# AGRICULTURAL PRACTICE MONITORING AND EVALUATION

## YEAR ONE REPORT

**Stone Project ID 112540-W**

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# 1. INTRODUCTION

Lake Champlain continues to suffer the effects of excessive phosphorus (P) loading from sources in the Lake Champlain Basin (LCB). It is estimated that more than 90% of the lake's current annual P load is derived from nonpoint sources (ANR 2008). Nonpoint source P lost from agricultural land is a significant component of the lake's annual P load (Troy et al. 2007). Although federal and state programs, as well as landowners, have made unprecedented investments in best management practices (BMPs) to address transport of P, sediment, and other pollutants from agricultural operations in the LCB, these efforts have not yet yielded the desired water quality results.

Vermont farmers are facing increasing pressure to reduce their contributions to water pollution in Lake Champlain. In 2011, the U.S. EPA withdrew their 2002 approval of the Vermont portion of the Lake Champlain total maximum daily load (TMDL) for P. A new TMDL will require quantitative estimates of the pollutant reduction performance of conservation practices to provide reasonable assurance that these practices can reduce P loads to Lake Champlain. Vermont farmers have shown strong interest in implementing BMPs such as conservation tillage, manure and nutrient management, and cover crops over the past decades. Although many producers attribute significant agronomic and water quality benefits to these management practices, the effectiveness of many of these practices on reducing P and sediment losses from agricultural land is not well documented. Only a limited number of studies exist from sites with similar climate and landscape settings to Vermont. In addition, many reported studies are plot-scale with simulated rainfall; such results may not apply directly to the field or watershed scales.

This study addresses an urgent need to evaluate and document the effectiveness of conservation practices in the Lake Champlain basin. This project was designed to meet the stated purpose of USDA-NRCS Conservation Practice Standard 799 – Monitoring and Evaluation, which is to *sample and measure water quality parameters to evaluate conservation system and practice performance*. More information about NRCS Conservation Practice Standards can be found at: www.nrcs.usda.gov/technical/Standards/nhcp.html

The project employs a paired-watershed design in order to document the effects of improved management on runoff losses of nutrients and sediments at the field scale. The principal hypothesis being tested is that application of these management practices will significantly reduce runoff losses of nutrients and sediment from agricultural fields in corn and hay production.

The agricultural practices to be evaluated are:

- Aeration on hayland (VT NRCS Practice Standard 633) prior to manure application;
- Reduced tillage (VT NRCS Practice Standard 329) with manure injection and cover cropping on corn land;
- Cover cropping (VT NRCS Practice Standard 340) on corn land; and
- A water and sediment control basin (WASCoB) (VT NRCS Practice Standard 638) treating runoff from corn land.

These practices are being evaluated on field/watershed sites at working farms in the Vermont-portion of the Lake Champlain Basin; locations of the monitored farms are shown in Figure 1.

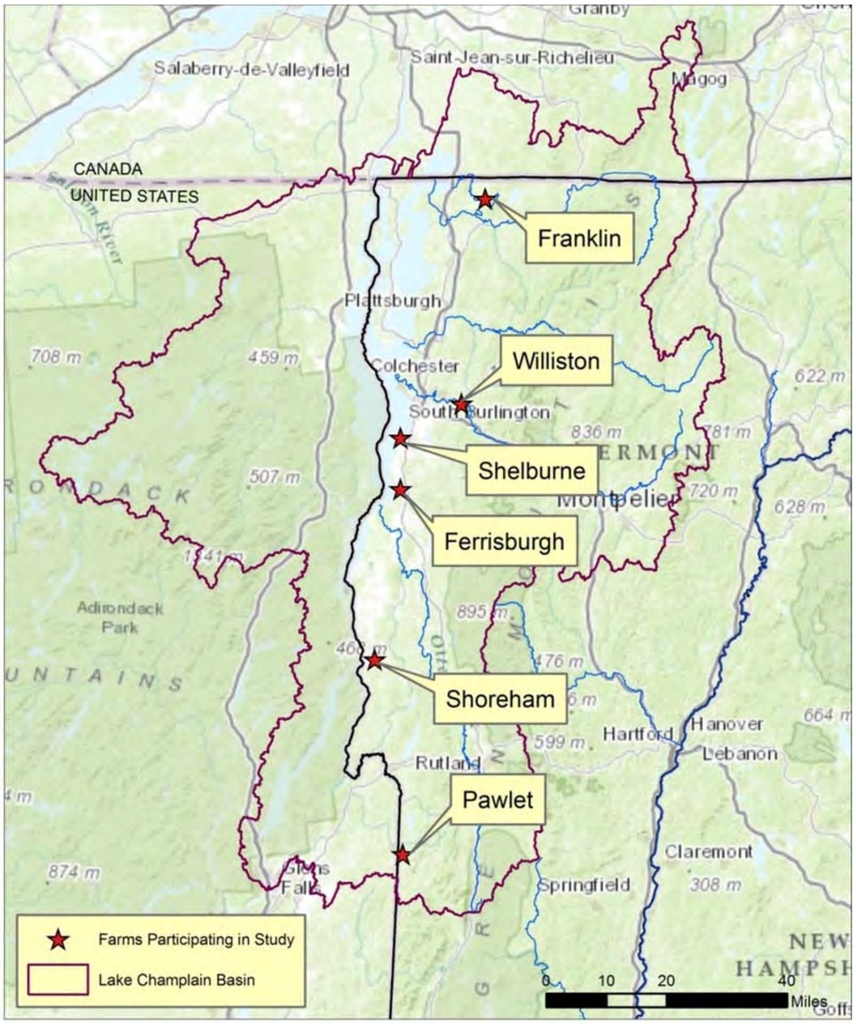


*Figure 1. Locations of farms participating in study*

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## 2. GOALS AND OBJECTIVES

The goal of the project is to quantify the treatment effect of specific conservation practices – cover cropping, reduced tillage with manure injection, soil aeration, and water and sediment control basins – in reducing runoff losses of nutrients, with particular emphasis on phosphorus, and sediment from agricultural fields in corn and hay production.

Specific project objectives include:

- Developing accurate estimates of pollutant reductions attributable to different conservation practices in Vermont-specific climate and landscape settings;
- Collecting scientifically sound data on BMP performance in support of TMDLs and other pollution-reduction programs;
- Analyzing data in a manner that can inform incentive program structure to ensure the most effective practices are emphasized; and
- Identifying potential modifications to BMPs that may improve performance.

## 3. STUDY PLAN

The project consists of nine major tasks, as described below. Work on tasks 1-4 has been completed; work on tasks 5-7 is on-going. Work on tasks 8 and 9 will not take place until site monitoring activities are concluded several years from now. The project will be conducted from May 2012 through at least mid-2015. By agreement with site landowners, exact site locations will not be publicly disclosed. Sites are referred to by town name.

Installation of monitoring facilities was completed in 2012. At the paired-watershed sites, calibration monitoring commenced in September 2012 and will continue through the 2013 growing season. At least one complete cropping season will be required for adequate calibration monitoring; it is possible that calibration monitoring will need to be extended further if sufficient high-flow events following manure application do not occur during the 2013 growing season. Implementation of treatments is planned to take place in late 2013 or early 2014, with exact timing depending on the treatment (e.g., cover crop treatment will occur in late summer/fall, while aeration could be initiated with the next hay cut once adequate calibration data has been collected). Post-treatment monitoring will continue through 2015 and possibly beyond, depending on a number of factors including: the availability of funding, the quality of the data obtained from the site, and the willingness of the landowner to continue with the project. Above-below monitoring at the WASCoB site began in late 2012 and will likely continue through the 2014 cropping season

**Task 1. Study design**: The overall study design employs a paired-watershed design in order to document the effects of improved management on runoff losses of nutrients and sediments at the field scale. The paired-watershed design includes two (or more) fields or watersheds—a control and a treatment—and two time periods—calibration and treatment. The watersheds need not be identical, but should be generally similar in size, slope, location, precipitation received, soils, and land cover (Hewlett 1971). The control watershed accounts for year-to-year climate variations and the management practices remain consistent during the entire study. The treatment watershed undergoes a change in management (e.g., soil aeration or cover cropping) at some point during the study.

The calibration period for the project was initiated in fall 2012 and is anticipated to continue through the 2013 growing season on all study farms. During the calibration period, the watersheds are treated identically and paired water quality data are collected. For this monitoring study, total event discharge, event mean concentration, and event export data are being collected and/or computed for each monitored event.

At the start of the treatment period, a change in management will be applied to the treatment watershed, while the control watershed remains in the original management. The basis of the paired-watershed approach is that there is a quantifiable relationship (i.e., a linear regression model) between paired data from the watersheds (calibration) and that this relationship is valid until a change is made in one of the watersheds (treatment). At that time, a new relationship will exist. The difference between the calibration and treatment relationships is used to evaluate and quantify the effect of treatment.

**Task 2. QAPP preparation and approval**: A Quality Assurance Project Plan was prepared and approved by the Lake Champlain Basin Program and U.S. EPA in June 2012, prior to commencement of the field work and data acquisition aspects of the project. The approved QAPP is included as Appendix A.

**Task 3. Site characterization**: Basic characterization data were collected for each field/watershed in 2012. Watershed boundaries were inferred from the topographic data and from observations of flow paths. The general physical and chemical properties of soils in the selected fields were evaluated through laboratory analysis of composite soil samples collected in each field. Agronomic management activities were recorded for each field/watershed for the 2012 growing season, based on observations on site, images collected using time lapse cameras, and interviews with participating farmers.

**4. Monitoring facility design and construction**: Monitoring facilities were constructed during the summer and early-fall of 2012. Each facility includes:

- An appropriately-sized H-flume with an ultrasonic water level sensor to continuously measure stage during runoff events.
- An autosampler programmed to collect a flow-proportional water sample from each monitored runoff event.
- A sensor and data logger installed in the runoff channel to measure water temperature and conductivity.
- A telemetry system that allows remote monitoring of station status, remote control and programming of the flowmeter and autosampler, and regular transfer of monitoring data to a computer server located at Stone Environmental's office in Montpelier.

In addition, a meteorological station has been installed at each participating farm for the continuous monitoring of rainfall and air temperature.

**Task 5. Study implementation (including site monitoring and implementation of treatments)**: Monitoring at each paired watershed monitoring station will be conducted identically during the calibration and treatment periods. During each monitored event, discharge is measured continuously. Event composite samples are analyzed for total phosphorus (TP), total dissolved phosphorus (TDP), total nitrogen (TN), total dissolved nitrogen (TDN), chloride (Cl), and total suspended solids (TSS) concentration. We will monitor up to 20 runoff events (weather permitting) each year of the study. Monitoring will generally be conducted between April 1 – November 30, with additional sampling during the winter months using either passive sampler arrays (a set of three single-stage sample bottles with intakes at different elevations to collect samples at different stages through the rising limb of the hydrograph) or the autosampling program when conditions allow. Use of the autosampling program during winter runoff events will be prioritized at those sites where data about practice performance outside of the growing season is most critical, such as at the Pawlet site where cover cropping is being evaluated. As called for in the paired-watershed design, calibration monitoring under present management will be conducted for 1 – 1.5 field seasons, with the exact duration depending on having monitored a reasonable range of magnitude of runoff events and on statistical analysis of the calibration period data (U.S. EPA 1993). After the calibration period, the new management practice will be implemented on the treatment field/watershed. Monitoring will then continue for 1.5 – 2 field seasons after treatment is established. At the WASCoB site, the inlet and outlet of the basin will be monitored for the same parameters and for a similar period as the paired-watershed sites.

**Task 6. Data management and analysis**: A data management system has been developed and used to organize and manage farm management practice data, weather data (temperature and rainfall), hydrologic data (runoff level and flow rate), runoff temperature and specific conductance, and analytical results. The data set used for the primary statistical analyses includes total event discharge, event mean concentration, and total event load for each monitored constituent for each event at each monitored location. Basic descriptive statistics, pair-wise comparisons, and exploratory data analysis have been conducted on the data collected between September 2012 and January 2013.

**Task 7. Project communication and reporting**: Julie Moore is the Stone Project Manager and has overall responsibility for coordinating the efforts of project personnel and serves as a single point of contact for project-related questions. Project personnel communicate with landowners at the field/watershed sites regularly, both to obtain agronomic management information and to provide information about project results on an ongoing basis. A Project Advisory Committee (PAC) has been established that includes personnel from USDA-NRCS, USGS, AAFM, ANR, UVM, the Lake Champlain Basin Program, landowners, and others with an expressed interest in the project. The PAC met three times between April 2012 and February 2013.

**Task 8. Practice evaluation**: At the conclusion of the study, an evaluation of the performance of each practice tested will be made based on the paired-watershed analysis of event discharge, mean concentration, and/or load changes resulting from the practice implementation. Experiences of the farmer and observations by project staff in the field will also be factored into an assessment of overall practice performance. Where the same practice is implemented on more than one farm, pollutant reductions due to treatment may be compared and contrasted.

**Task 9. Site decommissioning**: At the conclusion of the study, the Project Team will work with each farm owner, NRCS and AAFM to determine whether the monitoring stations should be decommissioned or left in place to support future study. Should the farm owner wish to decommission the monitoring stations, the

Project Team will remove the equipment and return it to the farmer and restore the monitoring sites to their pre-project condition.

# 4. STUDY SITES

Six working dairy farms in the Vermont portion of the Lake Champlain Basin contracted with NRCS, committing to participation in the project. The general locations of the participating farms are shown in Figure 1. Summary data describing each study watershed is presented in Table 1. Maps of the study watersheds are presented in the following sections. These maps depict the monitoring station location, field topography, the drainage area boundary, soil mapping units (SSURGO), and the extent of wingwalls.

*Table 1. Soil and Slope Descriptions of Study Watersheds*

| Watershed | Area (acre) | Mean slope (%) | Aspect | Soil Type | Hydrologic Soil Group |
|---|---|---|---|---|---|
| FER1 | 4.5 | 3.2 | SE | Covington silty clay, Cv: 54.6%<br>Vergennes clay, VeE: 9.4%<br>Vergennes clay, VeB: 36% | D<br>D<br>D |
| FER2 | 7.2 | 2.1 | W | Vergennes clay, VeB: 55.7%<br>Covington silty clay, Cv: 44.8% | D<br>D |
| FRA1 | 15.6 | 3.9 | W | Munson silt loam, MuC: 11%<br>Scantic silt loam, ScA: 19.4%<br>Belgrade silt loam, BeC: 14.8%<br>Georgia stony loam, GeB: 20.7%<br>St. Albans silty loam, SaB: 7.9%<br>Massena stony loam, MeA: 26.1% | D<br>D<br>B<br>C<br>B<br>C |
| FRA2 | 13.4 | 3.7 | W | Munson silt loam, MuC: 3.8%<br>Scantic silt loam, ScA: 23.8%<br>Belgrade silt loam, BeC: 6.4%<br>Georgia stony loam, GeB: 4.9%<br>St. Albans silty loam, SaB: 3.1%<br>Massena stony loam, MeA: 8.8%<br>Munson silt loam, MuB: 41%<br>Lordstown-Rock outcrop complex, LrC: 7.9% | D<br>D<br>B<br>C<br>B<br>C<br>D<br>C |
| PAW1 | 6.01 | 4.5 | SW | Bomoseen and Pittstown soils, 148B: 62.9%<br>Taconic-Macomber complex, 43C: 4.3%<br>Bomoseen and Pittstown soils, 148C: 33.5% | C<br>D<br>C |
| PAW2 | 3.44 | 11.6 | SE | Taconic-Hubbardton-Macomber complex, 12F: 0.7%<br>Raynham silt loam, 26A: 34.3%<br>Macomber-Dutchess complex, 52B: 24.4%<br>Bomoseen and Pittstown soils, 148C: 40.6% | D<br>C<br>C<br>C |
| SHE1 | 6.75 | 2.7 | SW | Covington silty clay, Cv: 89.4%<br>Palatine silt loam, PaD: 1.4%<br>Palatine silt loam, PaC: 9.4% | D<br>C<br>C |
| SHE2 | 5.79 | 3.0 | S | Vergennes clay, VeB: 100% | D |
| SHO1 | 5.9 | 3.8 | W | Vergennes clay, VgB: 100% | D |
| SHO2 | 2.4 | 6.9 | SW | Vergennes clay, VgB: 100% | D |
| WAS1 | 22.1 | 0.5 | E | Raynham silt loam, RaB: 59% | C |

| Watershed | Area (acre) | Mean slope (%) | Aspect | Soil Type | Hydrologic Soil Group |
|---|---|---|---|---|---|
| | | | | Binghamville silt loam, Bg: 41% | C |
| WAS2 | 22.68 | 0.5 | E | Raynham silt loam, RaB: 60%<br>Binghamville silt loam, Bg: 40% | C<br>C |
| WIL1 | 4.27 | 0.12 | S | Limerick silt loam, Le: 85.9%<br>Hadley very fine sandy loam, Hf: 7%<br>Winooski very fine sandy loam, Wo: 7% | C<br>B<br>B |
| WIL2 | 2.01 | 0.06 | N | Limerick silt loam, Le: 34.6%<br>Winooski very fine sandy loam, Wo: 65.3% | C<br>B |

## 4.1. Ferrisburgh Site

The Ferrisburgh study watersheds are located close to one another, separated by an intermittent stream. Each watershed is comprised of heavy clay soils of the Vergennes and Covington series (Table 1). These soils have high runoff potential, classified as hydrologic soil group D. The FER1 watershed (Figure 2) is 4.5 acres, substantially smaller than the 7.2 acre FER2 watershed (Figure 3), and FER1 is more sloping. There is a 4-inch diameter tile line that discharges immediately below the FER1 station. The area of the field drained by the tile is unknown, although the line is believed to be short, likely less than 100 feet in length. Both watersheds were in corn production in the year preceding this study and were seeded to red clover with a cover of peas/oats in April of 2012.

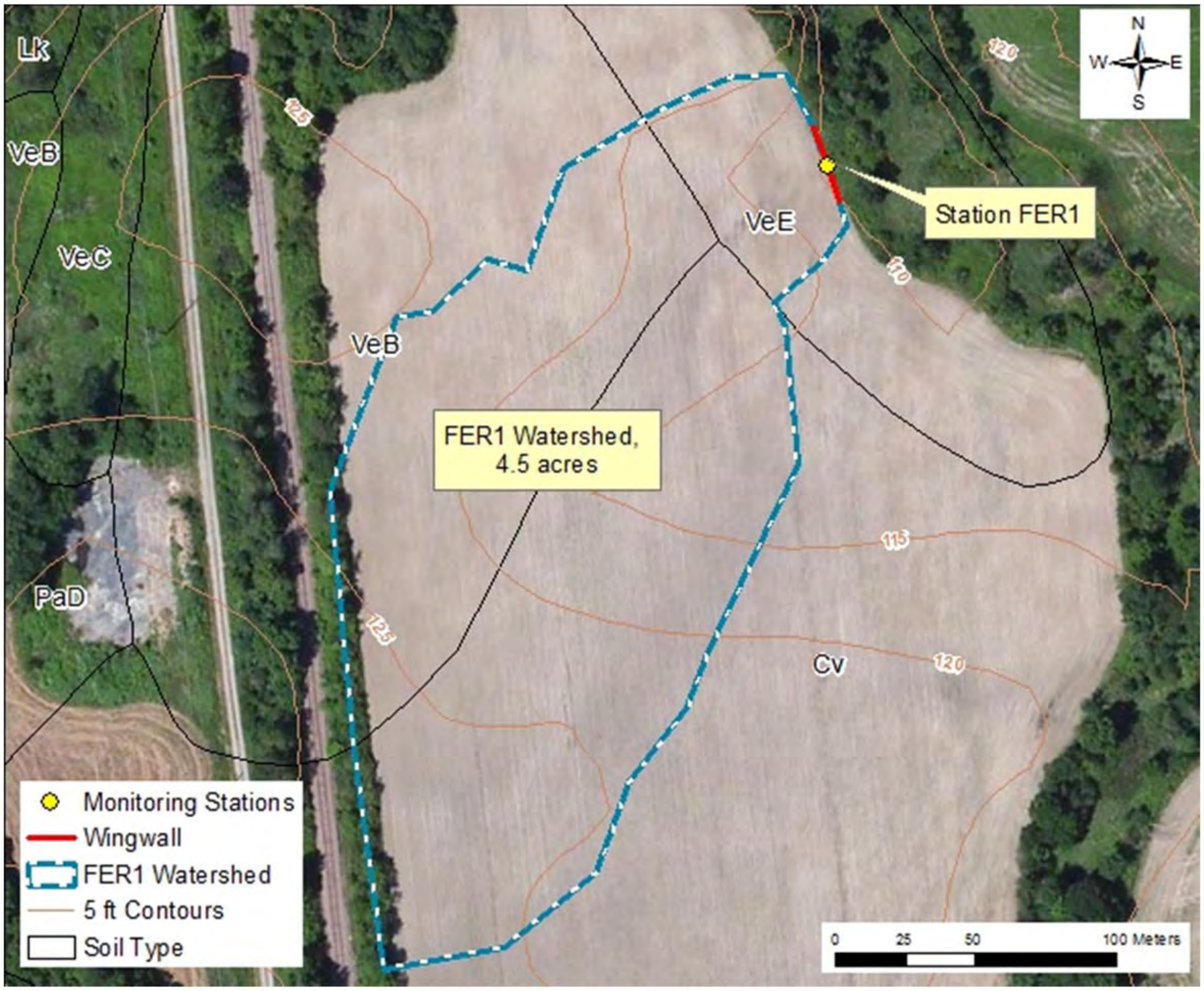


*Figure 2. FER1 watershed*

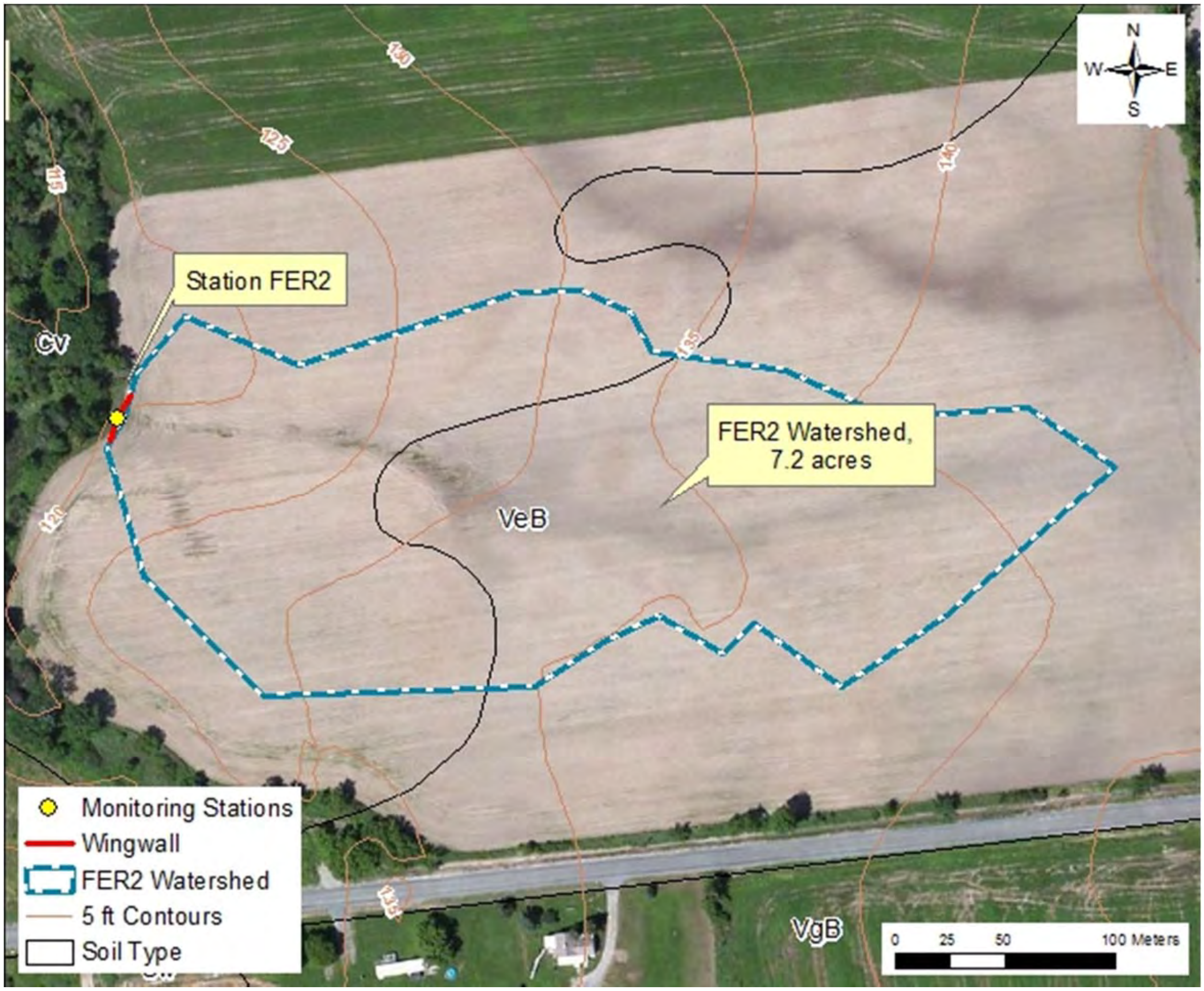


*Figure 3. FER2 watershed*

## 4.2. Franklin and WASCoB Sites

The Franklin study watersheds are distinct drainages within a large strip cropped field. The field is currently managed as a single unit. Corn and hay are grown in alternating strips planted on contour. In the spring of 2012 the strips were switched; grass was planted in the former corn strips and corn was planted into the hay strips after first cut. The strips are opposite from the pattern shown in Figure 8. The predominant soil texture in FRA1 and FRA2 is silt loam (Munson, Scantic, Belgrade, St. Albans), with lesser amounts of Georgia and Massena stony loam (Table 1). FRA1 and FRA2 are similar in size (15.6 and 13.4 acres respectively), slope, and aspect. There are tile outlets located at the base of the slope, west of the FRA1 and FRA2 stations; the tile lines reportedly run up through the sags in the FRA1 and FRA2 watersheds. During large runoff events, the tile outlets become submerged.

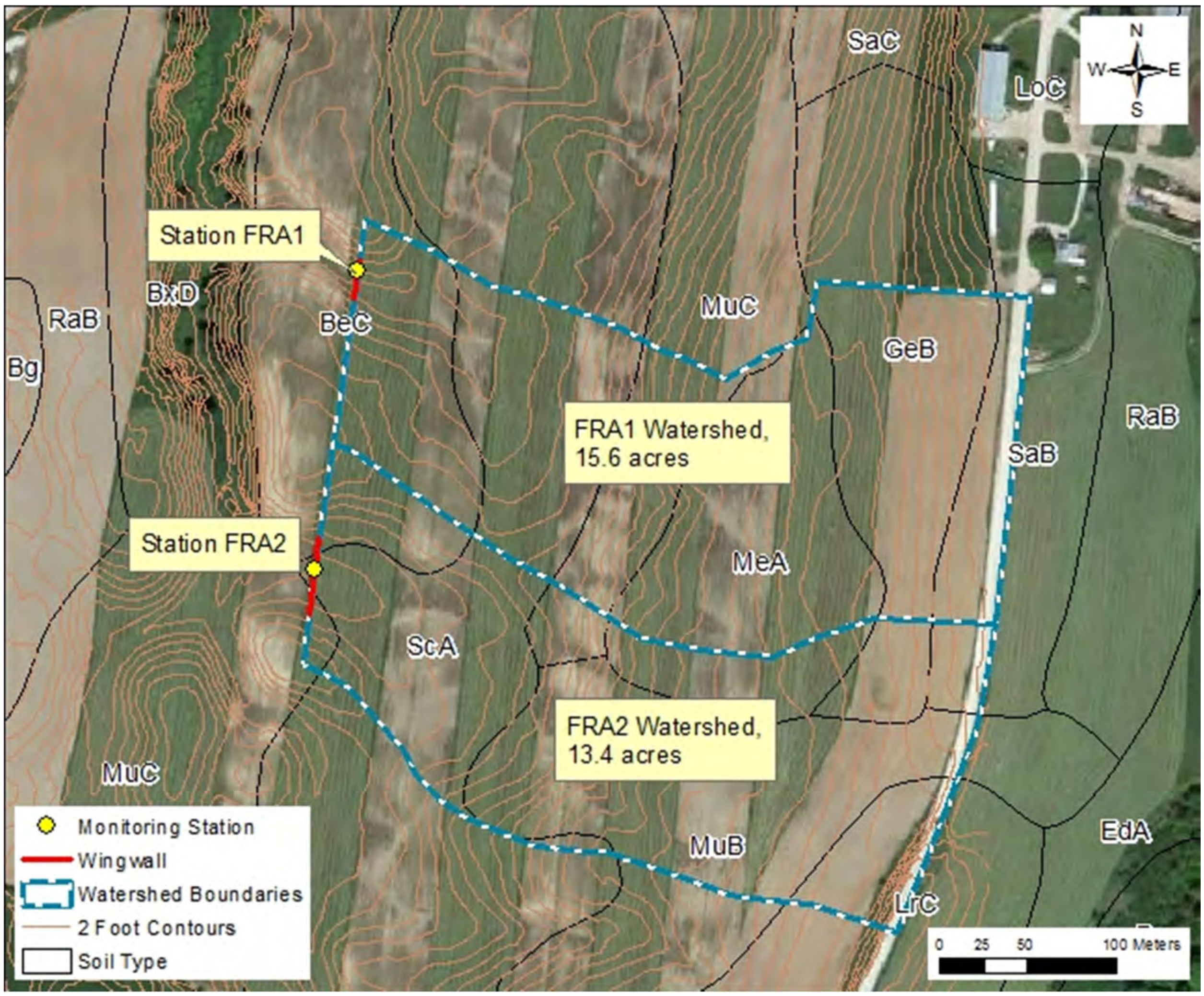


*Figure 4. FRA1 and FRA2 watersheds*

The WASCoB stations are located on the same farm as the FRA1 and FRA2 stations. The field draining to the WASCoB is the largest field in the study: 22.7 acres. The area draining to the upstream monitoring station

(WAS1) is slightly less, 22.1 acres, because 0.6 acres of cornfield drains directly to the WASCoB, bypassing the WAS1 station. The downstream station, WAS2, monitors the WASCoB outlet, receiving runoff from the entire field area. The field is in continuous corn production. Soils in the WASCoB field are Raynam (60%) and Binghamville (40%) silt loams, which are classified as moderately runoff prone (hydrologic soil group C). The extent of tile drainage in the WASCoB field is unknown.

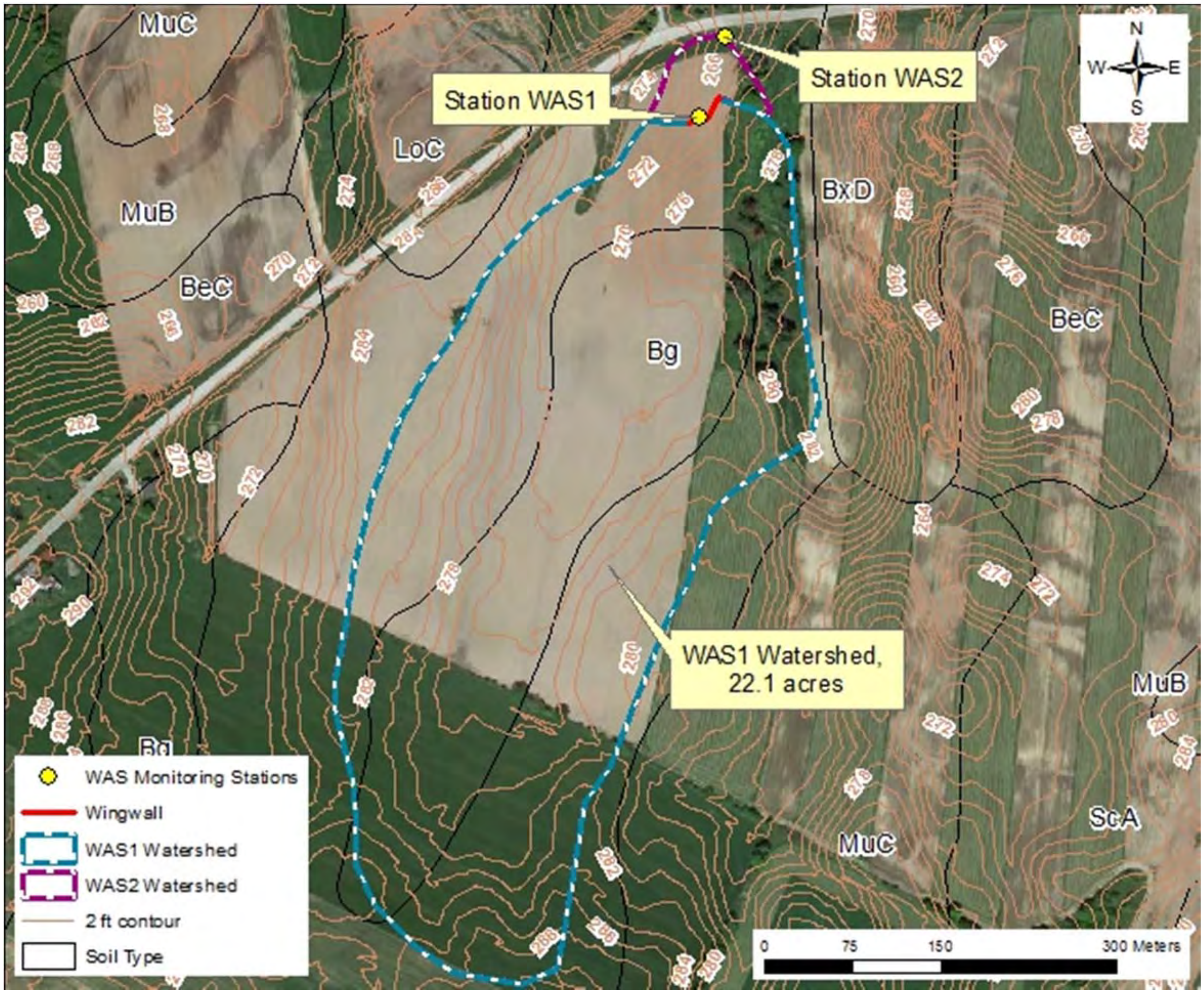


*Figure 5. WAS1 and WAS2 watersheds*

## 4.3. Pawlet Site

The Pawlet study watersheds are located approximately 500 m apart in West Pawlet. Field maps are included as Figures 6 and 7. Both fields are in continuous corn production. The PAW1 watershed is 43% larger than the PAW2 watershed (Table 1). Bomoseen and Pittstown soils make up more than 96% of the PAW1 watershed. Bomoseen and Pittstown soils are the most extensive (41%) soil type in the PAW2 watershed also, followed by Raynham silt loam (34%) and Macomber-Dutchess complex (24%). All these soils are classified as moderately runoff prone (hydrologic soil group C). There is no known tile drainage in either the PAW1 or PAW2 watershed. The PAW1 watershed was defined by wingwalls in the western portion of the field to avoid both a newly installed drainage tile and road runoff on the eastern side of the field.

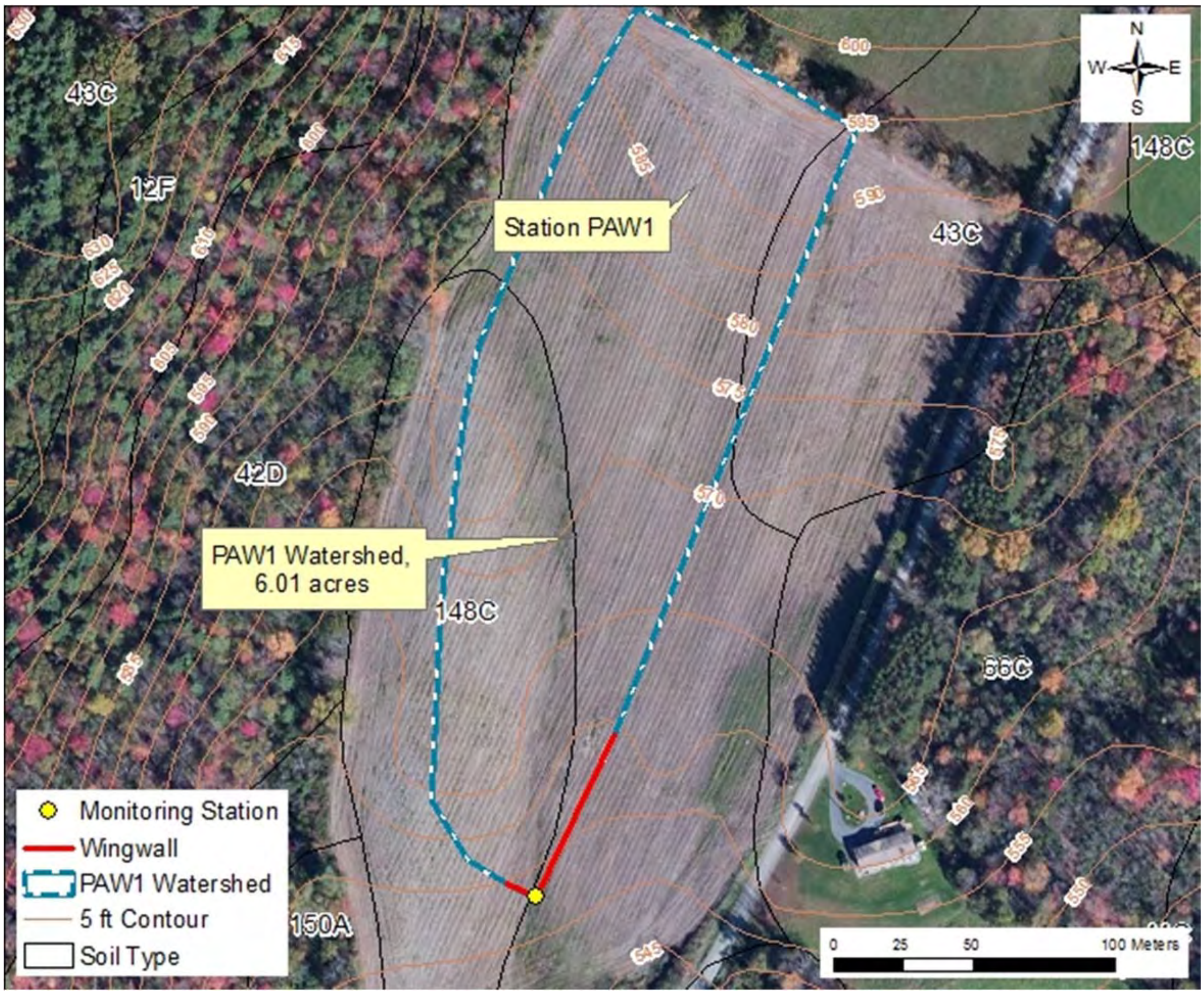


*Figure 6. PAW1 watershed*

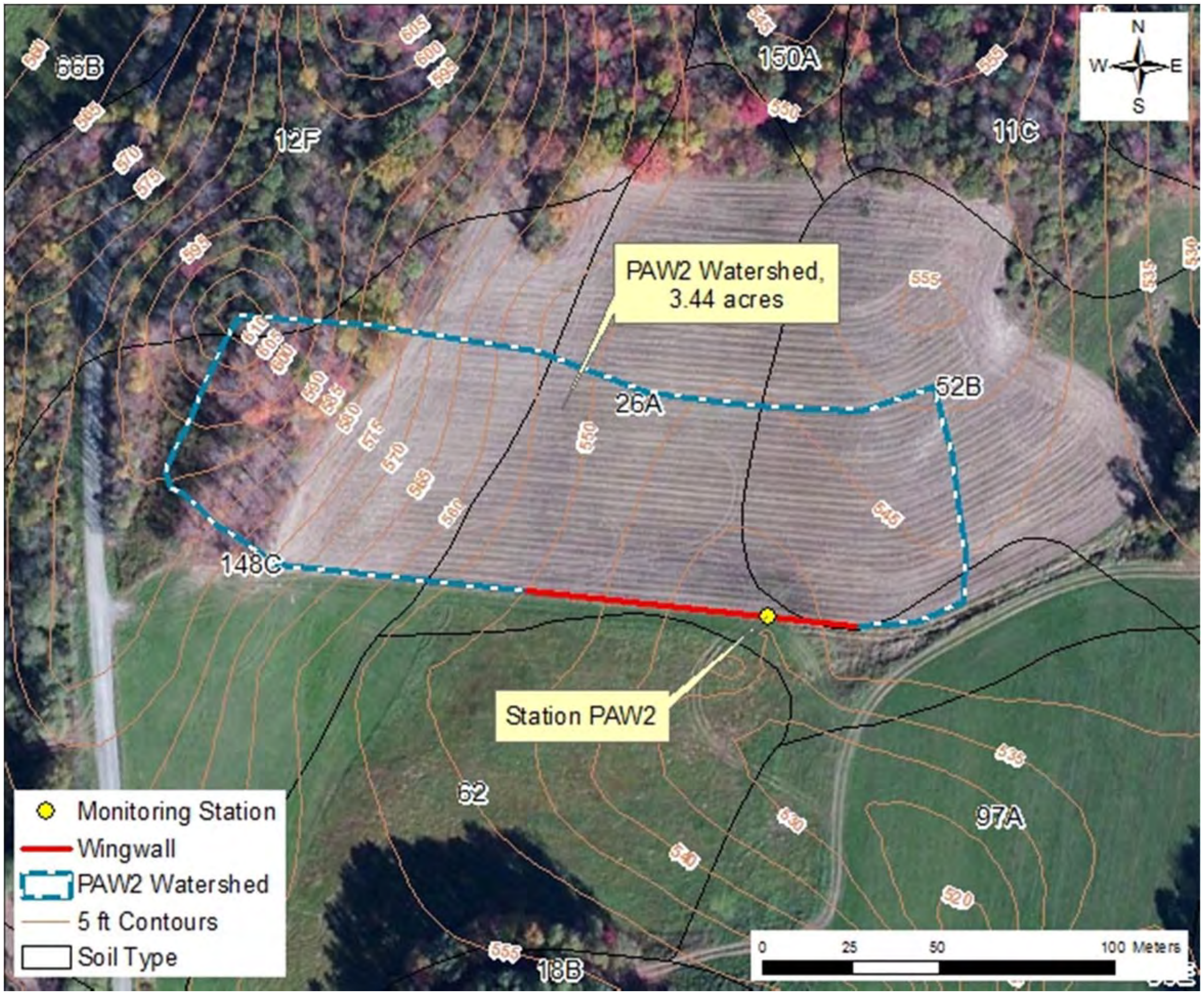


*Figure 7. PAW2 watershed*

## 4.4. Shelburne Site

The Shelburne study watersheds are in permanent hay production. Each watershed has clayey soils; Covington silty clay comprises almost 90% of the area of SHE1 and Vergennes clay comprises 100% of the area of SHE2 (Table 1; Figures 8 and 9). These soils have high runoff potential, classified as hydrologic soil group D. The SHE1 and SHE2 watersheds are similar in size, slope, and aspect. There is no known tile drainage in the SHE2 watershed. During station construction at SHE1 a broken section of drainage tile was removed from the area of the flume. This past winter a small sinkhole developed over a tile line within the watershed, opposite the instrument shelter. This tile line appeared collapsed and filled with soil, but it may have conveyed some water under the soil berm. The end of the pipe must be buried. After its discovery, the pipe was crushed and the hole was backfilled with bentonite.

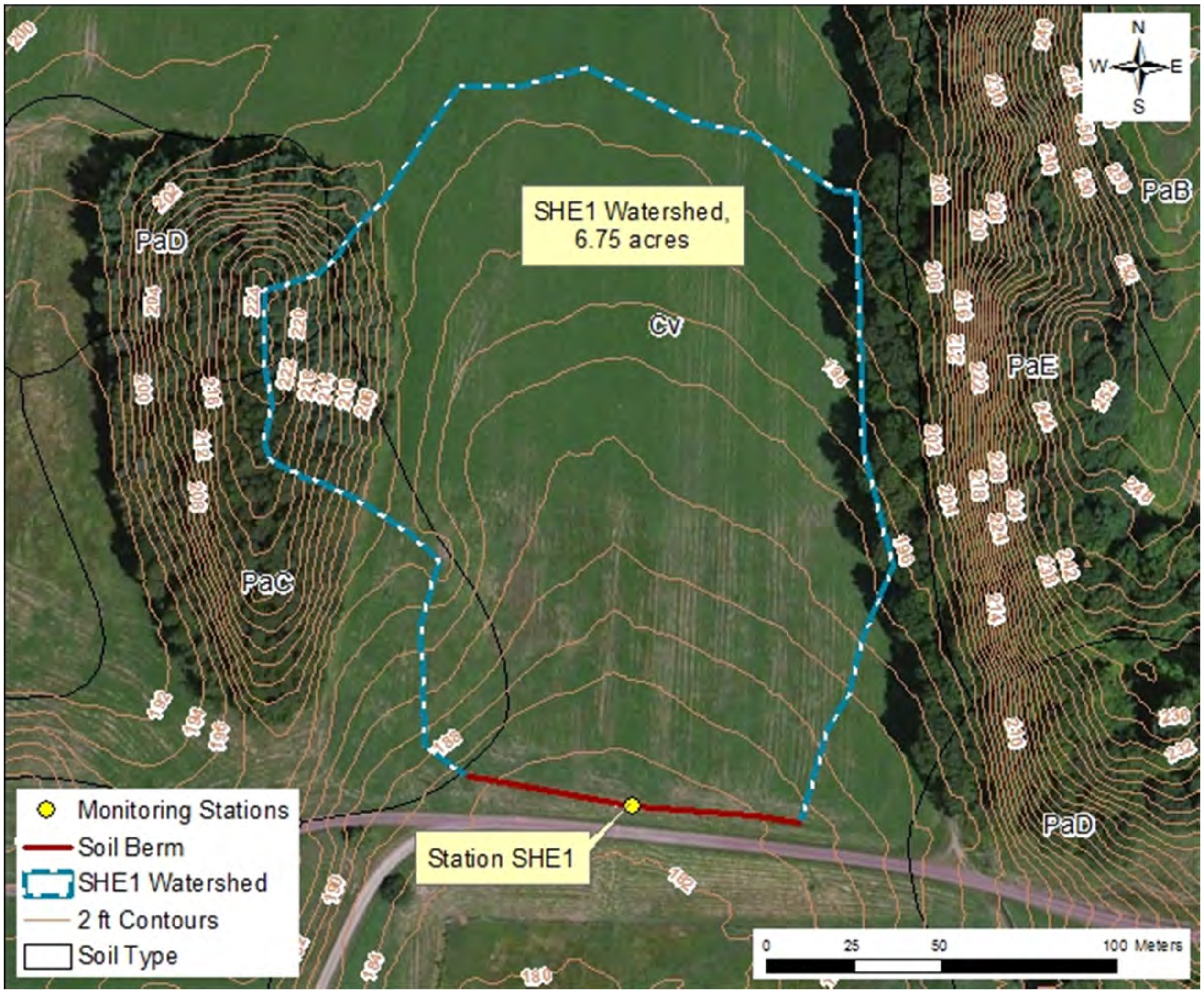


*Figure 8. SHE1 watershed*

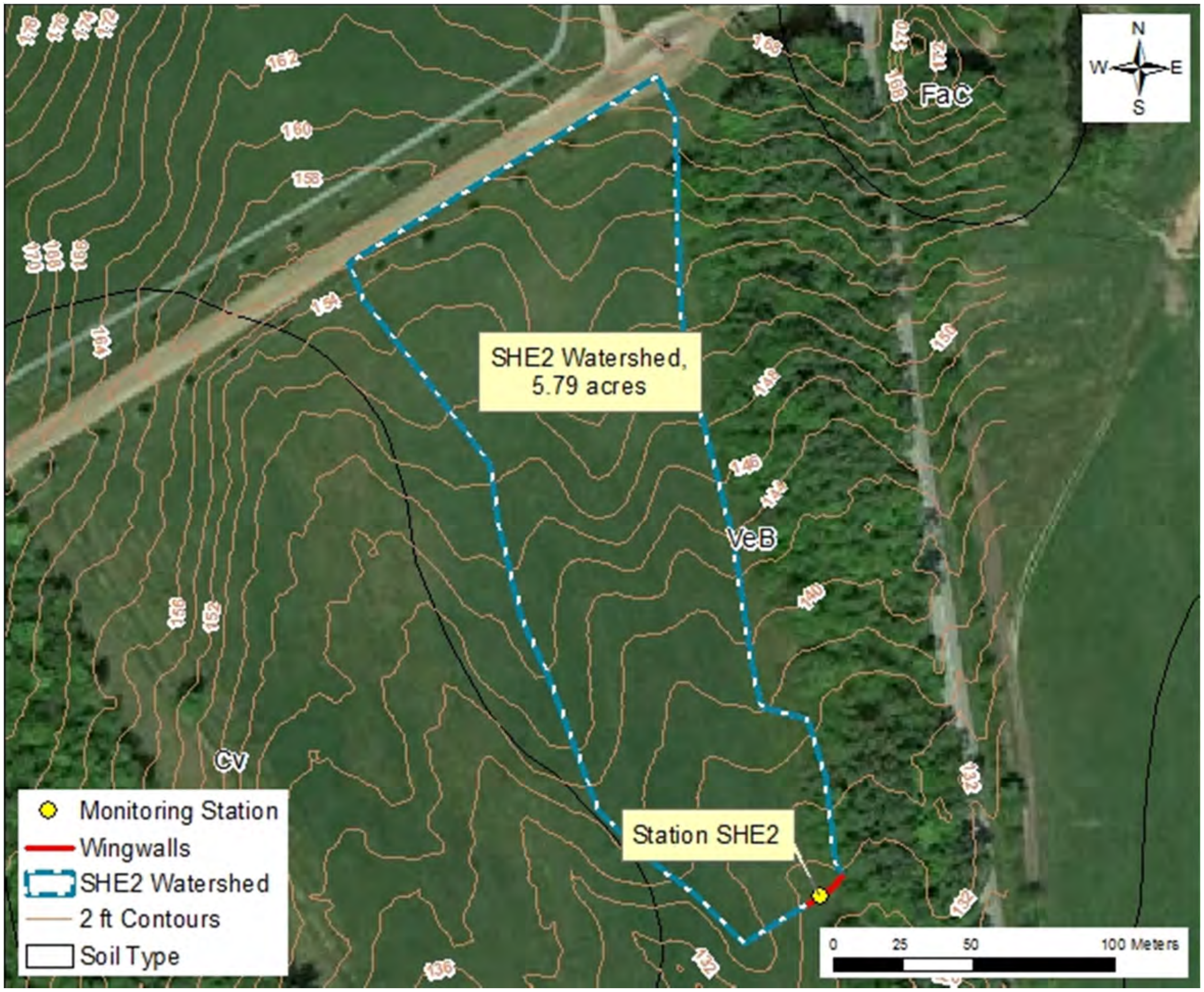


*Figure 9. SHE2 watershed*

## 4.5. Shoreham Site

The Shoreham study watersheds are distinct drainage areas within a large hayfield. The field is currently managed as a single unit. Historically the area was an orchard. The SHO1 watershed is more than twice the size of SHO2 (Table 1; Figures 10 and 11). SHO2 is substantially steeper than SHO1. Vergennes clay comprises 100% of both the SHO1 and SHO2 watersheds. These soils have high runoff potential, classified as hydrologic soil group D. During construction activities we found the soil to be particularly sticky and massive. Deep soil cracks developed upslope from the SHO1 station during the summer months, and lesser cracks were observed at SHO2. There is no known tile drainage at either SHO1 or SHO2.


*Figure 10. SHO1 watershed*


*Figure 11. SHO2 watershed*

## 4.6. Williston Site

The Williston study watersheds are adjacent to one another in a field with very low topographic relief (Figure 12). The monitoring stations are located near the end of two vegetated drainage swales or grassed waterways that extend into the cropped field. The WIL1 and WIL2 watersheds are partially defined by a soil berm on their southwestern boundary. Given uncertain runoff flow paths in this flat field, the soil berm was constructed to establish a consistent watershed boundary. The WIL1 watershed is more than twice as large as the WIL2 watershed, which is the smallest watershed in the study at only slightly more than 2 acres (Table 1). Limerick silt loam comprises 86% of the WIL1 watershed, whereas the dominant soil in the WIL2 watershed is Winooski very fine sandy loam (65%), followed by Limerick silt loam (35%). Limerick silt loam is classified as hydrologic soil group C and Winooski very fine sandy loam is in hydrologic soil group B. There is no known tile drainage in either the WIL1 or WIL2 watershed.

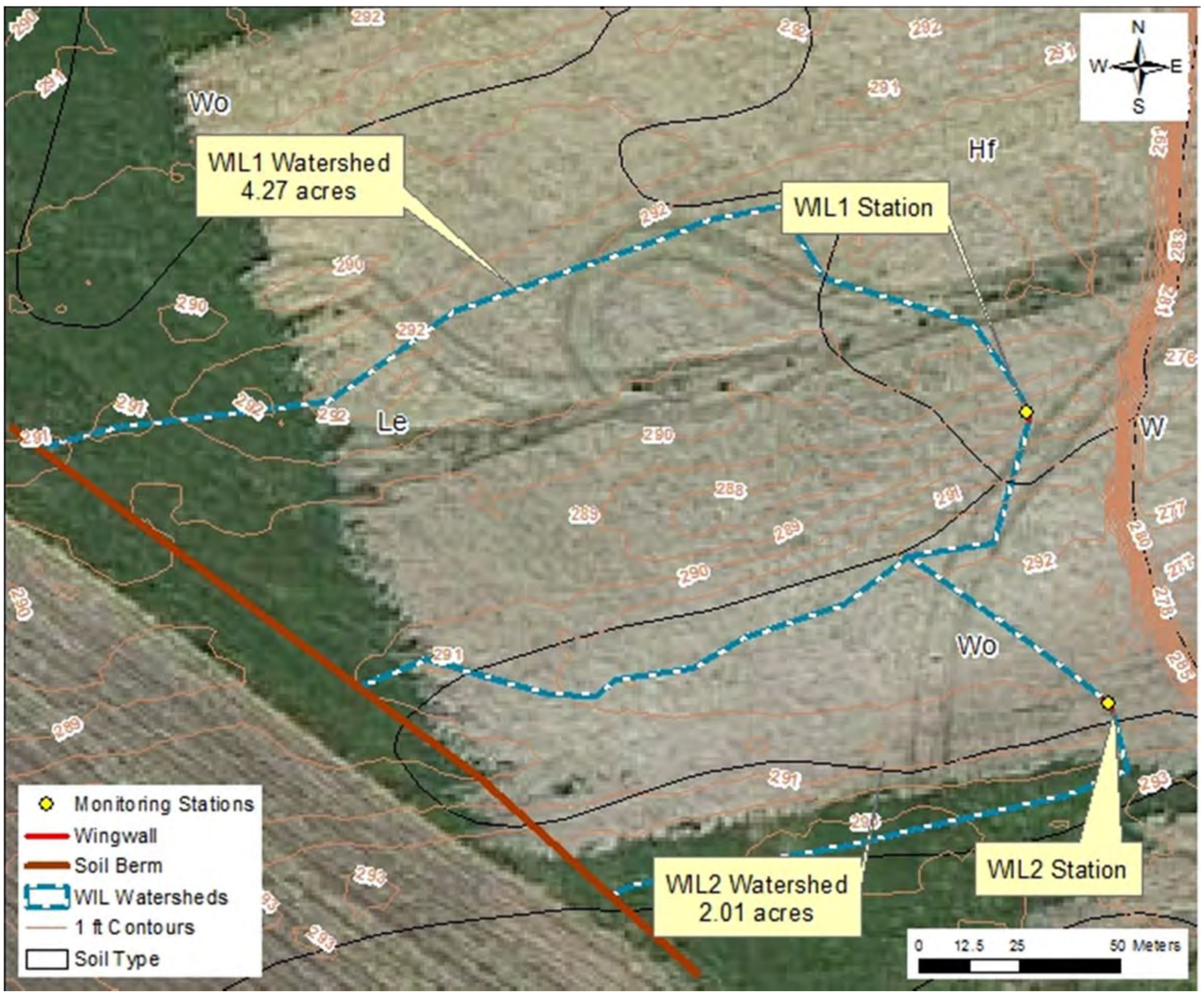


*Figure 12. WIL1 and WIL2 watersheds*

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Most of the area in the WIL1 and WIL2 watersheds was in corn or pumpkin production in 2011. However, due to the small size of the WIL1 and WIL2 watersheds, certain areas previously in grass were plowed and planted in corn in 2012 to increase the likelihood of detecting a response due to the reduced tillage/manure injection treatment. The northern side of the WIL1 watershed was in hay production in 2011 and was planted in corn in preparation for the study. Similarly, grass strips bordering the drainage swales were plowed and planted in corn, reducing the width of the grassed waterways. This was done to reduce treatment (through filtration, settling, and uptake) of runoff draining to the swales.

# 5. METHODS

## 5.1. Soil Characterization

Soil characterization sampling and analyses were conducted in the fall of 2012. A probe was used to collect soil cores throughout each watershed to 10 cm depth in hay fields and to 20 cm in corn fields. Cores were composited and blended in a plastic bucket using a trowel. Subsamples were transferred to polyethylene bags and analyzed for pH and available P, K, Mg, Ca, Fe, Mn, and Zn following extraction in modified Morgan solution, and for organic matter, cation exchange capacity, and soil particle sizes. The sampling procedure is further described in the Soil Sampling Procedure O&R, included as Appendix B.

Soil samples were delivered to the University of Vermont Agricultural and Environmental Testing Laboratory (AETL) and were analyzed by AETL and the University of Maine Analytical Laboratory and Maine Soil Testing Lab. Sample splits were also shipped to the USDA ARS Grassland Soil and Water Research Laboratory in Temple, Texas for analysis of soil health indicators.

*Figure 13. Soil probe used to collect composite soil samples*

## 5.2. Agronomic Data Collection

Data on agronomic and field management activities such as tillage (date, method); manure, nutrient, and agrichemical applications (date, method, rate); planting (date, method, variety); and harvest (date, method, yield) are collected for each study field directly from the participating farmers. These data are collected and maintained from farm records and/or by interviewing participating farmers. The forms used to collect these data are included as Appendix C (for corn sites) and Appendix D (for hay sites). Information on field management from the participating farmers is supplemented by direct observation by field sampling personnel, and by time-lapse photography from repeatable photopoints at each monitoring site.

## 5.3. Monitoring Station Construction

The primary hydraulic device being used at each runoff monitoring station is an appropriately-sized H-flume. Each flume was bolted to a plywood trough (the “flume approach channel”) which creates a laminar flow stream entering the flume. The approach channel is mounted to a manifold made from a sheet of ¾-inch plywood, which is partially buried such that the entrance is nearly level with the ground. The discharge end of the flume is suspended from a scaffold by chains. Tensioners on the chains are adjusted to precisely level the flume. Plywood wingwalls were installed, as needed, to direct flow into the flume.

An ultrasonic water level sensor (ISCO 2110 Ultrasonic Flow Module) was installed in each flume to continuously measure stage (water level). The 2110 Ultrasonic Flow Module converts level data to flow rate based on the established hydraulic properties of the flume. These data are used to generate runoff event hydrographs and to calculate pollutant transport rates.

Each monitoring station includes an ISCO 6712 autosampler. The autosampler draws water through an intake screen and suction line secured in a splash pan mounted below the flume outlet. The splash pan ensures that the sample is well mixed and that the intake is submerged even at relatively low flow rates, when an intake mounted in the flume would draw air.

The autosampler was programmed to pump runoff water on a flow proportional basis into bulk (10 L) sample containers. To minimize the occurrence of under-sampling and overfilling, a two-part program was developed whereby the autosampler pumps sample to two sets of containers at different intervals of accumulated flow. The first set of bottles is intended to capture a representative runoff sample from small to medium sized events and a second set of bottles is intended to capture the medium to large events. The second set fills at approximately $1/10^{th}$ to $1/20^{th}$ the frequency of the first set. If the capacity of the first set of bottles is exceeded, the sample will be rejected and the second set of bottles will be used instead. Using this sampling program, runoff events varying in size by more than a factor of 100 can be representatively and automatically sampled. The initial sampler pacing setting were defined using output from HydroCAD models developed for each study watershed. These initial sampler pacing settings have been adjusted based on the flow rates and volumes measured during the first months of operation. In addition, sampler pacing settings may be adjusted in advance of major predicted storms, with the intent of representatively sampling every runoff-producing storm.

Each station is powered by a solar panel and two 6-volt deep cycle batteries connected in series. To the extent practical, all project related equipment is housed in a secure instrument shelter. Photographs of field monitoring station components are presented in Figure 14.

*Figure 14. Photographs of field monitoring stations. Left: H-flume, splash pan, and siphon sampler array; Right: autosampler and sample collection bottles in station shelter.*

To measure water temperature and conductivity of the runoff stream, a HOBO® U24-001 Conductivity Data Logger is installed in the splash pan in the runoff channel below the flume. These data are downloaded onsite using a waterproof shuttle device.

### 5.4. Meteorological Monitoring

A simple meteorological station was installed at each participating farm for the continuous monitoring of rainfall and air temperature. An Onset HOBO® RG3 tipping bucket rain gage was calibrated and installed. Every tip marks the accumulation of 0.01 inches of rainfall and is recorded in memory with a time stamp. The air temperature sensor is housed in a solar radiation shield.

Raw precipitation data is post-processed to calculate daily, hourly, and 15-minute totals. Air temperature is recorded as hourly and daily, minimum, maximum and average values. The data are downloaded approximately monthly as part of routine site maintenance. Continuous precipitation monitoring is supplemented by an inexpensive manual rain gage located at each site as a backup.

### 5.5. Runoff Event Sampling

The project has been designed to monitor discrete runoff events that generate discharge at our monitoring stations. For the purpose of this study, a runoff event has been defined as a discrete episode of discharge from the flume (persisting for hours or days) generated by precipitation. Thus defined, the event begins when discharge begins and ends when discharge ceases at one or both of the paired watersheds. Because of the difficulty of accurately measuring and representatively sampling extremely low flows, a threshold stage of approximately 1 cm has been established. At this threshold stage, the autosampler becomes enabled and we consider an event to have begun. In cases where multiple precipitation events in rapid succession generate sustained discharge, we consider the period of continuous discharge to be a single runoff event.

Stations were visited as soon as possible after the end of a monitored event. Event data were recorded on the *Sample Retrieval/Routine Maintenance by Sampler Form* (Attachment to Sampling Procedure SSP—Appendix E). Runoff samples were processed in accordance with the Sampling Procedure SSP. Following collection, samples were refrigerated or stored on ice and arrangements were made for their transport to the Department of Environmental Conservation laboratory within five days of collection.

The study design calls for monitoring up to 20 runoff events (weather permitting) at each station in each year of the study. As shown in Table 2 below, as many as 19 paired flow events were observed at the individual study sites between September 2012 and January 2013; during this same period far fewer paired chemistry events were captured, ranging from a low of one event at SHO to a high of six events at PAW. It should be understood that paired events for flow include those when one watershed did not run off; whereas paired events for chemistry include only events for which samples from both watersheds were collected. Moreover, with one exception, sample collection was not attempted at the hay sites (FER, SHE, and SHO) past November 30, 2012, per the requirements of the QAPP (Appendix A) and the Sampling and Routine Maintenance Procedures (Appendix E). Operation during the winter was deemed less critical at these hay sites because the treatment to be tested (aeration) should be maximally effective during the growing season.

During the winter, we also piloted two different approaches to extend the traditional monitoring (ice-free) season beyond November 30. These are:

- Operating autosamplers remotely during rain storms and thaws in winter months to "opportunistically" collect samples when the flumes were clear. This approach required project staff to carefully monitor flow level and temperature and activate autosamplers if/when rain was imminent, and then stop the autosampler at the end of the event or slightly early if ice appeared to build up or temperature dropped to preclude collection of invalid flow data and non-representative sampling due to ice/snow accumulation in the flume.

- A three-bottle, single stage siphon sampler array, placed adjacent to each flume, was installed at the FRA, PAW, and WIL stations. The siphon samplers draw water from intake tubes secured at three levels on the sidewall of each flume. A description of the siphon sampler construction is included as Appendix F.

These approaches are potentially important because seven significant runoff events were observed between November 30, 2012 and January 31, 2103.

*Table 2. Number of paired events with valid data at each monitoring station, collected between September 2012 and January 2013.*

| Station | Number of Paired Flow Events | Number of Paired Chemistry Events |
|---|---|---|
| FER | 19 | 2 |
| FRA | 12 | 5 |
| PAW | 17 | 6 |
| SHE | 11 | 5 |
| SHO | 9 | 1 |
| WIL | 7 | 3 |

Going forward, in order to ensure that collected data are representative of a full seasonal span each year and, at the same time, collect data during critical periods of BMP performance (e.g., late fall and early spring for cover crop treatments, runoff closely following manure applications on hayland aeration treatments), some flexibility may be required in selecting which events to include for full sampling and analysis. Best professional judgment will be used to stratify the events we choose to monitor so that critical periods/conditions are included. In this process, samples from some events that occur under conditions already frequently sampled may be discarded so that we retain the capacity to monitor later events that represent critical conditions. For example, if we have monitored several events on a pair of hay fields that occurred several weeks or more after a manure application, we may choose to not submit samples for analysis for similar events that occur before the next manure application. Similarly, if we have monitored several comparable events on corn fields before cover crops are planted, we may decide to not submit samples from additional events under those conditions so that we can monitor runoff events that occur following cover crop establishment. The hydrologic magnitude of the event will, of course, be another consideration.

## 5.6. Routine Maintenance

Field staff visited monitoring stations at least monthly during the monitoring season for a maintenance check. At each maintenance visit, instrument batteries were checked and serviced or replaced if necessary; the tipping bucket datalogger, time lapse camera, and conductivity logger were downloaded; instrument desiccant was checked and replaced if necessary; the U24-001conductivity sensor was calibrated; the rainfall depth in the manual rain gauge was checked and the gauge was emptied; sample bottles, rinse water, filtration supplies, forms, labels, and other items were restocked; flumes and flume approaches were cleaned; flumes were re-leveled if necessary; a thorough check was made of berms, wingwalls, and flume approaches for leaks; and weeds were cut around the station and along the wingwalls. These maintenance activities are listed on the *Monthly Maintenance Checklist*, attached to the Sampling Procedure SSP (Appendix E). Sampling personnel complete a shorter list of maintenance checks on every visit. Finally, telemetry data from the flow monitoring and autosampling systems are checked approximately bi-weekly to ensure remote communications are successful, the voltage of the main batteries is good, and recorded level data are near zero during dry periods.

## 5.7. Runoff Sample Analysis

Analysis of all field runoff samples is being conducted by the VT DEC laboratory, currently stationed at the University of Vermont. For each sampling event, a sample retrieval sheet is completed which documents sample ID, sample type, source, and volume. The analytes for which splits are prepared, the personnel responsible for sample splitting, and the data and time sample splits are prepared is recorded. Samples are transported to the laboratory within the stated holding times for each analyte by project staff.

All water samples are analyzed in accordance with the standard methods of the VT DEC Laboratory. These methods and relevant data quality objectives, assessment procedures, and reporting limits are described in the laboratory's Quality Assurance Plan, Revision 20, dated January 2012 (VT DEC 2012).

## 5.8. Data Analysis Methods

All project data are archived in original form (digital downloads, laboratory reports) and organized in databases and Excel spreadsheets. Transcribed data are 100% error-checked between original source and files used for reporting and analysis. Data from some samples and/or events were excluded from some analyses for one or more reasons, including sampling instrument malfunction or non-representative sampling. Data analysis was conducted primarily on $\log_{10}$-transformed data to satisfy the assumptions of parametric statistics. All statistical analyses were conducted using JMP statistical software, version 7.0 (SAS Institute 2007).

# 6. RESULTS

## 6.1. Soil Characterization Data

Results of soil physical and chemical analysis of composite soil samples are presented in Tables 3 through Table 5.

*Table 3. Selected characteristics of composite soil samples from the study watersheds*

| Site | pH (water) | OM (%) | Sand (%) | Silt (%) | Clay (%) | USDA Texture | Avail. P (mg/kg) | K (mg/kg) | Mg (mg/kg) | Al (mg/kg) | Ca (mg/kg) | Zn (mg/kg) | S (mg/kg) | Mn (mg/kg) | B (mg/kg) | Cu (mg/kg) | Fe (mg/kg) | Na (mg/kg) | CEC (meq per 100g) | Ca (%) | K (%) | Mg (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| FER 1 | 6.3 | 3.5 | 8.4 | 52.9 | 38.7 | Silty cl. loam | 2.3 | 119 | 417 | 42 | 1896 | 0.7 | 16 | 13.9 | 0.1 | 0.55 | 11.1 | 63 | 13.3 | 71.5 | 2.3 | 26.2 |
| FER 2 | 6.4 | 3.1 | 10.1 | 57.8 | 32.1 | Silty cl. loam | 5.4 | 125 | 338 | 34 | 1820 | 0.7 | 19 | 14.5 | 0.2 | 0.65 | 10.8 | 65 | 12.2 | 74.4 | 2.6 | 23 |
| FRA 1 Corn | 7 | 4.3 | 28.5 | 52.8 | 18.7 | Silt loam | 10.5 | 98 | 174 | 22 | 2857 | 0.7 | 25 | 14.4 | 0.4 | 0.3 | 4.1 | 33 | 16 | 89.4 | 1.6 | 9.1 |
| FRA 1 Hay | 6.7 | 3.7 | 12.2 | 66.3 | 21.5 | Silt loam | 8.6 | 81 | 200 | 25 | 2287 | 0.5 | 19 | 14.7 | 0.3 | 0.2 | 5 | 23 | 13.3 | 85.9 | 1.6 | 12.5 |
| FRA 2 Corn | 7 | 3.9 | 21.4 | 57.5 | 21.2 | Silt loam | 9.6 | 92 | 165 | 28 | 2450 | 0.5 | 21 | 10.8 | 0.3 | 0.2 | 4.8 | 28 | 13.9 | 88.4 | 1.7 | 9.9 |
| FRA 2 Hay | 6.7 | 3.9 | 13.7 | 65.5 | 20.8 | Silt loam | 10.2 | 92 | 200 | 25 | 2278 | 0.5 | 18 | 12 | 0.25 | 0.25 | 4.8 | 23 | 13.3 | 85.7 | 1.8 | 12.5 |
| PAW 1 | 7.9 | 3.6 | 35.0 | 49.6 | 15.3 | Silt loam | 8.3 | 79 | 112 | 19 | 3540 | 0.5 | 21 | 13.9 | 0.25 | 0.35 | 2.2 | 17 | 18.8 | 94 | 1.1 | 5 |

| Site | pH (water) | OM (%) | Sand (%) | Silt (%) | Clay (%) | USDA Texture | Avail. P (mg/kg) | K (mg/kg) | Mg (mg/kg) | Al (mg/kg) | Ca (mg/kg) | Zn (mg/kg) | S (mg/kg) | Mn (mg/kg) | B (mg/kg) | Cu (mg/kg) | Fe (mg/kg) | Na (mg/kg) | CEC (meq per 100g) | Ca (%) | K (%) | Mg (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PAW 2 | 5.8 | 3.2 | 25.2 | 60.5 | 14.3 | Silt loam | 1.3 | 25 | 55 | 61 | 813 | 0.5 | 19 | 24.5 | 0.05 | 0.25 | 6.5 | 16 | 4.6 | 64.1 | 1 | 7.2 |
| SHE 1 | 7.3 | 4 | 43.9 | 25.5 | 30.7 | Clay loam | 8.4 | 89 | 187 | 12 | 3652 | 0.5 | 16 | 17.4 | 0.45 | 0.2 | 2.5 | 37 | 20 | 91.1 | 1.1 | 7.8 |
| SHE 2 | 7 | 5.1 | 11.9 | 49.7 | 38.3 | Silty cl. loam | 4.3 | 168 | 493 | 17 | 3304 | 0.7 | 20 | 9.6 | 0.35 | 0.2 | 4.7 | 64 | 21.1 | 78.4 | 2 | 19.5 |
| SHO 1 | 6.1 | 4.7 | 7.6 | 26.5 | 66.0 | Clay | 1.4 | 195 | 498 | 59 | 2530 | 0.9 | 12 | 13.7 | 0.25 | 0.3 | 16.6 | 52 | 17.3 | 68.8 | 2.7 | 22.6 |
| SHO 2 | 5.7 | 3.2 | 10.7 | 29.8 | 59.5 | Clay | 1.1 | 148 | 442 | 69 | 2147 | 1 | 9 | 14.6 | 0.15 | 0.35 | 18.4 | 40 | 14.8 | 63 | 2.2 | 21.6 |
| SHO 2-D | 5.8 | 3.5 | 11.5 | 29.0 | 59.5 | Clay | 1.1 | 140 | 442 | 65 | 1960 | 1 | 9 | 15.8 | 0.15 | 0.3 | 17.4 | 36 | 13.8 | 62.2 | 2.3 | 23.4 |
| WAS | 6.9 | 3.1 | 13.8 | 64.4 | 21.8 | Silt loam | 4.7 | 74 | 165 | 36 | 1669 | 0.3 | 14 | 9.3 | 0.15 | 0.2 | 6.4 | 27 | 9.9 | 84.2 | 1.9 | 13.9 |
| WIL 1 | 7.1 | 4.9 | 27.4 | 60.7 | 11.9 | Silt loam | 22.5 | 173 | 107 | 31 | 1959 | 0.9 | 12 | 4.2 | 0.3 | 0.45 | 3.9 | 19 | 11.1 | 88 | 4 | 8 |
| WIL 1-D | 7.2 | 5.1 | 20.8 | 66.6 | 12.6 | Silt loam | 23.4 | 159 | 109 | 33 | 2013 | 1 | 12 | 4.4 | 0.35 | 0.45 | 4.5 | 20 | 11.4 | 88.4 | 3.6 | 8 |
| WIL 2 | 7.3 | 3.6 | 31.3 | 55.9 | 12.8 | Silt loam | 43.5 | 148 | 121 | 15 | 2293 | 1.2 | 11 | 6.1 | 0.4 | 0.5 | 3.9 | 19 | 12.9 | 89.2 | 3 | 7.8 |

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*Table 4. Selected characteristics of composite soil samples from the study watersheds, USDA ARS Analyses.*

| Site | Total P (lbs/ac) | Inorganic P (lbs/ac) | Organic P (lbs/ac) | Total N (lbs/ac) | Inorganic N (lbs/ac) | Organic N (lbs/ac) |
|---|---|---|---|---|---|---|
| FER1 | 61.64 | 39.67 | 21.97 | 218.61 | 167.78 | 50.83 |
| FER2 | 118.68 | 95.30 | 23.38 | 221.19 | 159.97 | 61.22 |
| FRA1-corn | 133.17 | 120.90 | 12.27 | 219.21 | 157.92 | 61.29 |
| FRA1-hay | 114.08 | 105.78 | 8.30 | 125.20 | 83.41 | 41.79 |
| FRA2-corn | 135.70 | 123.84 | 11.86 | 194.63 | 142.66 | 51.97 |
| FRA2-hay | 136.16 | 128.17 | 7.99 | 158.94 | 104.35 | 54.59 |
| PAW1 | 68.31 | 59.09 | 9.22 | 189.49 | 149.99 | 39.51 |
| PAW2 | 19.16 | 12.25 | 6.91 | 126.21 | 95.09 | 31.12 |
| SHE1 | 89.70 | 67.04 | 22.66 | 197.66 | 130.33 | 67.32 |
| SHE2 | 74.75 | 47.74 | 27.01 | 223.95 | 157.40 | 66.55 |
| SHO1 | 37.49 | 13.42 | 24.07 | 111.94 | 23.93 | 88.01 |
| SHO1-D | 39.10 | 13.90 | 25.20 | 108.89 | 21.27 | 87.62 |
| SHO2 | 36.80 | 16.16 | 20.64 | 85.89 | 26.58 | 59.40 |

| Site | Total P (lbs/ac) | Inorganic P (lbs/ac) | Organic P (lbs/ac) | Total N (lbs/ac) | Inorganic N (lbs/ac) | Organic N (lbs/ac) |
|---|---|---|---|---|---|---|
| WAS | 89.01 | 80.99 | 8.02 | 113.41 | 78.59 | 34.82 |
| WIL1 | 239.20 | 220.96 | 18.24 | 188.44 | 139.50 | 48.94 |
| WIL2 | 292.10 | 282.35 | 9.75 | 135.98 | 106.22 | 29.76 |

*Table 5.. Selected characteristics of composite soil samples from the study watersheds, USDA ARS Analyses.*

| Site | Solvita 1-day CO2-C (ppm) | Organic C (ppm) | Organic N (ppm) | Organic C:N |
|---|---|---|---|---|
| FER1 | 44.20 | 265.98 | 25.42 | 10.47 |
| FER2 | 37.08 | 255.44 | 30.61 | 8.34 |
| FRA1-corn | 39.79 | 287.04 | 30.65 | 9.37 |
| FRA1-hay | 37.08 | 195.91 | 20.90 | 9.38 |
| FRA2-corn | 33.10 | 270.00 | 25.99 | 10.39 |
| FRA2-hay | 33.10 | 241.24 | 27.29 | 8.84 |
| PAW1 | 29.00 | 155.13 | 19.75 | 7.85 |
| PAW2 | 29.00 | 118.23 | 15.56 | 7.60 |
| SHE1 | 44.20 | 317.19 | 33.66 | 9.42 |
| SHE2 | 38.43 | 349.43 | 33.28 | 10.50 |
| SHO1 | 60.93 | 437.15 | 44.01 | 9.93 |
| SHO1-D | 56.75 | 437.16 | 43.81 | 10.80 |
| SHO2 | 49.58 | 276.24 | 29.70 | 9.30 |
| WAS | 31.05 | 153.42 | 17.41 | 8.81 |
| WIL1 | 26.96 | 172.62 | 24.47 | 7.05 |
| WIL2 | 25.93 | 98.71 | 14.88 | 6.63 |

## 6.2. Agronomic Data

Agronomic data provided by participating farms are presented in Tables 6 through Table 11.

*Table 6. Agronomic history of Ferrisburgh study watershed (FER1 and FER2)*

| Date | Activity |
|---|---|
| 04/12/12 | Fields harrowed. |
| 04/16/12 | Fields seeded in red clover with a cover of peas/oats. No manure or fertilizer applied in 2012. |
| 07/04/12 | First cut. Estimated yield: 1.5 T/acre. |
| 09/01/12 | Second cut. Estimated yield: 1 T/acre. |
| 09/??/12 | FER2 was reseeded with red clover using an interseeder. |

*Table 7. Agronomic history of Franklin study watershed (FRA1 and FRA2)*

| Date | Activity |
|---|---|
| 04/05/12 | Spring nitrogen (38-0-0) was broadcast on grass strips (that were later planted to corn, on 06/01/12) at 100 lbs/acres |
| 05/28/12 | Spring manure application, via low nozzle using a Houle 6300 gallon spreader at the following rates: #2-6 loads, #17-7 loads, #3-7 loads, #4-7 loads. Manure was taken from Pit 1 and well-agitated prior to spreading. Hay strips were aerated prior to manure application. Manure was tested and found to be 6.7% dry matter. |
| 06/01/12 | Corn was zone-till planted into the hay strips, at a depth of 2" in rows 30" on center and at a rate of 33,000/acre. Fields #2, 3, 4 were planted with Mycogen TMF2Q493; Field #17 was planted with TMF2Q493 and Pioneer P0125HRw/1250. |
| 06/01/12 | Corn starter (7-21-7 Mg 1) applied via the zone till planter at 55 lbs/acre; some fields did not get any corn starter due to malfunction of zone-till planter/operator error. |
| 06/07/12 | Pre-emerge pesticide application on corn strips; Lumax 1.5 qts/acre; Showdown 1 qt/acre; and Rifle 8 oz/acre |
| 06/18/12 | Post-emerge pesticide application on corn strips for army worms; Tombstone 2.8 oz/acre |
| 07/04/12 | Corn topdress (30-0-20) was broadcast at 225 lbs/acre |
| 07/09/12 | Pesticide application for grass control on corn strips; Glystar plus 4 oz/acre |
| 10/07/12 | Corn chopped for silage; yield ~15 T/acre; no residue |
| 10/26/12 | Fall manure application, via low nozzle using a Houle 6300 gallon spreader at the following rates: #2—8 loads; #17—10 loads; #3—9 loads; #4—12 loads. Manure was taken from Pit 1 and well-agitated prior to spreading. Manure was tested and found to be 6.7% dry matter. Manure was immediately incorporate via chisel plow. |

*Table 8. Agronomic history of Pawlet study watershed (PAW1 and PAW2)*

| Date | Activity |
|---|---|
| 5/12/12 | Spring manure application, via high nozzle, at a rate of 4,000 gallons per acre. Manure was incorporated via chisel plow. |
| 5/29/12 | Corn was planted in rows 30" on center at a rate of 32,000/acre; seed variety was 35A34 |
| | Fertilizer (30-10-20) was applied 200 lbs/acre |
| 9/27/12 | All corn chopped (based on time-lapse camera photos); yield 18-22 T/acre; no residue |
| | No fall manure application or tillage |

*Table 9. Agronomic history of Shelburne study watershed (SHE1 and SHE2)*

| Date | Activity |
|---|---|
| n.d. | SHE2 field history is old sod, hay grass, primarily orchard grass, fescue, canary grass, and clover. No crop was harvested in 2011 due to wet conditions in the field. |
| Spring 2009 | Northern portion (16.3 acres) of SHE1 seeded with timothy and clover. Southern portion (8.3 acres) remained in old sod, primarily orchard grass, brome grass, fescue, canary grass, and clover. |
| 6/5/12 | First hay cut on SHE2. Baled 6/11 (56 round bales @ 700#). Total yield 4215 lbs hay/acre, 4004 lbs dm/acre. |
| 6/9/12 | First hay cut on SHE1. Baled 6/12 (580 small square bales @ 35#, 75 round bales @ 700#. Remainder was rained on, not baled until 6/16 (49 round bales @ 700#). Total yield 4377 lbs hay/acre, 3939 lbs dm/acre. |
| 7/19/12 | Second hay cut on SHE2. Baled 7/20 (14 wrapped bales, 1350# @ 47% dm). Total yield 2032 lbs silage/acre, 955 lbs dm/acre. |
| 7/24/12 | Second hay cut on SHE1. Baled on 7/25 (53 wrapped bales, 1350# @ 47% dm). Total yield 2908 lbs silage/acre, 1367 lbs dm/acre. |
| 9/3-4/12 | Manure application on SHE1 with 7,300 gallon Houle manure tankers (by John Whitney Custom Farm Work) at a |

| Date | Activity |
|---|---|
| | rate of 5,561 gallons/acre. Manure analysis report available. |
| 9/4/12 | Manure application on SHE2 with 7,300 gallon Houle manure tankers (by John Whitney Custom Farm Work) at a rate of 6,193 gallons/acre. Manure analysis report available. |
| 12/4/12 | Sheep pen installed at SHE2. |
| 12/7-14/12 | 95 sheep were grazed at SHE2 during this time period, rotated between 3-5 paddocks. Sheep were moved out of SHE2 the morning of 12/14. |

*Table 10. Agronomic history of Shoreham study watershed (SHO1 and SHO2)*

| Date | Activity |
|---|---|
| 2006 | SHO2 seeded (predominant plant species in decreasing order are alfalfa, reed canary grass, fescue, and timothy) |
| 2009 | SHO1 seeded (predominant plant species in decreasing order are alfalfa, reed canary grass, fescue, and timothy) |
| Late March 2012 | Coated urea fertilizer broadcast at a rate of 150 lb/acre. |
| 5/18/12 | First hay cut. Loaded 5/19/12. Estimated yield 3 tons/acre. |
| 7/2/12 | Manure application with 4300 gallon Houle manure tank at a rate of 5,000 gallons/acre. Manure source was Home pit #1, pit was agitated very well. Manure was thick from lack of rain. |
| 7/4/12 | Second hay cut. Loaded 7/6/12. Estimated yield 20 small square bales/acre. |
| 8/21/12 | Third hay cut. Loaded 8/22/12. Estimated yield 2 tons/acre. |
| 11/20/12 | Fourth hay cut. Loaded 11/21/12. Estimated yield 1.5 tons/acre. |

*Table 11. Agronomic history of Williston study watershed (WIL1 and WIL2)*

| Date | Activity |
|---|---|
| 4/29/12 | Manure application, surface spread with Knight Hy-Push at a rate of 15 tons/acre. Manure source was farm's main pit, pit was not agitated, and there was substantial water in the pit. Manure was incorporated with disc chisel plow on 5/1/12. |
| 5/24/12 | Tillage with Sunflower finishing harrow. |
| 5/26/12 | Planted Syngenta N53-w3 corn seed at a rate of 34,000 seeds/acre, 30-in. row width. |
| 5/30/12 | Spray application of Lumax pesticide (EPA# 100-1152) at 2.5 oz/acre. Spray application of Atrazine 90DF (EPA# 9779-253) at 0.5 lb/acre. |
| 9/8/12 | Winter rye cover crop planted, helicopter seeding at 100 lb/acre. |
| 11/9/12 | Corn harvest with Snapper head-on chopper. Estimated yield 6 tons/acre. 95% residue left on field. |
| 12/8/12 | Manure application, surface spread with Knight Hy-Push at a rate of 15 tons/acre. Manure source was farm's main pit, pit was not agitated, and there was no substantial water in the pit. Manure was not incorporated. |

## 6.3. Precipitation

Precipitation data collected between September 1, 2012 and January 31, 3013 is presented in Figures 15-4.8, below.

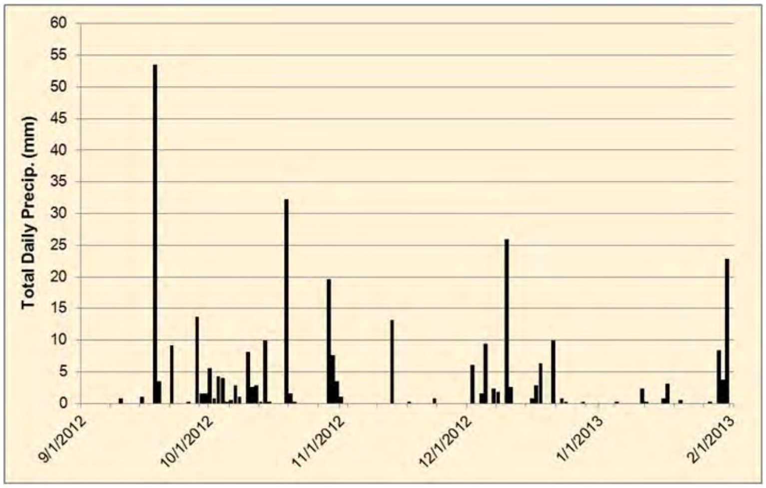


*Figure 15. Daily total precipitation for the West Pawlet sites, Sept. 2012-Jan. 2013.*

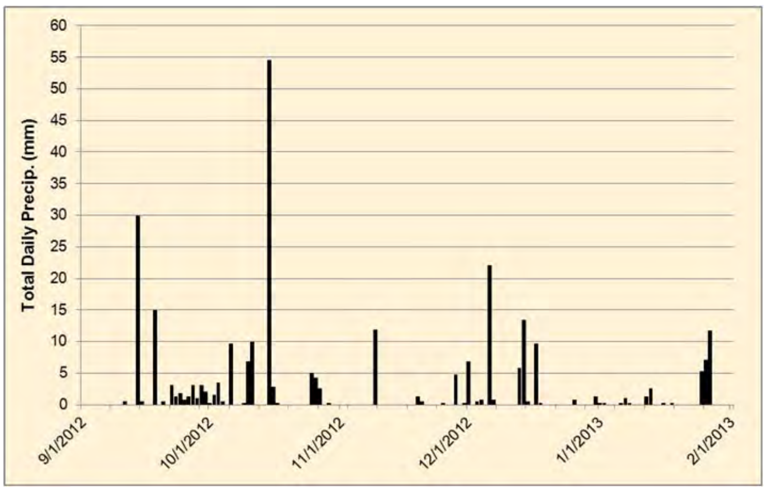


*Figure 16. Daily total precipitation for the Shoreham site, Sept. 2012-Jan. 2013.*

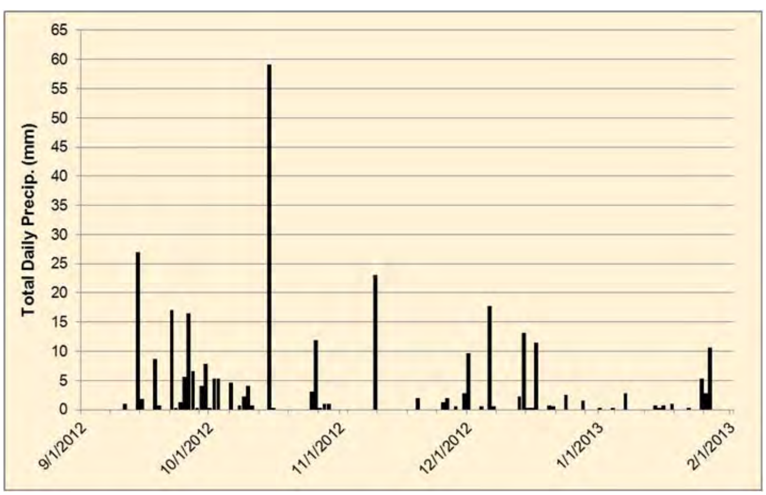


*Figure 17. Daily total precipitation for the Ferrisburgh site, Sept. 2012-Jan. 2013.*

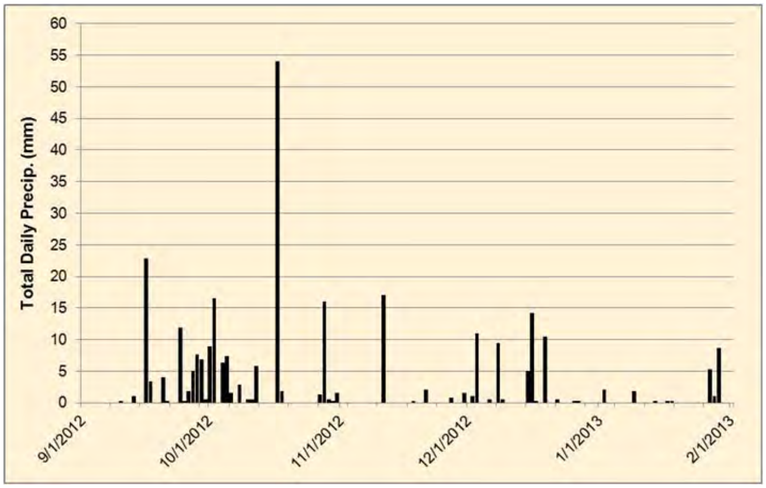


*Figure 18. Daily total precipitation for the Shelburne site, Sept. 2012-Jan. 2013.*

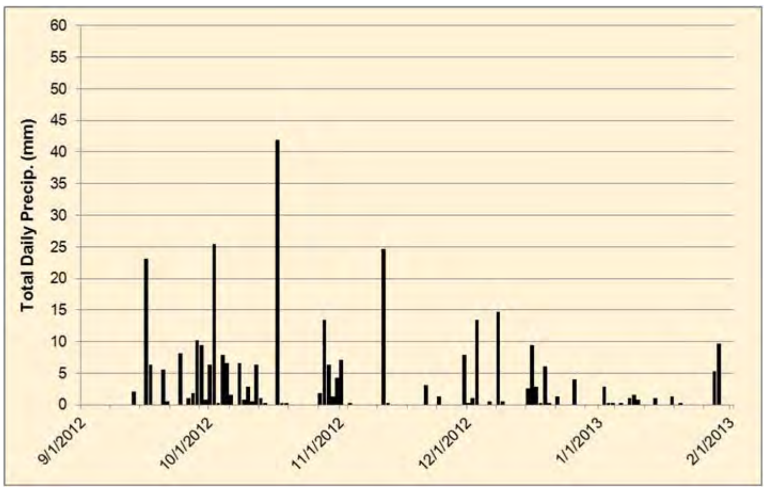


*Figure 19. Daily total precipitation for the Williston site, Sept. 2012-Jan. 2013.*

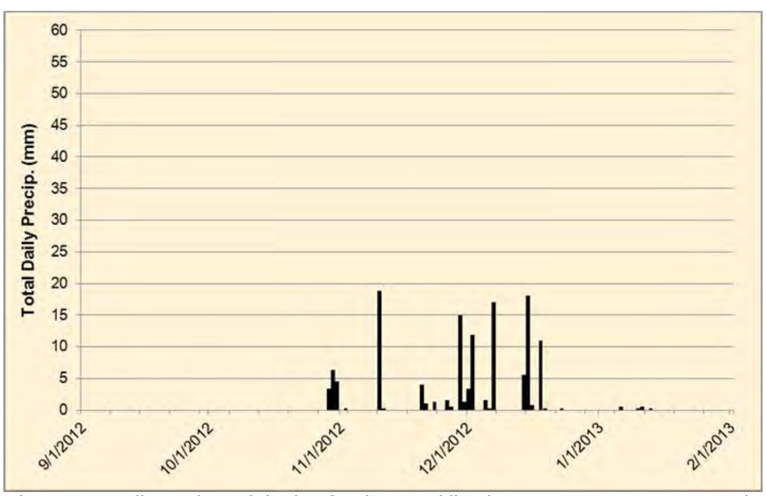


*Figure 20. Daily total precipitation for the Franklin site, Sept. 2012-Jan. 2013; data were not collected Sept-Oct 2012 and 1/24-31/2013*

*Table 12. Comparison of long-term mean air temperature and normal precipitation to temperature and precipitation recorded at West Pawlet site, Sept. 2012-Jan. 2013.*

| Month | Mean/Normal[1] | | 2012 | | 2013 | |
|---|---|---|---|---|---|---|
| | Mean air temp. (°C) | Normal precip. (mm) | Mean air temp. (°C) | Total precip. (mm) | Mean air temp. (°C) | Total precip. (mm) |
| January | -7.5 | 65 | -- | -- | -5.0 | 42 |
| February | -6.3 | 55 | -- | -- | -- | -- |
| March | -0.8 | 70 | -- | -- | -- | -- |
| April | 6.7 | 73 | -- | -- | -- | -- |
| May | 13.0 | 94 | -- | -- | -- | -- |
| June | 17.9 | 101 | -- | -- | -- | -- |
| July | 20.3 | 121 | -- | -- | -- | -- |
| August | 19.2 | 103 | -- | -- | -- | -- |
| September | 14.4 | 94 | 13.5 | 85 | -- | -- |
| October | 8.1 | 97 | 11.4 | 108 | -- | -- |
| November | 2.6 | 83 | 1.8 | 15 | -- | -- |
| December | -3.9 | 71 | -0.3 | 70 | -- | -- |

[1] Source: NCDC 2011; 1981 – 2010 climate normals for Rutland Airport NWS station USC00436995

*Table 13. Comparison of long-term mean air temperature and normal precipitation to temperature and precipitation recorded at Shoreham site, Sept. 2012-Jan. 2013.*

| Month | Mean/Normal[1] | | 2012 | | 2013 | |
|---|---|---|---|---|---|---|
| | Mean air temp. (°C) | Normal precip. (mm) | Mean air temp. (°C) | Total precip. (mm) | Mean air temp. (°C) | Total precip. (mm) |
| January | -7.5 | 65 | -- | -- | -5.8 | 32 |
| February | -6.3 | 55 | -- | -- | -- | -- |
| March | -0.8 | 70 | -- | -- | -- | -- |
| April | 6.7 | 73 | -- | -- | -- | -- |
| May | 13.0 | 94 | -- | -- | -- | -- |
| June | 17.9 | 101 | -- | -- | -- | -- |
| July | 20.3 | 121 | -- | -- | -- | -- |
| August | 19.2 | 103 | -- | -- | -- | -- |
| September | 14.4 | 94 | 13.6 | 55 | -- | -- |
| October | 8.1 | 97 | 10.9 | 111 | -- | -- |
| November | 2.6 | 83 | 1.6 | 14 | -- | -- |
| December | -3.9 | 71 | -1.1 | 67 | -- | -- |

[1] Source: NCDC 2011; 1981 – 2010 climate normals for Rutland Airport NWS station USC00436995

*Table 14. Comparison of long-term mean air temperature and normal precipitation to temperature and precipitation recorded at Ferrisburgh site, Sept. 2012-Jan. 2013.*

| Month | Mean/Normal[1] | | 2012 | | 2013 | |
|---|---|---|---|---|---|---|
| | Mean air temp. (°C) | Normal precip. (mm) | Mean air temp. (°C) | Total precip. (mm) | Mean air temp. (°C) | Total precip. (mm) |
| January | -7.4 | 52 | -- | -- | -5.3 | 27 |
| February | -5.8 | 45 | -- | -- | -- | -- |
| March | -0.6 | 56 | -- | -- | -- | -- |
| April | 7.1 | 72 | -- | -- | -- | -- |
| May | 13.5 | 88 | -- | -- | -- | -- |
| June | 18.8 | 94 | -- | -- | -- | -- |
| July | 21.4 | 106 | -- | -- | -- | -- |
| August | 20.4 | 99 | -- | -- | -- | -- |
| September | 15.8 | 92 | 13.9 | 80 | -- | -- |
| October | 8.9 | 91 | 11.0 | 117 | -- | -- |
| November | 3.4 | 80 | 2.1 | 30 | -- | -- |
| December | -3.4 | 60 | -0.6 | 63 | -- | -- |

[1] Source: NCDC 2011; 1981 – 2010 climate normals for Burlington NWS station USW00014742

*Table 15. Comparison of long-term mean air temperature and normal precipitation to temperature and precipitation recorded at Shelburne site, Sept. 2012-Jan. 2013.*

| Month | Mean/Normal[1] | | 2012 | | 2013 | |
|---|---|---|---|---|---|---|
| | Mean air temp. (°C) | Normal precip. (mm) | Mean air temp. (°C) | Total precip. (mm) | Mean air temp. (°C) | Total precip. (mm) |
| January | -7.4 | 52 | -- | -- | -5.0 | 20 |
| February | -5.8 | 45 | -- | -- | -- | -- |
| March | -0.6 | 56 | -- | -- | -- | -- |
| April | 7.1 | 72 | -- | -- | -- | -- |
| May | 13.5 | 88 | -- | -- | -- | -- |
| June | 18.8 | 94 | -- | -- | -- | -- |
| July | 21.4 | 106 | -- | -- | -- | -- |
| August | 20.4 | 99 | -- | -- | -- | -- |
| September | 15.8 | 92 | 15.0 | 58 | -- | -- |
| October | 8.9 | 91 | 11.5 | 131 | -- | -- |
| November | 3.4 | 80 | 2.4 | 22 | -- | -- |
| December | -3.4 | 60 | -0.5 | 55 | -- | -- |

[1] Source: NCDC 2011; 1981 – 2010 climate normals for Burlington NWS station USW00014742

*Table 16. Comparison of long-term mean air temperature and normal precipitation to temperature and precipitation recorded at Williston site, Sept. 2012-Jan. 2013.*

| Month | Mean/Normal[1] | | 2012 | | 2013 | |
|---|---|---|---|---|---|---|
| | Mean air temp. | Normal precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. |
| | (°C) | (mm) | (°C) | (mm) | (°C) | (mm) |
| January | -7.4 | 52 | -- | -- | -6.2 | 24 |
| February | -5.8 | 45 | -- | -- | -- | -- |
| March | -0.6 | 56 | -- | -- | -- | -- |
| April | 7.1 | 72 | -- | -- | -- | -- |
| May | 13.5 | 88 | -- | -- | -- | -- |
| June | 18.8 | 94 | -- | -- | -- | -- |
| July | 21.4 | 106 | -- | -- | -- | -- |
| August | 20.4 | 99 | -- | -- | -- | -- |
| September | 15.8 | 92 | 13.8 | 59 | -- | -- |
| October | 8.9 | 91 | 10.8 | 140 | -- | -- |
| November | 3.4 | 80 | 1.3 | 42 | -- | -- |
| December | -3.4 | 60 | -1.1 | 65 | -- | -- |

[1] Source: NCDC 2011; 1981 – 2010 climate normals for Burlington NWS station USW00014742

*Table 17. Comparison of long-term mean air temperature and normal precipitation to temperature and precipitation recorded at Franklin site, Sept. 2012-Jan. 2013; data were not collected Sept-Oct 2012 and 1/24-31/2013*

| Month | Mean/Normal[1] | | 2012 | | 2013 | |
|---|---|---|---|---|---|---|
| | Mean air temp. | Normal precip. | Mean air temp. | Total precip. | Mean air temp. | Total precip. |
| | (°C) | (mm) | (°C) | (mm) | (°C) | (mm) |
| January | -7.4 | 52 | -- | -- | -6.7 | 1.5 |
| February | -5.8 | 45 | -- | -- | -- | -- |
| March | -0.6 | 56 | -- | -- | -- | -- |
| April | 7.1 | 72 | -- | -- | -- | -- |
| May | 13.5 | 88 | -- | -- | -- | -- |
| June | 18.8 | 94 | -- | -- | -- | -- |
| July | 21.4 | 106 | -- | -- | -- | -- |
| August | 20.4 | 99 | -- | -- | -- | -- |
| September | 15.8 | 92 | -- | -- | -- | -- |
| October | 8.9 | 91 | -- | -- | -- | -- |
| November | 3.4 | 80 | 0.8 | 42 | -- | -- |
| December | -3.4 | 60 | -2.1 | 86 | -- | -- |

[1] Source: NCDC 2011; 1981 – 2010 climate normals for Burlington NWS station USW00014742

## 6.4. Event Runoff

Tables 18-23 summarize, by station, the total event discharge and water quality parameters for monitored runoff events that occurred between September 2012 and January 2013.

*Table 18. Summary of water quality parameters of monitored events at FER1 and FER2, September 2012 – January 2013. HQ is total event discharge in liters.*

| **FER1** | **HQ (l)** | **TP (ug/l)** | **TDP (ug/l)** | **TN (mg/l)** | **TDN (mg/l)** | **TSS (mg/l)** | **Cl (mg/l)** |
|---|---|---|---|---|---|---|---|
| **Range** | 0 – 360,312 | 286 – 660 | 154 - 444 | 1.5 – 1.8 | 1.0 – 1.2 | 43.6 – 82.9 | 9.9 – 11.5 |
| **Mean[1]** | 85.6 | 434.5 | 261.4 | 1.6 | 1.1 | 60.1 | 10.7 |
| **Median** | 0 | - | - | -- | - | - | - |
| **Std. Dev.** | 198 | - | - | - | - | - | - |
| **C.V.** | 118.6 | - | - | - | - | - | - |
| **N** | 18 | 2 | 2 | 2 | 2 | 2 | 2 |
| **FER2** | **HQ (l)** | **TP (ug/l)** | **TDP (ug/l)** | **TN (mg/l)** | **TDN (mg/l)** | **TSS (mg/l)** | **Cl (mg/l)** |
| **Range** | 2,614 – 1,201,853 | 343 – 1,336 | 248 – 1,400 | 1.6 – 2.4 | 1.2 – 2.0 | 4.4 – 288.1 | 7.5 – 47.3 |
| **Mean[1]** | 28,662 | 585 | 571 | 2.0 | 1.5 | 16.4 | 21.8 |
| **Median** | 20,371 | 505 | 575 | 2.0 | 1.5 | 19.0 | 22.6 |
| **Std. Dev.** | 304,008 | 290 | 395 | 0.32 | 0.23 | 73.7 | 11.5 |
| **C.V.** | 248.9 | 45.6 | 59.4 | 16.1 | 14.8 | 200.0 | 47.3 |
| **N** | 15 | 13 | 7 | 14 | 7 | 14 | 14 |

[1] anti-log of log mean

*Table 19. Summary of water quality parameters of monitored events at FRA 1 and FRA2, September 2012 – January 2013. HQ is total event discharge in liters.*

| FRA1 | HQ (l) | TP (ug/l) | TDP (ug/l) | TN (mg/l) | TDN (mg/l) | TSS (mg/l) | Cl (mg/l) |
|---|---|---|---|---|---|---|---|
| **Range** | 18,197 – 930,008 | 290 – 1,144 | 196 – 798 | 2.1 – 20.4 | 1.4 – 19.3 | 12.2 – 293 | 7.4 – 34.2 |
| **Mean**[1] | 133,991 | 556 | 390 | 5.3 | 4.4 | 47.0 | 16.3 |
| **Median** | 124,093 | 585 | 494 | 3.7 | 2.6 | 40.8 | 19.1 |
| **Std. Dev.** | 281,058 | 356.9 | 230.3 | 6.7 | 6.6 | 84.7 | 10.3 |
| **C.V.** | 108.7 | 55.8 | 51.9 | 90.8 | 98.4 | 120.0 | 54.5 |
| **n** | 12 | 7 | 7 | 7 | 7 | 7 | 7 |
| **FRA2** | **HQ (l)** | **TP (ug/l)** | **TDP (ug/l)** | **TN (mg/l)** | **TDN (mg/l)** | **TSS (mg/l)** | **Cl (mg/l)** |
| **Range** | 0 – 1,010,301 | 300 – 1,116 | 216 – 585 | 2.2 – 26.6 | 1.4 – 26.6 | 8.8 – 241.2 | 7.8 – 42.4 |
| **Mean**[1] | 7,821 | 533 | 388 | 5.6 | 4.7 | 33.7 | 14.8 |
| **Median** | 109,425 | 615 | 520 | 3.2 | 3.0 | 30.4 | 13.6 |
| **Std. Dev.** | 294,114 | 326.6 | 177.1 | 10.4 | 10.6 | 97.9 | 14.4 |
| **C.V.** | 131.9 | 54.6 | 41.9 | 113.5 | 123.2 | 145.3 | 78.2 |
| **n** | 12 | 5 | 5 | 5 | 5 | 5 | 5 |

[1] anti-log of log mean

*Table 20. Summary of water quality parameters of monitored events at PAW1 and PAW2, September 2012 – January 2013. HQ is total event discharge in liters.*

| PAW1 | HQ (l) | TP (ug/l) | TDP (ug/l) | TN (mg/l) | TDN (mg/l) | TSS (mg/l) | Cl (mg/l) |
|---|---|---|---|---|---|---|---|
| **Range** | 0 – 529,846 | 107 - 905 | 9 – 106 | 1.7 – 5.3 | 1.1 – 3.4 | 4.2 – 669 | 10 – 17 |
| **Mean**[1] | 3,242 | 252 | 39 | 2.9 | 2.0 | 75.8 | 12.3 |
| **Median** | 13,259 | 215 | 47 | 3.2 | 1.9 | 80.2 | 11.9 |
| **Std. Dev.** | 187,662.8 | 298.2 | 32.7 | 1.3 | 1.0 | 248.5 | 2.9 |
| **C.V.** | 141.0 | 90.2 | 66.8 | 41.0 | 46.6 | 135.4 | 22.9 |
| **n** | 15 | 6 | 6 | 6 | 6 | 6 | 6 |
| **PAW2** | **HQ (l)** | **TP (ug/l)** | **TDP (ug/l)** | **TN (mg/l)** | **TDN (mg/l)** | **TSS (mg/l)** | **Cl (mg/l)** |
| **Range** | 350 – 220,163 | 212 – 857 | 20 – 204 | 0.6 – 3.0 | 0.3 – 1.7 | 9.5 – 516 | 3.4 – 9.7 |
| **Mean**[1] | 13,677 | 413 | 45 | 1.5 | 0.6 | 131 | 5.9 |
| **Median** | 11,756 | 411 | 37 | 1.8 | 0.5 | 194 | 4.7 |
| **Std. Dev.** | 63,875.4 | 221.1 | 67.9 | 0.74 | 0.46 | 154.2 | 2.5 |
| **C.V.** | 130.4 | 48.3 | 102.9 | 44.3 | 65.3 | 78.2 | 39.9 |
| **n** | 15 | 8 | 7 | 8 | 7 | 8 | 7 |

[1] anti-log of log mean

*Table 21. Summary of water quality parameters of monitored events at SHE1 and SHE2, September 2012 – January 2013. HQ is total event discharge in liters.*

| SHE1 | HQ (l) | TP (ug/l) | TDP (ug/l) | TN (mg/l) | TDN (mg/l) | TSS (mg/l) | Cl (mg/l) |
|---|---|---|---|---|---|---|---|
| Range | 0 – 326,264 | 314 – 748 | 278 – 630 | 1.3 – 12.7 | 1.1 – 2.0 | 3.8 – 23.2 | 2.4 – 14.9 |
| Mean[1] | 3,578 | 505 | 432 | 2.3 | 1.4 | 12.0 | 3.5 |
| Median | 10,582 | 545 | 448 | 1.6 | 1.3 | 12.5 | 12.0 |
| Std. Dev. | 104,965.5 | 178.6 | 154.1 | 5.0 | 0.38 | 7.86 | 4.9 |
| C.V. | 149.5 | 33.7 | 33.9 | 132.0 | 27.0 | 55.3 | 50.4 |
| n | 10 | 5 | 5 | 5 | 5 | 5 | 5 |
| **SHE2** | **HQ (l)** | **TP (ug/l)** | **TDP (ug/l)** | **TN (mg/l)** | **TDN (mg/l)** | **TSS (mg/l)** | **Cl (mg/l)** |
| Range | 4,222 – 432,705 | 310 – 680 | 309 – 610 | 1.1 – 2.1 | 0.8 – 1.7 | 3.2 – 14.1 | 10.4 – 29.5 |
| Mean[1] | 35,757 | 481 | 456 | 1.5 | 1.2 | 5.4 | 19.7 |
| Median | 29,099 | 520 | 517 | 1.5 | 1.2 | 4.6 | 21.2 |
| Std. Dev. | 132,227.2 | 156.4 | 137.7 | 0.36 | 0.38 | 4.3 | 6.8 |
| C.V. | 142.8 | 31.1 | 29.0 | 23.5 | 30.2 | 67.5 | 32.9 |
| n | 10 | 7 | 6 | 7 | 6 | 7 | 7 |

[1] anti-log of log mean

*Table 22. Summary of water quality parameters of monitored events at SHO1 and SHO2, September 2012 – January 2013. HQ is total event discharge in liters.*

| SHO1 | HQ (l) | TP (ug/l) | TDP (ug/l) | TN (mg/l) | TDN (mg/l) | TSS (mg/l) | Cl (mg/l) |
|---|---|---|---|---|---|---|---|
| Range | 1,227 – 441,297 | 1,026 – 1,112 | 901 – 1,030 | 1.8 – 3.0 | 0.9 – 1.2 | 15.7 – 30.9 | 3.1 – 6.2 |
| Mean[1] | 55,717 | 1,068 | 963 | 2.3 | 1.0 | 22.0 | 4.4 |
| Median | 190,951 | - | - | - | - | - | - |
| Std. Dev. | 175,924 | - | - | - | - | - | - |
| C.V. | 95.4 | - | - | - | - | - | - |
| n | 7 | 2 | 2 | 2 | 2 | 2 | 2 |
| **SHO2** | **HQ (l)** | **TP (ug/l)** | **TDP (ug/l)** | **TN (mg/l)** | **TDN (mg/l)** | **TSS (mg/l)** | **Cl (mg/l)** |
| Range | 0 – 67,927 | 738 - 829 | 536 - 695 | 1.6 – 2.2 | 0.7 – 1.6 | 27.4 – 62.5 | 1.4 – 6.2 |
| Mean[1] | 382 | 782 | 610 | 1.9 | 1.0 | 41.4 | 2.9 |
| Median | 2,584 | - | - | - | - | - | - |
| Std. Dev. | 27,248.3 | - | - | - | - | - | - |
| C.V. | 162.1 | - | - | - | - | - | - |
| n | 6 | 2 | 2 | 2 | 2 | 2 | 2 |

[1] anti-log of log mean

*Table 23. Summary of water quality parameters of monitored events at WIL1 and WIL2, September 2012 – January 2013. HQ is total event discharge in liters.*

| WIL1 | HQ (l) | TP (ug/l) | TDP (ug/l) | TN (mg/l) | TDN (mg/l) | TSS (mg/l) | Cl (mg/l) |
|---|---|---|---|---|---|---|---|
| **Range** | 0 – 5,535 | 500 – 675 | 282 – 575 | 1.4 – 3.2 | 0.8 – 2.7 | 7.7 – 60 | 1.4 – 3.5 |
| **Mean[1]** | 72 | 605 | 406 | 2.0 | 1.4 | 25.8 | 2.0 |
| **Median** | 310 | 656 | 405 | 1.8 | 1.4 | 37.4 | 1.6 |
| **Std. Dev.** | 2,172.3 | 96.0 | 147.1 | 0.94 | 0.97 | 26.2 | 1.16 |
| **C.V.** | 135.7 | 15.7 | 35.0 | 44.3 | 59.5 | 74.9 | 53.5 |
| **n** | 7 | 3 | 3 | 3 | 3 | 3 | 3 |
| **WIL2** | **HQ (l)** | **TP (ug/l)** | **TDP (ug/l)** | **TN (mg/l)** | **TDN (mg/l)** | **TSS (mg/l)** | **Cl (mg/l)** |
| **Range** | 1,724 – 11,558 | 740 – 3,300 | 472 – 2,780 | 1.8 – 6.4 | 0.8 – 5.4 | 16.7 – 255 | 1.5 – 6.8 |
| **Mean[1]** | 4,217 | 1,425 | 922 | 2.9 | 1.7 | 87.4 | 3.6 |
| **Median** | 3,587 | 1,520 | 740 | 2.7 | 1.4 | 146 | 4.5 |
| **Std. Dev.** | 3,677.2 | 871.0 | 791.9 | 1.72 | 1.77 | 86.2 | 1.97 |
| **C.V.** | 70.1 | 54.3 | 72.6 | 53.1 | 82.3 | 71.0 | 47.7 |
| **n** | 7 | 7 | 7 | 7 | 7 | 7 | 7 |

[1] anti-log of log mean

# 7. REFERENCES

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# APPENDICES

# APPENDIX A: APPROVED QAPP

**QA Project Plan:**

**Agricultural Practice Monitoring and Evaluation**
**Version 1.0**

**Prepared by:**
Stone Environmental, Inc.
535 Stone Cutters Way
Montpelier, VT 05602

**Prepared for:**
Lake Champlain Basin Program
54 West Shore Road
Grand Isle, VT 05458

June 7, 2012

| | |
|---|---|
| Julie Moore, PE, Project Manager, Stone Environmental | 6/7/12 Date |
| Kim Watson, RQAP-GLP, Project QA Officer, Stone Environmental | 6/7/12 Date |
| Chris Stone, President, Stone Environmental | 6-7-12 Date |
| Eric Howe, Project Officer, LCBP | 6/7/12 Date |
| Laura DiPietro, Project Officer, VT AAFM | Date |
| Michael Jennings, Quality Assurance Program Manager, NEIWPCC | 6/7/12 Date |

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June 7, 2012

Julie Moore, PE, Project Manager, Stone Environmental — Date

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6/19/12

Laura DiPietro, Project Officer, VT AAFM — Date

6/7/12

Michael Jennings, Quality Assurance Program Manager, NEIWPCC — Date

**QA Project Plan:**

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54 West Shore Road
Grand Isle, VT 05458

June 7, 2012

| | |
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| Julie Moore, PE, Project Manager, Stone Environmental | Date |
| Kim Watson, RQAP-GLP, Project QA Officer, Stone Environmental | Date |
| Chris Stone, President, Stone Environmental | Date |
| Eric Howe, Project Officer, LCBP | Date |
| Laura DiPietro, Project Officer, VT AAFM | Date |
| Michael Jennings, Quality Assurance Program Manager, NEIWPCC | Date |

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# A – Project Management

## A.3 Distribution List

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## A.4 Project/Task Organization

The roles and responsibilities of all project personnel are described in Table 1. Project organization is outlined in Figure A1.

NEIWPCC:
Michael Jennings, Quality Assurance Program Manager: Review and approve QAPP and subsequent revisions in terms of quality assurance aspects.

LCBP:
Eric Howe, LCBP Project Officer: Point of communication for VT Agency of Agriculture, Farms and Markets Project Officer and NEIWPCC.

VT Agency of Agriculture, Farms and Markets
Laura DiPietro, VAAFM Project Officer: Overall coordination of the project and point of communication for Stone Environmental Project Manager and the LCBP.

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

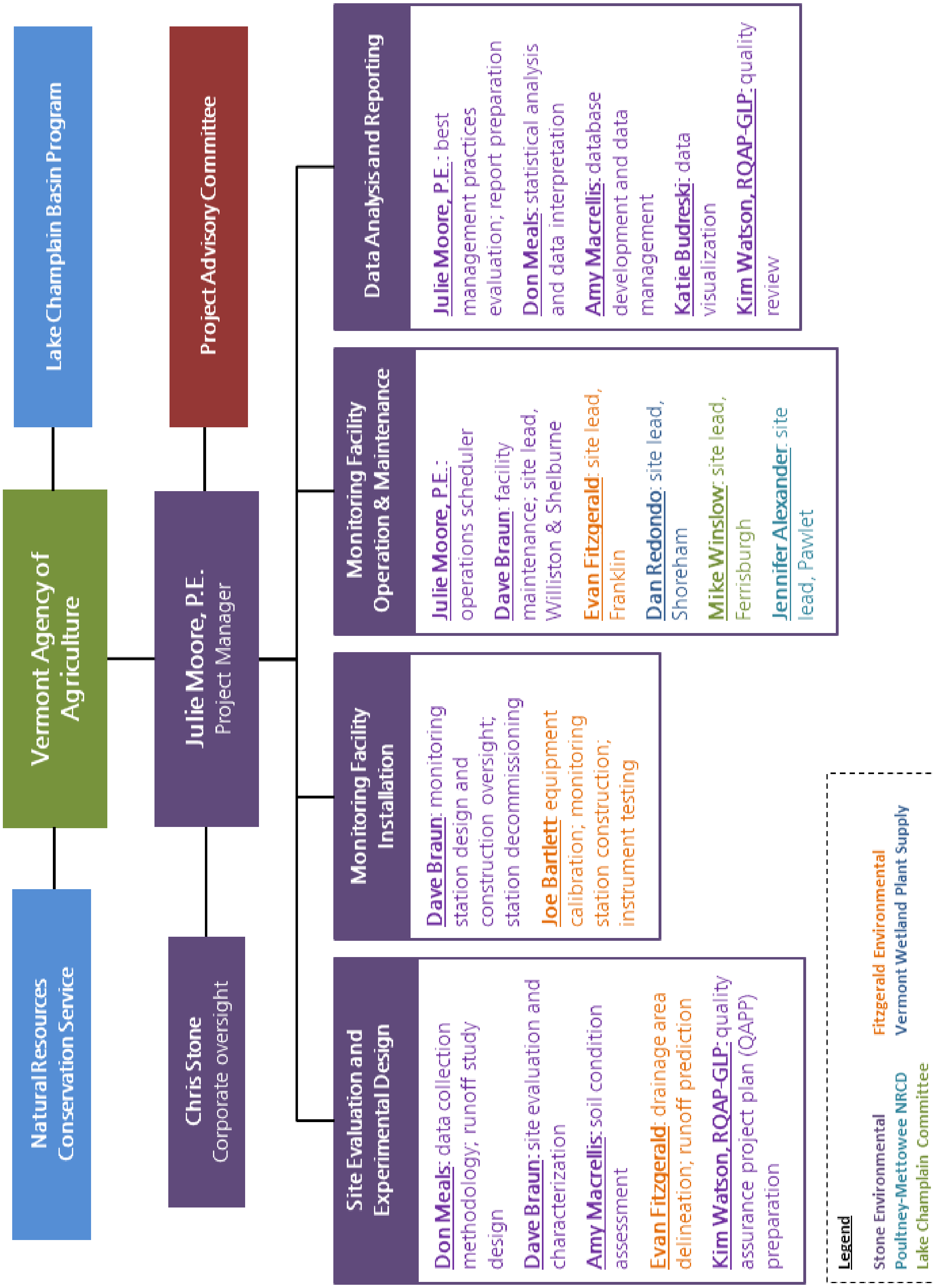
**Table 1: Roles and Responsibilities**

| Individual(s) assigned | Responsible for: | Authorized to: |
|---|---|---|
| **Stone Environmental** | | |
| Julie Moore, PE | Project manager, monitoring program manager, operations scheduler, best management practices evaluation, report preparation, conveying approved QAPP to subcontractors | Coordinate all aspects of project operations<br>Document and approve all major field operations repairs and project changes<br>Manage personnel schedules, including the courier service, and assign duties<br>Interim/Final Report Preparation |

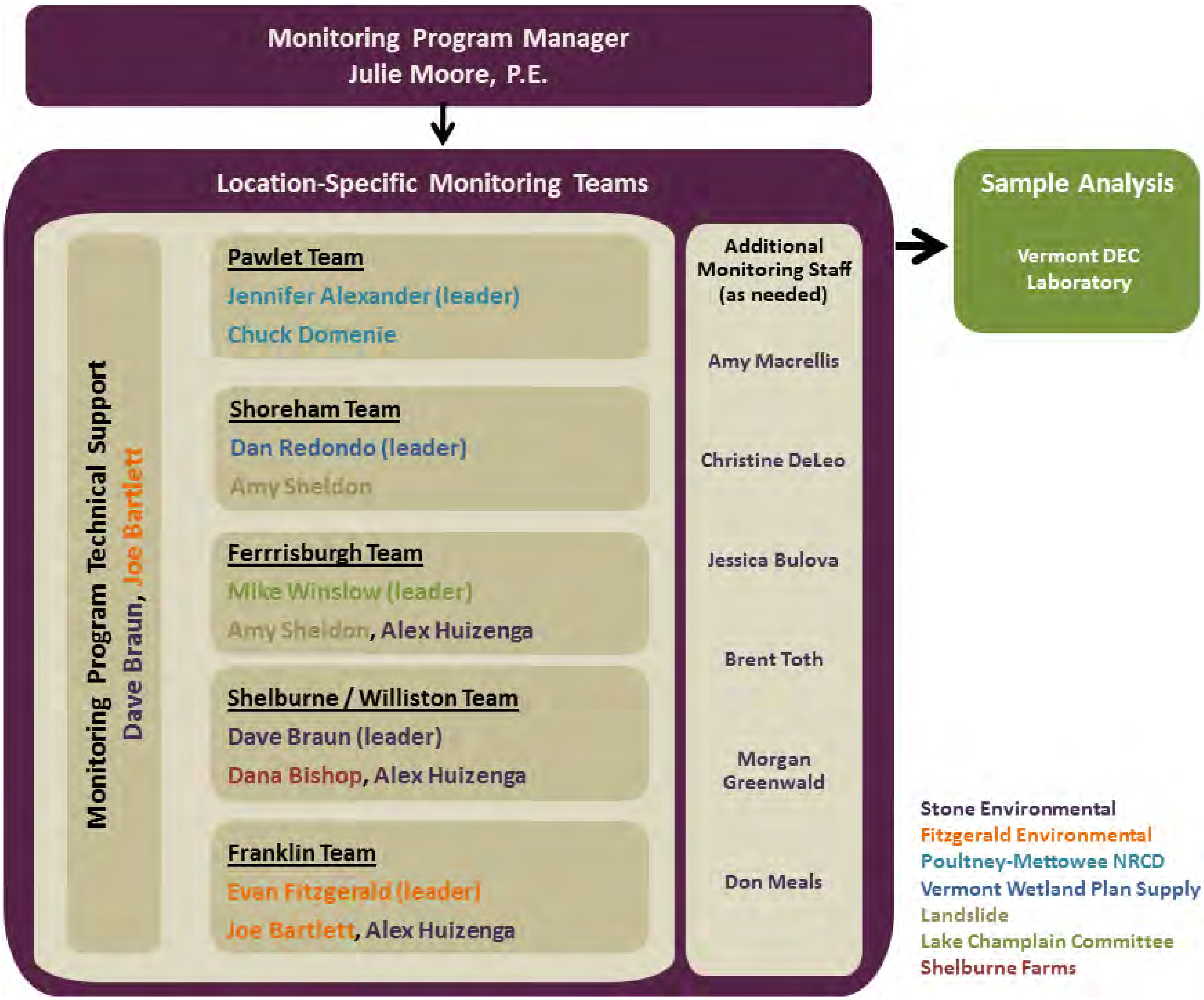
| **Individual(s) assigned** | **Responsible for:** | **Authorized to:** |
|---|---|---|
| David Braun | Monitoring station design, site evaluation and characterization, construction oversight, non-routine maintenance, site lead for Williston and Shelburne sites, station decommissioning | Develop and approve final station designs<br>Supervise station construction<br>Repair damage/breakdown in field stations<br>Calibrate and maintain monitoring equipment<br>Collect, handle, and ship water samples<br>Conduct routine operation and maintenance of field stations |
| Don Meals | Study design, data collection methodology, data analysis and interpretation | Approve overall study design<br>Receive and verify collected data<br>Conduct statistical data analysis<br>Interpret project findings and prepare interim/final reports |
| Jeremy Krohn | Agricultural practices data collection/compilation | Collect, verify, and record agricultural management data |
| Amy Macrellis | Soil conditions assessment, database development and data management | Collect soil samples and other field characterization data<br>Develop and maintain data management system<br>Provide data reports and outputs |
| Katie Budreski | Data visualization | Collect, analyze, and present spatial data in GIS and other software platforms |
| Charles Hofmann | Monitoring data management, GIS support | Develop and maintain data management system<br>Provide data reports and outputs<br>Provide support for GIS analysis |
| Kim Watson, RQAP-GLP | Quality review, maintaining the approved QAPP | Evaluate all aspects of project operations for compliance with approved QAPP<br>Resolve QA/QC issues |
| **Subcontractors** | | |
| Evan Fitzgerald, Fitzgerald Environmental | Drainage area delineation; runoff prediction, site lead for Franklin sites | Calibrate and maintain monitoring equipment<br>Collect, handle, and ship water samples<br>Conduct routine operation and maintenance of field stations |
| Joe Bartlett, Fitzgerald Environmental | Equipment calibration; monitoring station construction; instrument testing, and non-routine maintenance | Construct, calibrate, test, and maintain monitoring stations<br>Test, adjust, and repair field instruments<br>Repair damage/breakdown in field stations |
| Dan Redondo, Vermont Wetland Plant Supply | Site lead for Shoreham site | Calibrate and maintain monitoring equipment<br>Collect, handle, and ship water samples<br>Conduct routine operation and maintenance of field stations |

| Individual(s) assigned | Responsible for: | Authorized to: |
|---|---|---|
| Jennifer Alexander, Poultney-Mettowee Natural Resources Conservation District | Site lead for Pawlet site | Calibrate and maintain monitoring equipment<br>Collect, handle, and ship water samples<br>Conduct routine operation and maintenance of field stations |
| Mike Winslow, Lake Champlain Committee | Site lead for Ferrisburgh site | Calibrate and maintain monitoring equipment<br>Collect, handle, and ship water samples<br>Conduct routine operation and maintenance of field stations |

**Figure 1: Project Organizational Chart**
**Project Team:**



**Field Team:**


Monitoring Program Manager
Julie Moore, P.E.
Location-Specific Monitoring Teams
Monitoring Program Technical Support
Dave Braun, Joe Bartlett
Pawlet Team
Jennifer Alexander (leader)
Chuck Domenie
Shoreham Team
Dan Redondo (leader)
Amy Sheldon
Ferrrisburgh Team
Mike Winslow (leader)
Amy Sheldon, Alex Huizenga
Shelburne / Williston Team
Dave Braun (leader)
Dana Bishop, Alex Huizenga
Franklin Team
Evan Fitzgerald (leader)
Joe Bartlett, Alex Huizenga
Additional Monitoring Staff (as needed)
Amy Macrellis
Christine DeLeo
Jessica Bulova
Brent Toth
Morgan Greenwald
Don Meals
Sample Analysis
Vermont DEC Laboratory
Stone Environmental
Fitzgerald Environmental
Poultney-Mettowee NRCD
Vermont Wetland Plan Supply
Landslide
Lake Champlain Committee
Shelburne Farms

## A.5 Problem Definition/Background

Lake Champlain continues to suffer from the effects of excessive phosphorus (P) loading from sources in the Lake Champlain Basin (LCB). It is estimated that more than 90% of the lake's current annual P load is derived from nonpoint sources (ANR 2008). Nonpoint source P derived from agricultural land is a significant component of the lake's annual P load (Troy et al. 2007). Although federal and state programs, as well as landowners, have made unprecedented investments in best management practices (BMPs) to address P, sediment, and other pollutants from agricultural operations in the LCB, these efforts have not yet yielded the desired water quality results. Vermont farmers are facing increasing pressure to reduce their contributions to water pollution in Lake Champlain. In 2011, the USEPA withdrew their 2002 approval of the Vermont portion of the Lake Champlain total maximum daily load (TMDL) for P. A new TMDL will require quantitative estimates of pollutant reduction performance to provide reasonable assurance that conservation practices will reduce P loads to Lake Champlain. Vermont farmers have shown strong interest in implementing BMPs such as conservation tillage, manure and nutrient management, and cover crops over the past decades. The effectiveness of many of these practices on reducing P and sediment losses from agricultural land, however, is not well documented. Although many producers attribute significant agronomic and water quality benefits to these management practices, only a limited number of studies exist from sites with similar climate and landscape settings to Vermont. In addition, many reported studies are plot-scale with simulated rainfall; such results may not apply directly to the field or watershed scales.

This study addresses an urgent need to evaluate and document the effectiveness of conservation practices in the Lake Champlain basin. The studies conducted by this project will yield multiple benefits, including:

- Accurate estimates of pollutant reductions achievable by several BMPs in Vermont-specific climate, landscape, and management settings;
- Scientifically sound data on BMP performance in support of TMDLs and other pollution reduction programs;
- Data that inform incentive program structure to ensure that the most effective practices are emphasized; and
- Identification of potential modifications to BMPs that may improve performance.

This project is designed to meet the stated purpose of USDA-NRCS Conservation Practice Standard 799 – Monitoring and Evaluation, which is to *sample and measure water quality parameters to evaluate conservation system and practice performance*. More information about NRCS Conservation Practice Standards can be found at: www.nrcs.usda.gov/technical/Standards/nhcp.html

The project will employ a paired-watershed design in order to document the effects of improved management on runoff losses of nutrients and sediments at the field scale. Practices to be evaluated include: soil aeration on hayland prior to manure applications; cover cropping; reduced tillage with manure injection and cover cropping; reduced tillage with manure injection and no cover cropping; and a water and sediment control basin treating runoff from corn land. The principal hypothesis to be tested is that application of these management practices will significantly reduce runoff losses of nutrients and sediment from agricultural fields in corn and hay production.

## A.6 Project/Task Description

The agricultural practices to be evaluated in the project are:

- Aeration on hayland (VT NRCS Practice Standard 633) prior to manure application;
- Reduced tillage (VT NRCS Practice Standard 329) with manure injection and cover cropping on corn land;
- Reduced tillage (VT NRCS Practice Standard 329[1] ) with manure injection and no cover cropping on corn land;
- Cover cropping (VT NRCS Practice Standard 340) on corn land; and
- A water and sediment control basin (WASCoB) (VT NRCS Practice Standard 638) treating runoff from corn land.

These practices will be evaluated on field/watershed sites at working farms in the Vermont-portion of the Lake Champlain Basin; locations of the monitored farms are shown in Figure 2. The project will consist of nine major tasks, including:

**1. Study design**: The overall study design will follow the approaches described above and will include site assessments on the pre-selected study farms.

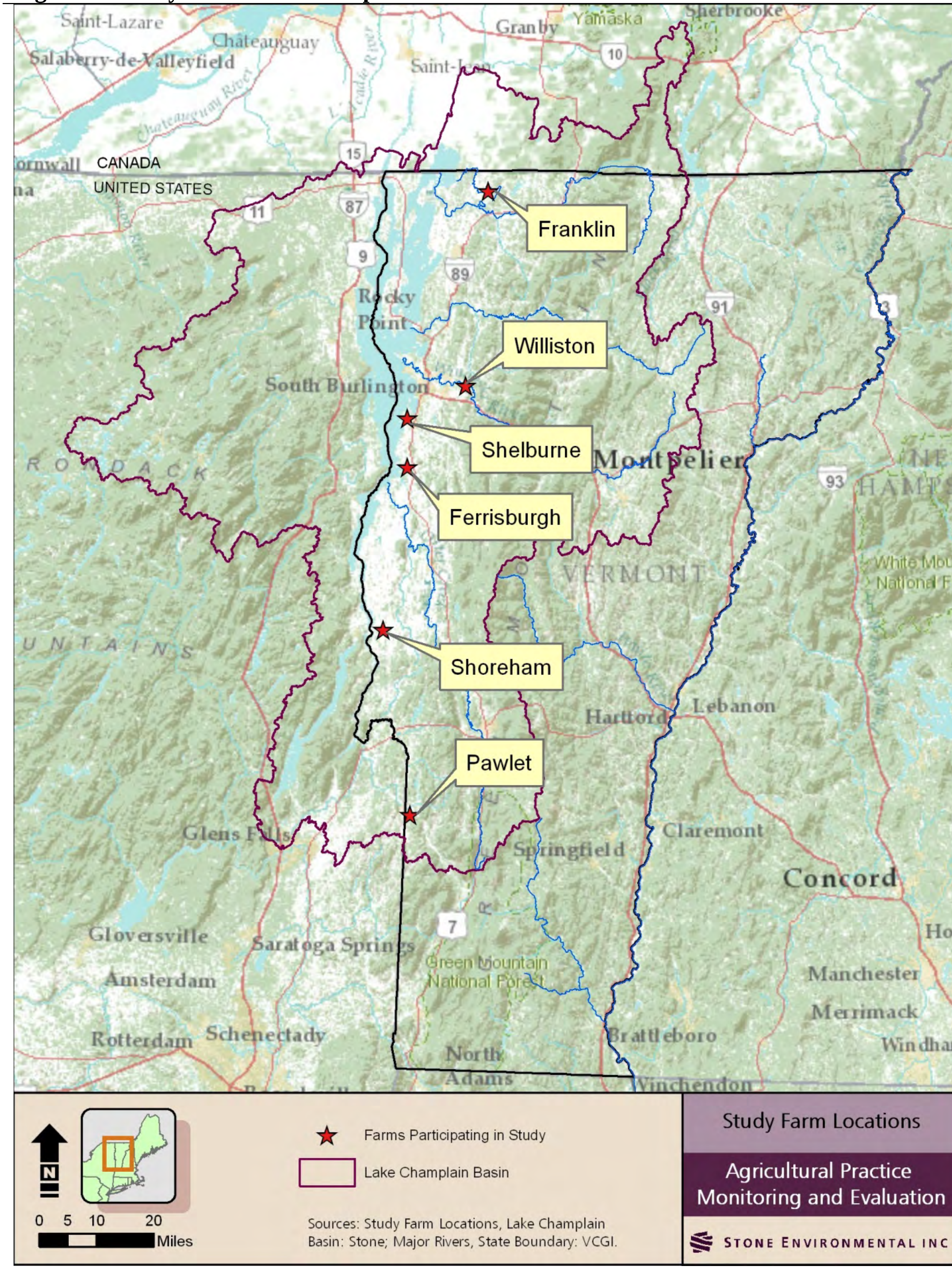
**2. QAPP preparation and approval**: A Quality Assurance Project Plan will be prepared and approved prior to commencement of the field work and data acquisition aspects of the project.

**3. Site characterization**: Basic characterization data will be collected for each field/watershed. A topographic survey will be done to define the area draining to each monitoring station. The general physical and chemical properties of soils in the selected fields will be evaluated through laboratory analysis of soil samples collected from the 1 – 15 cm depth in each field. Samples will be analyzed for pH and available P, K, Mg, Ca, Fe, Mn, and Zn following extraction in modified Morgan solution, and for organic matter and soil particle size. Agronomic management activities will be recorded for each field/watershed throughout the project, with data obtained from the farmer and from observations by project staff.

**4. Monitoring facility design and construction**: Monitoring facilities will include a meteorological station at each participating farm for the continuous monitoring of rainfall and air temperature. The primary hydraulic device used at each paired-watershed runoff monitoring station will be an appropriately-sized H-flume with an ultrasonic water level sensor installed to continuously measure stage during runoff events. Stage data will be converted to flow rate based on the established hydraulic properties of the flume. At the WASCoB monitoring stations, an area-velocity flow meter capable of measuring flow velocity and depth will be used to compute discharge. At both the paired-watershed and WASCoB sites, an autosampler will be programmed to collect a flow-proportional water sample from each monitored runoff event. Water temperature and conductivity will be measured using a sensor and data logger installed in the runoff channel just below the flume, or, in the case of the WASCoB stations, just below the discharge measuring point. Each station will include a communication system (Appendix A) that will allow remote monitoring and adjustment of station status and will push monitoring data to a remote server in near real-time.

[1] Absence of cover cropping represents an exception from Practice Standard 329

**Figure 2: Study Site Location Map**



**5. Study implementation (including site monitoring and implementation of treatments)**: By agreement with site landowners, exact site locations will not be publicly disclosed. The exact locations of the sites are maintained on file at Stone Environmental; the HUC12 location of each site is provided in Section B.1.2 of this document. Event monitoring at each paired watershed monitoring station will be conducted identically during the calibration and treatment periods. During each monitored event, discharge will be measured continuously. Event composite samples will be analyzed for total phosphorus (TP), total dissolved phosphorus (TDP), total nitrogen (TN), total dissolved nitrogen (TDN), chloride (Cl), and total suspended solids (TSS) concentration. We will monitor up to 20 runoff events (weather permitting) each year of the study. Monitoring will generally be conducted between April 1 – November 30, with additional sampling during the winter months using passive sampler arrays (a set of three single-stage sample bottles with intakes at different elevations to collect samples at different stages through the rising limb of the hydrograph, see Appendix B), where necessary to obtain data about practice performance outside of the growing season. As called for in the paired-watershed design, calibration monitoring under present management will be conducted for 1 – 1.5 field seasons, with the exact duration depending on having monitored a reasonable range of magnitude of runoff events and on statistical analysis of the calibration period data (USEPA 1993). After the calibration period, the new management practice will be implemented on the treatment field/watershed. Monitoring then continues for 1.5 – 2 field seasons after treatment is established. At the WASCoB site, the inlet and outlet of the basin will be monitored for the same parameters and for a similar period as the paired-watershed sites.

**6. Data management and analysis**: A relational database will be developed and used for the organization and management of farm management practice data, weather data (temperature and rainfall), hydrologic data (runoff level and flow rate), runoff temperature and specific conductance, autosampler logs, and analytical results. The data set used for the primary statistical analyses will include total event discharge ($m^3$), event mean concentration (mg/L), and total event load (kg) for each monitored constituent for each event at each monitored location. Basic descriptive statistics, pair-wise comparisons, and exploratory data analysis will be conducted on this data set. For the paired-watershed sites, changes in event discharge, event mean concentration, and event mass export in response to treatment will be tested using analysis of covariance (ANCOVA). For the WASCoB site, effects of treatment will be evaluated based on an input/output comparison (e.g., t-Test), both for individual events and over the entire monitoring period.

**7. Project communication and reporting**: The Project Manager will coordinate the efforts of all project personnel and serve as a single point of contact for the client's project-related questions. Project personnel will communicate with landowners at the field/watershed sites on a regular basis, both to obtain agronomic management information and to provide information about project results on an ongoing basis. The Project Team will work with the Vermont Agency of Agriculture, Food, & Markets (AAFM) to establish a Project Advisory Committee (PAC) that will include personnel from USDA-NRCS, USGS, AAFM, ANR, UVM, the Lake Champlain Basin Program, landowners, and others with an expressed interest in the project. Project staff will seek discussion with and advice from the PAC on major project decisions or proposed modifications. The PAC will meet approximately semi-annually.

**8. Practice evaluation**: Evaluation of the performance of each practice tested will be made on the basis of the paired-watershed analysis of event discharge, mean concentration, and/or load changes resulting from the practice implementation. Experiences of the farmer and observations by project staff in the field will also be factored into an assessment of overall practice performance. In consultation with AAFM and NRCS, the Project Team will suggest any potential modifications to conservation practice implementation requirements, based on the efficacy of the practices as implemented on the participating farms. Where the same practice is implemented on more than one farm, pollutant reductions due to treatment may be compared and contrasted.

**9. Site decommissioning**: At the conclusion of the study, the Project Team will work with each farm owner, NRCS and AAFM to determine whether the monitoring stations should be decommissioned or left in place to support future study. Should the farm owner wish to decommission the monitoring site(s), the Project Team will remove the equipment and return it to the farmer and restore the monitoring sites to their pre-project condition, including CREP buffers or other features modified during the project that are specified in the landowners' long-term contracts with USDA.

Work will be conducted from May 2012 through March 2015. Installation of monitoring facilities will take place in spring and summer, 2012. At the paired-watershed sites, calibration monitoring will commence during the 2012 cropping season and continue until spring, 2013. At least one complete cropping season will be required for adequate calibration monitoring; it is possible that calibration monitoring will need to be extended further into 2013 if sufficient high-flow events following manure application do not occur during 2012. For treatment with effects exerted primarily in fall and spring (e.g., cover cropping), calibration monitoring will continue through spring of 2013. Implementation of treatments will take place in 2013, with exact timing depending on the treatment (e.g., aeration treatments will commence at the first hay cut, whereas cover crop treatment will not occur until late summer/fall). Post-treatment monitoring will continue through fall 2014. The final report for this project will document the complete record of the timing of these activities.

Above-below monitoring at the WASCoB site will begin in summer 2012 and continue through the 2014 cropping season. The overall project schedule is shown in Table 2.

### Table 2: Project Schedule

| Task | Objective | Task | Deliverable | Timeline |
|---|---|---|---|---|
| 1 | Study design | Visit pre-selected study farms and select fields for monitoring | Identified field/watersheds for monitoring and treatment | 31-Jul-2012 |
| 2 | QAPP | Development and approval of Quality Assurance Project Plan | Approved QAPP | 31-May-2012 |
| 3 | Site characterization | Topographic survey and soil sampling | Topographic map and watershed boundary delineation for each monitored site; soil physical and chemical data | 31-Jul-2012 |
| 4 | Monitoring facility design and construction | Design monitoring stations, specify and purchase equipment and instrumentation, construct monitoring stations, install instruments | Fully functioning monitoring stations at each field/watershed monitoring site | 31-Jul-2012 |
| 5 | Monitoring Program Implementation | Collect water quality and agricultural management monitoring data | Monitoring data for:<br>Year 1 (2012)<br>Year 2 (2013)<br>Year 3 (2014) | 30-Nov-2012<br>30-Nov-2013<br>30-Nov-2014 |
| 6 | Data management and analysis | Build project database and manage monitoring data; conduct data analysis | Functioning database for entry, storage, and retrieval of all project data | 31-Jul-2012 |
| 7 | Project communication and reporting: | Communicate with project landowners, Project Advisory Committee, and management agency personnel | Collection of agronomic management data; quarterly reports to AAFM, semi-annual PAC meetings | ongoing |
| 8 | Practice evaluation | Analyze and interpret monitoring data to evaluate performance of tested management practices; suggest modifications based on project experience | Quantitative and qualitative evaluation of pollutant-reduction performance of evaluated management practices. | 31-Dec-2014 |
| 9 | Decommission sites | Remove station installations and return monitoring equipment to farmers | Monitoring sites restored to original condition | 31-Dec-2014 |
| | Complete final report | Compile project summary, maps, results, etc. | Final Report | 31-Mar-2015 |
| | Contract End Date | QAPP Expiration | None | 30-June-2015 |

## A.7 Quality Objectives and Criteria for Measurement Data

Objectives: 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 3 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 the Vermont Department of Environmental

Conservation (VT DEC) Laboratory, which is currently located on the University of Vermont campus in Burlington. The DEC laboratory is accredited by the National Environmental Laboratory Accreditation Conference Institute (TNI) for the target water quality parameters (Total Phosphorus, Total Dissolved Phosphorus, Total Dissolved Nitrogen, Chloride, and Total Dissolved Solids). Meteorological monitoring will produce data to characterize ambient temperature and rainfall conditions during the study. Flow measurement will document the rate and total quantity of runoff from each study field/watershed during each monitored event. Analysis of flow-proportional water samples will provide the event mean concentration (EMC) of each monitored constituent. Mass of each monitored constituent will be computed as the product of total event runoff volume and EMC. To ensure data quality objectives are met, all sampling activities will be well documented and will occur in strict accordance with the specifications presented in this QAPP. The data quality indicators considered in the study design include accuracy, precision, representativeness, comparability, completeness, and traceability.

### A.7.1 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. The Vermont DEC Laboratories Quality Assurance Plan (VT DEC 2012) provides acceptance criteria for spiked sample results for each analyte tested, with the exception of TSS which cannot be spiked. Calibration procedures, blank samples, and sample handling protocols provide additional information used to evaluate the accuracy of each analytical procedure.

### A.7.2 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 (see Section B.2.3). The most commonly used measure of precision is the relative percent difference (RPD). The formula for calculating the Relative Percent Difference is:

$$RPD = 100 * \text{Absolute Value}(X_1 - X_2)/((X_1 + X_2)/2)$$

where $X_1$ and $X_2$ are the two measurements being compared.

The method RPD is provided for the key analytical parameters in Table 3. Field duplicates will be prepared and delivered to the laboratory (blind) at a minimum rate of 10%.

### A.7.3 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. The treatments to be tested will be representative of other applications of the same treatment because they will conform to established USDA-NRCS practice standards. By continuously measuring event runoff from the entire field/watershed and collecting flow-proportional samples for chemical analysis, the data gathered will accurately represent water and pollutant export under true field conditions. The study sites themselves are not intended to be representative of all agricultural land in the LCB, or of some "average" condition for the Basin. This would be impossible to achieve. However, the study sites have been chosen for characteristics that are reasonably typical of dairy agricultural land in the Basin according to criteria that include soil type and slope, typical cropping practices, suitable crop rotation, and willingness of the landowner to participate in the project. By testing some of the practices (e.g., soil aeration) in different settings, we will represent some of the variability of response to treatment to be expected across the LCB. Thus, the processes (treatments) to be evaluated are believed to be representative of actual field conditions and management activities.

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.

### A.7.4 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 during both calibration and treatment periods and across all field/watershed monitoring sites. Such consistency will be reinforced by training and supervision of field staff (see section A.8). Comparability of laboratory measurements is ensured through following the Vermont DEC Laboratory Quality Assurance Plan, Revision 20, dated January 2012, and respective SOP for a given analyte.

### A.7.5 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 field/watershed runoff 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.

### A.7.6 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.

## Table 3: Data Quality Requirements and Assessments

| Matrix | Parameter | Units | PQL[1] | Accuracy[2] | Accuracy protocol | Precision Lab/Field[3] | Precision protocol | Method Range |
|---|---|---|---|---|---|---|---|---|
| Water | Level (ISCO 2110) | cm | N/A | The greater of ±0.396c m or 0.526 cm per foot (0.305 m) from calibration point | N/A | N/A | N/A | Varies with size of primary device |
| Water | Level (ISCO 2150) | cm | N/A | ±0.3 cm from 1 to 305 cm | N/A | N/A | N/A | 1.0 to 305 cm |
| Water | Velocity (ISCO 2150) | m/s | N/A | ±0.03 m/s from -1.5 to +1.5 m/s; ±2% of reading from 1.5 to 6.1 m/s | N/A | N/A | N/A | -1.5 to +6.1 m/s |
| Water | Total P | µg/L | 5 µg/L | 85-115% | Spike recovery | 15/20 | Field duplicate | 5 – 200 µg/L |
| Water | Total Dissolved P | µg/L | 5 µg/L | 85-115% | Spike recovery | 15/20 | Field duplicate | 5 – 200 µg/L |
| Water | Total N | mg/L | 0.1 mg/L | 85-115% | Spike recovery | 10/20 | Lab duplicate | 0.05 to 2.0 mg/L as N |
| Water | Total Dissolved N | mg/L | 0.1 mg/L | 85-115% | Spike recovery | 10/20 | Lab duplicate | 0.05 to 2.0 mg/L as N |
| Water | Total Suspended Solids | mg/L | 1 mg/L | 80-120%[4] | N/A | 15[4]/20 | Lab duplicate | 1 – 2000 mg/L |
| Water | Chloride | mg/L | 2 mg/L | 85-110% | Spike recovery | 5/20 | Lab duplicate | 2 – 25 mg/L |
| Water | Temperature | $^{o}$C | N/A | 0.1$^{o}$C | N/A | N/A | N/A | 5 to 40 $^{o}$C |
| Water | Specific Conductivity | µS/cm | N/A | The greater of 3% of reading or 5 µS/cm | N/A | N/A | N/A | 0 to 10,000 µS/cm |
| Air | Temperature | $^{o}$C | N/A | ± 0.47°C at 25°C | N/A | N/A | N/A | -20° to 70°C |
| Space | Precipitation | mm | N/A | ±1.0% (up to 20 mm/hr) | N/A | N/A | N/A | 0 to 12.7 cm/hr |

1. Practical Quantitation Limits (PQL) is the lower limit of quantitation (reporting).
2. Accuracy for analytical parameters are 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. Precision and accuracy for samples high in heavy sediment may be outside listed criteria, if the entire sample volume cannot be filtered and heavy particles settle quickly while decanting an aliquot of sample.

## A.8 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 runoff sample collection will be done by subcontracted personnel at some sites, initial training will be led for all field personnel by the Stone Environmental Monitoring Program Manager, 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 station maintenance, post-event assessment, sample retrieval, and collection of agronomic data (see Appendix C). 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 DEC laboratory under the direction of the Laboratory Director. No additional specialized training or certifications are necessary for personnel to conduct the project tasks.

### A.9 Documentation and Records

It will be the responsibility of the Project QA Manager to ensure that appropriate project personnel have the most current approved version of the QAPP. Distribution will be in electronic form only; any changes, revisions, or distribution of new versions of the QAPP will be documented in quarterly reports made to the AAFM.

All project data will be maintained in the project database, which will be subject to redundant storage through normal procedures at Stone Environmental.

All project data (in summary form) will be included in the project Final Report. In addition to complete documentation, analysis, and discussion of project tasks, appendices to the Final Report will include:

- Raw data from all monitored events, including flow (aggregated to hourly mean) and concentration data;
- Raw data from all QA/QC activities, including analysis of duplicates, blanks, and spikes;
- Meteorological data collected on-site and from National Weather Service stations if necessary;
- Summaries of agronomic management data for both calibration and treatment periods;
- Summaries of field notes describing monitoring station operation and field observations.

These data will be posted on the project web site on the Stone Environmental server, presented in printed form in the final report, and will be archived. Appropriate summaries will be transmitted electronically in spreadsheet form to the PAC and to AAFM. Oral presentation of the preliminary study data and the final report will be made by the investigators to appropriate audiences.

In addition to use of field data forms (Appendix C), project personnel will maintain detailed field logs during field activities, especially during and after monitored runoff events. Records generated by the sample log-in procedures at the Vermont DEC laboratory will be maintained on file during the course of the project. Electronic versions of project data and records will be maintained by Stone Environmental for a period of not less than 5 years after completion of the project.

# B – Data Generation and Acquisition

## B.1 Sampling Process Design (Experimental Design)

## B.1.1 Experimental design

### B.1.1.1 Paired watershed experiments

The project will use a paired-watershed design (USEPA 1993) at the field-watershed scale to test the effects of treatment on event discharge and pollutant concentration and export in surface runoff from study fields. The paired-watershed design includes two fields (watersheds)—control and treatment—and two time periods—calibration and treatment. The control watershed accounts for year-to-year climate variations and the management practices remain consistent during the entire study. The treatment watershed undergoes a change in management (e.g., soil aeration or cover cropping) at some point during the study. During the calibration period, the watersheds in each pair are treated identically and paired water quality data are collected. For this monitoring study, total event discharge, event mean concentration, and total event export data will be collected and/or computed for each monitored event. At the start of the treatment period, a change in management is applied to the treatment watershed, while the control watershed remains in the original management. The basis of the paired-watershed approach is that there is a quantifiable relationship (i.e., a linear regression model) between paired data from the watersheds (calibration) and that this relationship is valid until a change is made in one of the watersheds (treatment). At that time, a new relationship will exist. The difference between the calibration and treatment relationships is used to evaluate and quantify the effect of treatment.

The agricultural practices to be evaluated using a paired-watershed design are:

- Aeration on hayland (VT NRCS Practice Standard 633) prior to manure application [Ferrisburgh, Shelburne, Shoreham];
- Reduced tillage (VT NRCS Practice Standard 329) with manure injection and cover cropping on corn land [Williston] ;
- Reduced tillage (VT NRCS Practice Standard 329[2] ) with manure injection and no cover cropping on corn land [Franklin];
- Cover cropping (VT NRCS Practice Standard 340) on corn land [Pawlet]; and
- A water and sediment control basin (WASCoB) (VT NRCS Practice Standard 638) treating runoff from corn land [Franklin].

### B.1.1.2. Water and Sediment Control Basin (WASCoB)

At one of the farms participating in the paired-watershed experiment, a Water and Sediment Control Basin (WASCoB) was installed in 2011 to treat runoff from an adjacent cornfield. For the evaluation of the WASCoB treatment, an above-below design will be applied, wherein flow and pollutant concentrations will be measured simultaneously at the inlet and the outlet of the WASCoB. Total event discharge, event mean concentration, and total event export data will be collected and/or computed for each monitored event.

[2] Absence of cover cropping represents an exception from Practice Standard 329

## B.1.2 Sampling locations

### B.1.2.1 Paired-watershed sites

The locations of the participating farms are shown in Figure 2. These sites were pre-selected. Within each farm, a pair of field/watersheds was selected in advance of the study for monitoring based on the following criteria:

- Capability to isolate two drainages either through natural topography or constructed wingwalls, or both;
- Both fields of similar soil type based on NRCS soil survey;
- Both fields currently under similar crop, with no rotation planned for the entire study period;
- Both fields previously untreated with respect to the treatment to be tested (e.g., soil aeration);
- Similar management history;
- Roughly comparable size (ideally, within a factor of 0.5 – 2 times in area); and
- Ability of the farmer to apply treatment to one of fields at the appropriate point in the study.

Following identification of candidate field/watersheds, the sites will be characterized (see Section A.6) and the exact drainage area determined by topographic survey. Field/watersheds will be mapped in a Geographic Information System (GIS). Because landowner confidentiality is required, monitoring sites will be identified by town and HUC-12 only. Site locations are given in Table 4.

**Table 4: Sampling Locations**

| Site Location | HUC-12 | HUC-12 Name |
|---|---|---|
| Ferrisburgh | 020100080603 | Lakeshore-Town Farm Bay |
| Franklin | 020100081101 | Rock River |
| Pawlet | 020100010203 | Mettawee River-Flower Brook to Indian River |
| Shelburne | 020100080801 | LaPlatte River |
| Shoreham | 020100080303 | Lakeshore-East Creek to Crane Point |
| Williston | 020100030702 | Winooski River-Huntington River to Alder Brook |

Monitoring stations will be installed at the outlets of the field/watersheds where runoff can be concentrated by a combination of natural topography and field work (e.g., wingwalls, berms).

### B.1.2.2 WASCoB site

At the farm in Franklin (Figure 2), paired-watersheds will be monitored in one field and a WASCoB will be monitored in an adjacent field. This WASCoB, which was installed in 2011, receives runoff from conventionally tilled corn land. The WASCoB was selected in advance of the study for monitoring because it is the first such structure constructed by the Vermont Agency of Agriculture, Food, and Markets and there are no data at present regarding its effectiveness. Monitoring stations will be installed at the inlet and outlet of the WASCoB.

## B.1.3 Field characterization sampling

### B.1.3.1 Paired-watershed sites

At the paired-watershed sites, the area draining to each monitoring point was delineated during the site selection phase of the project, prior to submission of this QAPP, with funding outside of the LCBP-funded project. The drainage boundaries (watersheds) were delineated through heads up digitizing in an ArcGIS geodatabase. Three data sources were used to define the boundaries: existing elevation data captured by LiDAR (Light Detection And Ranging) where available, detailed survey conducted by Stone Environmental, and locations of features that affect drainage patterns, such as culverts, roads, and ditches. LiDAR data are currently available for the Franklin, Williston, and Shelburne sites. At these sites, a detailed survey was performed to: 1) verify and, as necessary, correct the watershed boundaries inferred from the LiDAR elevation data; and 2) to generate a detailed elevation profile in the immediate vicinity of the proposed monitoring stations to aid in design and construction of flume wingwalls and/or soil berms used to channel field runoff to the flumes. Surveys were conducted using either an autolevel or a total station. Watershed boundaries suggested by the topographic data were adjusted based on locations of roads, ditches, and culverts that were observed by Stone during initial site visits. At the remaining three sites, the best available elevation data (digital elevation model data based on 10-m postings) are not sufficiently detailed to delineate the study watershed boundaries. At these sites, a more extensive survey was conducted to define topographic breakpoints, slopes, and low points, to generate a three dimensional terrain map. At the Pawlet site, corn row orientation was also an important factor influencing drainage patterns; the watershed boundaries delineated for this site follow the microtopography of the prevailing row orientation in certain areas.

The general physical and chemical properties of soils in the selected fields will be evaluated through laboratory analysis. Within each field/watershed in corn production, soil samples from the 0-20 cm (0-8 in) depth will be collected at nodes in a sampling grid using a stainless steel probe. In fields/watersheds in hay production, soil samples from the 0-10 cm (0-4 in) depth will be collected. Samples from each field/watershed will be composited and homogenized using a trowel. Subsamples will be taken from each composite for analysis of physical and chemical properties by the University of Vermont Agricultural and Environmental Testing Lab and the Agricultural & Forestry Experiment Station Analytical Laboratory at the University of Maine, where all Vermont soil samples are currently being analyzed. Analyses will be performed for soil pH (1:2, V:V, in dilute calcium chloride), organic matter (loss on ignition), and soil particle size (by wet sieving and the hydrometer method). Available P, K, Ca, Mg, Fe, Mn, and Zn will be analyzed (by ICP, EPA method 200.7 [USEPA 1994]) following extraction with modified Morgans solution, and will be reported on a volume basis ($mg/dm^3$).

Using the calculated drainage areas, SSURGO soils maps (USDA-NRCS), published rainfall frequency/duration maps, slope, and cover, rainfall-runoff modeling will be performed for each watershed using standard USDA-NRCS methods (i.e., TR-55 model). Predicted runoff volumes will be used to guide monitoring station construction, primarily to appropriately size flumes.

### B.1.3.2 WASCoB site

Existing data from the design and construction of the WASCoB structure include contributing drainage area and modeled discharge rates for a range of design storms will be assembled. These existing data and the “as-built” plans will be considered in designing monitoring systems for the

WASCoB. Within the watershed area draining to the WASCoB, soil samples will be collected, processed, and analyzed according to the procedures identified previously in B.1.3.1.

### B.1.4 Event sampling

We will monitor discrete runoff events that generate discharge at our monitoring stations. For the purpose of this study, we generally define a runoff event for monitoring as a discrete episode of discharge from the flume (persisting for hours or days) generated by precipitation. Thus defined, the event begins when discharge begins and ends when discharge ceases at one or both of the paired watersheds. Because of the difficulty of accurately measuring extremely low flows and to prevent the sampling system from sucking air at very low flows, we will define discharge as beginning at a threshold stage of approximately 1 cm. The effective end of flow is similarly defined. If a field visit is made at a time when effective flow has ceased at one field/watershed of a pair, we will stop sampling and process accumulated samples from both of the field/watersheds, but will continue to count the flow over the tail of the hydrograph in the total event discharge. In cases where multiple precipitation events in rapid succession generate sustained discharge, we will consider the period of continuous discharge to be a single runoff event.

An exception to the above protocol may occur in long, low-intensity runoff events generated by snowmelt in winter thaws or spring runoff. In cases where episodic runoff is not generated by discrete precipitation events, we may define the runoff event either as that discharge that occurs during the above-freezing portion of the day (when flow freezes at night, for example) or as the accumulated discharge over a period of days defined either by ambient weather or by logistical convenience.

We plan to monitor up to 20 runoff events (weather permitting) at each monitoring station in each year of the study. We propose to extend the traditional monitoring (ice-free) season to April 1 – November 30, depending on weather, by covering flumes and sample lines in insulated housing as feasible. At the WASCoB, reduced tillage/manure injection, and cover crop-only treatment sites, a limited program of winter/early spring thaw event sampling will be undertaken. These practices were identified for winter and early spring monitoring because of the interest in quantifying reductions in sediment and nutrient export attributable to these practices outside of the growing season. At these sites, flow monitoring will be continued into the winter months as feasible with installed instrumentation and a three-bottle, single stage sampler array (Appendix B) placed adjacent to each flume. The siphon samplers will draw water from intake tubes secured at three levels on the sidewall of each flume. These winter and early spring data will be used to assess the magnitude of nutrient and sediment transport during this period relative to the other eight months of the year, but they will not be combined in statistical models with the composite sample data.

Available project resources permit us to monitor up to 20 runoff events a year at each monitoring station. In order to ensure that we collect data representative of a full seasonal span each year and, at the same time, collect data during critical periods of BMP performance (e.g., late fall and early spring for cover crop treatments, runoff closely following manure applications on hayland aeration treatments), we require some flexibility in selecting which events to include for full sampling and analysis. Therefore, we will use our best judgment to stratify the events we choose to monitor so that critical periods/conditions are included. In this process, samples from some events that occur under conditions already frequently sampled may be discarded so that we retain the capacity to monitor later events that represent critical conditions. For example, if we have monitored several events on a pair of hay fields that occurred several weeks or more after a manure application, we may choose to not submit samples for analysis for similar events that occur before the next manure application. Similarly, if we have monitored several comparable events on corn fields before cover crops are planted, we may decide to not submit samples from additional events under those conditions so that we can monitor runoff events that occur following cover crop establishment. The hydrologic magnitude of the event will, of course, be another consideration. Within the limits of our resources, we will monitor events of particularly large magnitude (e.g., a 25-year storm) even if we have previously monitored smaller events under similar field conditions.

### B.1.5 Sample parameters

As noted earlier (Section B.1.3), soil samples from the field characterization will be analyzed for available P, K, Mg, Ca, Fe, Mn, and Zn following extraction in modified Morgan solution, and for pH, organic matter, and soil particle size. Water samples from runoff events will be analyzed for TP, TDP, TN, TDN, TSS, and Cl.

The following table summarizes the number and type of samples that are anticipated in this study. The number of water samples is based on the assumption of 20 warm-weather runoff events/year at 14 stations plus up to four thaw events/year at six stations monitoring cover crop treatments over the three years of the study. A minimum of 10% additional QC samples are included.

**Table 5: Sample numbers and types to be collected.**

| Sample Matrix | Analytical Parameters | Sample Container | Number of Samples | Sample Preservation | Hold Time (days) |
|---|---|---|---|---|---|
| Soil | pH | Polyethylene bag | 14 | None | 180 |
| Soil | Available P | Polyethylene bag | 14 | None | 180 |
| Soil | Available K | Polyethylene bag | 14 | None | 180 |
| Soil | Available Mg | Polyethylene bag | 14 | None | 180 |
| Soil | Available Ca | Polyethylene bag | 14 | None | 180 |
| Soil | Available Fe | Polyethylene bag | 14 | None | 180 |
| Soil | Available Mn | Polyethylene bag | 14 | None | 180 |
| Soil | Available Zn | Polyethylene bag | 14 | None | 180 |
| Soil | Organic matter | Polyethylene bag | 14 | None | 180 |
| Soil | Particle size | Polyethylene bag | 14 | None | 180 |

| Sample Matrix | Analytical Parameters | Sample Container | Number of Samples | Sample Preservation | Hold Time (days) |
|---|---|---|---|---|---|
| Water | TP[1] | Polyethylene bottle (composite) / 60-mL glass vial (aliquot for lab) | 1003 | None | 28 |
| Water | TDP[1] | Polyethylene bottle (composite) / 60-mL glass vial (aliquot for lab) | 1003 | Filtered (0.45 µm) in field | 28 |
| Water | TN | Polyethylene bottle (composite) / 50-mL plastic centrifuge tube, blue cap (aliquot for lab) | 1003 | Cool (<6°C), 0.1 mL $H_2SO_4$ | 28 |
| Water | TDN | Polyethylene bottle (composite) / 50-mL plastic centrifuge tube, blue cap (aliquot for lab) | 1003 | Filtered (0.45 µm) in field, cool (<6°C), 0.1 mL $H_2SO_4$ | 28 |
| Water | TSS | Polyethylene bottle (composite) / 500-mL plastic bottle (aliquot for lab ) | 1003 | Cool (<6°C) | 7 |
| Water | Cl | Polyethylene bottle (composite) / 50 mL plastic centrifuge tube, purple cap (aliquot for lab) | 1003 | None | 28 |
| Water | Temperature | N/A[2] | N/A[3] | N/A | N/A |
| Water | Specific Conductance | N/A[2] | N/A[3] | N/A | N/A |

1 VT DEC 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.
2 Measured in situ
3 Measured continuously

## B.2 Sampling Methods

Monitoring and sampling methods will be consistent across all monitoring stations, study sites, and study periods. Trained field personnel will be responsible for satisfactory sampling operations, maintenance of sampling stations, and processing of field data, under the direction of the Monitoring Program Manager. Sampling performance will be evaluated and recorded after each monitored runoff event using the Post-Event Assessment Form (Appendix C), which will be maintained on file at the Stone Environmental office. Field personnel will be responsible for recording failures of sampling systems and taking corrective action immediately. The Monitoring Program Manager will be responsible for ensuring that immediate and subsequent corrective actions are effective and fully documented.

## B.2.1 Flow measurement

### B.2.1.1 Paired watershed sites

The primary hydraulic device used at each paired watershed runoff monitoring station will be an appropriately-sized H-flume manufactured by Tracom. Each flume will be bolted to a rectangular plywood approach channel (length equal to twice the flume height or 4 ft, whichever is less), which will be partially buried such that the flume entrance is flush with the ground. Plywood wingwalls embedded at least 60 cm in the ground will be installed as necessary to direct runoff into the flume approach channel. Through the life of the monitoring program, the flume will be kept level through regular adjustments using a system of turnbuckles and shims.

An ultrasonic water level sensor (ISCO 2110 Ultrasonic Flow Module) will be installed in each flume to continuously measure stage (water level). The stated accuracy of this instrument is the greater of ±0.00396 m or 0.00526 m per foot (0.305 m) from the calibration point. Level data will be converted to flow rate based on the established hydraulic properties of the flume. These data will be used for generation of runoff event hydrographs and total event discharge, and in calculation of pollutant export. Averaged level and flow rate data will be logged at approximately three-minute intervals on a connected Interface Module (ISCO 2105-Ci Interface Module).

### B.2.1.2 WASCoB site

Due to expected submergence at monitoring sites upstream and downstream of the WASCoB, a different flow monitoring system will be used at the WASCoB stations from those at the paired-watershed monitoring stations. An area-velocity flow meter (ISCO 2150 Area Velocity Module) will be installed at stations above and below the WASCoB. This instrument is capable of computing discharge from measured flow depth and velocity. From the depth measurements the area-velocity flowmeter will compute the cross sectional area of the flow stream according to entered channel dimensions, and then multiply the computed flow cross sectional area by corresponding velocity measurements to compute instantaneous discharge. The sensor will be secured at the base of the trapezoidal channels above and below the WASCoB, in a section of the channel we will harden with concrete pavers or similar material. This instrument's stated accuracy is ±0.003 m from 0.01 to 3.05 m for level measurement. For velocity measurement, the stated accuracy is ±0.03 m/s from -1.5 to +1.5 m/s and ±2% of reading from 1.5 to 6.1 m/s , in water with a uniform velocity profile. These data will be used for generation of runoff event hydrographs and total event discharge, and in calculation of pollutant export. Averaged level, velocity, and flow rate data will be logged at approximately two-minute intervals on a connected Interface Module (ISCO 2105-Ci Interface Module).

## B.2.2 Sampling instrumentation

An ISCO 6712 autosampler will be connected to the ISCO 2105-Ci Interface Module. The autosampler will be programmed to pump subsamples of runoff water on a flow-proportional basis into bulk (12-L polyethylene) sample containers. Runoff samples will be collected through a screened ~1 cm tygon intake line from a mixing trough that receives the H-flume discharge. In the case of the WASCoB stations, the sampler intake will be located immediately downstream of the area-velocity meter sensor. Each runoff event will be represented by a single composite sample. The composite sample will be split in the field to obtain aliquots for chemical analysis for total P (TP), total dissolved P (TDP), total N (TN), total dissolved N (TDN), total suspended solids (TSS), and chloride (Cl). All monitoring instrumentation will be powered by 12-volt deep cycle batteries connected in parallel and recharged by a solar panel/solar controller.

### B.2.3 Automated runoff event sampling protocols

Flow-proportional sampling is challenging because flow rates and total event discharge are highly variable and unpredictable. If individual subsample collection is too infrequent (e.g., in small runoff events), an event may be poorly representative and insufficient sample volume may be collected to perform the intended analyses. If subsamples are collected too frequently (e.g., in an unexpectedly large runoff event), the bulk sample container may not have the capacity to contain samples over the entire event, resulting in a non-representative sample. To minimize the occurrence of under-sampling and overfilling, a two-part program will be used whereby the autosampler pumps sample to two sets of containers at different intervals of accumulated flow. Each bottle set will consist of two 12-L polyethylene carboys. The first bottle set (Set A) is intended to capture a representative runoff sample from small to medium sized events and the second bottle set (Set B) is intended to capture sample from medium to large events. Set B will be filled at approximately one tenth the frequency of Set A. The second bottle in each set will be filled only after the first is full, at the same frequency as the first.

Sampling personnel will select either Set A or Set B for analysis, but not both sets. Any sample in the bottle set not chosen will be discarded. If Set B contains sufficient sample volume (approximately 750 mL is required) to perform the required analyses, Set B will be processed and Set A discarded. If Set B does not contain sufficient sample volume, Set A will be used and any sample in Set B will be discarded.

In most events, only Bottle #1 in the selected bottle set will contain sample. However, if both bottles #1 and #2 in the selected set contain sample, the sample volumes will be combined in the large capacity (14 L) churn splitter used to obtain sample splits, unless this would exceed the capacity of the churn splitter. If greater than 14 L is collected in total in the selected bottle set, then bottles #1 and #2 will be processed independently. Split samples from both bottles will be submitted for analysis to allow calculation of event mean concentrations mathematically proportioned by flow data at a later date.

Using this sampling program, most small storms will provide sufficient sample (approximately 750 mL is needed) to perform the required analyses and most large storms will not exceed the container capacity; runoff events varying in size by more than a factor of 300 can be representatively and automatically sampled. In addition to optimizing the autosampler program as described above, sampler pacing settings may be adjusted seasonally and in advance of major predicted storms, with the intent of representatively sampling every runoff-producing storm. Adjustment to the program to increase or decrease the sampling frequency will be made either by direct connection or via remote access. Failure of the system to collect at least three sample aliquots in bottle Set A during a runoff event or exceeding the capacity of all sample bottles in Set B may result in rejection of the event sample.

Within 24 hours of a monitored runoff event resulting in acceptable samples, field technicians will process the bulk sample into appropriate splits for delivery to the VT DEC laboratory. Sample will be poured into a 14-L polyethylene churn splitter, a device that consistently agitates the water to deliver representative subsamples from a spigot. A dedicated churn splitter will be stored in each instrument shelter and will be cleaned after each use with potable water from a well or other source that does not contain phosphorus-based corrosion inhibitors, with a final distilled water rinse. Aliquots will be collected from the churn splitter in containers provided by the DEC laboratory for transport and delivery to the lab.

Sample splits for TDP and TDN analyses will be filtered in the field by dispensing sample from the churn splitter directly into a filtration apparatus containing a Durapore® 0.45 µm membrane filter supplied by the VT DEC laboratory. The filtrate will be dispensed directly into the appropriate sample container, identified in Table 5.

Sample splits collected for TN and TDN analysis will be acidified immediately using one drop of concentrated sulfuric acid supplied by the DEC laboratory. A medicine dropper will be used to dispense the acid into the filled sample container.

Following the sample retrieval process, the polyethylene sample containers, the churn splitter, and the filtration apparatus will be double rinsed with potable water, then rinsed a third time with distilled water. The containers will be reinstalled and the station reset for the next event.

If insufficient sample is available to conduct all the intended analyses, and yet sampling is determined to have been reasonably representative of the event (a minimum of three sample aliquots were collected), then samples may be submitted for analysis according to the following priority system, which reflects both the primary water quality concern (phosphorus) and the fact that TSS analysis requires a much greater sample volume than the other analyses:

- TP
- TDP
- TN
- TDN
- Chloride
- TSS

Note that samples from some events may not be submitted for analysis (see Section B.1.4); however flow data and water temperature and conductance data will be collected and maintained for all runoff events that exceed the minimum stage threshold (see Section B.1.4).

Based on previous experience in event monitoring of agricultural fields, we anticipate that it is possible that sediment eroded from the field (especially corn fields before full crop canopy development and after harvest) will remain deposited in the flume and approach channel after event flow has ceased. While for the purpose of this study, we consider nutrient export from the field to include only that contained in water that exits the flume, we believe that sediment deposited in the flume/approach channel represents sediment lost from the field and therefore must be included in estimated TSS loss. Although we do not have resources to precisely quantify this component of field export, we will estimate significant sediment mass deposited in the flume/approach after a runoff event by the following standard procedure:

- After flow has ceased, the field technician will shovel any sediment accumulation in the flume/approach into graduated polyethylene buckets to obtain an estimate of sediment volume (±1 L). The total volume will be recorded.
- If the sediment volume represents < 1 cm accumulation in the flume/approach (e.g., ~13 L for a 2 ft. H-flume plus a 4 ft. approach), the accumulation will be considered negligible and the sediment discarded downstream of the monitoring station.
- If the sediment volume exceeds the negligible amount, a subsample of the accumulated sediment will be collected in a clean plastic bag for subsequent density analysis (dry weight) in order to derive an estimate of the sediment mass in the flume/approach. Remaining sediment will be discarded downstream of the monitoring station.
- The remaining subsample of accumulated sediment will be preserved by freezing to allow subsequent analysis for TP should the estimated mass of accumulated sediment exceed 5% of the TSS mass exported in runoff.

### B.2.4 In situ runoff quality measurements

Water temperature and conductivity will be measured continuously in the runoff stream using a HOBO® U24-001 Conductivity Data Logger installed in the mixing trough in the runoff channel below the flume. At the WASCoB stations, this instrument will be installed immediately downstream of the sampler intake line. These data will be downloaded on site using a waterproof shuttle device and brought into the project database.

### B.2.5 Meteorological data

A simple meteorological station (Onset HOBO®) will be installed at each participating farm for the continuous monitoring of rainfall and air temperature. Air temperature will be recorded as hourly and daily, minimum, maximum and average values throughout the study period. The temperature sensor will be housed in an appropriate solar radiation shield. A tipping bucket rain gage will be installed above the maximum crop canopy level. Every tip, marking accumulation of 0.2 mm of rainfall, will be recorded in memory with a time stamp. Continuous precipitation monitoring will be supplemented by an inexpensive manual rain gage located at each site as a backup.

### B.2.6 Agronomic and field management data

Data on agronomic and field management activities such as tillage (date, method), manure, nutrient, and agrichemical applications (date, method, rate), planting (date, method, variety), and harvest (date, method, yield) will be collected for each study field directly from the participating farmers. These data will be collected and maintained from farm records and/or by interviewing participating farmers using standard forms (Appendix C). Information on field management will be supplemented by direct observation by field sampling personnel, including field notes and time-lapse photography from repeatable photopoints at each monitoring site.

On fields where cover crops are part of the treatment, we will assess the quality of the cover crop establishment in the fall by estimating plant density as percent ground cover within 30 days of the cover crop planting date by one of two alternative methods: (1) the traditional line-intersect method, where a 30 x 30 cm quadrat frame strung with wires creating 64 cross-grids is placed ~50 cm above the ground and the number of grid crosses that are over cover crop plants are counted and converted to a percent ground cover (Laycock and Canaway 1980, Kershaw 1973) ;

or (2) a digital image analysis procedure that measures the proportion of pixels in a digital image determined to be green as an estimate of percent crop soil cover (Rasmussen et al. 2007).

## B.3 Sampling Handling & Custody

Each step in the sample handling and custody process will be documented to ensure traceability of samples from generation to analysis. For each sampling event, a sample retrieval sheet (Appendix C) will document sample ID, sample type, source, and volume. The analytes for which splits are prepared, the personnel responsible for sample splitting, and the data and time sample splits are prepared will be recorded. Samples will be transported to the laboratory within the stated holding times for each analyte by project staff (Stone Environmental or subcontractor) or courier service.

Soil samples will be delivered to the University of Vermont Agricultural and Environmental Testing Laboratory, where they will enter the lab's custody system, be assigned a lab identification number, and be sent to the Agricultural & Forestry Experiment Station Analytical Laboratory at the University of Maine, where all Vermont soil samples are currently being analyzed. Within the Maine lab, samples will be handled and analyzed according to the lab's approved QAPP (MAFES Analytical Laboratory 2006).

To simplify the sample log-in procedure at the VT DEC laboratory, the laboratory will provide "Pre-Log-In" sheets with assigned sample IDs and sets of corresponding sample labels. For each event at each station, sampling personnel will affix the provided labels, writing the time and date of collection and sampler initials, and complete the Pre-Log-In sheet. A Pre-Log-In sheet will be included with each batch of samples. Sampling personnel will transcribe the DEC laboratory ID from the Pre-Log-In sheet to the Sample Retrieval Form (Appendix C). Copies of the Pre-Log-In sheets and all field forms will be maintained at the offices of Stone Environmental. Hold times for all analytes are provided in Table 5.

## B.4 Analytical Methods

All water samples will be analyzed by the standard methods of the VT DEC Laboratory. These methods and relevant data quality objectives, assessment procedures, and reporting limits are described in the laboratory's Quality Assurance Plan, Revision 20, dated January 2012 (VT DEC 2012). Soil and sediment samples will be analyzed through the UVM Agricultural and Environmental Testing Lab per the methods indicated in Table 6.

Internal assessments and response actions with regard to laboratory analysis within the VT DEC and UVM Agricultural and Environmental Testing laboratories will occur under the terms of each lab's approved QA plan. Project investigators will examine data reports from the labs for problems or conditions of concern noted by analysts. Data flagged by the laboratory will be followed up with the analyst to determine the specific reason for the remark. Unless specifically advised otherwise by the analyst, estimated values will be considered usable for subsequent analysis with other project data. Corrective action within each lab will be the responsibility of each lab director; decisions and documentation of corrections, modifications, or rejection of data reported to the project staff will be the responsibility of the Monitoring Program Manager.

Methods for all analyses are summarized below:

**Table 6: Analytical Methods**

| Sample Matrix | Analytical Parameter | Lab | Method | Reference |
|---|---|---|---|---|
| Soil | pH | MAFES | Potentiometric measurement of soil slurry (1:2, V:V) with dilute calcium chloride, using electronic pH meter. | 1 |
| Soil | Available P | MAFES | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter.<br>Analysis: Molybdate blue procedure with colorimetric analysis. | 1 |
| Soil | Available K | MAFES | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter.<br>Analysis: ICP-AES. | 1 |
| Soil | Available Mg | MAFES | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter.<br>Analysis: ICP-AES. | 1 |
| Soil | Available Ca | MAFES | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter.<br>Analysis: ICP-AES. | 1 |
| Soil | Available Fe | MAFES | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter.<br>Analysis: ICP-AES. | 1 |
| Soil | Available Mn | MAFES | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter.<br>Analysis: ICP-AES. | 1 |
| Soil | Available Zn | MAFES | Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter.<br>Analysis: ICP-AES. | 1 |
| Soil | Organic matter | MAFES | Loss of weight on ignition | 1 |
| Soil | Particle size | MAFES | Wet sieve and hydrometer | 2 |
| Water | TP | VT DEC | 4500-P H | 3 |
| Water | TDP | VT DEC | 4500-P H | 3 |
| Water | TN | VT DEC | 4500-N C-modified | 3 |
| Water | TDN | VT DEC | 4500-N C-modified | 3 |
| Water | TSS | VT DEC | 2540-D | 3 |
| Water | Cl | VT DEC | 4500-$Cl^-$ G | 3 |

References:

1. Recommended Soil Testing Procedures for the Northeastern United States. 3rd Edition. Northeastern Regional Publication No. 493. Agricultural Experiment Stations of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia. Revised October 15, 2009
2. Gee, G.W. and J.W. Bauder. 1986. Particle-size analysis. p. 383-411. In A. Klute (ed.) Methods of Soil Analysis, Part 1. Physical and Mineralogical Methods. Agronomy Monograph No. 9 (2ed). American Society of Agronomy/Soil Science Society of America, Madison, WI.
3. Standard Methods for the Examination of Water and Wastewater; 21st Ed. 2005.

## B.5 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 samples 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 and QA Officer will be relied upon in evaluating results. Rejecting sample results based on wide variability is a possibility. Evaluation criteria noted in this section and in Section A7 above will be used for data review. Notations of field duplicate excursions and blank contamination will be noted in the final report.

Laboratory quality control will be conducted under the approved plans for the respective laboratories. QA/QC procedures used in the University of Maine Agricultural & Forestry Experiment Station Analytical Laboratory are documented in the laboratory's approved Quality Assurance Plan, dated November 2006 (MAFES Analytical Laboratory 2006). QA/QC procedures used in the VT DEC laboratory are documented in the laboratory's approved QA Plan, Revision 20, dated January 2012 (VT DEC 2012).

## B.6 Instrument/Equipment Testing, Inspection, and Maintenance

Prior to initiating data collection at each site, the monitoring instruments will be inspected to verify their proper functioning. Level sensing instruments (ISCO 2110 and 2150 flow meters) will be tested over the range of expected water levels by placing each sensor in a container and filling the container with water. Sensors will be tested in water depths from 0 cm to the height of the installed flume, at approximately 15 cm intervals. The water depth will be measured with a ruler and compared with the flowmeters' recorded level. A single point calibration of the level sensor will be performed at approximately 15-cm depth. After calibration, the instruments will be accepted if the difference between the water depths recorded with the ruler and the flowmeter are within the stated accuracy of the instruments (see Table 3) over the range of flow levels expected. If any sensor is found to be less accurate than stated by the manufacturer, it will be replaced.

The velocity sensor supplied with the ISCO 2150 flow meter cannot be calibrated by the user. The velocity sensor should read zero when submerged in still water. If the velocity sensor does not read to within ±0.03 m/s of zero when submerged in still water, the unit will be replaced.

Specific conductance measurement of the HOBO® U24-001 Conductivity Data Logger will be calibrated using a low range (~447 µS/cm) standard. If after calibration the instrument is found to be less accurate than stated by the manufacturer (see Table 3), the instrument will be replaced. The temperature sensor on the HOBO® U24-001 Conductivity Data Logger cannot be calibrated by the user. Proper operation will be verified using a NIST traceable thermometer in a water-filled vessel. If the instrument is found to be less accurate than stated by the manufacturer (see Table 3), the instrument will be replaced.

The HOBO Data Logging Rain Gauge - RG3 used for rainfall measurement will be calibrated by slowly releasing a known volume of water equivalent to a specific rainfall depth into the collection funnel. In repeated testing, the tipping bucket mechanism will be adjusted until the recorded water volume is within 2% of the known addition in two successive tests. The air temperature sensor supplied with this instrument cannot be calibrated by the user. Temperature readings in air will be compared with a NIST traceable thermometer. If the sensor instrument is found to be less accurate than stated by the manufacturer (see Table 3), the instrument will be replaced.

Routine maintenance (conducted on maintenance visits every two weeks and/or immediately following each monitored event) will include:

- Downloading the HOBO® data loggers (precipitation / air temperature and conductivity / water temperature)
- Checking/cleaning the tipping bucket funnel, the solar panel, and the sample intake tubing and screen
- Cleaning the ultrasonic level and conductivity sensors
- Checking/replacing instrument desiccant
- Checking/servicing batteries
- Verifying that the flume is level
- Clearing vegetation from around the stations
- Checking for erosion and rodent holes near the flume approach and wingwalls

Maintenance logs will be maintained by the Project Manager and made available to the Project QA Officer. The logs will document any maintenance and service of the equipment. A log entry will include the following information:

- Name of person maintaining the instrument/equipment
- Date and description of the maintenance procedure
- Date and description of any instrument/equipment problems
- Date and description of action to correct problems
- List of follow-up activities after maintenance
- Date the next maintenance will be needed

Instrument and equipment testing, inspection, and maintenance for water analysis will be routinely carried out by the VT DEC Laboratory under its EPA approved Quality Assurance Plan, Revision 20, dated January 2012.

Instrument and equipment testing, inspection, and maintenance for soil and sediment analysis will be conducted under the normal QA programs in force at the UVM Agricultural and Environmental Testing Laboratory and the University of Maine Agricultural & Forestry Experiment Station Analytical Laboratory.

### B.7 Instrument/Equipment Calibration and Frequency

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

After installation, the accuracy of level sensing by the ISCO 2110 flowmeter will be verified monthly or more frequently by placing a block of known height in the path of the ultrasonic beam. The instrument will be recalibrated if the measured level differs from the known height of the block by more than +/-0.002 m.

The tipping bucket rain gage will be calibrated annually using the procedure above.

The conductivity sensor/logger will be recalibrated monthly using an appropriate conductivity standard.

Instrument and equipment calibration for water analysis will be routinely carried out by the VT DEC laboratory under their EPA approved Quality Assurance Plan, Revision 20, dated January 2012.

Instrument calibration for manure analysis will be conducted under the normal QA programs in force at the UVM Agricultural and Environmental Testing Laboratory.

### B.8 Inspection/Acceptance of Supplies & Consumables

All supplies and consumables for field activities purchased from commercial vendors will be inspected for compliance with the acceptance criteria by Stone Environmental prior to use. Supplies or consumables not meeting the acceptance criteria upon inspection will not be used. Any equipment determined to be in an unacceptable condition will be replaced. Supplies and consumables will be stored in accordance with identified storage requirements of each item.

The VT DEC laboratory will perform their own inspections and acceptance of supplies as described in their Quality Assurance plan. The DEC lab will also be responsible for supplying sampling teams with clean sample containers specified for each analyte in water (see Table 5).

### B.9 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 supplement on-site meteorological data during monitored events or 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 each 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, soils mapping based on the USDA-NRCS county soil surveys, and engineering plans prepared for design and construction of the WASCoB in Franklin, under the direction of Vermont AAFM.

The supplementary data will not contribute directly to project decision-making, with the exception of field agronomic practices data recorded by the participating farmer. These farm record data will be subject to verification by Stone Environmental, to the extent possible through on site observation and time-lapse photography.

### B.10 Data Management

The Stone Environmental Project Manager 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 VT DEC and UVM Agricultural and Environmental Testing laboratory directors have the same responsibility for the laboratory data and information they generate.

Detailed field logs will be maintained by project personnel during field activities, especially during runoff events. Standard field data sheets (Appendix C) will document sample location, station and field conditions, date and time of collection, and personnel responsible for collection for all samples collected in the field. The “Pre-Log-In” sheets provided by the DEC laboratory will be used by the laboratory to track samples and by sampling personnel to associate the assigned field sample ID with the corresponding laboratory sample ID. Soil samples collected for field characterization or other purposes will be logged into the UVM Agricultural and Environmental Testing Lab’s sample tracking system. Copies of all field sheets and log-in records will be maintained in the project file at the offices of Stone Environmental.

Data management within the respective laboratories will be conducted according to their standard systems. Final reports for analytical data from the VT DEC lab will be issued after all internal review has been completed. Electronic copies of data reports will be transmitted to project investigators. The UVM lab follows similar procedures.

Field and laboratory data – including continuous sensor data pushed to the Stone Environmental server by station instrumentation and manually-entered data from field logs – will be entered into a database by project personnel. Following data entry, recorded values will be error-checked against original data reports and field sheets by the QA manager or his/her designee. Final error-checked copies of data files will be maintained in redundant storage at the offices of Stone Environmental.

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 LCBP and VT AAFM Project Officers for archiving. The files will be archived for a minimum of five years at Stone Environmental following completion of the project.

## C – Assessment/Oversight

### C.1 Assessments and Response Actions

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 will review all project output. 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.

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.

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 recorded during dry weather, drift from the zero in recorded water level during dry weather, 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 incidents of instrument malfunctions and other problems. Certain basic maintenance activities will be conducted after every runoff event, to clean bulk sample containers, churn splitters, sampler lines, and flumes (if necessary) and to reset the sampler to a standby condition. In the absence of a runoff event, site visits will be conducted for routine maintenance approximately twice monthly during the monitoring period. A Routine Maintenance Checklist will be completed during each routine maintenance visit (Appendix C). Deficiencies noted will be corrected by the responsible sampling personnel so that each station is ready to effectively collect monitoring data during the next runoff event. In the event that corrective action is required that is beyond the training of sampling 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 at the end of each event (Appendix C). Subsequent to receipt of laboratory analytical data, the Monitoring Program Manager or her designee will assess the quality of event data using a Post-Event Assessment form (Appendix C). The correction of any deficiencies noted will be verified at that time and any additional required corrective action will be taken immediately.

Internal assessments and response actions with regard to laboratory analysis within the VT DEC Laboratory will occur under the terms of the lab's approved QA plan (VT DEC 2012). Project investigators will examine data reports from the DEC lab for problems or conditions of concern noted by analysts, based on *Sample Remark codes*. Examples of such codes include:

**Table 7: Sample Remark Codes**

| Sample Remark Code | VT DEC 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. |

Data flagged by the laboratory will be followed up with the analyst to determine the specific reason for the remark, if the reason is not clear. Unless specifically advised otherwise by the analyst, estimated values will be considered usable for subsequent analysis with other project data. The impact of missing data points on the analysis and interpretation of the study data and on the study conclusions will be discussed in the study final report.

The overall status of monitoring data collection will be assessed through regular examination of accumulating data (e.g., time series plots) and regular informal reports to the PAC by the data analysis/interpretation staff at Stone Environmental. In this way, any anomalies in the ongoing data stream will be detected and addressed as promptly as possible.

## C.2 Reports to Management

Preparation and distribution of laboratory analytical reports will be conducted according to the standard procedures of the laboratory conducting the analyses. All QA/QC data associated with project samples will be available to project investigators. Progress reports addressing all project activities will be submitted quarterly to the AAFM and semi-annually to the project PAC by the last day of June and December of each project year. Interim project results will be presented in an annual report delivered to AAFM by February 15th of each year. A final report will be prepared for AAFM documenting all methods, data, and project results by the end of March 2015. The final report will include complete documentation and discussion of project QA/QC data. All of these reports will be prepared by project investigators and submitted to the AAFM Project Manager. The AAFM Project Manager will be responsible for distribution of progress reports and the final report.

# D – Data Validation and Usability

## D.1 Data Review, Verification, and Validation

The data quality will be reviewed for logical consistency and coding errors as identified in appropriate standards. The Stone Environmental QA Officer will be responsible for overall validation and final approval of the data in accordance with project purpose and use of the data.

Upon inspection by Stone Environmental of the field-collected and laboratory analytical data, the data are accepted for the study unless there is a noted occurrence of field instrumentation malfunction, or a laboratory note indicating that the required analysis was not performed in accordance with one or more of the criteria associated with the particular analysis. These conditions will be clearly noted within field data collection notes and on laboratory analytical reports. Data will be reviewed and evaluated using the data quality objectives noted above and will be deemed usable for the overall study objectives. If a data point is deemed unusable the data would be flagged and noted as such.

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.

## D.2 Verification and Validation Methods

The Quality Assurance Officer or her designee will be responsible for verifying and validating all sample tracking information and laboratory analysis data, while the Monitoring Program Manager or her designee will be responsible for the verification and validation of measurements taken in the field and field data records. Results will be conveyed to data users in the form of database tables, spreadsheets, and annual reports. Verification and validation within the DEC laboratory will be conducted under the approved procedures in place. Any discrepancies or excursions discovered in this verification and validation process will be discussed between the Quality Assurance Officer and the Stone Environmental Project Manager and the resolution will be documented in the final project report. See Section D.3, below, for more details.

Analytical chemistry data will be reviewed according to U.S. EPA Region I Data Validation Functional Guidelines for Evaluating Environmental Analysis (USEPA, 1996) as described in Section 4.5 of that document. One hundred percent of the analytical data will be subjected to review modeled after the EPA Tier I guideline (USEPA, 1996). The modified Tier I review will include a review of completeness. And if necessary, based on narrative comments, the review may be upgraded to a Tier II review which will compare selected QC parameters and data objectives with the acceptance criteria described in the QAPP. If necessary, and appropriate as addressed by the laboratory, analytical data that require changes to the analyte concentrations reported by the laboratory (e.g., analytes that are rejected or changed to "non-detect at the reporting limit" with an elevated reporting limit due to blank contamination) will be explained in the data validation narrative.

## D.3 Reconciliation with User Requirements

During the course of the project, situations may arise that will require some degree of corrective action or reconciliation, ranging from simple corrections on routine field documentation to systematic problems that may necessitate shutting down a process until the problem is corrected.

Described below are how situations requiring reconciliation are to be handled and documented in both the field and the laboratory for the purposes of this project.

Any or all deviations from stated work plans and this QAPP will be reconciled with the Stone Environmental Project Manager. Reconciliations will be documented as a memorandum to the project file with copies sent to all individuals noted in the distribution list. If there are limitations regarding the use of both primary and secondary data these will be documented as such and reported to the project team.

In field operations, malfunctions may occur and require subsequent corrective action. Wherever possible, immediate corrective action will be taken; such actions will be clearly described in the field logs, but no formal documentation is required unless further corrective action is deemed necessary. Reconciliation of the situation will be fully documented by monitoring team personnel and reported to the Project Manager.

Some potential malfunction or error conditions that may arise and the planned responses include:

| Condition | Response |
|---|---|
| Severe tunneling or erosion damage observed at monitoring station after runoff event, indicating probable errors in flow measurement and representative sampling | Reject data for that event at that site if more than 30% of field runoff is estimated to have bypassed the flume |
| Event sample lost or in error from one field of site pair | Do not include event in paired-watershed analysis; however data from properly-sampled field will be included in overall field characterization |
| No runoff from one field of site pair | Do not include event in paired-watershed analysis for pollutant concentrations; however, assign flow and export values of zero for that event and include data from both fields of the pair for paired-watershed analysis |
| Field or lab duplicates outside limits | Evaluate and determine need for rejection of data for that sample |

In the course of data analysis, the assumptions for the general linear model of independence, constancy of variance, and normality of distribution will be tested and appropriate transformations will be made on flow, concentration, and load data to assure the validity of use of parametric statistical analysis. 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 the most current version of JMP statistical software (SAS Institute).

Once the data are compiled, the QA Officer and Stone Environmental Project Manager will review the data quality to determine if it falls within acceptable limits per user requirements. Limitations of the data will be discussed with the end user and documented within the project final report. Completeness will be evaluated to determine if the completeness goal for this project has been met. If the quality of the data does not meet the project's requirements, the data may be reevaluated to determine why the data quality did not meet the goals. Efforts will be made to determine inconsistencies in the base data or correct errors in the attribute data. If inconsistencies are found in the quality of the base data, an effort will be made to identify and obtain more accurate base data and will be documented in the final report.

## References

ANR (Agency of Natural Resources). 2008. Report on Progress in Establishing and Implementing the Total Maximum Daily Load (TMDL) Plan for Lake Champlain. Submitted to the Vermont General Assembly in accordance with Act 43 (2007), Section 4.

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Troy A., D. Wang. and D. Capen. 2007. Updating the Lake Champlain Basin Land Use Data to Improve Prediction of Phosphorus Loading. LCBP Technical Report #54. Lake Champlain Basin Program, Grand Isle, VT.

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USEPA. 1994. METHOD 200.7 Determination of Metals and Trace Elements in Water and Wastes by Inductively Coupled Plasma-Atomic Emission Spectroscopy, Revision 4.4. Environmental Monitoring Systems Laboratory, Office of Research and Development, US EPA, Cincinnati, OH.

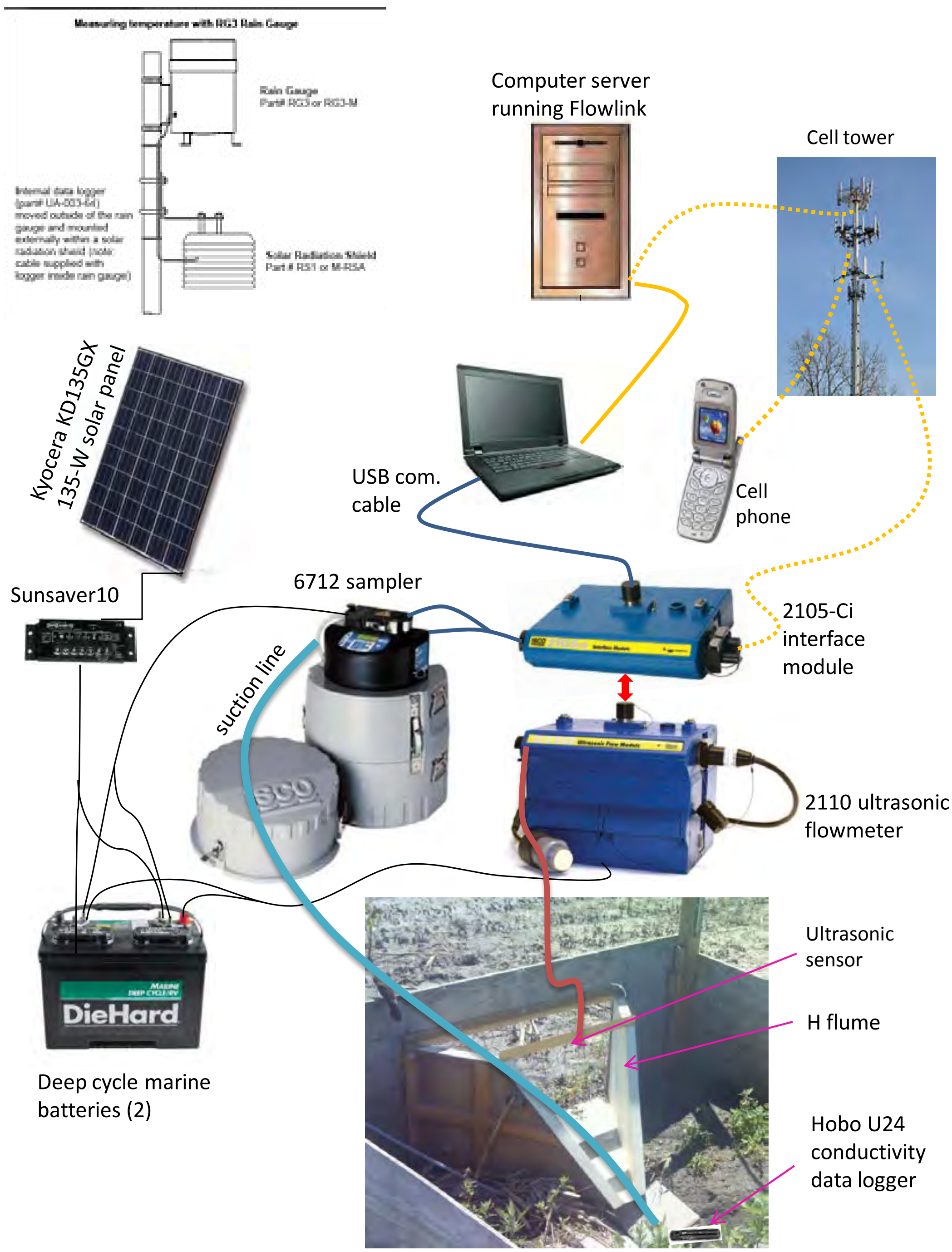
USEPA, 1996. EPA Region I Data Validation Functional Guidelines for Evaluating Environmental Analysis. Revised December 1996. http://www.epa.gov/region1/oeme/DVMANUAL.pdf

VT DEC. 2012. Department of Environmental Conservation Laboratory Quality Assurance Plan, Revision No. 20, January, 2012. http://www.anr.state.vt.us/dec/lab/docs/QAPLAN.pdf. (accessed April 26, 2012).

# Appendices

## Appendix A: Runoff monitoring station diagram

### Monitoring station instrument Diagram



## Appendix B: Example of Single-stage Passive Sampling Array

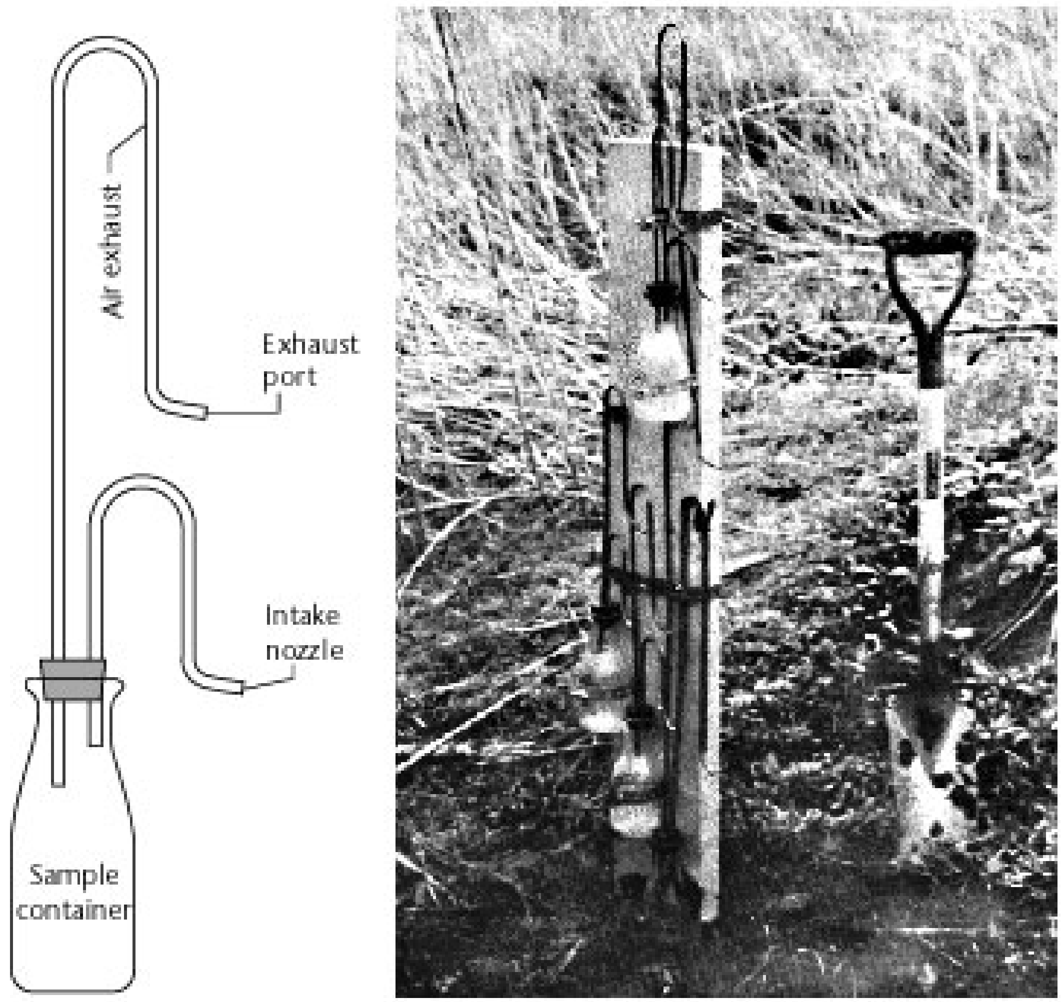



**Figure 2-6.** US U-59 sampler: (A) single stage, and (B) a bank of U-59 samplers installed on a plank post. (A, from Edwards and Glysson, 1986; B, photograph by J.C. Mundorff.)

# Appendix C: Forms

## Routine Maintenance Checklist

| Location: | | Date: | Technician: |
|---|---|---|---|
| Activity | Site __ | Site __ | Notes |
| Battery voltage check | | | |
| Solar panel clean, check | | | |
| Flume level | | | |
| Flume clean | | | |
| Approach clear | | | |
| Outlet clear | | | |
| Wingwall Visual (burrows, etc.) | | | |
| Current stage | | | |
| Flow meter calibrate | | | |
| Sampler on standby | | | |
| Sample line open/attached | | | |
| Sampler desiccant | | | |
| Sample containers prepped | | | |
| Sensors clean/calibrate | | | |
| Field condition | | | |
| Comments: | | | |

**SEI Form AGO-1, v. 1**

**Sample Retrieval Sheet**

Location:________________________ Collected by:___________________________

| Site name: | Retrieval date/time: | |
|---|---|---|
| FIELD STATUS | Site: | Site:: |
| Weather | | |
| Station condition | | |
| Field/crop condition | | |
| Other | | |
| FLOW | Site: | Site: |
| H in flume | | |
| H @ meter | | |
| Calibrate? | | |
| Flow units accumulated | | |
| Flow pulse setting | | |
| Max head setting | | |
| Change desiccant? | | |
| Other | | |
| SAMPLER | Site: | Site: |
| Inhibited/active? | | |
| Interval setting (#pulses) | | |
| Countdown to next | | |
| Change desiccant? | | |
| Other | | |
| SAMPLE | Site: | Site: |
| Approx. volume (L) | A1: A2: B1: B2: | |
| Time sample removed | | |
| Field sample ID assigned | | |
| Sample split (circle all) | TP TDP TN TDN Cl TSS | TP TDP TN TDN Cl TSS |
| Duplicates collected? | TP TDP TN TDN Cl TSS | TP TDP TN TDN Cl TSS |
| DEC lab ID assigned | | |
| Container clean/replace? | | |
| Other | | |
| Additional comments: | | |

**SEI Form AGO-2, v. 1**

**Post-Event Assessment Form**

| | | | | | | |
|---|---|---|---|---|---|---|
| Location: Site: Date: Technician: | | | | | | |
| STATION OPERATION | | | | | | |
| Did station equipment operate properly?<br>_______Y ______N | | | If No, explain: | | | |
| Additional comments: | | | | | | |
| FLOW | | | | | | |
| Is event record complete?<br>_______Y ______N | | | If No, explain: | | | |
| Does flow data require correction?<br>_______Y ______N | | | If Yes, explain: | | | |
| Flow total: | | | | | | |
| Did both fields generate a runoff event? | | | | | | |
| Additional comments: | | | | | | |
| SAMPLES | | | | | | |
| Samples collected on program:<br>_______A ______B | | | Comment: | | | |
| Sample volume(s) collected: | | | Comment: | | | |
| Number of discrete samples: | | | Comment: | | | |
| Additional comments: | | | | | | |
| MONITORING DATA | | | | | | |
| Temp/Cond data downloaded? | | | Met data downloaded? | | | |
| Were samples analyzed within holding times? (Y/N) | | | | | | |
| TP | TDP | TN | TDN | TSS | Cl | |
| | | | | | | |
| Additional comments: | | | | | | |

**SEI Form AGO-3, v. 1**

## Appendix D: Stone Environmental Standard Operating Procedures (SOPs) Master List

### Chapter 1 ADMINISTRATION

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-1.1.11 | Orientation and Training of Stone Environmental, Inc. (Stone) Employees | 11/22/93 | 09/02/10 | 09/02/10 |
| SEI-1.2.4 | General Procedures For Regulatory Agency Inspections, Sponsors Audits, or Third Party Inspections | 11/22/93 | 01/18/02 | 02/04/2011 |
| SEI-1.3.4 | Assignment of Internal Study Numbers and/or Project Numbers | 04/14/94 | 03/29/12 | 03/29/12 |
| SEI-1.4.11 | Curriculum Vitae | 05/12/93 | 06/30/05 | 02/04/2011 |
| SEI-1.5.4 | Filing Procedures for Project/Study Records | 06/20/94 | 01/18/02 | 08/03/05 |
| SEI-1.6.3 | Backing up the Corporate Network File System | 01/17/01 | 01/18/08 | 01/18/08 |
| SEI-1.7.3 | Archiving Project Folders from the Corporate Network | 01/17/01 | 01/18/08 | 01/18/08 |
| SEI-1.8.1 | Data Recovery Procedure | 08/03/05 | 01/18/08 | 01/18/08 |

### Chapter 2 PROTOCOLS AND REPORTS

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-2.1.5 | Protocol Preparation Requirements | 09/02/93 | 01/18/02 | 02/04/2011 |
| SEI-2.2.5 | Final Report Requirements | 09/02/93 | 03/15/02 | 02/04/2011 |
| SEI-2.3.1 | Interim, Progress, and Quarterly Reporting | 07/29/99 | 01/18/02 | 02/04/2011 |

### Chapter 3 STANDARD OPERATING PROCEDURES

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-3.1.8 | Creating and Revising Standard Operating Procedures | 04/09/93 | 11/26/01 | 02/04/2011 |
| SEI-3.2.6 | Review of Standard Operating Procedures by Personnel | 11/16/93 | 11/26/01 | 02/04/2011 |
| SEI-3.4.3 | Retirement of Standard Operating Procedures | 04/14/94 | 01/15/02 | 02/04/2011 |
| SEI-3.5.2 | Creating and Revising Study Specific Procedures | 03/14/97 | 01/15/02 | 02/04/2011 |

## Chapter 4 DOCUMENTATION

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-4.1.5 | Documentation of Amendments or Deviations from Protocols and Standard Operating Procedures | 04/12/93 | 01/15/02 | 10/17/07 |
| SEI-4.2.6 | Chain of Custody Records | 04/09/93 | 03/15/02 | 10/17/07 |
| SEI-4.4.4 | Documentation of Project Specific Phone Conversations and Correspondence | 09/02/93 | 03/15/02 | 10/17/07 |
| SEI-4.5.10 | Data Handling, Storage, Retrieval and Error Coding | 09/02/93 | 07/11/03 | 10/17/07 |
| SEI-4.6.6 | Significant Figures, Rounding Procedures and Use of Conversion Factors | 12/08/93 | 02/28/03 | 10/17/07 |
| SEI-4.7.4 | Labeling Reagents, Solutions and Standards | 04/18/94 | 02/19/03 | 10/17/07 |
| SEI-4.8.3 | Documentation and Reconstruction of Pesticide Use History | 04/14/94 | 02/19/03 | 04/17/08 |
| SEI-4.10.3 | Computer Software Verification | 04/21/94 | 04/04/03 | 12/28/05 |
| SEI-4.14.2 | Quality Control Check on Transcribed Data, Data Calculations, Figures, and Tables | 07/29/99 | 03/06/03 | 05/02/08 |
| SEI-4.15.2 | Construction of Maps to Illustrate Groundwater Elevation and Depth to Groundwater Contours | 07/19/99 | 03/06/03 | 05/02/08 |
| SEI-4.17.1 | Receipt, Storage, and Documentation of Test Substances | 03/03/00 | 12/17/01 | 05/02/08 |
| SEI-4.18.1 | Data Collection and Analysis Practices for the Campbell Scientific, Incorporated, Data Loggers and Related Hardware | 05/05/00 | 03/06/03 | 05/02/08 |
| SEI-4.19.1 | Receipt and Storage of Electronic Data | 12/13/00 | 02/28/03 | 02/04/2011 |

## Chapter 5 EQUIPMENT

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-5.1.5 | Maintenance and Decontamination of Field Equipment | 04/09/93 | 02/20/04 | 04/17/08 |
| SEI-5.3.4 | Use of Borrowed and Rented Equipment | 04/18/94 | 02/20/04 | 04/11/08 |
| SEI-5.6.4 | Maintenance of Bailers | 11/22/93 | 02/20/04 | 04/11/08 |
| SEI-5.11.2 | Maintenance and Calibration of the Oakton ORPTester (Oxidation and Reduction Potential (ORP) Meter) | 02/16/96 | 02/20/04 | 04/9/08 |

| | | | | |
|---|---|---|---|---|
| SEI-5.14.2 | Use, Maintenance and Calibration of Electronic Balances Model GL1002R, OHAUS CT-200 Top Loading, Adam Equipment 2T200 and/or Other Similar Models | 06/17/97 | 02/20/04 | 04/9/08 |
| SEI-5.19.2 | Maintenance, and Calibration of the Cole Parmer Model DspH3 and 1484-44 and Similar Type pH and Conductivity Meters | 06/17/97 | 02/24/04 | 04/17/08 |
| SEI-5.20.2 | Maintenance, and Calibration of the Cole Parmer Model 19815-00 Conductivity Meter | 03/10/98 | 02/24/04 | 04/17/08 |
| SEI-5.21.2 | Maintenance, and Calibration of the Cole Parmer Model 59000-25 pH Tester | 03/10/98 | 02/24/04 | 04/17/08 |
| SEI-5.22.2 | Maintenance, and Calibration of the Troll SP4000 Datalogger | 05/14/99 | 02/24/04 | 04/17/08 |
| SEI-5.23.3 | Maintenance, and Calibration of the pH/CON 10 Meter | 05/14/99 | 02/24/04 | 04/14/08 |
| SEI-5.24.2 | Maintenance, and Calibration of the GPI Industrial Grade Flow Meter | 06/08/99 | 05/15/03 | 04/17/08 |
| SEI-5.25.0 | Use, Maintenance, and Calibration of the Multi-Parameter Troll 9000 and 9500 | 04/18/08 | na | na |
| SEI-5.26.0 | Use, Maintenance, and Calibration of the Lamotte Model 2020e Turbidity Meter | 06/23/05 | na | 04/14/08 |
| SEI-5.27.0 | Use, Maintenance, and Calibration of the Hydrolab MS5 Water Quality Multiprobes | 04/17/08 | na | na |
| SEI-5.28.0 | Use, Maintenance and Calibration of the HACH LDO Portable Dissolved Oxygen Meters (HACH Models HQ10 and HQ30d) | 02/04/2011 | na | 02/04/2011 |
| SEI-5.29.0 | Use, Maintenance, and Calibration of the MultiRAE IR Multi-Gas Monitor (PGM-54) | 02/04/2011 | na | 02/04/2011 |

## Chapter 6 FIELD WORK

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-6.1.6 | Collection of Soil Samples for Preliminary Site Selection | 10/26/92 | 11/18/05 | 04/2/08 |
| SEI-6.2.6 | Water Level measurement, Use, Maintenance and Calibration of Electronic Water Level Indicators | 04/09/93 | 02/20/04 | 04/2/08 |
| SEI-6.3.4 | Surface Water Sampling | 04/09/93 | 02/24/04 | 04/2/08 |
| SEI-6.4.5 | Installation, Development and Decommissioning of Monitoring Wells and Observation Wells | 04/09/93 | 08/01/07 | 04/10/08 |
| SEI-6.6.9 | Installation and Testing of Bladder Pumps for Sampling | 04/09/93 | 03/31/04 | 05/02/08 |

| | | | | |
|---|---|---|---|---|
| | of Monitoring Wells | | | |
| SEI-6.8.5 | Guelph Permeameter Testing, Use, Maintenance and Calibration of the Guelph Permeameter | 04/12/93 | 02/20/04 | 05/02/08 |
| SEI-6.10.4 | Soil Characterization Study | 04/09/93 | 03/31/04 | 04/15/08 |
| SEI-6.11.8 | Slug Tests | 04/12/93 | 03/02/06 | 05/02/08 |
| SEI-6.12.9 | Porous Cup Lysimeter Installation, Testing, and Sampling | 05/17/93 | 04/16/04 | 11/17/05 |
| *SEI-6.13.8* | *Porous Cup Lysimeter Sampling (Included in SOP 6.12.9)* | *06/02/93* | *Retired* | *Retired* |
| SEI-6.14.3 | Test System Preparation, Care and Observations | 04/18/94 | 04/16/04 | 05/02/08 |
| SEI-6.16.4 | Handling, Collection and Transportation of Samples | 11/22/93 | 04/16/04 | 04/14/08 |
| SEI-6.17.4 | Evaluation of Soil Texture, Moisture Content, and Mottling, Using the USDA Soil Classification Scheme | 11/15/94 | 04/16/04 | 05/02/08 |
| *SEI-6.18.2* | *Installation and Reading of Irometer AWatermark@ Soilmoisture Sensors* | *05/19/95* | *Retired* | *Retired* |
| SEI-6.19.2 | Use, Maintenance and Calibration of the IonScience PhoCheck 1000+ Photo Ionization Detector (PID) | 07/19/99 | 02/04/2011 | 02/04/2011 |
| SEI-6.20.3 | Undisturbed Soil Sample Collection Using a Thin Walled (Shelby) Tube | 02/16/96 | 11/18/05 | 04/17/08 |
| SEI-6.23.1 | Observation and Monitoring Well Surveying | 07/19/99 | 11/29/05 | 04/15/08 |
| SEI-6.24.1 | Locating Soil Sampling Points in a Sampling Area | 07/19/99 | 11/18/05 | 04/14/08 |
| SEI-6.25.3 | Operation and Maintenance of the Concord Model Ss4804 Soil Sampler | 06/17/97 | 11/18/05 | 05/02/08 |
| SEI-6.26.2 | Spray Tank Sample Collection | 06/17/97 | 11/18/05 | 04/17/08 |
| SEI-6.27.3 | Groundwater Sampling of Monitoring Wells | 03/03/00 | 11/18/05 | 04/16/08 |
| SEI-6.34.0 | Procedure for Sampling Groundwater Monitoring Wells Using Low Stress (Low Flow) Technique | 01/21/05 | 01/21/05 | 04/16/08 |
| SEI-6.35.0 | Passive Collection of Pore Water Samples Using Passive Diffusion Bags | 06/22/07 | na | 05/02/08 |
| SEI-6.36.0 | Procedure for Collection of Soil Gas Samples Using the GeoProbe® PRT System and Vacuum "Lung" Box | 6/22/07 | na | 05/02/08 |
| SEI-6.37.0 | Field Methods for Retrieval, Collection, Handling, and Preservation of Rock Samples to be Analyzed for VOCs and Physical Properties | 7/01/08 | na | 07/01/08 |
| SEI-6.38.0 | Optical Brightener Testing | 9/10/08 | na | 09/10/08 |

## Chapter 7 ARCHIVES

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-7.1.4 | Transfer of Raw Data to the Sponsor or Client | 09/02/93 | 02/18/03 | 02/04/2011 |
| SEI-7.2.6 | Document Control, Record System and Archiving | 11/16/93 | 03/04/03 | 02/04/2011 |
| SEI-7.3.3 | Procedures to be Followed when Terminating a Study | 04/18/94 | 02/20/03 | 02/04/2011 |

## Chapter 8 MANAGEMENT

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-8.1.5 | Duties and Responsibilities of the Study Director | 09/02/93 | 03/18/03 | 02/04/2011 |
| SEI-8.2.4 | Duties and Responsibilities of Principal Investigator and/or Project Manager | 09/02/93 | 03/18/03 | 02/04/2011 |
| SEI-8.3.6 | Duties and Responsibilities of Test Facility Management | 11/22/93 | 02/18/03 | 02/04/2011 |
| SEI-8.4.0 | Client Inquiries, Data Revision Requests & Complaint Resolution | 10/20/05 | n/a | 02/04/2011 |

## Chapter 9 QUALITY ASSURANCE

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-9.1.1 | Use of Contract Quality Assurance | 07/19/99 | 2/18/03 | 04/18/08 |
| *SEI-9.2.0* | *Transfer of Data to Contract Quality Assurance (included* | *07/19/99* | *Retired* | *Retired* |
| SEI-9.3.1 | Construction and Maintenance of the Master Schedule | 07/19/99 | 2/18/03 | 04/18/08 |
| SEI-9.4.2 | Duties and Responsibilities of SEI Quality Assurance Personnel | 03/28/97 | 2/18/03 | 04/18/08 |

## Chapter 10 ENVIRONMENTAL DRILLING AND DIRECT PUSH TECHNOLOGY

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-10.1.6 | Determination of Aromatic and Chlorinated Volatile Organics and Light Weight Petroleum Hydrocarbon Compounds Using Solid Phase Microextraction (SPME) and A Gas Chromatograph in Soil and Water Samples (Modified SW846 Methods 8021/8015 & ASTM D6520) | 02/21/03 | 05/26/09 | 05/26/09 |
| SEI-10.2.0 | Determination of Polychlorinated Biphenyl (PCB) by Gas Chromatography with an Electron Capture Detector (ECD) in Sediment and Soil Samples | 08/17/04 | n/a | 02/15/08 |
| SEI-10.5.2 | Groundwater Profiling and K-Pro Testing | 08/13/02 | 05/13/08 | 05/13/08 |
| SEI-10.7.1 | Use, Calibration, and Maintenance of The YSI Model 699xl Multi-parameter Water Quality Monitoring System(Temperature, Specific Conductance, Ph, Redox Potential, Dissolved Oxygen) | 08/13/02 | 10/15/04 | 04/17/08 |
| | *Analysis of VOC=s in Water and Soils Using Solid* | | | |

| | | | | |
|---|---|---|---|---|
| *SEI-10.9.0* | *Phase Microextraction (SPME) and Capillary GC* | *12/12/00* | *Retire* | *Retire* |
| *SEI-10.10.0* | *Analysis of VOC=s in Water and Soils Using Equilibrium Headspace Sample Preparation and Capillary GC* | *12/12/00* | *Retire* | *Retire* |
| SEI-10.11.0 | Geologic Description of Unconsolidated Deposits | 01/18/02 | n/a | 04/17/08 |
| SEI-10.12.1 | Use, Calibration, and Maintenance of the Membrane Interface Probe (MIP) | 08/4/04 | 05/30/08 | 05/30/08 |
| SEI-10.13.0 | Policy Requirements for Manual Integration of Chromatographic Peaks | 08/05/04 | n/a | 05/02/08 |
| SEI-10.14.0 | On-Site Laboratory Waste Handling, Storage and Disposal | 10/20/04 | n/a | 05/02/08 |
| SEI-10.15.7 | The Determination of Volatile Organic Compounds By Gas Chromatography/Mass Spectrometry (SW846 EPA Method 8260) (includes water, soil and air) | 08/19/04 | 02/06/12 | 02/06/2012 |
| SEI-10.16.0 | Determination of Selected Elements in Soil and Sediment Samples Using Field Portable X-Ray Fluorescence Spectrum Analyzers, SW846 6200 | 10/22/04 | n/a | 05/02/08 |
| SEI-10.17.0 | Microwave Assisted Extraction of Volatile Organic Compounds From Rock Samples | 07/2/08 | n/a | 07/02/08 |
| SEI-10.18.0 | The Determination of Volatile Organic Compounds By Gas Chromatography/Dual ECD Detectors in Rock Samples (Using Cool On-Column Injection and Split Method Injection ) | 07/02/08 | n/a | 07/02/08 |

## Chapter 11 HEALTH AND SAFETY

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-11.1.2 | Preparing and Amending a Site Health and Safety Plan (HASP) | 12/13/00 | 11/29/05 | 10/17/07 |

## Chapter 12 GEOGRAPHIC INFORMATION SYSTEMS (GIS)

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| *SEI-12.1.0* | *Managing Paths in ArcView Project Files* | *draft* | n/a | n/a |

## Chapter 13 SURFACE DRINKING WATER STUDIES

| | | ISSUED | REVISED | REVIEWED |
|---|---|---|---|---|
| SEI-13.1.1 | Watershed Estimation Process for Surface Drinking Water Studies | 05/30/01 | 03/18/03 | 02/04/2011 |
| SEI-13.2.1 | Training of Sampling Personnel for Surface Water Drinking Studies | 12/13/00 | 01/15/02 | 02/04/2011 |
| SEI-13.3.1 | Community Water System Visit and On-Site Data Collection for Surface Drinking Water Studies | 12/13/00 | 03/18/03 | 02/04/2011 |
| SEI-13.4.2 | Collection of Samples for Surface Drinking Water Studies | 12/13/00 | 04/04/03 | 02/04/2011 |
| SEI-13.5.1 | Assigning System Identification Numbers for Surface Drinking Water Studies | 12/13/00 | 05/08/02 | 02/04/2011 |
| SEI-13.6.0 | Composition of Watershed Shapefiles in Preparation For Community Water system Watershed Characterization | 04/04/03 | n/a | 02/04/2011 |
| SEI-13.7.0 | Composition of Community Water System Intake Shapefiles For Watershed Characterization | 04/04/03 | n/a | 02/04/2011 |

N.B. - italicized SOPs have been retired or are still in draft form
Retired SOPs will be removed from the list after one year.
n/a – not applicable

# APPENDIX B: SOIL SAMPLING FOR CHARACTERIZATION ANALYSES

## O&R

STONE ENVIRONMENTAL INC
535 Stone Cutters Way
Montpelier, Vermont
05602 USA
Phone / 802.229.4541
Fax / 802.229.5417
Web Site / www.stone-env.com

# Observations & Remarks

Project: AAFM Runoff monitoring study Date: 12/11/12
Client Study #:
SEI Study #: 112540-W
Subject: Soil sampling for characterization analyses

PURPOSE/OBJECTIVE:
Soil samples were collected from each study field to characterize nutrient and organic matter content, major cation concentrations, pH, particle size, and other qualities. Most analyses will be performed by the Maine Soil Testing Service. The Agricultural and Environmental Testing Laboratory at the University of Vermont is receiving and drying the samples prior to shipment to the Maine lab.

Soil samples will also be analyzed by the USDA-ARS Laboratory in Temple, Texas for various soil health indicators, including the Solvita Test.

PROCEDURE:
Soil samples were collected from each study field using a stainless steel soil probe. In each field/watershed, individual sample cores were composited in a 5-gallon bucket. To collect a representative composite sample from each field, scientists collected cores along transects spanning the drainage area, generally making a zigzag pattern of transects across the field. Along this course, cores were taken at intervals of 20 to100 paces, with fewer paces between samples in small watersheds and more paces between samples in larger watersheds. Obvious differences in texture were not observed across any watershed/field, except that certain field areas had more gravel than other areas. Therefore, it was appropriate to collect a single composite sample from the entire field rather than dividing the field/watershed into different sampling areas by soil type. This relatively uniform surface soil texture is consistent with the USDA-NRCS soil mapping data.

The sampling depth in cornfields was approximately 8 inches (20 cm). Corn stubble, residue, and larger pebbles were avoided when inserting the soil probe. In hayfields, the core depth was approximately 4 inches (10 cm). Each core was shaken by the grass stems into a 5-gallon bucket to remove the sod layer.

The composite sample was blended in the bucket using a garden trowel prior to subsampling. The trowel was used to transfer approximately two cups of soil from the bucket into each of two ziplock bags, one for analysis by the Maine Soil Testing Service and one for analysis by ARS. The remaining soil was discarded. In addition to splitting the composite sample into portions for the Maine lab and ARS lab, duplicate splits were prepared from composite samples collected in the WIL and SHO1 watersheds.

The following notes indicate the soil sampling personnel and date for each study watershed.

**FRA1 and FRA2**

Jeremy Krohn collected soil samples from FRA1 and FRA2 on October 23, 2012. Separate samples were collected for the corn and hay strips in each watershed, yielding four composite samples: FRA1-Corn, FRA1-Hay, FRA2-Corn, and FRA2-Hay. The corn strips had recently been chopped for corn silage, but had not yet been plowed.

**PAW1 and PAW2**

Dave Braun collected soil samples from PAW1 and PAW2 on October 24, 2012. The corn had been chopped on both fields a few weeks prior, but the field had not yet been plowed.

**SHE1 and SHE2**

Serena Matt collected soil samples from SHE1 and SHE2 on October 26, 2012.

**FER1 and FER2**

Serena Matt collected soil samples from FER1 and FER2 on October 26, 2012.

**WAS**

Serena Matt collected a soil sample from field WAS (which drains to the WASCoB) on November 12, 2012.

**WIL1 and WIL2**

Serena Matt collected soil samples from WIL1 and WIL2 on November 12, 2012.

**SHO1 and SHO2**

Alex Huizenga collected soil samples from SHO1 and SHO2 on December 5, 2012.

Signed: Dave Braun

Date: 12/11/12

# APPENDIX C: AGRONOMIC INFORMATION FORM (CORN SITE)

# 2012 Agronomic Information Form (Corn site)

For 2012, please fill in the requested information. If the two monitored fields were managed identically, just fill it out once. If not, please fill out the information for each.

1) Indicate the date, rate, and method of spring manure application in 2012. For the rate, the number of spreader loads and spreader volume(s) is preferable to a guessed rate. For the equipment, indicate the brand/model and settings if variable.
   - Date:
   - Rate:
   - Method of application (e.g., high nozzle, low nozzle, dragline, injection):
   - Equipment:
   - Source of manure (identify pit):
   - Was pit agitated? If YES, how well?
   - Was manure incorporated? If YES, date and method:
   - Manure percent dry matter, if known:
   - Describe any recent management changes that noticeably changed manure, such as changes in the feeding regime:
   - Was there substantial water (from rain or snowmelt) in the pit?
   - Describe any additions to the manure pit, such as whey, since previous application:

2) Indicate the date of spring tillage (other than manure incorporation as described in #1). Describe the tillage method (including characteristics like depth/spacing if variable) and equipment used.
   - Date:
   - Tillage method:
   - Equipment:

3) Indicate the corn planting date, planting rate, row width, and variety.
   - Planting date:
   - Planting rate:
   - Row width:
   - Corn variety:

4) Indicate the date, rate, and method of all fertilizer applications in 2012, including any corn starter, and indicate the fertilizer type and formula (N-P-K).

- Date:
- Rate:
- Fertilizer type and formula (N-P-K):
- Method of application:

- Date:
- Rate:
- Fertilizer type and formula (N-P-K):
- Method of application:

- Date:
- Rate:
- Fertilizer type and formula (N-P-K):
- Method of application:

5) Indicate the date, rate, and method of all pesticide applications in 2012. Also indicate the chemical name and formulation.

- Date:
- Rate:
- Chemical name and formulation:
- Method of application:

- Date:
- Rate:
- Chemical name and formulation:
- Method of application:

- Date:
- Rate:
- Chemical name and formulation:
- Method of application:

6) Indicate harvest date, method, estimated yield, and residue cover.
- Date:
- Method:
- Yield (estimated tonnage per acre):
- Residue (% cover) left on field (visual assessment):

7) Indicate the date, rate, and method of fall manure application in 2012. For the rate, the number of spreader loads and spreader volume(s) is preferable to guessed rate. For the equipment, indicate the brand/model and settings if variable.
   - Date:
   - Rate:
   - Method of application (e.g., high nozzle, low nozzle, dragline, injection):
   - Equipment:
   - Source of manure (identify pit):
   - Was pit agitated? If YES, how well?
   - Was manure incorporated? If YES, date and method:
   - Manure percent dry matter, if known:
   - Describe any recent management changes that noticeably changed manure, such as changes in the feeding regime:
   - Was there substantial water (from rain or snowmelt) in the pit?
   - Describe any additions to the manure pit, such as whey, since previous application:

8) Indicate the date of fall tillage (other than manure incorporation as described in #7). Describe the tillage method (including characteristics like depth/spacing if variable) and equipment used.
   - Date:
   - Tillage method:
   - Equipment:

9) If a cover crop was planted, indicate the planting date, variety, method, and stand quality.
   - Date planted:
   - Variety planted:
   - Method/seeding rate:
   - Stand quality (visual assessment):

10) Was there any vehicle traffic on the field (other than farm machinery and our sampling vehicle)? If yes, please describe.

11) Describe the condition of the crop and any damage to the crop or the field (drought, erosion, observations, results of PSNT, etc.).

THANK YOU!

# APPENDIX D: AGRONOMIC INFORMATION FORM (HAY SITE)

# 2012 Agronomic Information Form (Hay Site)

For 2012, please fill in the requested information. If the two monitored fields were managed identically, just fill it out once. If not, please fill out the information for each. Feel free to call me (802-272-8819) if you have any questions.

1) What year were the ______ and ______ fields last seeded?

2) What are the plant species in the ______ and _____ fields (list from most to least dominant)?

3) For each hay cut, indicate the mowing date, date baled/bagged/loaded, and estimated yield.

<u>1st cut</u>

- Date:
- Date baled/bagged/loaded (if different):
- Yield (estimated tonnage per acre):

<u>2nd cut</u>

- Date:
- Date baled/bagged/loaded (if different):
- Yield (estimated tonnage per acre):

<u>3rd cut (if made)</u>

- Date:
- Date baled/bagged/loaded (if different):
- Yield (estimated tonnage per acre):

<u>4th cut (if made)</u>

- Date:
- Date baled/bagged/loaded (if different):
- Yield (estimated tonnage per acre):

4) Indicate the dates, rates, and methods of manure application in 2012. For the rate, the number of spreader loads and spreader volume(s) is preferable to a guessed rate. For the equipment, indicate the brand/model and settings.

<u>1st application (if made)</u>

- Date:
- Rate:
- Method:
- Equipment:
- Source of manure (identify pit):
- Was pit agitated? If YES, how well?
- Was manure incorporated? If YES, date and method:
- Manure percent dry matter, if known:

- Describe any recent management changes that noticeably changed manure, such as changes in the feeding regime:
- Was there substantial water (from rain or snowmelt) in the pit?
- Describe any additions to the manure pit, such as whey, since previous application:

<u>2nd application (if made)</u>

- Date:
- Rate:
- Method:
- Equipment:
- Source of manure (identify pit):
- Was pit agitated? If YES, how well?
- Was manure incorporated? If YES, date and method:
- Manure percent dry matter, if known:
- Describe any recent management changes that noticeably changed manure, such as changes in the feeding regime:
- Was there substantial water (from rain or snowmelt) in the pit?
- Describe any additions to the manure pit, such as whey, since previous application:

5) Indicate the date, rate, and method of all fertilizer applications in 2012 and indicate the fertilizer type and formula (N-P-K).

- Date:
- Rate:
- Fertilizer type and formula (N-P-K):
- Method of application:

- Date:
- Rate:
- Fertilizer type and formula (N-P-K):
- Method of application:

- Date:
- Rate:
- Fertilizer type and formula (N-P-K):
- Method of application:

6) Indicate the date, rate, and method of all pesticide applications in 2012. Also indicate the chemical name and formulation.

- Date:
- Rate:
- Chemical name and formulation:
- Method of application:

- Date:
- Rate:

- Chemical name and formulation:
- Method of application:

- Date:
- Rate:
- Chemical name and formulation:
- Method of application:

7) Please describe any other management activities on these fields in 2012.

8) Was there any vehicle traffic on the field (other than farm machinery and our sampling vehicle)? If yes, please describe.

9) Describe the condition of the crop and any damage to the crop or the field (drought, erosion, observations, results of PSNT, etc.).

# APPENDIX E: SAMPLING PROCEDURES AND ROUTINE MAINTENANCE SSP

## STUDY SPECIFIC PROCEDURE

# *Sampling Procedures and Routine Maintenance for the Agricultural Practice Monitoring and Evaluation Project*

SSP Number: 112540-W SSP#1 Date Issued: 10/17/12

Version Number: 2 Date of Revision: NA

## 1.0 OBJECTIVE

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

## 2.0 POLICIES

All field staff performing sampling duties for the Vermont Agency of Agriculture, Food, and Markets' Agricultural Practice Monitoring and Evaluation Project must read this SSP and implement the procedures written herein.

## 3.0 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:

### 3.1 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.

### 3.2 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.

### 3.3 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.

### 3.4 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.

## 4.0 STUDY DESIGN

The project will use a paired-watershed design at the field-watershed scale to test the effects of treatment on event discharge and pollutant concentration and export in surface runoff from study fields. The paired-watershed design includes two fields (watersheds)—control and treatment—and two time periods—calibration and treatment. During the calibration period, the watersheds in each pair are treated identically and paired water quality data are collected. At some point during the study, the treatment watershed undergoes a change in management (e.g., soil aeration or cover cropping); this change begins the treatment period. Management practices on the control watershed remain consistent during the entire study, therefore the control watershed accounts for year-to-year climate variations.

The basis of the paired-watershed design is that there is a quantifiable relationship (i.e., a linear regression model) between paired data from the watersheds (calibration) and that this relationship is valid until a change is made in one of the watersheds (treatment). At that time, a new relationship will exist. The difference between the calibration and treatment period relationships is used to evaluate and quantify the effect of treatment.

Practices to be evaluated include: soil aeration on hayland prior to manure applications; cover cropping; reduced tillage with manure injection and cover cropping; reduced tillage with manure injection and no cover cropping; and a water and sediment control basin (WASCoB) treating runoff from corn land. The principal hypothesis to be tested is that application of these management practices will significantly reduce runoff losses of nutrients and sediment from agricultural fields in corn and hay production.

## 5.0 MONITORING PROGRAM SUMMARY

Event monitoring at each paired watershed monitoring station will be conducted identically during the calibration and treatment periods. During each monitored event, discharge will be measured continuously. Event composite samples will be analyzed for total phosphorus (TP), total dissolved phosphorus (TDP), total nitrogen (TN), total dissolved nitrogen (TDN), chloride (Cl), and total suspended solids (TSS) concentration. We will monitor up to 20 runoff events (weather permitting) each year of the study. Monitoring will generally be conducted between April 1 – November 30, with additional sampling during the winter months using passive sampler arrays (a set of three single-stage sample bottles with intakes at different elevations to collect samples at different stages through the rising limb of the hydrograph), where necessary to obtain data about practice performance outside of the growing season. As called for in the paired-watershed design, calibration monitoring under present management will be conducted for 1 – 1.5 field seasons, with the exact duration depending on having monitored a reasonable range of magnitude of runoff events and on statistical analysis of the calibration period data. After the calibration period, the new management practice will be implemented on the treatment field/watershed. Monitoring then continues for 1.5 – 2 field seasons after the treatment is established. At the WASCoB site, the inlet and outlet of the basin will be monitored for the same parameters and for a similar period as the paired-watershed sites.

## 5.1 Event sampling

We will monitor discrete runoff events that generate discharge at our monitoring stations. For the purpose of this study, we generally define a runoff event for monitoring as a discrete episode of discharge from the flume (persisting for hours or days) generated by precipitation. Thus defined, the event begins when discharge begins and ends when discharge ceases at one or both of the paired watersheds. Because of the difficulty of accurately measuring extremely low flows and to prevent the sampling system from drawing air at very low flows, we will define discharge as beginning at a threshold stage of approximately 1 cm. The effective end of flow is similarly defined. In cases where multiple precipitation episodes in rapid succession generate sustained discharge, we will consider the period of continuous discharge to be a single runoff event.

An exception to the above protocol may occur in long, low-intensity runoff events generated by snowmelt in winter thaws or spring runoff. In cases where episodic runoff is not generated by discrete precipitation events, we may define the runoff event either as that discharge that occurs during the above-freezing portion of the day (when flow freezes at night, for example) or as the accumulated discharge over a period of days defined either by ambient weather or by logistical convenience.

Available project resources permit us to monitor up to 20 runoff events a year at each monitoring station. In order to ensure we collect data representative of a full seasonal span each year and, at the same time, collect data during critical periods of BMP performance (e.g., late fall and early spring for cover crop treatments, runoff closely following manure applications on hayland aeration treatments), we require some flexibility in selecting which events to include for full sampling and analysis. Therefore, we will use our best judgment to stratify the events we choose to monitor so that critical periods/conditions are included. In this process, samples from some events that occur under conditions already frequently sampled may be discarded so that we retain the capacity to monitor later events that represent critical conditions. For example, if we have monitored several events on a pair of hay fields that occurred several weeks or more after a manure application, we may choose to not submit samples for analysis for similar events that occur before the next manure application. Similarly, if we have monitored several comparable events on corn fields during the height of the growing season and well before cover crops are planted, we may decide to not submit samples from additional events under those conditions so that we can monitor runoff events that occur following cover crop establishment. The hydrologic magnitude of the event will, of course, be another consideration.

Within the limits of our resources, we will monitor events of particularly large magnitude (e.g., a 25-year storm) even if we have previously monitored smaller events under similar field conditions.

### 5.2 Processing flow-proportional composite samples

Flow-proportional sampling is challenging because flow rates and total event discharge are highly variable and unpredictable. If individual sample aliquots are collected too infrequently (e.g., in small runoff events), an event may be poorly represented and insufficient composite sample volume may be collected to perform the intended analyses. If sample aliquots are collected too frequently (e.g., in an unexpectedly large runoff event), the capacity of the sample carboys may be exceeded, causing the sampling program to terminate before the event is over, resulting in a non-representative sample. To minimize the occurrence of under-sampling and overfilling, a two-part sampling program will be used in which the autosampler pumps sample aliquots to two sets of carboys at different intervals of accumulated flow. Each set will consist of two 10-L polyethylene carboys. The first set (Set A) is intended to capture a representative runoff sample from small to medium sized events and the second set (Set B) is intended to capture sample from medium to large events. Set B will be filled at approximately one tenth to one twentieth the frequency of Set A. The second carboy in each set will be filled only after the first is full, at the same frequency as the first. Sampling personnel will select either Set A or Set B for analysis (see logic in Step 4 of the sampling procedure), but not both sets. Any sample in the bottle set not chosen will be discarded. Using this two-part sampling program, sufficient sample should be collected (approximately 750 mL is needed) during small events to perform all the required analyses and the sampler container capacity will not be exceeded during most large storms.

The autosampler program will be further optimized by adjusting sampler pacing settings according to season and in advance of major predicted storms, with the intent of representatively sampling every runoff-producing storm. Adjustment to the program to increase or decrease the sampling frequency will be made either by direct connection or via remote access.  Changes to sampling frequency will never be made while an event is in progress.

Within 24 hours of a monitored runoff event resulting in acceptable samples, field technicians will process the bulk sample into appropriate splits for delivery to the VT DEC laboratory. Sample will be poured into a 14-L polyethylene churn splitter, a device that agitates the water while representative subsamples are drawn off from a spigot. Each site will be equipped with a churn splitter. Aliquots will be collected from the churn splitter in containers provided by the DEC laboratory for transport and delivery to the lab.

Sample splits for TDP and TDN analyses will be filtered in the field using a 0.45 $\mu$m membrane filter supplied by AAFM or the VT DEC laboratory. The filtrate will be dispensed directly into the appropriate sample container. Sample splits collected for TN and TDN analysis will be acidified immediately using one drop of concentrated sulfuric acid. A medicine dropper will be used to dispense the acid into the filled sample container.

Following sample processing, the sample carboys, churn splitter, and filtration apparatus will be double rinsed with potable water, then rinsed a third time with distilled water. The carboys will be reinstalled and the sampling program restarted for the next event.

### 5.3 Deposited Sediment

Based on previous experience in event monitoring of agricultural fields, we anticipate that it is possible that sediment eroded from the field (especially corn fields before full crop canopy development and after harvest) will be deposited in the flume and approach channel during an event and remain after an event flow has ceased. Sediment deposited in the flume/approach channel represents sediment lost from the field and must therefore be included in estimated TSS loss. Although we do not have resources to precisely quantify this component of field export, we will estimate significant sediment mass deposited in the flume/approach after a runoff event by shoveling sediment into a graduated bucket to measure volume, subsampling a known volume, and performing density analysis (dry weight) and phosphorus analysis. The sample may be preserved by freezing.

## 6.0 SAMPLING PROCEDURE

1. Record information from sampler display (see attached sampling form). Note that the sampler 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 (which is to be expected at very low flows) or that there is a clog in the line or intake strainer. If this warning is displayed, inspect the line and strainer for a clog or kink and otherwise ignore it. For all other warning messages, please contact Stone.
2. If flow has ceased or the level has fallen below 1 cm (0.4 in), stop the sampling program by pressing the red button to pause the program and then selecting STOP PROGRAM. If the level has fallen below 1 cm at only one station in a pair, it is permissible to stop the program and retrieve samples from this station and return at a later time to retrieve samples from the other station.

   In certain cases, the sampling program may be stopped remotely by Stone. Stopping the program remotely can ensure that aliquots from a subsequent runoff event are not mixed with the sample from the first event. This may be particularly useful when the first event ends after dark, when it is not reasonable to visit the station to reset the sampling program and retrieve samples, and additional rainfall is possible overnight. If samples cannot be retrieved shortly after the level falls below 1 cm and additional rain is possible, it is preferable to stop the sampling program remotely even though this may result in a subsequent (overnight) event being missed, rather than combine distinct events, especially if the other watershed in the pair has stopped running off entirely. Other exceptions may be discussed with the Stone project manager.
3. Record approximate sample volumes in each carboy.
4. Select the appropriate set of carboys, the As (A1 and A2) or the Bs (B3 and B4). Select the appropriate carboys according to the following logic:
   a. If carboy B3 contains greater than 1 liter, use set B.
   b. If carboy B3 contains less than 1 liter, use set A unless the sampler display indicates the Part A program is DONE. If the sampler display indicates Part A is DONE and there is less than

1 liter in carboy B3, contact the Stone project manager for direction. We will need to evaluate whether the set A sample is sufficiently representative of the entire event.

c. If the sampler attempted to collect fewer than three aliquots into carboy A1 or the total volume collected is under 500 mL, discard the sample. The number of aliquots attempted can be determined by viewing the sampler display. The display will indicate Part A, "2, 50 Bottle 1 after *X* pulses" if only one aliquot was attempted, or Part A, "3, 50 Bottle 1 after *X* pulses" if only two aliquots were attempted. In this example, "3" indicates that the next aliquot the sampler will attempt dispense to Bottle 1 is its third; "50" indicates that it will dispense a maximum of 50 aliquots to Bottle 1; "Bottle 1" indicates that the sampling container in use is Bottle 1, which we refer to as carboy A1; and "X pulses" indicates how many flow pulses are remaining before the sampler attempts the next aliquot.

   Bottle A1 should also contain a minimum of 500 mL for sample splits to be prepared for analysis. Since the programmed aliquot volume is 200 mL, three aliquots should produce 600 mL of sample. If three or more sample aliquots were attempted and the volume in carboy A1 is less than 500 mL, then the suction line strainer was likely exposed during pumping, drawing air rather than water. This is to be expected at very low flows. You may also view the sampling report for further information about which sampling attempts were successful.

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 $H_2SO_4$ | 28 |
| TDN | 50-mL plastic centrifuge tube, blue cap | Filtered (0.45 µm) in field, cool (<6°C), 0.1 mL $H_2SO_4$ | 28 |
| TSS | 500-mL plastic bottle | Cool (<6°C) | 7 |
| Chloride | 50-mL plastic centrifuge tube, purple cap | None | 28 |

The Sample ID field is a concatenation of the Site ID (PAW1, PAW2, SHE1, etc.), the collection date (mmddyy), and the carboy(s) from which sample splits are taken [A1, A2, B3, B4, A12 (if the samples from carboys A1 and A2 are added together in the churn splitter), or B34 (if the samples from B3 and B4 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 SHE1 on October 2, 2012 only from carboy A1: **SHE1-100212-A1**
- A sample collected at PAW2 on September 27, 2012 by combining the contents of carboys B3 and B4 in the churn splitter: **PAW2-092712-B34**

6. Put on lab gloves
7. Pour sample from the selected carboy set into the churn splitter. Try to swirl the water to suspend sediment as you pour the sample into the churn splitter. NEVER combine sample from set A and set B in the churn splitter.

   In many cases, only the first carboy in each set (A1 or B3) will contain sample. If the second carboy (A2 or B4) 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 A1 contains 10 liters and carboy A2 contains 2 liters, these can be composited in the churn splitter; and the resulting sample ID would be in the form: SITE ID-mmddyy-A12.

   If the combined volume will exceed 14 L, each carboy in the selected set should be split individually, resulting in two sets of sample splits for analysis. For example, if the set A carboys are split individually, the resulting sample IDs would be in the form Site ID-mmddyy-A1 for the carboy A1 splits and Site ID-mmddyy-A2 for the carboy A2 splits.
8. 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:
   a. TP sample split: While operating the churn splitter, fill the glass vial up to the line.
   b. TN sample split: While operating the churn splitter, fill a blue capped centrifuge tube to the 50 mL line.
   c. TSS sample split: While operating the churn splitter, fill a 1-liter plastic bottle to at least 500 mL.
   d. Let the contents of the churn splitter settle for 1-5 minutes.
   e. Use forceps to place a clean 45-mm, 0.45-$\mu$m filter in the filter holder. Wet the filter with a spray of distilled water.
   f. TDP sample split: 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 line. If the filter clogs prematurely, it may be replaced with a new filter and the process repeated.
   g. TDN sample split: Remove the plunger and attach the filter holder to the syringe (the same filter used to prepare the TDP split may be used for TDN). Fill the syringe with settled water from the churn splitter. Squirt approximately 10 mL onto the ground and then fill a blue capped tube to the 50 mL line. If the filter clogs prematurely, it may be replaced with a new filter and the process repeated.
   h. Chloride sample split: Dispense 50 mL of settled sample from the churn splitter to a purple capped centrifuge tube, filling to the 50 mL line.
9. Preservation. Put on safety glasses. Add 1 drop of concentrated sulfuric acid to preserve the TN and TDN samples. 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.

10. Washing equipment. The standard washing procedure is for two rinses with well water followed by one rinse with distilled water. Well water can be obtained in carboys from the participating farms. Treated municipal drinking water should not be used because it typically contains added phosphorus. After each event, the churn splitter, filter holder, and carboys should be washed.
11. Reinstall carboys in the following clock positions: A1 at 6:00, A2 at 3:00, B3 at 12:00, and B4 at 9:00.
12. If significant sediment has accumulated (more than a dusting), shovel sediment into a graduated bucket and record the volume to the nearest liter. If the volume of sediment is below 1 L, discard it outside the watershed. If more than one liter has accumulated, collect and freeze a representative sample of known volume, then discard the remainder outside the watershed.
13. 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 and disabled. The sampler display should indicate that program Part A and Part B are "active" and "disabled".
14. 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.
15. Samples must be delivered to the laboratory within the holding times indicated in Table 1.

## 7.0 ROUTINE MAINTENANCE

### 7.1 Tasks to be performed by sampler, bi-weekly and after each runoff event

1. On the sampling form, record the amount of rainfall collected in the manual gauge 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. The sampler display should indicate that program Part A and Part B are "active" and "disabled".
3. Confirm that the sampler suction line and pump tubing are attached.
4. Confirm that the sample carboys are installed properly.
5. Check the funnel on the tipping bucket rain gauge; remove and clean if necessary.
6. Check that the tipping bucket datalogger is logging data. To access the datalogger, remove the wingnuts securing the bottom plates of the solar radiation shield. Remove the plates. There is a small circular window on the datalogger next to the word "OK". If the logger is working, a small LED light should blink in this window approximately every 4 seconds. Contact Stone if the light is not blinking.

7. Sweep leaves and debris from flume and flume approach.
8. Clean debris from splash trough.
9. Check sample intake tubing and screen and remove any debris.
10. Check for erosion and rodent holes near the flume approach and wingwalls. Minor erosion and small holes should be repaired immediately by the sampler, if possible. If there appears to be any potential of flow bypassing the flume, sampling staff should alert the Stone project manager.
11. Describe field/crop condition.
12. 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.

### 7.2 Tasks to be performed by Stone approximately monthly

1. Record the amount of rainfall collected in the manual gauge 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. Download the tipping bucket pendant datalogger. After download, confirm the status reads launched/logging and that the LED light is blinking.
3. Check tipping bucket pendant datalogger desiccant and replace if necessary.
4. Check the tipping bucket for debris. Remove the funnel and carefully clean the funnel and the tipping bucket mechanism if needed. Debris may be cleaned from the tipping bucket mechanism using the end of a heavy duty plastic cable tie.
5. Download U24-001 conductivity logger. After download, confirm the status reads launched/logging. Perform a calibration check by inserting both the U24-001 and a calibrated conductivity probe into a calibration solution, waiting 15 minutes for the sensors to stabilize, and then making simultaneous readings of conductivity and temperature with both units. These paired measurements enable post-processing of the logged conductivity data using Hoboware software.
6. Download images from time-lapse cameras and confirm the battery level. Replace all four AA batteries if the level is below 50%. After download, switch the selector to Auto, close the housing, and confirm that the LED is blinking.
7. Confirm that the sampler program is running. The sampler display should indicate that program Part A and Part B are “active” and “disabled”.
8. Confirm that the sampler suction line and pump tubing are attached and that the intake is fixed to the bottom of the splash trough. Check the sampler suction line for any sags; zip-tie if necessary to maintain a consistent downward slope in the line.
9. Confirm that the sample carboys are installed properly.
10. Check the desiccant cartridges of the 2110 and 2105ci modules and replace desiccant if necessary.

11. Restock monitoring stations with bottles, sample retrieval forms, labels, filtration supplies, gloves, and distilled water.
12. Refill or replace acid dropper bottles.
13. Clean the ultrasonic level sensor with a wet, non-abrasive cloth if visibly dirty (otherwise do not disturb). Do not use detergent or any type of solvent.
14. Clean any debris from the flume and flume approach. Check the flume level and relevel if necessary.
15. Wipe the solar panel with a wet, non-abrasive cloth if visibly dirty.
16. Verify that the white charging light and the green battery status light are illuminated on the solar charge controller. If the white light is not lit, check the two breaker switches in the gray box mounted near the charge controller.
17. Check battery electrolyte levels and fill wells with distilled water using the squirt bottle if the level is low. The level should be maintained at approximately ¼ inch above the top of the plates. Do not overfill. There should be an air space between the liquid level in each well and the underside of the battery's top plate. Clean the battery terminals if corroded.
18. Cut weeds from around the shelters and flume and along the wingwalls.
19. Check for erosion and rodent holes near the flume approach and wingwalls and repair problems if present.
20. Describe field/crop condition.

### 7.3 Routine Tasks to be performed remotely by Stone through Flowlink

1. Check battery voltage and notify Dave Braun if less than 12.0 V.
2. Check ultrasonic sensor level baseline and notify Dave Braun if greater than or equal to +0.005 m or less than or equal to -0.010 m.

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## 8.0 AUTHORIZATION

Written by: ________________________________________ Date: _____________

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

Approved by: ________________________________________ Date: _____________

Julie Moore, Project Manager, Stone Environmental, Inc.

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## 9.0 REVISION HISTORY

Not Applicable

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## 10.0 FORMS

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**AAFM Agricultural Practice Monitoring and Evaluation Project (112540-W)**
**Monthly maintenance checklist**

Technician:_______________________________________ Date:__________________________

Manual rain gauge:___________inches (*read then empty*) Time:__________________________

Tipping bucket: □ Debris checked/cleared □ Downloaded □ Relaunched
Battery: ___________ volts Battery replaced? Y N □ Status is launched/logging

| ACTIVITY | SITE:_________ | SITE:_________ | NOTES |
|---|---|---|---|
| U24-001 logger downloaded | □ | □ | |
| U24-001 calibration check<br>(*record readings*) | □ Not done / NA<br>Exact Time:<br>Temp. (°C):<br>Sp. Cond. (µS): | □ Not done / NA<br>Exact Time:<br>Temp. (°C):<br>Sp. Cond. (µS): | |
| Clean U24-001 sensor window | □ | □ | |
| Camera downloaded and restarted | □ | □ | |
| Camera batteries | □ OK<br>□ Replaced | □ OK<br>□ Replaced | |
| Sampler program active and disabled | □ | □ | |
| Sampler tubing is attached | □ | □ | |
| Sample carboys installed properly | □ | □ | |
| 2100 module desiccant | □ OK<br>□ Replaced | □ OK<br>□ Replaced | |
| Restock sampling supplies | □ | □ | |
| Scan or retrieve forms. Restock forms and labels if needed. | □ | □ | |
| Cleaned the ultrasonic level sensor (*only clean if dirty*) | □ No<br>□ Yes | □ No<br>□ Yes | |
| Clear any debris from flume, approach, and splash trough | □ | □ | |
| Check the flume level. Relevel if necessary | □ OK<br>□ Leveled | □ OK<br>□ Leveled | |
| Check/fill battery electrolyte levels. Clean terminals if corroded | □ OK<br>□ Filled | □ OK<br>□ Filled | |
| Check solar panel. Clean if needed | □ | □ | |
| Mow weeds | □ | □ | |
| Check flume and wingwalls for erosion, rodent holes, etc. | □ OK<br>□ Repaired | □ OK<br>□ Repaired | |
| Field Condition: | | | |
| Comments: | | | |

**AAFM Agricultural Practice Monitoring and Evaluation Project (112540-W)**
**Sample retrieval/Routine maintenance by sampler form – PAGE 1**

Collected by:_______________________________ Date:____________________________

Weather:___________________________________________________________________________

Manual rain gauge:__________inches (*read then empty*) Time:_____________________________

Tipping bucket: Funnel: □ OK □ Cleaned; Datalogger LED blinking: □ Yes □ No (*notify Stone if no*)

| | Site: _______1 | Site: _______2 |
|---|---|---|
| FIELD STATUS | | |
| Station condition | □ OK □ Other______________________ | □ OK □ Other______________________ |
| Field/crop condition | | |
| AUTOSAMPLER | | |
| Part A status:<br>(circle one) | 1. ACTIVE, DISABLED<br>2. PART A DONE<br>3. ACTIVE, Enabled | 1. ACTIVE, DISABLED<br>2. PART A DONE<br>3. ACTIVE, Enabled |
| If ACTIVE and enabled, display reads: | PART A<br>____, ____ bottle__ _ after____ pulses | PART A<br>____, ____ bottle_ __ after____ pulses |
| Part B status:<br>(circle one) | 1. ACTIVE, DISABLED<br>2. PART B DONE<br>3. ACTIVE, Enabled | 1. ACTIVE, DISABLED<br>2. PART B DONE<br>3. ACTIVE, Enabled |
| If ACTIVE and enabled, display reads: | PART B<br>____, ____ bottle___ after____ pulses | PART B<br>____, ____ bottle___ after____ pulses |
| RUNOFF SAMPLE COLLECTION | | |
| Time you stopped the autosampler (pressed the red button) | _______________ AM or PM | _______________ AM or PM |
| Current water level in flume | ________ cm or □ No Flow | ________ cm or □ No Flow |
| Carboy volume (L) | A1: A2: B3: B4: | A1: A2: B3: B4: |
| Carboys split (circle) | A1 A2 A1+A2 composite<br>B3 B4 B3+B4 composite | A1 A2 A1+A2 composite<br>B3 B4 B3+B4 composite |
| Sample ID assigned | _______ - _________ - _______<br>(Site ID) (mmddyy) (carboy(s)) | _______ - __________ - _______<br>(Site ID) (mmddyy) (carboy(s)) |
| Splits collected (circle) | TP TN TSS TDP TDN $Cl^-$ | TP TN TSS TDP TDN $Cl^-$ |
| Duplicates collected? | TP TN TSS TDP TDN $Cl^-$ | TP TN TSS TDP TDN $Cl^-$ |
| TN/TDN splits acidified? | Yes No | Yes No |
| SEDIMENT IN FLUME | | |
| Sediment in flume/ flume approach (circle) | None Dusting Significant | None Dusting Significant |
| If significant, remove sediment, measure volume, and sample | Sediment volume: _______ L NA<br>Sample collected? Yes No NA | Sediment volume: _______ L NA<br>Sample collected? Yes No NA |

**AAFM Agricultural Practice Monitoring and Evaluation Project (112540-W)**
**Sample retrieval/Routine maintenance by sampler form – PAGE 2**

| RESETTING STATIONS | | |
|---|---|---|
| STOP then Re-RUN SAMPLING PROGRAM | □ Sampler ACTIVE, DISABLED | □ Sampler ACTIVE, DISABLED |
| Sampler suction line and pump tubing attached? | □ OK □ Other________________ | □ OK □ Other________________ |
| Carboys and churn splitter triple rinsed? | Yes No NA | Yes No NA |
| Carboys installed properly? | Yes No | Yes No |
| Debris cleared from: | Flume/approach: Yes No None<br>Splash trough: Yes No None<br>Sampler intake: Yes No None | Flume/approach: Yes No None<br>Splash trough: Yes No None<br>Sampler intake: Yes No None |
| Check wingwalls for undercutting, rodent holes, etc. | □ OK<br>□ Problem___________________<br>Problem fixed? Yes No NA | □ OK<br>□ Problem___________________<br>Problem fixed? Yes No NA |
| Additional comments: | | |

v. 3

**Accessing and Using Stone's Flowlink Website**

The ISCO 2105ci interface module is programmed to send data to a SQL server located in Stone's offices in Montpelier though an Internet Protocol cellular connection. The data "pushed" to the SQL server are runoff level, flow rate, and total volume, plus battery voltage, ultrasonic level sensor temperature and signal strength, and sampler event marks (which mark the time of each autosampler pump cycle). The 2105ci interface module is currently programmed to send these data to the server every 30 minutes. These data may be viewed in near real time using a Flowlink website hosted by Stone. The Flowlink site is simply a data viewer. It is not possible to make changes to the data or to the sampling programs through this Flowlink website (you cannot mess anything up).

Having the ability to view these data remotely is critical to the success of the monitoring program. Sampling personnel can see in near real time the runoff level in the flume rise and fall through a runoff event. This should allow sampling personnel to better judge when a runoff event is occurring and when it is nearing its end, reducing unnecessary field visits to check on runoff conditions. Using the viewer sampling personnel can also notice untypical level data caused by ice or debris in the flumes, which typically produce noisy level data and/or strangely flat hydrographs rather than a smooth response. The "sampler" event marks may be used to determine whether the autosampler has collected enough sample for analysis (one can also view the autosampler display or the sampling report for this information). If one clicks on the event mark (the triangle symbols) the legend will display the bottle number into which the aliquot was dispensed. Finally, Stone is using the Flowlink website to routinely check battery voltage and ultrasonic sensor drift and to evaluate whether the sampling program settings should be adjusted.

Using the Flowlink website may require some initial tweaks to your internet browser settings. If you cannot see the data on the viewer and cannot readily click on and display different datasets, try the instructions below. If you are still having trouble, please contact John Landis, Stone's IT manager, for assistance (802-229-5381). All sampling personnel working on this study really need the ability to see the data for their sites.

To access the site:

1. You must use Internet Explorer
2. Enter the following URL in your browser address window: Http://67.217.115.146/fl112540-w/login.aspx.
   NOTE: inside Stone's offices use: http://flowlink.stone-env.com/fl112540-W/login.aspx
3. In Internet Explorer, select Tools, then "Compatibility view settings". If the address 67.217.115.146 appears in the block beneath "Add this website", select "Add"; otherwise enter 67.217.115.146 and select "Add". Close the window.
4. To function properly, the Flowlink site requires a browser add-on called "Active X controls". You must get the Active X controls to load by one or both of the following methods (try Method 1 first) :
   a. Method 1: From the log-in page, select: Tools -> Internet options -> Security tab -> Trusted sites -> Sites -> uncheck "Require server verification". If the address http://67.217.115.146 appears in the block beneath "Add this website", select "Add";

otherwise enter http://67.217.115.146 and select “Add”. Close the window. Then lower the slider for security level for trusted sites to the bottom "low" and select “OK”.

b. Method 2: From the log-in page, select: Tools -> Internet options -> Security -> Custom level. Scroll down the list to “Download unsigned ActiveX controls” and select “Prompt”.

5. Bookmark the login page or add it to Favorites.
6. On the log-in page, enter User Name: sqladmin and Password: sqladmin123
7. Now refresh the page or close and restart the browser. You will be prompted with a message “Do you want to allow the following program from an unknown publisher to make changes to this computer?” Select Yes. This downloads the ActiveX controls. The file name of the Flowlink Active X add-on is 67.217.115.146/pe6.cab.
8. The ISCO data should show up after a few seconds.
9. If Method 2 was used to enable the Active X Controls to load, return to Tools -> Internet options -> Security -> Custom level, and change the settings back to their original state.

All the sites should now be listed on the left hand side of the webpage. You may need to expand (click on) the plus sign next to “Sites” to open up the list. Next, expand one or more sites by clicking on their + signs.

Under each site, two instruments should be listed, “2105 Interface” and “2110 Ultrasonic”. Now, expand the 2105 Interface and click on the box next to “Level” and hit “view graph”. This will display the water level information for the site in meters. Now, expand “2105 Interface” and select “Sampler”. This displays the sampler event marks as little triangles (only present when an event is in progress).

Navigating the site is relatively simple. The right arrow above the graph moves forward in time and the left arrow moves backward. To skip to the most recent data, click on the right arrow with the bar next to it, “>|”. You can select up to four datasets to display at one time. Deselect datasets you are done viewing to enable you to view others. A small data table is displayed below the graph showing data from the selected datasets. This data table shows only five records. The data shown correspond with the position of your cursor on the graph. Moving your cursor across the graph moves a vertical line on the graph and immediately shifts the time period displayed in the data table. You can also zoom in to portions of the graph by clicking and dragging a box over the graph. Hold the mouse button down while you drag and then release it. You may also change the time scale; selecting “This week” seems to work well.

The two most useful comparisons are to select “Level” for both stations in a pair or select “Sampler” and “Level” for one station. You can also display both sample event marks and level data for two stations at the same time but the display gets rather squeezed.

# APPENDIX F: SIPHON SAMPLER CONSTRUCTION AND INSTALLATION O&R

STONE ENVIRONMENTAL INC
535 Stone Cutters Way
Montpelier, Vermont
05602 USA
Phone / 802.229.4541
Fax / 802.229.5417
Web Site / www.stone-env.com

# Observations & Remarks

| | | | |
|---|---|---|---|
| Project: | AAFM Runoff monitoring study | Date: | 12/11/12 |
| Client Study #: | | | |
| SEI Study #: | 112540-W | | |
| Subject: | Siphon sampler construction and installation | | |

PURPOSE/OBJECTIVE:

Siphon samplers were constructed and installed to collect runoff samples when conditions made use of the autosampler impossible or impractical. Siphon samplers were installed at each corn site (FRA1, FRA2, WAS1, WAS2, WIL1, WIL2, PAW1, and PAW2) to extend the monitoring period in late fall and early spring.

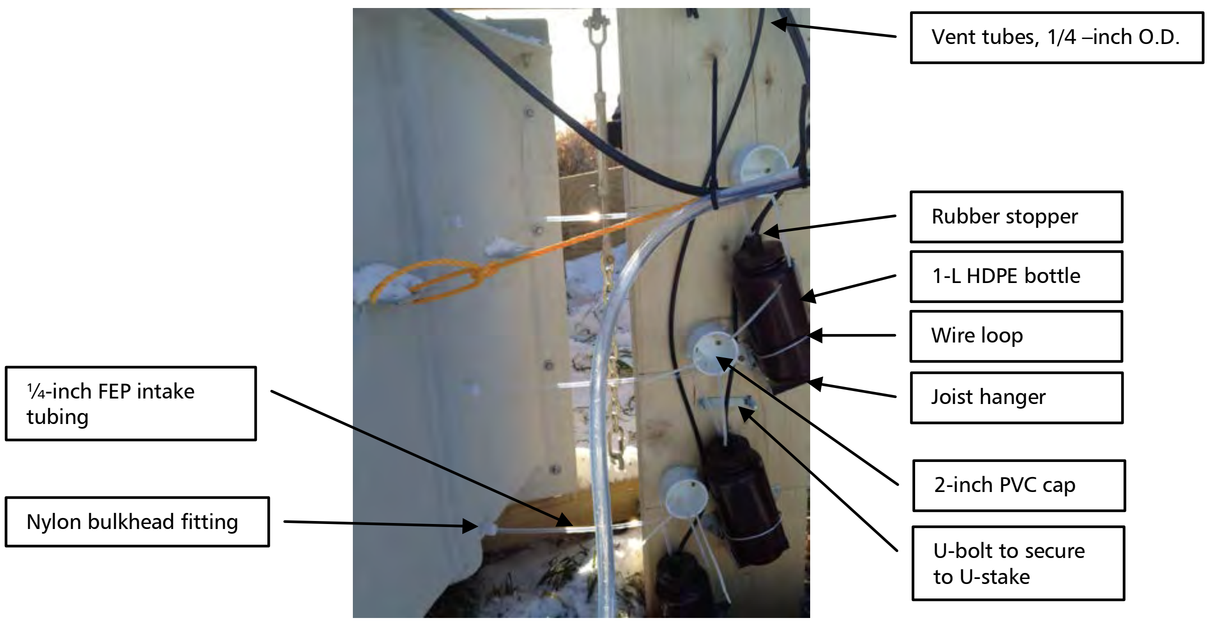
The samplers are designed to collect nearly instantaneous runoff samples at specific stages in the rising limb of the runoff hydrograph. Once a bottle is filled, which takes between one and two minutes, no additional water should pass into or through the sampler.

PROCEDURE:

There is no widely accepted design for siphon samplers. Designs are tailored to specific monitoring applications. However, all siphon samplers include an intake tube that arcs upward, allowing water to rapidly siphon to a bottle below the level of the intake tube, and a vent tube that ends at a higher level than the intake, allowing air from the bottle to be released as the bottle fills. In theory, when the water level in the sample bottle rises to the tip of the vent tubing, the bottle will stop filling, leaving headspace under the cap.

The siphon samplers consist of a 1-L bottle secured to a 2-inch thick by 12-inch wide board using a joist hanger, a two-holed rubber stopper inserted through a hole drilled in the bottle cap, sample intake and vent tubing inserted in the rubber stopper, and plastic fittings to bend and secure the flexible tubing. Three siphon samplers were installed at each station. These are arranged vertically on the board, with their intakes secured at specific, pre-determined levels. At the site with flumes the intakes are: 2 cm, 1/3 of the flume height, and 2/3 of the flume height above the floor of the flume. At the WAS2 station, the intake lines were secured at specific levels relative to the outlet structures, as follows: level of lowest orifices, level of larger holes in standpipe, level of the top of the standpipe.

The photograph below show a siphon sampler after installation. The FEP intake tubing is attached to the flume using nylon compression bulkhead fittings. On the inside of the flume, short pieces (2-inch long) of stainless steel tubing are attached to the compression fittings. The intake tubing is wrapped once around and cable-tied to a 2-inch PVC pipe end cap, which is screwed to the board. The vent tubing is run to the top of the board, such that it is above the level of the maximum predicted stage. Inside the bottle, the intake tube protrudes slightly (about ¼ inch) through the rubber stopper. The vent tube protrudes 2 inches from the bottom of the stopper, allowing head space within the bottle.




Siphon samplers were installed on the following dates:

FRA1, FRA2, WAS1, and WAS2: November 30, 2012, by Dave Braun and Alex Huizenga
WIL1 and WIL2: December 4, 2012, by Dave Braun and Alex Huizenga
PAW1 and PAW2: December 5, 2012, by Alex Huizenga

Signed: Dave Braun　　　Date: 12/11/12