# Section 1. Project Management

## 1.1 Title and approvals

**Assessment of Tile Drainage System Impacts to Lake Champlain and Phosphorus Loads in Tile Drainage in the Jewett Brook Watershed of St. Albans Bay**

**Quality Assurance Project Plan, Version 1.0, Amendment 1**

**Adding: Task 2–Assessment of Tile Drainage Systems in the Jewett Brook Watershed**

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## 1.4 Project/Task Organization

The diagram in Figure 1 below outlines the primary project participants and their roles in the project, by task. The scope of this QAPP document is currently limited to Tasks 1 (Literature Review Examining Tile Drainage Systems) and 2 (Monitoring and Assessment of Tile Drainage Systems); a second amendment to this QAPP for secondary data work as part of Task 3 will be prepared in at a future point in time.

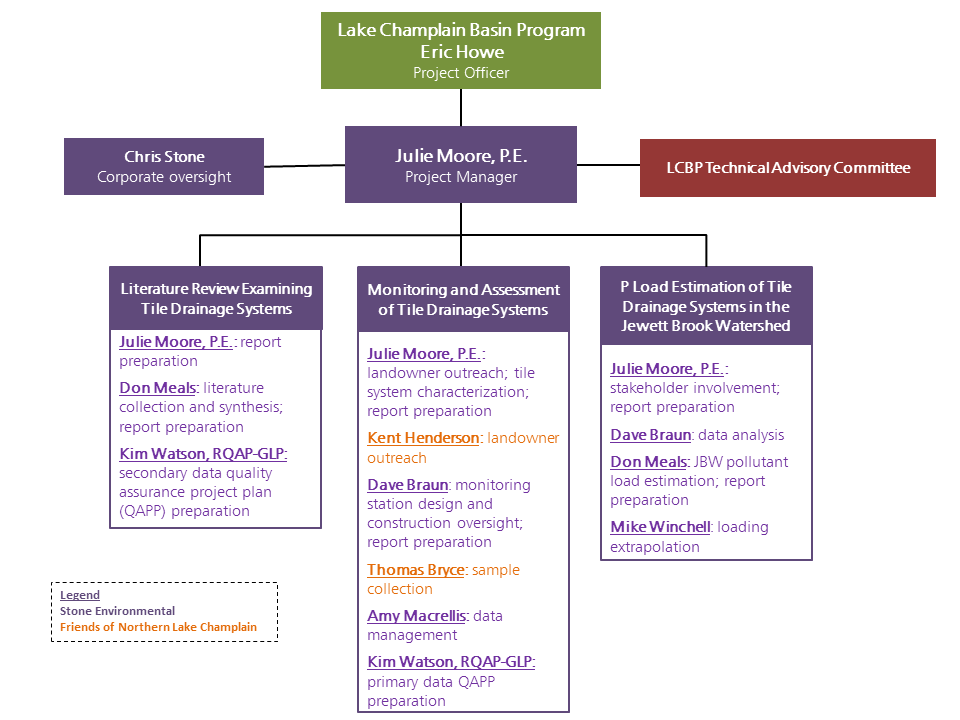


Figure 1: Project Organizational Chart

Stone Environmental, Inc.:

Staff members from Stone Environmental, Inc. (and their authorized subcontractor) will report to 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 and documenting and ascertaining that the work performed is technically correct and meets all aspects of the QAPP.

Table 1: Roles and Responsibilities

| **Individual(s) assigned** | **Responsible for:** | **Authorized to:** |
| --- | --- | --- |
| **Stone Environmental** |  |  |
| Julie Moore, PE | Project manager, overall study design, landowner outreach, primary contact with the Lake Champlain Basin Program. | Coordinate all aspects of project operations  Document and approve all major project changes  Manage personnel schedules and assign duties  Approve overall study design  Conduct site evaluation and characterization activities  Interim/Final Report preparation |
| David Braun | Monitoring station design, construction oversight, monitoring program oversight, non-routine maintenance, data management | Develop and approve final station designs  Supervise station construction  Repair damage/breakdown in field stations  Calibrate and maintain monitoring equipment  Oversee collection and handling of water samples  Conduct routine operation and maintenance of field stations  Perform data QA and reduction  Interim/Final Report preparation |
| Don Meals | Literature review, statistical analysis of monitoring data, and interpretation of results. | Collect and synthesize relevant literature  Receive and verify collected data  Conduct statistical data analysis  Interpret project findings  Interim/Final Report preparation |
| Amy Macrellis | Database development and data management | Develop and maintain data management system  Provide data reports and outputs |
| Mike Winchell | Load extrapolation | Evaluate and apply most-suitable approach for developing load estimates |
| Kim Watson, RQAP-GLP | Quality review, maintaining the approved QAPP | Evaluate all aspects of project operations for compliance with approved QAPP  Resolve QA/QC issues |

|  |  |  |
| --- | --- | --- |
| **Subcontractors** |  |  |
| Kent Henderson, Friends of Northern Lake Champlain | Landowner outreach, sample collection | Collect project-related data from participating landowners  Collect, handle, and ship water samples  Conduct routine operation and maintenance of field stations |
| Thomas Bryce, Friends of Northern Lake Champlain | Sample collection | Collect, handle, and ship water samples  Conduct routine operation and maintenance of field stations |

## 1.5 Special Training Requirements/Certifications

Personnel with considerable expertise and experience in performing the project tasks will conduct all sampling and analysis for the project. Because station operation and maintenance, field data collection, and water sample collection will be done by subcontracted personnel at some sites, initial training will be led by the Stone Environmental Project Manager, or her designee, who will also be responsible for continued coordination of field operations and maintenance of consistency among field sampling personnel. This consistency will be aided by the use of standard checklists and forms for sample retrieval and station maintenance (see Appendix A, Study Specific Procedure). All personnel performing the project tasks will have documented training in their respective duties and shall have read the applicable SOPs. Stone Environmental maintains training records for all staff that document relevant training and SOP review. Laboratory analysis will occur at the Vermont Agriculture and Environmental Laboratory (VAEL) under the direction of the Laboratory Director. No additional specialized training or certifications are necessary for personnel to conduct the project tasks.

# Section 2. Project Definition and Objectives

## 2.1 Problem Definition/Background

Subsurface drainage is an essential agronomic practice on many agricultural fields in the Lake Champlain Basin (LCB), allowing timely equipment access, reduced soil compaction and increased crop yields in fields otherwise too wet to efficiently farm. The combined effects of drawing down the water table and providing rapid conveyance of subsurface water to an outlet can significantly change the hydrologic behavior of a field, generally reducing surface runoff by enhancing infiltration and ground water transmission. Until recently, it was widely believed that, despite hydrologic changes caused by implementation of subsurface drainage, phosphorus (P) losses from agricultural lands occurred primarily via surface runoff and that very little P was lost through subsurface drainage such that tiling a field could reasonably be expected to reduce P losses.

Recent research has revealed that subsurface drainage systems in agricultural fields can discharge significant quantities of P under a wide range of soil characteristics and management practices and should be considered in management strategies seeking to minimize nonpoint source pollution of surface waters.

In Vermont and across the LCB, little is known about the extent of tile drainage systems, and the potential impacts of tile drainage systems on water quality have not been assessed. To address this knowledge gap, the Project Team will review and synthesize published research documenting P loading impacts of tile drainage systems that can be related to conditions commonly found in the LCB, monitor representative tile drainage systems in the Jewett Brook watershed (JBW), estimate P loading to Jewett Brook from these tile systems, and assess the significance of this loading to the overall P export from the JBW and similar areas of the LCB.

This QAPP applies to both the primary (Task 2) and secondary (Task 1) monitoring and data collection activities described in the project Work Plan.

## 2.2 Project Objectives

**2.2.1 Task 1: Literature Review of Published Research Examining Tile Drainage Systems**

The objective of this task (Task 1: *Literature Review of Published Research Examining Tile Drainage Systems*, as described in the approved project Work Plan) is to synthesize the current state of knowledge of P loading from tile drainage systems from published scientific literature and expert knowledge within the Lake Champlain Region.

The Project Team will identify existing literature and data using a variety of methods, including:

* Search of online scientific databases including but not limited to Web of Science, the National Agricultural Library (AGRICOLA), Elton B. Stephens Co. (EBSCO), and the web search engine Google Scholar;
* Search of federal, state, and stakeholder websites for recent materials (articles, technical papers, reports, and abstracts) and materials addressing topics not covered by sources listed above; and
* Sources proposed by members of the LCBP Technical Advisory Committee (TAC) and other stakeholders/experts within the LCB.

Emphasis will be on peer-reviewed articles, but data from gray literature of suitable quality (see Section 3) will be included to the extent available.

References cited within each reviewed source will be searched for additional resources. If a review article summarizes data from another study or report, the Project Team will obtain the original document so that information is collected from original sources. The search will be repeated with multiple iterations of keywords and in multiple databases until no additional references are identified.

Once the Project Team identifies a potential reference for inclusion in the literature review, they will use the decision process diagramed in Figure 2 and assess the quality of that reference according to five assessment factors recommended by the EPA’s Science Policy Council (US EPA 2003): soundness; applicability and utility; clarity and completeness; uncertainty and variability; and evaluation and review. These factors are described in more detail in Section 3. Once an article is qualified, key data from the source will be logged into a set of spreadsheets. The spreadsheets will include fields for all important aspects of the work reported, including full citation, publication date, geographic location, scale, tile drainage system characteristics (e.g., depth, spacing, age), land use, crop and crop management, precipitation and flow, manure and fertilizer applications, soil type, slope, tillage, erosion control, nutrient management, and annual P concentrations and/or loads. Where papers generate multiple cases (e.g., unique combination of study year, study site, treatment condition, and measured constituent) as individual records, each case will be reported as a separate record.

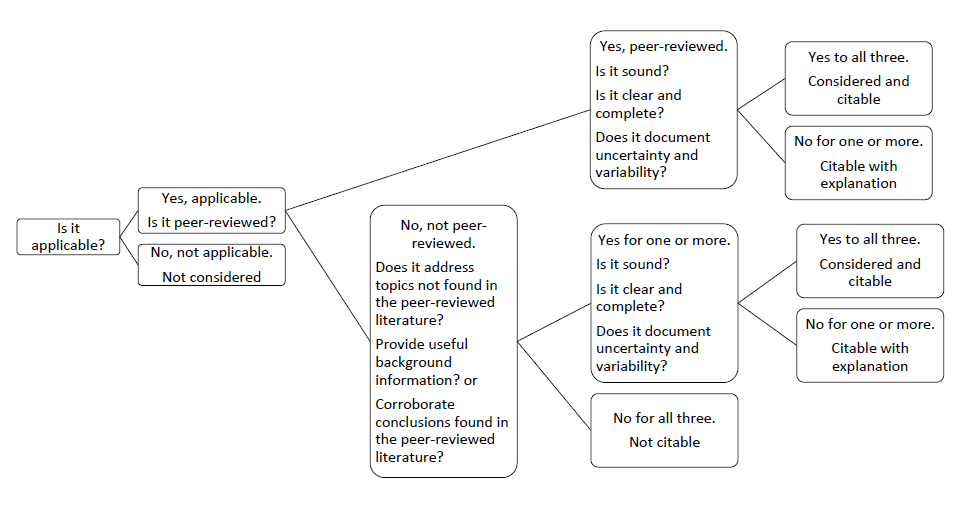


Figure 2. Process for literature screening and inclusion.

**2.2.2 Task 2: Assessment of Tile Drainage Systems in the Jewett Brook Watershed**

The objectives of Task 2 (*Assessment of Tile Drainage Systems in the Jewett Brook Watershed)*, as described in the approved project Work Plan, are:

1. To evaluate characteristics of the Jewett Brook Watershed and provide detailed characterization of field areas drained by 12 tile drainage systems selected for monitoring;
2. To measure total and dissolved P concentrations and flow and calculate P loads from 12 representative tile drainage systems in the Jewett Brook Watershed.

# Section 3. Secondary Data Collection, Review and Evaluation of Available Literature

## 3.1 Sources of Secondary Data

The data needed for Task 1 of this project fall under the category of non-direct measurements and may include data from the following types of sources:

***Peer-Reviewed Literature***

* Journal publications
* Reports, white papers, fact sheets, and similar publications developed by federal and state agencies
* Reports on industry-sponsored research, including white papers, fact sheets, and similar publications
* Symposium/conference proceedings

***Non Peer-Reviewed Literature***

* Non peer-reviewed government documents
* Other types
  + Workshop or conference presentations/proceedings
  + Master’s/PhD theses (approved)
  + Reports and white papers from private companies, associations, or non-governmental organizations
  + Textbooks
  + Maps
  + Publications with unknown peer-review status

***Datasets***

* Online databases
* Unpublished government data

All data and existing literature will be evaluated using the guidelines given in Section 3.3 of this QAPP. It is expected that information included in the synthesis report will be drawn primarily from peer-reviewed publications. These publications will be viewed generally as containing the most reliable information, particularly if all of the criteria in Table 2 are met. High reliability will be ascribed to publications with high levels of review and evaluation and where extensive tabulation of supporting information is often available. Similarly, some agencies (e.g., EPA, USGS, etc.) are known to follow extensive quality assurance and review procedures for documents they produce.

Non peer-reviewed publications may provide useful information as long as they enhance understanding from peer-reviewed sources, or if peer-reviewed sources prove too scarce or insufficient to answer certain research questions by themselves. Because workshop and conference papers may be abbreviated, and may present works-in-progress, these are not expected to form the sole basis of conclusions presented in the report. Generally, these publications may be of most use to support results presented from peer-reviewed work, to identify promising ideas of investigation and to discuss further in-depth work needed.

Once information for this report has been collected and reviewed for adequate quality (see Section 3.2 Data Quality Requirements below), the Project Team will develop a draft narrative report and other deliverables (see Section 3.6). Any further data sources that become available during the course of the project will be vetted for utility for the final deliverable as well as for quality.

## 3.2 Secondary Data Quality Requirements

Literature and data identified in the course of the search strategy above will be evaluated using the five assessment factors outlined by the Science Policy Council in *A Summary of General Assessment Factors for Evaluating the Quality of Scientific and Technical Information* (US EPA, 2003): Applicability and Utility; Evaluation and Review; Soundness; Clarity and Completeness; and Uncertainty and Variability. Those factors are defined by the following criteria:

Table 2. Criteria for each quality factor used for assessing data and literature.

|  |  |
| --- | --- |
| **Factor** | **Criteria** |
| Applicability | Document provides information useful for assessing the magnitude of P loading from tile drainage, agronomic or site factors influencing P loss through tile drainage, or documents the effectiveness of measures to reduce or avoid potential P losses in tile drainage.  Work and results reported are relevant to the environmental conditions found in the Champlain region (e.g., soil types, climate, and representative agronomic practices). |
| Review | Document has been peer-reviewed. |
| Soundness | Document relies on sound scientific principles and approaches, and conclusions are consistent with data presented. |
| Clarity/completeness | Document provides underlying data, assumptions, procedures, and measured parameters, as applicable, as well as information about sponsorship and author affiliations. |
| Uncertainty/variability | Document identifies uncertainties, variability, sources of error and/or bias and properly reflects them in any conclusions drawn. |

Our objective will be to include literature that conforms in full to all five criteria. However, from previous search efforts, we have learned that the preponderance of literature on some topics does not fully conform to some aspect of the outlined criteria. For instance, there are many white papers and reports in technical areas in which independent peer-review is not standard practice or is not well documented. Should non-peer reviewed references address topics not found in the peer reviewed literature, provide useful background information, or corroborate conclusions in the peer reviewed literature, we may cite them with clear explanation. The same kind of explanation will also be offered should references be cited that do not fully conform to one of the other criteria.

The process for considering literature sources for inclusion is described in the decision tree shown in Figure 2 above. Any limitations and gaps in data included in the final deliverables for this project will be fully disclosed within the report, and it will be noted that these data should be used with caution. For example, certain datasets or published research may only cover a limited window in time but still be crucial to complement or provide a perspective for other available work. Data developed from laboratory or `plot studies may be difficult to extrapolate to field or watershed scale. Even if data do not fully satisfy all the quality criteria, they may represent the best available knowledge for that particular topic and may not only provide a glimpse into current conditions, but also point to the need for improved data collection efforts to help refine recommendations of future projects.

## 3.3 Secondary Data Review and Evaluation

The quality of the secondary data will be determined according to the decision tree shown in Figure 2 and based on data quality requirements defined in Section 3.2 of this document. Unless the Project Team identifies specific issues or shortcomings in the reported work, data from peer-reviewed journal articles will be assumed to have been generated, analyzed, and reported according to acceptable quality standards. Data from non peer-reviewed sources will be evaluated according to procedures outlined above and reported with appropriate caveats.

All tables and figures created from existing literature and data sources will undergo an appropriate review process to ensure that the data were correctly transcribed. This process will include checking the created tables and figures against the original sources. The report text associated with the selected citations will be checked against the original sources to ensure that the report text accurately reflects the information in the original source. Electronic copies of all sources used in the literature will be included in project deliverables (see Section 3.6).

## 3.4 Documentation of Data Sources and Records

All published research accessed for this project to inform the final deliverables developed for this project will be considered for data quality as described in Section 3.2 and documented in the final report if used. More detailed information about the data source and interpretation methods will be documented by the Project Team and available upon request, as noted in Section 3.6.

## 3.5 Data Validation

The reporting of accurate project data will generally be ensured by carefully conducting and clearly expressing data reduction (if and when needed) and visual inspection of data before synthesizing for the final report. Specifically:

* A copy of every original source will be saved in a separate folder where it will not be edited in the event the integrity of the working datasets is compromised.
* Working data will be stored in spreadsheet format and will include all relevant raw data.
* Data manipulation will be minimized to decrease the chances of inadvertently introducing errors; such manipulations will be limited to unit conversion, summation of intermediate values (e.g., seasonal) to annual values, and the like. In rare cases, it may be necessary to visually interpret numerical values from graphs if the data are not reported in tabular form. Any such manipulations will be documented and checked by a member of the Project Team who did not perform the original manipulation. All formulas, along with units and conversion factors, will be shown in the spreadsheet; in addition, the formulas will be visible in each cell containing the reduced values.
* Transcribed data, calculations, tables and figures will be checked in accordance with Stone’s standard operating procedure; SEI-4.14.2 Quality Control Check On Transcribed Data, Data Calculations, Figures, And Tables.

In-house documentation of assembled datasets will be reviewed to verify references to the use and limitations of the data.

## 3.6 Records Management

Secondary data and publications collected by Project Team used in the final deliverables for this project will be stored on the Stone server in Montpelier, VT. Techniques used to interpret and display data in the report will also be documented by the Project Team and stored on the server and available to the public upon inquiry. All data published in the final project deliverables will be cited to its original source in the final publication. The data will be provided to the LCBP.

**3.7 Disclaimers**

References and data sources that do not strictly meet the criteria listed in Section 3.2 may still be included in the synthesis report at the discretion of the Project Team, particularly with respect to data that have not undergone external peer review (e.g., data collected by states or industry). The literature review leader is responsible for deciding to include these data, documenting the rationale for inclusion and providing all available background information on these data in order to place these results in the appropriate context.

As stated previously, any limitations in data quality will be fully disclosed with the final report deliverables. If a decision is made to use data of unknown quality, this will be indicated in a disclaimer that will be added to any project deliverable. The disclaimer will read: “These data are of unknown quality and presented here for illustrative purposes only. No inferences regarding the impacts of tile drainage on water quality in the Lake Champlain Basin should be made based on these data until their quality can be determined.

# Section 4. Primary Data Collection Activities for Select Tile Drain Systems in the JBW

## 4.1 Study Location

The Jewett Brook Watershed (JBW) is in the Town of St. Albans, Vermont. Jewett Brook flows to St. Albans Bay, a eutrophic bay of Lake Champlain (see Map 1). Monitoring stations will be constructed near the outfalls of the 12 tile drainage systems selected for monitoring in the JBW. Equipment will be installed at the edge of the farm field above the ditch or stream to which the tile drain discharges.

## 4.2 Monitoring Site Selection

Through a comprehensive outreach effort to farmers and agricultural agents operating in the Jewett Brook Watershed (JBW), Stone secured agreements with 6 of the 11 farmers believed to crop tile-drained land in the Jewett Brook Watershed to allow for monitoring of selected tile drain outlets. Taken together, 18 tile drain systems were identified across these farmers’ managed lands. Several of these tile drains are clearly not suitable for monitoring. The main reason certain tile drains were determined to be unsuitable is that they drained very small areas (<5 acres) and will thus produce relatively little drainflow. Most of these tile drains were in fact dry when visited this past summer (2016). One other tile drain was eliminated from consideration because it was installed primarily to drain barn roof runoff via surface inlets. After excluding these unsuitable tile drains, we identified 15 tile drains that could potentially be monitored, although several of these have obvious drawbacks, including 2 with known surface inlets (standpipes and/or rock inlets). Given that the number of tile drain outlets available for monitoring is only slightly higher than the number to be monitored, no formal site selection criteria need be established. Unfortunately, farmer cooperation and practical realities will necessarily supersede efforts to intentionally represent a range of field conditions (e.g., cropping system, soil type, hydrologic soil group, soil test P, and age, layout, and depth of tile drain system) in the watershed.

## 4.3 Characterization of Tile Drained Field Areas

The best available geographic data for the JBW will be assembled and reviewed, including cropping patterns and soils data. In characterizing these fields, producer confidentiality will be strictly maintained. Statistics regarding cropping patterns in the watershed (acreage in permanent corn or hay production or in specific rotations) and dominant soil types and slope classes, for land with and without tile drainage will be summarized without attribution to individual farmers or land ownership.



Detailed information will be obtained for fields served by the 12 tile outlets selected for monitoring. Extent of drained area, drain spacing, tile depth, and system construction and age will be defined based on information provided by the landowner; soil types, slope, cropping system, and manure/fertilizer inputs within the drained area will also be documented. Phosphorus application rates and soil test P data will be assembled from nutrient management plans and interviews with the participating farmers and/or their technical service providers.

Project personnel will communicate with landowners at the monitoring sites on a regular basis, both to obtain agronomic management information and to provide information about project results on an ongoing basis.

## 4.4 Monitoring System Design

At each of the 12 selected tile drains, drainflow will be recorded continuously and flow-proportional composite water samples will be collected approximately weekly to provide total phosphorus (TP), total dissolved phosphorus (TDP), and total nitrogen (TN) concentration data representing the preceding period. Weekly discharge and weekly composite sample data will be used to compute weekly P and N loads; flow, concentration, and load data will be aggregated to calculate flow volume, distributions of TP, TDP, and TN concentrations, and cumulative TP, TDP, and TN loads at outflows by season and over the entire monitoring period. Field visits to retrieve and process composite water samples will be conducted each week when the monitored tile drain is flowing. The sampling schedule may be influenced by weather and agronomic considerations, including collecting more frequent samples during certain farm operations such as manure or fertilizer application.

## 4.5 Monitoring Duration and Frequency

Construction of the monitoring stations will occur after corn harvest in the fall of 2016 so that vehicles can reach the station locations. System operation, sample collection, and sample analysis will continue from November 2016 through November 2017. Stations will remain operational though dry periods, although samples will obviously not be collected if tile outlets cease flowing. During the winter of 2016-17, autosamplers will be turned off to avoid damage. However, weekly grab samples will be collected from the tile drains when discharge occurs.

Weekly retrieval, processing, and analysis of flow-proportional composite water samples will provide data representing an event mean concentration (EMC) for each constituent for the preceding period. Samples will be retrieved on the same day each week, to the maximum extent practicable.

The sampling schedule will be influenced by weather and agronomic considerations; however, we expect the following general schedule of monitoring activities:

1. Monitoring systems installation completed and sampling initiated in November 2016.
2. System operation, sample collection, and sample analysis will continue from November 2016 through November 2017 with the exception of January – March 2017 when continuous monitoring may be suspended due to freezing conditions.

## 4.6 Pollutants of Concern

The principal pollutant of concern is phosphorus. In addition to the potential impacts of P on immediate receiving waters, P is the primary cause of eutrophication-related impairments in Lake Champlain. Nitrogen losses are also of concern. Both N and P losses are also undesirable from an agronomic standpoint.

**4.6.1 Constituents to be monitored**

All water samples will be analyzed for TP, TDP, and TN.

## 4.7 Sampling Procedures

Monitoring and sampling methods will be consistent for the duration of the study period. Trained personnel will be responsible for satisfactory sampling operations, maintenance of monitoring stations, and processing of field data. Field personnel will be responsible for recording failures of sampling systems and taking corrective actions.

Table 3 summarizes the number and type of samples that are anticipated in this study. The estimates of samples intended for TP, TDP, and TN analysis are based on weekly sample collection at all monitoring stations over the 12-month monitoring period. We assumed that, on average, tile drains would flow 42 weeks per year (no discharge would be present on 10 weekly sampling visits due to dry or frozen conditions). During most weekly sampling events, we assumed that a single set of sample splits will be processed. On one in four sampling events, we assumed two carboys would need to be processed into two sample splits per analyte. A minimum of 10% additional QC samples are included in the sample estimates.

The estimated number of samples at all stations was calculated as:

|  |  |  |
| --- | --- | --- |
|  | 12 | stations |
| x | 42 | weeks (assumes tile outlets are not flowing 12 weeks per year) |
| x | 1.25 | samples per event per station (assumes a single set of splits will be taken most weeks and two sets of splits will be taken roughly one week out of four) |
| x | 1.1 | accounts for 10% field duplicates |
| = | 693 | Total estimated samples per analyte |

Table 3. Sample types to be collected

| **Analytical Parameters** | **Sample**  **Container** | **Number**  **of Samples** | **Sample Preservation** | **Hold Time (days)** |
| --- | --- | --- | --- | --- |
| TP1 | Polyethylene bottle (composite) /  60-mL glass vial (aliquot for lab) | 700 | None | 28 |
| TDP1 | Polyethylene bottle (composite) /  60-mL glass vial (aliquot for lab) | 700 | Filtered (0.45 µm) in field | 28 |
| TN | Polyethylene bottle (composite) /  50-mL plastic centrifuge tube,  blue cap (aliquot for lab) | 700 | Cool (<6°C), 0.1 mL H2SO4 | 28 |
| 1. VAEL employs an EPA-approved variant of standard methods wherein samples for phosphorus analysis are digested in the same glass storage vial in which they are collected. No acidification is necessary. | | | | |

**4.7.1 Water sampling instrumentation**

ISCO 6712 and 3700 automatic samplers will be used to collect samples of drainage water from each of the selected tile drains. The autosamplers will be programmed to withdraw sample aliquots on a flow-proportional basis, according to the frequency of flow pulses received from the flowmeter. The sampling frequency will be constant during the collection of each weekly composite sample. The autosampler will sequentially fill four 10-L polyethylene carboys. When the first carboy is filled, the autosampler will begin dispensing sample aliquots to the second carboy, and so on until either the fourth carboy is filled or the sampling program is stopped. The flow proportional sampling frequency at each station will be adjusted seasonally with the goal of obtaining an average of approximately 5 L of sample per week (one half-full carboy), which will minimize the risk of under-sampling during large flow events (total sample capacity = 40 L).

At free-flowing outlets where flumes are used to measure discharge, sample lines will be affixed to the flume. At non-free flowing outlets (e.g., those which experience submerged conditions), the sample line will be inserted approximately 10 feet into the outlet pipe in order to avoid sampling tile drainflow that has mixed with the receiving water. Discharge monitoring is discussed in more detail in Section 4.8.

**4.7.2 Collection of water samples**

Approximately weekly, field technicians will visit each station to process water samples according to the Study Specific Procedure included as Appendix A. If the tile line has not flowed, no sample will have been collected; this will be noted on the Sample Retrieval Form (Appendix A).

Collected water samples will be transported on ice to VAEL in Burlington, VT, approximately 20 km/25 min from the monitoring sites, within the stated holding times for each analyte. Samples will be tracked using a Chain of Custody form (Appendix A) that will be completed by the sampler and will accompany all water samples delivered to VAEL. The Chain of Custody form includes sample IDs, number of containers of each sample being sent to the lab, and the analyses requested. Once the water samples are accepted by VAEL, they will be subject to the lab’s internal tracking system.

## 4.8 Discharge Measurement

Depending on the elevation of the tile drain outlet relative to the water surface in the receiving ditch or stream, one of two types of flow monitoring installations will be made. Where submergence of the tile drain outlet is unlikely, an appropriately sized flume with ultrasonic level sensor will be installed at the outlet. Where the outlet is likely to become submerged during high water levels, an excavation will be made to install a magnetic flowmeter within a pipe loop constructed in a section of the tile line above the outfall.

**4.8.1 Discharge measurement at free-flowing outlets**

The primary hydraulic device used at free-flowing (not submerged) tile outlets will be an appropriately-sized H-flume or Palmer-Bowlus flume. Each flume will be bolted to a rectangular approach channel. A baffle wall at the front of the approach will allow the drain tile to be inserted into the flume/approach. Through the life of the monitoring program, the flume will be kept level through regular adjustments using a system of turnbuckles and threaded rods.

An ultrasonic water level sensor (ISCO 2110 Ultrasonic Flow Module) will be mounted over the flume to continuously measure stage (water level). The stated accuracy of this instrument is the greater of ±0.00396 m or 0.00256 m per foot (0.305 m) from the calibration point. Level data will be converted to discharge rate based on the established hydraulic rating of the flume. These data will be used in calculation of discharge corresponding to each weekly sample and in calculation of pollutant export.

**4.8.2 Discharge measurement at non-free-flowing outlets**

To monitor flow at the tile drain outlets which are submerged or likely to become submerged at high water levels, a trap or loop will be constructed in the pipeline to ensure full-pipe flow and a pipeline flowmeter will be installed in the trap section. This method will require excavation of a trench along the drain tile to install the pipe trap and flowmeter. A short section of pipe will be cut out and replaced with rigid pipe and fittings, forming a trap. A Krohne Waterflux 3000 electromagnetic flowmeter will be installed in the trap section, cabled to a signal converter (Krohne IFC 100) mounted above ground in an instrument enclosure. This sensor has outstanding accuracy at high flow rates (less than +/-0.3% in a 6-inch diameter pipe at flows above 300 gallons per minute) and better accuracy at low flows than any similar pipeline flowmeter (for example, 3% in a 6-inch diameter pipe at 5 gallon per minute). The sensor is rated for full submergence and direct burial.

## 4.9 Testing and measurement protocols

All water samples will be analyzed by the standard methods of the Vermont Agriculture and Environmental Laboratory. These methods and relevant data quality objectives, assessment procedures, and reporting limits are described in the VAEL’s Quality Systems Manual, Revision 23, dated December 18, 2015. Methods of analysis are summarized in Table 4.

Table 4. Analytical methods

| **Sample Matrix** | **Analytical Parameter** | **Lab** | **Method** |
| --- | --- | --- | --- |
| Water | TP | VAEL | 4500-P H |
| Water | TDP | VAEL | 4500-P H |
| Water | TN | VAEL | 4500-N C-modified |
| References: Standard Methods for the Examination of Water and Wastewater; 21st Ed. 2005. | | | |

## 4.10 Quality Assurance/ Quality Control (QA/QC)

**4.10.1 Quality objectives and criteria for measurement data**

The project data-quality objective is to collect, provide, maintain, analyze, display, and document valid water quantity and quality data. The monitoring information that will be collected to support project objectives will meet the quality assurance objectives outlined in this section. Data quality will be measured in terms of accuracy and precision, completeness, representativeness, comparability, completeness, and traceability.

Table 5 summarizes data quality requirements associated with the sampling program and the accuracy and precision levels reported by the analytical laboratory for each parameter. The analytical laboratory for the water samples is VAEL, which is currently located on the University of Vermont campus in Burlington. VAEL is accredited by the National Environmental Laboratory Accreditation Conference Institute (TNI) for the specified water quality parameters. Discharge measurement will document the rate and total quantity of drain flow over the course of the study. Analysis of flow-proportional water samples will provide mean concentrations of each monitored constituent. Mass of each monitored constituent will be computed from interval and total discharge volumes and constituent concentrations. To ensure data quality objectives are met, all sampling activities will be well-documented and will occur in accordance with the specifications presented in this QAPP.

For the QC samples, field duplicates will be collected of TP, TDP, and TN samples. Duplicates will be collected on a rotating basis among stations. Samples from one or two stations will be collected in duplicate on every event, such that at least 10% of the total sample load is collected in duplicate. Grab samples collected during the winter months will be collected in duplicate according to the same scheme used for the composite sample splits.

Table 5. Data quality requirements and assessments

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Matrix** | **Parameter** | **Units** | **PQL1** | **Accuracy2** | **Accuracy protocol** | **Precision**  **Lab/Field3** | **Precision protocol** | **Method Range** |
| Water | TP | µg/L | 5 µg/L | 85-115% | Spike recovery | 15/20 | Field duplicate | 5 – 200 µg/L |
| Water | TDP | µg/L | 5 µg/L | 85-115% | Spike recovery | 15/20 | Field duplicate | 5 – 200 µg/L |
| Water | TN | mg/L | 0.1 mg-N/L | 85-115% | Spike recovery | 10/20 | Field duplicate | 0.05 – 2.0 mg-N/L |
| 1. Practical Quantitation Limits (PQL) is the lower limit of quantitation (reporting).  2. Accuracy for analytical parameters is expressed as Percent Recovery of Sample Matrix Spike. Analyte Percent Recovery acceptance criteria are method specified limits or generated from historical laboratory data. Recoveries are matrix/sample dependent.  3. Laboratory Analytical Duplicate Relative Percent Difference (RPD) acceptance criteria/Field Duplicate RPD acceptance criteria. | | | | | | | | |

**4.10.2 Accuracy**

Accuracy is defined as a measure of how close a result is to the true value. For physical/chemical parameters, accuracy is generally assessed through the analysis of spiked samples, with results expressed as percent recovery. VAEL’s Quality Systems Manual, Revision 23, provides acceptance criteria for spiked sample results for each analyte tested. Calibration procedures, blank samples, and sample handling protocols provide additional information used to evaluate the accuracy of each analytical procedure.

**4.10.3 Precision**

Precision is defined as a measure of the reproducibility of individual measurements of the same property under a given set of conditions. Precision is generally assessed through field and laboratory duplicate analyses. In this case, duplicate analysis will be conducted on splits of field-collected composite samples. The most commonly used measure of precision is the relative percent difference (RPD). The formula for calculating the Relative Percent Difference is:

RPD = 100\* Absolute Value(X1-X2)/((X1+X2)/2)

where X1 and X2 are the two measurements being compared.

The method RPD is provided for the key analytical parameters in Table 5. Field duplicates will be prepared and delivered to the laboratory at a minimum rate of 10%.

**4.10.4 Representativeness**

In the context of this study, representativeness expresses the degree to which the data gathered by the project accurately and precisely represent field conditions. By continuously measuring discharge and collecting flow-proportional samples for chemical analysis, the data gathered will accurately represent water and pollutant export under true field conditions.

Data representativeness for primary source data for this project will be accomplished through implementing standard sampling procedures and analytical methods which are appropriate for the intended data uses.

**4.10.5 Comparability**

Comparability expresses the confidence with which one data set can be compared to another. Comparability of the field measurements is ensured by adhering to consistent standard sampling techniques and protocols. Such consistency will be reinforced by training and supervision of field staff (see Section 1.5). Comparability of laboratory measurements is ensured through following VAEL’s Quality Systems Manual, Revision 23, dated December 18, 2015, and the respective SOP for a given analyte.

**4.10.6 Completeness**

Completeness is a measure of the percentage of planned samples collected or the percentage of usable data points per measurement, with a usable result defined as one that meets criteria for accuracy, precision, and representativeness. Project specific completeness goals account for all aspects of sample handling, from collection through reporting. The minimum completeness objective for the key parameters measured in tile flow is determined to be 95 percent.

% Completeness = # of Usable Points / Total # of Data Points Collected x 100

A usable result is defined as a result that meets all criteria for accuracy, precision, and representativeness.

**4.10.7 Traceability**

Traceability is defined as the ability to trace the generation of each analytical result from sample collection through analysis and reporting. To accomplish this, all activities must be fully documented. Specific requirements will be met for documenting operation and maintenance of field instrumentation, sample tracking, analytical methodology including NIST traceable standards, record-keeping, data reduction procedures, and data presentation; these requirements are described elsewhere in this document. The data quality objective for traceability with respect to all primary data analyses for all samples is 100 percent.

## 4.11 Quality Control Requirements

All data acquired or generated will be fully documented as to original source, quality, and history.

Field quality control sampling will consist of the following:

* At least 10% of composite sample splits will be duplicated in the field by collecting a second aliquot from the churn splitter for delivery to the lab.
* No travel blanks will be collected because the parameters are not susceptible to cross contamination during shipment.

Data from field duplicates will be accepted if the RPD is less than or equal to 20%; in such cases, the mean of accepted field duplicates will be used to represent data from the sample involved. In cases where the RPD of field duplicates exceeds 20%, the data may be deemed unusable. Sampling QC excursions are evaluated by the Project Manager. Field duplicate sample results are used to assess the entire sampling process, including environmental variability; therefore the arbitrary rejection of results based on predetermined limits is not practical. The professional judgment of the Project Manager or her designee will be relied upon in evaluating results. Rejecting sample results based on wide variability is a possibility. Notations of field duplicate excursions and blank contamination will be noted in the final report.

## 4.12 Instrument/Equipment Calibration and Frequency

Field analytical equipment that may be used in this project includes instruments for measuring water stage and flow rate. Calibration procedures for the equipment will follow manufacturer instructions.

Instrument and equipment calibration for water analysis will be routinely carried out by VAEL under their EPA approved Quality Systems Manual, Revision 23, dated December 18, 2015.

## 4.13 Data Acquisition Requirements for Non‐direct Measurements

Sources of supplementary data considered in this project may include weather data obtained from a local NWS cooperating station. Such data may be used to compare contemporary weather conditions against long-term averages or normals. These data will be accepted as valid if officially published by the NWS. Second, historical soil and manure test data from the farm’s nutrient management plan (if available) may be reviewed to help characterize site soils and agronomic management. Soil and manure samples for this purpose are typically collected by certified crop management consultants and analyses are performed through the UVM Agricultural and Environmental Testing Laboratory. The data reported in this manner will be accepted as valid if it is contained in a nutrient management plan recognized by the AAFM. Farm records maintained by the participating farmers will be reviewed for information regarding management of the study fields. Collection of these data by the farmer meets record keeping requirements of Vermont AAFM. Additional supplemental data sources used include published topographic data and soils mapping based on the USDA-NRCS county soil surveys.

The supplementary data will not contribute directly to project decision-making, with the exception of field agronomic practices data recorded by the participating farmer.

## 4.14 Data Summaries

Summary data tables will be prepared for each station using the procedures described in Section 4.16. These tables will include total discharge, mass export, and mean concentrations of all monitored constituents. Using these summary data tables, descriptive statistics (range, mean, median, standard deviation, coefficient of variation) will be calculated by station. These summary data tables and statistical summaries will be stored electronically on Stone Environmental’s servers, which are backed up daily to a Unitrends backup appliance. Once per week the most recent backup will be written to a drive which is taken to a storage vault offsite.

## 4.15 Methods for Data Acquisition and Storage

To protect personally identifiable information (PII) in any publications or public discussions of project results, the study site will be identified by an alphanumeric code consisting of the abbreviation “JBT” (Jewett Brook Tile) followed by a number between 1 and 12 (i.e., JBT01 through JBT12). Once data are reported to LCBP, they will be subject to standard measures required to protect participants’ PII.

The Stone Environmental Project Manager or her designee will be responsible for organization and oversight of data generation, disbursement, processing and storage so that the data will be documented, accessible and secure for the foreseeable time period of its use. The VAEL director has the same responsibility for the laboratory data and information s/he generates.

Standard sample retrieval forms (Appendix A) will be used to document sample location, station and field conditions, date and time of collection, and personnel responsible for collection for all samples collected in the field. A Chain of Custody form (Appendix B) will be used by the laboratories to confirm sample delivery. VAEL will complete log-in sheets to document sample receipt and condition. Copies of all field sheets will be maintained in the project file at the offices of Stone Environmental.

Analytical data from VAEL will be transmitted in electronic format to the Project Manager or her designee after all internal review has been completed.

Data from the flowmeters and autosamplers will be automatically pushed to Stone’s computer server every 30 minutes. These raw electronic data will be maintained on the server for the duration of the project and will be viewable in near real-time through a web user interface. These data will be extracted into Access databases, Excel workbooks, and *R* for manipulation and preparation of data summaries.

All electronic files on Stone’s servers, including raw data pushed from monitoring stations, will be backed up daily to a Unitrends backup appliance. Once per week the most recent backup will be written to a drive which is taken to a storage vault offsite. Paper and electronic files will be archived for a minimum of five years at Stone Environmental following completion of the project.

**4.16 Methods of Analyses**

The ISCO 2105ci interface module at each station will record instantaneous discharge rates measured by the flowmeters at five minute intervals. Discharge and sample event mark data will be transmitted automatically to a computer server located at Stone Environmental’s offices in Montpelier, VT.

An Access database has been created to import and process analytical data from electronic tables transmitted by VAEL, import and aggregate corresponding event discharge data from the SQL server, and calculate total discharge, constituent mean concentrations, and mass export. This data processing will be performed using a series of database queries that will accomplish the following data manipulations:

1. Analytical results of duplicate samples will be averaged
2. Analytical results will be linked to specific sampling events on a common ID (LabID)
3. The constituent mass corresponding to the collection period of each composite sample (concentration multiplied by associated discharge total) will be calculated
4. Where multiple composite samples are subsampled for analysis (for example, carboys 1 and 2), the partial event constituent masses from #3 will be summed to derive total export for the interval.

There are several common sources of inaccuracy in discharge measurement that we are attempting to minimize through selection of the most appropriate instruments and certain station design innovations. These sources of inaccuracy include submergence of the tile drain outlets, level sensor drift, and flumes becoming non-level. Submergence of many of the outlets will be addressed by ensuring full pipe flow conditions at all times and installing an appropriate flowmeter for this condition. Flume level will be maintained by checking level during every maintenance visit and making appropriate adjustments. In some cases, level and discharge data may warrant adjustments to account for sediment or ice accumulation in monitored pipes and flumes.

The data set used for the primary statistical analyses will include total discharge (m3) and mean concentration (mg/L) and mass export (kg) for each monitored constituent for each sampling event for each monitored location. Data reported as less than a detection limit will be assigned a value of one-half the detection limit for purposes of data analysis, but will be flagged as below detection in reported concentration data tables. All statistical analyses will be done using version 10.0 of JMP statistical software (SAS Institute). Basic descriptive statistics and exploratory data analysis will be conducted on this data set.

# Section 5. Assessment and Oversight

It will be the responsibility of the Project QA Officer to ensure that project QA/QC activities, assessments, and responses are conducted according to this QAPP. The QA Officer (or designee) will have the authority to issue a stop work order upon finding a significant condition that would adversely affect the quality and usability of the data. The QA Officer will document, implement, and verify the effectiveness of corrective actions, such as an amendment to the QAPP, and take steps to ensure that everyone on the distribution list is notified.

Monitoring station readiness will be assessed through routine (minimum of twice weekly) review of flowmeter, sampler, and battery voltage data transmitted in near real-time to a server located at Stone Environmental’s office. Several important and not uncommon problems may be detected remotely and quickly using these data, for example, sampler error messages, erroneous autosampling attempts, and low battery voltage. Early detection of these problem conditions will enable timely response by sampling teams to visit the monitoring station in question and correct the problem. Regular maintenance of the monitoring station and instruments will minimize the incidence of instrument malfunctions and other problems. Certain basic maintenance activities will be conducted after sampling event, to clean bulk sample containers, churn splitters, sampler lines, and flumes (if necessary) and to reset the autosampler. Site visits will be conducted for more intensive maintenance activities approximately monthly during the monitoring period. A Routine Maintenance Form will be completed during each maintenance visit (Appendix C). Deficiencies noted will be corrected by the responsible personnel. In the event that corrective action is required that is beyond the training of the maintenance personnel, a Stone Environmental project scientist with expertise in the monitoring systems will diagnose and correct the problem.

The effectiveness of monitoring will be assessed by the responsible sampling personnel at each site using data collected at the time of sample retrieval (Appendix A). Section 4.10 describes several common sources of inaccuracy in discharge measurement and how these will be addressed.

Periodically, when summary data tables are prepared for reporting purposes, the Project Manager or her designee will assess the quality of all discharge and analytical data and will be responsible for verifying/validating all sample tracking information and laboratory analysis data. Any deficiencies will be flagged with a qualifying statement in summary data tables and necessary corrective action will be taken. As part of final report preparation, the Project Manager or her designee will also review field and data management operations for the preceding year for consistency with the requirements outlined in this QAPP.

Internal assessments and response actions with regard to laboratory analysis within VAEL will occur under the terms of the lab’s approved Quality Systems Manual (Revision 23). Project investigators will examine data reports from the laboratory for problems or conditions of concern noted by analysts, based on *Sample Remark Codes.* Examples of such codes are included in Table 6.

Table 6. Sample remark codes used by VAEL

| **Sample Remark Code** | **Description** |
| --- | --- |
| B | Reported value is associated with a lab blank contamination. |
| BH | Reported value may be biased high. |
| BL | Reported value may be biased low. |
| E | Estimated Value |
| D | Dilution resulted in instrument concentration below PQL. |
| H | Hold time exceeded. |
| I | Matrix Interference |
| N | Not processed or processed but results not reported. |
| O | Outside calibration range, estimated value. |
| OL | Outside Limit |
| P | Preservation of sample inappropriate, value may be in error. |
| S | Surrogate recovery outside acceptance limits. |
| T | Time not provided |
| W | Sample warm on arrival, no evidence cooling has begun. |

If water quality data are suspect (e.g., flagged by the lab, duplicate RPD too high, unusual extreme concentrations), the first response will be to contact the laboratory and verify that no simple errors have been made. If questions cannot be resolved and suspect concentration data remain, the concentration data may be rejected for that constituent for the sampling event in question.

NEIWPCC may implement, at its discretion, various audits or reviews of this project to assess conformance and compliance to the quality assurance project plan in accordance with the NEIWPCC Quality Management Plan.

Quarterly reports will be submitted to LCBP and NEIWPCC, per the standard LCBP reporting process for review and approval. The LCBP Project Officer will be presented with the final project deliverables and a summary of any QA/QC actions taken before providing final approval to the report.

Any limitations and gaps in data included in the analysis will be fully disclosed within the project final report, and it will be noted that these data should be used with caution.

# Section 6. Deliverables

As part of Task 1, Stone will develop and submit a narrative report for LCBP review summarizing all information obtained through the literature review, including an executive summary suitable for wide distribution beyond the scientific community. The deliverables for this project will include:

* The narrative report and executive summary with complete list of references;
* Spreadsheets summarizing detailed information from each literature source; and
* Electronic copies of all sources cited.

As part of Task 2, Stone will produce a report detailing the methods and results of the watershed and drainage area characterization. The memo will document cropping patterns in the JBW (acreage in permanent corn or hay production or in specific rotations) and dominant soil types and slope classes, for land with and without tile drainage, as well as providing descriptive information for the agricultural areas served by each of 12 tile drain systems included in the study. In addition, photo-documentation of each monitoring installation will be submitted.

Stone will also produce a succinct monitoring and assessment report summarizing the methods and results of the watershed and drainage area characterization, and the flow and water quality monitoring. The report will also include an analysis of agronomic and water quality factor associations. GIS layers used or generated to support the analyses will also be provided to LCBP, subject to confidentiality requirements of the Vermont Agency of Agriculture. Total and dissolved P concentrations and loads for each of the 12 monitored tile drainage systems will be summarized in monthly and annual statistics.

In addition to the task-specific deliverables described above, quarterly reports will be submitted to LCBP, per the standard LCBP reporting process for review and approval. Relevant LCBP advisory committees, notably the Technical Advisory Committee, will be presented with the final report deliverables and a summary of any QA/QC actions taken before providing final approval to the report.

# Section 7. References

U.S. Environmental Protection Agency. 2003. A Summary of General Assessment Factors for Evaluating the Quality of Scientific and Technical Information. Washington, DC: Office of Research and Development, Science Policy Council; Report No. EPA/100/B-03/001.

# APPENDIX A: Sampling Procedures and Routine Maintenance for Assessment of Tile Drainage System Impacts to Lake Champlain and Phosphorus Loads in Tile Drainage in the Jewett Brook Watershed

**STUDY SPECIFIC PROCEDURE**

***Sampling Procedures and Routine Maintenance for Assessment of Tile Drainage System Impacts to Lake Champlain and Phosphorus Loads in Tile Drainage in the Jewett Brook Watershed***

SSP Number: 1 Date Issued: 11/14/16

Version Number: 1 Date of Revision: NA

**OBJECTIVE**

To facilitate collection of high-quality water samples, preventative maintenance of monitoring stations and equipment, and accurate recording of monitoring activities and data.

**POLICIES**

All field staff performing sampling duties for the project must read this SSP and implement the procedures written herein.

**Health and Safety**

A health and safety plan (HASP) was prepared for this project identifying possible health and safety risks involved in field activities, how these risks are to be managed, and responsibilities of project management and staff. This HASP must be read and signed by every direct employee of Stone Environmental engaged in fieldwork for this project. Contractors assisting Stone with sampling and other field activities are not similarly bound by the HASP, but should nonetheless remain alert and responsive to potential health and safety risks. Stone Environmental assumes no responsibility and will accept no liability for the health and safety of personnel who are not direct employees of Stone Environmental.

There are several common health and safety risks which demand particular attention, as follows:

**Insects**

Hornets, wasps, bees, and yellow jackets are common in edge-of-field settings in Vermont. These insects may build nests in the monitoring shelters. A spray can of insecticide should be available at each monitoring shelter. Personnel known to be allergic to hornet, wasp, bee, and/or yellow jacket stings should carry with them an Epipen or similar medication as directed by their physician.

Mosquitos may carry dangerous pathogens including West Nile virus and eastern equine encephalitis. Use repellant and appropriate clothing to minimize mosquito bites.

Ticks are common in areas bordering agricultural fields. Tick populations should be reduced by mowing work areas. Long pants, tucked into socks, should be worn when possible. Skin and clothing should be checked for ticks upon leaving the field.

**Plants**

In addition to poison ivy and stinging nettle, personnel must avoid contact with wild parsnip, a new invasive plant in Vermont that can produce a painful and lasting burning of the skin after exposure of affected areas to sunlight. This plant has been seen in the area of the Ferrisburgh monitoring stations and may exist at other stations as well.

**Severe weather**

Sampling activities will often take place shortly following storm events. Under no circumstances should personnel visit monitoring stations during lightning storms. Personnel should also be alert to high wind or other conditions and avoid exposure.

**Cold/heat stress**

Personnel will be working under both very cold and very warm conditions in the course of the monitoring program. Standard recommendation for minimizing the risk of heat stress and hypothermia need to be observed.

**Flow Proportional Composite Sampling ProcedureS**

An ISCO 6712 or 3700 autosampler will be operated to collect flow-proportional composite samples during times of the year where conditions are expected to remain above freezing. Approximately weekly, field technicians will visit each station to process the bulk composite samples into appropriate splits.

1. Record information from autosampler display (see attached Sample Retrieval Form). Note that the autosampler may display various error messages, some of which may be important, others not. If the display indicates a warning about excessive pump tubing counts, you may disregard this. If the sampler displays “No Liquid Detected”, this may indicate either that the intake was exposed to air during one or more sampling attempts or that there is a clog in the sampling line. If this warning is displayed, inspect the sampling line for a clog, kink, or ice blockage and otherwise ignore it. For all other warning messages, please contact Stone.
2. Stop the sampling program by pressing the red button to pause the program and then selecting STOP PROGRAM. In certain cases, the sampling program may have been stopped remotely by Stone. Stopping the program remotely can mitigate certain problems and potential risks, such as frozen sampling lines on cold nights.
3. Record approximate sample volumes in each carboy.
4. Select the appropriate carboy(s). Carboy 1 should contain a minimum of 300 mL for sample splits to be prepared for analysis. Since the programmed aliquot volume is 100 mL, three aliquots should produce 300 mL of sample. If three or more sample aliquots were attempted and the volume in carboy 1 is substantially less than 300 mL, then the suction line was likely exposed during pumping, drawing air rather than water. You may also view the sampling report for further information about which sampling attempts were unsuccessful.
5. Fill out and affix labels to the appropriate containers. The correct container for each analyte is given in Table 1.

*Table 1. Sample containers, preservation, and permissible holding times*

| **Analyte** | **Container** | **Preservation** | **Hold Time (days)** |
| --- | --- | --- | --- |
| TP | 60-mL glass vial | None | 28 |
| TDP | 60-mL glass vial | Filtered (0.45 µm) in field | 28 |
| TN | 50-mL plastic centrifuge tube, blue cap | Cool (<6°C), 0.1 mL H2SO4 | 28 |

The Sample ID field is a concatenation of the Site ID (JBT01, JBT02, etc.), the collection date (mmddyy), and the carboy(s) from which sample splits are taken [1, 2, 3, 4, or 1/2 (if the samples from carboys 1 and 2 are added together in the churn splitter)]. See step 7 regarding the sample splitting procedure. The following examples illustrate the sample IDs syntax:

* A sample collected at JBT01 on May 2, 2017 only from carboy 1: **JBT01-050217-1**
* A sample collected at JBT02 on September 27, 2017 by combining the contents of carboys 1 and 2 in the churn splitter: **JBT02-092717-1/2**

1. Put on lab gloves
2. Pour sample from the selected carboy(s) into the churn splitter. Try to swirl the water to suspend sediment as you pour the sample into the churn splitter.  
     
   In many cases, only the first carboy will contain sample. If the second carboy also contains sample, this can be added to the churn splitter so long as the combined volume will not exceed 14 liters, the capacity of the churn splitter. For example, if carboy 1 contains 9 liters and carboy 2 contains 4 liters, these can be composited in the churn splitter; and the resulting sample ID would be in the form: SiteID-mmddyy-1/2.   
     
   If the combined volume will exceed 14 L, each carboy should be split individually, resulting in two sets of sample splits for analysis.
3. Operate the churn splitter for 5-10 seconds. With sample containers in hand, open the stopcock and let spill on the ground for 1-2 seconds to clear the line. Then prepare:
   1. TP sample split: While operating the churn splitter, fill the glass vial up to the line.
   2. TN sample split: While operating the churn splitter, fill a blue capped centrifuge tube to the 50 mL line.
   3. Let the contents of the churn splitter settle for 1-5 minutes.
   4. TDP sample split: Sample splits for TDP analyses will be filtered in the field by dispensing sample from the churn splitter directly into a filtration apparatus containing a 45-mm Durapore® 0.45-µm acetate membrane filter. Use forceps to place a clean filter in the filter holder. Wet the filter with a spray of distilled water. Remove the plunger and attach the filter holder to the syringe. Fill a syringe with settled water from the churn splitter. Squirt approximately 10 mL onto the ground and then fill a glass vial to the 50-mL line. If the filter clogs prematurely, it may be replaced with a new filter and the process repeated.
4. Preservation. Put on safety glasses. Add 1 drop of concentrated sulfuric acid to preserve the TN sample. Place all samples on ice and store on ice or refrigerate until delivery to the laboratory. Clean up acid spills with acid neutralizing solution or copious amounts of water. To use acid neutralizing solution, shake bottle of acid neutralizing solution and cover affected area until bubbling stops.
5. Washing equipment. The standard washing procedure is for three rinses with distilled water. After each event, the churn splitter, filter holder, and carboys should be washed.
6. Reinstall carboys in the following clock positions: 1 at 6:00, 2 at 3:00, 3 at 12h, and 4 at 9:00.
7. Press the red button and select “run program” on the autosampler to ready the station for the next event. Confirm that the sampler program is running.
8. Complete the Chain of Custody form, including sample IDs, number of containers of each sample being sent to the lab, and the analyses to be performed. The Chain of Custody form must be kept with the samples, either by sticking it into the plastic sleeve taped to the underside of the cooler lid or in a ziplock bag with the samples.
9. Samples must be delivered to the laboratory within the holding times indicated in Table 1.

**Grab Sampling ProcedureS**

The autosampler programs will be stopped during the winter months when temperatures are expected to remain below freezing. During this period, field technicians will visit each station approximately weekly to collect grab samples if tile lines are flowing.

1. Fill out and affix labels to the appropriate containers. The correct container for each analyte is given in Table 1.
2. For grab samples, the Sample ID field is a concatenation of the Site ID (JBT01, JBT02, etc.), the collection date (mmddyy), and the word “GRAB”. The following example illustrate the sample IDs syntax:

* A grab sample collected at JBT01 on February 2, 2017: **JBT01-020217-GRAB**

1. Grab sample collection.
   1. Put on lab gloves
   2. If the air temperature is above freezing:
      1. Collect samples for TP and TN analysis directly into the sample container. The preferred method is to use the autosampler to pump a sample directly into the sample container, using the manual sample mode. The autosampler pump tubing should be detached from the autosampler housing and a stream of water directed into the sample container. Set the sample volume to 200 mL and dispense the first approximately 5 pump cycles (50 mL) onto the ground, then collect sample up to the fill line on the sample container.
      2. Samples for TDP analysis may be dispensed directly into the filtration apparatus containing a 45-mm Durapore® 0.45-µm acetate membrane filter. Use forceps to place a clean filter in the filter holder. Wet the filter with a spray of distilled water. Remove the plunger and attach the filter holder to the syringe. Use the autosampler to pump sample into the syringe, using the manual sample mode. The autosampler pump tubing should be detached from the autosampler housing and a stream of water directed into the syringe. Set the sample volume to 200 mL and dispense the first approximately 5 pump cycles (50 mL) onto the ground, then collect appromately 60 mL of sample in the syringe. Squirt approximately 10 mL onto the ground and then fill a glass vial to the 50-mL. If the filter clogs prematurely, it may be replaced with a new filter and the process repeated.
   3. If the air temperature is below freezing:
      1. The autosampler may be damaged by ice accumulation. If the tile line continues flowing under freezing conditions, grab samples may be withdrawn using a portable centrifugal pump inserted into the flow metering chamber via a sampling port. Using this pump, sample should be dispensed directly into the sample containers, dispensing the first approximately 50 mL onto the ground, then collecting sample up to the fill line on the sample containers.
      2. Because field filtration is not generally successful under freezing conditions, grab samples collected for TDP analysis will be filtered at VAEL. In this case, TDP samples must be brought to VAEL for processing on the day of collection.
2. Preservation. Put on safety glasses. Add 1 drop of concentrated sulfuric acid to preserve the TN sample. Place all samples on ice and store on ice or refrigerate until delivery to the laboratory. Clean up acid spills with acid neutralizing solution or copious amounts of water. To use acid neutralizing solution, shake bottle of acid neutralizing solution and cover affected area until bubbling stops.
3. The filter holder and syringe should be washed by rinsing three times with distilled water after sampling at each station.
4. Complete the Chain of Custody form, including sample IDs, number of containers of each sample being sent to the lab, and the analyses to be performed. The Chain of Custody form must be kept with the samples, either by sticking it into the plastic sleeve taped to the underside of the cooler lid or in a ziplock bag with the samples.
5. Samples must be delivered to the laboratory within the holding times indicated in Table 1.

**Routine Maintenance**

**Tasks to be performed by sampler after each sampling event**

1. On the Sample Retrieval Form, record the amount of rainfall collected in any manual gauges and the date and time. Record the amount of rainfall collected in the graduated cylinder to the nearest 0.01 inch then empty it. If water is present in the outer (overflow) cylinder, carefully decant this into the graduated cylinder and add this amount to the first reading. Repeat if necessary until the overflow cylinder is empty.
2. Confirm that the sampler program is running.
3. Confirm that the sampling line and pump tubing are attached.
4. Confirm that the sample carboys are installed properly.
5. Describe field/crop condition.
6. Verify that sufficient sampling supplies (bottles, filters, gloves) remain for at least two sampling events. Notify the Stone project manager if any supplies are low.

**Tasks to be performed by Stone approximately monthly**

1. Confirm that the sampler program is running.
2. Check the sampling line for any kinks or sags; zip-tie if necessary to maintain a consistent downward slope in the line.
3. Confirm that the sample carboys are installed properly.
4. Check the desiccant cartridges of the flowmeters and 2105ci modules and replace desiccant if necessary.
5. Restock monitoring stations with bottles, sample retrieval forms, labels, filtration supplies, gloves, and distilled water.
6. Refill or replace acid dropper bottles.
7. Cut weeds from around the shelters and flume and along the wingwalls.
8. Describe field/crop condition.

**AUTHORIZATION**

Written by: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_

Dave Braun, Water Quality Scientist, Stone Environmental, Inc.

Approved by: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date: \_\_\_\_\_\_\_\_\_\_\_\_

Julie Moore, Project Manager, Stone Environmental, Inc.

**Revision history**

None

**Forms**

**Sample Retrieval Form**

Collected by:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Weather:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Rainfall (if gauge is deployed) \_\_\_\_\_\_\_\_ in.

|  |  |  |
| --- | --- | --- |
|  | **Station JBT01** | **Comment** |
| Station condition | □ OK Other \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |  |
| Field/crop condition |  |
| SAMPLE COLLECTION | | |
| Type of sample(s) collected (circle) | Composite split Grab None |  |
| Sampler display | \_\_\_\_\_\_\_, \_\_\_\_\_\_\_ bottle\_\_\_\_\_\_ |  |
| Time you stopped the autosampler | \_\_\_\_\_\_\_\_\_\_\_\_\_ AM or PM |  |
| Carboy volume (L) | 1: 2: 3: 4: or NA |  |
| Sample ID assigned | JBT01 – \_\_\_\_\_\_\_\_\_\_ – \_\_1\_\_\_  (Station) – (mmddyy) – (carboy)  JBT01 – \_\_\_\_\_\_\_\_\_\_ – \_\_2\_\_\_  (Station) – (mmddyy) – (carboy)  JBT01 – \_\_\_\_\_\_\_\_\_\_ – \_\_3\_\_\_  (Station) – (mmddyy) – (carboy)  JBT01 – \_\_\_\_\_\_\_\_\_\_ – \_\_4\_\_\_  (Station) – (mmddyy) – (carboy)  JBT01 – \_\_\_\_\_\_\_\_\_\_ – \_\_12\_\_  (Station) – (mmddyy) – (carboy)  JBT01 – \_\_\_\_\_\_\_\_\_\_ – \_\_\_\_\_  (Station) – (mmddyy) – (GRAB) |  |
| Splits collected (circle) | TP TDP TN |  |
| Duplicates collected? (circle) | TP TDP TN  Carboy \_\_\_\_\_\_\_\_ |  |
| RESETTING STATIONS | | |
| STOP then Re-RUN SAMPLING PROGRAM (circle) | Yes No |  |
| Carboys and churn splitter triple rinsed? (circle) | Yes No NA |  |
| Desiccant good? (circle) | Yes Changed |  |
| Carboys installed properly? (circle) | Yes No |  |
| Additional comments: | | |

**Chain of Custody Form for Water Samples**

Stone Project ID: 15-309

Lab Program #:

Stone Contact: Dave Braun, 802-272-8819, dbraun[@stone-env.com](mailto:jmoore@stone-env.com)

|  |  |  |  |
| --- | --- | --- | --- |
| **Collection Date** | **Sample ID** | **Total # of**  **Containers** | **Analyses Requested**  **(circle those collected)** |
|  |  |  | TP TDP TN |
|  |  |  | TP TDP TN |
|  |  |  | TP TDP TN |
|  |  |  | TP TDP TN |
|  |  |  | TP TDP TN |
|  |  |  | TP TDP TN |
|  |  |  | TP TDP TN |
|  |  |  | TP TDP TN |
|  |  |  | TP TDP TN |
|  |  |  | TP TDP TN |
|  |  |  | TP TDP TN |
|  |  |  | TP TDP TN |
|  |  |  | TP TDP TN |
|  |  |  | TP TDP TN |
|  |  |  | TP TDP TN |
|  |  |  | TP TDP TN |
|  |  |  | TP TDP TN |

Sampled by: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

print name signature

**Routine Maintenance Form**

Technician:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| ACTIVITY | SITE: \_\_\_\_\_\_\_\_\_ | SITE: \_\_\_\_\_\_\_\_\_ | SITE: \_\_\_\_\_\_\_\_\_ | SITE: \_\_\_\_\_\_\_\_\_ | |
| Sampler program running | □ | □ | □ | □ | |
| Sampler tubing is attached | □ | □ | □ | □ | |
| Sample carboys installed properly | □ | □ | □ | □ | |
| Signal converter desiccant | □ OK  □ Replaced  □ NA | □ OK  □ Replaced  □ NA | □ OK  □ Replaced  □ NA | □ OK  □ Replaced  □ NA | |
| 2105ci module desiccant | □ OK  □ Replaced  □ NA | □ OK  □ Replaced  □ NA | □ OK  □ Replaced  □ NA | □ OK  □ Replaced  □ NA | |
| Restock sampling supplies | □ | □ | □ | □ | |
| Restock forms and labels if needed | □ | □ | □ | □ | |
| Mow weeds | □  □ NA | □  □ NA | □  □ NA | □  □ NA | |
| Field Condition: |  |  |  |  |
| Comments: | | | | |

# APPENDIX B: Determination of Phosphorus by Flow Injection Analysis 24 8 1-2015 (Acid Persulfate Digestion Method)

# APPENDIX C: Determination of Total Nitrogen by Flow Injection Analysis 24 7 1-2015 (Persulfate Digestion Method)