Agricultural Practice Monitoring and Evaluation

YEAR TWO 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 (VTANR 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 implementing 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 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. Recently modeling efforts undertaken by EPA have estimated that almost 40% of the annual phosphorus load delivered to Lake Champlain is attributable to agriculture and that the vast majority of the agricultural load is attributable to hay and cropland (USEPA 2013). 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*. Although the 799 Standard has since been discontinued by NRCS, this project continues subject to its guidelines. More information about NRCS Conservation Practice Standards can be found at: www.nrcs.usda.gov/technical/Standards/nhcp.html. The principal hypothesis being tested is that application of these conservation practices will significantly reduce runoff losses of nutrients and sediment from agricultural fields in corn and hay production. The agricultural practices being evaluated are:

- Soil 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. By agreement with site landowners, exact site locations will not be publicly disclosed. Sites are referred to by town name.

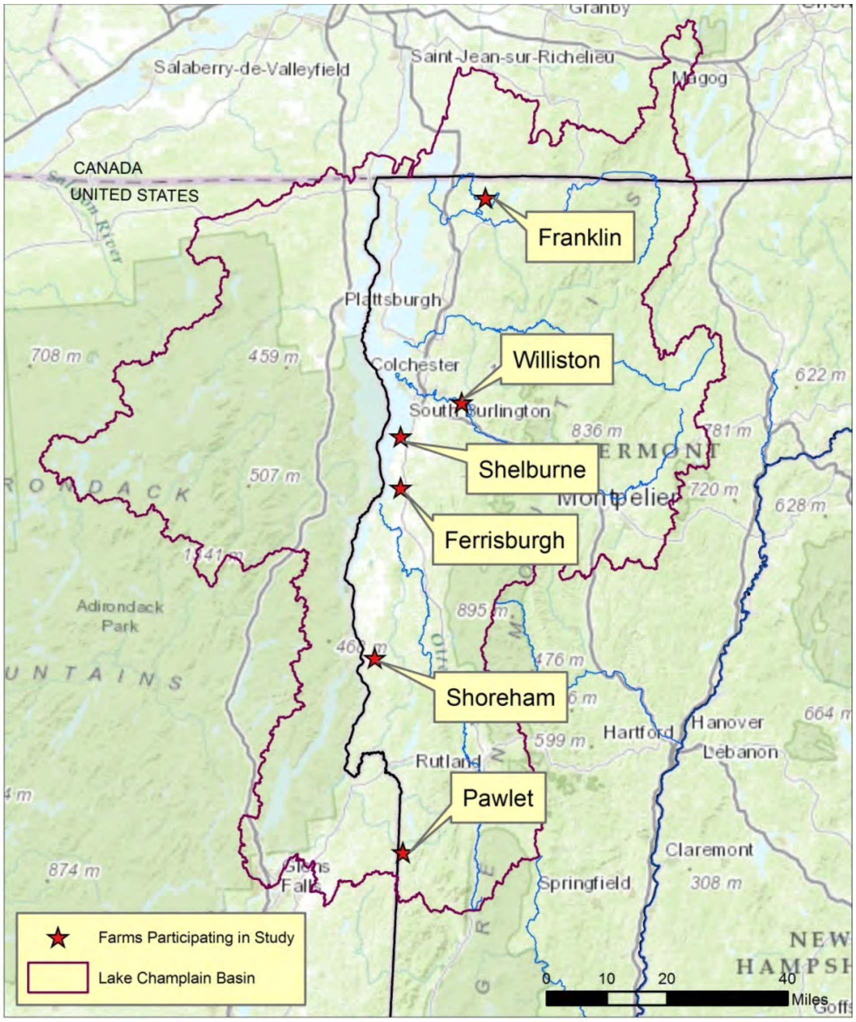

Figure 1. Locations of participating farms

The project employs a paired-watershed design in order to document the effects of these conservation practices 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 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 primary datasets that are being used to assess the strength of the calibration period relationships and effects of treatment are:

- Total event discharge;
- Event mean concentrations of total phosphorus (TP), total dissolved phosphorus (TDP), total nitrogen (TN), total dissolved nitrogen (TDN), total suspended solids (TSS), and chloride; and
- Event mass export of TP, TDP, TN, TDN, TSS, and chloride.

Monitoring data of secondary importance include: precipitation, air temperature, runoff specific conductance, and runoff temperature.

This Year 2 annual report summarizes agronomic, discharge, and water quality data collected through December, 2013. Certain material is repeated from the Year 1 annual report, where needed to provide context. For other material, including soil and agronomic data collection methods and 2012 results, please refer to the Year 1 annual report.

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. CURRENT STATUS OF THE MONITORING PROGRAM

Calibration period monitoring began in September 2012. In August 2013, event discharge and analytical data collected through July were processed and regression analyses were performed to determine the strength of regression relationships between each watershed pair. This was done so that prior to fall 2013 harvest operations project leaders could advise the participating farms regarding the timing of conservation practice implementation. For each watershed pair, regression analyses were performed on event discharge and event mean concentrations and export of TP, TDP, TN, TDN, TSS, and chloride. At the time the statistical analyses were performed, there were fewer paired event mean concentration and export data points available for TN, TDN, and chloride than for event discharge, TP, TDP, and TSS, because analytical data for these constituents were delayed. As such, decisions regarding practice implementation were made primarily on the basis of the strength of regressions relationships between paired event discharge and TP, TDP, and TSS event mean concentration and export data.

The interim statistical analyses indicated that calibration period regressions on event discharge and TP, TDP, and TSS event mean concentration and export were reasonably strong in most cases for the three cornfield sites (FRA, PAW, and WIL) and two of the three hayfield sites (FER and SHE). The regression relationships tended to be weaker for the Shoreham site, which had the fewest paired events.

Based on the results of the interim statistical analyses, agronomic considerations, and the overall monitoring program schedule, project leaders made decisions regarding implementation of the conservation practices at each site. These decisions were revisited by project leaders on March 19, 2014, considering agronomic practices in the fall of 2013 and additional monitoring data collected through January 2014. Current plans for implementing conservation practices at each site are summarized in Table 1, along with the current monitoring plan for each site.

Table 1. Plans for conservation practice implementation and monitoring

Site	Conservation Practice Implementation Plan	Monitoring Plan
FER	Begin soil aeration of the selected treatment watershed (FER2) following first hay cut in 2014 and apply manure to both watersheds. Also aerate FER2 and apply manure to both after second or third hay cut.	Continue calibration period monitoring until first soil aeration, then perform treatment period monitoring through December 2014.
FRA	In 2013, FRA1 (the treatment watershed) was aerially seeded with cover crop into the standing corn. Following corn harvest, manure was injected on the FRA1 corn strips and surface applied on FRA2. The FRA2 corn strips were then chisel plowed. This began the treatment period. In Spring 2014, strip-tillage will be performed at FRA1, while FRA2 will be prepared and then planted with a conventional planter.	Treatment period monitoring is in progress. Continue through December 2014 and then re-evaluate need for extending monitoring into 2015.
PAW	In 2013, cover crop was mistakenly seeded on both PAW1 (the treatment watershed) and PAW2 (the control watershed) following corn harvest. In Spring 2014, assess cover crop percent cover. If cover crop is well established on PAW1, spray any cover crop on PAW2 with herbicide, assuming this can be accomplished at least several weeks prior to corn planting. If cover crop is not well established on PAW1 and/or cover crop on PAW2 cannot be eliminated at least several weeks prior to corn planting, consider aerial seeding PAW1 early in season to improve establishment.	Resume monitoring after cover crop is established on PAW1 and no cover crop is present on PAW2. Continue treatment period monitoring through 2015.
SHE	Begin soil aeration of the treatment watershed following first cut in 2014 and apply manure to both watersheds. Also aerate the treatment watershed and apply manure to both after second or third hay cut. Pending concurrence of the farmer, SHE1 will be selected as the treatment watershed.	Suspend monitoring until first soil aeration, then begin treatment period monitoring through December 2014. Evaluate need for extending monitoring into 2015.
SHO	Begin soil aeration on the treatment watershed after adequate statistical calibration for priority parameters is achieved, but no later than June-July 2014 (after second cut). Apply manure to both watersheds following aeration of the treatment watershed. Also aerate the treatment watershed and apply manure to both after third and/or fourth hay cut. SHO1 is tentatively designated as the treatment watershed.	Continue calibration period monitoring until first soil aeration, then perform treatment period monitoring through December 2015.
WIL	Following corn harvest in 2013, manure was injected on WIL1 (the treatment watershed) and surface applied on WIL2 (the control watershed). This began the treatment period. In Spring 2014, manure will be injected on WIL1, followed by reduced-tillage and planting. Manure will be surface applied on WIL2 and incorporated. WIL2 will then be planted with a conventional planter.	Treatment period monitoring is in progress. Continue through December 2014. Re-evaluate need for extending monitoring into 2015.
WASCoB	The cornfield draining to the WASCoB is conventionally tilled. No experimental treatment is planned for this field.	Monitor through the ice-free period in 2014.

3.1. Misapplication of Conservation Practices

In mid-July 2013, Stone learned that the producer at the Shoreham site had received outdated information indicating that it would be acceptable to aerate one of his fields after taking the second cut of hay. Stone staff visited the site with NRCS on July 29, 2013 to view the impact the aeration had on field conditions. Figure 2 shows slots made by the aerator in the SHO2 watershed. Although there was evidence of aeration in several areas in the SHO2 watershed, it appeared that the aerator may not have been set properly for the soil conditions. The pattern of slots was inconsistent and in most areas could not be discerned at all. Further, soil cracking throughout both study watersheds appeared more significant than the partial aeration of SHO2 in terms of opening up the soil (Figure 3). Between this aeration event and January 31, 2014, there were no paired runoff events at the Shoreham site (with the exception of small events that could not be accurately measured because ice-affected flow measurements). Given the minimal degree of soil aeration achieved at SHO2 and considering the passage of time, project leaders expect that there is little or no lingering effect of this mis-timed aeration.

Figure 2. Slots made by aerator, SHO2 watershed, July 29, 2013

Figure 3. Soil cracks, SHO2 watershed, July 29, 2013

In November 2013, the producer at the Pawlet site communicated that he had applied cover crop seed on October 15th to both PAW1 and PAW2. Apparently the producer did not recall the agreed on plan to apply cover crop to PAW1 (the treatment watershed) only. The cover crop was seeded at the very end of the date range that cover cropping is considered viable in Vermont. Based on cover crop density measurements made during November (see Section 6.2), the catch was quite poor (<1% cover). Because both watersheds were seeded and the catch was so poor, paired runoff events occurring between mid-October and December 2013 were included with the calibration period data for purposes of statistical analysis.

To attempt to correct the misapplication of cover crop to the PAW2 watershed, the cover crop that establishes must be destroyed. The tentative plan is to spray herbicide on the cover crop in PAW2 (the intended control watershed) shortly after it begins to grow in the spring. AAFM and NRCS have been consulted regarding this plan, and have indicated their support.

4. DESCRIPTION OF STUDY SITES

A map and description of each study watershed was presented in the Year 1 annual report. This information is included in Appendix A for reference, with the exception of the detailed soil characterization data.

In 2013, an error was found in the previously reported watershed boundary delineation for the PAW2 watershed. In this watershed, the orientation of the crop rows influences the drainage area. This watershed is the only paired study watershed that was not surveyed, because it was substituted after the originally intended area (adjacent to PAW1) was surveyed and then determined to be unworkable. The PAW2 watershed was delineated using coarse topographic data; apparently our interpretation was in error (Figure 4). The corrected boundary was determined using a GPS unit to mark

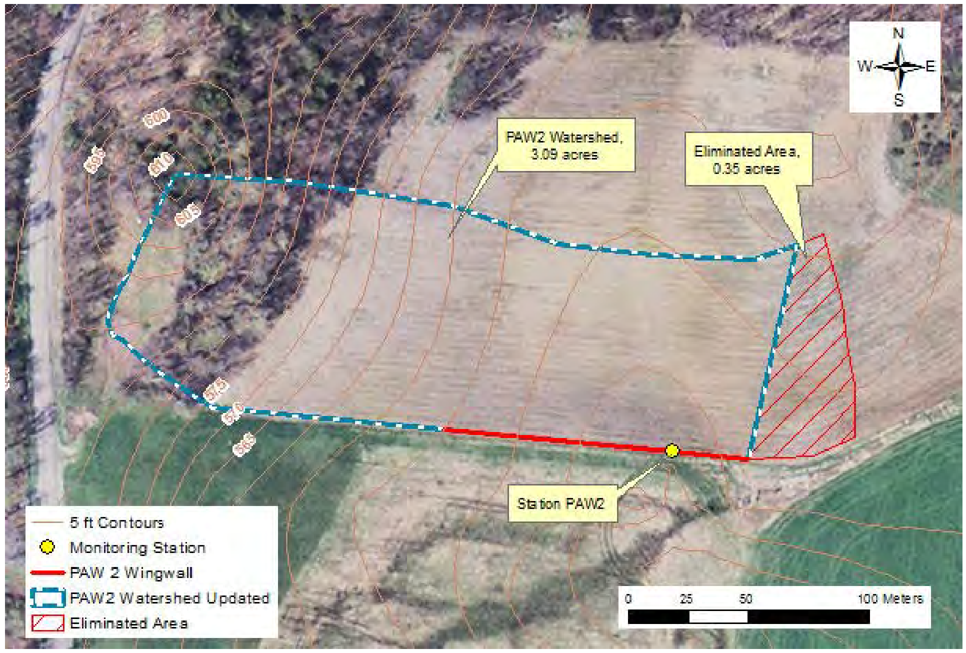

Figure 4. Updated PAW2 watershed boundary and eliminated watershed area

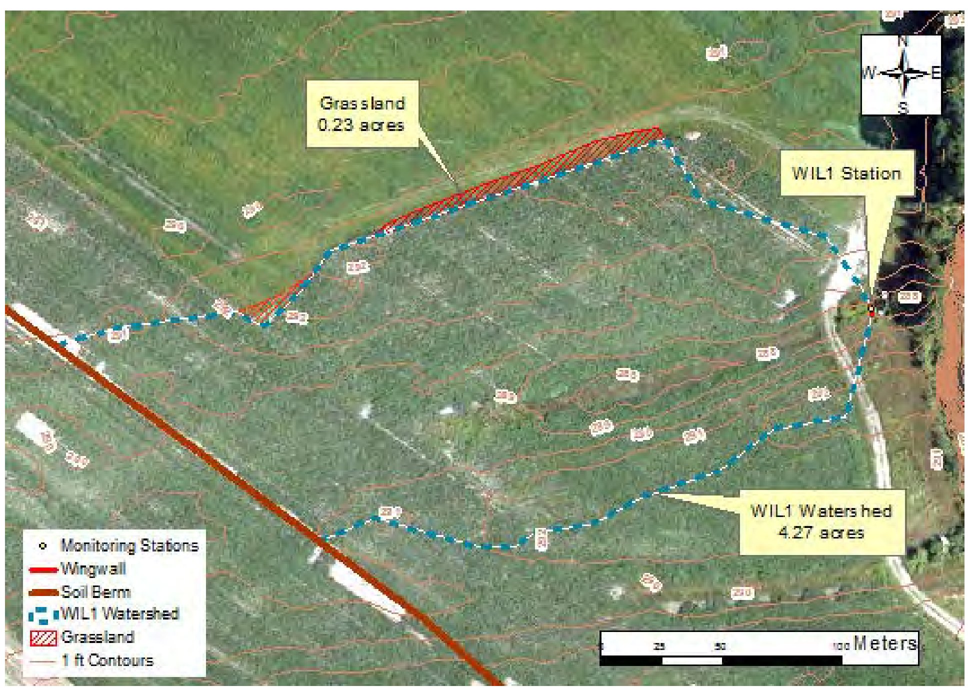

Figure 5. WIL1 watershed with strip of hayland indicated

waypoints along the apparent height of land. An area of 0.35 acres that appears to drain away from the PAW2 station was excluded, a 10.2 percent reduction in watershed area.

On October 30, 2013, it was discovered that the WIL1 watershed includes a narrow strip of hayland, totaling 0.23 acres or 5.3 percent of the watershed area (Figure 5). Apparently this area was not plowed in when the northern portion of the WIL1 watershed was converted from hay to corn production in 2012.Maintaining this area in grass should not have a substantial effect on the study and no corrective action in recommended at this point in the study.

5. METHODS

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. Following the fall 2012 monitoring period, the QAPP was revised to account for changes in staffing, instrumentation, and monitoring and sample handling procedures. Version 2.0 of the QAPP was distributed for signature on July 9, 2013. Version 2.0 is included as Appendix B.

5.1. Routine Maintenance

Field staff visited each monitoring stations at least monthly during the monitoring season to perform routine maintenance, download instruments, and restock supplies. These maintenance activities are listed on the *Monthly Maintenance Checklist*, attached to the QAPP Version 2.0 (Appendix B). Data transmitted from the stations were checked approximately bi-weekly to verify that data communications were successful, the voltage of the main batteries was good, and recorded level data were near zero during dry periods.

5.2. Agronomic Data Collection

In 2012 and 2013, data on agronomic and field management activities including tillage (date, method); manure, nutrient, and agrochemical applications (date, method, rate); planting (date, method, variety); and harvest (date, method, yield) were collected for each study field directly from the participating farmers. These data were collected on an agronomic practice data form prepared for each farm and/or by interviewing participating farmers. Information on field management from the participating farmers was supplemented by direct observation by sampling personnel, and by time-lapse photography from repeatable photo points at each monitoring site. The agronomic practice data forms sent to each participating farmer were “seeded” with information available from Stone’s review of the time-lapse camera photographs. For example, we were able to indicate the dates hay cuts were made.

Agronomic practice data forms for 2013 were completed by all six participating farmers, in some cases during interviews with Stone staff. Meetings were held with each participating farmer early this spring to review monitoring results to date and discuss agronomic practices planned for 2014.

Cover crop and residue percent cover measurements were made at the three corn sites (FRA, PAW, and WIL) after corn harvest in 2013. A Study Specific Procedure (SSP) was established to perform these measurements. This procedure is included as Appendix C. Between 12-20 randomized locations were surveyed in each study watershed on each survey date using a gridded quadrat with 64 measuring points (Figure 6). The cover crop surveys were performed at PAW on November 14, 2013; at WIL on October 30, 2013; and at FRA on October 18 and November 21, 2013. These surveys will be resumed in the spring following snowmelt and performed approximately monthly until corn is planted.

Figure 6. Quadrat used in cover crop percent cover measurements

5.3. 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. Continuous precipitation monitoring is supplemented by an inexpensive manual rain gage located at each site as a backup. 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.

Calibration of the tipping bucket rain gages was verified in the field in April 2013 and the gages were recalibrated as necessary. Through 2013, the meteorological data were downloaded approximately monthly during routine site maintenance. There were no data gaps or known instrument malfunctions during 2013. However, precipitation falling as snow may not have been measured accurately by the tipping bucket rain gages.

5.4. Runoff Event Sampling

Stations were visited as soon as possible after the end of a monitored event. Runoff samples were processed in accordance with the QAPP Version 2.0 (see Appendix B). Event data were recorded on the *Sample Retrieval/Routine Maintenance by Sampler Form*, which is included in the QAPP (Version 2.0). Following collection, samples were refrigerated or stored on ice and arrangements were made for their transport to the Department of Environmental Conservation laboratory within seven days of collection.

The monitoring stations were essentially dormant from February 1 to March 12, 2013, but were quickly brought on-line in order to capture a significant runoff event resulting from a rain-on-snow beginning on March 12. The stations were operated continuously from mid-March through December 6, 2013. Following the mid-March event, there was a period of nearly two months of dry weather and low activity at all stations.

There were zero runoff events at the Williston, Shoreham, Franklin, and WASCoB sites during this period, while the Shelburne, Ferrisburgh, and Pawlet sites recorded between two and four events. A significant change in the weather pattern occurred in mid-May, and late-May, June, and early-July were characterized by record-breaking rainfall totals and saturated soil conditions. Although it was wet throughout Vermont during this period, the more intense rainfall events were concentrated in Chittenden County and areas further to the south. The remainder of the summer and the fall were drier. The number of paired sampling events for each station from March 12 through December 6 is presented in Table 2, below.

Table 2. Number of paired events with valid data at both stations, through January 2014

Station	Number of Paired Flow Events[1]	Number of Paired Chemistry Events
FER	19	16
FRA	17	11
PAW	40	28
SHE	24	20
SHO	11	6
WIL	18	15
WAS	7	5

1. Includes only events with measureable runoff and valid data at both stations in a pair

In several cases, adjustments were made to raw flow data to account for sediment or ice accumulation in flumes. These adjustments were made by fitting a linear regression line to a portion of the declining limb of the hydrograph, spanning the period of suspect data. In most cases, there is an obvious drop in measured flow when the sediment or ice was cleared from the flume by field staff. The

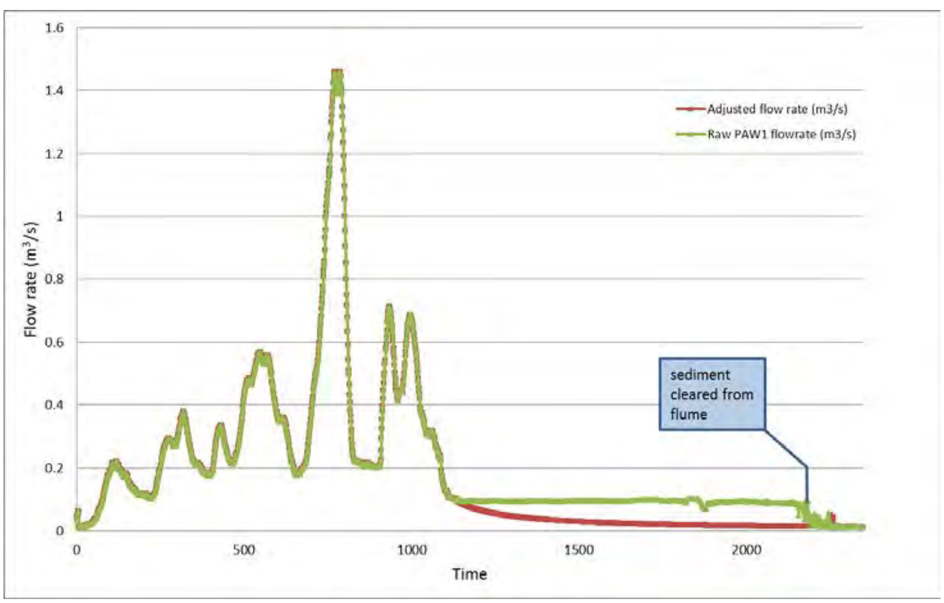

Figure 7. Uncorrected and adjusted flow rate at PAW1, Event 1

regression lines were fit to the “good” data points immediately prior to the period of suspected sediment- or ice-affected flow and to the points immediately after sediment or ice was cleared from the flume. Figure 7 shows one instance where the raw flow data were adjusted to account for sediment in the flume. Stations and events with adjusted flow data in 2013 were as follows:

- FER2, Event 1 (March 12-14, 2013)
- FER1, Event 7 (June 11-12, 2013)
- FER2, Event 21 (November 27-28, 2013)
- PAW1, Event 1 (March 12-13, 2013)
- PAW1, Event 10 (June 2-4, 2013)
- PAW1, Event 14 (June 24-27, 2013)
- PAW1, Event 15 (June 27-30, 2013)
- PAW1, Event 17 (July 5-7, 2013)
- PAW1, Event 19 (July 10-11, 2013)

For FER1, Event 7, an adjustment was made to account for a minor leak beneath the wingwall. The bypass flow resulting from this leak was estimated as the additional flow occurring immediately after the leak was temporarily plugged by field staff. This flow was added to the measured flow over the declining limb of the hydrograph.

Operating autosamplers remotely during rain storms and thaws in the winter months of 2013-2014 to “opportunistically” collect samples when the flumes were clear was less successful than during the early winter months of 2012-2013. This approach requires project staff to carefully monitor flow level and temperature and activate autosamplers if/when rain is imminent, and then to stop the autosampler at the end of the event or slightly early if ice appears to build up or temperature drops to preclude collection of invalid flow data and non-representative samples. During the winter of 2013-2014, many of the flumes filled with ice in December and flow measurement during runoff events in December and January were generally badly affected by ice. The last sampled event occurred on December 6, 2013 at FER (paired) and FRA, SHO, and WIL (unpaired). There was also a paired event at SHE on this date, but it was not sampled. On January 6-7, 2013, there was an ice-affected event at FER1/ FER2, FRA2, PAW1/ PAW2, and SHO1/SHO2. Between January 11 and 16, there was a substantial, ice-affected event at all 14 monitoring stations. None of the January events could be accurately measured and sampled. An attempt was made to sample a paired runoff event at the Shoreham site beginning on January 21, 2014; however, both flumes iced up significantly overnight, resulting in collection of non-representative samples that were discarded.

5.4.1. Problems encountered at monitoring stations in 2013

Considering fourteen monitoring stations were operated continuously for approximately nine months in 2013, there were relatively few technical problems encountered. There were essentially no problems with the power supply systems, flow meters, autosamplers, tipping bucket rain gages, or air temperature sensors. Any problems with the telemetry systems were minor and were rectified without any loss of data. The most significant problem experienced in 2013 was flow that bypassed five different station flumes during very large events, either by undermining or flowing around the wingwall. These and other less critical problems, along with the remedial measures implemented, are described below.

- We experienced significant erosion and undermining ("blow-outs") along the wingwalls at the FER1, FER2, and PAW1 stations during three different, very large events in the spring of 2013. These blow-outs resulted in the loss of data from the event (i.e., we don't know how much water passed under the wingwall) and required significant, unanticipated repairs. In each case, soil surrounding the eroded section was excavated and a thick layer of bentonite chips was placed along the base of the wall on both sides, followed by backfill to the surface with tamped native soil. Each repair held successfully during the multiple rain events that followed. These blow-outs resulted in exclusion of the following events from statistical analysis:
    - FER2, Event 6: Discharge and analytical data excluded
    - PAW1, Event 10 (June 2-4, 2013): Discharge and analytical data excluded
- On July 11, 2013 there was a very large event (Event 15) at SHO1 and SHO2, with peak flows substantially higher than any seen to date at these sites. Time-lapse photographs showed the ponded level behind the SHO1 flume reaching the end of the wingwall. Comparing total runoff volume for SHO1 and SHO2 across all events demonstrated that the July 11 event was an outlier, with relatively less flow at SHO1 than would be expected given the total flow at SHO2. On October 8, we surveyed the flumes and the ends of the wingwalls at SHO1 and SHO2 and found that the ground surface elevations at the ends of the wingwalls were not high enough and bypass flow could occur at both stations. The problem was more significant at SHO1 than at SHO2. We believe that substantial bypass flow occurred around the SHO1 wingwall and minor bypass flow occurred around the SHO2 wingwall during the July 11 event. We do not believe bypass flow occurred during any other events. The problem at SHO1 likely resulted from a combination of settling/compaction of the soil berms that were created during station construction and extended beyond the plywood wingwalls and installation of the flume too high on the wingwall. Therefore, in late October, Stone staff reinstalled the SHO1 flume several inches lower and built up the soil berms adjacent to the wingwalls at both stations. Flow and analytical data from the July 11 event were excluded from statistical analysis.
- On the April 17, 2013, the pressure transducer was reinstalled at site WAS2 to measure water level. The pressure transducer began transmitting erroneous readings almost immediately. A borrowed unit was installed on April 19, 2013 and the faulty unit was sent in for repair. The repaired unit was reinstalled on May 22, 2013. These reinstallations necessitated multiple level adjustments. For the period April 19 through May 2, the necessary level adjustment cannot be determined with confidence. Since there were no events during this period, these data have simply been eliminated.
- The conductivity sensor/logger installed at SHE2 malfunctioned (it stopped recording data) in July and again in August. We determined that it needed to be returned to the manufacturer for service. The repaired meter was reinstalled at SHE2 on October 11, 2013.

- The conductivity sensor/logger installed at WAS2 malfunctioned (it stopped recording data) after October 18, 2013. During a field visit on November 21, 2013, we determined that it needed to be returned to the manufacturer for service. The unit was repaired and will be reinstalled in the spring of 2014.

5.5. Water and Sediment Control Basin (WASCoB) Monitoring

The WASCoB was monitored from April 19 through December 15, 2013. Surveys were conducted on three occasions to check the accuracy of stage readings made with the pressure transducer relative to the WASCoB outlet structures. From May 22 through December 15, 2013, a stage correction of -0.0067 m was applied to all readings. Preliminary discharge and volume data for the year were also adjusted by substituting a complex (5-part) rating curve for the preliminary rating taken from the HydroCAD model upon which the WASCoB hydraulic design was based. This rating was developed from three sources of information: 1) the HydroCAD model; 2) survey of the WASCoB outlet structures and orifices; and 3) paired pond stage and outlet flow measurements made using an auxiliary area-velocity flowmeter from May 23 - 28, 2013.

5.6. Runoff Sample Analysis

Analysis of all field runoff samples is being conducted by the VT DEC laboratory, currently stationed at the University of Vermont. 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).

5.7. Sediment Sampling and Analysis

Per QAPP Version 2.0 (Appendix B), sediment samples were collected when the total sediment volume cleared from the flume and approach channel after an event was greater than one liter. Sediment was shoveled from the flume/approach into a 5-gallon polyethylene bucket, incremented with 1-L marks. After recording the collected sediment volume, the sediment was homogenized and a subsample was collected into an 8-ounce (237 mL) plastic jar. The jar was transferred under chain of custody to the University of Vermont's Agricultural and Environmental Testing Laboratory for dry matter and total phosphorus analysis. Remaining sediment was discarded downstream of the monitoring station.

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 checked for errors 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 the problems noted in Section 5.4.1. 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 10 (SAS Institute 2012).

6. RESULTS

6.1. Study Field Practices

Field management activities were recorded for each field/watershed for the 2012 and 2013 growing seasons, based on direct field observations, images collected using time lapse cameras, and interviews with participating farmers. Agronomic data provided by participating farmers are presented in Tables 3 - 8.

6.1.1. Ferrisburgh site

Table 3 summarizes field management activities at the Ferrisburgh site in 2013. The farmer at the Ferrisburgh site did not apply any manure following the first three hay cuts in 2013. In October, manure was applied to FER2 but not to FER1. Several calls were placed to the farmer to ascertain his ability to correct this "unpaired" manure application. The farmer was unable to apply manure again until early December, at which time manure was applied to both fields, although less (4 loads) was apparently applied to FER2.

Table 3. Agronomic history of Ferrisburgh study watersheds (FER1 and FER2)

Date	Activity
04/28/13	The entire FER1 field was interseeded. The FER2 field was interseeded in certain spots ("touched up"). Seeding rates and equipment are unknown.
06/18/13	First cut of hay at FER1. Yield was 2.8 tons/acre.
06/19/13	First cut of hay at FER2. Yield was 2.8 tons/acre.
07/24/13	Second cut of hay at FER1 and FER2. Yields were 2.7 tons/acre and 2.8 tons/acre, respectively.
08/24/13	Third cut of hay at FER1. Yield was 3 tons/acre.
08/25/13	Third cut of hay at FER2. Yield was 3 tons/acre.
09/19/13	Fourth cut hay at FER1 and FER2. Yields on both fields were 3 tons/acre.
10/11/13	Wood ash was broadcast at a rate of 2 tons/acre on both fields.
10/17/13, 10/18/13	On FER2, manure was broadcast at 5000 gal./acre using a traveling reel and gun. Manure was from the home farm pit and was not agitated prior to spreading or incorporated afterwards.
12/05/13	On FER1, manure was broadcast at 4000 gal./acre using a tank spreader. Manure was from the home farm pit and was agitated for ½-day prior to spreading. It was not incorporated.
12/06/13	On FER2, manure was broadcast at 4000 gal./acre using a tank spreader. A portion of the field was not spread due to wetness (only four loads were applied). Manure was from the home farm pit and was agitated for ½-day prior to spreading. It was not incorporated.

6.1.2. Franklin site

Table 4 summarizes field management activities at the Franklin site in 2013. The first application of the conservation practice (manure injection/reduced tillage) during fall 2013 was successful. Figure 8, from the time lapse camera, shows the manure injector in operation.

Table 4. Agronomic history of Franklin study watersheds (FRA1 and FRA2)

Date	Activity
05/06/13	Spring tillage using disc harrows and grubbers
05/08/13	Corn was planted into strips in rows 30-inches on center at a rate of 33,000 seeds per acre. The corn variety used was Mycogen TMF2L538
05/08/13	Corn starter fertilizer (19-19-19) applied via subsurface band at a rate of 150 lbs/acre
05/09/13	Pre-emergent pesticide (Lumax EZ 2.7 qts/acre) surface sprayed on corn strips
06/03/13	Hay strips cut and harvested
07/05/13	Corn fertilizer (46-0-0) was top dressed at a rate of 369 lbs/acre
09/17/13	On FRA1, winter rye cover crop spread via helicopter at a rate of 120 lbs/acre. Stand quality ~30%
10/02/13	Corn chopped for silage. Estimated yield of 23 tons/acre. Percent residue unknown.
10/09/13	Hay strips cut and harvested
10/11/13	On FRA1, manure injected using a Jamesway 4500 gallon spreader at a rate of 6,729 gal./acre. Manure was taken from Pit 1 and well-agitated prior to spreading. Manure was tested and found to contain 4.8% dry matter.

Date	Activity
10/10/13, 10/11/13	On FRA2, manure applied via low nozzle using a Houle 6300 gallon spreader at a rate of 5,040 gal./acre. Manure was taken from Pit 1 and well-agitated prior to spreading. Manure was tested and found to contain 4.8% dry matter. Manure was immediately incorporated with an International chisel plow.
10/15/13	Manure surface applied on hay strips

Figure 8. Manure injection at FRA1 on October 11, 2013

Manure injection/reduced tillage on FRA1 and chisel plowing of FRA2 produced very different field surface conditions. Figures 9 and 10 illustrate these different surface conditions. Chisel plowing FRA2 created furrows perpendicular to the slope and voids between soil clods. These furrows and voids provided substantial depression storage within the FRA2 watershed, which was largely absent on the smoother surface of the FRA1 watershed.


Figure 9. Surface condition of FRA1 field area following manure injection

Figure 10. Surface condition of FRA2 watershed following manure application and chisel plowing

Figure 11 shows the approximate boundary between the FRA1 (foreground) and FRA2 (background) watersheds. Note the apparent soil sealing and wheel tracks present in the FRA1 watershed. We suspect the differences in soil surface condition increased the runoff potential of the FRA1 watershed relative to the FRA2 watershed during fall 2013; it is unclear whether the differences is surface condition will be as pronounced in the spring following freeze-thaw action. This possible effect will continue to be tracked and explored further when more treatment phase data are available.

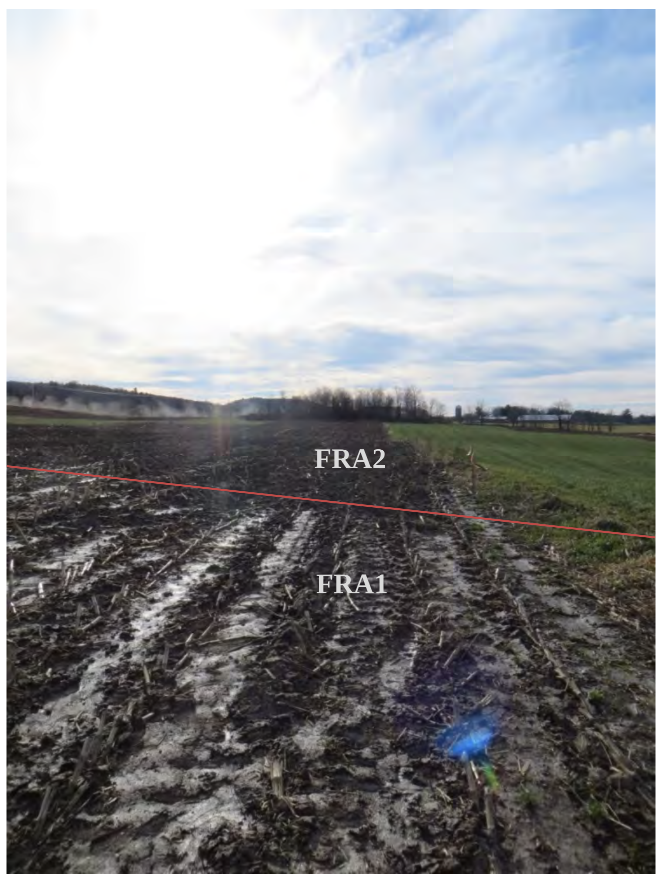

Figure 11. Boundary between FRA1 and FRA2 watersheds

6.1.3. Pawlet site

Table 5 presents a summary of agronomic data at the PAW site in 2013. Manure was applied to both fields in early May (Figure 12) and incorporated by chisel plow a day later. No manure was applied in the fall. The participating farmer commented that in 2013 both the corn yield and the soil erosion on the study fields were the "worst he has ever seen".

Table 5. Agronomic history of Pawlet study watersheds (PAW1 and PAW2)

Date	Activity
5/2/13	On PAW1, manure applied via a high nozzle tanker at a rate of 4500 gallons/ acre. Manure was taken from a well agitated pit. The manure contained 7% dry matter.
5/3/13	Manure incorporated on PAW1 by chisel plow; spring tillage by harrow connected to a Case IH 8930 tractor
5/6/13	On PAW2, manure applied via a high nozzle tanker at a rate of 4500 gallons/ acre. Manure was taken from a well agitated pit. The manure contained 7% dry matter.
5/7/13	Manure incorporated on PAW2 by chisel plow; spring tillage by harrow connected to a Case IH 8930 tractor
5/8/13	Corn was planted in rows 30-inches on center at a rate of 32,000 seeds per acre; seed variety was 95-day Pioneer. Fertilizer (27-9-18) was applied through the planter at 225 lbs/acre
5/9/13	Herbicide applied by spraying at a rate of 3 quarts/acre. Herbicide used was Lexar-EZ (EPA# 100-1414)
9/27/13	PAW2 corn harvested for silage; yield 7 tons/acre; farmer reported 60% weed cover
10/1/13	PAW1 corn harvested for silage; yield 7 tons/acre; farmer reported 60% weed cover
10/15/13	Wheat cover crop spread at 100 lbs/acre on both fields; stand quality was poor

Figure 12. Manure application on the PAW2 field area, May 6, 2013

Several large runoff events in the spring of 2013 caused substantial soil erosion of the PAW1 field. Figure 13 shows rill erosion upslope of the PAW1 station on June 5, 2014. A thick layer of sediment was deposited both immediately upslope of the PAW1 flume (Figures 13 and 14) and at the lower end of the field, smothering young corn plants.

Figure 13. Erosion and sediment deposition upslope of the PAW1 station, June 5, 2013

Figure 14. Sediment deposition immediately upslope of the PAW1 station, June 5, 2013

On October 15, a winter wheat cover crop was spread on both study fields, rather than only on the PAW1 field as planned. This mis-application of the conservation practice is discussed in Section 3.1.

6.1.4. Shelburne site

The Shelburne study fields remained wet for much of the spring and summer of 2013, which limited opportunities to cut hay and spread manure. Two hay cuts were made in 2013 and each field received one highly diluted (0.6 % dry matter) manure application. Agronomic data for the Shelburne study fields are presented in Table 6.

Table 6. *Agronomic history of Shelburne study watersheds (SHE1 and SHE2)*

Date	Activity
7/13/13	First hay cut at both SHE1 and SHE2. Baled 7/16/13. SHE1 yield was 2.12 ton dry matter/acre. SHE2 yield was 2.45 ton dry matter/acre
8/2/13	Liquid manure applied with Houle 7300 gallon tankers (by John Whitney Custom Farm Work) at a rate of 7300 gallons/acre. Manure was from a poorly agitated and very wet pit. Manure was composed of 0.6% dry matter. Manure was not incorporated.
9/3/13	Second hay cut at SHE1. Baled on 9/6/13. Yield was 0.74 ton dry matter/acre
9/4/13	Second hay cut at SHE2. Baled on 9/6/13. Yield was 0.64 ton dry matter/acre

6.1.5. Shoreham site

In 2013, there were four hay cuts and two manure applications to the Shoreham study fields (Table 7). In mid-July 2013, the SHO2 watershed was accidentally aerated, due to outdated information the participating farmer received from USDA-NRCS. This mistiming of the conservation practice is discussed further in Section 3.1.

Table 7. Agronomic history of Shoreham study watersheds (SHO1 and SHO2)

Date	Activity
4/15/13	Dry fertilizer broadcasted on both SHO1 and SHO2 at a rate of 150 lbs/acre (46-0-0 urea with coating)
5/18/13	First hay cut on both SHO1 and SHO2. Loaded 5/20/13. Estimated yield of 3.5 ton/acre as fed.
7/12/13	Second hay cut on both SHO1 and SHO2. Loaded 7/13/13. Estimated yield of 3 ton/acre as fed.
7/20/13	Manure applied on both SHO1 and SHO2 with a Peterbilt towing a Diller 4,500 gallon tank at a rate of 4,500 gallons/acre. Manure sourced from Home Pit 1, which was very well agitated prior to application. Manure was not incorporated.
8/16/13	Third hay cut on both SHO1 and SHO2. Loaded on 8/17/13. Estimated yield of 1.5 ton/acre as fed.
9/29/13	Fourth hay cut on both SHO1 and SHO2. Loaded on the same day. Estimated yield of 1 ton/acre as fed.
10/14/13	Second manure application on both SHO1 and SHO2 via a Case IH 7250 tractor towing a Houle 4300 gallon tank and a Case IH MX220 tractor towing a 4300 gallon Badger tank. Rate applied was 4300 gallons/acre. Manure sourced from Home Pit 1, which was well agitated prior to application. The manure dry matter content was unknown, but was estimated to be high.

6.1.6. Williston site

Manure was surface applied to WIL1 and WIL2 in early May, followed by tillage with a finishing harrow (Table 8). A winter rye cover crop was aerially seeded into the standing corn on both watersheds (the standard practice on this field) on September 1, 2013. The corn was chopped on October 9. 2013. After corn harvest, manure was surface applied on WIL2 and injected on WIL1. The difference in manure application method is apparent in Figure 15, taken by the time-lapse camera on the day of application, November 10, 2013. This manure application marked the beginning of treatment monitoring period.

Table 8. Agronomic history of Williston study watersheds (WIL1 and WIL2)

Date	Activity
5/713	Manure was surface applied to both WIL1 and WIL2 with a Jamesway low nozzle spreader. Each watershed received 4.5 loads with a 9,000 gallon tanker. Manure was sourced from a main pit and was moderately agitated before application. Substantial water was present in the main pit.
5/9/13	Tillage with Sunflower finishing harrow to a depth of 4-5 inches.

Date	Activity
5/16/13	Planted Mycogen F2F569 corn seed in rows 30-inches on center at a rate of 34,000 seeds/acre
5/20/13	Spray application of Lumax pesticide (EPA# 100-1152) at 2.5 oz./acre and Atrazine 90DF (EPA# 9779-253) at 0.5 lb./acre
9/1/13	WIL1 and WIL2 seeded with a winter rye cover crop by helicopter at 100 lbs/acre. The stand quality looked very light after corn harvest.
10/9/13	Corn harvested with whole plant corn chopper. Estimated yield of 16 tons/acre. 5% residue cover was left on field.
11/10/13	Manure surface applied to WIL2 with a Jamesway low nozzle spreader. Manure was injected on WIL1. Each watershed received 4.5 loads with a 9,000 gallon tanker. Manure was sourced from a main pit and was moderately agitated before application. Substantial water was present in the main pit.

Figure 15. WIL2 watershed (left of flag) and WIL1 watershed (right of flag) after manure application

6.2. Cover Crop Density Measurement

Cover crop seed was spread at the Pawlet site after corn harvest. Cover crop seed was spread over standing corn at the Franklin site (FRA1 only) and Williston site (both WIL1 and WIL2) using a helicopter. Figure 16 shows a winter wheat sprout. Cover crop establishment was poor at all three sites.

Figure 16. Germination of winter wheat seed, PAW1 watershed, November 14, 2013

Figure 17. Typical cover in FRA1 watershed, November 21, 2013

Cover crop seed was spread on FRA1 on September 17, 2013. Due to aerial application, some seed may have landed within the boundary of FRA2, the control watershed. Any seed landing in FRA2 was buried on October 11 when the field was chisel plowed. Establishment was poor in FRA1. Figure 17 presents typical surface cover beneath a quadrat in FRA1 two months after the cover crop was seeded.

Although cover crop establishment on FRA1 was generally poor, successful growth was seen in a few rows. Figure 18 shows several corn rows in which cover crop density was reasonably good. The reasons why the cover crop established more successfully in these narrow rows is not fully understood. The participating farmer noted that the harvesting equipment used in some portions of the field had "float" tires, which may have produced better seed contact with the soil, than in other areas of the field where trucks with narrow tires were used. The farmer also questioned the uniformity of seed application because the pilot apparently spread up and down the slope, starting and stopping the seeder over each corn strip.

Figure 18. Rows with successful cover crop establishment, FRA1, November 21, 2013

Percent cover measurements were recorded at FRA1 on October 18 and November 21, 2013. These surveys yielded very similar results. On both dates, about three quarters of the watershed area was bare soil and about one fifth had crop residue cover (Figure 19). Weeds and cover crop together comprised only 2-3% of the surface area.

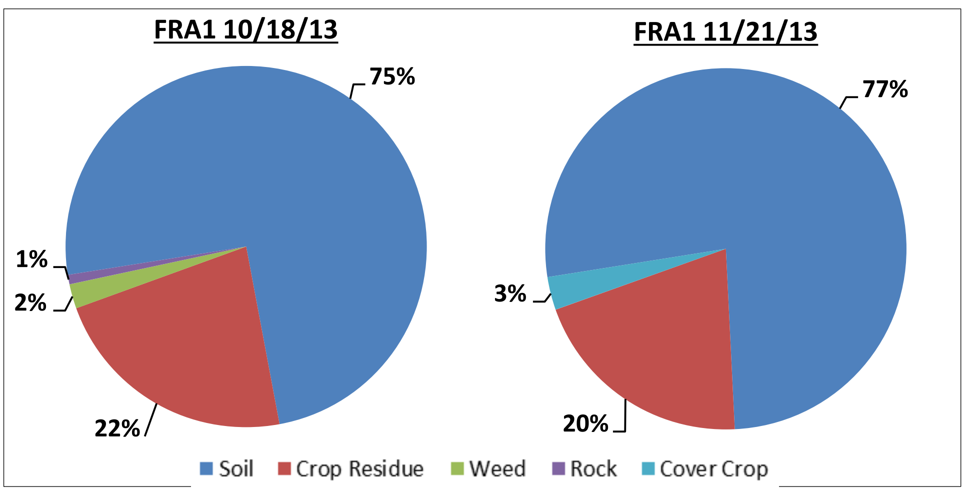

Figure 19. Percent cover in FRA1 watershed on October 18 and November 21, 2013

Cover crop establishment at both PAW1 and PAW2 was poor. This was likely due to seeding very late in the season, on October 15, 2013. Figure 20 illustrates typical surface cover observed on PAW1 and PAW2 one month after seeding.

Figure 20. Typical cover in PAW2 watershed, November 14, 2013

Percent cover measurements were recorded at PAW1 and PAW2 on November 14, 2013 (Figure 21). Slightly more than half of the surveyed area in PAW1 was bare soil, followed by crop residue and weeds. The PAW2 watershed had slightly greater weed and crop residue cover than PAW1, and therefore approximately 10 percent less bare soil. While the total vegetative cover was 45 percent on PAW1 and 55 percent on PAW2, the extent of the cover crop was negligible in both watersheds.

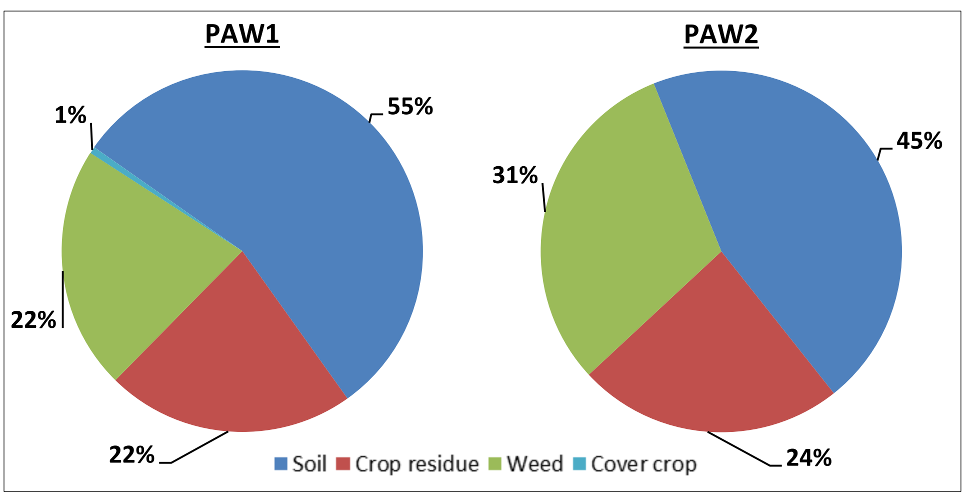

Figure 21. Percent cover in PAW1 and PAW2 watersheds on November 14, 2013

Winter rye seed was reportedly aerially spread on both WIL1 and WIL2 on September 1, 2013. Because seeding a cover crop was the standard practice on these fields, this practice was continued on both the control and treatment watersheds. Cover crop establishment was very poor. Figure 22 illustrates typical surface cover observed in both WIL1 and WIL2 two months after seeding.

Figure 22. Typical cover in WIL1 watershed, October 30, 2013

Percent cover measurements were made at WIL1 and WIL2 on October 30, 2013 (Figure 23). Bare soil, crop residue, and weeds each made up about one third of the total cover. The surface condition of WIL1 and WIL2 were very similar on the assessment date.

On the same date cover crop seed was reportedly spread on WIL1 and WIL2, the pilot seeded the fields directly across the river. Establishment on these fields was good. Based on successful establishment on these neighboring fields and the lack of any cover crop on WIL1 and WIL2, the participating farmer has speculated that the pilot made an error and did not actually seed WIL1 and WIL2.

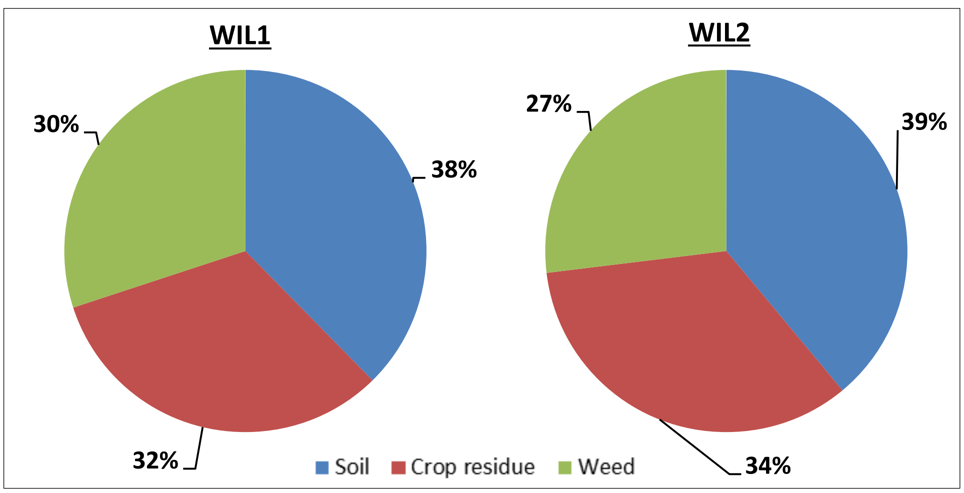

Figure 23. Percent cover in WIL1 and WIL2 watersheds on October 30, 2013

6.3. Weather Data

The following series of graphs (Figures 24 through 47) present daily precipitation totals and daily minimum, maximum, and average temperatures at each site in 2012 and 2013. These data are from the onsite tipping bucket rain gages and temperature sensors. Temperature data are presented for the whole year, beginning when the stations became operational in 2012. Daily precipitation totals are presented for the period April 1 through November 30, 2013.The tipping bucket rain gages do not accurately record solid precipitation and attempting to differentiate winter rainfall from snowmelt over the whole season is beyond the scope of this study. Some snowmelt in early spring and late fall is likely included in the daily precipitation totals presented.

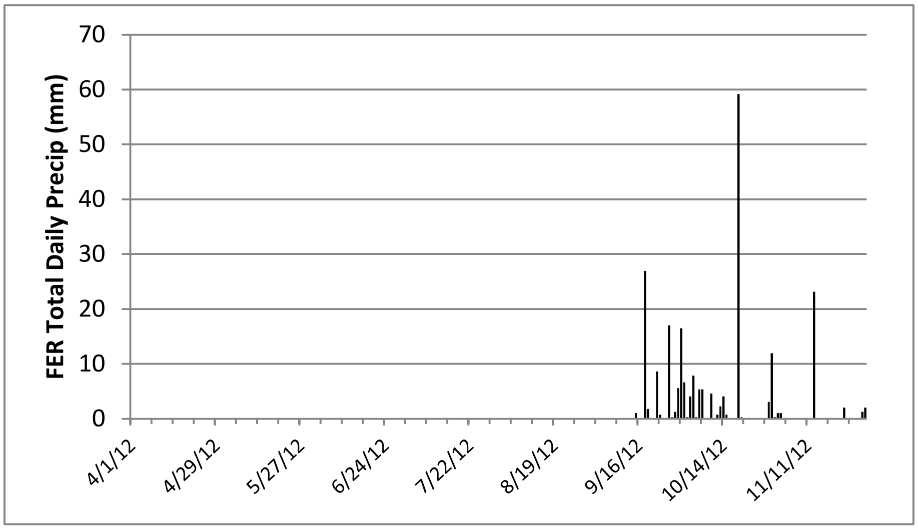

Figure 24. Ferrisburgh total daily precipitation (mm) for 2012

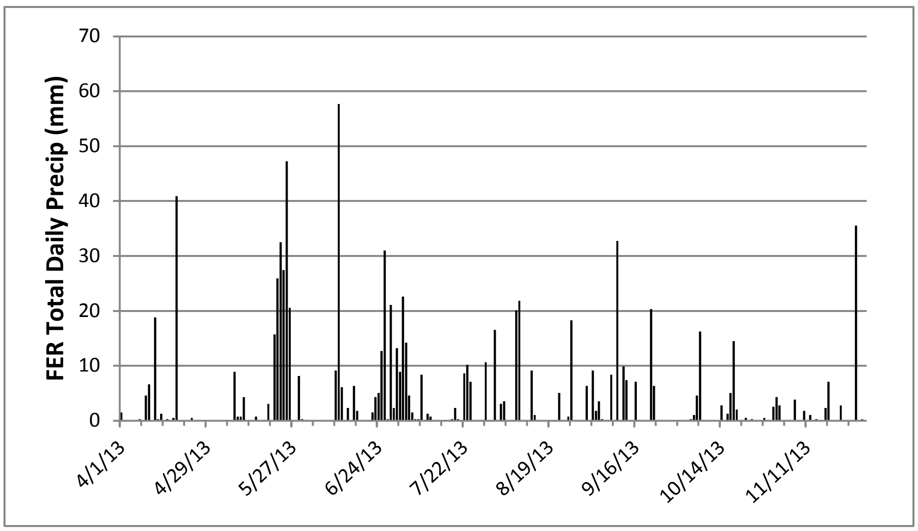

Figure 25. Ferrisburgh total daily precipitation (mm) for 2013

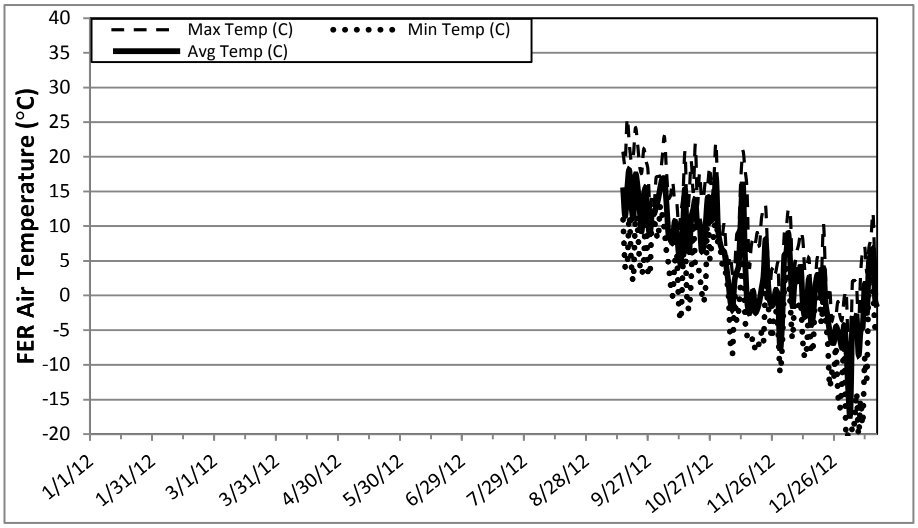

Figure 26. Ferrisburgh daily average, maximum, and minimum air temperature for 2012

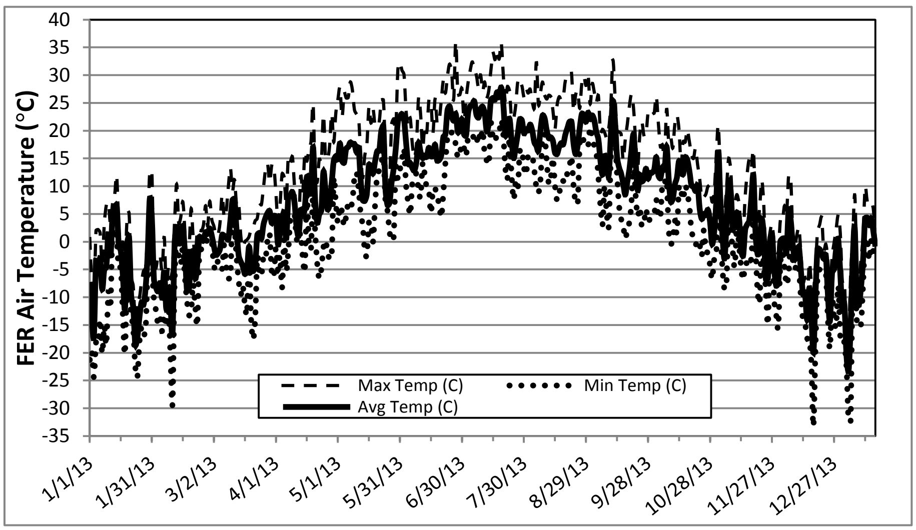

Figure 27. Ferrisburgh daily average, maximum, and minimum air temperature for 2013

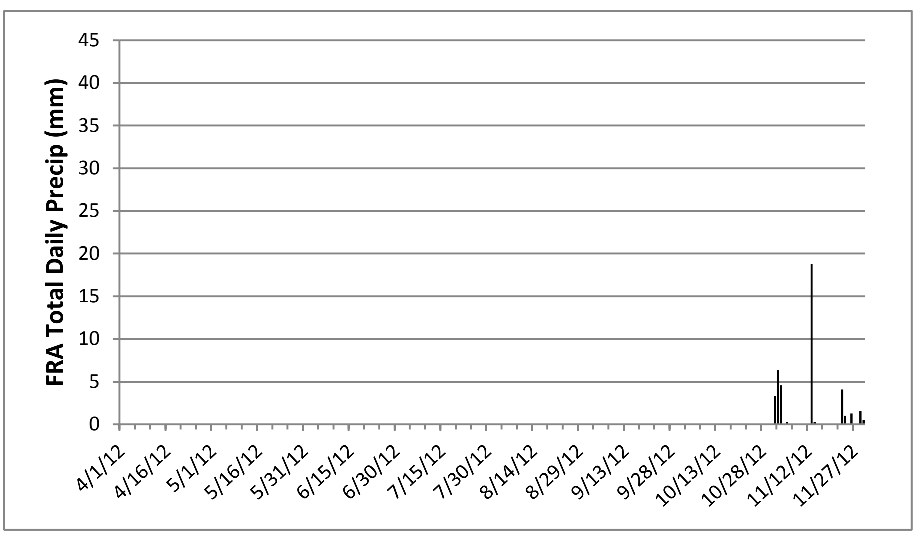

Figure 28. Franklin total daily precipitation (mm) for 2012

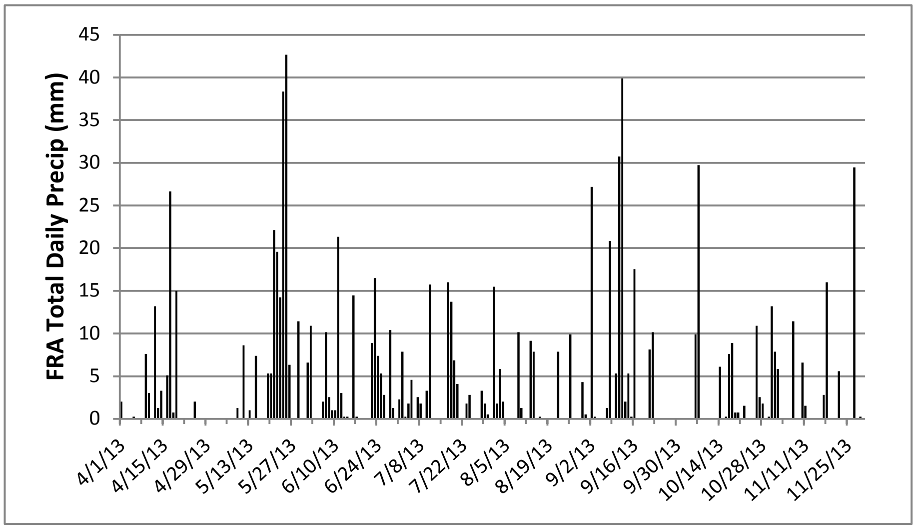

Figure 29. Franklin total daily precipitation (mm) for 2013

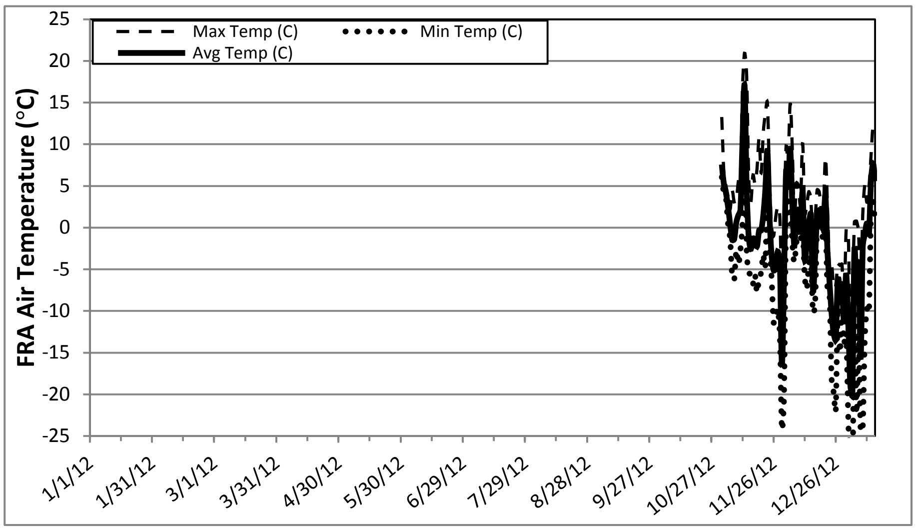

Figure 30. Franklin daily average, maximum, and minimum air temperature for 2012

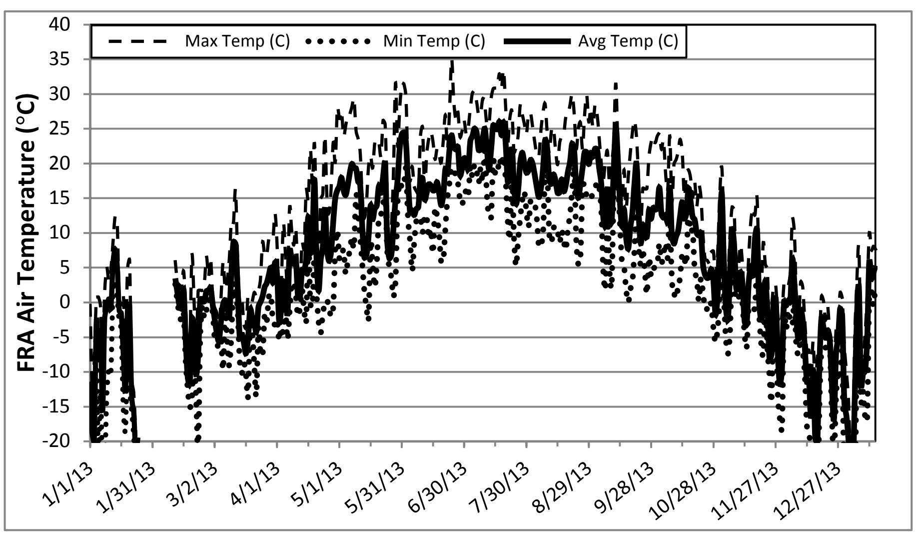

Figure 31. Franklin daily average, maximum, and minimum air temperature for 2013

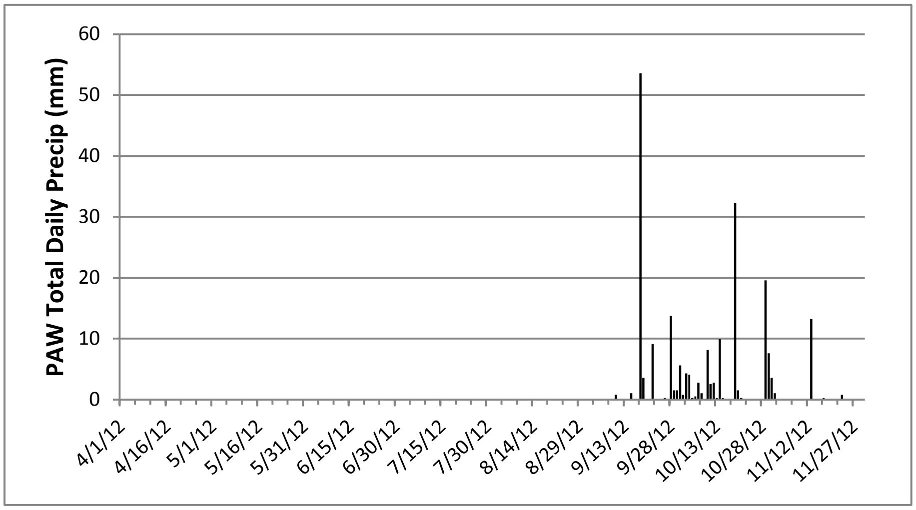

Figure 32. Pawlet total daily precipitation (mm) for 2012

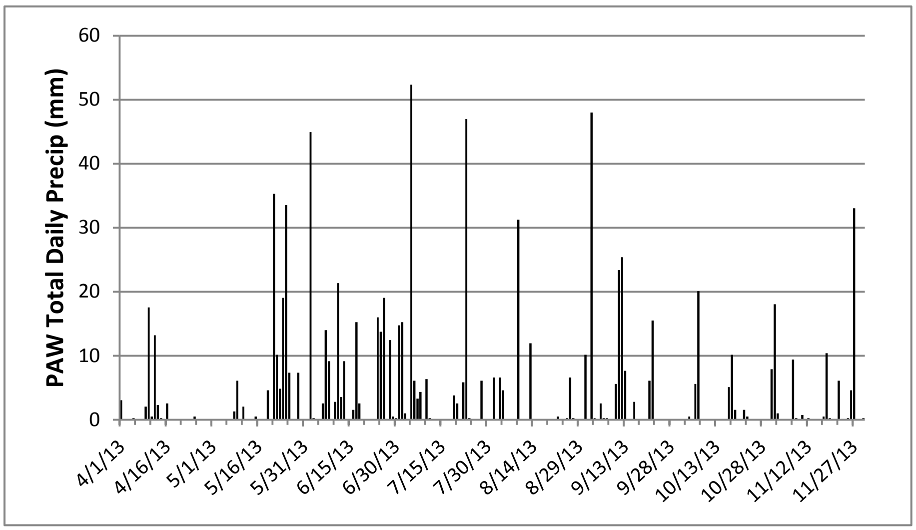

Figure 33. Pawlet total daily precipitation (mm) for 2013

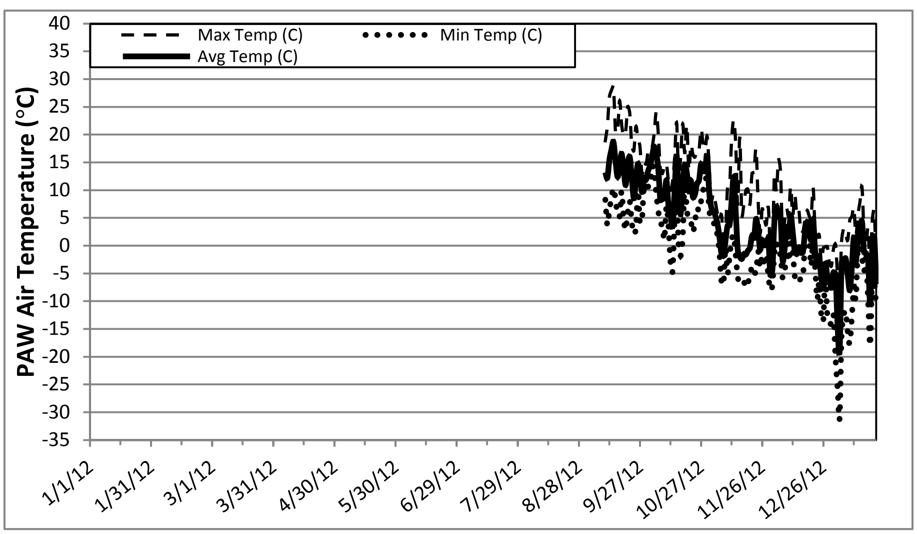

Figure 34. Pawlet daily average, maximum, and minimum air temperature for 2012

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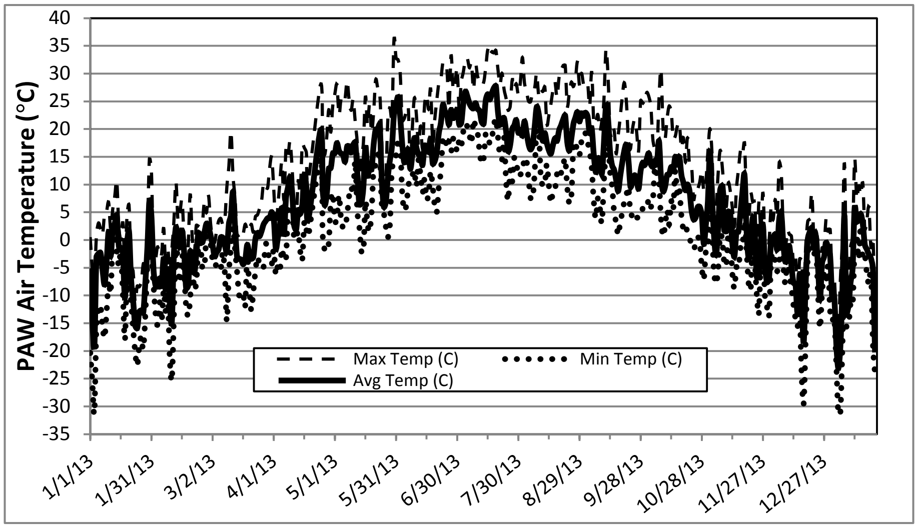

Figure 35. Pawlet daily average, maximum, and minimum air temperature for 2013

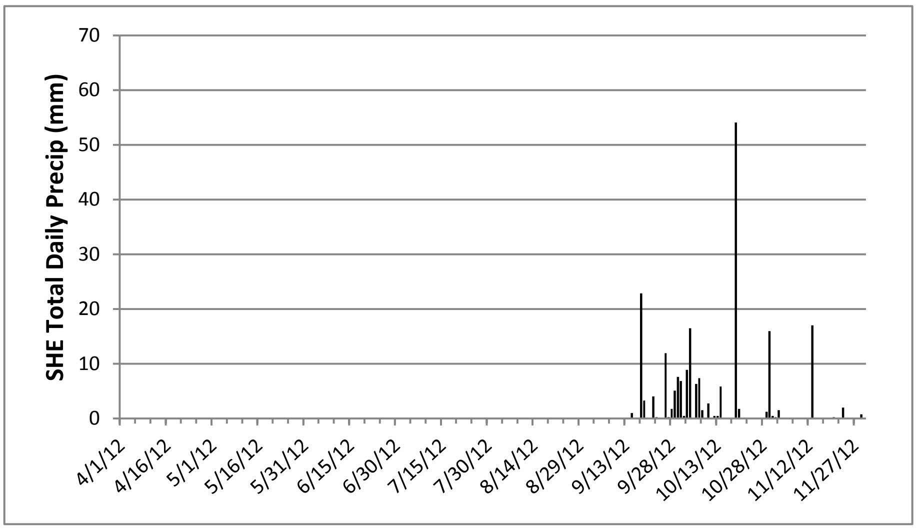

Figure 36. Shelburne total daily precipitation (mm) for 2012

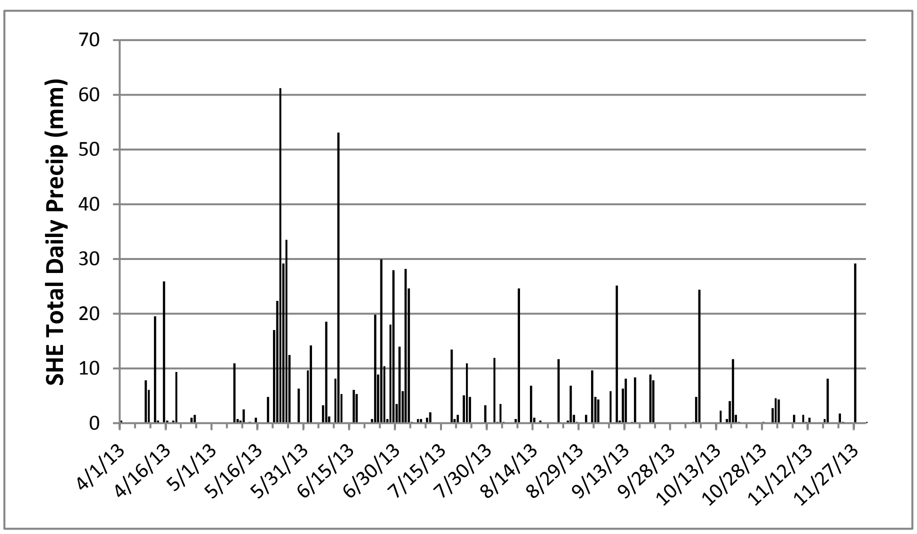

Figure 37. Shelburne total daily precipitation (mm) for 2013

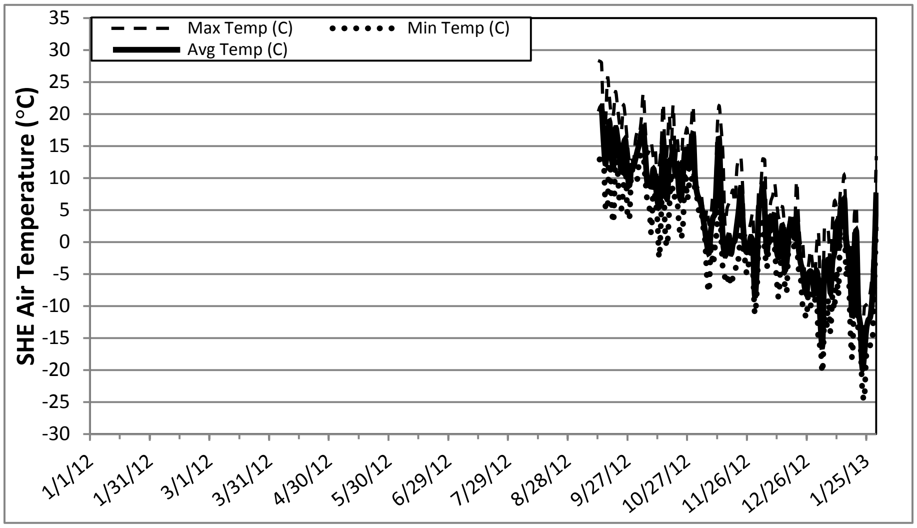

Figure 38. Shelburne daily average, maximum, and minimum air temperature for 2012

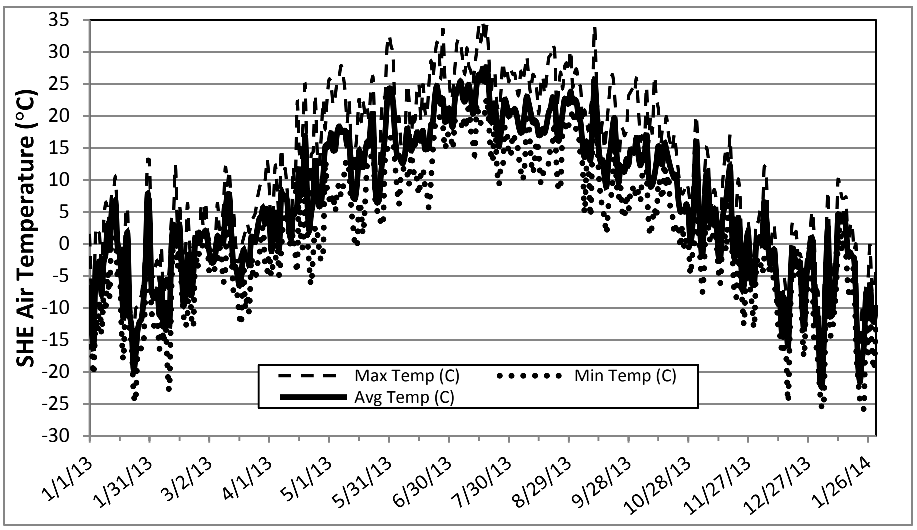

Figure 39. Shelburne daily average, maximum, and minimum air temperature for 2013

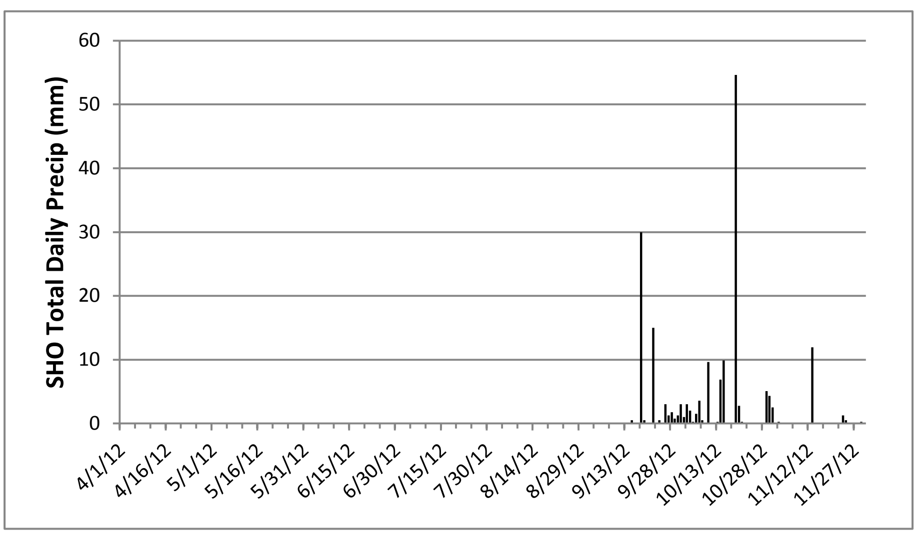

Figure 40. Shoreham total daily precipitation (mm) for 2012

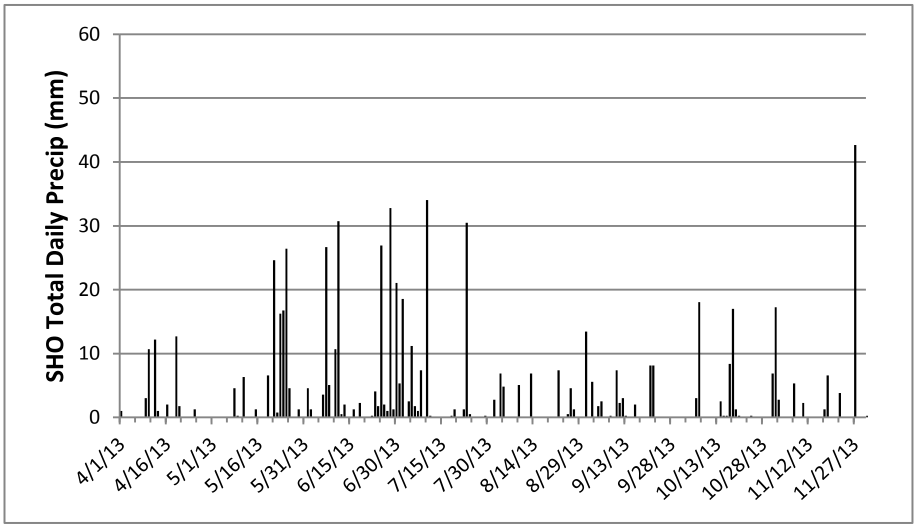

Figure 41. Shoreham total daily precipitation (mm) for 2013

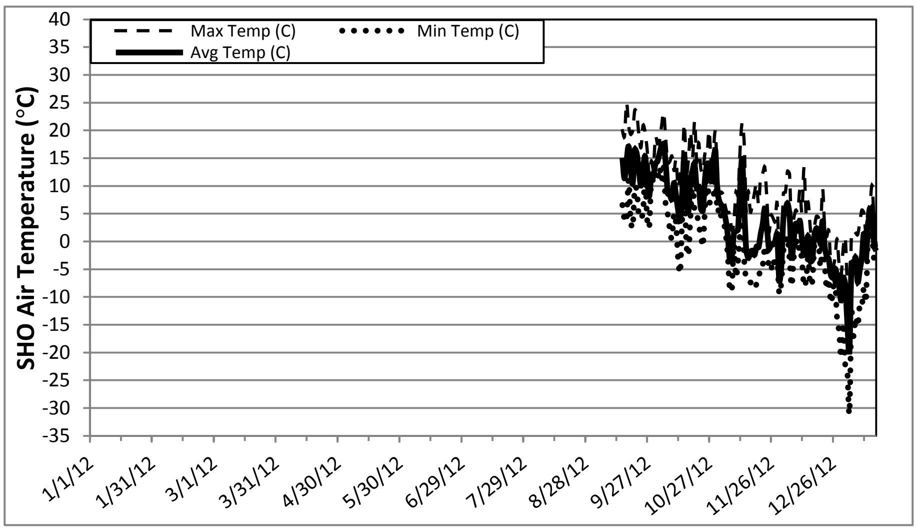

Figure 42. Shoreham daily average, maximum, and minimum air temperature for 2012

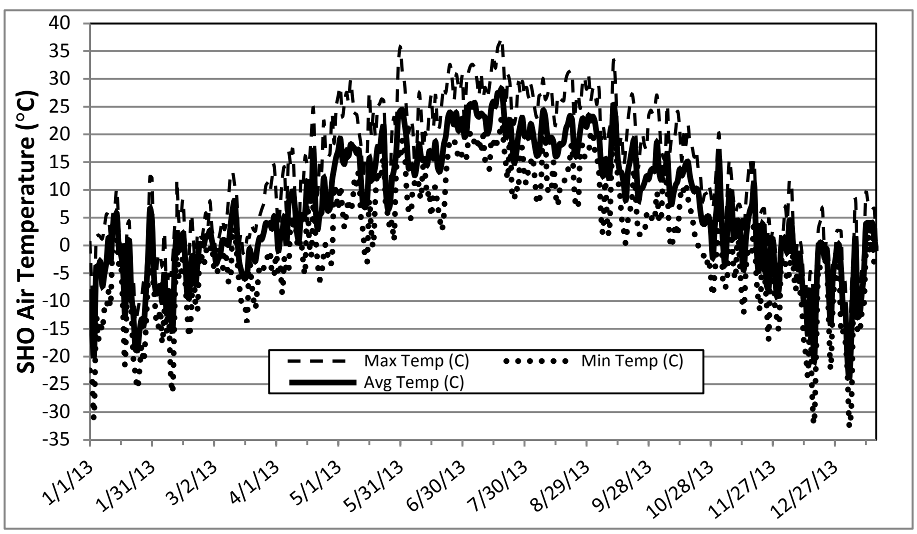

Figure 43. Shoreham daily average, maximum, and minimum air temperature for 2013

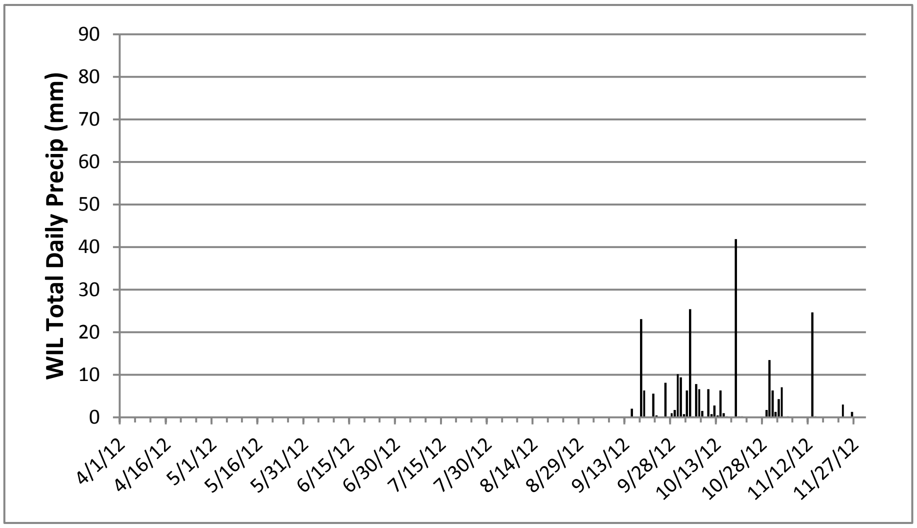

Figure 44. Williston total daily precipitation (mm) for 2012

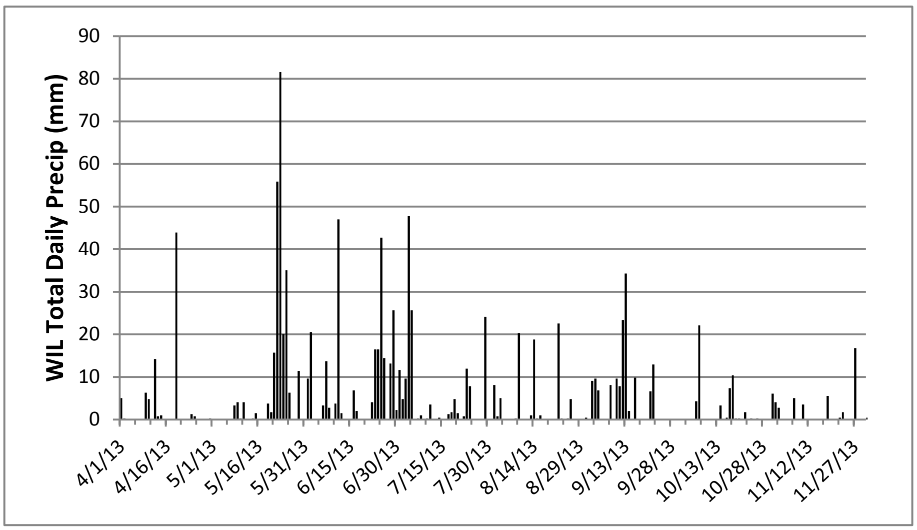

Figure 45. Williston total daily precipitation (mm) for 2013

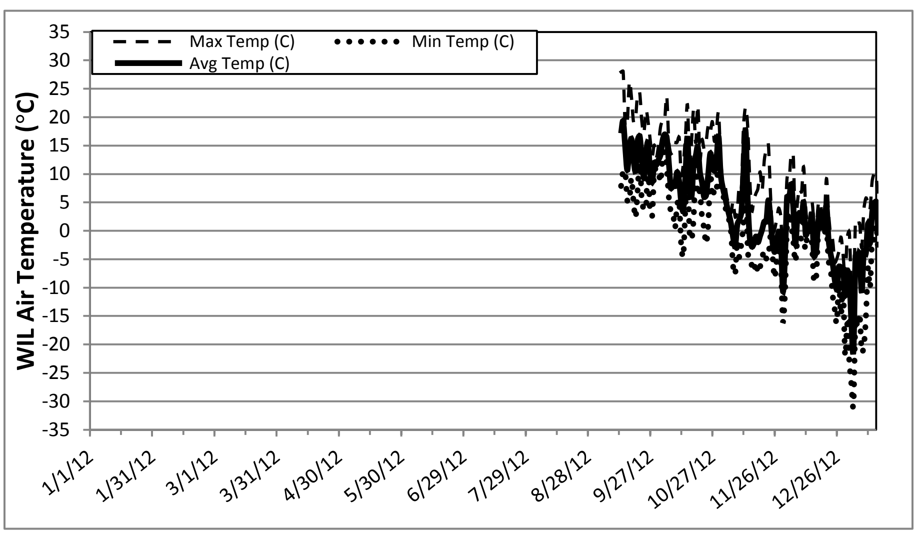

Figure 46. Williston daily average, maximum, and minimum air temperature for 2012

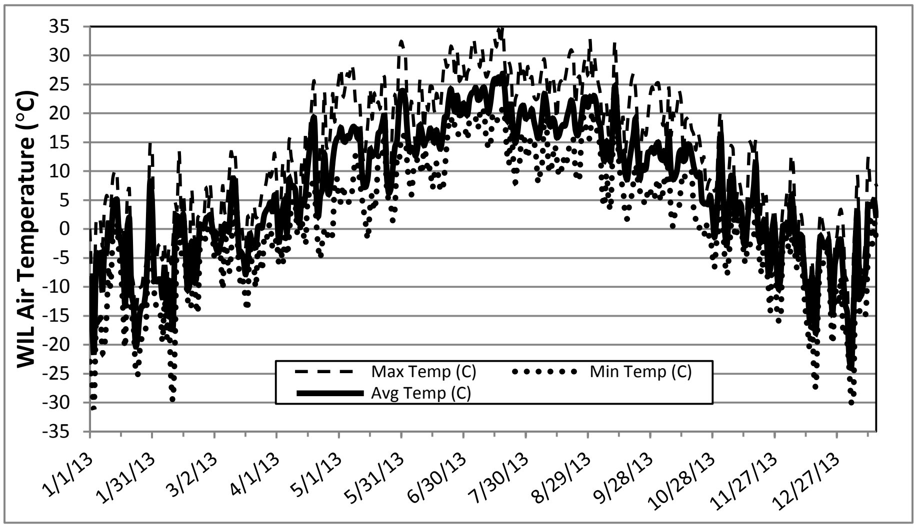

Figure 47. Williston daily average, maximum, and minimum air temperature for 2013

Monthly precipitation totals presented for each site in Tables 9 through 14 attest to the abnormally wet spring and early summer in 2013, especially at the sites in Chittenden County. In May and June, all sites received substantially more rain than the long-term normal. The Ferrisburgh, Franklin, Shelburne, and Williston sites received more than twice the long-term normal monthly rainfall total in May. In June, the Shelburne and Williston sites again received more than twice the normal amount of rain. The highest rainfall totals were at Williston for both months; 245 mm in May and 247 mm in June. The late summer and early fall was much dryer. All sites except Ferrisburgh received below average rainfall in August and Ferrisburgh, Pawlet, Shoreham, and Williston all received below average rainfall in October. The Shoreham site received below average rainfall each month between July and November.

Note that precipitation totals for winter months are included in Tables 9 through 14 and these must be interpreted with caution. The winter month totals will include a mixture of rainfall and snowmelt. Only a portion of the precipitation falling as snow is collected and melts to be recorded as liquid precipitation.

Table 9. Air temperature and precipitation compared with long-term averages, FER site

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	--	--	-5.3	27
February	-5.8	45	--	--	-4.1	27
March	-0.6	56	--	--	0.4	64
April	7.1	72	--	--	7.0	75
May	13.5	88	--	--	14.6	196
June	18.8	94	--	--	17.9	175
July	21.4	106	--	--	22.3	102
August	20.4	99	--	--	19.5	106
September	15.8	92	13.9	80	14.8	107
October	8.9	91	11.0	117	9.8	52
November	3.4	80	2.1	30	1.9	62
December	-3.4	60	-0.6	63	-4.9	34

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

Table 10. Air temperature and precipitation compared with long-term averages, FRA site

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 [2]	1.5 [2]
February	-5.8	45	--	--	-2.2 [3]	19 [3]
March	-0.6	56	--	--	-0.3	45
April	7.1	72	--	--	6.4	80
May	13.5	88	--	--	15.0	184
June	18.8	94	--	--	17.8	126
July	21.4	106	--	--	21.6	91
August	20.4	99	--	--	18.8	76
September	15.8	92	--	--	14.4	169
October	8.9	91	--	--	9.8	94
November	3.4	80	0.8	42	1.1	87
December	-3.4	60	-2.1	86	-6.5	9

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

[2] No data collected January 24-31, 2013

[3] No data collected February 1- 11, 2013

Table 11. Air temperature and precipitation compared with long-term averages, PAW site

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	-7.5	65	--	--	-5.0	42
February	-6.3	55	--	--	-3.6	36
March	-0.8	70	--	--	0.1	60
April	6.7	73	--	--	7.2	42
May	13.0	94	--	--	14.8	132
June	17.9	101	--	--	18.4	189
July	20.3	121	--	--	22.8	169
August	19.2	103	--	--	19.6	79
September	14.4	94	13.5	85	14.8	138
October	8.1	97	11.4	108	10.1	53
November	2.6	83	1.8	15	1.7	85
December	-3.9	71	-0.3	70	-3.5	60

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

Table 12. Air temperature and precipitation compared with long-term averages, SHE site

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	--	--	-5.0	20
February	-5.8	45	--	--	-4.2	15
March	-0.6	56	--	--	0.4	45
April	7.1	72	--	--	6.7	73
May	13.5	88	--	--	14.6	203
June	18.8	94	--	--	17.8	245
July	21.4	106	--	--	22.3	117
August	20.4	99	--	--	20.0	72
September	15.8	92	15.0	58	15.4	90
October	8.9	91	11.5	131	10.5	53
November	3.4	80	2.4	22	2.4	53
December	-3.4	60	-0.5	55	-4.4	37

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

Table 13. Air temperature and precipitation compared with long-term averages, SHO site

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	-7.5	65	--	--	-5.8	32
February	-6.3	55	--	--	-4.3	24
March	-0.8	70	--	--	0.3	63
April	6.7	73	--	--	6.9	46
May	13.0	94	--	--	15.0	110
June	17.9	101	--	--	18.1	180
July	20.3	121	--	--	22.6	116
August	19.2	103	--	--	19.9	54
September	14.4	94	13.6	55	15.1	41
October	8.1	97	10.9	111	10.0	58
November	2.6	83	1.6	14	1.3	82
December	-3.9	71	-1.1	67	-4.6	50

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

Table 14. Air temperature and precipitation compared with long-term averages, WIL site

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	--	--	-4.9	18
March	-0.6	56	--	--	0.0	47
April	7.1	72	--	--	6.7	79
May	13.5	88	--	--	14.4	245
June	18.8	94	--	--	17.8	247
July	21.4	106	--	--	21.9	159
August	20.4	99	--	--	19.3	84
September	15.8	92	13.8	59	14.5	140
October	8.9	91	10.8	140	9.7	57
November	3.4	80	1.3	42	1.4	40
December	-3.4	60	-1.1	65	-5.2	15

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

6.4. Summary of Event Mean Concentrations by Site

On January 7, 2014, the DEC laboratory provided an electronic file of approved analytical data for all samples submitted in 2013. These data were used with event discharge to calculate event mean concentrations and loads of each analyzed constituent. Tables 15-17 present summary statistics for event discharge ("HQ") and event mean concentrations for the hay sites and Tables 18-20 present data for the corn sites. Events excluded from statistical analysis due to ice-affected flow, bypass flow, or non-representative sampling are not included.

6.4.1. Hay site pairs

At the FER1 station, the maximum event mean concentrations of TP (15,560 µg/L), TDP (15,140 µg/L), TN (100.6 mg/L), and Cl^- (155 mg/L) were far higher than any observed at the other stations (Table 15). These EMC values were from an event on December 6, 2013, which began shortly following manure application. Manure application on the FER2 watershed was in fact cut short before spreading was finished due to rain, in part explaining the lower EMCs from FER2 compared with FER1 for this event. Relative to other events at FER1, the December 6 event also produced exceptionally high TDN and TSS values.

Despite the timing of the event and the exceptionally high TP and TDP concentrations measured, the mass of phosphorus lost in runoff during the December 6, 2013 event was only a small fraction of the P applied in manure, 1.7 percent at FER1 and 2.3 percent at FER2. Approximately 98 percent of the P applied in manure remained on the field. Total P mass transport during the December 6 event was 0.58 kg from FER1 and 0.48 kg from FER2. The mass of TP applied in manure was estimated as 28.5 kg at FER1 and 25.3 kg at FER2, calculated from the manure volume applied to the fields and a typical literature value for TP concentration in liquid dairy manure (8 lb./1000 gal. as P_2O_5 or 0.42 g/L as P) from the University of Vermont Extension's *Nutrient Recommendations for Field Crops in Vermont* (2004). This comparison was made with the expectation that this event should approximate "worst case" conditions for nutrient washoff and transport.

Table 15. Event discharge and event mean concentration statistics through January 2014, FER site

FER1	HQ (L)	TP (µg/L)	TDP (µg/L)	TN (mg/L)	TDN (mg/L)	TSS (mg/L)	Cl (mg/L)
Range	0 – 764,878	188 – 15,560	144 – 15,140	1.1 - 100.6	1 - 34.1	15.3 - 700	1 - 155
Mean[1]	42,205	548	463	2.7	2.3	96.7	3.9
Median[1]	58,594	423	397	2.1	1.9	82.9	4.1
Std. Dev.[2]	0.8	0.4	0.5	0.4	0.4	0.5	0.6
Coef.Var.[2]	18.1	15.7	17.6	101.4	107.0	24.0	96.2
N	23	17	16	17	16	17	16
FER2	**HQ (L)**	**TP (µg/L)**	**TDP (µg/L)**	**TN (mg/L)**	**TDN (mg/L)**	**TSS (mg/L)**	**Cl (mg/L)**
Range	992 – 1,201,853	343 – 4,040	230 – 3,840	1.6 - 19.7	1.2 - 7.9	4.4 - 288.1	1.3 - 47.3
Mean[1]	46,754	619	562	2.5	2.3	28.8	11.6
Median[1]	49,416	515	492	2.3	2.0	26.5	15.5
Std. Dev.[2]	0.8	0.2	0.3	0.2	0.2	0.5	0.5
Coef.Var.[2]	17.1	8.5	10.6	56.2	63.0	32.9	43.4
N	36	27	21	28	21	28	28

[1] Anti-log of statistic calculated on $\log_{10}$ transformed data

[2] Calculated on $\log_{10}$ transformed data

Despite being about an acre (0.96 A or 0.39 ha) smaller, the SHE2 watershed is more prone to runoff than the SHE1 watershed; 34 events were recorded at SHE2 compared with 24 at SHE1. The small unpaired events recorded at SHE2 were generally not sampled, but their inclusion in the summary statistics (Table 16) for total event discharge lower the calculated mean and median values for SHE2 relative to SHE1.

Constituent EMCs tended to be lower for both SHE1 and SHE2 than for other study watersheds. There was no commercial fertilizer application and only one manure application to SHE1 and SHE2 during the monitoring period, and no runoff events closely following the manure application. Despite the low nutrient inputs on these permanent hay fields, TP event mean concentrations (mean = 249 µg/L at SHE1 and 312 µg/L at SHE2), while lower than from any other study watersheds, were nonetheless roughly an order of magnitude higher than proposed criteria for wadeable streams in Vermont (VTDEC 2014) and roughly 20-30 times higher than relevant in-lake criteria for Lake Champlain (14 µg/L for Shelburne Bay and 10 µg/L for the main lake segment; VTANR and NYSDEC 2004).

Table 16. Event discharge and event mean concentration statistics through January 2014, SHE site

SHE1	HQ (L)	TP (µg/L)	TDP (µg/L)	TN (mg/L)	TDN (mg/L)	TSS (mg/L)	Cl (mg/L)
Range	0 – 2,156,106	123 - 748	88 - 630	0.8 - 12.7	0.7 - 2	3.8 - 152.2	0.5 - 14.9
Mean[1]	82,765	249	185	1.5	1.04	13.7	3.1
Median[1]	121,757	201	130	1.3	1.05	11.0	2.4
Std. Dev.[2]	0.9	0.2	0.3	0.3	0.1	0.3	0.4
Coef.Var.[2]	17.8	9.8	12.1	146.8	747.1	28.9	74.1
N	24	20	20	20	20	20	20
SHE2	**HQ (L)**	**TP (µg/L)**	**TDP (µg/L)**	**TN (mg/L)**	**TDN (mg/L)**	**TSS (mg/L)**	**Cl (mg/L)**
Range	1,418 – 1,984,944	131 - 698	114 - 635	0.9 - 2.1	0.7 - 1.7	1.8 - 20.4	7.1 - 29.5
Mean[1]	56,813	312	276	1.3	1.10	6.3	12.8
Median[1]	86,112	293	246	1.3	1.09	6.1	10.7
Std. Dev.[2]	0.8	0.2	0.2	0.1	0.1	0.3	0.2
Coef.Var.[2]	17.0	8.4	8.8	84.9	244.2	32.7	19.6
N	34	23	22	23	22	23	23

[1] Anti-log of statistic calculated on $\log_{10}$ transformed data

[2] Calculated on $\log_{10}$ transformed data

The SHO2 watershed is less than half the size of the SHO1 watershed and has produced fewer runoff events. Many runoff events at SHO1 were not paired and were therefore not sampled. Total and dissolved P and N concentrations tended to be lower at SHO2 than SHO1, while TSS concentrations were somewhat higher (Table 17).

Table 17. Event discharge and event mean concentration statistics through January 2014, SHO site

SHO1	HQ (L)	TP (µg/L)	TDP (µg/L)	TN (mg/L)	TDN (mg/L)	TSS (mg/L)	Cl (mg/L)
Range	395 – 561,791	168 – 1,698	167 – 1,780	1.7 - 5.1	0.9 - 5	6.9 - 77.5	1.7 - 21.1
Mean[1]	39,519	419	397	2.6	2.2	18.7	4.2
Median[1]	57,132	283	254	2.5	2.4	17.4	3.3
Std. Dev.[2]	0.9	0.4	0.4	0.2	0.2	0.3	0.4
Coef.Var.[2]	19.3	15.5	15.8	37.9	72.6	25.6	60.4
N	24	8	8	8	8	8	8
SHO2	**HQ (L)**	**TP (µg/L)**	**TDP (µg/L)**	**TN (mg/L)**	**TDN (mg/L)**	**TSS (mg/L)**	**Cl (mg/L)**
Range	0 – 82,244	214 - 829	198 - 695	1.4 - 2.5	0.7 - 2.5	21.3 - 62.5	1.4 - 6.2
Mean[1]	12,331	324	295	2.0	1.7	27.5	2.7
Median[1]	34,799	258	250	2.1	1.8	24.9	2.0
Std. Dev.[2]	0.9	0.2	0.2	0.1	0.2	0.1	0.2
Coef.Var.[2]	21.3	9.5	8.1	31.8	78.0	10.3	58.3
N	11	8	8	8	8	8	8

[1] Anti-log of statistic calculated on $\log_{10}$ transformed data

[2] Calculated on $\log_{10}$ transformed data

6.4.2. Corn site pairs

Tables 18-20 present summary statistics for calibration period runoff events that occurred between September 2012 and January 2014. These tables do not include events at the Franklin and Williston sites that occurred after conservation practices were implemented (i.e., after fall manure applications). There are insufficient data from the treatment period at these sites to analyze these data separately.

Under conventional management, the FRA1 watershed was more prone to runoff than the FRA2 watershed; 20 events were recorded at FRA1 compared with 14 at FRA2 during the calibration period. The small unpaired events recorded at FRA1 were generally not sampled, but their inclusion in the summary statistics (Table 18) for total event discharge lowers the calculated mean and median values for FRA1 relative to FRA2. Both FRA1 and FRA2 yielded relatively high event mean concentrations of total and dissolved P and N. Nitrogen concentrations have been especially high, which is discussed further in Section 6.5.

Table 18. Event discharge and event mean concentration statistics through January 2014, FRA site

FRA1	**HQ (L)**	**TP (µg/L)**	**TDP (µg/L)**	**TN (mg/L)**	**TDN (mg/L)**	**TSS (mg/L)**	**Cl (mg/L)**
Range	31 – 1,437,397	195 – 2,080	154 - 853	2.1 - 20.4	1.4 - 19.3	12.2 – 2,398	2.5 - 34.2
Mean[1]	80,781	594	369	5.7	4.5	58.1	11.4
Median[1]	134,134	585	417	4.3	2.9	34.7	11.5
Std. Dev.[2]	1.1	0.3	0.3	0.4	0.4	0.7	0.4
Coef.Var.[2]	21.5	11.2	10.2	46.9	61.0	38.3	34.8
N	20	11	11	11	11	11	11
FRA2	**HQ (L)**	**TP (µg/L)**	**TDP (µg/L)**	**TN (mg/L)**	**TDN (mg/L)**	**TSS (mg/L)**	**Cl (mg/L)**
Range	0 – 1,374,919	230 – 1,910	173 - 870	2.2 - 26.6	1.4 - 26.6	8.8 – 1,414	2.8 - 42.5
Mean[1]	176,708	606	404	6.1	4.7	48.3	10.4
Median[1]	207,884	620	485	5.0	3.3	30.4	7.8
Std. Dev.[2]	0.6	0.3	0.2	0.4	0.4	0.7	0.4
Coef.Var.[2]	11.2	10.6	8.9	47.5	65.3	39.9	36.4
N	14	9	9	9	9	9	9

[1] Anti-log of statistic calculated on log_{10} transformed data

[2] Calculated on log_{10} transformed data

The Pawlet study watersheds have produced more runoff events than any other study watersheds. PAW1 (6.0 A, 2.6 ha) is medium-sized compared with other study watersheds and PAW2 (3.1 A, 1.4 ha) is among the smallest, yet they appear to be the most prone to runoff off all the watersheds. Total and dissolved P and N EMCs have been highly variable and have occasionally been quite high (maximum of 2,280 µg/L P at PAW1 and 1.555 µg/L P at PAW2; Table 19). However, the more exceptional results from the Pawlet watersheds have been the exceedingly high total suspended solids concentrations measured during certain events (maximum TSS EMCs were 4,428 mg/L for PAW1 and 1,850 mg/L for PAW2).

Table 19. Event discharge and event mean concentration statistics through January 2014, PAW site

PAW1	HQ (L)	TP (µg/L)	TDP (µg/L)	TN (mg/L)	TDN (mg/L)	TSS (mg/L)	Cl (mg/L)
Range	0 – 818,197	68 – 2,280	9 - 734	0.9 - 34.1	0.6 - 36.5	3.7 – 4,428	1.4 - 43.5
Mean[1]	76,466	382	87	3.3	2.0	125.6	9.7
Median[1]	126,151	390	67	3.1	1.6	140.0	10.2
Std. Dev.[2]	0.8	0.5	0.5	0.4	0.4	0.8	0.3
Coef.Var.[2]	15.6	17.6	23.3	75.5	144.5	38.4	33.4
N	40	29	29	29	29	29	28
PAW2	**HQ (L)**	**TP (µg/L)**	**TDP (µg/L)**	**TN (mg/L)**	**TDN (mg/L)**	**TSS (mg/L)**	**Cl (mg/L)**
Range	350 – 370,825	72 – 1,555	16 - 974	0.6 – 31	0.3 - 22.1	7.9 – 1,850	2.2 - 43.7
Mean[1]	32,153	323	78	2.3	1.3	89.8	7.8
Median[1]	47,616	332	60	2.1	0.9	90.2	7.9
Std. Dev.[2]	0.7	0.4	0.5	0.4	0.5	0.7	0.4
Coef.Var.[2]	16.1	15.2	28.1	110.7	400.2	35.2	39.3
N	45	33	32	33	32	33	32

[1] Anti-log of statistic calculated on $\log_{10}$ transformed data

[2] Calculated on $\log_{10}$ transformed data

Both WIL1 and WIL2 have tended to produce runoff with high concentrations of total phosphorous. For the calibration period, the mean of the WIL2 EMC exceeded 1,100 µg P/L (Table 20). The highest TP EMC measured at WIL2 was 3,300 µg/L. TDP EMCs from WIL2 have also been exceptionally high.

Table 20. Event discharge and event mean concentration statistics through January 2014, WIL site

WIL1	HQ (L)	TP (µg/L)	TDP (µg/L)	TN (mg/L)	TDN (mg/L)	TSS (mg/L)	Cl (mg/L)
Range	0 – 520,034	295 – 1,558	180 - 575	1.4 - 6	0.7 - 6.4	7.7 - 596	0.7 - 3.6
Mean[1]	17,324	624	295	2.4	1.8	69.4	1.8
Median[1]	16,291	652	278	2.0	1.5	60.0	1.9
Std. Dev.[2]	0.8	0.2	0.1	0.2	0.3	0.6	0.2
Coef.Var.[2]	19.7	6.5	5.6	50.1	106.7	30.3	78.2
N	18	15	15	15	15	15	15
WIL2	**HQ (L)**	**TP (µg/L)**	**TDP (µg/L)**	**TN (mg/L)**	**TDN (mg/L)**	**TSS (mg/L)**	**Cl (mg/L)**
Range	1724 – 233,489	429 – 3,300	222 – 2,780	1.1 - 6.4	0.4 - 5.4	16.2 – 1,383.5	0.7 - 6.8
Mean[1]	12,029	1,126	564	2.5	1.2	145.9	1.8
Median[1]	9,898	1,293	545	2.3	1.1	166.3	1.4
Std. Dev.[2]	0.6	0.3	0.3	0.2	0.3	0.6	0.3
Coef.Var.[2]	15.3	8.7	10.6	57.4	324.0	25.8	128.4
N	23	20	20	20	20	20	20

[1] Anti-log of statistic calculated on $\log_{10}$ transformed data

[2] Calculated on $\log_{10}$ transformed data

6.5. Comparing Event Mean Concentrations across Paired Watershed Sites

Figures 48-49 and 51-54 compare the distributions of event mean concentrations of the monitored constituents among the study watersheds. The WIL and FRA sites (both corn) tend to have the highest TP EMCs, whereas PAW (corn) and SHE (continuous hay) tend to have the lowest (Figure 48). TP concentrations have been most variable at PAW and least variable at FER (hay) and SHE. PAW and SHE have generally shown the lowest TDP concentrations, and WIL and FER the highest (Figure 49).

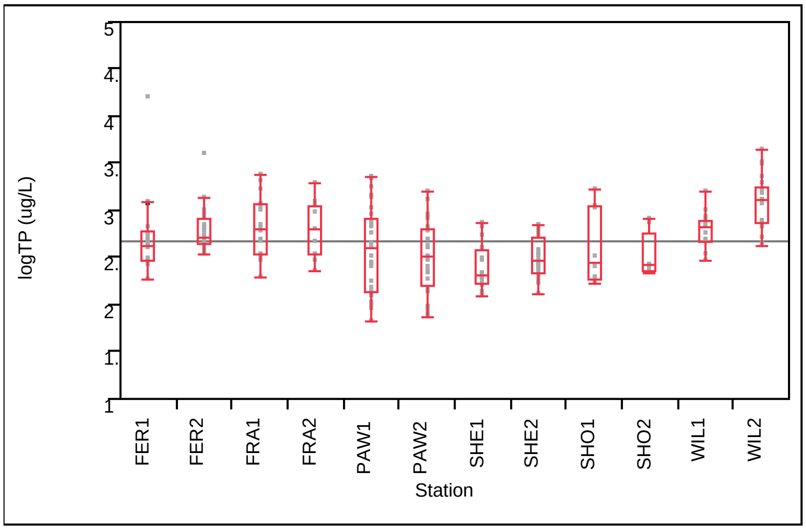

Figure 48. Distributions of total P event mean concentrations through 2013

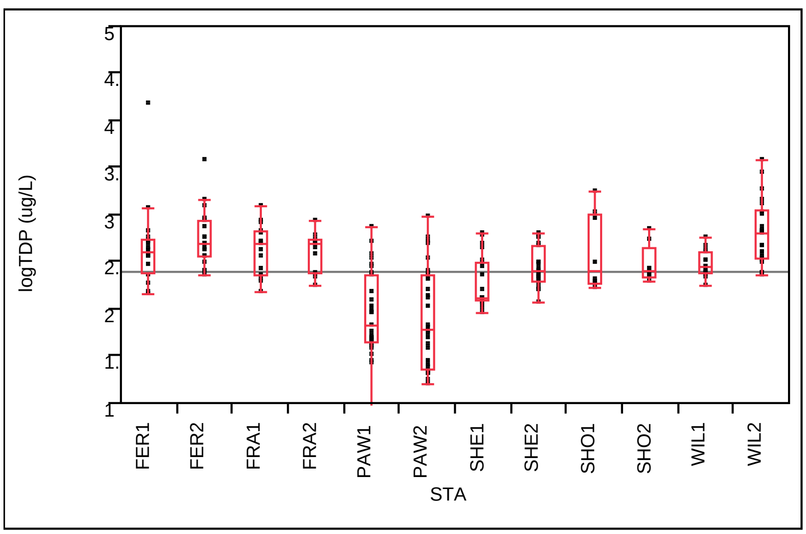

Figure 49. Distributions of total dissolved P event mean concentrations through 2013

Event mean concentrations of TP and TDP are clearly positively correlated with soil phosphorus levels among the study watersheds. Composite soil samples were collected from the study watersheds between October and December 2012 and were analyzed by both USDA ARS Grassland Soil and Water Research Laboratory (Temple, TX) and the UVM Agricultural and Environmental Testing Laboratory. USDA ARS reported nutrient mass in each field in pounds per acre; these results were presented in the Year 1 report. Through

January 2014, there was a reasonably strong relationship between the soil nutrient mass data calculated by USDA ARS and event mean concentrations of TP in runoff. Both total P and inorganic P in soil were positively associated with median TP EMCs in runoff, with R^2 values of 0.79 and 0.82, respectively (Figure 50). Surprisingly, total and inorganic P levels in soil explained less of the observed variance in median TDP EMCs (R^2 = 0.33 for total soil P and R^2 = 0.35 for inorganic soil P).

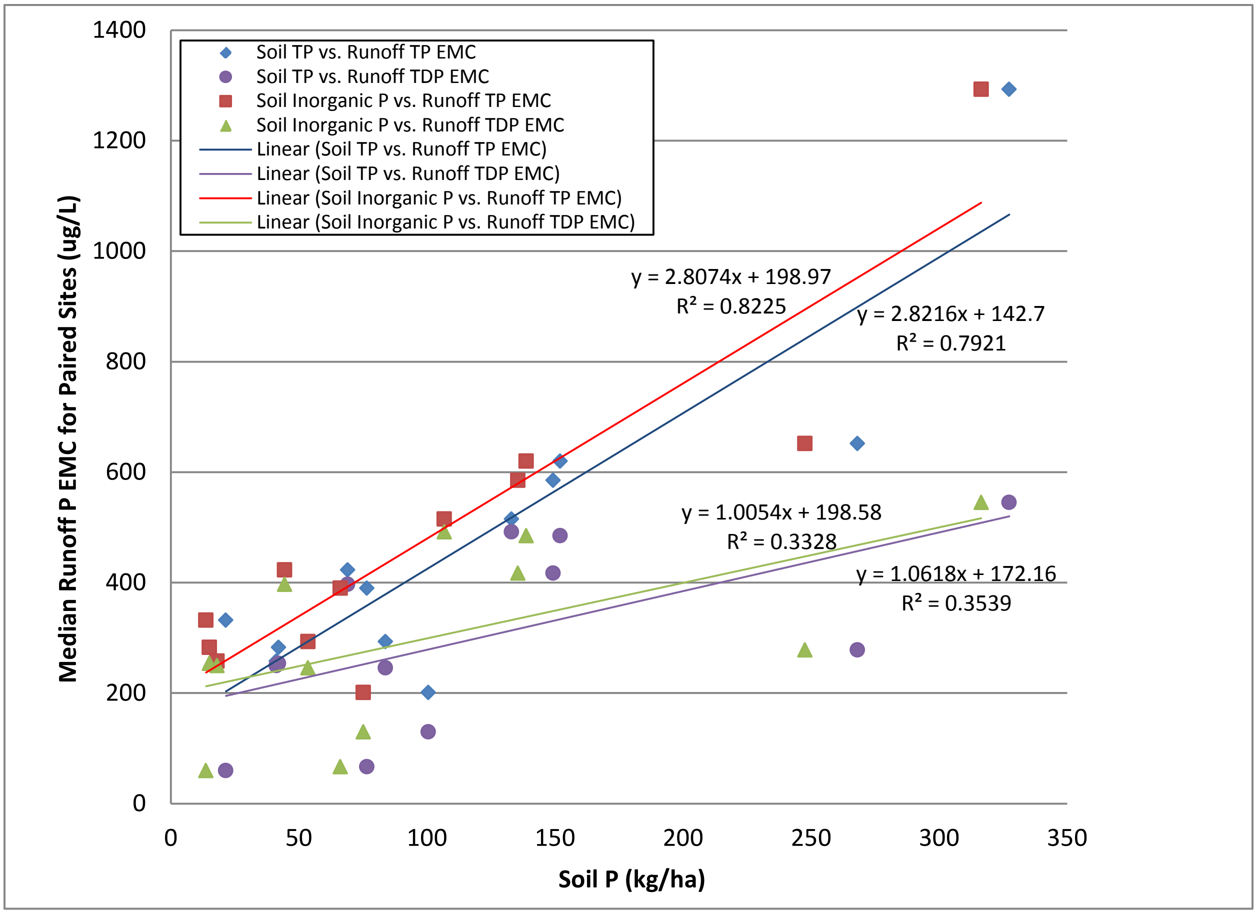

Figure 50. Relationships between soil P[1] and median P EMCs[2] in runoff from study watersheds

1. Soil P values based on analyses conducted by USDA ARS Grassland Soil and Water Research Laboratory (Temple, TX) of watershed composite soil samples collected from Oct. – Dec., 2012 (See Year 1 Report)

2. Median TP and TDP concentrations in runoff calculated as the anti-log of the median of log10 transformed EMCs for each station through January 2014 (see Tables 15 – 20)

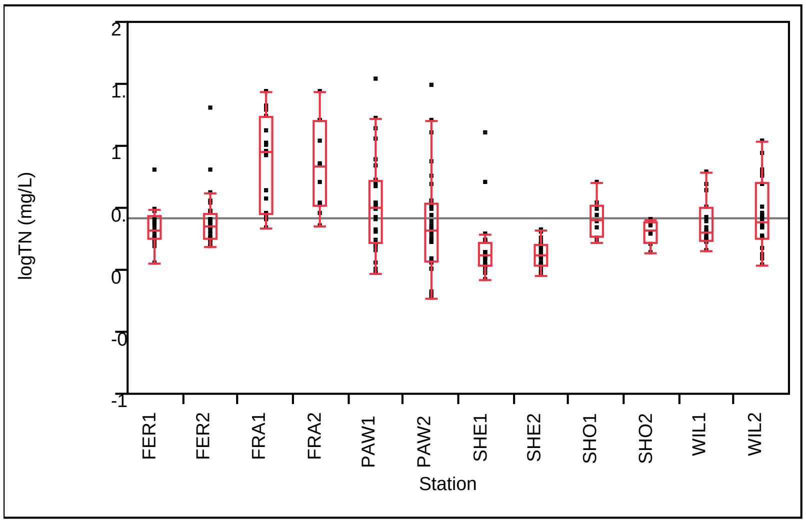

Figure 51. Distributions of total N event mean concentrations through 2013

The FRA and PAW sites (both corn) have shown the highest TN and TDN EMCs, with N levels at FRA being highly variable (Figure 51-52). N concentrations at SHE (permanent hay) have generally been the lowest and least variable among the monitored fields. The high N concentrations in runoff from the FRA1 and FRA2 watersheds may reflect high inputs; in both 2012 and 2013, the application rates of commercial nitrogen fertilizer at the FRA site were far higher than in the other study watersheds. A preliminary comparison of TN and TDN concentrations in runoff with total and inorganic soil N levels calculated by USDA ARS demonstrated only very weak relationships.

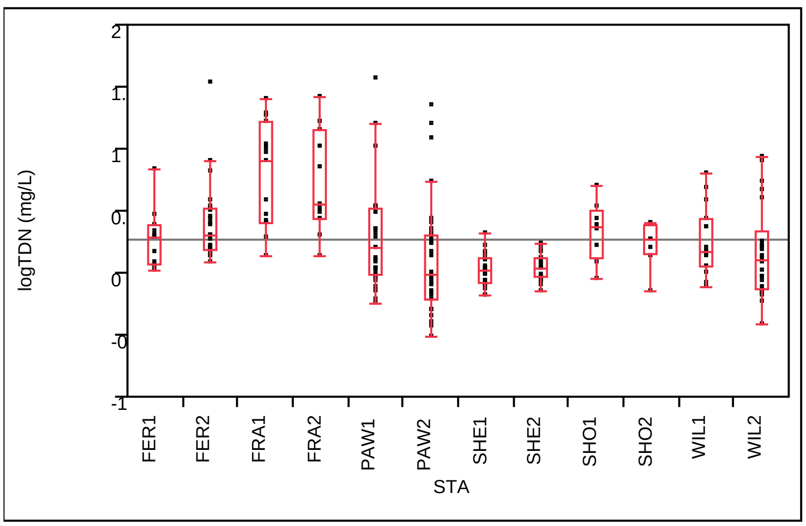

Figure 52. Distributions of total dissolved N event mean concentrations through 2013

PAW, WIL and FRA (all corn) have generally recorded the highest and most variable TSS EMCs (Figure 53). TSS concentrations have been lowest and least variable at SHE and SHO, suggesting markedly lower erosion rates on these permanent hay fields.

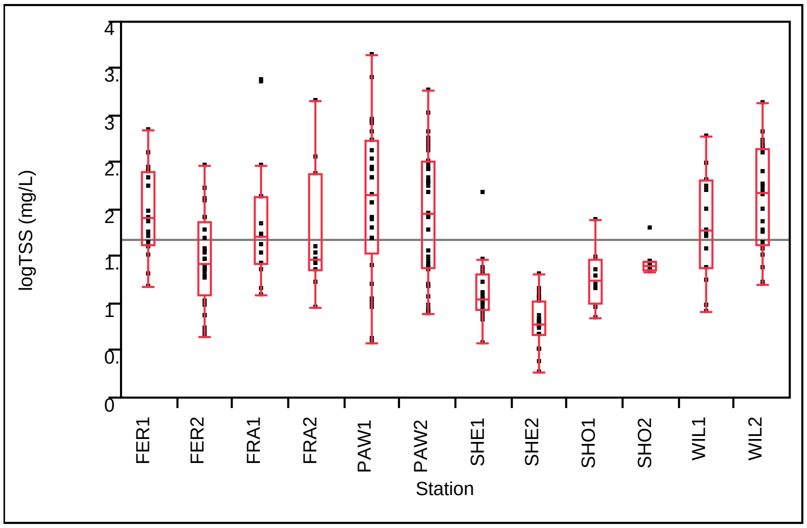

Figure 53. Distributions of total suspended solids event mean concentrations through 2013

Figure 54 illustrates the distributions of event mean chloride concentrations by station. FRA (corn), PAW (corn), and FER2 (hay) have produced the highest chloride concentrations; chloride concentrations have tended to be lowest at WIL (corn) and SHO (hay).

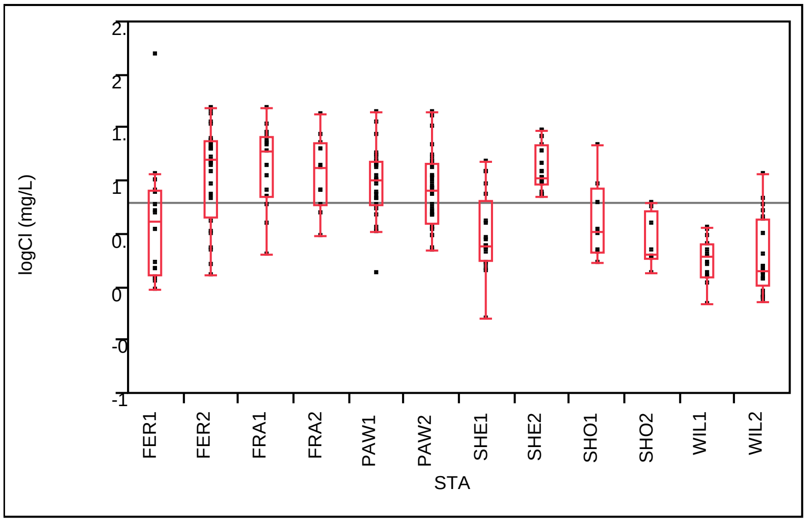

Figure 54. Distributions of chloride event mean concentrations through 2013

On the average across all monitored stations, about 65 percent of TP has occurred as TDP (Figure 55). However, there have been strong differences among the stations. Although they have occasionally exhibited high proportions of TDP, PAW and WIL (both corn) have generally shown the lowest percentage of dissolved P, with PAW averaging 50 percent or lower dissolved P and sometimes less than 10 percent. On the other hand, FER, SHE, and SHO (all hay) have tended to have the highest proportion of dissolved P, with TDP comprising almost 100 percent of TP on some events. Finding the highest proportion of dissolved P in runoff from the hayland sites (FER, SHE, and SHO) and the lowest and most variable from the corn sites (PAW and WIL) is not surprising given the low erosion potential from hayland.

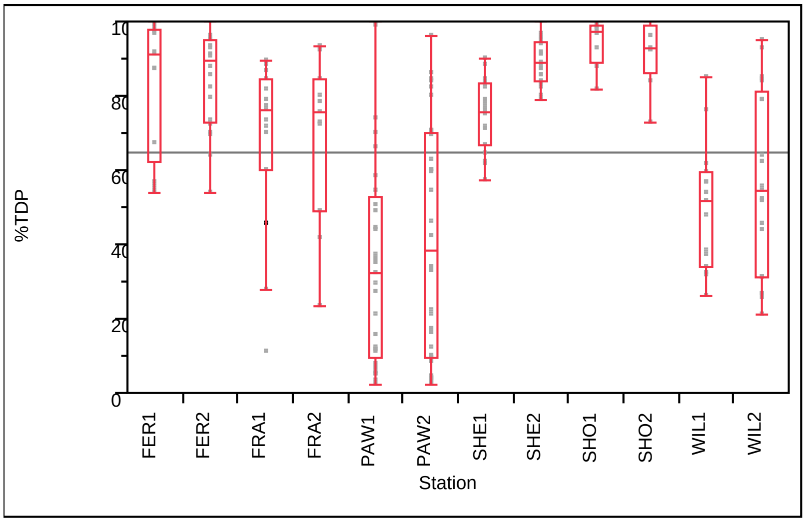

Figure 55. Percent of total phosphorus as dissolved through 2013

On average, nearly 75 percent of TN measured at the paired watershed monitoring stations occurred as TDN (Figure 56). All stations except SHE1 and WIL1 expressed 100 percent of TN in the dissolved form at times. Variability was highest at PAW, WIL, and FRA sites, consistent with the greater erosion potential from these corn fields.

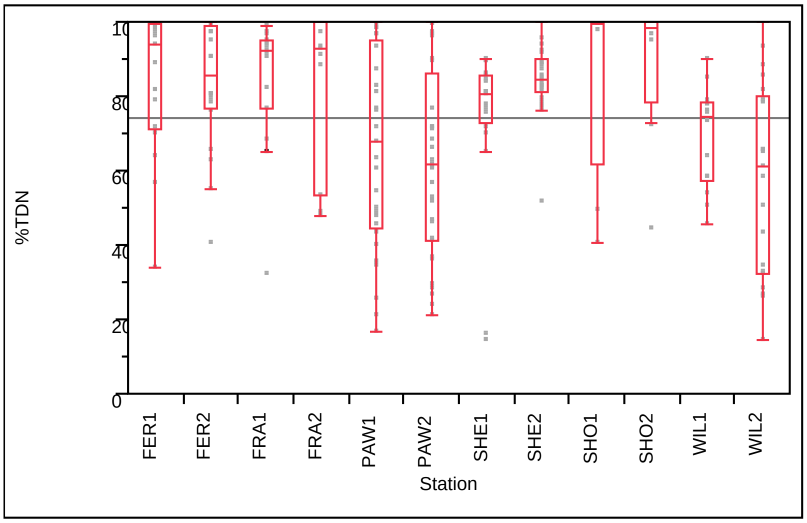

Figure 56. Percent of total nitrogen as dissolved through 2013

6.6. Regression Analysis Results

The data set used for the primary statistical analyses includes total event discharge (Q), event mean concentration (TP, TDP, TN, TDN, TSS, and Cl), and total event load (TPx, TDPx, TNx, TDNx, TSSx, and Clx) for each event at each monitored location. Because significant regression relationships between variables measured at the control and treatment watershed pairs during the pre-treatment (calibration) period are fundamental requirements of the paired watershed analysis, these regression relationships were re-evaluated with all the calibration period data through January 2014. All regression models were calculated using $\log_{10}$ transformed data. Tables 21 through 26 present calibration period regression equations and statistics for each watershed pair at each study site. Regression plots and additional statistics are given in Appendix D.

Calibration regressions in Tables 21 through 26 for all monitored variables between watershed pairs are statistically significant at $P < 0.10$ with the exception of the TDP and TDN concentration at the Williston site (76 out of 78 relationships tested were statistically significant). Because the relationships between the two watersheds for TDP and TDN at the WIL site are not significant, it will not be possible to assess the effect of implementing the conservation practice at this site on these dissolved constituents. It will be possible to analyze the effect of treatment on any other parameter if the corresponding treatment period regression is also significant.

In Tables 21-26, the regression equation describes the line that best fits the paired, log-transformed data points (by the sum of least squares regression method). The coefficient of determination, R^2, is a statistic representing the goodness of fit of the regression model. R^2 values range from 0 to 1, with higher values indicating better model fit to the data (i.e., less unexplained variance). The adjusted R^2 statistic adjusts the R^2 based on the number of terms in the regression model and the sample size; it is therefore a more comparable statistic than R^2 in many regression applications. The F ratio tests the null hypothesis that all of the regression coefficients (the intercept and slope terms in the equation) are equal to zero. The F ratio is the ratio of the mean regression sum of squares divided by the mean error sum of squares. In Tables 21-26, the value of Prob>F is the probability that the regression model's intercept and slope terms are zero. For example, a Prob>F value of <0.01 means that there is less than a one percent chance that both the slope and intercept are zero, indicating that the equation is valid (i.e., the independent variable is not purely random with respect to the dependent variable).

6.6.1. Ferrisburgh site (hay)

Regression equations for all variables were statistically significant, with R^2 values in the 0.6 – 0.9 range, except for chloride export (Clx) with $R^2 = 0.42$ (still significant at $P < 0.005$) (Table 21). Observed data occurred over two to three orders of magnitude, suggesting a reasonable likelihood that the range of treatment period will overlap that of the calibration period, a feature that facilitates interpretation of treatment effects. Discharge and concentration and export of most constituents did not differ significantly between FER1 and FER2 (statistics not shown); mean TSS concentration at FER1 was significantly higher than at FER2 and mean chloride concentration and export were higher at FER2 than at FER1. Finally, it should be noted that the regressions for P and N concentration are highly leveraged by a single outlier (representing the runoff event that occurred immediately after a manure application). Although the calibration regressions are statistically adequate to proceed with treatment, it will be desirable to collect additional pre-treatment data at high P and N concentrations to confirm the regression relationships across the full range of observed data. Unfortunately, given the low probability of another manure application before treatment is applied, collection of additional calibration data at high runoff nutrient concentrations appears unlikely.

Table 21. Calibration period linear regression statistics, FER site

Variable	Symbol	Equation	R^2 adj.	F Ratio	*Prob > F*
Event Discharge	Q	log(FER2 Q) = 0.536 log(FER1 Q) + 2.81	0.75	55.0	<0.001
TP Concentration (µg /L)	[TP]	log(FER2 TP) = 0.604 log(FER1 TP) + 1.13	0.87	99.7	<0.001
TDP Concentration (µg/L)	[TDP]	log(FER2 TDP) = 0.593 log(FER1 TDP) + 1.14	0.78	49.8	<0.001
TN Concentration (mg/L)	[TN]	log(FER2 TN) = 0.553 log (FER1 TN) + 0.230	0.82	67.7	<0.001
TDN Concentration (mg/L)	[TDN]	log(FER2 TDN) = 0.523 log(FER1 TDN) + 0.205	0.67	29.6	<0.001
TSS Concentration (mg/L)	[TSS]	log(FER2 TSS) = 0.577 log(FER1 TSS) + 0.513	0.61	24.2	<0.001
Cl Concentration (mg/L)	[Cl]	log(FER2 Cl) = 0.764 log(FER1 Cl) + 0.372	0.82	62.9	<0.001
TP Export (g)	TPx	log(FER2 TPx) = 0.570 log(FER1 TPx) + 1.27	0.86	95.6	<0.001
TDP Export (g)	TDPx	log(FER2 TDPx) = 0.621 log(FER1 TDPx) + 1.15	0.84	72.3	<0.001
TN Export (g)	TNx	log(FER2 TNx) = 0.518 log(FER1 TNx) + 1.66	0.75	45.3	<0.001
TDN Export (g)	TDNx	log(FER2 TDNx) = 0.516 log(FER1 TDNx) + 1.62	0.59	21.53	<0.001
TSS Export (g)	TSSx	log(FER2 TSSx) = 0.671 log(FER1 TSSx) + 1.49	0.82	71.6	<0.001
Cl Export (g)	Clx	log(FER2 Clx) = 0.540 log(FER1 Clx) + 1.88	0.42	11.1	0.005

6.6.2. Franklin site (corn)

Regression equations for all variables were highly significant, with R^2 values greater than 0.85 for all variables (Table 22). Observed P and N concentrations occurred over a one to two order of magnitude range; it is possible that dramatically different conditions in the treatment period (e.g., much larger or smaller runoff volumes) may generate data in a different range, potentially making interpretation of change difficult. Except for the opportunity to expand the range of measured nutrient concentrations, there would be little benefit to collecting additional calibration data. No significant differences in discharge, concentration, or export between the FRA1 and FRA2 watersheds were observed.

Table 22. Calibration period linear regression statistics, FRA site

Variable	Symbol	Equation	R^2 adj.	F Ratio	*Prob > F*
Event Discharge	Q	log(FRA2 Q) = 1.21 log(FRA1 Q) – 1.26	0.98	528.9	<0.001
TP Concentration (µg /L)	[TP]	log(FRA2 TP) = 0.910 log(FRA1 TP) + 0.262	0.98	399.4	<0.001
TDP Concentration (µg/L)	[TDP]	log(FRA2 TDP) = 0.830 log(FRA1 TDP) + 0.493	0.85	47.9	<0.001
TN Concentration (mg/L)	[TN]	log(FRA2 TN) = 0.929 log (FRA1 TN) + 0.090	0.88	59.5	<0.001
TDN Concentration (mg/L)	[TDN]	log(FRA2 TDN) = 1.05 log(FRA1 TDN) + 0.002	0.99	538.0	<0.001
TSS Concentration (mg/L)	[TSS]	log(FRA2 TSS) = 0.906 log(FRA1 TSS) + 0.086	0.98	383.2	<0.001
Cl Concentration (mg/L)	[Cl]	log(FRA2 Cl) = 0.932 log(FRA1 Cl) + 0.128	0.98	321.7	<0.001
TP Export (g)	TPx	log(FRA2 TPx) = 1.11 log(FRA1 TPx) – 0.383	0.97	235.4	<0.001
TDP Export (g)	TDPx	log(FRA2 TDPx) = 1.11 log(FRA1 TDPx) – 0.326	0.95	157.8	<0.001
TN Export (g)	TNx	log(FRA2 TNx) = 1.09 log(FRA1 TNx) – 0.397	0.93	104.6	<0.001
TDN Export (g)	TDNx	log(FRA2 TDNx) = 1.16 log(FRA1 TDNx) – 0.631	0.97	265.2	<0.001
TSS Export (g)	TSSx	log(FRA2 TSSx) = 1.04 log(FRA1 TSSx) – 0.418	0.96	185.0	<0.001
Cl Export (g)	Clx	log(FRA2 Clx) = 1.19 log(FRA1 Clx) – 0.775	0.98	332.9	<0.001

6.6.3. Pawlet site (corn)

Calibration between PAW1 and PAW2 appears to be very strong for all monitored variables (Table 23). Values of R^2 are in the 0.60 – 0.90 range. Data were recorded over 3 – 4 orders of magnitude, suggesting a strong likelihood that the ranges recorded during the treatment period will overlap those of the calibration period. This site has the highest number of monitored events among the study sites; there would be little benefit for continued calibration monitoring. Although not statistically significant for all constituents, there is a tendency for discharge, concentration, and export to be higher from PAW1 than from PAW2 (data not shown). Because there would be a greater chance of showing significant change at high concentrations, PAW1 was selected as the treatment watershed.

Table 23. Calibration period linear regression statistics, PAW site

Variable	Symbol	Equation	R^2 adj.	F Ratio	*Prob > F*
Event Discharge	Q	log(PAW2 Q) = 0.720 log(PAW1 Q) + 1.09	0.72	103.5	<0.001
TP Concentration (µg /L)	[TP]	log(PAW2 TP) = 0.667 log(PAW1 TP) + 0.746	0.61	43.0	<0.001
TDP Concentration (µg/L)	[TDP]	log(PAW2 TDP) = 0.923 log(PAW1 TDP) + 0.076	0.67	55.0	<0.001
TN Concentration (mg/L)	[TN]	log(PAW2 TN) = 0.829 log (PAW1 TN) – 0.108	0.75	79.7	<0.001
TDN Concentration (mg/L)	[TDN]	log(PAW2 TDN) = 0.839 log(PAW1 TDN) – 0.168	0.71	67.9	<0.001
TSS Concentration (mg/L)	[TSS]	log(PAW2 TSS) = 0.693 log(PAW1 TSS) + 0.434	0.62	45.2	<0.001
Cl Concentration (mg/L)	[Cl]	log(PAW2 Cl) = 0.920 log(PAW1 Cl) – 0.011	0.83	125.8	<0.001
TP Export (g)	TPx	log(PAW2 TPx) = 0.640 log(PAW1 TPx) + 0.149	0.88	199.1	<0.001
TDP Export (g)	TDPx	log(PAW2 TDPx) = 0.737 log(PAW1 TDPx) – 0.135	0.82	120.6	<0.001
TN Export (g)	TNx	log(PAW2 TNx) = 0.750 log(PAW1 TNx) + 0.125	0.84	137.8	<0.001
TDN Export (g)	TDNx	log(PAW2 TDNx) = 0.786 log(PAW1 TDNx) – 0.033	0.78	97.6	<0.001
TSS Export (g)	TSSx	log(PAW2 TSSx) = 0.656 log(PAW1 TSSx) + 0.891	0.77	90.0	<0.001
Cl Export (g)	Clx	log(PAW2 Clx) = 0.705 log(PAW1 Clx) + 0.475	0.81	108.7	<0.001

6.6.4. Shelburne site (hay)

Calibration between SHE1 and SHE2 is not universally strong, but still statistically significant for all measured variables (Table 24). Values of R^2 are in the 0.20 – 0.80 range. Concentration data were recorded over a fairly narrow range, raising some potential concern over comparability to treatment period data if field conditions (i.e., events closely following manure application) are very different from those of the calibration period. However, given time constraints and the low probability of another manure application before first cut, there seems little benefit in continuing calibration monitoring. Differences in monitored variables between SHE1 and SHE2 were inconsistent. Mean TDP concentration and mean Cl concentration and load were significantly higher from SHE2 than from SHE1 (data not shown) but mean TSS concentration was higher from SHE1 than SHE2. The two watersheds behaved comparably for other constituents. Selection of treatment watershed will likely be made on agronomic criteria.

Table 24. Calibration period linear regression statistics, SHE site

Variable	Symbol	Equation	R^2 adj.	F Ratio	*Prob > F*
Event Discharge	Q	log(SHE2 Q) = 0.596 log(SHE1 Q) + 2.21	0.83	110.8	<0.001
TP Concentration (µg /L)	[TP]	log(SHE2 TP) = 0.740 log(SHE1 TP) + 0.683	0.82	88.0	<0.001
TDP Concentration (µg/L)	[TDP]	log(SHE2 TDP) = 0.617 log(SHE1 TDP) + 1.01	0.77	64.3	<0.001
TN Concentration (mg/L)	[TN]	log(SHE2 TN) = 0.165 log (SHE1 TN) + 0.068	0.22	6.3	0.022
TDN Concentration (mg/L)	[TDN]	log(SHE2 TDN) = 0.503 log(SHE1 TDN) + 0.016	0.49	19.3	<0.001
TSS Concentration (mg/L)	[TSS]	log(SHE2 TSS) = 0.328 log(SHE1 TSS) + 0.403	0.16	4.6	0.047
Cl Concentration (mg/L)	[Cl]	log(SHE2 Cl) = 0.466 log(SHE1 Cl) + 0.880	0.59	28.0	<0.001
TP Export (g)	TPx	log(SHE2 TPx) = 0.595 log(SHE1 TPx) + 0.836	0.74	54.9	<0.001
TDP Export (g)	TDPx	log(SHE2 TDPx) = 0.614 log(SHE1 TDPx) + 0.839	0.75	57.6	<0.001
TN Export (g)	TNx	log(SHE2 TNx) = 0.538 log(SHE1 TNx) + 1.13	0.67	39.1	<0.001
TDN Export (g)	TDNx	log(SHE2 TDNx) = 0.589 log(SHE1 TDNx) + 1.05	0.78	67.2	<0.001
TSS Export (g)	TSSx	log(SHE2 TSSx) = 0.576 log(SHE1 TSSx) + 1.18	0.67	39.1	<0.001
Cl Export (g)	Clx	log(SHE2 Clx) = 0.480 log(SHE1 Clx) + 2.12	0.60	29.0	<0.001

6.6.5. Shoreham site (hay)

Most calibration regressions between SHO1 and SHO2 were strong; all relationships were statistically significant (Table 25). Values of R^2 ranged from 0.35 to 0.98. However, data were recorded over a fairly narrow range, generally less than two orders of magnitude; N concentrations were in a particularly narrow range. Extending calibration monitoring may extend the range and improve some of the regressions, particularly if runoff events occur after manure application following the first hay cut. Therefore, calibration monitoring will be continued until second cut, at which point we expect the treatment watershed to be aerated.

Concentrations and loads of measured constituents tended to be higher in runoff from SHO1 than from SHO2. This pattern suggests that application of treatment to SHO1 might yield more measureable results; therefore SHO1 is tentatively designated as the treatment watershed.

Table 25. Calibration period linear regression statistics, SHO site

Variable	Symbol	Equation	R^2 adj.	F Ratio	*Prob > F*
Event Discharge	Q	log(SHO2 Q) = 0.646 log(SHO1 Q) + 0.813	0.35	6.37	0.033
TP Concentration (µg /L)	[TP]	log(SHO2 TP) = 0.703 log(SHO1 TP) + 0.739	0.89	40.8	0.003
TDP Concentration (µg/L)	[TDP]	log(SHO2 TDP) = 0.656 log(SHO1 TDP) + 0.842	0.93	65.3	0.001
TN Concentration (mg/L)	[TN]	log(SHO2 TN) = 0.858 log (SHO1 TN) – 0.030	0.92	56.7	0.002
TDN Concentration (mg/L)	[TDN]	log(SHO2 TDN) = 0.992 log(SHO1 TDN) – 0.092	0.98	217.1	<0.001
TSS Concentration (mg/L)	[TSS]	log(SHO2 TSS) = 0.172 log(SHO1 TSS) + 1.19	0.50	6.0	0.070
Cl Concentration (mg/L)	[Cl]	log(SHO2 Cl) = 0.653 log(SHO1 Cl) + 0.022	0.62	9.1	0.039
TP Export (g)	TPx	log(SHO2 TPx) = 0.810 log(SHO1 TPx) – 0.528	0.66	10.7	0.031
TDP Export (g)	TDPx	log(SHO2 TDPx) = 0.806 log(SHO1 TDPx) – 0.530	0.61	8.9	0.041
TN Export (g)	TNx	log(SHO2 TNx) = 1.22 log(SHO1 TNx) – 1.55	0.49	5.7	0.075
TDN Export (g)	TDNx	log(SHO2 TDNx) = 1.43 log(SHO1 TDNx) – 2.09	0.59	8.1	0.047
TSS Export (g)	TSSx	log(SHO2 TSSx) = 0.840 log(SHO1 TSSx) – 0.064	0.62	9.1	0.039
Cl Export (g)	Clx	log(SHO2 Clx) = 0.925 log(SHO1 Clx) – 0.808	0.59	8.3	0.045

6.6.6. Williston site (corn)

Calibration regressions between WIL1 and WIL2 ranged from moderately weak (R^2 = 0.39) to strong (R^2 = 0.90) and were non-significant for TDP and TDN concentrations (Table 26). Observed data generally varied over 2 to 3 orders of magnitude, except for TN and TP concentrations which occurred over a fairly narrow range. The combined effect of non-significant relationships between the dissolved N and P concentrations and the narrow range of N and P concentrations may be that response to treatment will be challenging to measure for nutrient concentrations at this site. The two watersheds behaved fairly similarly with respect to mean concentrations and loads in runoff, although TP, TDP, and TSS concentrations were significantly higher from WIL2 than from WIL1.

Table 26. Calibration period linear regression statistics, WIL site

Variable	Symbol	Equation	R^2 adj.	F Ratio	*Prob > F*
Event Discharge	Q	log(WIL1 Q) = 1.08 log(WIL2 Q) – 0.345	0.59	25.0	<0.001
TP Concentration (µg /L)	[TP]	log(WIL1 TP) = 0.444 log(WIL2 TP) + 1.45	0.48	14.1	0.002
TDP Concentration (µg/L)	[TDP]	log(WIL1 TDP) = 0.043 log(WIL2 TDP) + 278.8	0.002	1.03	0.330
TN Concentration (mg/L)	[TN]	log(WIL1 TN) = 0.592 log (WIL2 TN) + 0.161	0.48	14.1	0.002
TDN Concentration (mg/L)	[TDN]	log(WIL1TDN) = 0.340 log(WIL2 TDN) + 0.225	0.08	2.21	0.161
TSS Concentration (mg/L)	[TSS]	log(WIL1 TSS) = 1.06 log(WIL2 TSS) + 0.185	0.90	123.1	<0.001
Cl Concentration (mg/L)	[Cl]	log(WIL1 Cl) = 0.535 log(WIL2 Cl) + 0.168	0.43	11.7	0.005
TP Export (g)	TPx	log(WIL1 TPx) = 0.835 log(WIL2 TPx) + 0.088	0.69	32.2	<0.001
TDP Export (g)	TDPx	log(WIL1 TDPx) = 0.676 log(WIL2 TDPx) + 0.168	0.50	15.0	0.002
TN Export (g)	TNx	log(WIL1 TNx) = 0.894 log(WIL2 TNx) + 0.293	0.68	31.1	<0.001
TDN Export (g)	TDNx	log(WIL1 TDNx) = 0.794 log(WIL2 TDNx) + 0.550	0.39	10.0	0.007
TSS Export (g)	TSSx	log(WIL1 TSSx) = 0.937 log(WIL2 TSSx) + 0.382	0.90	123.9	<0.001
Cl Export (g)	Clx	log(WIL1 Clx) = 0.879 log(WIL2 Clx) + 0.370	0.45	12.5	0.004

6.7. 2013 WASCoB Results

In December 2012, two paired events were recorded at the WASCoB inlet (WAS1) and outlet (WAS2). At WAS1, the events began on December 2 and December 10 and lasted 1-2 days, while the WASCoB outlet flowed for 4-6 days. Since the only paired samples collected during these events were siphon samples of questionable quality, these data are not presented.

The first event monitored at the WASCoB in 2013 began a few hours after the repaired pressure transducer (see Section 5.4.1) was reinstalled on May 22, 2013. WAS2, the outlet station, then ran continuously for 48 days, ending July 8, 2013. During this event, there were two events at the inlet station, May 22-27 and May 29-30. The outlet flowed continuously through June and the first week in July despite receiving no or negligible flow through WAS1. We suspect the main source of flow in June and early July was groundwater entering the basin. Following this event, there was no inflow or outflow through the stations until mid-September, 2013. There were five events recorded at WAS2 between mid-September and mid-November. From review of time lapse photographs, the WASCoB first iced over on November 25, 2013 and permanent ice developed as of November 28. Discharge data are not valid for periods when the WASCoB was iced-over; therefore events occurring after November 25 were excluded from analysis. The seven remaining events are summarized in Table 27. Events 4 and 6 were very small and did not produce sufficient sample to analyze.

Table 27. Event discharge and constituent mean concentrations and loads at WASCoB stations

Station	Event	End Date	Discharge (L)	Precip (in.)	TP (µg/L)	TDP (µg/L)	TN (mg/L)	TDN (mg/L)	TSS (mg/L)	Cl (mg/L)	TP (g)	TDP (g)	TN (g)	TDN (g)	TSS (kg)	Cl (g)
WAS1	1	05/30/13	3547450	4.78	372	137	14.5	14.7	252	24.6	1320	487	51387	52224	893	87323
WAS2	1	07/08/13	4992572	10.60	320	118	12.4	11.8	182	22.7	1600	590	61943	59016	908	113450
WAS1	2	09/16/13	768819	2.13	752	564	2.0	1.5	100	4.3	578	434	1504	1126	77	3306
WAS2	2	09/21/13	1073640	2.85	861	646	3.5	2.7	50	5.3	924	693	3788	2902	54	5700
WAS1	3	10/08/13	784935	1.08	6500	2825	17.2	7.2	2646	29.4	5102	2217	13514	5658	2077	23077
WAS2	3	10/10/13	865445	1.17	4870	1270	6.5	2.9	2908	16.9	4215	1099	5649	2553	2517	14626
WAS1	4	10/18/13	15717	0.56	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
WAS2	4	10/19/13	8172	0.65	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
WAS1	5	11/01/13	478527	0.87	1050	370	7.6	5.3	160	27.8	502	177	3624	2543	77	13303
WAS2	5	11/04/13	523658	1.06	838	351	3.4	2.3	186	17.1	439	184	1796	1210	97	8955
WAS1	6	11/07/13	4468	0.15	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
WAS2	6	11/09/13	17778	0.26	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
WAS1	7	11/18/13	508651	0.84	2332	307	6.8	2.0	3130	15.2	1186	156	3441	1007	1592	7731
WAS2	7	11/25/13	622013	0.84	2020	83	9.6	1.0	5255	13.7	1256	52	5975	610	3269	8522

In 2013, the WASCoB does not appear to have consistently reduced the total discharge of nutrients or sediment. Table 28 shows the percentage difference between discharge and constituent mass exported from the WASCoB at WAS2 and that entering via WAS1, with negative numbers indicating removal and positive numbers indicating addition. Flow at the outlet ranged from 9 to 29 percent higher than inflows via WAS1. This increased flow is likely a combination of direct runoff to the WASCoB (roughly 0.6 acres drains directly to the WASCoB), precipitation on the WASCoB, and groundwater discharge. Total phosphorus and nitrogen removal was only observed in Events 3 and 5.

Table 28. Difference (%) in event discharge and constituent loads at WASCoB stations[1]

Event	Discharge[2] (%)	TP load (%)	TDP load (%)	TN load (%)	TDN load (%)	TSS load (%)	Cl load (%)
1	29	17	18	17	12	2	23
2	28	37	37	60	61	-43	42
3	9	-21	-102	-139	-122	17	-58
5	9	-14	4	-102	-110	21	-49
7	18	6	-203	42	-65	51	9

1. The percent difference was calculated as: 100 x (WAS2 – WAS1) / WAS2
2. The WASCoB was not specifically designed to reduce discharge

Possible explanations for the apparent lack of consistent nutrient reductions include: 1) the lack of vegetation along the sides of the WASCoB may have resulted in sediment erosion into the WASCoB and limited filtering function; 2) nutrients may circumvent WAS1, entering the WASCoB through direct runoff or groundwater flow; and 3) the WASCoB may have insufficient hydraulic capacity to allow settling of solids, given the size of the watershed and its fine textured soils. The WASCoB volume when filled to the spillway elevation is approximately 3,900 cubic feet. The inflow at WAS1 represented between 4 times (Event 5) and 32 times (Event 1) the volume of the WASCoB (assuming it was full to the spillway), suggesting that time for solids settling was likely inadequate during some events. Because the WASCoB is becoming vegetated and our dataset for 2013 was small, these results should be viewed as preliminary.

When aggregated over the monitoring season (excluding events 4 and 7, which were small and not effectively sampled) it is apparent that the flow weighted mean concentrations of total and dissolved P and N were all lower in WASCoB discharge than in WAS1 inflow (Table 29). For the season, mean concentrations at the outflow were 37 and 76 percent lower for total and dissolved P and 23 and 25 percent lower for total and dissolved N (Table 30). The mean TSS concentration in the outflow was slightly (9 percent) higher than in WAS1 inflow. The 25 percent increase in flow between the inlet and outflow roughly balances out the reductions in TP, TN, and TDN mean concentrations, such that changes in loading are small (< ± 10 percent). Part of the explanation for this result may simply be flow dilution within the WASCoB (due to direct rainfall and groundwater discharge). The more substantial (76 percent) reduction in mean TDP concentration is reflected in a 33 percent reduction in TDP load, despite the increased discharge. The 18 percent reduction in flow weighted chloride concentration in the WASCoB also may indicate dilution.

The mass of chloride discharged from the WASCoB was 151 kg over the 2013 monitoring season, 11 percent greater than at the WAS1 inflow. Since chloride is a conservative ion in the environment, this modest increase in load may result either from direct runoff to the WASCoB, over-estimation of WAS2 discharge, or both. In future analyses of WASCoB nutrient and sediment data, it may be advisable to use the change in chloride loading as a correction factor. Whether caused by over-estimation of WAS2 discharge or by direct runoff to the WASCoB, applying the change in chloride loading to the 2013 data would suggest marginally improved nutrient and sediment treatment performance.

Table 29. Mean concentrations and total discharge and loads at WASCoB stations for 2013 season[1]

Station	HQ (L)	[TP] (µg/L)	[TDP] (µg/L)	[TN] (mg/L)	[TDN] (mg/L)	[TSS] (mg/L)	[Cl] (mg/L)	TP load (g)	TDP load (g)	TN load (g)	TDN load (g)	TSS load (kg)	Cl load (g)
WAS1 (inlet)	6,088,382	1,427	570	12.1	10.3	775	22.1	8,689	3,471	73,469	62,560	4,716	134,741
WAS2 (outlet)	8,077,327	1,044	324	9.8	8.2	847	18.7	8,434	2,618	79,151	66,290	6,845	151,252

1. Calculations based on Events 1–3, 5, and 7 only

Table 30. Difference (%) in mean concentrations and total discharge and loads at WASCoB stations for 2013 season[1,2,3]

HQ	[TP]	[TDP]	[TN]	[TDN]	[TSS]	[Cl]	TP load	TDP load	TN load	TDN load	TSS load	Cl load
25	-37	-76	-23	-25	9	-18	-3	-33	7	6	31	11

1. Calculations based on Events 1–3, 5, and 7 only
2. Percent difference was calculated as: 100 x (WAS2 – WAS1) / WAS2
3. The WASCoB was not specifically designed to reduce discharge

6.8. Results of Sediment Collection and Analysis

Through January 2014, sediment deposition within the flumes and their attached approach channels has been negligible at the FRA and WIL sites and at all three hay sites. Events with significant sediment deposition (operationally defined as one liter or more) have occurred at only three stations: PAW1, PAW2, and WAS1. The PAW1 flume and approach channel accumulated sediment during nine events, with collected volumes ranging from 1 to 34 L. Both the PAW2 and WAS2 stations accumulated sediment during two events. Depending on the timing of sample collection and weather conditions, sediment removed from the flumes and approach channels at PAW1, PAW2, and WAS1 ranged from a slurry to nearly dry.

Sediment removed from the flume and approach channel was transferred to buckets and the volume was recorded to the nearest liter. Buckets were subsampled for total solids and total phosphorus analysis; these concentrations were multiplied by sediment volume to calculate the masses of solids and total phosphorus deposited in the flume/approach channel. For each station/event with significant sediment accumulation, Table 31 presents the masses of solids ("Solids in Flume") and total phosphorus ("TP in Flume Sediment") deposited in the flume and approach channel. Note that Table 31 includes data for certain events at the Pawlet site where problems in discharge measurement (blowout at PAW1 on Event 10) and autosampler collected samples (Event 1 at PAW1) dictated that these data not be included in the paired watershed statistical analyses. While these data were not considered sufficiently accurate for inclusion in paired watershed statistical analyses, we considered them adequate for the sediment and total phosphorus mass comparison. Similarly, in one instance (PAW1, Event 16), the total solids and total phosphorus content of deposited sediment were estimated as averages from the preceding events.

In most cases, the mass of solids deposited in the flume was minor compared to the amount transported in runoff (measured as TSS). With two exceptions, the mass of solids deposited in the flume/approach was 6 percent or less of the total mass of solids transported (TSS+ deposited sediment; Table 31). The exceptions were Event 5 (84.8 %) and Event 16 (19.0%) at PAW1. In these two events, the high percentage of solids deposited in the flume/approach results from relatively low TSS loads rather than from substantial sediment deposition in the flume/approach. In particular, Event 5 was a very small event that transported only 0.2 kg of solids as TSS, and the solids in the flume (1.2 kg) were likely mobilized in one of the large events preceding it and deposited above the flume approach, creating a condition where a small event carried these sediments into the flume.

Table 31. Mass of solids and total phosphorus deposited in flume/approach relative to mass in runoff

Station	Event	Hydro Event End Date	Event Discharge (L)	TSS Load (kg)	Solids in Flume (kg)	Total Solids Load (kg)	% of Total Solids In Flume	TP Load in Runoff (g)	TP in Flume Sediment (g)	TP Load Total (g)	% of TP Load in Flume	Note
PAW1	1	3/13/2013	423,744	841.3	23.6	864.9	2.7	1112.3	19.3	1131.6	1.7	A
PAW1	5	4/14/2013	8,447	0.2	1.2	1.4	84.8	1.1	1.3	2.4	54.1	
PAW1	7	4/20/2013	194,857	164.7	2.0	166.6	1.2	261.1	2.2	263.3	0.8	
PAW1	10	6/4/2013	312,411	4376.9	25.4	4402.3	0.6	2655.5	24.6	2680.1	0.9	B
PAW2	10	6/3/2013	247,840	458.5	NS	NS	NS	385.4	NS	NS	NS	C
PAW1	11	6/9/2013	159,903	43.0	2.7	45.7	6.0	42.6	2.5	45.1	5.5	
PAW1	12	6/15/2013	547,895	27.4	0.5	27.9	1.8	74.6	0.5	75.1	0.6	
PAW1	13	6/19/2013	218,166	966.0	15.5	981.5	1.6	462.5	14.1	476.6	3.0	
PAW2	13	6/19/2013	102,149	NS	0.9	NS	NS	NS	0.6	NS	NS	D
PAW1	14	6/27/2013	367,295	915.3	31.2	946.5	3.3	655.7	22.6	678.3	3.3	
PAW1	16	7/4/2013	324,507	37.8	8.9	46.7	19.0	90.5	8.1	98.6	8.2	E
WAS1	1	5/30/2013	3,547,450	893.2	12.1	905.3	1.3	1320.1	8.8	1328.9	0.7	
WAS1	3	10/8/2013	784,935	2076.9	2.5	2079.4	0.1	5102.1	2.1	5104.1	0.0	

A. Autosampling error. Low siphon sample analyzed. Event excluded from paired watershed analysis.

B. Bypass flow occurred. Discharge and TSS and TP loads presented for comparison with sediment deposited in flume. Event excluded from statistical analysis.

C. Sediment sample analyzed but volume removed from flume not recorded

D. Sediment sample analyzed and volume recorded but corresponding runoff sample not obtained

E. Sediment volume recorded but no sediment sample analyzed. Solids and TP concentrations of sediment estimated as averages of PAW1 events in 2013

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APPENDICES

APPENDIX A: STUDY WATERSHED DESCRIPTIONS

A.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. These soils have high runoff potential, classified as hydrologic soil group D. The FER1 watershed (Figure 1) is 4.5 acres, substantially smaller than the 7.2 acre FER2 watershed (Figure 2), 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. On April 9, 2013, the end of the tile line was capped by AAFM, in an attempt to make the FER1 and FER2 watersheds more hydrologically comparable. 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.

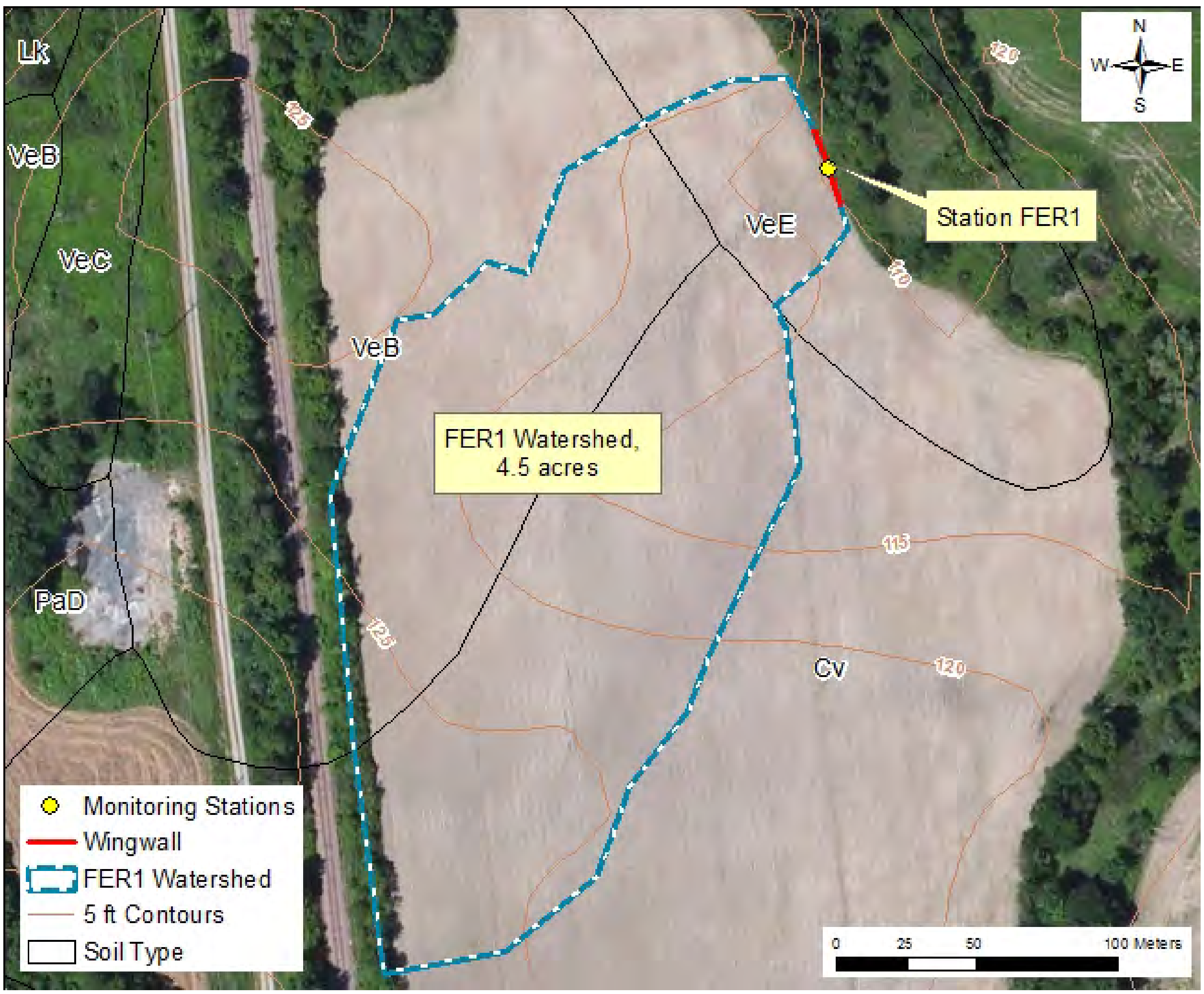

Figure 1. FER1 watershed

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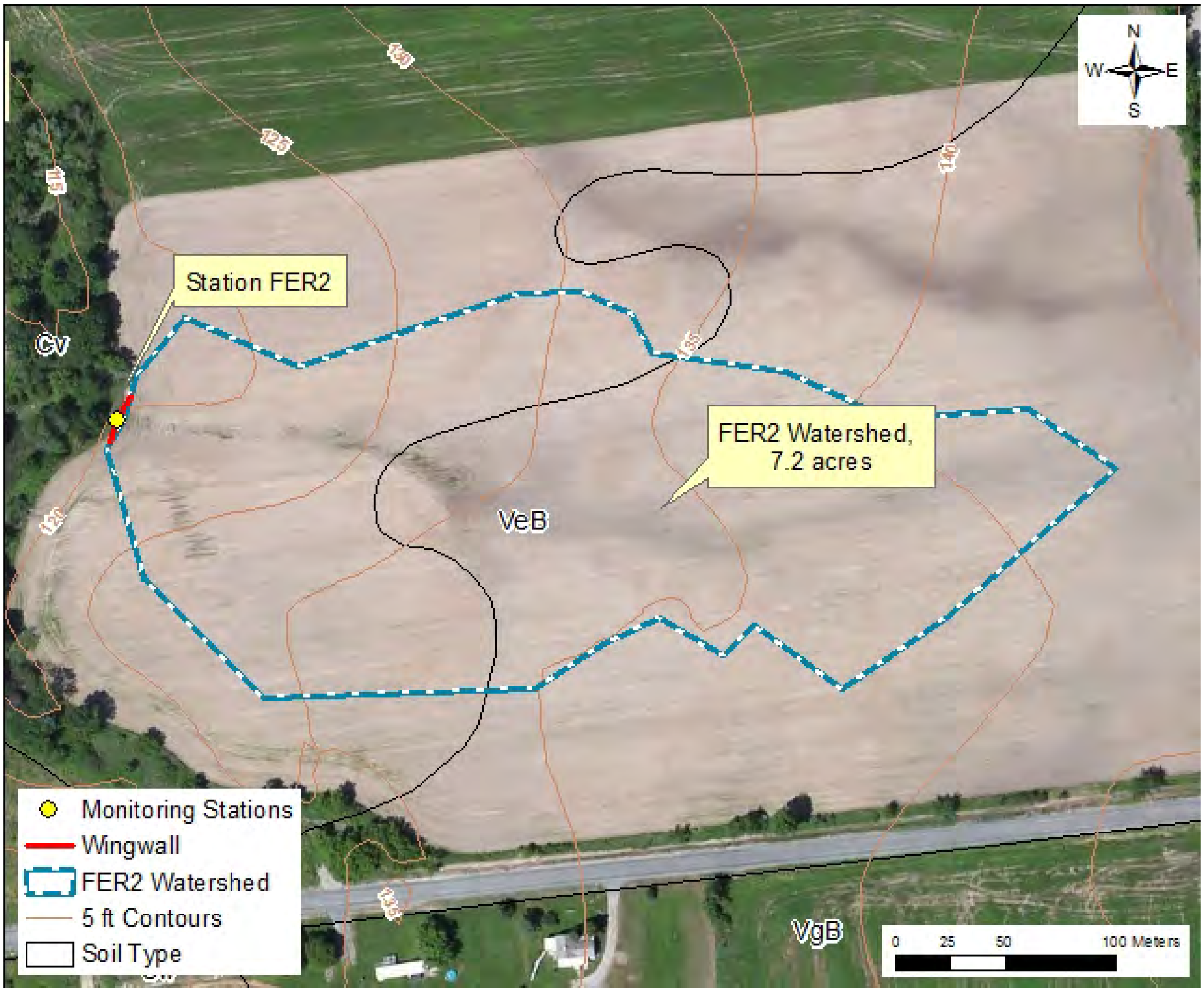

Figure 2. FER2 watershed

A.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 3. The predominant soil texture in the FRA1 and FRA2 watersheds is silt loam (Munson, Scantic, Belgrade, St. Albans), with lesser amounts of Georgia and Massena stony loam. 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.

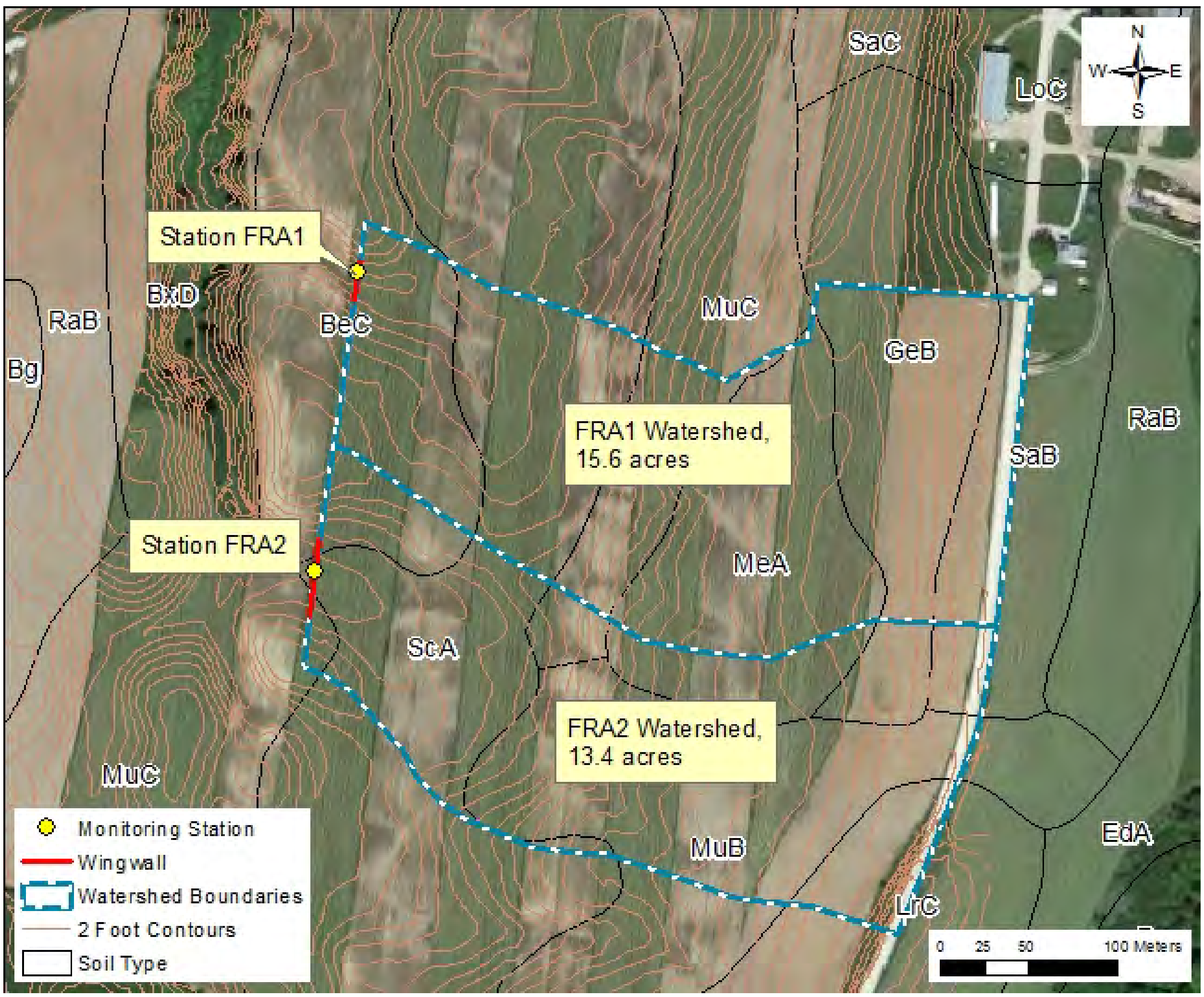

Figure 3. FRA1 and FRA2 watersheds

The WASCoB stations (Figure 4) 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.

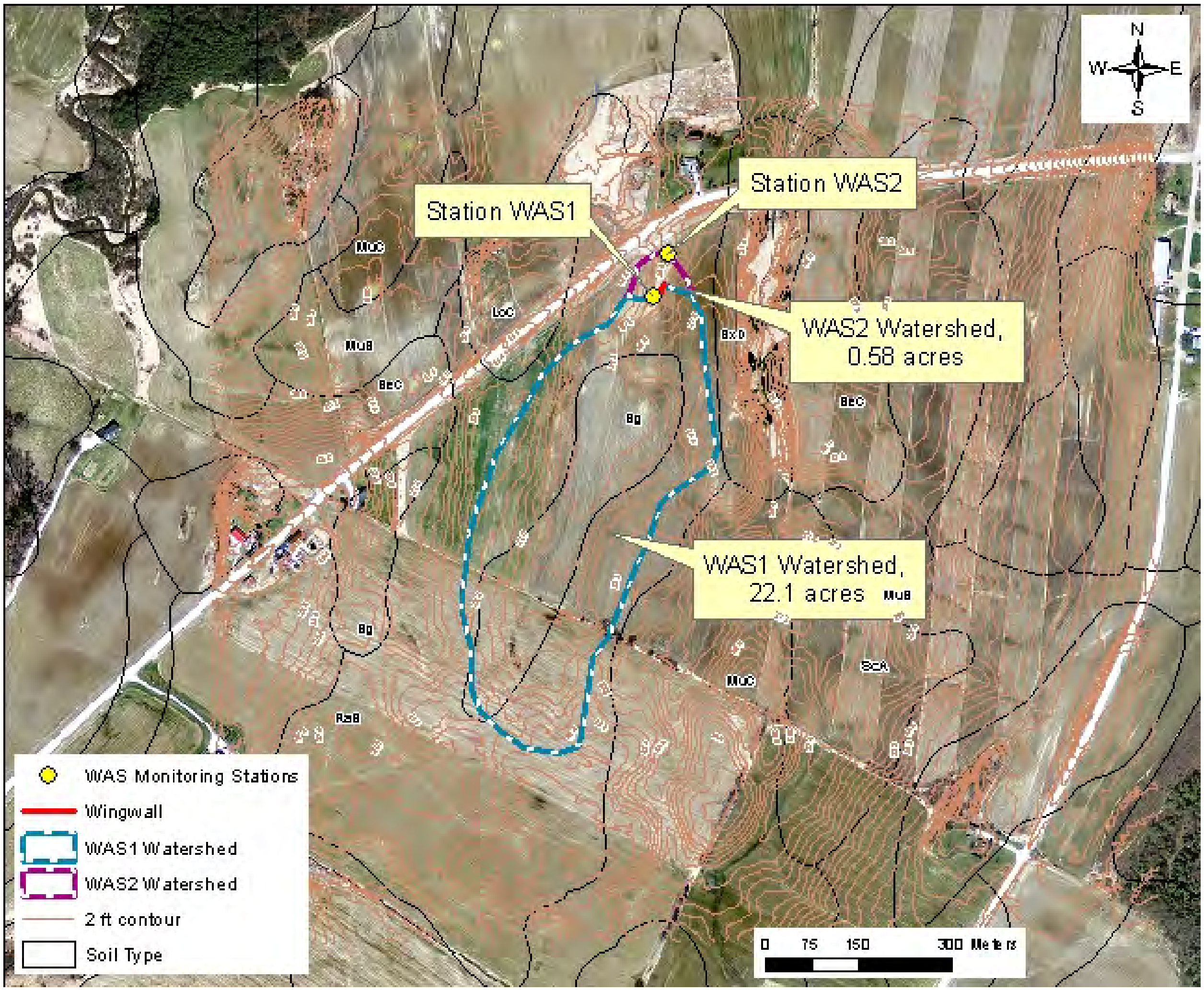

Figure 4. WAS1 and WAS2 watersheds

A.3. **Pawlet Site**

The Pawlet study watersheds are located approximately 500 m apart in West Pawlet. Field maps are included as Figures 5 and 6. Both fields are in continuous corn production. The PAW1 watershed is 43% larger than the PAW2 watershed. 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.

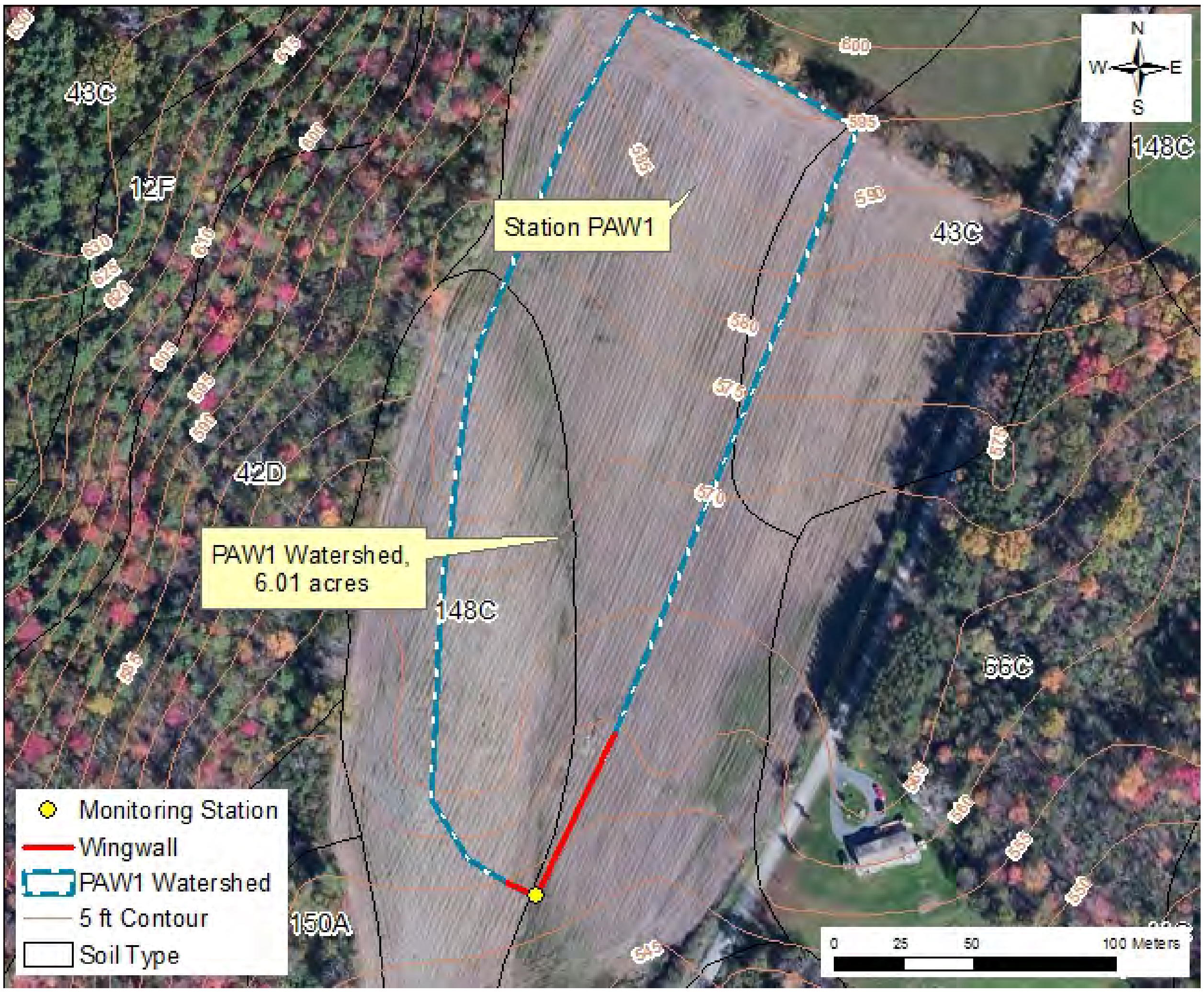

Figure 5. PAW1 watershed

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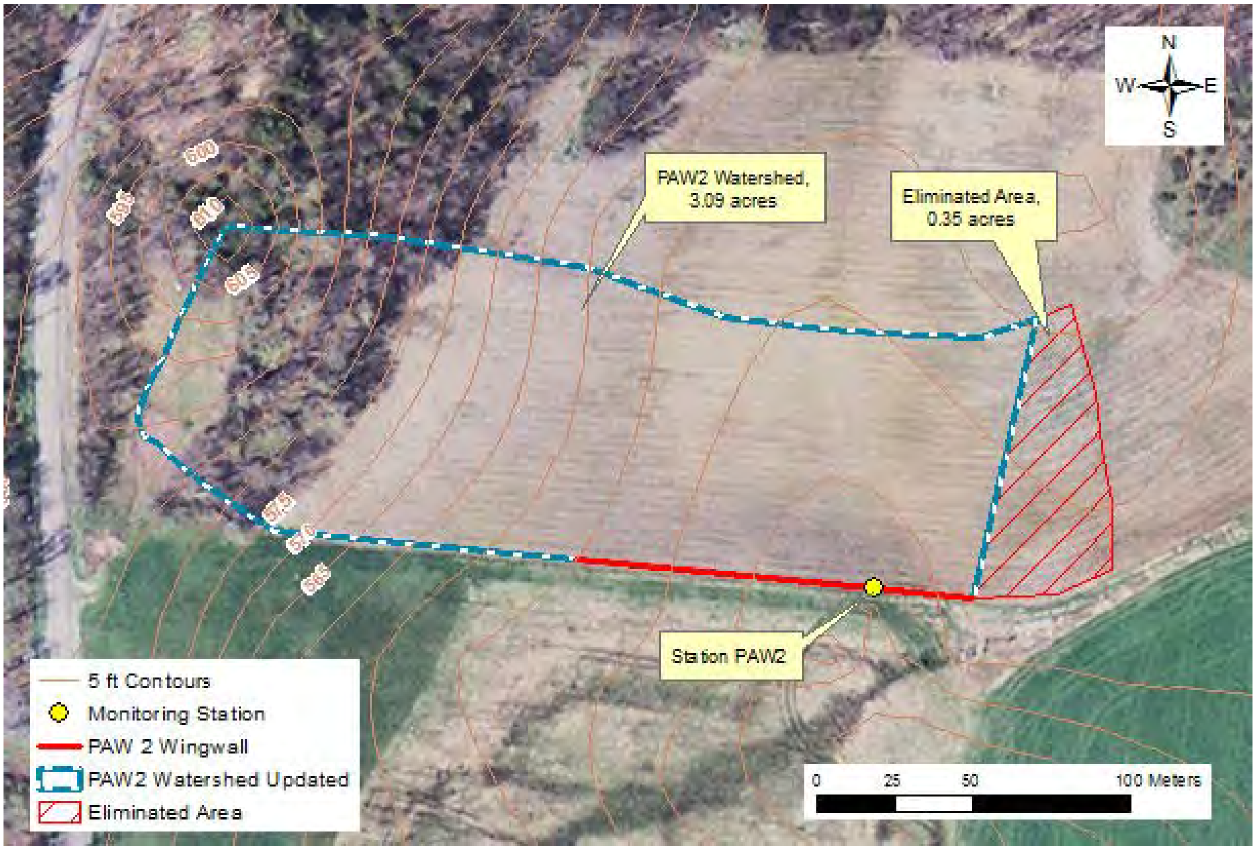

Figure 6. PAW2 watershed

A.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 (Figures 7 and 8). 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.

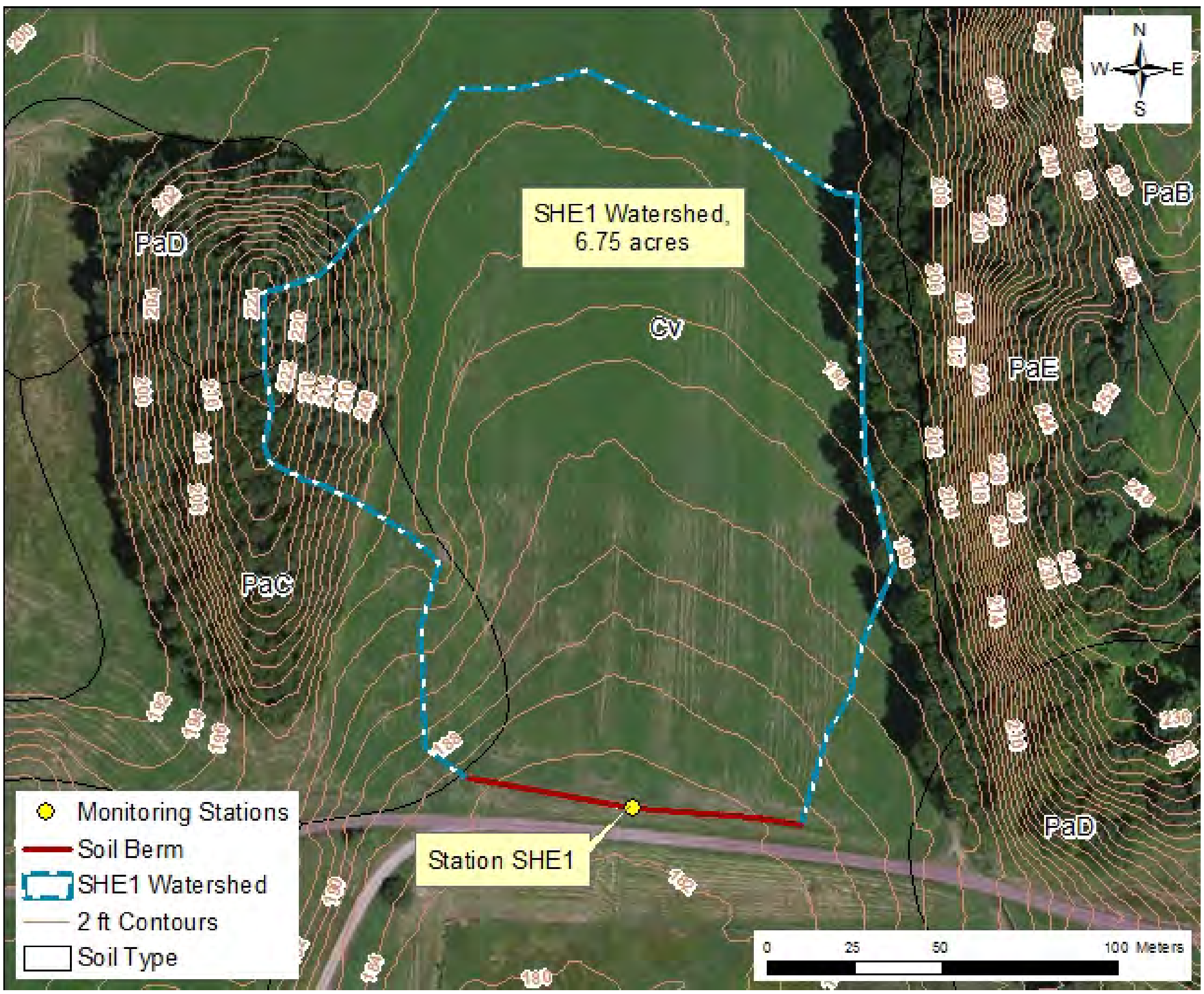

Figure 7. SHE1 watershed

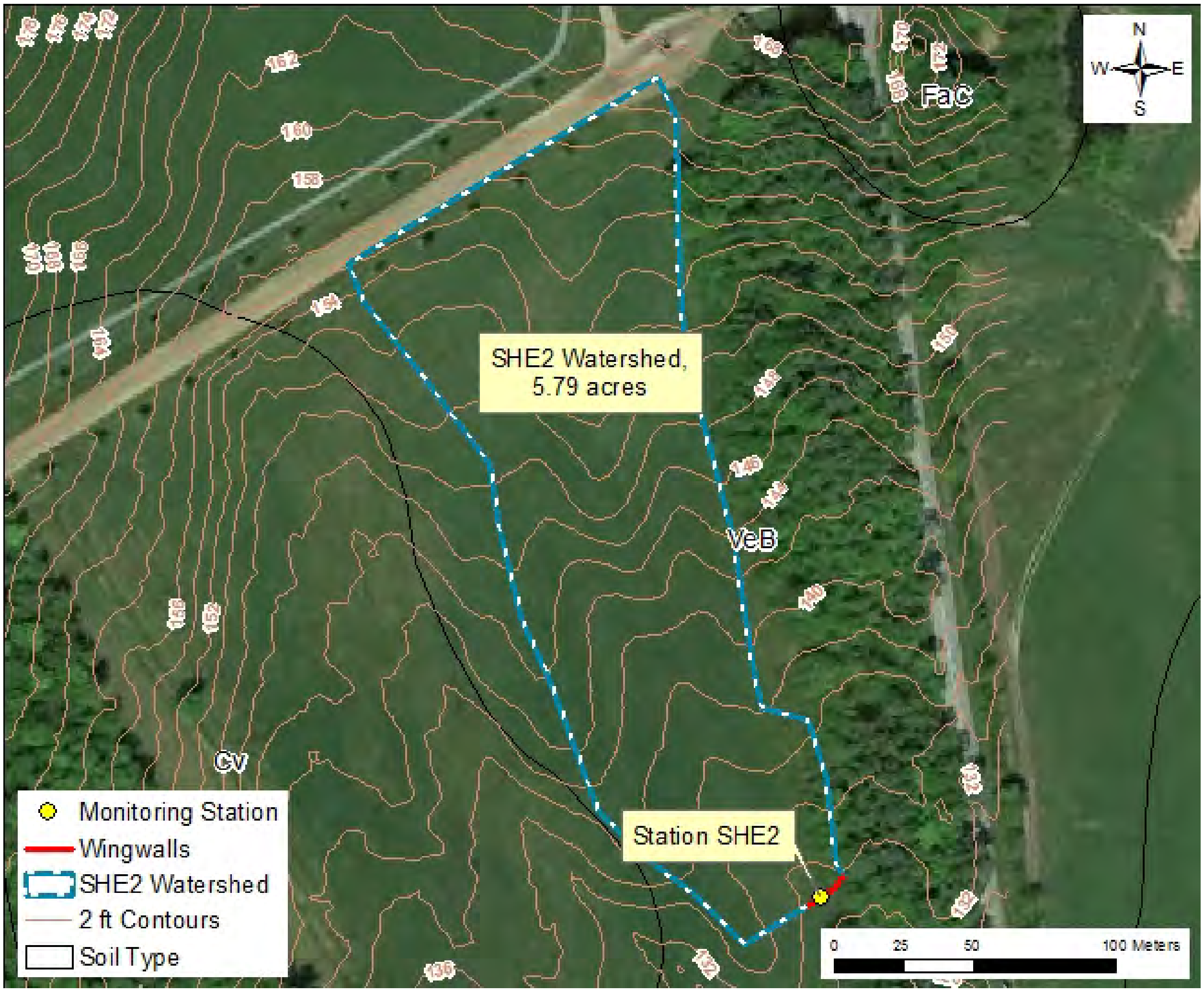

Figure 8. SHE2 watershed

A.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 (Figures 9 and 10). 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 develop in these fields during dry conditions. There is no known tile drainage at either SHO1 or SHO2.

Figure 9. SHO1 watershed

Figure 10. SHO2 watershed

A.6. Williston Site

The Williston study watersheds are adjacent to one another in a field with very low topographic relief (Figure 11). 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. 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.

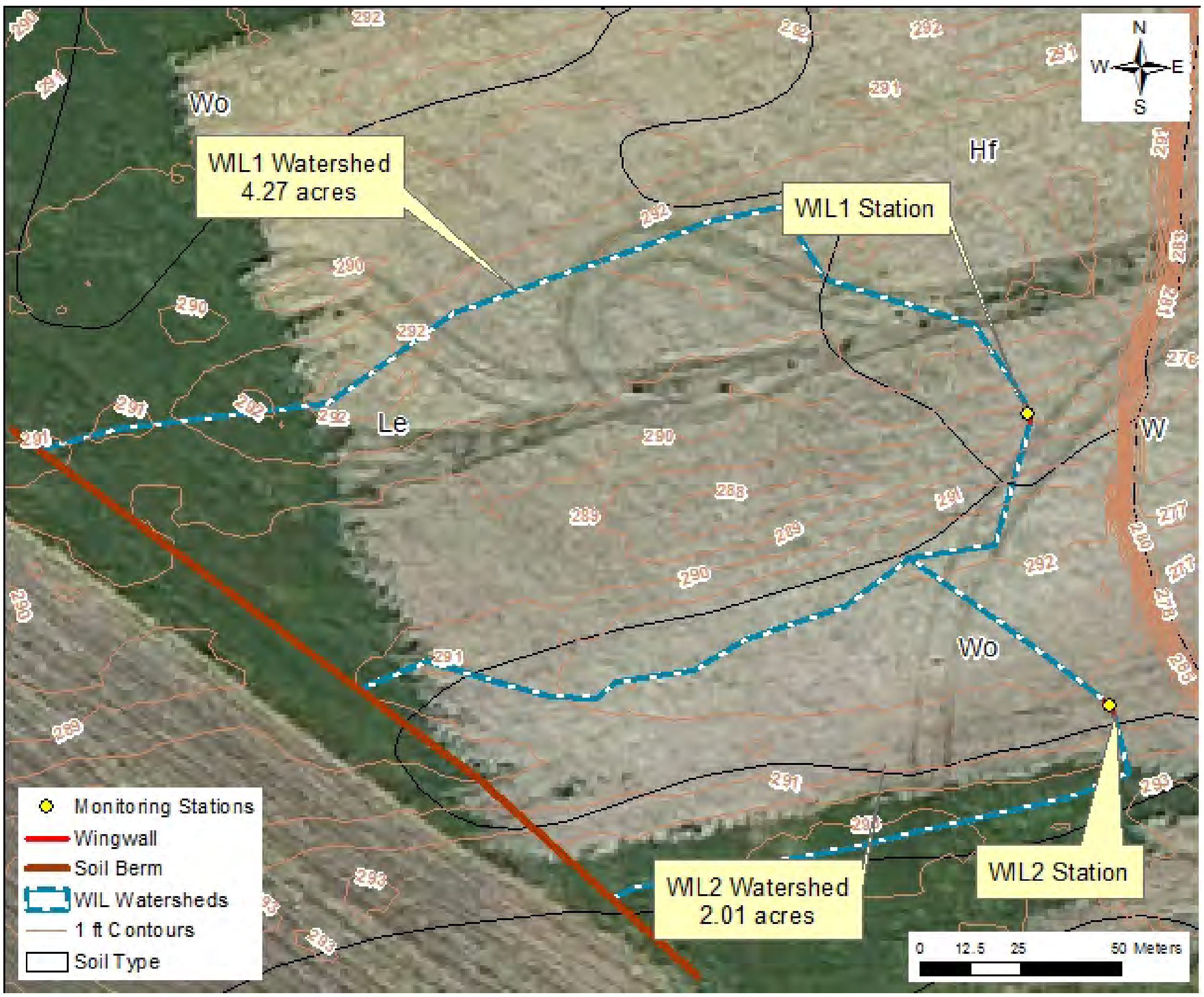

Figure 11. WIL1 and WIL2 watersheds

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.

APPENDIX B: QUALITY ASSURANCE PROJECT PLAN, VERSION 2.0

QA Project Plan:

Agricultural Practice Monitoring and Evaluation
Version 2.0

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

July 9, 2013
Version 2

Julie Moore, PE, Project Manager, Stone Environmental	3-5-14 Date
Chris Stone for Kim Watson, RQAP-GLP, Project QA Officer, Stone Environmental	3-5-14 Date
Chris Stone, President, Stone Environmental	3-5-14 Date
Eric Howe, Project Officer, LCBP	2/27/14 Date
FOR LAURA Laura DiPietro, Project Officer, VT AAFM	3-6-14 Date
Michael Jennings, Quality Assurance Program Manager, NEIWPCC	2/27/14 Date

QA Project Plan:

Agricultural Practice Monitoring and Evaluation
Version 2.0

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535 Stone Cutters Way
Montpelier, VT 05602

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54 West Shore Road
Grand Isle, VT 05458

July 9, 2013
Version 2

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

Kim Watson, RQAP-GLP, Project QA Officer, Stone Environmental | Date

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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

Table of Contents

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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.

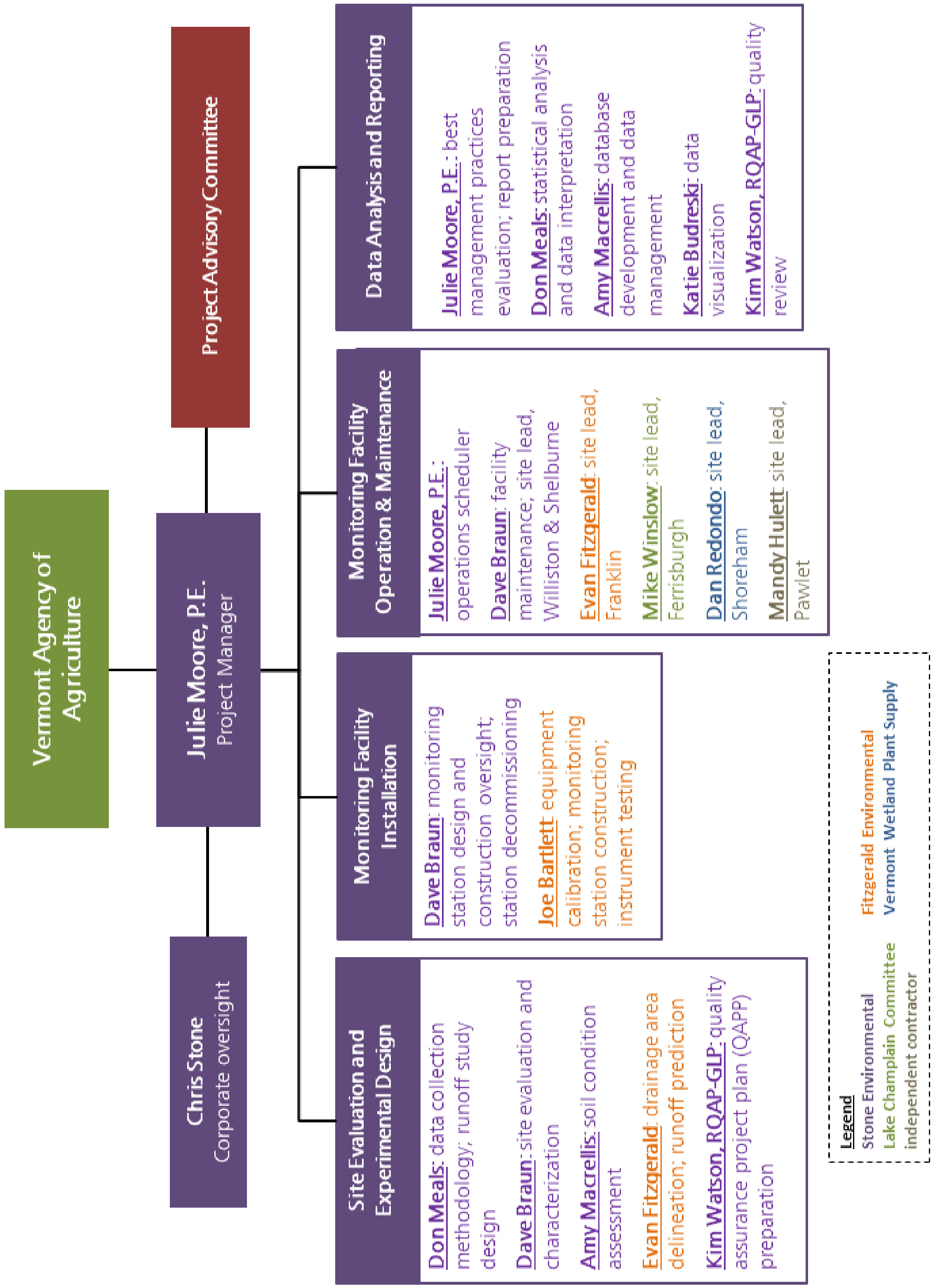
Table 1: Roles and Responsibilities

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 Document and approve all major field operations repairs and project changes Manage personnel schedules, including the courier service, and assign duties Interim/Final Report Preparation

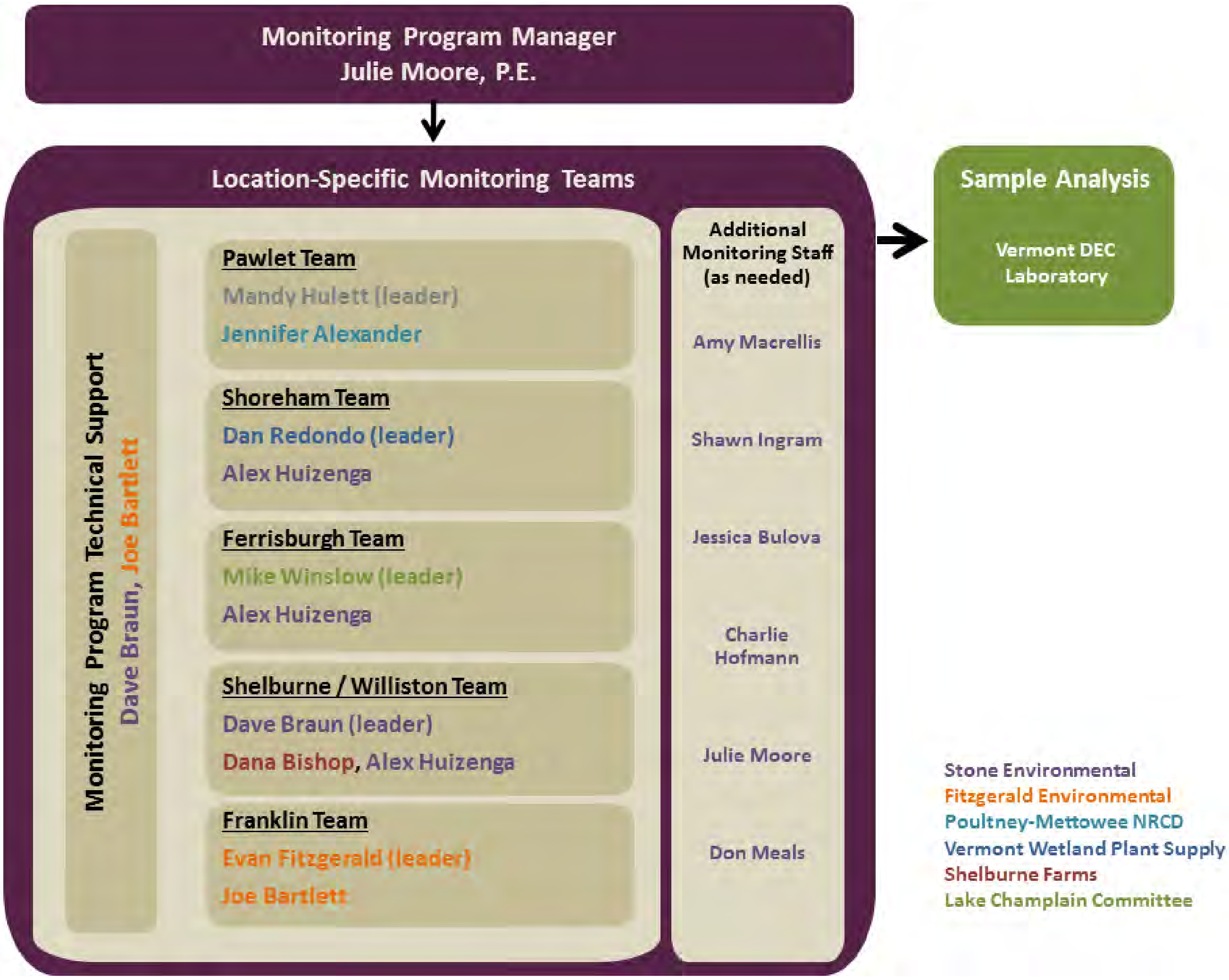
Individual(s) assigned	Responsible for:	Authorized to:
David Braun	Monitoring station design, site evaluation and characterization, construction oversight, non-routine maintenance, site lead for Williston and Shelburne sites, station decommissioning	Develop and approve final station designs Supervise station construction Repair damage/breakdown in field stations Calibrate and maintain monitoring equipment Collect, handle, and ship water samples Conduct routine operation and maintenance of field stations
Don Meals	Study design, data collection methodology, data analysis and interpretation	Approve overall study design Receive and verify collected data Conduct statistical data analysis 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 Develop and maintain data management system 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 Provide data reports and outputs 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 Resolve QA/QC issues
Subcontractors		
Evan Fitzgerald, Fitzgerald Environmental	Drainage area delineation; runoff prediction, site lead for Franklin sites	Calibrate and maintain monitoring equipment Collect, handle, and ship water samples 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 Test, adjust, and repair field instruments Repair damage/breakdown in field stations
Dan Redondo, Vermont Wetland Plant Supply	Site lead for Shoreham site	Calibrate and maintain monitoring equipment Collect, handle, and ship water samples 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 Collect, handle, and ship water samples Conduct routine operation and maintenance of field stations
Mike Winslow, Lake Champlain Committee	Site lead for Ferrisburgh site	Calibrate and maintain monitoring equipment Collect, handle, and ship water samples 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
Mandy Hulett (leader)
Jennifer Alexander
Shoreham Team
Dan Redondo (leader)
Alex Huizenga
Ferrisburgh Team
Mike Winslow (leader)
Alex Huizenga
Shelburne / Williston Team
Dave Braun (leader)
Dana Bishop, Alex Huizenga
Franklin Team
Evan Fitzgerald (leader)
Joe Bartlett
Additional Monitoring Staff (as needed)
Amy Macrellis
Shawn Ingram
Jessica Bulova
Charlie Hofmann
Julie Moore
Don Meals
Sample Analysis
Vermont DEC Laboratory
Stone Environmental
Fitzgerald Environmental
Poultney-Mettowee NRCD
Vermont Wetland Plant Supply
Shelburne Farms
Lake Champlain Committee

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.

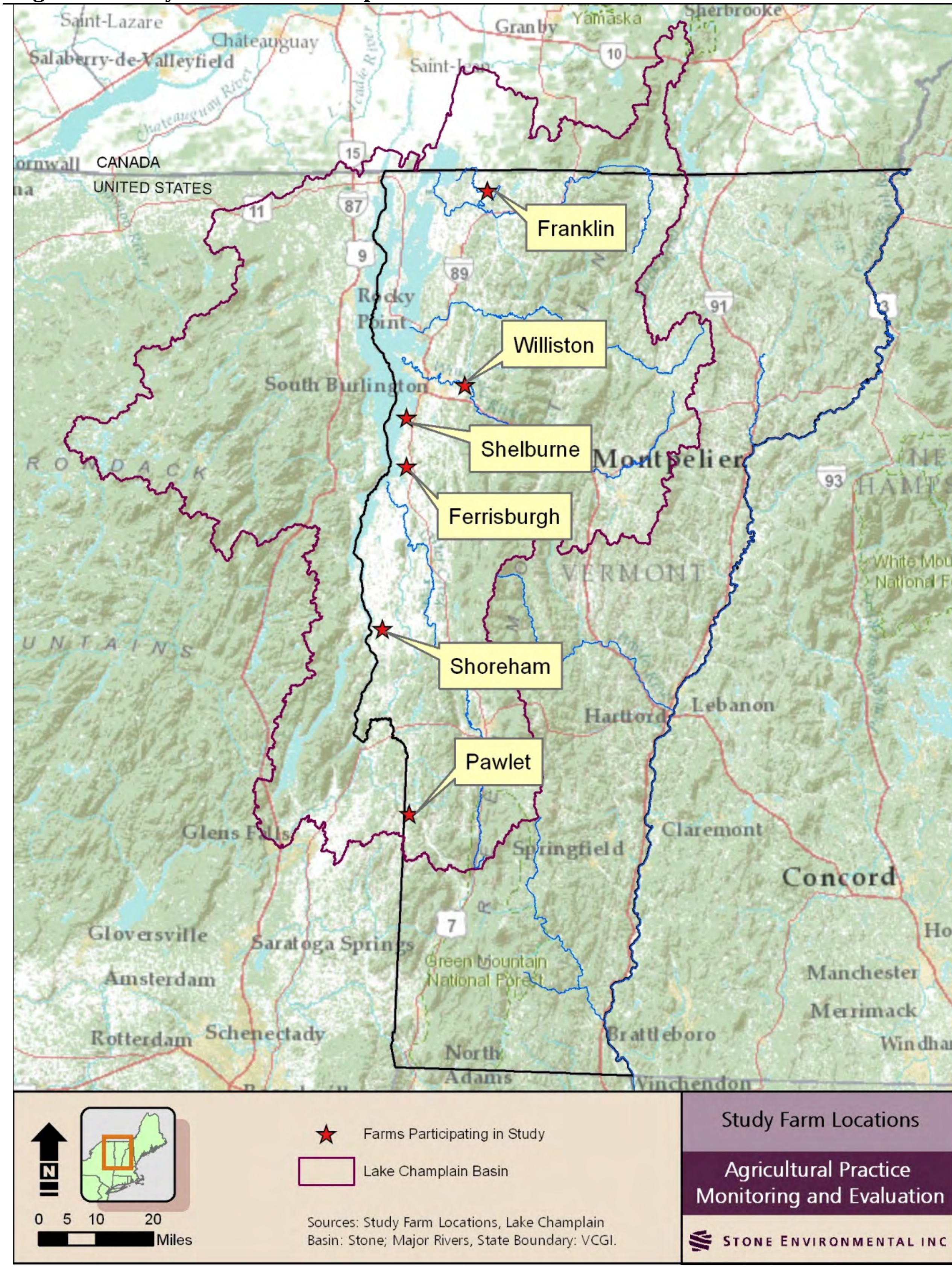
2. QAPP preparation and approval: A Quality Assurance Project Plan will be prepared and approved prior to commencement of the field work and data acquisition aspects of the project.

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 and at the upstream WASCoB 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 downstream WASCoB monitoring station, a pressure transducer 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.I In the case of the downstream WASCoB station, the temperature and conductivity sensor was installed within the pond itself. 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 to obtain data about practice performance outside of the growing season. Specifically, autosamplers will be operated remotely during rain storms and thaws in winter months to "opportunistically" collect samples when the flumes are clear. Project staff will carefully monitor flow level and temperature and activate autosamplers if/when rain is imminent, and then stop the autosampler at the end of the event or slightly early if ice appears to build up or temperature drops to preclude collection of invalid flow data and non-representative sampling due to ice/snow accumulation in the flume. 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 summer and fall, 2012. At the paired-watershed sites, calibration monitoring will commence late in the 2012 cropping season and continue through much or all of 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 2013. For treatment with effects exerted primarily in fall and spring (e.g., cover cropping), calibration monitoring will continue through spring of 2014. The exact timing of the implementation of treatments will depend on the treatment (e.g., aeration treatments will commence at the first hay cut after adequate calibration, whereas cover crop treatment will not occur until late summer/fall). Post-treatment monitoring will continue through at least spring 2015. 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 late 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	7-Jun-2012
3	Site characterization	Topographic survey and soil sampling	Topographic map and watershed boundary delineation for each monitored site; soil physical and chemical data	30-Nov-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	30-Sep-2012
5	Monitoring Program Implementation	Collect water quality and agricultural management monitoring data	Monitoring data for: Year 1 (2012) Year 2 (2013) Year 3 (2014)	1-Apr-2013 1-Apr-2014 30-Sep-2015
6	Data management and analysis	Build project database and manage monitoring data; conduct data analysis	Functioning data management system for entry, storage, and retrieval of all project data	31-Dec-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-2015
9	Decommission sites	Remove station installations and return monitoring equipment to farmers	Monitoring sites restored to original condition	31-Dec-2015
	Complete final report	Compile project summary, maps, results, etc.	Final Report	31-Dec-2015
	Contract End Date	QAPP Expiration	None	31-Mar-2016

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	°C	N/A	0.1°C	N/A	N/A	N/A	5 to 40 °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	°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, 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 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 presented in printed form in the annual and final reports, and will be archived. Appropriate summaries will be presented to the PAC and transmitted electronically, in spreadsheet form, 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. 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.

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);

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

- 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 properties (e.g., soil texture) by the University of Vermont Agricultural and Environmental Testing Lab and chemical properties by 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 a discharge event as beginning at a threshold stage of approximately 1 cm. That said, if an event occurred the total runoff flow was calculated, including the tails of the hydrograph. Generally, we wait until runoff at both ceased or the level at both stations fell below 1 cm. before making a field visit. However, if a field visit is made at a time when effective flow has ceased at only 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. Generally, monitoring will target runoff events that occur between April 1 and November 30. We propose to extend the monitoring season at the WASCoB, reduced tillage/manure injection, and cover crop-only treatment sites, with a limited program of winter/early spring event sampling. 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, autosamplers will be operated remotely during rain storms and thaws in winter months to “opportunistically” collect samples when the flumes are clear. Project staff will carefully monitor flow level and temperature and activate autosamplers if/when rain is imminent, and then stop the autosampler at the end of the event or slightly early if ice appears to build up or the temperature drops to preclude collection of invalid flow data and non-representative sampling due to ice/snow accumulation in the flume.

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
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

Sample Matrix	Analytical Parameters	Sample Container	Number of Samples	Sample Preservation	Hold Time (days)
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. 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 and at the upstream WASCoB station will be an appropriately-sized H-flume manufactured by Tracom. Each flume will be bolted to a rectangular plywood approach channel of varying length (approach channel length was 5 ft for 1.5-ft H flumes and 6 ft for 2.0-ft and the 2.5-ft H flumes). Plywood wingwalls embedded at least 60 cm in the ground will be installed as necessary to direct runoff into the flume approach channel. The approach channel will be mounted to the wingwall such that the opening is nearly flush with the ground. Through the life of the monitoring program, the flume will be kept level through regular adjustments using a system of turnbuckles.

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 0.00256 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.

B.2.1.2 Downstream WASCoB station

Due to backwater conditions in the channel downstream of the WASCoB, a different flow monitoring system was used at the downstream station (WAS2) from those at the other monitoring stations. A pressure transducer module (ISCO 720 Module) was installed within the pond to measure pond levels. This instrument's stated accuracy is ±0.008 m/m from 0.01 to 1.52 m and ±0.012 m/m above 1.52 m.

When the 720 pressure transducer module is connected to an ISCO 6712 autosampler, the autosampler can compute discharge according to a rating table of entered stage-discharge points. A preliminary rating table was developed using HydroCAD and the dimensions and elevations of the outlet structures. This rating table will be adjusted as necessary through discharge measurements over a range of pond stages. Averaged level and flow rate data will be logged at stage-dependent intervals (15 minutes at stages < 1 cm or 1 min at stages >=1 cm) on a connected Interface Module (ISCO 2105-Ci Interface Module).These data will be used for generation of runoff event hydrographs and total event discharge, and in calculation of pollutant export.

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 (10-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 WAS2 station, the sampler intake will be secured within the WASCoB, near the outlet. 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 two 6-volt deep cycle batteries connected in series 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 10-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 the fact that TP, TN, and TSS samples require a homogeneously mixed split, whereas for TDP, TDN, and chloride the procedure is to let the sample settle for at least one minute before filtering:

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

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 it 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 is less than 1 L, the accumulation will be considered negligible and the sediment discarded downstream of the monitoring station.
- If the sediment volume exceeds 1 L, a subsample of the accumulated sediment will be collected in a clean plastic jar for subsequent total phosphorus and density analysis (dry weight) in order to derive an estimate of the phosphorus and sediment mass in the flume/approach. Remaining sediment will be discarded downstream of the monitoring station.

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 WAS2 station, this instrument will be installed next to the sample intake line in the pond. 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 0.01 in (0.254 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 (AETL), where they will enter the lab's custody system, be assigned a lab identification number. The soil particle size analysis will be performed AETL; a portion of the sample will also be sent to the Agricultural & Forestry Experiment Station Analytical Laboratory at the University of Maine for chemical analysis, 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).

A Chain of Custody form will be completed by the sampler and will accompany all water quality samples delivered to the Department of Environmental Conservation lab for analysis (Appendix C). The Chain of Custody form includes sample IDs, number of containers of each sample being sent to the lab, and the analyses to be performed.

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. Analysis: Molybdate blue procedure with colorimetric analysis.	1
Soil	Available K	MAFES	Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES.	1
Soil	Available Mg	MAFES	Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES.	1

Sample Matrix	Analytical Parameter	Lab	Method	Reference
Soil	Available Ca	MAFES	Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES.	1
Soil	Available Fe	MAFES	Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES.	1
Soil	Available Mn	MAFES	Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES.	1
Soil	Available Zn	MAFES	Extraction: Modified Morgan solution, 5:1 V:V, shake 15 minutes, filter. Analysis: ICP-AES.	1
Soil	Organic matter	MAFES	Loss of weight on ignition	1
Soil	Particle size	AETL	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 flowmeters and ISCO 720 module) will be tested over the range of expected water levels, at approximately 15-cm depth intervals. For the 2110 ultrasonic level flowmeters, a single point calibration will be performed at 0-cm. The accuracy of the level readings will be assessed by stacking blocks of known thickness beneath the beam of the ultrasonic sensor. For the 720 pressure transducer module, the water depth will be measured with a ruler and compared with the recorded level displayed on the connected auosampler. After calibration, the instruments will be accepted if the difference between the measured water depths recorded 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.

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 at least weekly by analyzing the level data transmitted to Stone's server. The level will be adjusted if it differs from zero by more than +/- 0.002 m on dry days when the flume is clear of debris. An exception is that during sunny days heating of the sensor can result in substantial negative level readings. This problem is minimized to the extent practicable by shading the sensor from direct sunlight. The problem is not of significant concern during most rainfall/runoff events because the sky is typically overcast. However, because of this sensor anomaly, the accuracy of the level data will be assessed--and adjusted if necessary--after dark (usually at approximately 9:00 P.M.). Further, the sensor level may be zeroed even when the departure is only +/- 0.001 m or 0.002 m from zero during dry weather, particularly when the level data from one station in a pair is consistently higher or lower than the other station in the pair.

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 Chain of Custody sheets will be used by the laboratory to confirm sample receipt and crosswalk field-assigned sample IDs with those assigned by the laboratory. 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 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. Site visits will be conducted for more intensive maintenance activities approximately monthly during the monitoring period. A Maintenance Checklist will be completed during each maintenance visit (Appendix C). Deficiencies noted will be corrected by the responsible 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 the maintenance personnel, a Stone Environmental project scientist with expertise in the monitoring systems will diagnose and correct the problem.

The effectiveness of monitoring will be assessed by the responsible sampling personnel at each site using data collected at the time of sample retrieval at the end of each event (Appendix C). The Monitoring Program Manager or her designee will ensure data for each event is entered into the project database as it available. Once there is a complete data record for an event in the database, the Monitoring Program Manager or her designee will assess the quality of all event data (e.g., flow, analytical, weather) and will be responsible for verifying/validating all sample tracking information and laboratory analysis data. Any event data deficiencies will be flagged with a qualifying statement in the project database and necessary 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 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 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.

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

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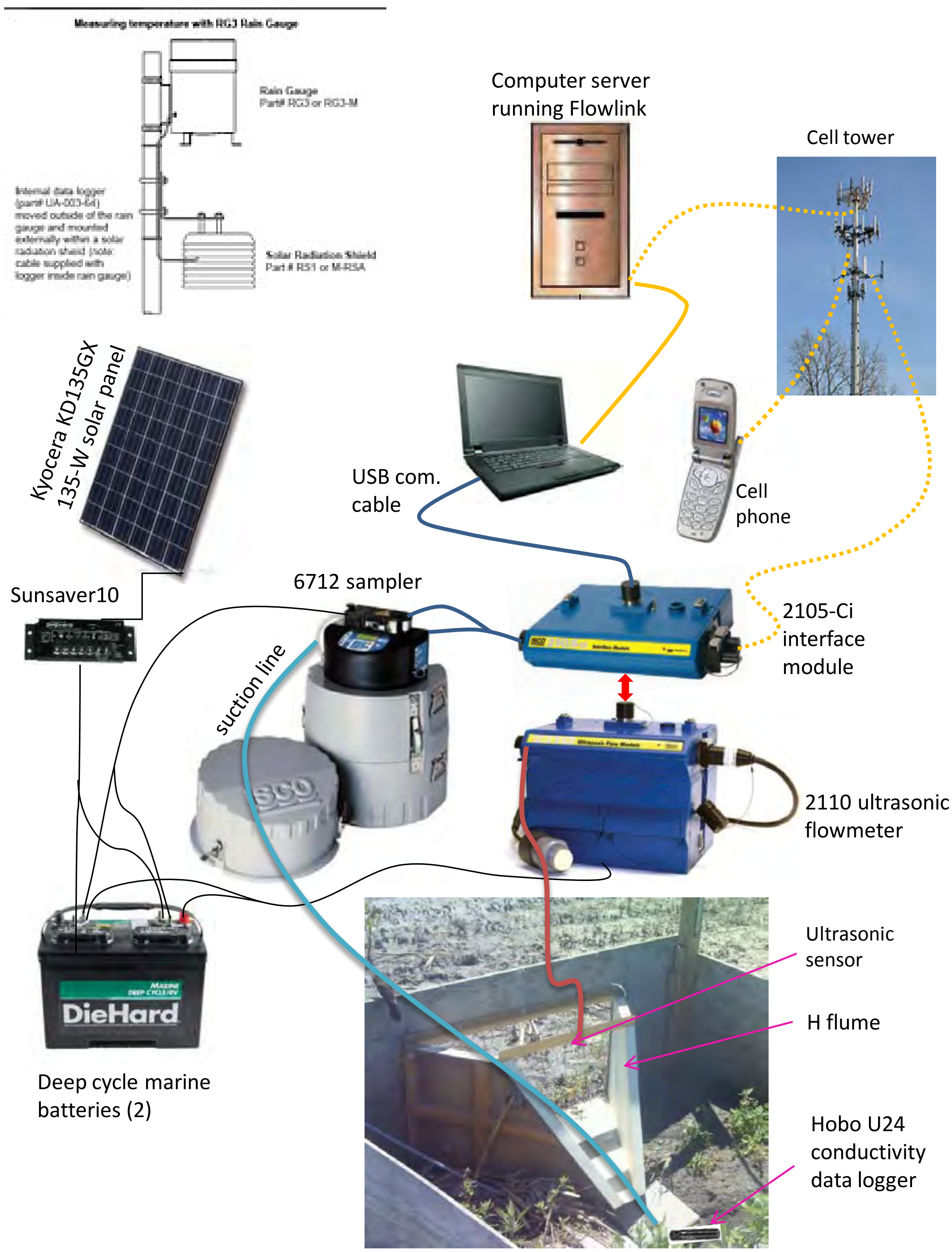
Appendices

Appendix A: Runoff monitoring station diagram

Monitoring station instrument Diagram



Appendix B: Example of Single-stage Passive Sampling Array

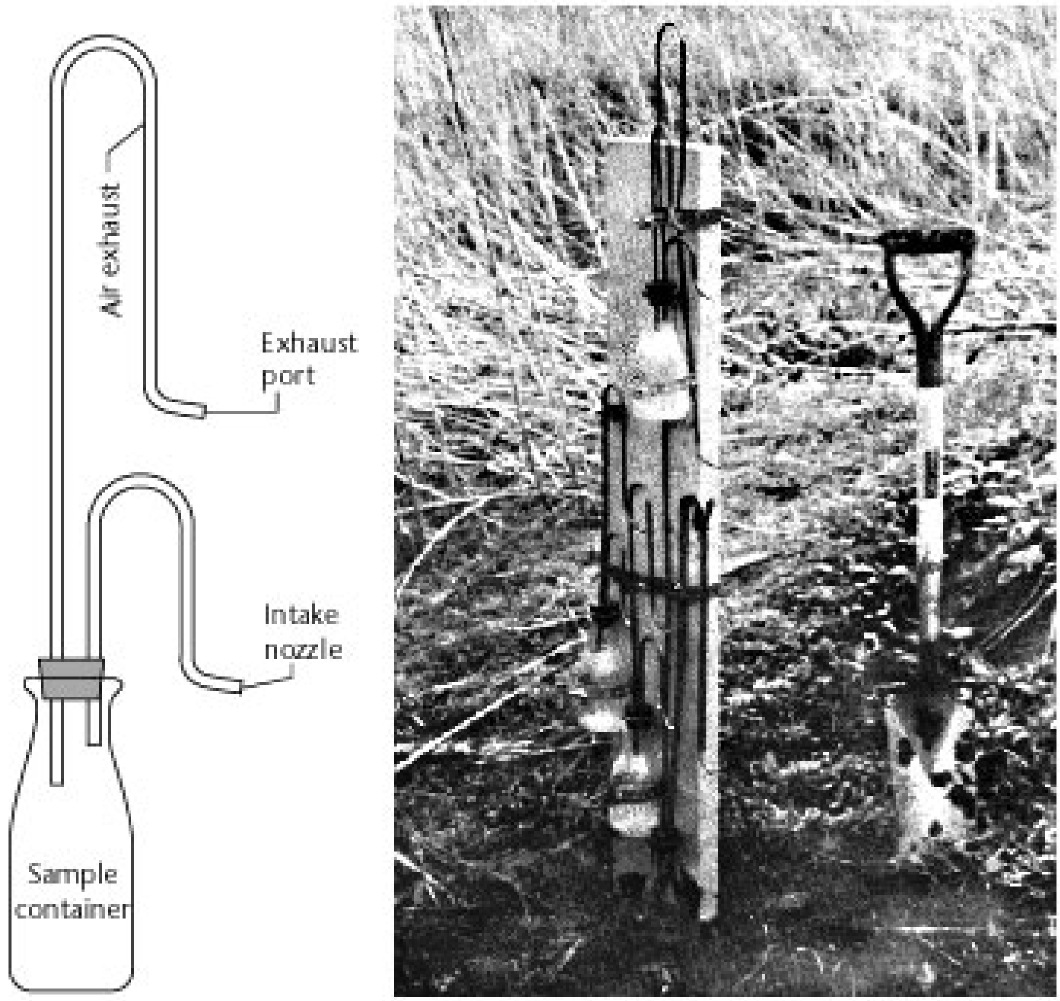


Figure 2-6. US U-59 sampler: (A) single stage, and (B) a bank of U-59 samplers installed on a plank post. (A, from Edwards and Glysson, 1986; B, photograph by J.C. Mundorff.)

Appendix C: Forms

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 (*record readings*)	☐ Not done / NA Exact Time: Temp. (°C): Sp. Cond. (µS):	☐ Not done / NA Exact Time: Temp. (°C): Sp. Cond. (µS):	
Clean U24-001 sensor window	☐	☐	
Camera downloaded and restarted	☐	☐	
Camera batteries	☐ OK ☐ Replaced	☐ OK ☐ Replaced	
Sampler program active and disabled	☐	☐	
Sampler tubing is attached	☐	☐	
Sample carboys installed properly	☐	☐	
2110 module desiccant	☐ OK ☐ Replaced	☐ OK ☐ Replaced	
Restock sampling supplies	☐	☐	
Scan or retrieve forms. Restock forms and labels if needed.	☐	☐	
Cleaned the ultrasonic level sensor (*only clean if dirty*)	☐ No ☐ Yes	☐ No ☐ Yes	
Clear any debris from flume, approach, and splash trough	☐	☐	
Check the flume level. Relevel if necessary	☐ OK ☐ Leveled	☐ OK ☐ Leveled	
Check/fill battery electrolyte levels. Clean terminals if corroded	☐ OK ☐ Filled	☐ OK ☐ Filled	
Check solar panel. Clean if needed	☐	☐	
Mow weeds	☐	☐	
Check flume and wingwalls for erosion, rodent holes, etc.	☐ OK ☐ Repaired	☐ OK ☐ 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: (circle one)	1. ACTIVE, DISABLED 2. PART A DONE 3. ACTIVE, Enabled	1. ACTIVE, DISABLED 2. PART A DONE 3. ACTIVE, Enabled
If ACTIVE and enabled, display reads:	PART A ____, ____ bottle__ _ after____ pulses	PART A ____, ____ bottle_ __ after____ pulses
Part B status: (circle one)	1. ACTIVE, DISABLED 2. PART B DONE 3. ACTIVE, Enabled	1. ACTIVE, DISABLED 2. PART B DONE 3. ACTIVE, Enabled
If ACTIVE and enabled, display reads:	PART B ____, ____ bottle___ after____ pulses	PART B ____, ____ 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 B3 B4 B3+B4 composite	A1 A2 A1+A2 composite B3 B4 B3+B4 composite
Sample ID assigned	_______ - _________ - _______ (Site ID) (mmddyy) (carboy(s))	_______ - _________ - _______ (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 Sample collected? Yes No NA	Sediment volume: _______ L NA 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 Splash trough: Yes No None Sampler intake: Yes No None	Flume/approach: Yes No None Splash trough: Yes No None Sampler intake: Yes No None
Check wingwalls for undercutting, rodent holes, etc.	□ OK □ Problem__________________ Problem fixed? Yes No NA	□ OK □ Problem__________________ Problem fixed? Yes No NA
Additional comments:		

v. 3

Chain of Custody

Stone Project ID: 112540-W

Lab Program #: 182

Stone Contact: Julie Moore, 279-5323, jmoore@stone-env.com

Collection Date	Sample ID	Total # of Containers	Analytes (circle those collected)
			TP TDP TN TDN TSS Cl-
			TP TDP TN TDN TSS Cl-
			TP TDP TN TDN TSS Cl-
			TP TDP TN TDN TSS Cl-
			TP TDP TN TDN TSS Cl-
			TP TDP TN TDN TSS Cl-
			TP TDP TN TDN TSS Cl-
			TP TDP TN TDN TSS Cl-

Sampled by: ______________________ ______________________

print name signature

Chain of Custody: Soil

Stone Project ID: 112540-W

Stone Contact: Julie Moore, 279-5323, jmoore@stone-env.com

Analytical Lab: Agricultural and Environmental
Testing Lab University of Vermont,
Plant & Soil Science Dept.
Room 262 Jeffords Hall
Burlington, VT 05405-1737
802-656-3030
agtesting@uvm.edu
Attention: Joel Tilley

Collection Date	Sample ID (Site-MMDDYY-SED)*	Total # of Containers Submitted	Analyses Requested
			Bulk density TP other:
			Bulk density TP other:
			Bulk density TP other:
			Bulk density TP other:
			Bulk density TP other:
			Bulk density TP other:
			Bulk density TP other:
			Bulk density TP other:

*Example: PAW1-031313-SED

Sampled by: ______________________ ______________________
print name signature

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	04/09/93	08/01/07	04/10/08

	Monitoring Wells and Observation Wells			
SEI-6.6.9	Installation and Testing of Bladder Pumps for Sampling of Monitoring Wells	04/09/93	03/31/04	05/02/08
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 C: COVER CROP MEASUREMENT PROCEDURE

STUDY SPECIFIC PROCEDURE

Cover Crop Measurement Procedure for the Agricultural Practice Monitoring and Evaluation Project

SSP Number: 112540-W SSP#2

Version Number: 1

Date Issued: 10/28/13

Date of Revision: NA

1.0 OBJECTIVE

To facilitate collection of high-quality crop cover data.

2.0 MATERIALS

1. GPS unit (Trimble if possible) containing random sampling coordinates
2. Digital camera
3. Quadrat
4. Data sheets
5. Index Cards

3.0 PROCEDURE

1. Before going into the field, generate randomized coordinate pairs (X,Y) within each study watershed using the "Create Random Points" tool in ArcMap's Data Management toolbox. Generate a sufficient number of coordinate pairs for a season of cover crop measurements. Each coordinate pair should be labeled with a sequential location ID.
2. A subset of the coordinate pairs (approximately 20) should then be loaded on a GPS device (e.g. Trimble GeoXT). The watershed boundary polygons should also be loaded to the GPS device to assist with navigation.
3. A 30 x 30cm PVC-framed quadrat should be utilized. The frame is strung with string to create 64 cross-grids. Exact dimensions are graphically displayed in section 8.0 and are sourced from Laycock and Canaway (1980) and Kershaw (1973).
4. Once at the watershed of interest, begin by taking photographs of the field. Note field condition and any other qualitative information that may prove helpful in later data analysis.
5. Use the GPS device from Step 1 to navigate to the randomly generated sampling points. Once at a point, and from that point, toss the quadrat 5-10 ft in any direction. If the quadrat lands outside the watershed boundary, start over.
6. Repeat the procedure between 10-20 times per watershed, selecting coordinate pairs in order from the list of random points. Fewer (i.e., 10-12) quadrat measurements are needed where cover is relatively homogeneous. More (i.e., 16-20) are needed where the surface cover is more variable.
7. Ready the data sheet by noting the location ID. Stand directly over the quadrat. Beginning in the upper left-hand corner marked "Start", take note of the cover type (cover crop, crop residue, soil, weed) directly below the intersection of the first two strings. Move from left to right until the final intersection is reached in the lower right-hand corner of the quadrat. One full column on the data sheet should be completed per quadrat.

8. Take a picture of each quadrat from above. If available, include an index card with the location ID in the pho

4.0 AUTHORIZATION

Written by: _Ryan Sleeper_ Date: 11/8/13

Ryan Sleeper, Water Quality Scientist, Stone Environmental, Inc.

Approved by: _Dave Braun_ Date: 11/8/13

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

5.0 REFERENCES

Laycock, R.W., and P.M. Canaway. 1980. An optical point quadrat frame for the estimation of cover in closely-mown turf. J. Sports Turf Res. Inst. 56:91–92.

Kershaw, K.A. 1973. Quantitative and dynamic plant ecology. 2nd ed. Am. Elsevier Publishing Co., New York.

6.0 REVISION HISTORY

Not Applicable

Cover Crop Percent Coverage Data Sheet

Study watershed ______________ Name ______________ Date ______________

Key: C = cover crop, R = crop residue, S = soil, W = weed, A=rock

		Loc___	Loc___	Loc___	Loc___	Loc___	Loc___	Loc___	Loc___		
1	1	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	1	1
	2	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	2	
	3	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	3	
	4	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	4	
	5	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	5	
	6	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	6	
	7	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	7	
	8	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	8	
2	1	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	1	2
	2	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	C R S W	2	
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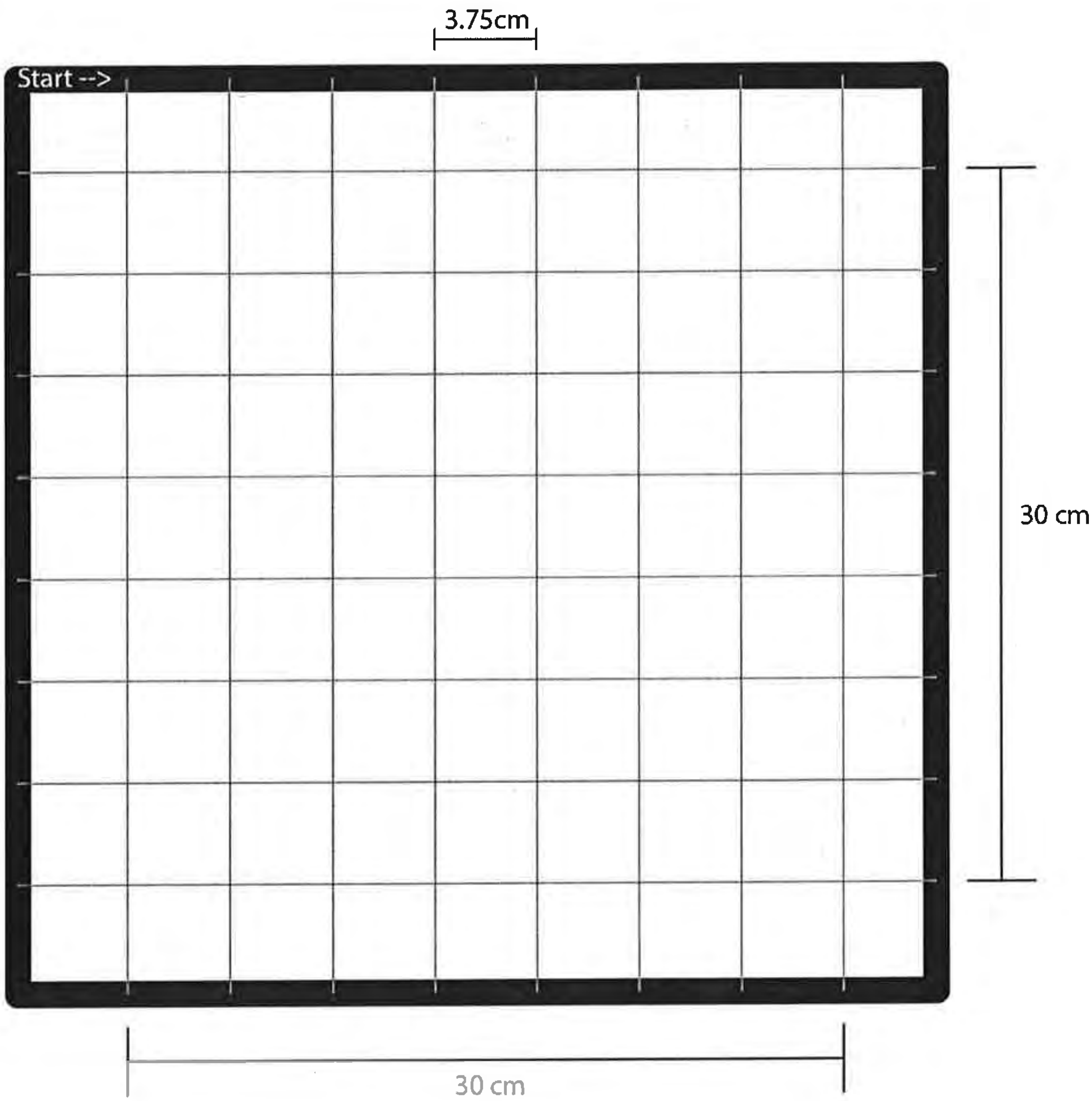
8.0 QUADRAT DESIGN

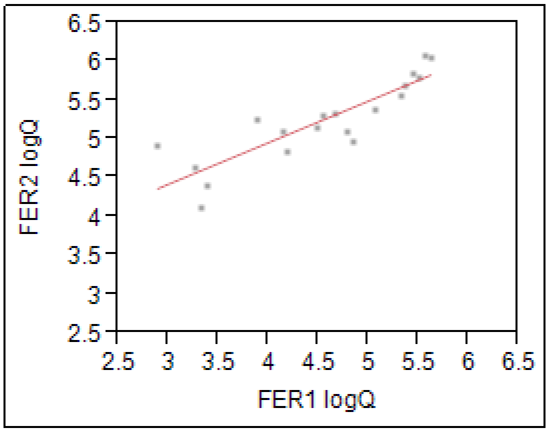


APPENDIX D: CALIBRATION PERIOD REGRESSION ANALYSES

D.1. Ferrisburgh Site Regressions

Q

CALIBRATION



Summary of Fit

RSquare	0.763821
RSquare Adj	0.749928
Root Mean Square Error	0.266167
Mean of Response	5.246338
Observations (or Sum Wgts)	19

Analysis of Variance

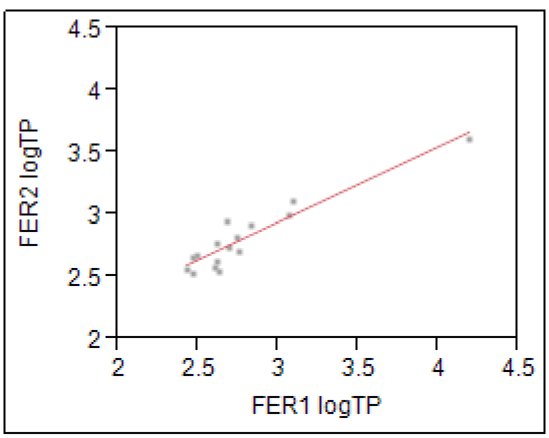
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	3.8950045	3.89500	54.9792
Error	17	1.2043665	0.07085	Prob > F
C. Total	18	5.0993709		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.8145147	0.333605	8.44	<.0001*
FER1 logQ	0.536318	0.072331	7.41	<.0001*

TP

CALIBRATION



Summary of Fit

RSquare	0.876906
RSquare Adj	0.868114
Root Mean Square Error	0.099673
Mean of Response	2.804091
Observations (or Sum Wgts)	16

Analysis of Variance

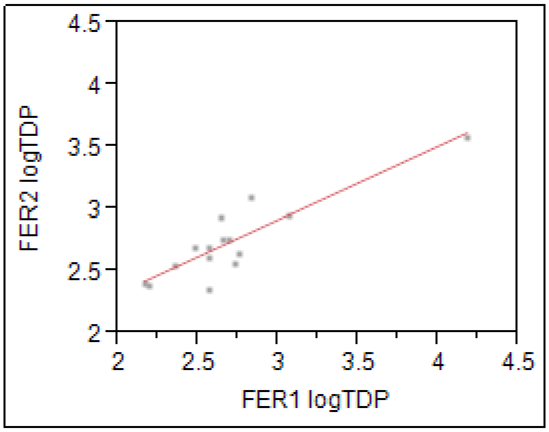
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.9908397	0.990840	99.7346
Error	14	0.1390867	0.009935	Prob > F
C. Total	15	1.1299264		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.1308655	0.169388	6.68	<.0001*
FER1 logTP	0.6044374	0.060524	9.99	<.0001*

FER statistics update February 2014

TDP
CALIBRATION



Summary of Fit

RSquare	0.792883
RSquare Adj	0.77695
Root Mean Square Error	0.14881
Mean of Response	2.732722
Observations (or Sum Wgts)	15

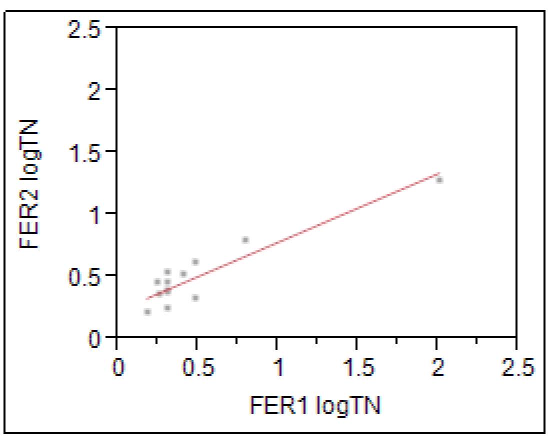
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.1020531	1.10205	49.7663
Error	13	0.2878793	0.02214	**Prob > F**
C. Total	14	1.3899324		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.1375067	0.229368	4.96	0.0003*
FER1 logTDP	0.5926267	0.084007	7.05	<.0001*

TN
CALIBRATION



Summary of Fit

RSquare	0.828745
RSquare Adj	0.816512
Root Mean Square Error	0.113901
Mean of Response	0.479167
Observations (or Sum Wgts)	16

Analysis of Variance

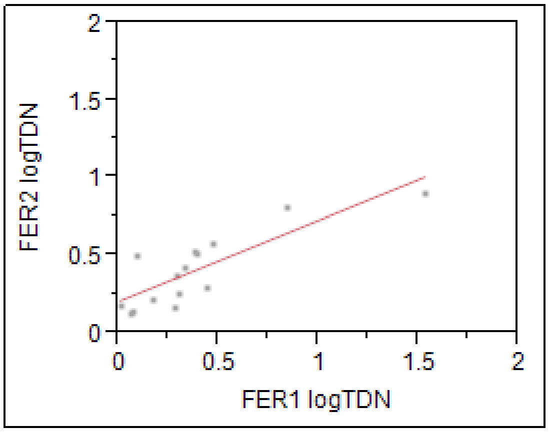
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.8789482	0.878948	67.7493
Error	14	0.1816297	0.012974	**Prob > F**
C. Total	15	1.0605778		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.2299794	0.041562	5.53	<.0001*
FER1 logTN	0.5529276	0.067176	8.23	<.0001*

FER statistics update February 2014

TDN
CALIBRATION



Summary of Fit

RSquare	0.694748
RSquare Adj	0.671267
Root Mean Square Error	0.137277
Mean of Response	0.402103
Observations (or Sum Wgts)	15

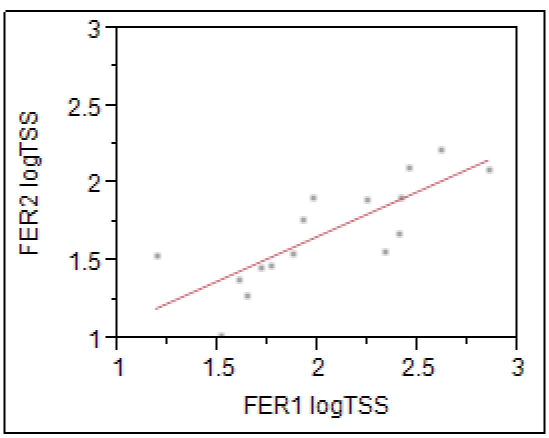
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.55758478	0.557585	29.5878
Error	13	0.24498615	0.018845	**Prob > F**
C. Total	14	0.80257093		0.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.2052734	0.050653	4.05	0.0014*
FER1 logTDN	0.5225722	0.09607	5.44	0.0001*

TSS
CALIBRATION



Summary of Fit

RSquare	0.633084
RSquare Adj	0.606876
Root Mean Square Error	0.207571
Mean of Response	1.682635
Observations (or Sum Wgts)	16

Analysis of Variance

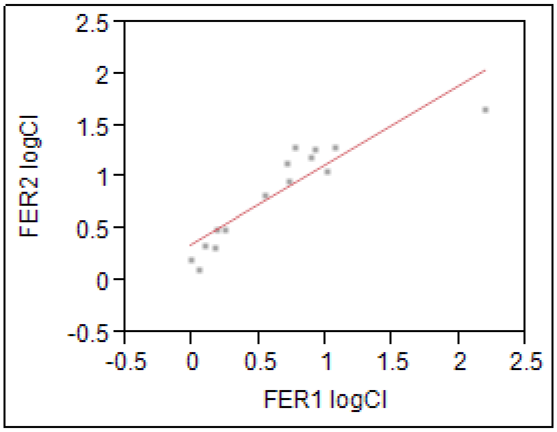
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.0407780	1.04078	24.1559
Error	14	0.6032025	0.04309	**Prob > F**
C. Total	15	1.6439805		0.0002*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.512702	0.24363	2.10	0.0539
FER1 logTSS	0.5768633	0.117371	4.91	0.0002*

Cl

CALIBRATION



Summary of Fit

RSquare	0.828806
RSquare Adj	0.815637
Root Mean Square Error	0.206403
Mean of Response	0.851947
Observations (or Sum Wgts)	15

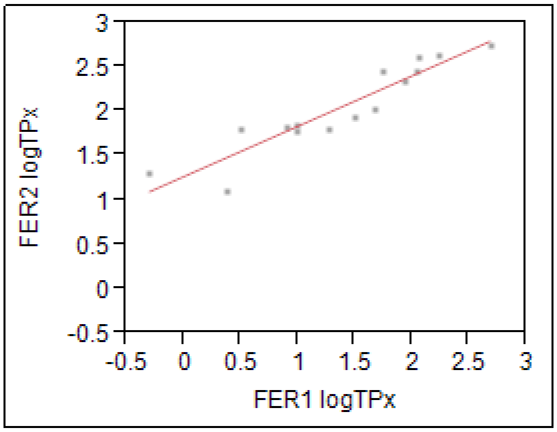
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2.6812628	2.68126	62.9372
Error	13	0.5538288	0.04260	**Prob > F**
C. Total	14	3.2350916		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.3719708	0.080626	4.61	0.0005*
FER1 logCl	0.7643064	0.096342	7.93	<.0001*

TPx
CALIBRATION



Summary of Fit

RSquare	0.87224
RSquare Adj	0.863115
Root Mean Square Error	0.178585
Mean of Response	2.071229
Observations (or Sum Wgts)	16

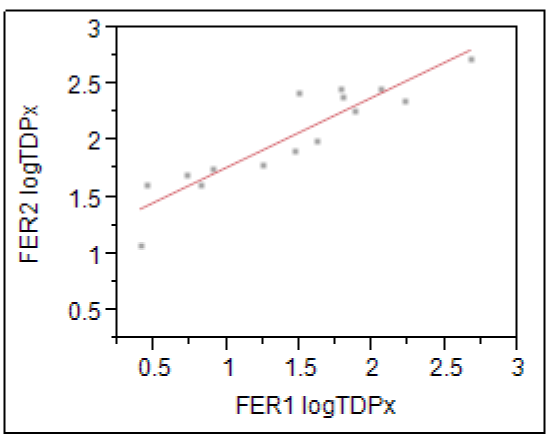
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	3.0483036	3.04830	95.5806
Error	14	0.4464947	0.03189	Prob > F
C. Total	15	3.4947983		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.2657427	0.093709	13.51	<.0001*
FER1 logTPx	0.5701614	0.058319	9.78	<.0001*

TDPx
CALIBRATION



Summary of Fit

RSquare	0.847574
RSquare Adj	0.835849
Root Mean Square Error	0.182623
Mean of Response	2.041495
Observations (or Sum Wgts)	15

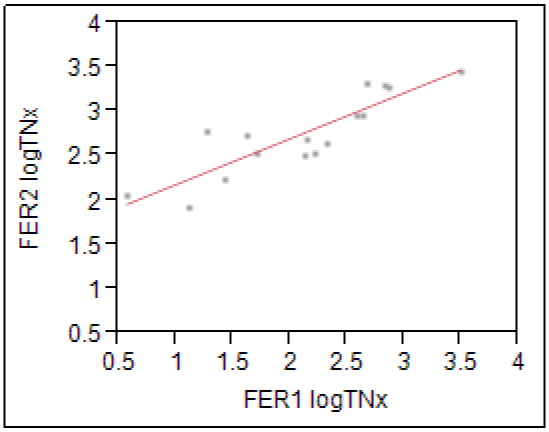
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2.4108727	2.41087	72.2876
Error	13	0.4335648	0.03335	Prob > F
C. Total	14	2.8444375		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.1527926	0.11467	10.05	<.0001*
FER1 logTDPx	0.6212663	0.073071	8.50	<.0001*

TNx
CALIBRATION



Summary of Fit

RSquare	0.763732
RSquare Adj	0.746856
Root Mean Square Error	0.228333
Mean of Response	2.746458
Observations (or Sum Wgts)	16

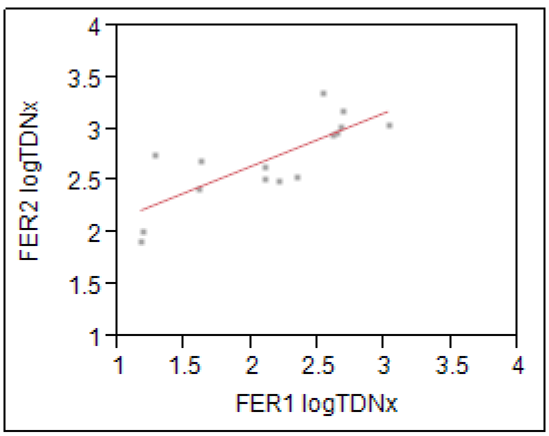
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2.3594087	2.35941	45.2547
Error	14	0.7299066	0.05214	Prob > F
C. Total	15	3.0893153		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.6584704	0.171509	9.67	<.0001*
FER1 logTNx	0.5184217	0.077064	6.73	<.0001*

TDNx
CALIBRATION



Summary of Fit

RSquare	0.623489
RSquare Adj	0.594526
Root Mean Square Error	0.253842
Mean of Response	2.710982
Observations (or Sum Wgts)	15

Analysis of Variance

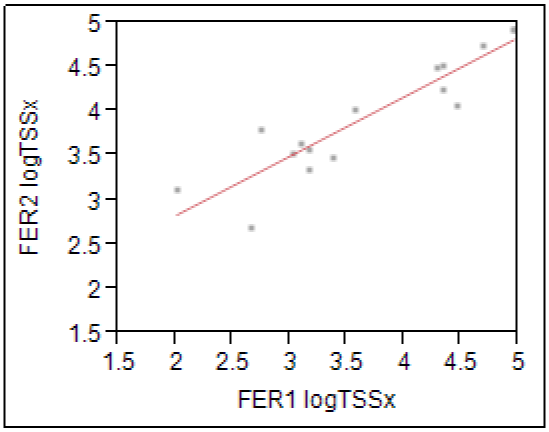
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.3871449	1.38714	21.5275
Error	13	0.8376668	0.06444	Prob > F
C. Total	14	2.2248117		0.0005*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.6190413	0.244299	6.63	<.0001*
FER1 logTDNx	0.5164907	0.111318	4.64	0.0005*

TSSx

CALIBRATION



Summary of Fit

RSquare	0.836469
RSquare Adj	0.824788
Root Mean Square Error	0.276864
Mean of Response	3.949827
Observations (or Sum Wgts)	16

Analysis of Variance

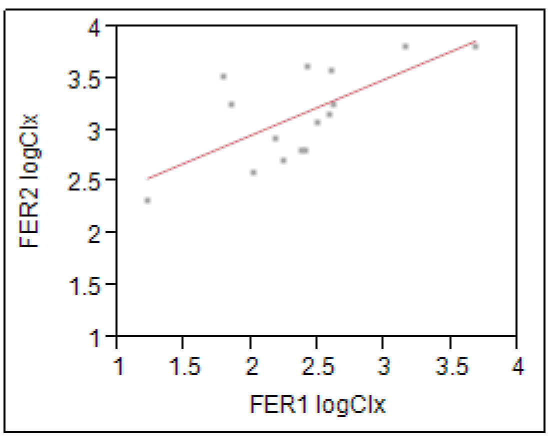
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	5.4891895	5.48919	71.6105
Error	14	1.0731485	0.07665	Prob > F
C. Total	15	6.5623381		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.485207	0.299359	4.96	0.0002*
FER1 logTSSx	0.6708838	0.079279	8.46	<.0001*

Clx

CALIBRATION



Summary of Fit

RSquare	0.461364
RSquare Adj	0.419931
Root Mean Square Error	0.348384
Mean of Response	3.160812
Observations (or Sum Wgts)	15

Analysis of Variance

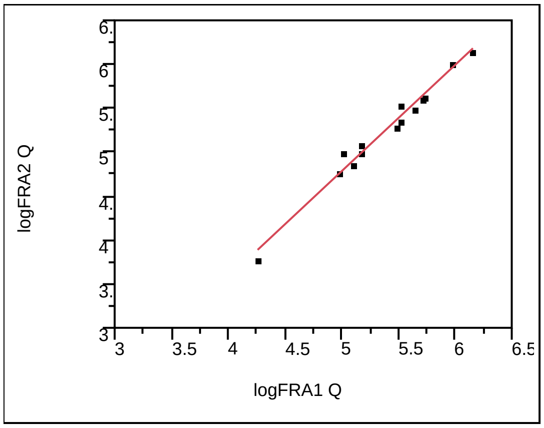
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.3514755	1.35148	11.1351
Error	13	1.5778264	0.12137	Prob > F
C. Total	14	2.9293019		0.0054*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.8817987	0.393705	4.78	0.0004*
FER1 logClx	0.5404921	0.161973	3.34	0.0054*

D.2. Franklin Site Regressions

Q
CALIBRATION



Summary of Fit

RSquare	0.977816
RSquare Adj	0.975967
Root Mean Square Error	0.091285
Mean of Response	5.247257
Observations (or Sum Wgts)	14

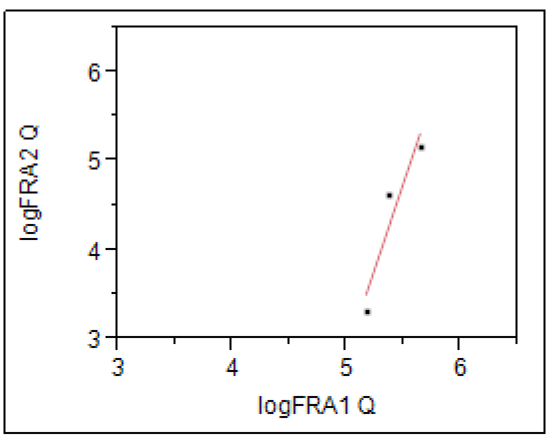
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	4.4075224	4.40752	528.9231
Error	12	0.0999961	0.00833	**Prob > F**
C. Total	13	4.5075186		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-1.263064	0.284127	-4.45	0.0008*
logFRA1 Q	1.2090302	0.05257	23.00	<.0001*

TREATMENT

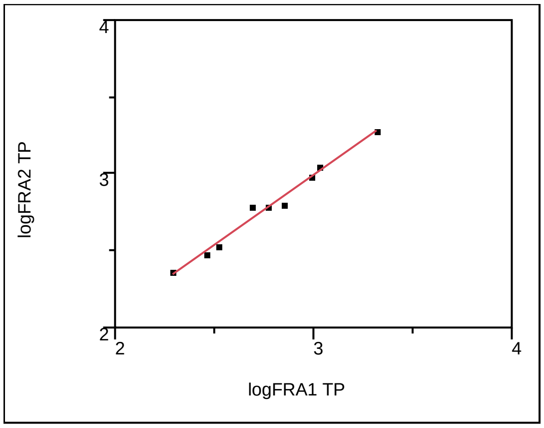


Summary of Fit

RSquare	0.912291
RSquare Adj	0.824583
Root Mean Square Error	0.398353
Mean of Response	4.368589
Observations (or Sum Wgts)	3

F Ratio
10.4014
Prob > F
0.1914

TP
CALIBRATION
Regression Plot



Summary of Fit

RSquare	0.982776
RSquare Adj	0.980315
Root Mean Square Error	0.041274
Mean of Response	2.782941
Observations (or Sum Wgts)	9

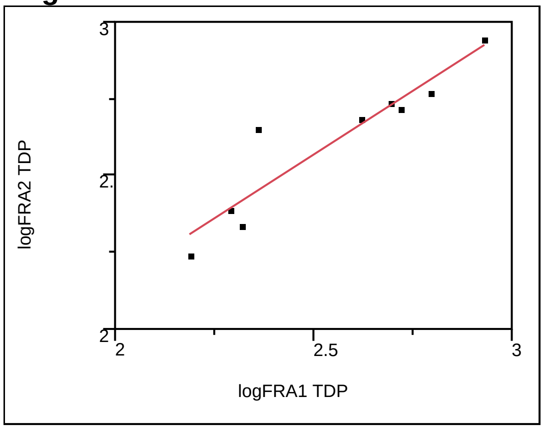
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.68038510	0.680385	399.4000
Error	7	0.01192463	0.001704	Prob > F
C. Total	8	0.69230973		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.262408	0.126869	2.07	0.0774
logFRA1 TP	0.91015	0.045542	19.98	<.0001*

TDP
CALIBRATION
Regression Plot



Summary of Fit

RSquare	0.872537
RSquare Adj	0.854328
Root Mean Square Error	0.088655
Mean of Response	2.60622
Observations (or Sum Wgts)	9

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.37661902	0.376619	47.9181
Error	7	0.05501752	0.007860	Prob > F
C. Total	8	0.43163654		0.0002*

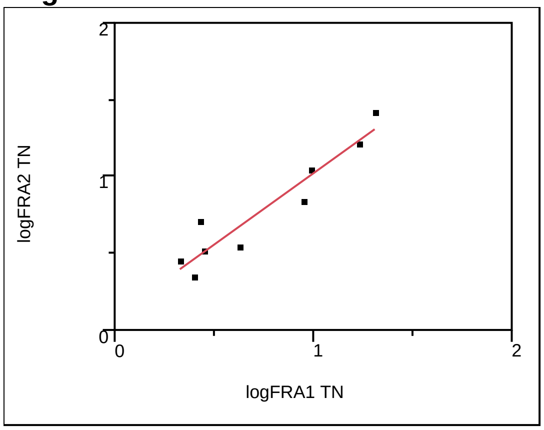
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.4931839	0.306678	1.61	0.1518
logFRA1 TDP	0.8297112	0.119861	6.92	0.0002*

TN

CALIBRATION

Regression Plot



Summary of Fit

RSquare	0.894692
RSquare Adj	0.879648
Root Mean Square Error	0.129099
Mean of Response	0.784091
Observations (or Sum Wgts)	9

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.9911847	0.991185	59.4714
Error	7	0.1166660	0.016667	**Prob > F**
C. Total	8	1.1078507		0.0001*

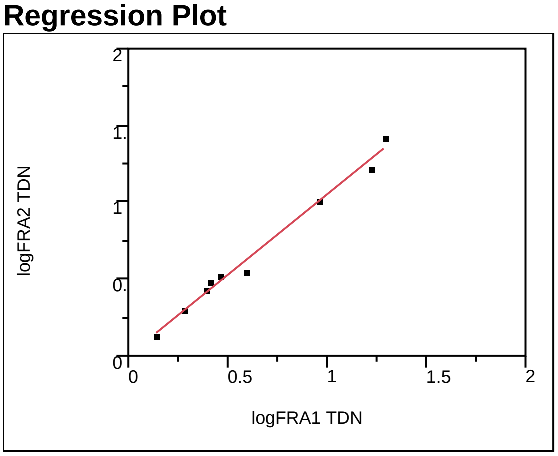
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0903689	0.099719	0.91	0.3949
logFRA1 TN	0.9291155	0.12048	7.71	0.0001*

TDN

CALIBRATION

Regression Plot



Summary of Fit

RSquare	0.987155
RSquare Adj	0.98532
Root Mean Square Error	0.053187
Mean of Response	0.671912
Observations (or Sum Wgts)	9

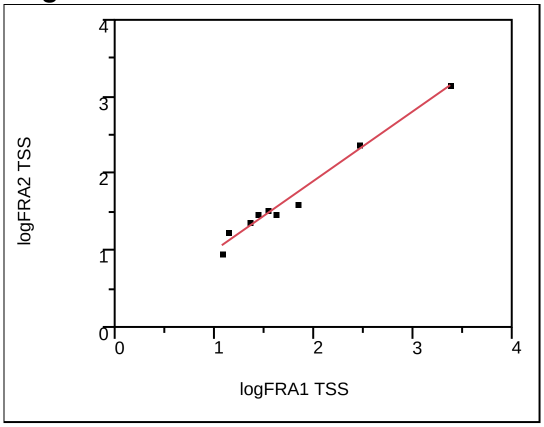
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.5218164	1.52182	537.9697
Error	7	0.0198017	0.00283	**Prob > F**
C. Total	8	1.5416181		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0019083	0.033893	0.06	0.9567
logFRA1 TDN	1.0484516	0.045203	23.19	<.0001*

TSS
CALIBRATION
Regression Plot



Summary of Fit

RSquare	0.98206
RSquare Adj	0.979497
Root Mean Square Error	0.096076
Mean of Response	1.683549
Observations (or Sum Wgts)	9

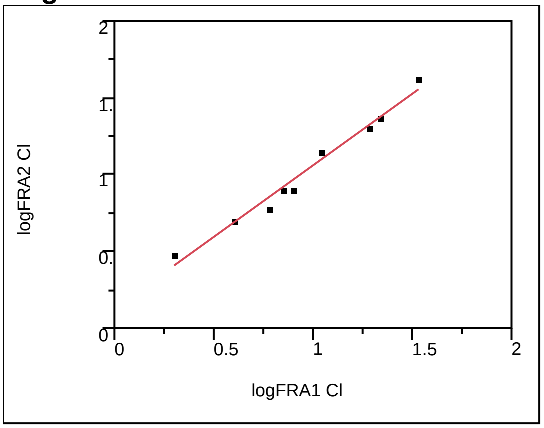
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	3.5370824	3.53708	383.1893
Error	7	0.0646145	0.00923	**Prob > F**
C. Total	8	3.6016969		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0861325	0.087663	0.98	0.3586
logFRA1 TSS	0.9064319	0.046305	19.58	<.0001*

Cl
CALIBRATION
Regression Plot



Summary of Fit

RSquare	0.978706
RSquare Adj	0.975664
Root Mean Square Error	0.056763
Mean of Response	1.021395
Observations (or Sum Wgts)	9

Analysis of Variance

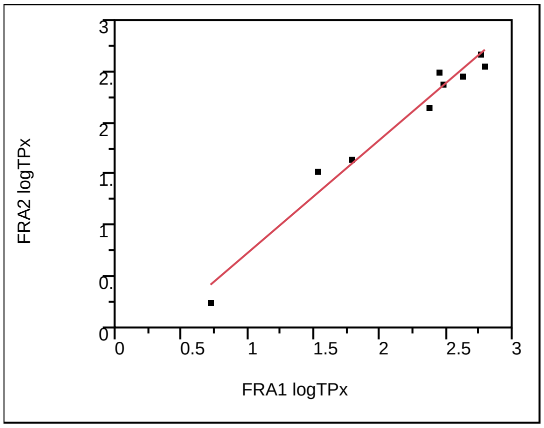
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.0366066	1.03661	321.7288
Error	7	0.0225539	0.00322	**Prob > F**
C. Total	8	1.0591605		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.1282055	0.05327	2.41	0.0470*
logFRA1 Cl	0.9321887	0.051971	17.94	<.0001*

TPx
CALIBRATION

Regression Plot



Summary of Fit

RSquare	0.971128
RSquare Adj	0.967003
Root Mean Square Error	0.140707
Mean of Response	2.015513
Observations (or Sum Wgts)	9

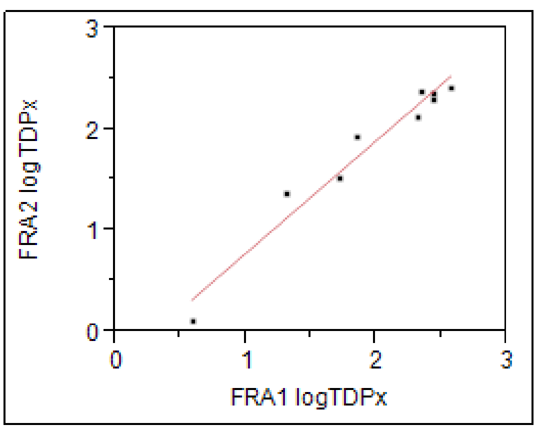
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	4.6615073	4.66151	235.4489
Error	7	0.1385887	0.01980	**Prob > F**
C. Total	8	4.8000960		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.383251	0.163213	-2.35	0.0512
FRA1 logTPx	1.1063946	0.072104	15.34	<.0001*

TDPx
CALIBRATION



Summary of Fit

RSquare	0.957535
RSquare Adj	0.951469
Root Mean Square Error	0.165159
Mean of Response	1.83885
Observations (or Sum Wgts)	9

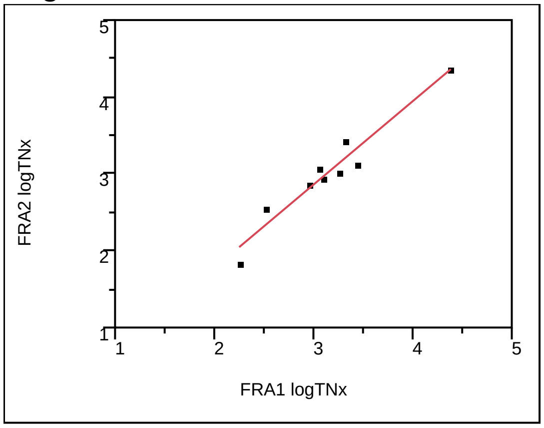
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	4.3055459	4.30555	157.8417
Error	7	0.1909433	0.02728	**Prob > F**
C. Total	8	4.4964892		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.326208	0.180909	-1.80	0.1144
FRA1 logTDPx	1.1130056	0.08859	12.56	<.0001*

TNx
CALIBRATION
Regression Plot



Summary of Fit

RSquare	0.937296
RSquare Adj	0.928338
Root Mean Square Error	0.180493
Mean of Response	3.015905
Observations (or Sum Wgts)	9

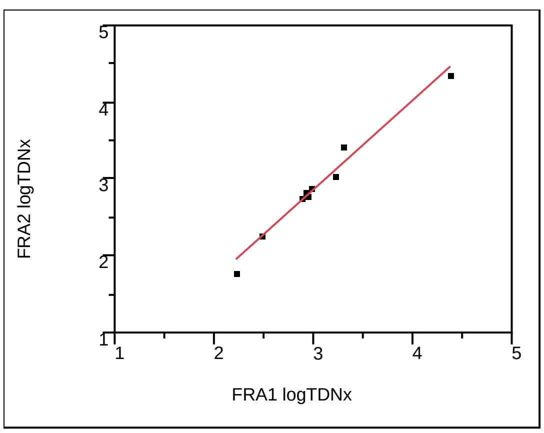
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	3.4088001	3.40880	104.6358
Error	7	0.2280442	0.03258	**Prob > F**
C. Total	8	3.6368443		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.397012	0.339027	-1.17	0.2799
FRA1 logTNx	1.0850705	0.106076	10.23	<.0001*

TDNx
CALIBRATION
Regression Plot



Summary of Fit

RSquare	0.974287
RSquare Adj	0.970614
Root Mean Square Error	0.122301
Mean of Response	2.903747
Observations (or Sum Wgts)	9

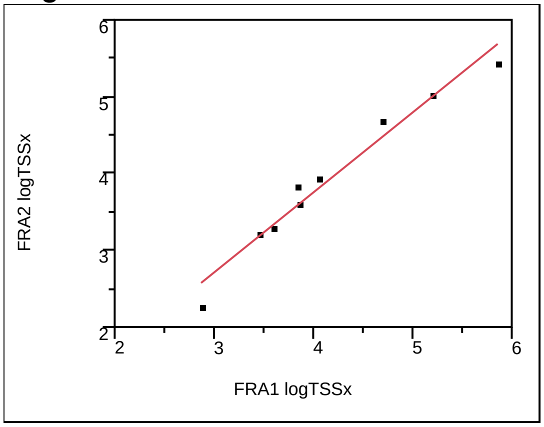
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	3.9672769	3.96728	265.2379
Error	7	0.1047020	0.01496	**Prob > F**
C. Total	8	4.0719789		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.630252	0.220791	-2.85	0.0245*
FRA1 logTDNx	1.1633294	0.071431	16.29	<.0001*

TSSx
CALIBRATION
Regression Plot



Summary of Fit

RSquare	0.963535
RSquare Adj	0.958326
Root Mean Square Error	0.201647
Mean of Response	3.916236
Observations (or Sum Wgts)	9

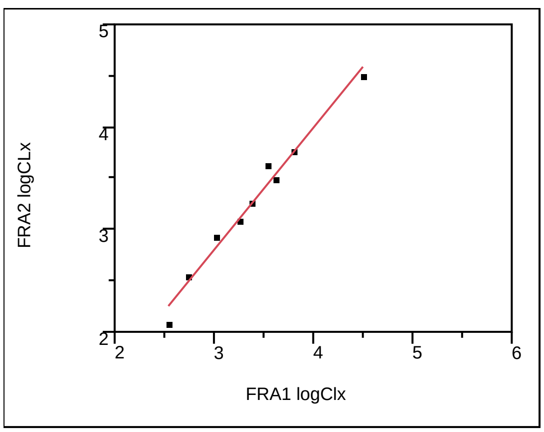
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	7.5209360	7.52094	184.9646
Error	7	0.2846305	0.04066	**Prob > F**
C. Total	8	7.8055664		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.417558	0.325669	-1.28	0.2406
FRA1 logTSSx	1.0419299	0.076612	13.60	<.0001*

Clx
CALIBRATION
Regression Plot



Summary of Fit

RSquare	0.979403
RSquare Adj	0.976461
Root Mean Square Error	0.108697
Mean of Response	3.249268
Observations (or Sum Wgts)	9

Analysis of Variance

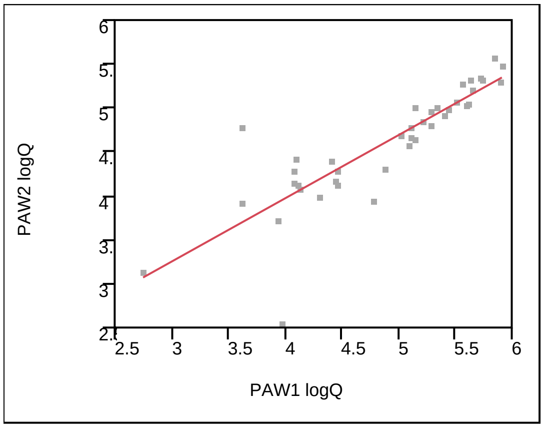
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	3.9327367	3.93274	332.8570
Error	7	0.0827057	0.01182	**Prob > F**
C. Total	8	4.0154424		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.775119	0.223538	-3.47	0.0104*
FRA1 logClx	1.1911756	0.06529	18.24	<.0001*

D.3. Pawlet Site Regressions

Q
CALIBRATION



Summary of Fit

RSquare	0.731423
RSquare Adj	0.724355
Root Mean Square Error	0.336793
Mean of Response	4.605147
Observations (or Sum Wgts)	40

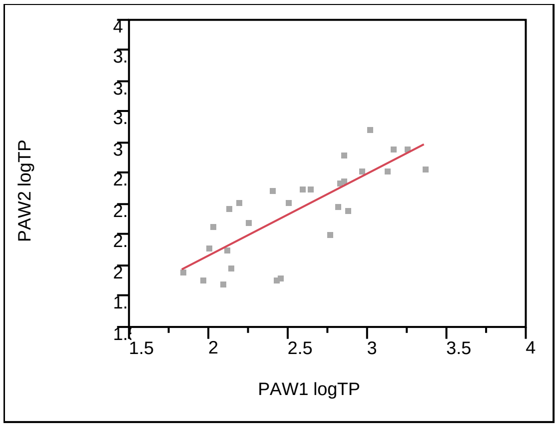
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	11.738384	11.7384	103.4864
Error	38	4.310311	0.1134	**Prob > F**
C. Total	39	16.048695		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.0897034	0.349651	3.12	0.0035*
PAW1 logQ	0.7198668	0.070764	10.17	<.0001*

TP
CALIBRATION



Summary of Fit

RSquare	0.623178
RSquare Adj	0.608685
Root Mean Square Error	0.231626
Mean of Response	2.451421
Observations (or Sum Wgts)	28

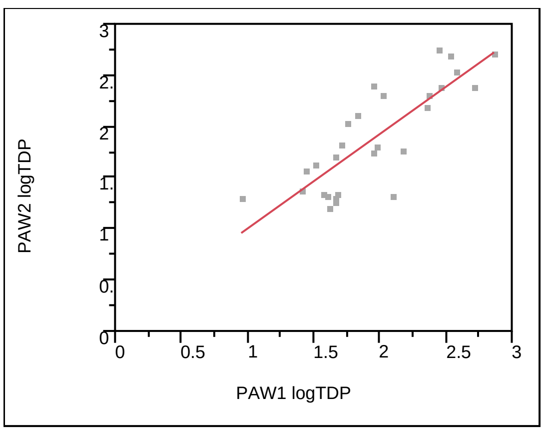
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2.3068719	2.30687	42.9981
Error	26	1.3949151	0.05365	**Prob > F**
C. Total	27	3.7017869		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.7456649	0.263788	2.83	0.0089*
PAW1 logTP	0.6673742	0.101776	6.56	<.0001*

TDP
CALIBRATION



Summary of Fit

RSquare	0.678941
RSquare Adj	0.666592
Root Mean Square Error	0.295091
Mean of Response	1.876669
Observations (or Sum Wgts)	28

Analysis of Variance

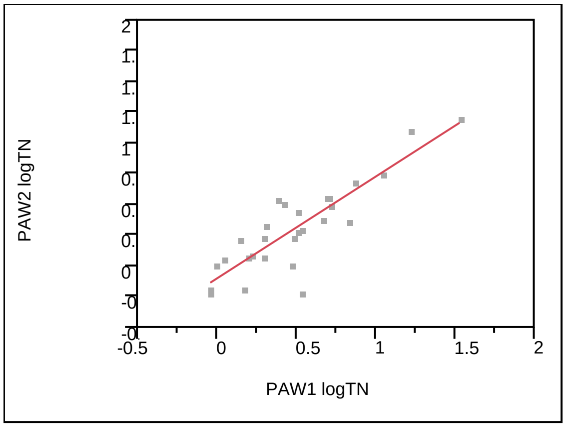
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	4.7877501	4.78775	54.9819
Error	26	2.2640450	0.08708	**Prob > F**
C. Total	27	7.0517952		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0759297	0.249172	0.30	0.7630
PAW1 logTDP	0.9229922	0.124477	7.41	<.0001*

TN

CALIBRATION



Summary of Fit

RSquare	0.753971
RSquare Adj	0.744508
Root Mean Square Error	0.182373
Mean of Response	0.301925
Observations (or Sum Wgts)	28

Analysis of Variance

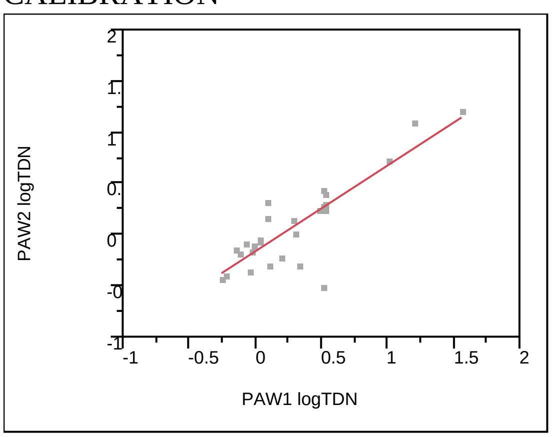
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2.6500921	2.65009	79.6786
Error	26	0.8647546	0.03326	**Prob > F**
C. Total	27	3.5148467		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.108206	0.057436	-1.88	0.0708
PAW1 logTN	0.8288359	0.092853	8.93	<.0001*

TDN

CALIBRATION



Summary of Fit

RSquare	0.723228
RSquare Adj	0.712583
Root Mean Square Error	0.227457
Mean of Response	0.073679
Observations (or Sum Wgts)	28

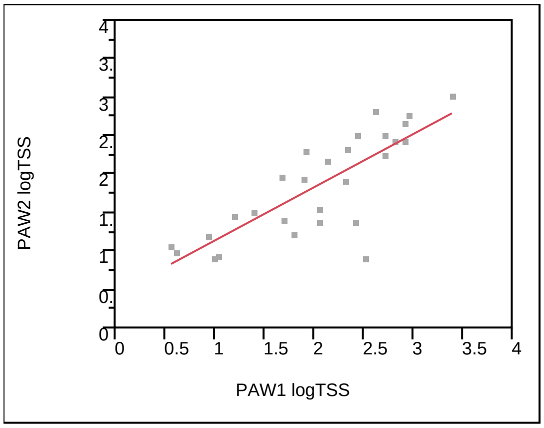
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	3.5150047	3.51500	67.9402
Error	26	1.3451546	0.05174	**Prob > F**
C. Total	27	4.8601593		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.168417	0.052062	-3.23	0.0033*
PAW1 logTDN	0.8385203	0.10173	8.24	<.0001*

TSS
CALIBRATION



Summary of Fit

RSquare	0.634616
RSquare Adj	0.620563
Root Mean Square Error	0.408985
Mean of Response	1.849622
Observations (or Sum Wgts)	28

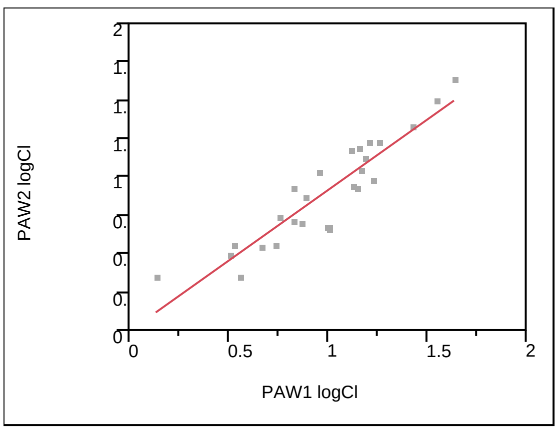
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	7.553517	7.55352	45.1580
Error	26	4.348982	0.16727	**Prob > F**
C. Total	27	11.902499		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.4337914	0.22442	1.93	0.0642
PAW1 logTSS	0.6927936	0.103095	6.72	<.0001*

Cl
CALIBRATION



Summary of Fit

RSquare	0.834166
RSquare Adj	0.827533
Root Mean Square Error	0.140317
Mean of Response	0.893562
Observations (or Sum Wgts)	27

Analysis of Variance

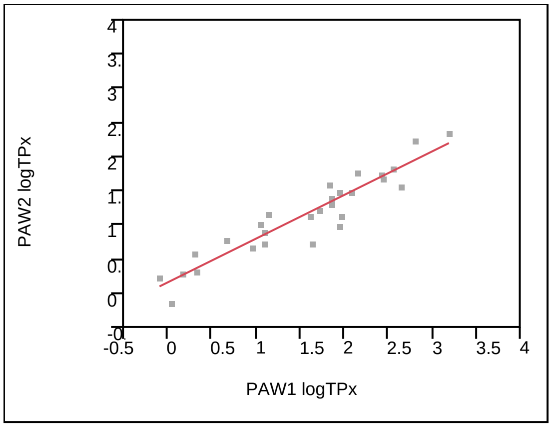
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2.4759263	2.47593	125.7531
Error	25	0.4922198	0.01969	**Prob > F**
C. Total	26	2.9681462		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.010808	0.085048	-0.13	0.8999
PAW1 logCl	0.9197576	0.082019	11.21	<.0001*

TPx

CALIBRATION



Summary of Fit

RSquare	0.884486
RSquare Adj	0.880043
Root Mean Square Error	0.209955
Mean of Response	1.144749
Observations (or Sum Wgts)	28

Analysis of Variance

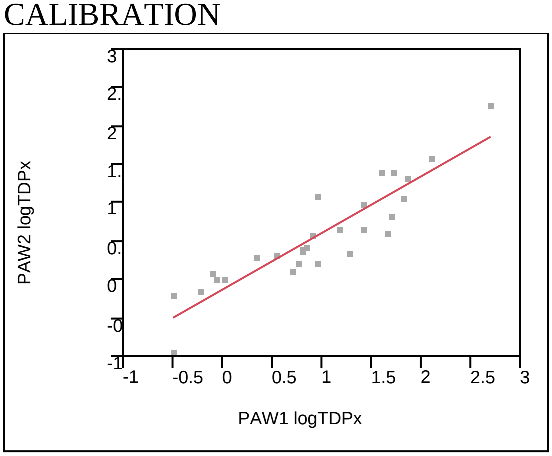
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	8.7757566	8.77576	199.0814
Error	26	1.1461122	0.04408	**Prob > F**
C. Total	27	9.9218688		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.149082	0.080957	1.84	0.0770
PAW1 logTPx	0.6398049	0.045345	14.11	<.0001*

TDPx

CALIBRATION



Summary of Fit

RSquare	0.822655
RSquare Adj	0.815834
Root Mean Square Error	0.283559
Mean of Response	0.568077
Observations (or Sum Wgts)	28

Analysis of Variance

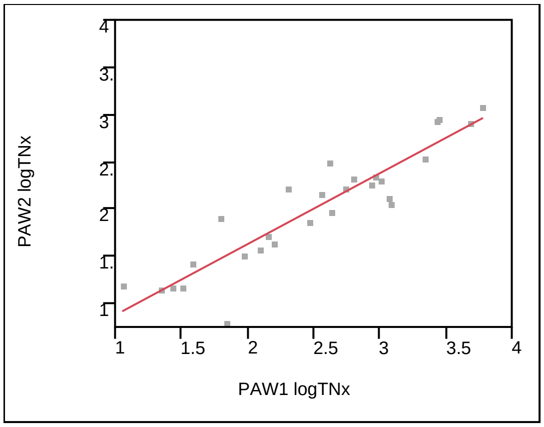
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	9.697506	9.69751	120.6070
Error	26	2.090551	0.08041	**Prob > F**
C. Total	27	11.788057		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.134607	0.08346	-1.61	0.1189
PAW1 logTDPx	0.7370787	0.067116	10.98	<.0001*

TNx

CALIBRATION



Summary of Fit

RSquare	0.841308
RSquare Adj	0.835205
Root Mean Square Error	0.247166
Mean of Response	1.995942
Observations (or Sum Wgts)	28

Analysis of Variance

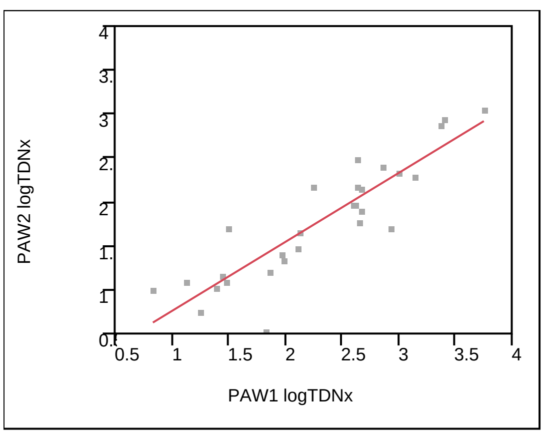
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	8.420767	8.42077	137.8397
Error	26	1.588367	0.06109	**Prob > F**
C. Total	27	10.009134		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.1248599	0.166074	0.75	0.4589
PAW1 logTNx	0.7500833	0.063888	11.74	<.0001*

TDNx

CALIBRATION



Summary of Fit

RSquare	0.789597
RSquare Adj	0.781504
Root Mean Square Error	0.312173
Mean of Response	1.767497
Observations (or Sum Wgts)	28

Analysis of Variance

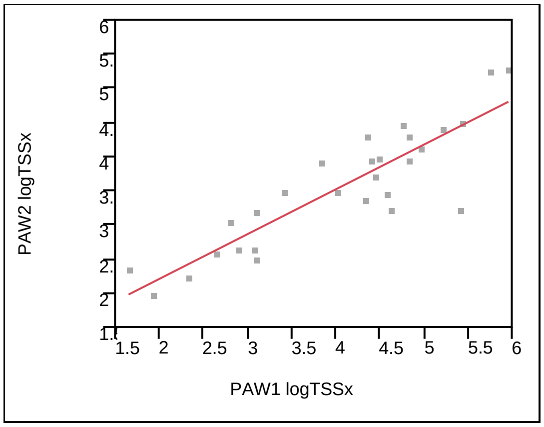
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	9.508644	9.50864	97.5723
Error	26	2.533759	0.09745	**Prob > F**
C. Total	27	12.042403		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.032601	0.191547	-0.17	0.8662
PAW1 logTDNx	0.78604	0.079576	9.88	<.0001*

TSSx

CALIBRATION



Summary of Fit

RSquare	0.775833
RSquare Adj	0.767211
Root Mean Square Error	0.419323
Mean of Response	3.543002
Observations (or Sum Wgts)	28

Analysis of Variance

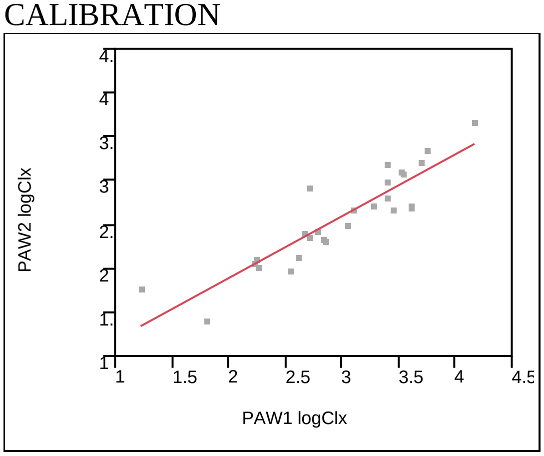
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	15.822175	15.8222	89.9848
Error	26	4.571624	0.1758	**Prob > F**
C. Total	27	20.393800		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.8912854	0.290554	3.07	0.0050*
PAW1 logTSSx	0.655692	0.069122	9.49	<.0001*

Clx

CALIBRATION



Summary of Fit

RSquare	0.812962
RSquare Adj	0.805481
Root Mean Square Error	0.229726
Mean of Response	2.575588
Observations (or Sum Wgts)	27

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	5.7345758	5.73458	108.6630
Error	25	1.3193489	0.05277	**Prob > F**
C. Total	26	7.0539247		<.0001*

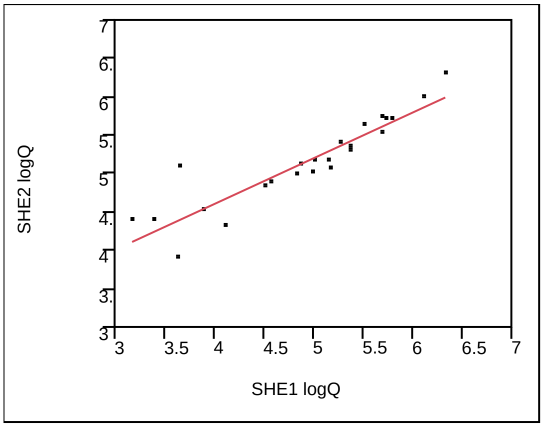
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.4746726	0.206335	2.30	0.0300*
PAW1 logClx	0.7054902	0.067678	10.42	<.0001*

D.4. Shelburne Site Regressions

Q

CALIBRATION



Summary of Fit

RSquare	0.834393
RSquare Adj	0.826866
Root Mean Square Error	0.237553
Mean of Response	5.14534
Observations (or Sum Wgts)	24

Analysis of Variance

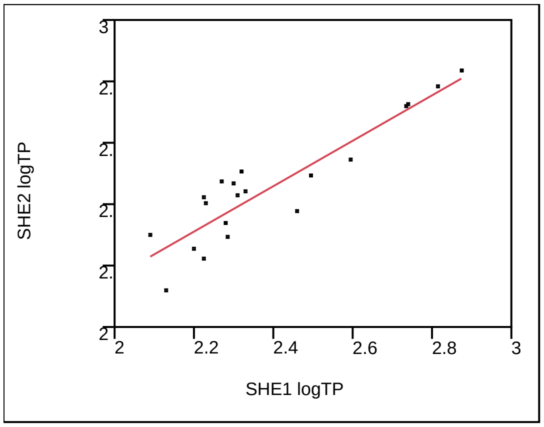
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	6.2551185	6.25512	110.8450
Error	22	1.2414870	0.05643	**Prob > F**
C. Total	23	7.4966055		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.2140673	0.28261	7.83	<.0001*
SHE1 logQ	0.5960481	0.056614	10.53	<.0001*

TP

CALIBRATION



Summary of Fit

RSquare	0.830242
RSquare Adj	0.820811
Root Mean Square Error	0.080788
Mean of Response	2.45516
Observations (or Sum Wgts)	20

Analysis of Variance

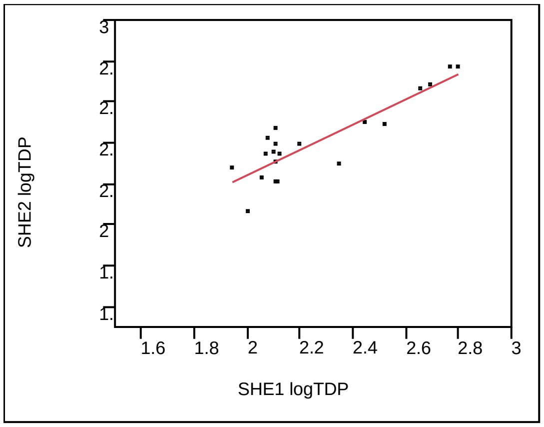
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.57456687	0.574567	88.0332
Error	18	0.11748068	0.006527	Prob > F
C. Total	19	0.69204755		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.6831815	0.18972	3.60	0.0020*
SHE1 logTP	0.7397185	0.078839	9.38	<.0001*

TDP

CALIBRATION



Summary of Fit

RSquare	0.78139
RSquare Adj	0.769245
Root Mean Square Error	0.092186
Mean of Response	2.406122
Observations (or Sum Wgts)	20

Analysis of Variance

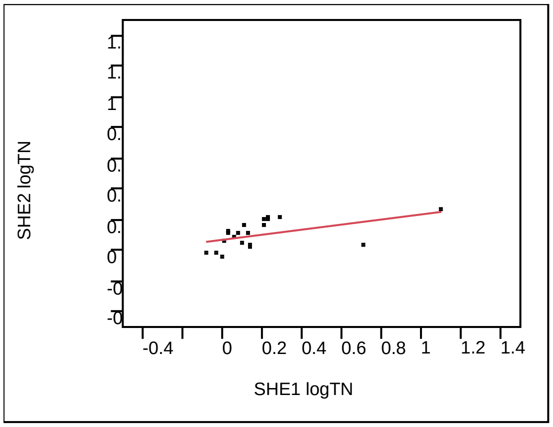
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.54676487	0.546765	64.3382
Error	18	0.15296919	0.008498	Prob > F
C. Total	19	0.69973406		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.0069446	0.175651	5.73	<.0001*
SHE1 logTDP	0.6171981	0.076947	8.02	<.0001*

TN

CALIBRATION



Summary of Fit

RSquare	0.258788
RSquare Adj	0.217609
Root Mean Square Error	0.078013
Mean of Response	0.098361
Observations (or Sum Wgts)	20

Analysis of Variance

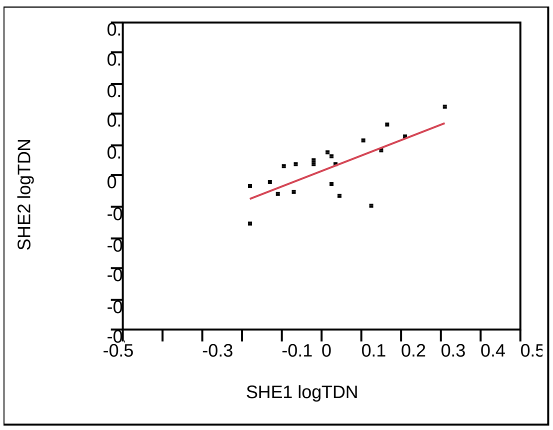
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.03824787	0.038248	6.2845
Error	18	0.10954830	0.006086	**Prob > F**
C. Total	19	0.14779617		0.0220*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0677897	0.021284	3.18	0.0051*
SHE1 logTN	0.1651464	0.065877	2.51	0.0220*

TDN

CALIBRATION



Summary of Fit

RSquare	0.517563
RSquare Adj	0.490761
Root Mean Square Error	0.06578
Mean of Response	0.025054
Observations (or Sum Wgts)	20

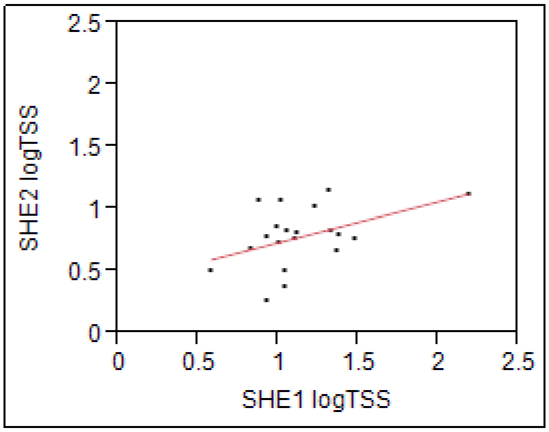
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.08355768	0.083558	19.3106
Error	18	0.07788668	0.004327	**Prob > F**
C. Total	19	0.16144436		0.0003*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0163206	0.014843	1.10	0.2860
SHE1 logTDN	0.5030178	0.114468	4.39	0.0003*

TSS
CALIBRATION - **CORRECTED**



Summary of Fit

RSquare	0.201938
RSquare Adj	0.157602
Root Mean Square Error	0.219626
Mean of Response	0.775696
Observations (or Sum Wgts)	20

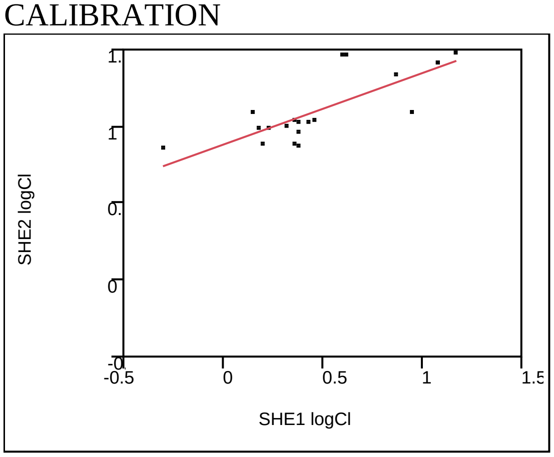
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.2196954	0.219695	4.5546
Error	18	0.8682375	0.048235	**Prob > F**
C. Total	19	1.0879329		0.0468*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.4030023	0.181406	2.22	0.0394*
SHE1 logTSS	0.3280155	0.153698	2.13	0.0468*

Cl
CALIBRATION



Summary of Fit

RSquare	0.608859
RSquare Adj	0.587129
Root Mean Square Error	0.143182
Mean of Response	1.111041
Observations (or Sum Wgts)	20

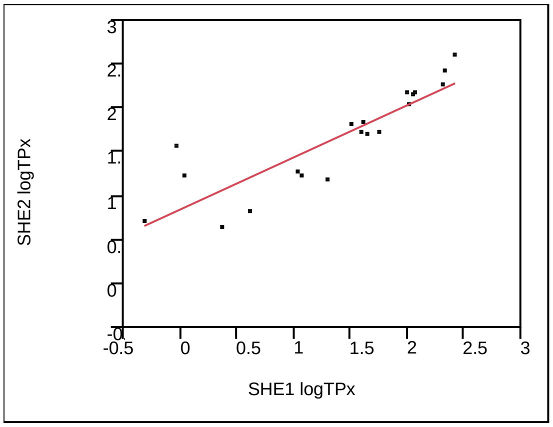
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.57442420	0.574424	28.0192
Error	18	0.36901929	0.020501	**Prob > F**
C. Total	19	0.94344348		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.8799984	0.054131	16.26	<.0001*
SHE1 logCl	0.4658222	0.088002	5.29	<.0001*

TPx
CALIBRATION



Summary of Fit

RSquare	0.753249
RSquare Adj	0.739541
Root Mean Square Error	0.293516
Mean of Response	1.652853
Observations (or Sum Wgts)	20

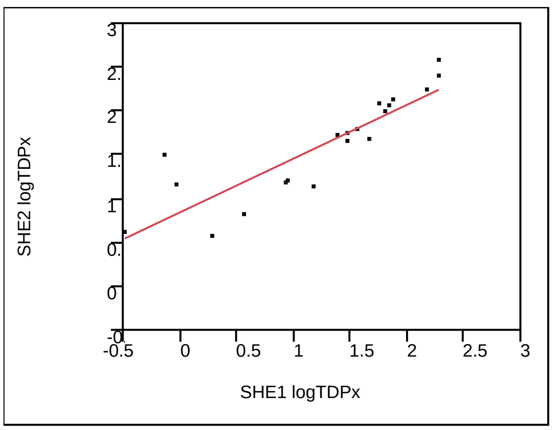
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	4.7338546	4.73385	54.9480
Error	18	1.5507271	0.08615	**Prob > F**
C. Total	19	6.2845817		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.8357314	0.128292	6.51	<.0001*
SHE1 logTPx	0.5947013	0.080227	7.41	<.0001*

TDPx
CALIBRATION



Summary of Fit

RSquare	0.762008
RSquare Adj	0.748786
Root Mean Square Error	0.289968
Mean of Response	1.603966
Observations (or Sum Wgts)	20

Analysis of Variance

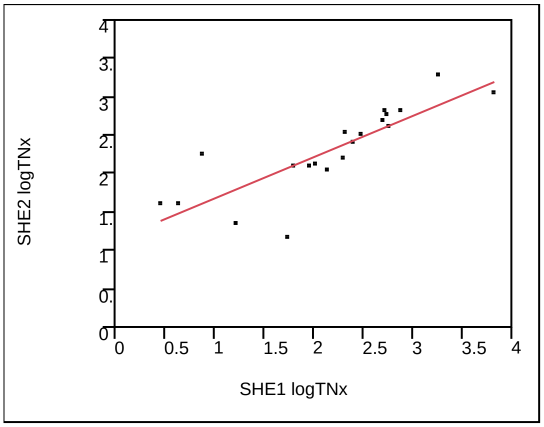
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	4.8458573	4.84586	57.6328
Error	18	1.5134684	0.08408	**Prob > F**
C. Total	19	6.3593257		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.8386811	0.119858	7.00	<.0001*
SHE1 logTDPx	0.6142451	0.080911	7.59	<.0001*

TNx

CALIBRATION



Summary of Fit

RSquare	0.684573
RSquare Adj	0.667049
Root Mean Square Error	0.323129
Mean of Response	2.296337
Observations (or Sum Wgts)	20

Analysis of Variance

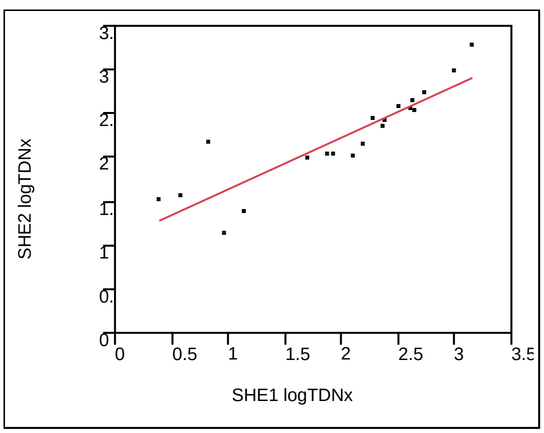
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	4.0789082	4.07891	39.0655
Error	18	1.8794177	0.10441	**Prob > F**
C. Total	19	5.9583259		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.1318658	0.199828	5.66	<.0001*
SHE1 logTNx	0.5381472	0.0861	6.25	<.0001*

TDNx

CALIBRATION



Summary of Fit

RSquare	0.788689
RSquare Adj	0.77695
Root Mean Square Error	0.25578
Mean of Response	2.223311
Observations (or Sum Wgts)	20

Analysis of Variance

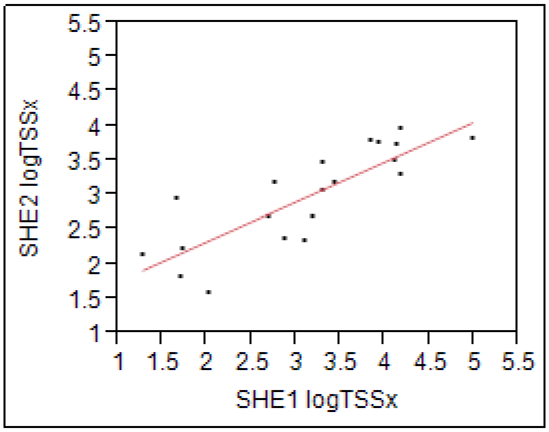
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	4.3953008	4.39530	67.1825
Error	18	1.1776187	0.06542	**Prob > F**
C. Total	19	5.5729196		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.0468595	0.154507	6.78	<.0001*
SHE1 logTDNx	0.5892874	0.071895	8.20	<.0001*

TSSx

CALIBRATION - CORRECTED



Summary of Fit

RSquare	0.685025
RSquare Adj	0.667526
Root Mean Square Error	0.412939
Mean of Response	2.973432
Observations (or Sum Wgts)	20

Analysis of Variance

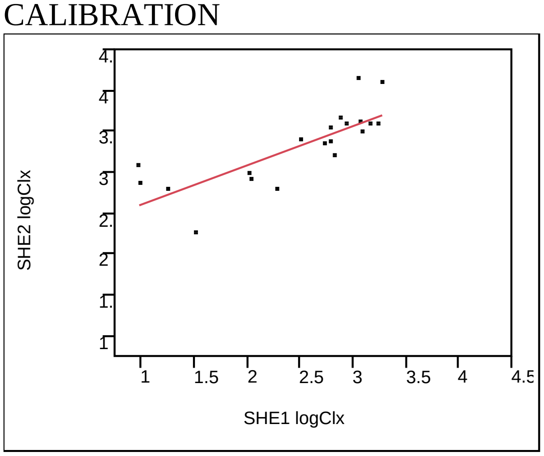
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	6.6753514	6.67535	39.1473
Error	18	3.0693352	0.17052	**Prob > F**
C. Total	19	9.7446865		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.1786759	0.301345	3.91	0.0010*
SHE1 logTSSx	0.5761835	0.092089	6.26	<.0001*

Clx

CALIBRATION



Summary of Fit

RSquare	0.616901
RSquare Adj	0.595618
Root Mean Square Error	0.292932
Mean of Response	3.308289
Observations (or Sum Wgts)	20

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2.4871972	2.48720	28.9853
Error	18	1.5445615	0.08581	**Prob > F**
C. Total	19	4.0317587		<.0001*

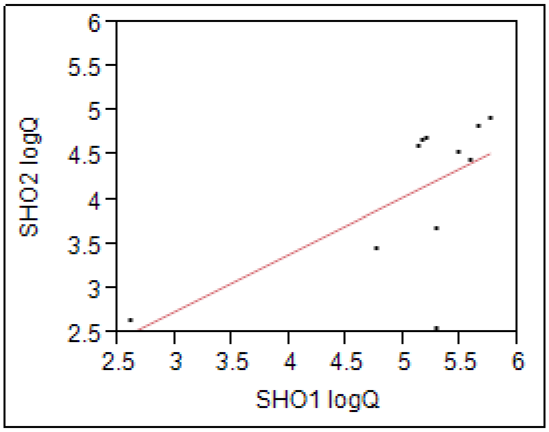
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	2.120389	0.230161	9.21	<.0001*
SHE1 logClx	0.4796429	0.08909	5.38	<.0001*

SHE statistics update February 2014 – includes TSS corrections

D.5. Shoreham Site Regressions

Q
CALIBRATION



Summary of Fit

RSquare	0.414561
RSquare Adj	0.349512
Root Mean Square Error	0.70285
Mean of Response	4.09098
Observations (or Sum Wgts)	11

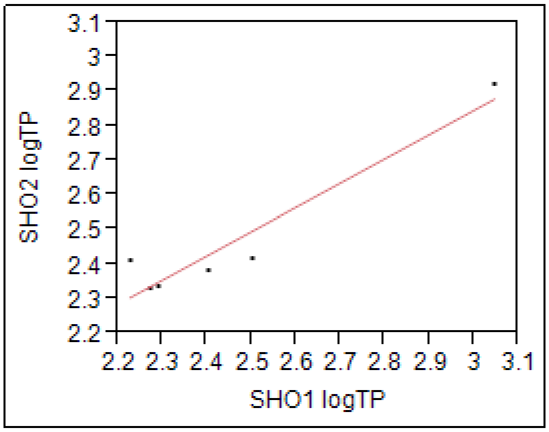
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	3.1482843	3.14828	6.3731
Error	9	4.4459850	0.49400	**Prob > F**
C. Total	10	7.5942694		0.0325*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.8125039	1.315844	0.62	0.5522
SHO1 logQ	0.645529	0.255706	2.52	0.0325*

TP
CALIBRATION



Summary of Fit

RSquare	0.910645
RSquare Adj	0.888307
Root Mean Square Error	0.075264
Mean of Response	2.464759
Observations (or Sum Wgts)	6

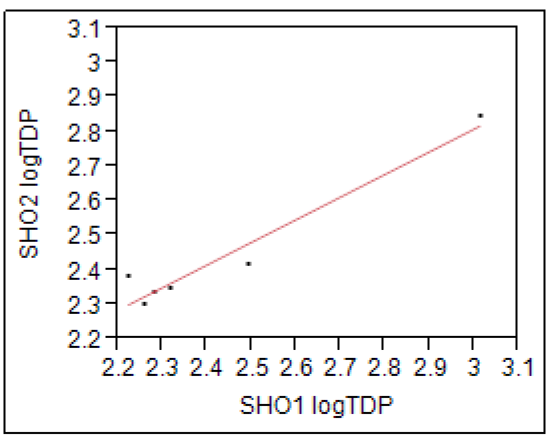
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.23092023	0.230920	40.7655
Error	4	0.02265841	0.005665	Prob > F
C. Total	5	0.25357864		0.0031*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.7394381	0.271965	2.72	0.0530
SHO1 logTP	0.7025041	0.110028	6.38	0.0031*

TDP
CALIBRATION



Summary of Fit

RSquare	0.942293
RSquare Adj	0.927867
Root Mean Square Error	0.054534
Mean of Response	2.435774
Observations (or Sum Wgts)	6

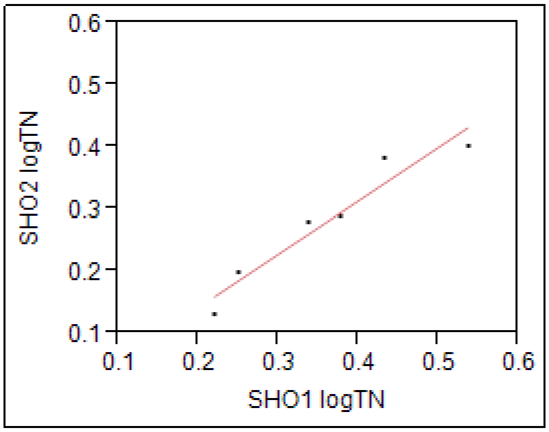
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.19424460	0.194245	65.3161
Error	4	0.01189567	0.002974	Prob > F
C. Total	5	0.20614028		0.0013*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.8417217	0.198491	4.24	0.0133*
SHO1 logTDP	0.6557909	0.081144	8.08	0.0013*

TN CALIBRATION



Summary of Fit

RSquare	0.934115
RSquare Adj	0.917643
Root Mean Square Error	0.029911
Mean of Response	0.278685
Observations (or Sum Wgts)	6

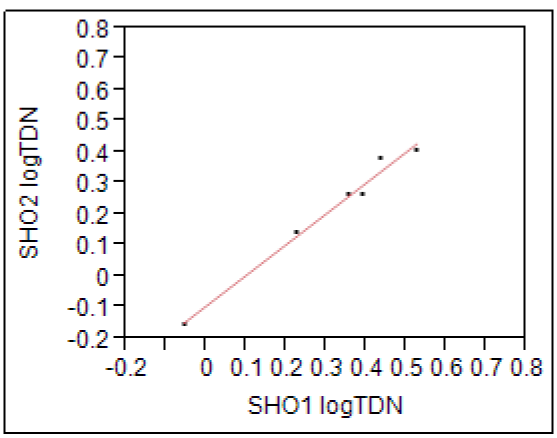
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.05073760	0.050738	56.7116
Error	4	0.00357864	0.000895	**Prob > F**
C. Total	5	0.05431624		0.0017*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.029856	0.042752	-0.70	0.5234
SHO1 logTN	0.8582844	0.113971	7.53	0.0017*

TDN CALIBRATION



Summary of Fit

RSquare	0.981912
RSquare Adj	0.97739
Root Mean Square Error	0.030942
Mean of Response	0.216816
Observations (or Sum Wgts)	6

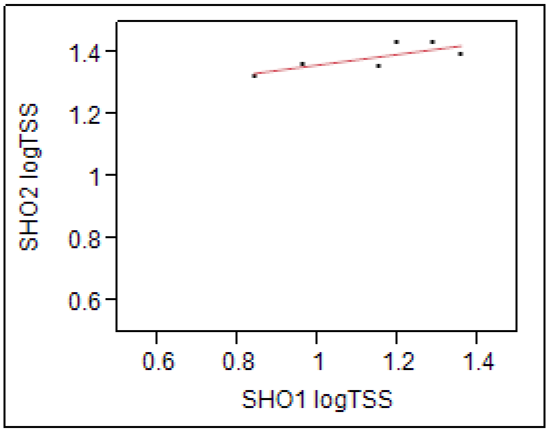
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.20789008	0.207890	217.1383
Error	4	0.00382963	0.000957	**Prob > F**
C. Total	5	0.21171972		0.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.092259	0.024485	-3.77	0.0196*
SHO1 logTDN	0.9917989	0.067306	14.74	0.0001*

TSS
CALIBRATION



Summary of Fit

RSquare	0.601351
RSquare Adj	0.501688
Root Mean Square Error	0.030878
Mean of Response	1.387598
Observations (or Sum Wgts)	6

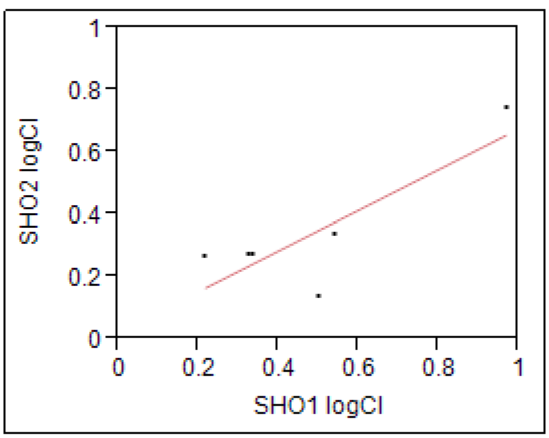
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.00575314	0.005753	6.0339
Error	4	0.00381389	0.000953	Prob > F
C. Total	5	0.00956703		0.0700

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.1925407	0.080402	14.83	0.0001*
SHO1 logTSS	0.1723502	0.070164	2.46	0.0700

Cl
CALIBRATION



Summary of Fit

RSquare	0.695724
RSquare Adj	0.619655
Root Mean Square Error	0.128822
Mean of Response	0.336413
Observations (or Sum Wgts)	6

Analysis of Variance

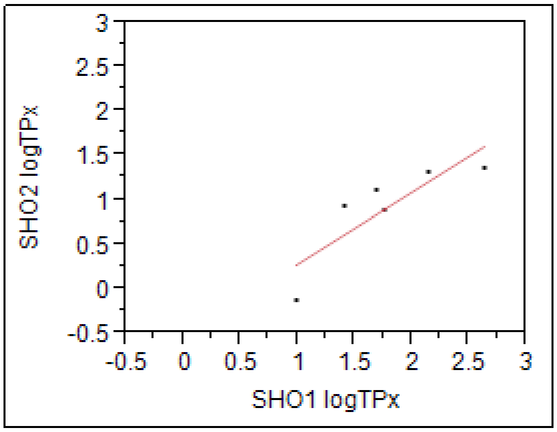
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.15177855	0.151779	9.1460
Error	4	0.06638056	0.016595	Prob > F
C. Total	5	0.21815911		0.0390*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0222147	0.116446	0.19	0.8580
SHO1 logCl	0.6527968	0.215856	3.02	0.0390*

SHO statistics update February 2014

TPx
CALIBRATION



Summary of Fit

RSquare	0.727192
RSquare Adj	0.658991
Root Mean Square Error	0.318708
Mean of Response	0.906304
Observations (or Sum Wgts)	6

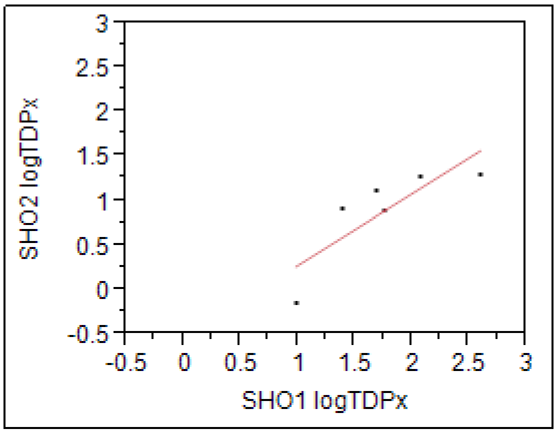
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.0830239	1.08302	10.6624
Error	4	0.4062984	0.10157	**Prob > F**
C. Total	5	1.4893222		0.0309*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.527858	0.458077	-1.15	0.3134
SHO1 logTPx	0.8101392	0.248104	3.27	0.0309*

TDPx
CALIBRATION



Summary of Fit

RSquare	0.689907
RSquare Adj	0.612384
Root Mean Square Error	0.336489
Mean of Response	0.877406
Observations (or Sum Wgts)	6

Analysis of Variance

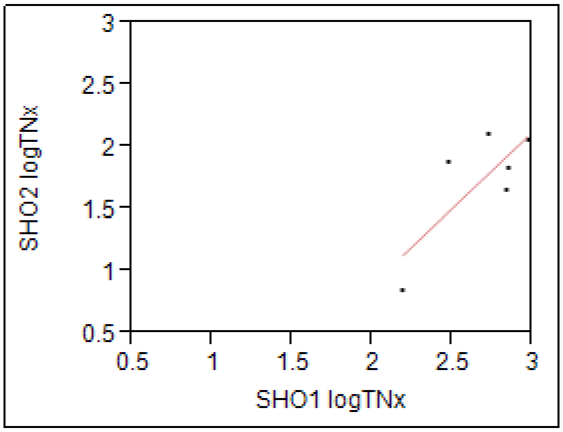
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.0076250	1.00763	8.8993
Error	4	0.4528983	0.11322	**Prob > F**
C. Total	5	1.4605234		0.0406*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.52958	0.491238	-1.08	0.3417
SHO1 logTDPx	0.806463	0.270337	2.98	0.0406*

SHO statistics update February 2014

TNx
CALIBRATION



Summary of Fit

RSquare	0.589031
RSquare Adj	0.486289
Root Mean Square Error	0.332415
Mean of Response	1.720448
Observations (or Sum Wgts)	6

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.6335070	0.633507	5.7331
Error	4	0.4419994	0.110500	**Prob > F**
C. Total	5	1.0755063		0.0748

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-1.554292	1.374388	-1.13	0.3213
SHO1 logTNx	1.2248333	0.511543	2.39	0.0748

TDNx
CALIBRATION

Summary of Fit

RSquare	0.669482
RSquare Adj	0.586852
Root Mean Square Error	0.318609
Mean of Response	1.658144
Observations (or Sum Wgts)	6

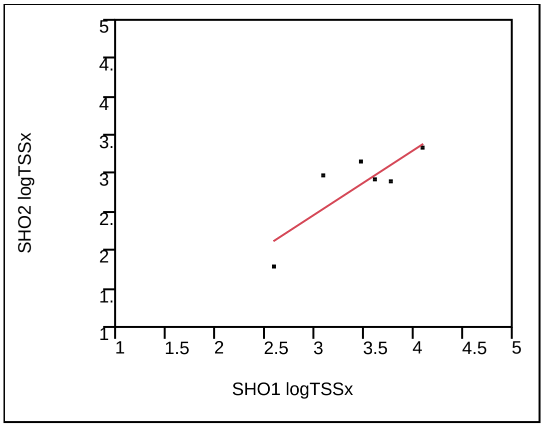
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.8224704	0.822470	8.1022
Error	4	0.4060480	0.101512	**Prob > F**
C. Total	5	1.2285184		0.0466*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-2.094783	1.324866	-1.58	0.1890
SHO1 logTDNx	1.4291347	0.502079	2.85	0.0466*

TSSx
CALIBRATION



Summary of Fit

RSquare	0.695803
RSquare Adj	0.619754
Root Mean Square Error	0.331714
Mean of Response	2.829462
Observations (or Sum Wgts)	6

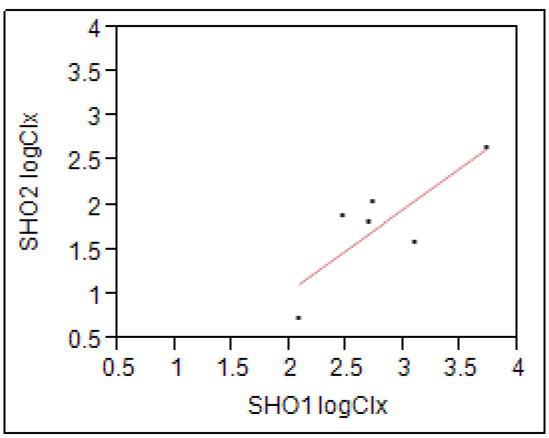
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.0067429	1.00674	9.1494
Error	4	0.4401365	0.11003	Prob > F
C. Total	5	1.4468793		0.0390*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.064385	0.966246	-0.07	0.9501
SHO1 logTSSx	0.8397675	0.277628	3.02	0.0390*

Clx
CALIBRATION



Summary of Fit

RSquare	0.674702
RSquare Adj	0.593377
Root Mean Square Error	0.402021
Mean of Response	1.778156
Observations (or Sum Wgts)	6

Analysis of Variance

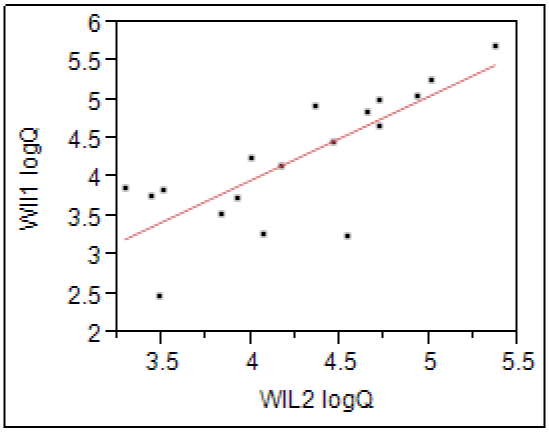
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.3408740	1.34087	8.2964
Error	4	0.6464840	0.16162	Prob > F
C. Total	5	1.9873580		0.0450*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.808093	0.912771	-0.89	0.4260
SHO1 logClx	0.9251832	0.321205	2.88	0.0450*

D.6. Williston Site Regressions

Q
CALIBRATION



Summary of Fit

RSquare	0.609647
RSquare Adj	0.58525
Root Mean Square Error	0.536569
Mean of Response	4.238618
Observations (or Sum Wgts)	18

Analysis of Variance

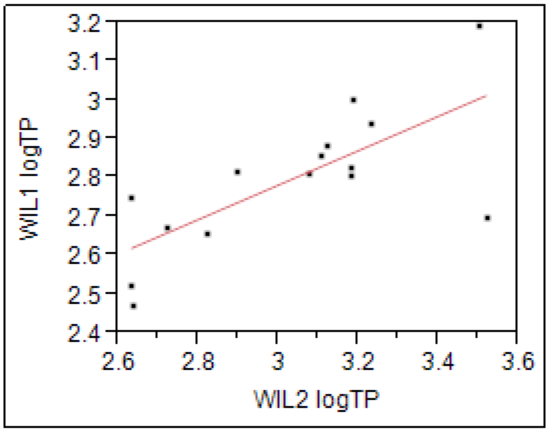
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	7.194341	7.19434	24.9885
Error	16	4.606495	0.28791	**Prob > F**
C. Total	17	11.800837		0.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.34484	0.925583	-0.37	0.7144
WIL2 logQ	1.0808286	0.216215	5.00	0.0001*

WIL data through January, 2014 – includes TSS corrections

TP
CALIBRATION



Summary of Fit

RSquare	0.5195
RSquare Adj	0.482539
Root Mean Square Error	0.130741
Mean of Response	2.795267
Observations (or Sum Wgts)	15

Analysis of Variance

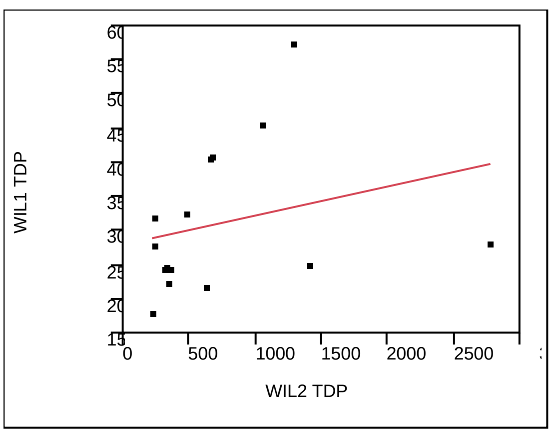
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.24024638	0.240246	14.0552
Error	13	0.22221031	0.017093	**Prob > F**
C. Total	14	0.46245670		0.0024*

Data Table=WIL_Jan_2014_conc_regression

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	1.4496872	0.360499	4.02	0.0015*
WIL2 logTP	0.4442778	0.118505	3.75	0.0024*

TDP
CALIBRATION



Summary of Fit

RSquare	0.073172
RSquare Adj	0.001878
Root Mean Square Error	107.4264
Mean of Response	310
Observations (or Sum Wgts)	15

Analysis of Variance

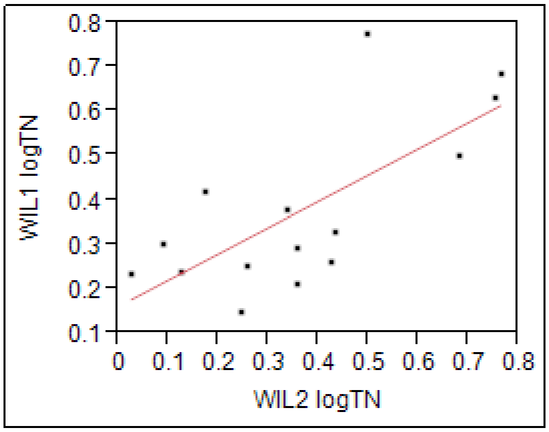
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	11844.37	11844.4	1.0263
Error	13	150025.63	11540.4	**Prob > F**
C. Total	14	161870.00		0.3295

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	278.81523	41.43546	6.73	<.0001*
WIL2 TDP	0.0425634	0.042014	1.01	0.3295

WIL data through January, 2014 – includes TSS corrections

TN
CALIBRATION



Summary of Fit

RSquare	0.520982
RSquare Adj	0.484135
Root Mean Square Error	0.136059
Mean of Response	0.378485
Observations (or Sum Wgts)	15

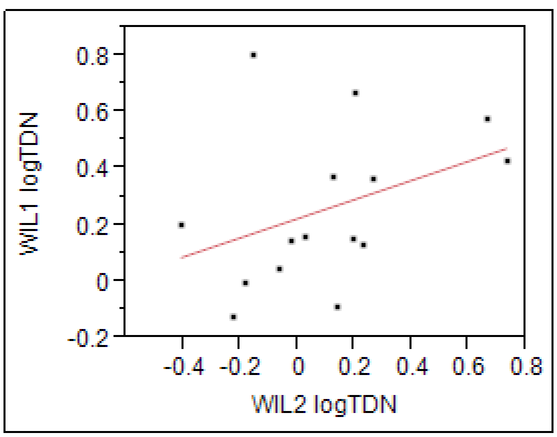
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.26174058	0.261741	14.1389
Error	13	0.24065784	0.018512	Prob > F
C. Total	14	0.50239842		0.0024*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.160997	0.067673	2.38	0.0334*
WIL2 logTN	0.5919137	0.157417	3.76	0.0024*

TDN
CALIBRATION



Summary of Fit

RSquare	0.145302
RSquare Adj	0.079557
Root Mean Square Error	0.264338
Mean of Response	0.257885
Observations (or Sum Wgts)	15

Analysis of Variance

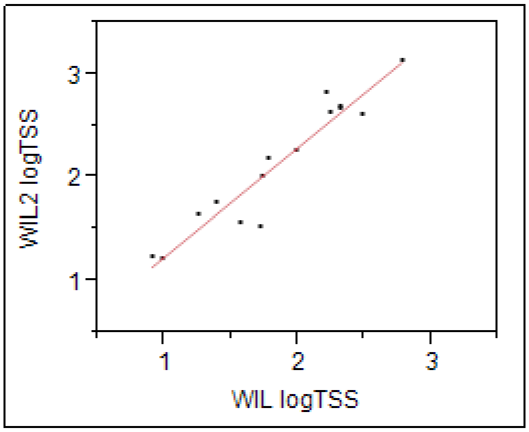
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.1544273	0.154427	2.2101
Error	13	0.9083715	0.069875	Prob > F
C. Total	14	1.0627988		0.1610

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.2247782	0.071793	3.13	0.0080*
WIL2 logTDN	0.3397197	0.228517	1.49	0.1610

WIL data through January, 2014 – includes TSS corrections

TSS
CALIBRATION - CORRECTED



Summary of Fit

RSquare	0.904455
RSquare Adj	0.897105
Root Mean Square Error	0.198169
Mean of Response	2.130817
Observations (or Sum Wgts)	15

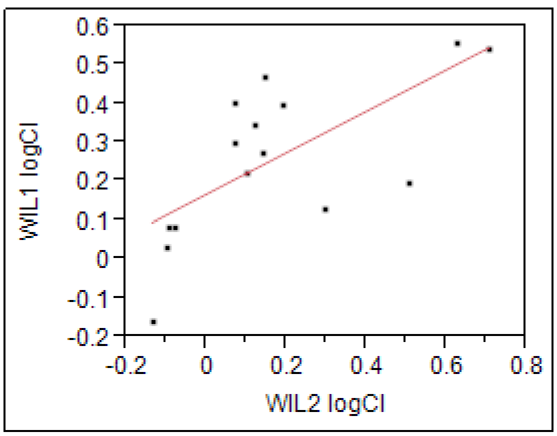
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	4.8327585	4.83276	123.0615
Error	13	0.5105239	0.03927	**Prob > F**
C. Total	14	5.3432824		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.1848883	0.182725	1.01	0.3301
WIL logTSS	1.0561484	0.095206	11.09	<.0001*

Cl
CALIBRATION



Summary of Fit

RSquare	0.473382
RSquare Adj	0.432873
Root Mean Square Error	0.152633
Mean of Response	0.259214
Observations (or Sum Wgts)	15

Analysis of Variance

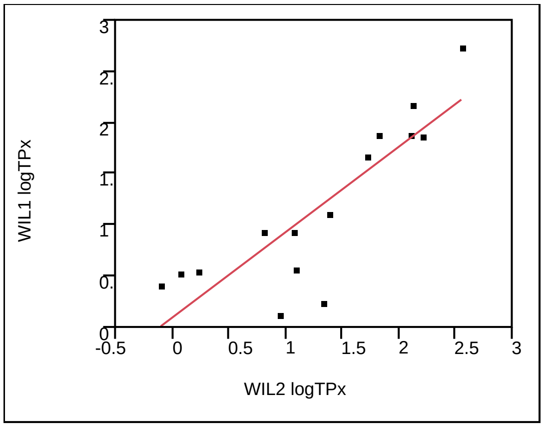
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.27224276	0.272243	11.6858
Error	13	0.30285837	0.023297	**Prob > F**
C. Total	14	0.57510113		0.0046*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.1681283	0.047572	3.53	0.0037*
WIL2 logCl	0.534801	0.156445	3.42	0.0046*

WIL data through January, 2014 – includes TSS corrections

TPx
CALIBRATION



Summary of Fit

RSquare	0.712263
RSquare Adj	0.69013
Root Mean Square Error	0.446831
Mean of Response	1.168544
Observations (or Sum Wgts)	15

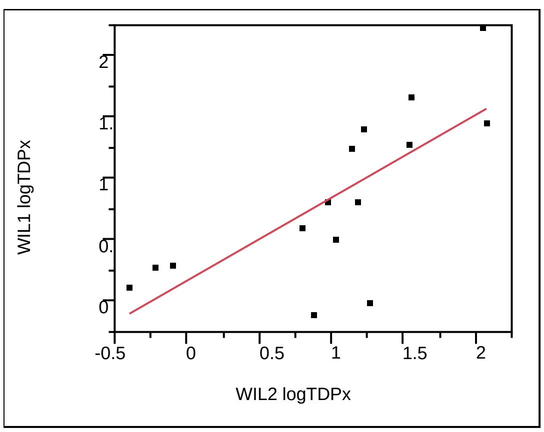
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	6.4250306	6.42503	32.1802
Error	13	2.5955544	0.19966	**Prob > F**
C. Total	14	9.0205850		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.0877785	0.222728	0.39	0.6999
WIL2 logTPx	0.8349057	0.147178	5.67	<.0001*

TDPx
CALIBRATION



Summary of Fit

RSquare	0.536182
RSquare Adj	0.500503
Root Mean Square Error	0.484464
Mean of Response	0.842376
Observations (or Sum Wgts)	15

Analysis of Variance

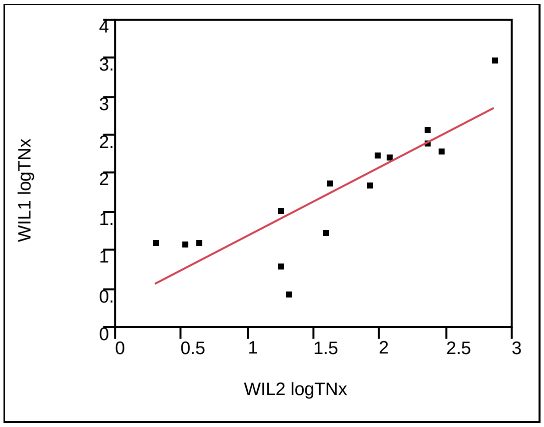
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	3.5272075	3.52721	15.0282
Error	13	3.0511741	0.23471	**Prob > F**
C. Total	14	6.5783815		0.0019*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.1675422	0.21436	0.78	0.4485
WIL2 logTDPx	0.6757963	0.174326	3.88	0.0019*

WIL data through January, 2014 – includes TSS corrections

TNx
CALIBRATION



Summary of Fit

RSquare	0.704901
RSquare Adj	0.682202
Root Mean Square Error	0.456237
Mean of Response	1.751222
Observations (or Sum Wgts)	15

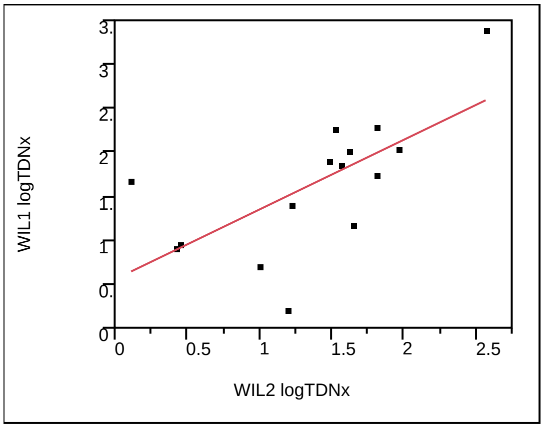
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	6.4637718	6.46377	31.0531
Error	13	2.7059806	0.20815	Prob > F
C. Total	14	9.1697524		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.2925303	0.28705	1.02	0.3268
WIL2 logTNx	0.8938831	0.160409	5.57	<.0001*

TDNx
CALIBRATION



Summary of Fit

RSquare	0.435833
RSquare Adj	0.392435
Root Mean Square Error	0.608386
Mean of Response	1.63141
Observations (or Sum Wgts)	15

Analysis of Variance

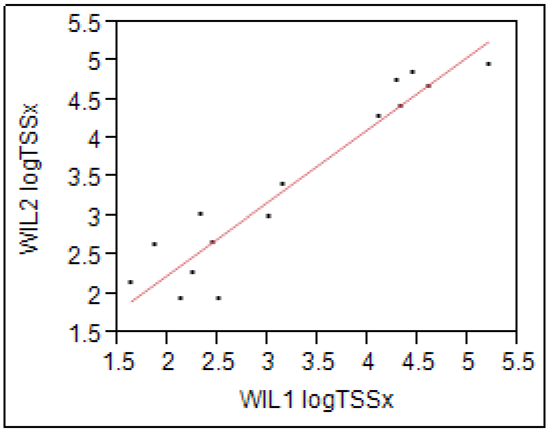
Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	3.7171770	3.71718	10.0428
Error	13	4.8117306	0.37013	Prob > F
C. Total	14	8.5289076		0.0074*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.5499087	0.375688	1.46	0.1670
WIL2 logTDNx	0.7939386	0.25053	3.17	0.0074*

WIL data through January, 2014 – includes TSS corrections

TSSx
CALIBRATION - CORRECTED



Summary of Fit

RSquare	0.905049
RSquare Adj	0.897745
Root Mean Square Error	0.366784
Mean of Response	3.395403
Observations (or Sum Wgts)	15

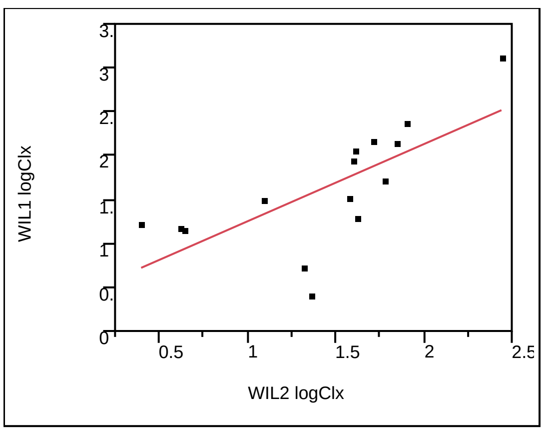
Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	16.670050	16.6701	123.9129
Error	13	1.748895	0.1345	Prob > F
C. Total	14	18.418946		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.3822359	0.286774	1.33	0.2055
WIL1 logTSSx	0.9372916	0.084201	11.13	<.0001*

Clx
CALIBRATION



Summary of Fit

RSquare	0.489428
RSquare Adj	0.450154
Root Mean Square Error	0.510682
Mean of Response	1.63226
Observations (or Sum Wgts)	15

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	3.2499579	3.24996	12.4617
Error	13	3.3903550	0.26080	Prob > F
C. Total	14	6.6403129		0.0037*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	0.3698807	0.381139	0.97	0.3495
WIL2 logClx	0.879301	0.249086	3.53	0.0037*

WIL data through January, 2014 – includes TSS corrections