in the Health and Safety Plan or Work Plan.

II. Materials

The following materials will be available during equipment cleaning, as needed:

- Personal protection equipment (as required in the Health and Safety Plan);
- Distilled/deionized water;
- Non-phosphate detergent (Alconox, Liquinox, or equivalent);
- Tap water;
- Appropriate cleaning solvent (e.g., methanol, nitric acid);
- High-pressure hot water/steam cleaning unit;
- Wash basins;
- Brushes;
- Polyethylene sheeting;
- Aluminum foil;
- Plastic overpack drum, garbage can, or stainless steel tubes (for bladder or other pumps);
- Large heavy-duty garbage bags;
- Spray bottles (to hold tap water, distilled/deionized water, methanol, or nitric acid); and
- Disposable and/or heavy duty reusable (PVC, latex or nitrile) gloves.

III. Storage of Equipment

All cleaned sampling equipment will be stored in a clean environment and, if appropriate, the equipment will be covered/sealed with aluminum foil.

IV. Safety Procedures During Equipment Cleaning

1. Personnel will wear the following personal protection equipment as necessary, when cleaning sampling equipment (e.g., Kemmerer sampler, split-spoon sampler, trowels) and larger equipment (e.g., drill rig, augers):

- Safety glasses, goggles, or a splash shield; and
- PVC, latex, or nitrile outer gloves,
- Coated Tyvek® disposable coveralls or rainsuit, optional for small equipment cleaning; and
- Chemical resistant over boots, optional for small equipment cleaning.

2. All solvent rinsing if required, will be conducted in an adequately ventilated area.

3. All solvents transported into the field will be stored and packaged in appropriate containers with care taken to avoid exposure to extreme heat.

4. Handling of solvents will be consistent with the manufacturer's Material Safety Data Sheets (MSDS).

V. Field Cleaning Procedures

A. Cleaning Station

If a designated field equipment cleaning station location is required, it will be established to conduct all cleaning at each work area of the Site. The field equipment cleaning station will be located away from the immediate work area to minimize adverse impacts from work activities on the cleaning procedures, but close enough so the sampling teams can minimize equipment handling and transport. All heavy equipment such as drill rigs and backhoes will receive an initial cleaning prior to use at the Site. The frequency of subsequent cleaning will depend on the amount of use the heavy equipment receives and the extent of exposure to dirt and contaminants during the sampling event.

B. Cleaning of Smaller Sampling Equipment

Cleaning of smaller sampling equipment (e.g., Kemmerer samplers, sample composite vessels, split-spoon samplers, bailers, trowels) will be conducted according to the following sequential procedure:

- Non-phosphate detergent (Alconox, Liquinox, or equivalent) and tap water wash;
- Tap water rinse;
- Solvent rinse, if required (e.g., methanol for organic constituent analysis, nitric acid for inorganic constituent analysis); and
- Triple distilled/deionized water rinse.

The first step, non-phosphate detergent and tap water scrub, is intended to remove all visible particulate matter and residual oil and grease. This may be preceded by a steam cleaning to facilitate soils removal. The tap water rinse is necessary to remove all soapy residue. The need for a specific solvent used for the solvent rinse, if required in the work plan or QAPP,

will depend upon what the sample will be analyzed for. The final rinse of distilled/deionized water will be repeated three times. The equipment will then be allowed to air dry.

C. Cleaning of Submersible Pumps

Submersible pumps may be used to evacuate stagnant groundwater from the well casing (e.g., air lift or turbine pumps) or to collect samples (e.g., bladder pump). The pumps will be cleaned and flushed between wells using an external detergent wash and tap water rinse. Steam cleaning may be substituted for pump casing, hose, and cables followed by a flushing with potable water through the pump. The flushing process for development and purge pumps may be performed by pumping potable water from a clean plastic overpack drum or plastic garbage can until a sufficient amount of water has flushed the system. The flushing process for sampling pumps will consist of filling each of three stainless steel tubes (5 feet long by 6 inch diameter) with detergent water, tap water, and deionized/distilled water, placing the sampling pump into each tube, respectively, and pumping sufficient liquid from each chamber through the pump chamber and hose. If electric power pumps are used, care should be taken to avoid contact with the pump casing and water in the drum while the pump is running to avoid electric shock. The pump and hose will be placed on clean polyethylene sheeting to avoid contact with the ground surface.

D. Cleaning of Heavy Equipment

Other equipment and materials, such as drill rigs, well casings, tools, and auger flights, associated with sampling events, will be cleaned prior to use. This equipment may retain chemical constituents from sources unrelated to the sampling site such as roadways, storage areas, or material from previous job sites that were not adequately removed. Heavy equipment will be thoroughly steam cleaned and/or manually scrubbed and rinsed upon arrival on site and when moved between sampling locations, as necessary. Drill rig items such as auger flights, wrenches, drill rods, and drill bits will also be cleaned before changing sample locations.

E. Collection and Disposal of used Solvents, Residuals and Rinse Solutions

All solvents, residuals, and rinse waters generated during the cleaning of equipment on-site will be collected, containerized, and stored on-site until arrangements can be made for proper disposal.

Appendix B

Laboratory Quality Assurance Program