Silver Creek Pilot Watershed Project

Final Report

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This version of the report does not contain appendix materials. Contact NEW Water staff with additional inquiries.

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Acronyms and Abbreviations

App	application
BMP	best management practices
C&ENMP	Conservation and Enhanced Nutrient Management Plan
CAP	Critical Area Planting
cfs	cubic feet per second
CRP	Conservation Reserve Program
CSA	cost share agreement
ENMP	Enhanced Nutrient Management Plan
EPA	U.S. Environmental Protection Agency
EPT	Proportion of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)
EQIP	Environmental Quality Incentives Program
GBF	Green Bay Facility
GIS	geographic information system
GLRI	Great Lakes Restoration Initiative
HBI	Hilsenhoff Biotic Index
ID	identification
lbs/day	pounds per day
lbs/yr	pounds per year
LFR	Lower Fox River
LFRB	Lower Fox River Basin
mg/L	milligrams per liter
NMP	nutrient management plan
NPV	Net Present Value
NRCS	Natural Resources Conservation Service
Pilot Project	Silver Creek Pilot Watershed Project
PIP	Public Involvement Plan
ppy	pounds per year
STEPL	Spreadsheet Tool for Estimating Pollutant Load
SWAT	Soil and Water Assessment Tool
TKN	Total Kjeldahl Nitrogen
TMDL	total maximum daily load
TNC	The Nature Conservancy
TSS	total suspended solids

USFWS	U.S. Fish and Wildlife Service
USGS	United States Geological Survey
UWGB	University of Wisconsin-Green Bay
VWTS	vegetated water treatment systems
WASCB	Water and Sediment Control Basin
WDNR	Wisconsin Department of Natural Resources
WPDES	Wisconsin Pollutant Discharge Elimination System

1. Introduction

NEW Water, the brand of the Green Bay Metropolitan Sewerage District, maintains a Wisconsin Pollutant Discharge Elimination System (WPDES) permit for the combined outfalls of its two wastewater treatment facilities. NEW Water discharges to the Lower Fox River (LFR) in the Lower Fox River Basin (LFRB), where the Wisconsin Department of Natural Resources (WDNR) applies WPDES standards for permit calculations at the Green Bay Facility (GBF) outfall near the mouth of the Fox River at the bay of Green Bay. The Fox River and bay of Green Bay are impaired for phosphorus and sediment, as are many of the major tributaries in the basin. In 2012, the U.S. Environmental Protection Agency (EPA) approved a total maximum daily load (TMDL) for phosphorus and total suspended solids (TSS) in the LFRB and Lower Green Bay. The TMDL quantifies point and nonpoint phosphorus and sediment contributions in the watershed.

In April 2014, WDNR issued NEW Water a WPDES discharge permit that included TMDL-based effluent limits for phosphorus and TSS. A Petition for Review was filed to request a contested case hearing challenging the TSS and mercury limits. In August 2015, WDNR and NEW Water executed a Settlement Agreement for modifications to the WPDES permit, included in Appendix A.

Through further discussions with WDNR and EPA, NEW Water executed a Memorandum of Understanding (Appendix B) in January 2018 with WDNR for identifying specific details of the scope and scale of an Adaptive Management Plan. State statute, administrative code, and guidance documentation provided some framework of adaptive management, but the site-specific conditions for NEW Water's combined discharges and location at the downstream end of a very large watershed required a site-specific operating framework for selecting an area to complete adaptive management. Gaining consensus on interim phosphorus limits was important for consistency with the Settlement Agreement and how WDNR had established limits for other uses in adaptive management.

NEW Water undertook the Silver Creek Pilot Watershed Project (Pilot Project) in 2014 to gain firsthand experience in phosphorus and sediment reduction with nonpoint sources. Silver Creek is an agricultural-dominated watershed that was selected because of its manageable size (4,800 acres), in-stream water quality that did not meet water quality standards, upstream location in the LFRB, and overlap with Outagamie County, Brown County, and the Oneida Nation, among other potential project partners. The Pilot Project engaged landowners, growers, and numerous public, private, and nongovernmental organizations with the goal of implementing phosphorus and sediment best management practices (BMPs) during a 5-year project to assess watershed-level changes in water quality, the ability to implement adaptive management, and to demonstrate an ability to work collaboratively with a diverse stakeholder and partner community.

This report summarizes the approach and activities completed between 2014 to 2019 and reflects on successes and lessons learned that informed a full-scale Adaptive Management Program. Annual reports for the Pilot Project were prepared for years 2015, 2016, 2017, and 2018[1] Previous annual reports and this final report also support reporting requirements for NEW Water's Great Lakes Restoration Initiative (GLRI) grant and the EPA's Environmental Accomplishments in the Great Lakes information system.

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[1] Annual reports were completed for work and accomplishments completed within the first 4 calendar years. Those reports are not included in the appendix in this final report because of their length and to avoid repetition with the contents of this final report.

2. Organization

2.1 Mission, Vision, and Goal Development

The Project Team worked with stakeholders to develop a detailed Project goal through a series of workshops. Each stakeholder has individual goals that may or may not be satisfied by the Pilot Project. NEW Water's goal for the Pilot Project overlapped with many stakeholder goals, and developing a unified goal together guided a successful Project where entities were aligned. The Project goal and detailed sub-definitions of the goal are as follows:

Project Goal: Design, implement, and evaluate stakeholder capacity for a cost-effective, scientific-based agricultural-focused adaptive management Pilot Project that allows Silver Creek to achieve the phosphorus and sediment in-stream water quality standards.

- Design a process that engages stakeholders, leverages relationships, baselines water quality, and collects soils and land management information on all agricultural lands to support nutrient and conservation planning and predictive watershed water quality modeling (e.g., Soil and Water Assessment Tool [SWAT]) that is repeatable and scalable.
- Implement the recommendations within the plans through collaborative partnerships with agronomic, grower, and owner support that will achieve water quality and maintain or enhance the vitality of farming, while evaluating the incentives required for permanent installation.
- Evaluate stakeholder capacity for current and future ability to be evaluated to provide professional, regulatory, and personal support to landowners, growers, and NEW Water, and to determine resource needs and delivery platforms that could be scalable for future implementation.
- Evaluate the cost of the Pilot Project in terms that are scalable, that capture realized and future costs, and are comparable to other permit compliance options.
- Use a scientific-based process that integrates agronomic experts and other technical experts, regulators, advocates, and modelers to support plan implementation through partnerships with landowners and growers, to reduce uncertainty in evaluating project success and scalability.
- Implement an agricultural-focused project design with partners that may have the opportunity to simultaneously improve operations while improving water quality and soil health but may not have the resources to do so.
- Ensure a Silver Creek watershed that is a representative agricultural-dominated headwater watershed of manageable size where compliance can be associated with internal activities to determine if compliance at its pour point can be achieved.
- Evaluate the attainment of water quality standards including the phosphorus criterion of 0.075 milligrams per liter (mg/L) and the narrative TSS standard set to be 18 mg/L in the TMDL.

2.2 Stakeholders, Partners and Team Chartering

An important start to the Pilot Project was aligning project partners and key stakeholders with the mission, vision, and goal of the Project. This allowed for a common understanding of the Pilot Project at its onset, an introduction of stakeholders to the Project Team, and the ability to begin establishing roles within the project. Jacobs Engineering, Inc. (Jacobs; formerly CH2M HILL) was retained by NEW Water to provide Pilot Project design and implementation strategy. The Jacobs' team included McMahon Associates and local civil and water resource engineers to assist with municipal coordination, and Tilth Agronomy and AgVentures, two agronomy firms with extensive agricultural and nutrient management experience in northeast Wisconsin. Other stakeholders and partners included nonprofit organizations, county land and water conservation departments, the Oneida Nation, and federal agencies (Figure 2-1). The organizations and their support of the Pilot Project included:

- Oneida Nation—Silver Creek is wholly within the reservation boundaries, the Oneida Nation has significant land holdings and an environmental conservation department, and the Oneida Nation Farm operates some of the cropland. The Oneida Nation assisted with planning and implementing agricultural BMPs and completing macroinvertebrate biological monitoring of Silver Creek.
- Natural Resources Conservation Service (NRCS)—Local Outagamie County NRCS office staff assisted with identification of resource concerns and BMP design, funding, and implementation support.
- Brown and Outagamie County Land and Water Conservation Departments—Local county conservation staff assisted with planning, NRCS coordination, grant support, design, construction oversight, and post-construction verification of BMP implementation.
- U.S. Geological Survey (USGS)—Local field office provided real-time flow monitoring and event-based water quality sampling.
- University of Wisconsin-Green Bay (UWGB)—Local university assisted with event-based water quality monitoring and conducted technical studies and research on biomass plantings, grazing, and water quality modeling.
- The Nature Conservancy (TNC)—Local nonprofit offices provided financial and planning support for a wetland conversion and assisted with BMP identification and implementation using tools developed by statewide TNC resources.
- U.S. Fish and Wildlife Service (USFWS)—Local federal office helped with design and implementation of wetland BMPs.
- Ducks Unlimited—Local nonprofit office supported the planning, design, funding, and implementation of wetland-based BMPs.
- WDNR—State regulatory agency provided support for Pilot Project design and implementation and evaluation of the Pilot Project for a full-scale Adaptive Management Program.
- EPA—Provided funding for BMP implementation and hosted educational roundtable and knowledge transfer meetings to support watershed restoration projects throughout the Great Lakes basin.

Figure 2-1. Silver Creek Project Partners Engaged During Planning and Implementation

The Pilot Project chartering was completed during a workshop with key and interested stakeholders in the first few months of the Project. It was endorsed by all stakeholders and was used to set the over-arching direction and goals of the Pilot Project, along with setting expectations of stakeholder participation, support, and Pilot Project critical success factors. Figure 2-2 shows the resulting team charter.

NEW Water
The brand of the Green Bay Metropolitan Sewerage District

Silver Creek Pilot Watershed Project Team Charter

September 8, 2014

PROJECT	Design and Implementation of an Adaptive Management Pilot Project for the Silver Creek Watershed	
CLIENT	NEW Water (the brand of the Green Bay Metropolitan Sewerage District)	
PROJECT VISION	A robust and collaborative pilot study in the Silver Creek subwatershed that is consistent with stakeholder ecological restoration goals, and that provides NEW Water with the information to make an informed and confident decision on whether to use the adaptive management approach to meet the phosphorus and total suspended solids reductions required to meet designated use and water quality goals in the Lower Fox River Basin.	
CRITICAL SUCCESS FACTORS	Safety	Implement pilot study with no recordable safety incidents.
	Cost	Manage study costs effectively and identify total cost for NEW Water adaptive management compliance.
	Schedule	Complete initial study to begin implementing BMPs in 2015 growing season and provide information for milestones included in the NEW Water permit.
	Regulatory Compliance	Define compliance with adaptive management approach and determine whether these goals could be met.
	Stakeholder Participation	Active and timely participation, completion of action items, and open communication that maintains commitments and project schedule.
	Stakeholder Acceptance	Maximize the implementation of agricultural BMPs by owners and operators, and track factors that influence decision making.
	Quality	Development of a scientifically defensible adaptive management approach that can be repeatable, adaptable, predictable, and implemented across the watershed.
ROLES AND RESPONSIBILITIES (see stakeholder participation matrix)	**NEW Water** – Project leader, organize partners/stakeholders, participate in meetings, and direct consultant team. **Consultant Team** – Plan and carry out project, support and attend meetings, coordinate with stakeholders and partners, GIS management, execute soil sampling, support County and NRCS conservation planning, and project reporting. **Counties and NRCS** – Participate in meetings, provide data from on-going studies, support coordination with landowners/operators, support soil sampling, and lead conservation planning and implementation. **Oneida Nation** – Participate in meetings, provide data from on-going studies, coordinate with Tribal operators, execute soil sampling and field walks on tribal lands, and support conservation planning and implementation. **Cooperating Partners/Agencies** – Participate in meetings, provide GIS data and information on existing projects and SWAT modeling, review sampling plans and data analysis, review conservation plans, and provide technical support for monitoring programs.	

COMMITMENTS			
NEW Water	Oneida Nation	Outagamie County	Brown County
Outagamie County NRCS	Brown County NRCS	Oneida Tribal NRCS	US Fish and Wildlife Service
UW Green Bay	Tilth Agronomy	US Geological Survey	The Nature Conservancy
Fox Wolf Watershed Alliance	Ducks Unlimited	The Alliance for the Great Lakes	WI Depart. of Natural Resources
CH2M HILL	AgVentures	McMahon Associates	

Figure 2-2. Team Charter

2.3 Public Involvement Plan

A preliminary draft Public Involvement Plan (PIP) was developed to provide a framework to facilitate communication among NEW Water, project partners, property owners, and other interested stakeholders to encourage project participation and support from those identified as being instrumental in successful end outcomes. The team of partners for the project agreed on the team charter (Section 2.2), which included the following two critical success factors related to public involvement:

- **Stakeholder Participation:** Active and timely participation, completion of action items, and open communication that maintains commitments and project schedule.
- **Stakeholder Acceptance:** Maximize the implementation of agricultural BMPs by owners and operators, and track factors that influence decision-making.

Appendix C contains the preliminary draft PIP.

2.4 Organizational Chart

An organizational chart (Figure 2-3) defined major work tasks, leadership and support roles, and participation by the project stakeholders and partners. The organization chart adjusted over the years of the Pilot Project, but the overall structure was maintained throughout the project duration.

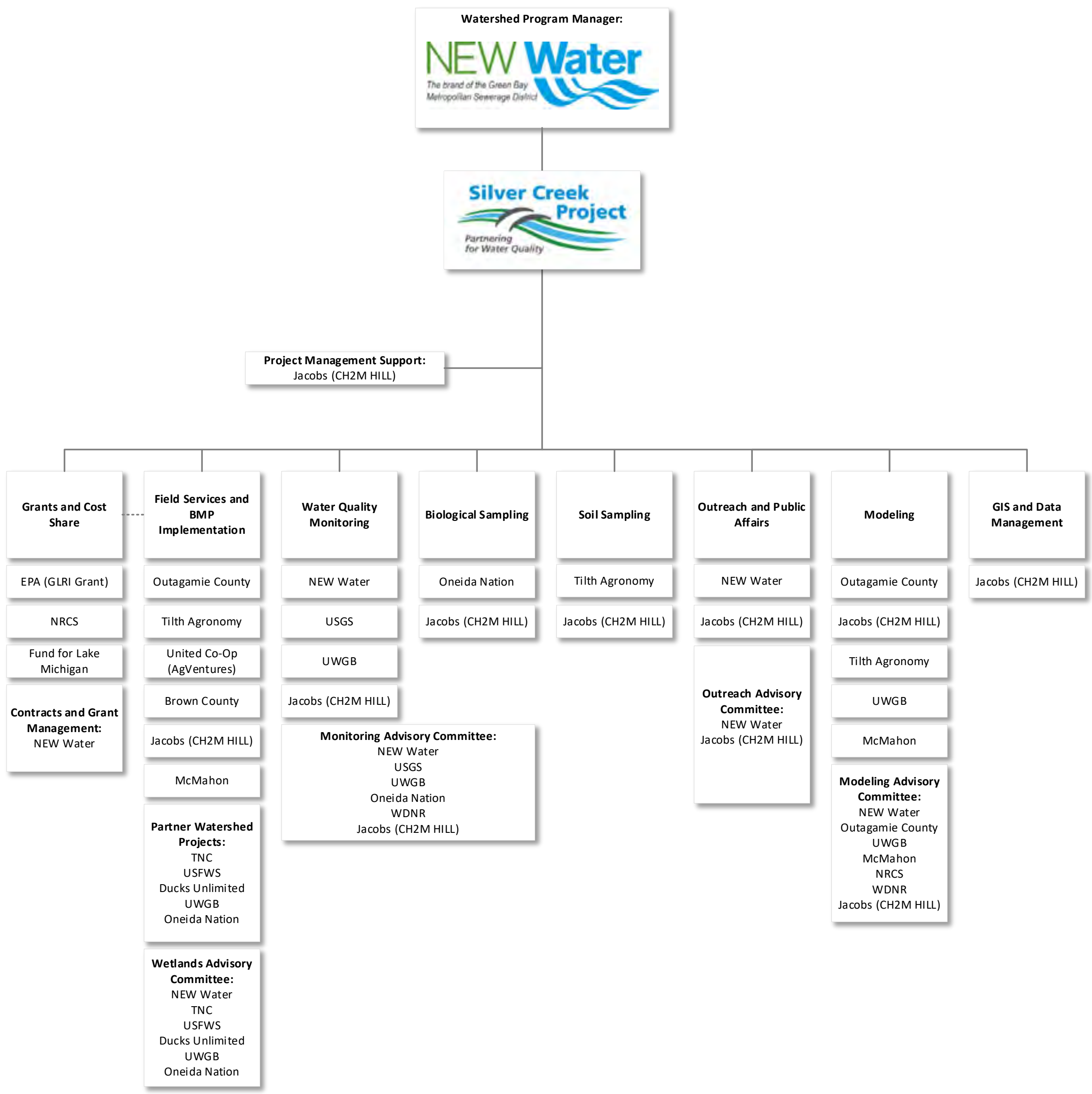


Figure 2-3. Silver Creek Pilot Project Organizational Chart

2.5 Meetings and Workshops

Collaboration among Project Team members and stakeholders was a critical success factor of the Pilot Project. Several meetings and workshops occurred to allow for coordination and integrated planning. The following subsections describe significant or recurring meetings.

2.5.1 Landowner and Grower Meetings

The first kickoff meeting to introduce the Project to landowners and growers in the Project area was held on February 25, 2015. Annual meetings were held as "appreciation luncheons" where the Project Team provided updates from the past year of work and a schedule and anticipated activities for the upcoming year. These events provided a forum for landowners and growers to ask questions and provide feedback for the Project Team. The meetings were valued by the landowner and growers, and the Project Team obtained important insights to their operations and decision-making criteria. The meetings also provided an informal setting to simply discuss the project, successes, challenges, and opportunities for greater collaboration. Meetings were hosted in December 2015, 2016, 2017, 2018, and 2019. Appendix D contains presentation materials and meeting summaries.

2.5.2 Stakeholder Meetings

Stakeholder meetings occurred frequently throughout the Pilot Project to keep stakeholders informed and coordinated with Project activities and to receive feedback on the Project work plan. Stakeholders also presented related activities to share updates and lessons learned, providing a benefit for gathering a diverse group to discuss broader watershed coordination outside of the Project. Attendance often reached meeting-space capacity, because the meetings provided an organized forum for discussion, strategy development for BMP implementation, identification of research needs or data gaps, and a time for diverse groups to discuss challenges, opportunities, and collaboration. The kickoff stakeholder meeting was held on April 21, 2015, to develop the Pilot Project mission, vision, and goals and review the initial Project work plan. Following the kickoff and chartering meetings, additional stakeholder meetings were held in September 2015 and December 2016, 2017, 2018, and 2019.

2.5.3 Oneida Nation Coordination

Coordination between the Project Team and the Oneida Nation occurred throughout the Pilot Project and consisted of meetings between technical staff, the Oneida Nation Farm, and management. The frequency of formal meetings ranged from annual to quarterly depending on the Project stage, the need for technical collaboration, and the need to meet with management staff to gain approval or request further assistance in implementing planned BMPs on Oneida-owned and rented lands. Meetings with technical staff and the Oneida Nation Farm allowed for collaboration to identify BMP opportunities and plan and implement BMPs across several fields. Because implementation involved several groups within the Oneida Nation, such as the Oneida Nation Farm, forestry, environmental, legal/leasing, and fisheries, and entities outside Oneida, such as USFWS and TNC, the coordination meetings allowed for planning between these groups and with the Project Team. The meetings were critical to the success of the BMP implementation and for efficient communication and workflow (Figures 2-4 and 2-5) between the Oneida Nation and the Project.

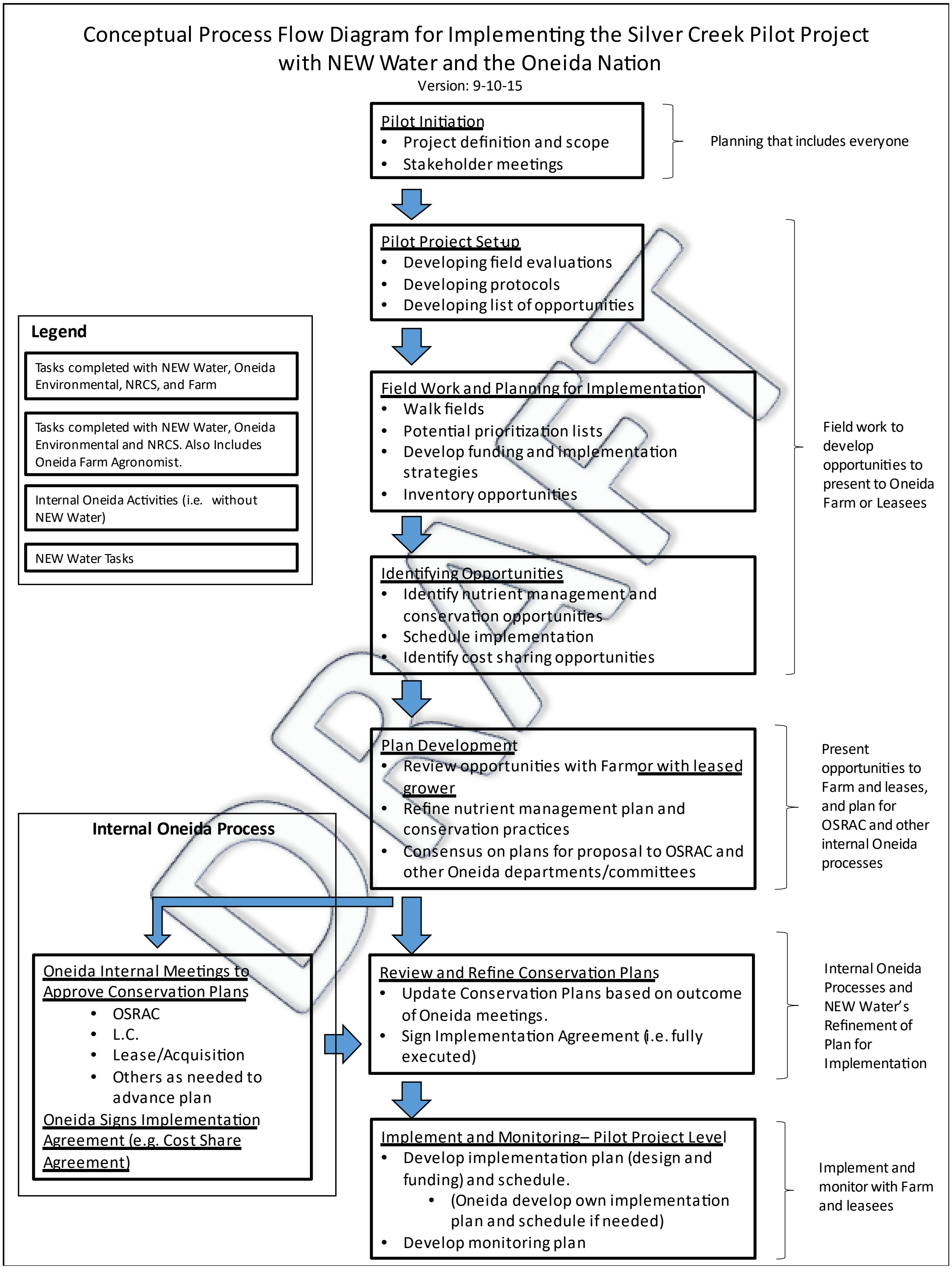


Figure 2-4. Conceptual Process Flow Diagram for Implementing the Silver Creek Pilot Project with NEW Water and the Oneida Nation

Figure 2-5. Conceptual Process Flow Diagram for Environmental Quality Incentives Program Application, Contracting, and Practice Implementation on Oneida Nation Farm Lands

2.5.4 Small Group Advisory Committees

Small working groups were established, including stakeholders and partners as subject matter experts, to assist in guiding wetland implementation, outreach, modeling, and water quality and biological monitoring. The members of each advisory committee are shown in the organizational chart in Figure 2-3. The small group advisory committees included:

- Wetlands—Identified and evaluated project sites and designed wetlands to meet the site-specific needs of each location. Stakeholders from Outagamie County, TNC, Ducks Unlimited, Fund for Lake Michigan, USFWS, and the Oneida Nation assisted in design, implementation, and/or funding.
- Monitoring—UWGB, USGS, and the Oneida Nation advised and assisted with water quality monitoring, USGS gauge collection, and biological sampling.
- Outreach—NEW Water's Public Affairs and Education staff advised and assisted the Project Team for outreach and public involvement.
- Modeling—Outagamie County, UWGB, NRCS, and WDNR advised on watershed and BMP modeling strategies for phosphorus and TSS.

Annual reports and data summaries from the small group advisory committees were prepared and shared with the larger stakeholder groups. These small groups were beneficial to bring together stakeholders to brainstorm, design, and implement purposeful action in Silver Creek.

2.5.5 Coordination Meetings with Agronomists and County Conservationists

Frequent meetings were held with agronomists and county conservationists to coordinate BMP planning and implementation. Conservation planning meetings were held in spring and fall 2016, 2017, 2018, and 2019 to discuss the plan for each growing season and document the actual implementation and update Enhanced Nutrient Management Plans (ENMPs) at the end of each growing season. Additional meetings were held for further coordination when BMP implementation was the most intense—quarterly meetings occurred in 2017 and annually in 2018 and 2019.

2.5.6 Biweekly Coordination Calls with Core Project Team

Biweekly coordination calls between Jacobs and NEW Water were initiated at the start of the Pilot Project and were valuable to discuss Project progress, strategy, and any impromptu opportunities or challenges. Depending on the week's agenda, other core Program team members such as agronomists and county conservationists attended the call to provide specific feedback. The frequency of communication allowed the Project Team to manage tasks in a timely manner and provided a forum for discussion, problem-solving, and reflections throughout the life of the Pilot Project.

3. Approach

The Pilot Project was completed in four general phases: baselining, planning, implementation, and verification, while monitoring occurred throughout the Project. Baselining occurred in 2014 and was completed by early 2015. Planning was initiated in 2015, and most implementation occurred from 2016 to 2018. Multiple cycles of planning, implementation, and verification occurred between 2015 and 2019, allowing the Project Team to continuously evaluate opportunities for BMPs in the watershed.

3.1 Baselining

Baseline water quality, biological, and soil data were collected throughout the watershed in 2014. The baseline data were used to document the condition of the watershed before the implementation of BMPs and allowed the Pilot Project to evaluate progress by comparing data collected during and post-completion.

3.1.1 Soil Sampling

Soil samples were collected across the watershed to inform nutrient management recommendations and conservation planning. Traditional soil sampling on agricultural fields is completed on 5-acre grids in accordance with University of Wisconsin Extension publication A2100 (Sampling Soils for Testing) and to satisfy the NRCS Nutrient Management Code 590. However, initial soil sampling in 2014 was completed on 108 agricultural fields in the watershed at 2.5-acre grids. Additional points on non-cropped land were collected to support SWAT modeling. The agricultural fields were sampled again in 2019 for the same parameters and at the same locations as the 2014 sampling event where possible. Appendix E contains the memorandums documenting the 2014 and 2019 sampling results and also includes the sampling protocol for the Project.

A mobile ArcGIS Collector Application (App) was developed for the field crew to locate predetermined sampling points within a minimum 30-foot accuracy. The Collector App also included a Field Condition Table to record site-specific conditions at the time of sampling, including previous or existing crop, fall tillage, recent manure applications, and photos of the field. Logging information in the geographic information system (GIS) database allowed real-time progress updates as samples were collected and the ability to import laboratory results back to geolocated points to spatially interpret the data.

A retrospective analysis on the effectiveness of sampling on 2.5- versus 5-acre grids was completed using the 2014 soil sampling data, included as Appendix F. There was no clear statistical evidence to support sampling on either a 2.5-acre or a 5-acre grid. Increasing the sampling density is desirable if a field shows high variability in soil phosphorus across the field, if the field average is near a nutrient application threshold, or if the grower is interested in variable-rate technologies for planting, manure, or fertilizer application. Five-acre grid sampling is appropriate in cases where the field average phosphorus is well above the nutrient application thresholds or there is relative uniformity of soil phosphorus. Regardless of a 2.5- or 5-acre grid protocol, a Full-Scale Program should consider having every field laid out on a 2.5-acre grid and removing approximately one-half of the locations to perform a first-pass sample at the density of the 5-acre grid. This makes it possible to form a pseudo-2.5-acre grid, if necessary, by combining two offset 5-acre grid sampling events, providing initial cost and labor savings while still including flexibility to increase sampling density where appropriate.

3.1.2 Water Quality and Biological Monitoring

NEW Water began the Watershed Monitoring Program in Silver Creek in late 2013. Five road crossings were identified as water quality monitoring sites to assess changes of in-stream water quality from the headwaters to the confluence with Duck Creek (Figure 3-1). A USGS gauge unit was installed in fall 2013 at the Florist Drive station to capture both stream gauge data (i.e., flow data) and event-based water quality samples. Macroinvertebrate sampling was completed through a partnership with the Oneida Nation at Florist Drive. Water quality monitoring began in 2014 at five sites along the main stem of Silver Creek (Figure 3-1). 2014 and 2015 are considered baseline years for water quality and biological monitoring data in Silver Creek before BMP implementation began in 2016.

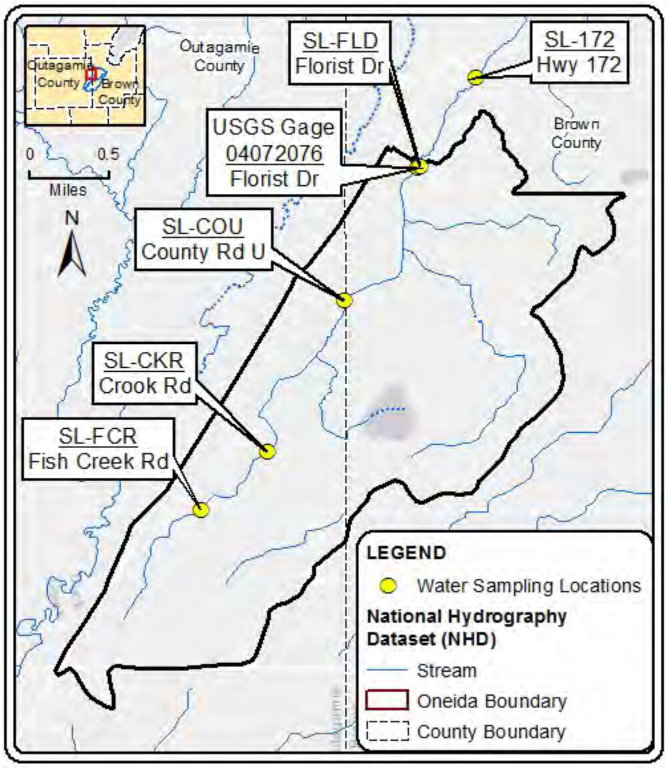


Figure 3-1. Pilot Project Water Quality Sampling Locations Along Silver Creek

Grab samples were collected at each sampling location from the ice-off period in spring (approximately March) to the ice-on conditions in late fall (approximately November). Grab samples were collected weekly during spring and fall and biweekly in summer when flows subsided and changes in water quality were negligible. Water quality grab samples were collected on a fixed time schedule independent of flow conditions, following all USGS sample collection protocols.[2]

Water quality grab samples were processed at NEW Water's state-certified laboratory where the samples were analyzed for total phosphorus, Total Kjeldahl Nitrogen (TKN), and TSS. Water temperature, specific conductance, dissolved oxygen, pH, and turbidity values were recorded at Florist Drive during grab sample collection using a YSI EXO2 multiparameter sonde. NEW Water partnered with USGS and UWGB to collect monthly low-flow grab samples at the Florist Drive location throughout the entire year, regardless of ice conditions, to compliment the water quality sampling plan and fill in potential data gaps. A USGS stream gauge (USGS 04072076) was installed at Florist Drive to monitor continuous stream flow and collect automated event samples to further characterize water quality and calculate phosphorus and TSS loads. Event water quality samples at Florist Drive were collected by an ISCO 3700R auto sampler based on changes in stage and flow over time. As the stream responded to precipitation and/or snowmelt events,

[2] U.S. Geological Society (USGS). 2000. *Interagency Field Manual for the Collection of Water-Quality Data*. https://pubs.usgs.gov/of/2000/ofr00-213/.

water quality samples were automatically collected once the stage exceeded a pre-set sampling threshold set forth by USGS. UWGB collected additional event water quality samples based on changes in flow in order to characterize the water quality of the individual event hydrograph, including the rising limb, peak, and recessional limb. These samples were stored in the autosampler and delivered to the NEW Water laboratory for analysis.

3.1.3 Sediment Sampling

Sediment sampling of the Silver Creek streambed was conducted by NEW Water staff on July 28, 2016, at four of the five water quality monitoring stations (SL-172, SL-FLD, SL-COU, and SL-CKR). Sites were sampled in the same day, moving from the furthest downstream site upstream in order to minimize bed sediment disturbance, remobilization, and collection bias. Site conditions and streambed substrate observations were noted for each location. Clay silt loam soils are the predominant soil type in the watershed. At each site, three replicate cores were taken randomly across the streambed by kneeling downstream of the sample site and pushing the core tube down to a predetermined depth mark on the outside of the core tube. These cores were capped and removed from the stream, sliding a large putty knife under the core before breaking surface tension (Figure 3-2). The core tube diameter was 5 centimeters, and a depth of 5 centimeters was determined to be sufficient for capturing material readily available to re-suspension, based on field observation and discussion with local researchers familiar with area sedimentation rates. The core sediment was extruded into pre-labeled (date, site, volume metrics, and replicate) plastic bags.

The replicate site cores were used for bulk-density analysis. Bulk-density samples were dried according to standard protocol in glass dishes in an oven at 105 degrees Celsius.[3] Empty glass dish and initial wet sediment weights were recorded and checked daily until sediment weight loss stabilized, indicating all moisture had been removed from the samples. Final bulk density was calculated using the dry weight of each sample over the soil volume. At the same four locations, five individual cores were taken randomly across the streambed, following the same metrics as above. Core tubes were cleaned in the field with stream water and deionized water before sampling at a new location to reduce the possibility of site sample contamination. At each site, all five cores were extruded into a pre-labeled plastic bag and immediately hand-homogenized into one wet sample to account for site sediment variability. This process produced one homogenized sample per site. Each sample was sent to an external laboratory for analysis of physical properties, including total nitrate nitrogen, TKN, total phosphorus, total organic carbon, percent solids, and ammonia nitrogen.

[3] Natural Resources Conservation Service (NRCS). 2004. NRCS 3.3.1.4, Soil Cores. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051670.pdf

Figure 3-2. Jeff Smudde and Erin Houghton Conducting In-Stream Sediment Core Collection in Silver Creek

3.1.4 Watershed Modeling

A SWAT model was created and calibrated in 2015 using information from the United States Department of Agriculture Cropland Data Layer, land use, elevation, soil samples, cropping practices, tillage practices, and fertilizer application in the watershed. Data was sourced from Brown County, Outagamie County, baseline soil sampling, and primary accounts from growers and agronomists in the watershed. Appendix G contains a technical memorandum documenting the Silver Creek SWAT Model.

3.2 Planning

The development of a centralized GIS database streamlined planning by allowing diverse members of the Project Team to contribute data in real time through field walks and other field activities. Planning was done on a field-by-field basis, where data collected and decisions made were summarized across years in a Conservation and Enhanced Nutrient Management Plan (C&ENMP).

3.2.1 Field Walks and Recommendation of Best Management Practices

Comprehensive field walks were initially completed in 2015, and fields were re-walked periodically as needed to assess changing field conditions and operations. Field walks were executed by a team of experts including agronomists, county conservationists, the landowner and/or grower, and for some fields, a stormwater engineer. The primary goal was to walk the entire field, discuss a consistent and comprehensive set of conservation opportunities, and recommend a suite of BMPs that could be opportunities for implementation. Table 3-1 summarizes types of BMPs considered.

Table 3-1. BMPs Considered for Implementation in Silver Creek

Practice	Definition[a]
Biomass Planting	Establishing adapted and/or compatible species, varieties, or cultivars of herbaceous species suitable for pasture, hay, or biomass production.
Conservation Reserve Program (CRP)	CRP pays growers a yearly rental payment in exchange for removing environmentally sensitive land from agricultural production and planting species for environmental quality.
Cover Crops, Residue/Tillage Management, and Nutrient Management	Cover crops are grasses, legumes, or forbs planted for seasonal vegetative cover. Residue and tillage management is limiting soil disturbance to manage the amount, orientation, and distribution of crop and plant residue on the soil surface year-round. Nutrient management plans (NMPs) are completed in SnapPlus by agronomic professionals to limit soil and phosphorus runoff from agricultural fields while maintaining healthy soil and crops.
Critical Area Planting	Establishing permanent vegetation on sites that have, or are expected to have, high erosion rates, and on sites that have physical, chemical, or biological conditions that prevent the establishment of vegetation with normal seeding/planting methods.
Filter Strip	A strip or area of herbaceous vegetation that removes contaminants from overland flow.
Food Plot	A native mix of grass and vegetative habitat favorable to local herbivore species.
Grassed Waterway	A shaped or graded channel that is established to convey surface water at a non-erosive velocity using a broad and shallow cross-section to a stable outlet.
Grazing	Using a rest-rotation system of pastures for livestock farming.
Pollinator Habitat	Planting bee and butterfly habitat to attract pollinator species and reduce pollutants from overland runoff.
Vegetated Wetland Buffer	Permanent strips of stiff, dense vegetation established along the general contour of slopes or across concentrated flow areas.
Water and Sediment Control Basin	An earthen embankment or ridge and channel constructed across the slope of a minor drainageway.
Wetland	The return of a wetland and its functions to a close approximation of its original condition as it existed prior to disturbance on a former or degraded wetland site.

[a] Definitions obtained from the NRCS Conservation Practice standards: https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/cp/ncps/

The Field Walk App, an ArcGIS Collector App, was developed to assist with collecting geolocated data in real time during field walks. Baseline map layers and information such as aerial photography, topography, soil sample results, Erosion Vulnerability Assessment for Agricultural Lands (EVAAL) output, and field boundaries were included in the background of the Field Walk App to provide additional context to the conditions teams observed in the field. Predefined point, line, and polygon features for conservation opportunities each included a unique form in the GIS to capture field conditions, notes, and photos of the site. Figure 3-3 shows the base map layers and collected features with their symbology. A Field Reference Guide, included as Appendix H, was prepared to explain each feature and provide a generalized field record sheet in case written notes were needed. Figure 3-4 shows an example of data collected as part of the field walks.

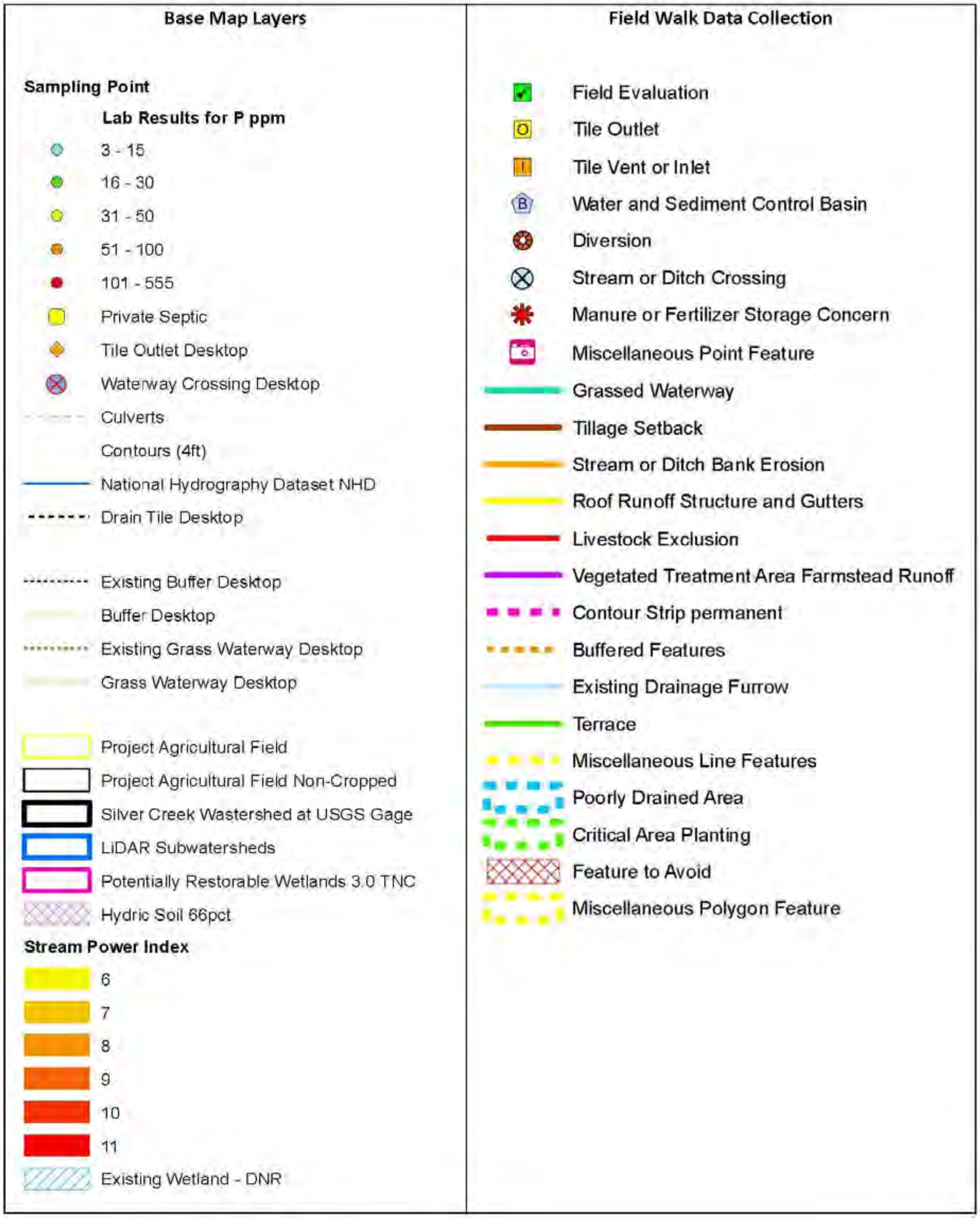


Figure 3-3. Base Map and Collector Features used for the Field Walks

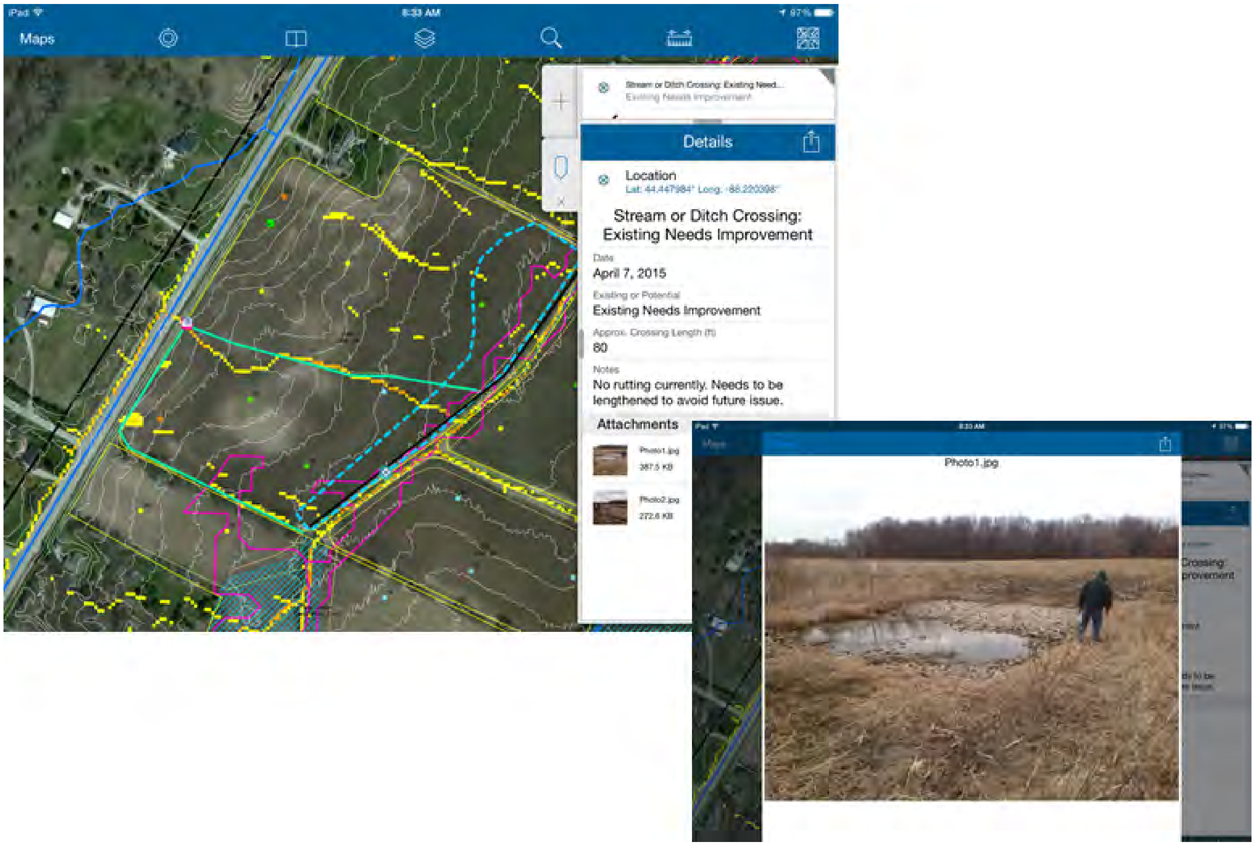


Figure 3-4. Example Field Data Collection for a Stream Crossing Needing Repair

Following the completion of the field walks, review meetings with the Project Team (agronomists, county conservationists, stormwater engineers, and NEW Water) discussed and prioritized conservation opportunities identified on each field. Because the field teams identified conservation *opportunities*, conservation *needs* were sometimes addressed by multiple practices based on the professional judgement of the diverse field teams. As a result, some practice opportunities identified in the field were not recommended following review because other practices were equally or more protective of runoff water quality.

3.2.2 Conservation and Enhanced Nutrient Management Plans

C&ENMPs were developed for each agricultural field following field walks and the prioritization of BMPs. The goal of each C&ENMP was to document the recommendations from the field walks, track the status of planned and implemented BMPs, and summarize SnapPlus output for ENMPs. While nutrient management planning is required by *Wisconsin Administrative Code* NR 151 performance standards, the Pilot Project used the term “Enhanced Nutrient Management Plans” to recognize the difference between the regulatory-driven nutrient management and nutrient management to support further agricultural runoff reductions for achieving in-stream water quality criteria. C&ENMPs were updated on each field biannually in the spring and fall seasons to capture planned versus actual field conditions and implementation activities. Appendix I contains C&ENMPs updated through the end of the 2019 growing season.

The Project GIS was leveraged in several ways to streamline the generation of C&ENMPs. Information from the database is summarized in a Hypertext Markup Language (HTML) report automatically generated by a Python script (script). The Conservation Planning App, an ArcGIS Web App, allowed for Project Team members to input SnapPlus data, notes, and high-level field summaries unique to the conservation planning process directly into the GIS database. Appendix J includes user manuals for inputting ENMP and Conservation Plan data using the Conservation Planning App. The tools created for the Pilot Project required SnapPlus output be input to the Conservation Planning App by hand; future versions of these tools could include the development of a script to directly import the SnapPlus Excel reports to the database.

3.3 Implementation

An ArcGIS Collector App was developed for use by field staff and NEW Water during the BMP planning, design, construction, and annual inspection process. The Silver Creek Verification 3.0 (Verification App) tool allowed field teams to collect data in the field on BMPs throughout the implementation process and assisted NEW Water with executing cost share payments. Figure 3-5 shows a screenshot of the web interface for the Verification App. Appendix K contains a Quick Reference Guide on the features, attributes, and instructions for the Verification App.

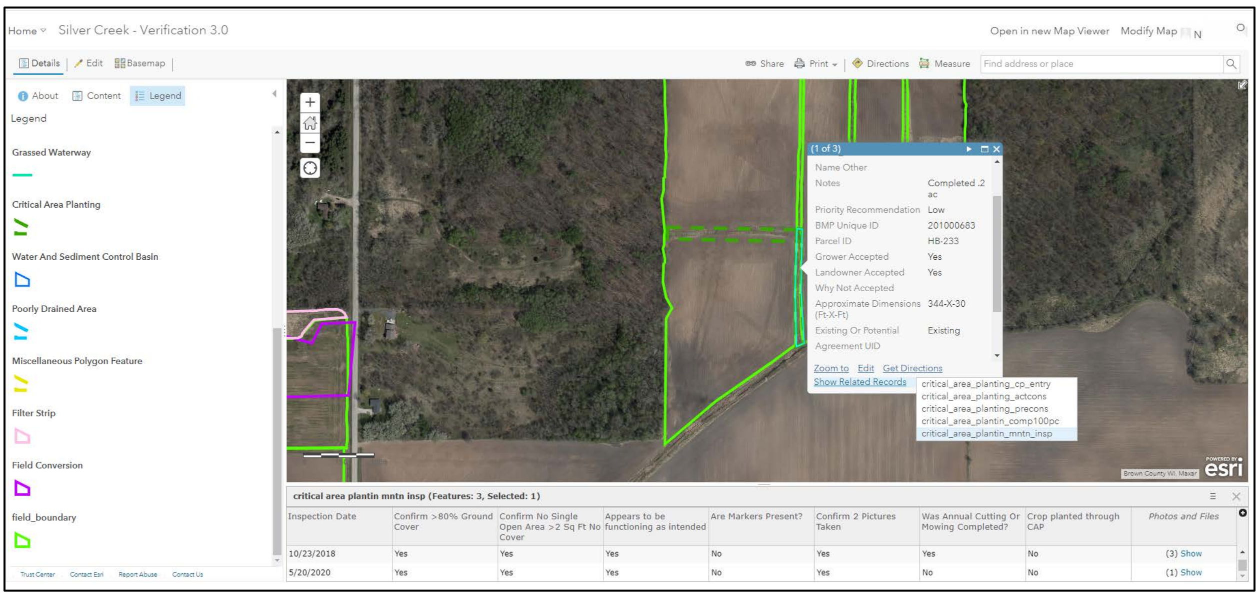


Figure 3-5. Silver Creek Verification 3.0 Map

BMPs were recommended by the field team and added to the Verification App. Structural BMPs were added as points, lines, and polygons. Operational BMPs were added as records related to the agricultural field boundary. The GIS automatically assigned each BMP a permanent unique identification number (BMP ID) to help track and record data and related information. Figure 3-6 is a diagram of the organization of the Verification App structure and the relationships between BMPs.

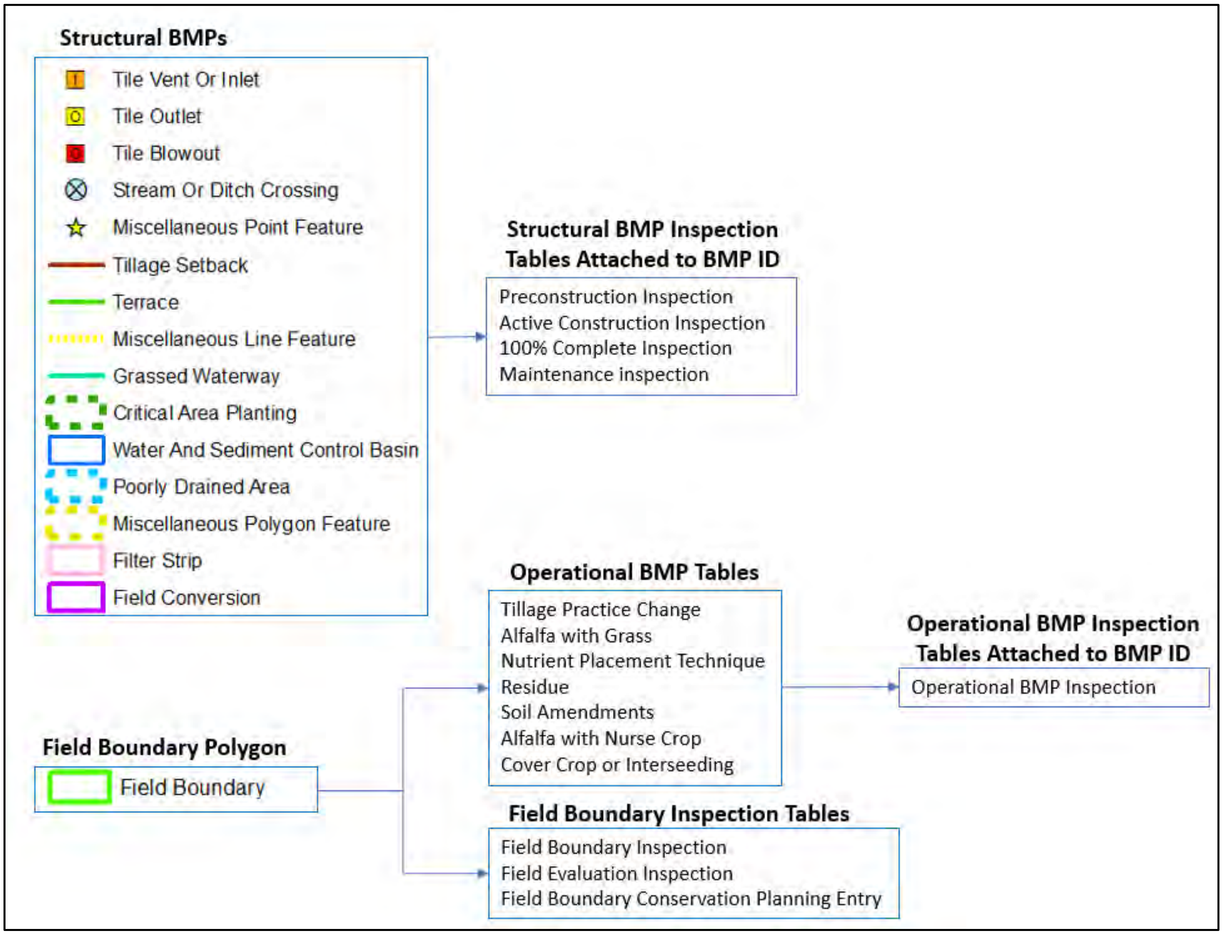


Figure 3-6. Verification App Structure and Relationships

Field staff worked with growers and landowners to approve the installation of recommended BMPs. Throughout the implementation process, the Verification App was used to track the status of BMPs and to generate reports and summaries to keep Project Team members informed. Opportunities to add and store photos or related files were included in almost all features and tables. Several “inspections” were created as tables related to either the BMP ID or agricultural field boundary.

Structural BMPs had four inspection types: preconstruction, active construction, 100% complete, and maintenance. NEW Water received notifications and report summaries for each stage of BMP implementation. The preconstruction inspection included the planned install date, funding source, design, estimated cost, estimated total phosphorus reductions, estimated TSS reductions, and pictures. Active construction inspections were completed throughout the installation process to document notes and photos. The 100% complete inspection included the date construction was complete, who completed the inspection, redline designs, final BMP acres, final cost, as-built total phosphorus reductions, as-built TSS reductions, notes, photos, and the ready-for-payment date. NEW Water was notified by an automated message from the GIS when a BMP was ready for payment and would review the inspections completed by field staff before approving the final cost share for the landowner or grower.

Operational BMP practices were stored as tables with unique BMP IDs related to the field boundary. The field staff added operational BMPs to the Verification App after the BMP had been planned with the grower and a cost share agreement (CSA) (if applicable, see Section 3.3.1) was signed. Operational BMPs had an operational BMP inspection table related to each unique BMP ID. This inspection documented the user entering information, planned implantation date, cost share number, and funding source. Each operational BMP inspection was unique to the BMP type implemented. For example, the cover crop inspection included inspection date, name of inspector, ready-for-payment date, average ground cover, average cover height, implemented acres, final rate per acre, final cost, and photos. Figure 3-7 includes photos from a cover crop inspection completed using the Verification App.

Figure 3-7. Photos from a Cover Crop Inspection

The Verification App was the primary tool used to document BMP implementation and supported many tasks and workflows during the Pilot Project, including the execution of CSAs. However, most of the cost share process existed outside of the GIS and opportunities to streamline the implementation and cost share process were limited in the Pilot Project. Opportunities to fully integrate the CSA into the GIS will be considered for the Full-Scale Program.

3.3.1 Cost Share

NEW Water primarily used grant funding from GLRI to fund cost share for BMP implementation. To provide timely funding to CSA recipients, NEW Water authorized Outagamie County to initiate payment to the respective landowner or grower once a BMP was verified as complete. Outagamie County invoiced NEW Water quarterly for reimbursement. Several BMPs were installed using other locally available funding sources through NRCS such as the Environmental Quality Incentives Program (EQIP), Conservation Stewardship Program, and CRP.

When a BMP was identified for implementation, NEW Water staff initiated the cost share process by drafting notarized and legally binding CSAs to document payments made by NEW Water to landowners and operators. BMP IDs were included on the CSA to be able to reference information stored in the GIS database and apps. The CSA commits the landowner(s), their heirs, successors, assigns, and users of the land to fulfill the agreement and all conditions set forth in the document for the specified period; conditions covered the installation of the BMP and associated operation and maintenance requirements required following BMP implementation. All structural practices were installed with an agreement that the BMP would remain in perpetuity, and each was recorded at the County Register of Deeds' offices for the respective parcels. If future land use of the property were to change to non-agricultural, the landowner may contact NEW Water to request an update or clarification of the recorded CSA. Project field staff met with landowners and growers to review the CSA, sign and notarize the documents, and returned to NEW Water for final signature. The NEW Water Executive Director signed the CSA, and a signed copy of the agreement was shared with the respective landowner or grower.

NEW Water developed standard CSA templates that were used during the Pilot Project, included in Appendix L. Each agreement included a table with a list of BMPs planned to be implemented or constructed by the landowner or operator according to the NRCS Technical Guides.[4] The CSA also listed estimated and final BMP installation costs and corresponding cost share amounts. The cost share rate for each listed BMP was based on the maximum cost allowable. There were two kinds of structural CSA templates: One was used for properties owned by the Oneida Nation and one for non-Oneida Nation properties. The agreements are very similar, except for the following two specific items:

- Oneida Nation landowner:
  - The CSA is not recorded on the property deed; however, it does constitute a covenant that remains tied to the property and is a legally binding document.
  - Technical services are provided by staff of the Oneida Nation, County Land Conservation Departments, and NEW Water representatives.
- Non-Oneida Nation landowner:
  - Technical services are provided by County Land Conservation Department staff and NEW Water representatives.
  - The fully executed CSA (and any addenda) is recorded on the property deed.

Cost share for structural BMPs was dependent on the BMP type and eligibility of the BMP for funding from outside sources. Grassed waterways and CAPs were fully funded at no cost to the landowner to offset the cost of construction and seeding. Buffers and filter strips were cost shared at a higher one-time rate of $3,500 per acre plus the cost of establishment to compensate for cropland taken out of production. These additional payments for filter strips were predominantly funded by NEW Water's EPA GLRI grant, although in 2016 some practices were also cost shared using NRCS EQIP funding.

CSAs for operational BMPs were short-term, annual agreements with the operator of the BMP, not necessarily a landowner, and were not recorded at the County Register of Deeds' office. Operational practices were funded using several different strategies throughout the Pilot Project. In 2016 and 2017, cost share for cover crops and residue/tillage was offered as a flat rate that closely followed the NRCS EQIP funding rate. Later in the Pilot Project, a pay-for-performance cost share structure was established to encourage growers to plant cover crops earlier and leave more residue on the field after planting in the spring. A cost share rate was also established for the use of low-disturbance manure application techniques along with seeding grass into alfalfa mixes in hay fields. Figure 3-8 includes an example rate sheet for pay-for-performance operational practices.

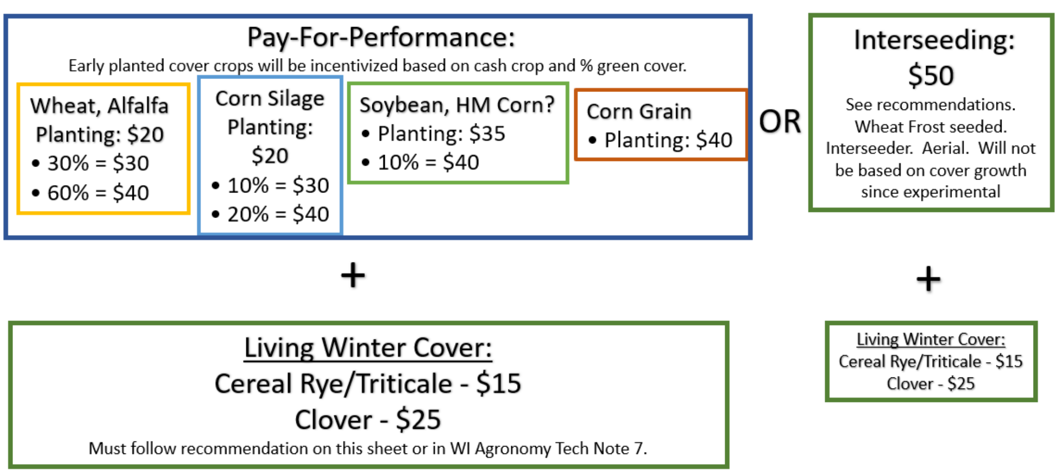


Figure 3-8. Operational Pay-For-Performance Cost Share Strategy

[4] NRCS Technical Guides are localized to each geographic area for which they are prepared. Field Office Technical Guides can be accessed electronically from the USDA webpage, https://efotg.sc.egov.usda.gov/#/state/WI.

During the 5-year Pilot Project, 19 structural CSAs were initially signed, of which 12 were fully executed and 9 were recorded at the Outagamie and Brown Country Register of Deeds. An additional 44 operational CSAs were initially signed and 36 were fully completed. Crop planting changes such as installing alfalfa into a row-cropped field designated for a cover crop were often the reason why signed operational CSAs were not completed. Other signed CSAs were not fully completed due to weather; wet weather in the fall or delayed crop harvest timelines limited opportunities to plant cover crops or spread manure.

3.3.2 Leveraging Partnerships

Throughout the Pilot Project, NEW Water leveraged local partners to maximize BMP implementation throughout the Silver Creek watershed, summarized in Section 4.2. These project partners provided technical expertise and financial support or grant funding for individual projects that aligned with their organizations' goals. Wetland restoration projects were a joint effort involving USFWS, Ducks Unlimited, the Oneida Nation, and TNC. The Oneida Nation was actively involved in several ways throughout the Pilot Project as a landowner, operator, and an entity with environmental staff that provided expertise and assistance in the field.

3.4 Verification and Maintenance

Verification and maintenance of installed BMPs was done throughout the Project using the Verification App. For structural practices, this involved biannual inspections for the first year and annual inspections subsequently to ensure practices remained in good condition and functioning as expected. If maintenance was identified as being needed for any practice during an inspection, it was noted in the inspection on the App, and those responsible for the identified maintenance were notified. Inspections were also performed after heavy rain events that could potentially impact either newly installed practices or those identified as being susceptible to rain events (Table 3-2).

Table 3-2. BMP Inspection Schedule

BMP Type	First-Year Inspections	Second Year+ Inspections
Critical Area Planting	6 months, rain events	Annually
Grassed Waterway	6 months, rain events	Annually
Wetland	6 months, rain events	Annually, rain events
Inlet, outlet	6 months, rain events	Annually, rain events
Terrace	6 months, rain events	Annually, rain events
Filter Strip	6 months, rain events	Annually
CRP	6 months, rain events	Annually
Biomass	6 months, rain events	Annually
Food Plot	6 months, rain events	Annually
Grazing	6 months, rain events	Annually
Water and Sediment Control Basin	6 months, rain events	Annually

The App notified field staff to inspect the practices listed in Table 3-2 whenever the rain measured at Austin Straubel International Airport reached 1 inch or more in any 24-hour period. Notifications were sent through an automated email report, and practices that needed inspections exhibited a red highlight within the Verification App until an inspection was completed, as shown in Figure 3-9. Once a post-rainfall inspection was completed, the red highlighting within the App would disappear to indicate to users the required inspection had been completed. Experience in the Pilot Project demonstrated that frequent rainfall inspections may not be needed for well-established BMPs; the Full-Scale Program is evaluating options for different thresholds, such as dropping the requirement for inspection to a 25-year rainfall event for BMPs established two or more seasons prior.

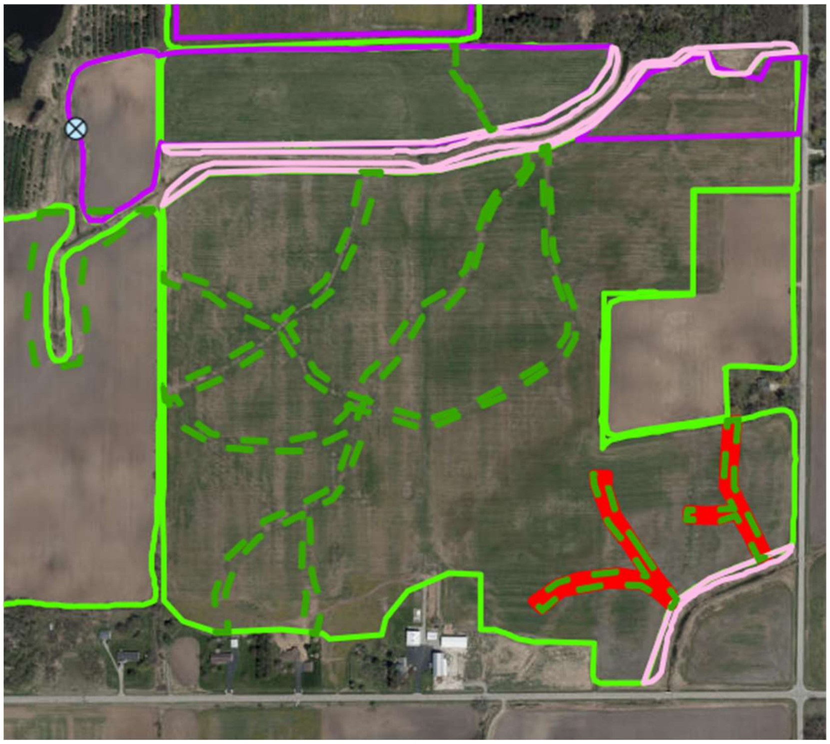


Figure 3-9. Two Critical Area Plantings
Red highlight indicates the need for a post-rainfall inspection.

Operational practices were inspected once planted and then once fully established to ensure they were implemented as expected and to approve payment to growers where cost share was involved. Residue/tillage practices were inspected once in the spring to determine if they met the guidelines for implementation and to receive the agreed-upon cost share value.

An ArcGIS Web App map was created that showed the locations of installed structural BMPs within the agricultural fields (Figure 3-10). The purpose of the map was to allow growers and their operators to track their real-time location within the fields relative to the installed BMPs, so that the BMPs would be protected. Each BMP had warnings that became visible on the map to inform the grower or operator of special precautions needed to preserve the BMP. For example, warnings included no spraying, no manure, no tilling, and no crossing. The map was non-editable, did not require a login, did not contain any personal or identifying information, and could be accessed by anyone with the link[5]. This allowed the growers to share this information with anyone working on their fields and access it through a regular web browser on their phone, tablet, or desktop computer.

[5] https://jacobs.maps.arcgis.com/apps/webappviewer/index.html?id=cc93571ae02d41ef861a2c3c8f5ebc9f

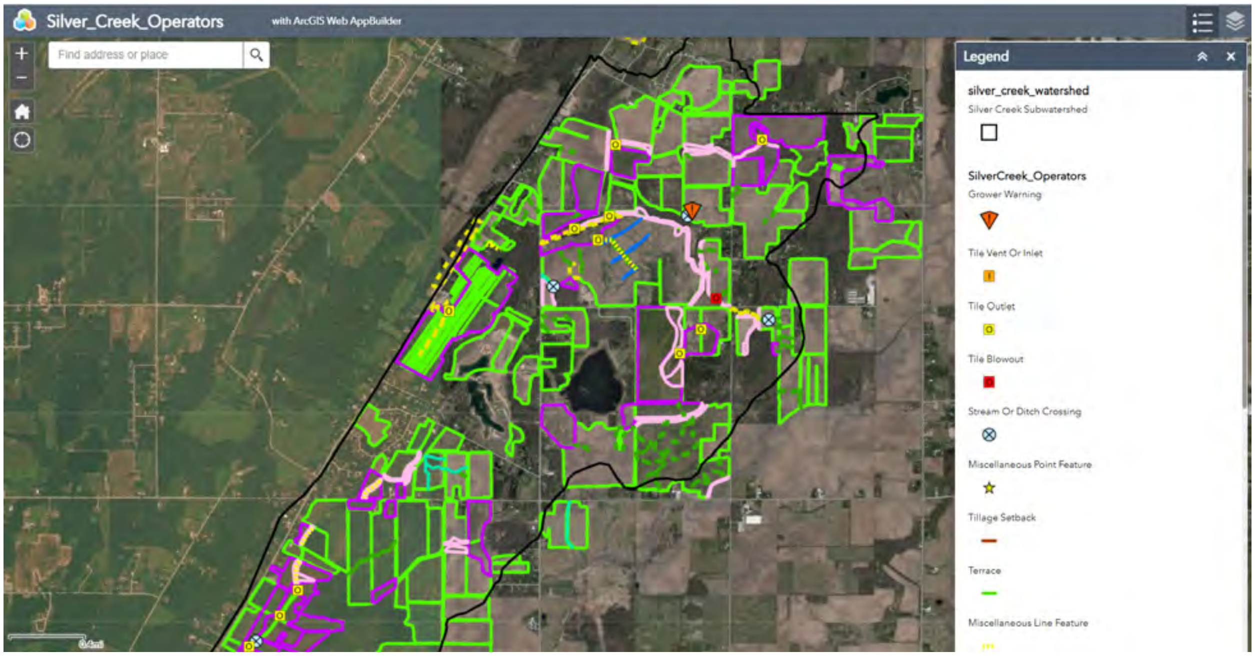


Figure 3-10. The Silver Creek Operators Web App

3.5 Workflow

The Pilot Project trialed several approaches to workflow that were streamlined by the end of the Pilot to leverage the evolving GIS as a central tool. In general, workflows involved multiple communication steps between field teams and NEW Water staff that were streamlined by automated email reports or other notifications in the GIS Apps. Figures 3-11 to 3-13 outline key workflows for implementing BMPs. These workflows best illustrate the processes implemented toward the end of the Pilot and will be further expanded upon for the Full-Scale Program.

Figure 3-11 shows the process for updating C&ENMP reports, which occurred twice per year. This process evolved many times throughout the Pilot Project and ultimately relied on agronomists to hand-enter data from SnapPlus into a form in the Conservation App. An automated script summarizes the input information into a PDF C&ENMP report (see Section 3.2 and Appendix I). Improvements to this process, such as including a semiautomated process that can directly import data from SnapPlus to the GIS database, will be considered for the Full-Scale Program.

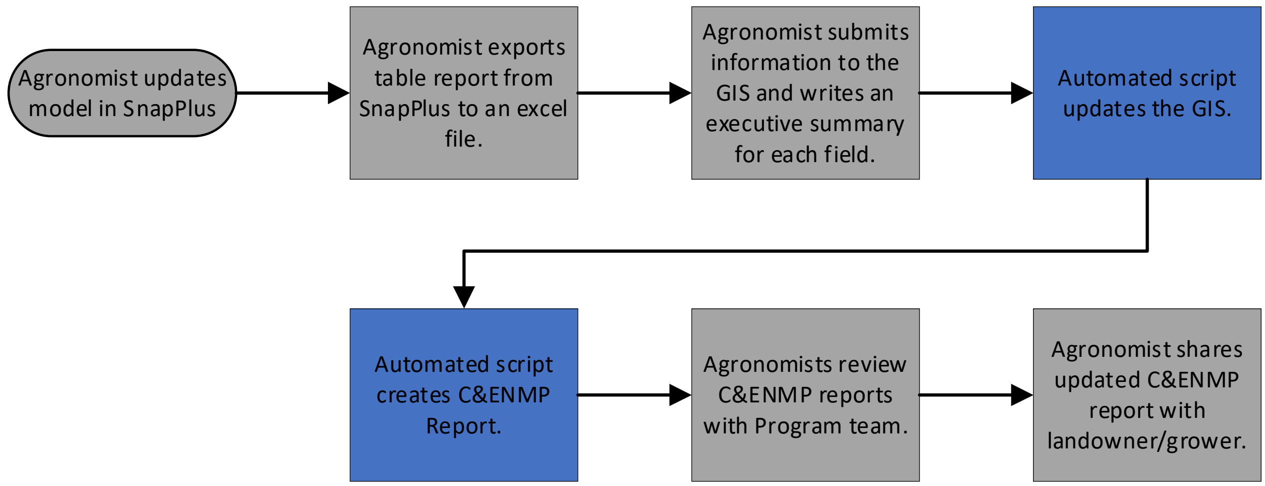


Figure 3-11. Workflow for Updating C&ENMPs

Figures 3-12 and 3-13 outline the workflows for implementing structural and operational BMP opportunities, executing a CSA, design, construction, and deed recording for structural practices. These processes include several steps where information must flow between the County, agronomists, and NEW Water. The GIS assists in key steps with email-based notifications to facilitate the workflow. This process is expected to be similar for the Full-Scale Program.

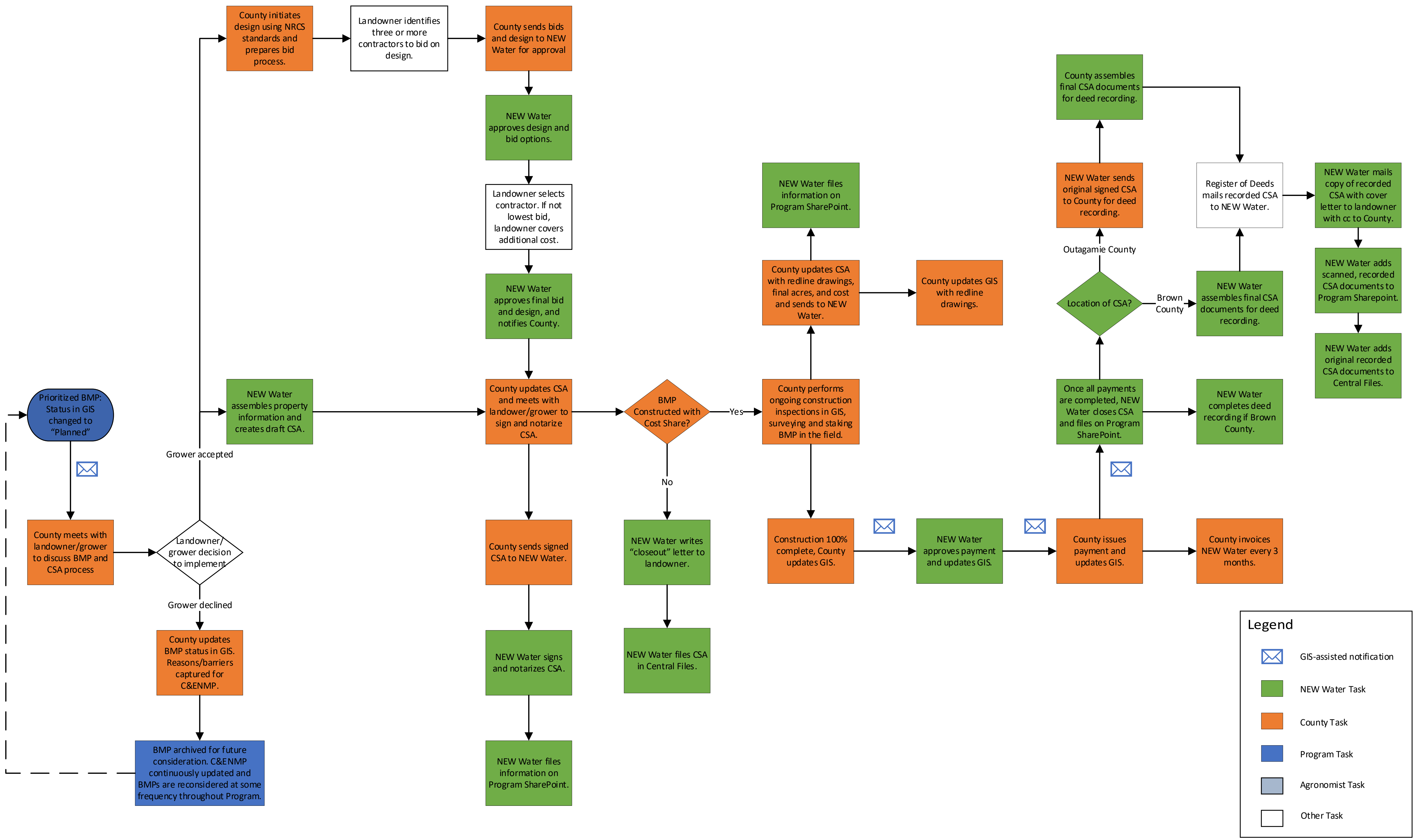


Figure 3-12. Workflow for Implementing Structural BMPs

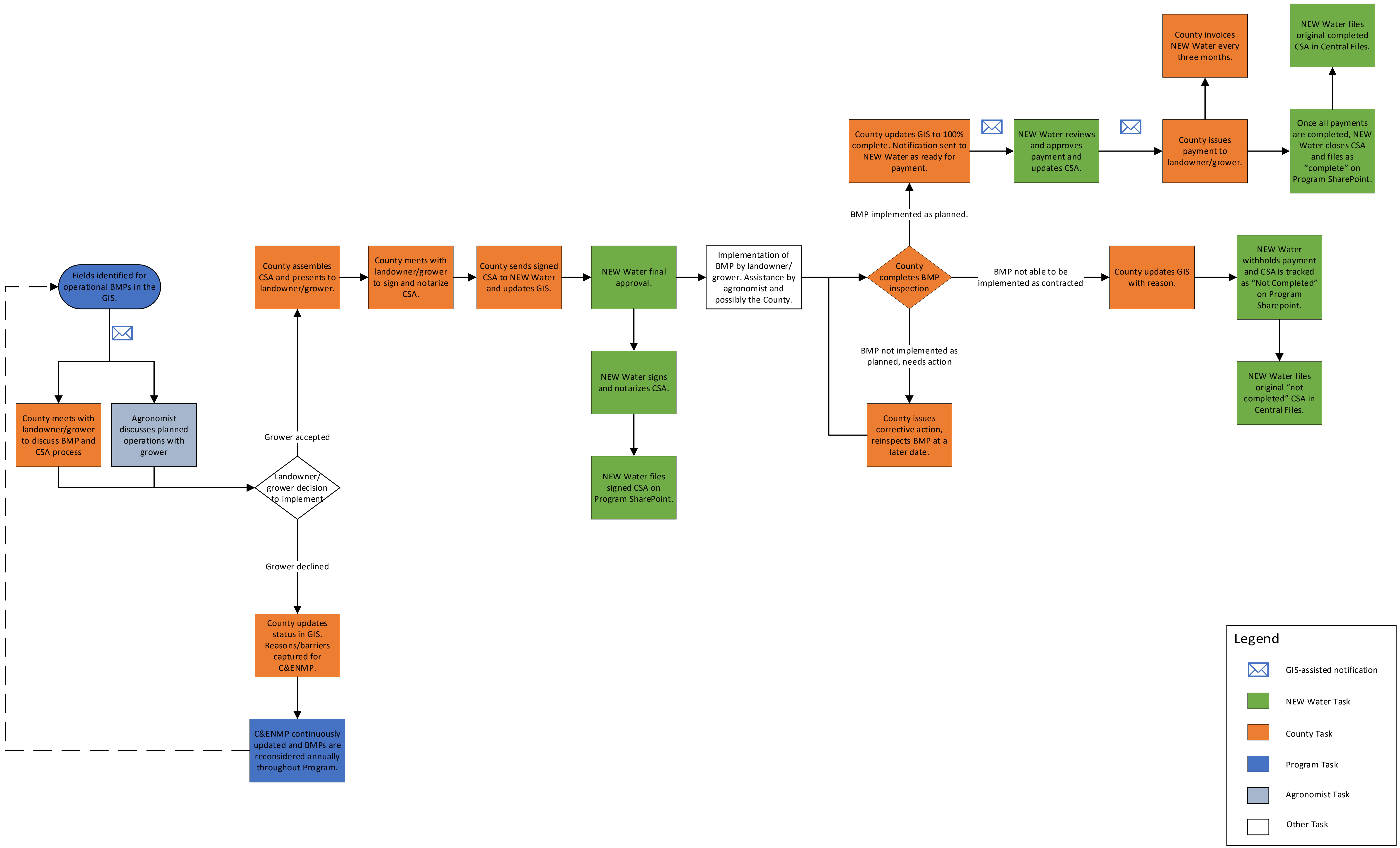


Figure 3-13. Workflow for implementing Operational BMPs

4. Results

4.1 Best Management Practice Implementation

The C&ENMPs completed for each field document the implemented BMPs through 2019 and are included in Appendix I. Implementation for structural practices began in 2016 and continued through 2020. Table 4-1 shows the total acreage of structural BMPs implemented throughout the duration of the Pilot Project.

Table 4-1. Implemented Acres of Structural BMPs throughout the Pilot Project

	2016	2017	2018	2019	2020	End of 2020 Total
CAPs	4.1	4.8	5.6	10.8	0	25.3
Filter Strips	14.7	16.9	16.1	1.3	0.9	49.9
Grassed Waterways	3.9	0	0	0	0	3.9
WASCB	3.4	0	0	0	0	3.4
CRP	0	21.0	12.8	0	0	33.8
Wetland	0	21.0	25.4	0	0	46.4
Food Plot	10.8	0	0	0	0	10.8
Field Conversion: Vegetated Buffer Seeding	0	15.9	14.7	0	0	30.6
Grazing	0	98.0	0	0	0	98.0
Pollinator	0	0	34.5	0	0	34.5
Biomass	9.9	22.0	19.8	0	0	51.7
TOTAL	46.8	199.6	128.9	12.1	0.9	388.3

Operational practices, mainly consisting of cover crops and residue/tillage practices, were first implemented through in-kind efforts beginning in 2015. Cost sharing these practices began in 2016 and continued through 2020. Table 4-2 shows acres of implementation for these practices.

Table 4-2. Implemented Acres of Operational BMPs throughout the Pilot Project

BMP	2015	2016	2017	2018	2019	2020
Cover Crops	260	704	530	269	216	343
Residue/Tillage	472	48	596	357	476	341

More than 700 acres of cover crops were implemented in 2016 in the Pilot Project watershed, which accounts for approximately 33% of the agricultural field acreage. The purchase of the InterSeeder™, which NEW Water purchased in partnership with Brown County and the Fund for Lake Michigan, allowed growers to plant a cover crop on a field early in the planting season while the current crop is growing rather than waiting until post-harvest. This technique interrupts the typical linear timeline for implementation of winter cover that is subject to weather and other factors out of grower control. The InterSeeder™, which can also be used to side-dress nitrogen and as a no-till grain drill, was offered to any grower within the Pilot Project watershed interested in implementing these practices. For more information on the InterSeeder™ or progress through 2017, see Appendix M for the InterSeeder™ fact sheet (CH2M 2017) and the *Interseeding Progress Report for 2017 Crop Year* (CH2M 2017).

Phosphorus and TSS reductions from structural practices were modeled by Outagamie County using the Spreadsheet Tool for Estimating Pollutant Load (STEPL). Appendix N includes a summary of the modeling parameters used for STEPL and SnapPlus in the Pilot Project. For completed structural practices, the reductions in the first year carry over from year to year as long as that practice remains in the ground and functioning. Table 4-3 includes the cumulative total phosphorus and TSS mass reduction for implemented practices through the end of 2020. A phosphorus and TSS reduction efficiency are also included in Table 4-3, which is an estimate of the average mass reduction observed per acre of installed BMP.

Table 4-3. Phosphorus and TSS Mass Reductions from Implemented Structural Practices through 2020

	Phosphorus Reduction (lbs/yr)	Phosphorus Reduction Efficiency (lbs/BMP acre/yr)	TSS Reduction (tons/yr)	TSS Reduction Efficiency (tons/BMP acre/yr)
Critical Area Plantings	105	7.3	136	9.5
Filter Strips	112	2.4	60	1.3
Grassed Waterways	98	25	138	36
WASCB	55	16.3	78	23
CRP	87	2.6	61	1.8
Wetland	25	0.5	13	0.3
Food Plot	28	2.6	19	1.8
Field Conversion: Vegetated Buffer Seeding	101	3.3	70	2.3
Grazing	130	1.3	198	2.0
Pollinator	74	2.1	47	1.4
Biomass	220	4.3	121	2.3
TOTAL	1,035	2.6	941	2.4

Reductions from operational practices were modeled using SnapPlus output provided by agronomists for the C&ENMPs. Modeling was not completed in 2020. Operational practices were installed and modeled annually, and reductions do not carry over from year-to-year. For evaluating reductions compared to the TMDL, the SnapPlus-calculated phosphorus mass is equivalent to the phosphorus delivered to the nearest receiving water. For TSS mass, the SnapPlus calculation represents a field edge calculation; WDNR instructed the modeled output of TSS in tons per year to be multiplied by 10% to estimate the sediment delivery to the receiving water. Table 4-4 includes the annual mass reductions and average annual mass reduction from implemented operational practices. Where values are negative, there was a calculated net increase in phosphorus or TSS load compared to 2015.

Table 4-4. Phosphorus and TSS Mass Reductions from Implemented Operational Practices through 2019

BMP	2016	2017	2018	2019	Annual Average
Cover Crop Only					
Phosphorus Reduction (lbs/yr)	334	198	-2	157	172
TSS Reduction (tons/yr)	24	26	1	45	24
Residue/Tillage Only					
Phosphorus Reduction (lbs/yr)	0	340	207	185	183
TSS Reduction (tons/yr)	0	12	8	7	7
Cover Crops and/or Residue/Tillage Management ("Managed Acreage")					
Phosphorus Reduction (lbs/yr)	318	769	343	446	469
TSS Reduction (tons/yr)	22	49	56	57	46
Nutrient Management Planning Only					
Phosphorus Reduction (lbs/yr)	106	405	1,026	1,047	646
TSS Reduction (tons/yr)	174	93	69	79	103
Total Operational Practices					
Phosphorus Reduction (lbs/yr)	424	1,175	1,369	1,493	1,115
TSS Reduction (tons/yr)	73	127	144	133	119

Combining the overall reductions calculated from SnapPlus for operational BMPs and nutrient management planning, and for structural BMPs from STEPL, a total reduction for phosphorus and TSS within the agricultural fields was calculated. Accounting for all agricultural field acres in the Silver Creek watershed, even those that did not have BMPs implemented or that otherwise did not participate in the Pilot Project, the Pilot achieved an overall phosphorus reduction of 1.0 pound per agricultural field acre per year and an overall TSS reduction of 0.50 ton per agricultural field acre per year through 2020 (Table 4-5). By including all the BMPs implemented and all agricultural field acres within the Silver Creek watershed, the phosphorus and TSS reduction efficiencies account for actual implementation conditions. The reduction efficiencies do not assume 100% participation and success; instead, they use the total agricultural field acres in the calculation to account for landowners and growers who did not participate in the Pilot or who only participated for some parts of it, failures of BMPs, and removal of BMPs as crop rotations changed.

Table 4-5. Overall Phosphorus and TSS Reduction Efficiencies in Silver Creek Pilot Project

Phosphorus	
SnapPlus Average Phosphorus Reduction, lbs/yr	1,115
Overall STEPL Phosphorus Reduction, lbs/yr	1,035
Combined Phosphorus Reduction, lbs/yr	2,150
Total Field Acres*	2,134
Combined Phosphorus Reduction, lbs/field acre/yr	1.0
TSS	
SnapPlus Average TSS Reduction, tons/yr	119
Overall STEPL TSS Reduction, tons/yr	941
Combined TSS Reduction, tons/yr	1,060
Total Field Acres*	2,134
Combined TSS Reduction, tons/field acre/yr	0.50

* Acres within field boundaries in Silver Creek in 2020, including those of growers without NMPs and not working with the Pilot Project.

The modeling strategy during the Pilot Project evolved over time through conversations between Outagamie County, WDNR, UWGB, agronomists, and other outside resources. Modeling completed in 2019 was used to support NEW Water's Adaptive Management Plan; the results presented within this final report have been updated for 2020 implementation and include a refinement of some STEPL inputs for structural BMPs. The following are lessons learned and recommendations for modeling in the Full-Scale Program:

- Modeling operational practices using SnapPlus should consider using inputs for predominant soils rather than the default calculation, which uses critical soil type.
- Model versions should be tracked as part of the modeling documentation. As model versions are updated, calculations should be reviewed for potential changes. Alternatively, commit to using one modeling version for the duration or re-calculate models at the time of reporting.
- Develop a modeling quality assurance and quality control plan to follow in completing its modeling and modeling reviews. The plan should include review forms, modeling input and output archiving, model files, and documentation of each BMP and modeling exercise.
- Develop a modeling approach memorandum to summarize the means and methods for quantifying BMP effectiveness to ensure consistency in modeling across all team members. To the extent possible, review with WDNR to gain approval, and routinely review the modeling approach for refinement with new or updated techniques.

4.2 Partner Watershed Projects

NEW Water completed several watershed projects with partner entities, including TNC, the Oneida Nation, Ducks Unlimited, USFWS, and UWGB, to supplement the BMP implementation described in Section 4.1. Projects were jointly completed with NEW Water and partner entities each contributing funds, expertise, and labor. Several of these projects were executed to advance research and development through partner organizations and to contribute to a greater regional understanding of water quality improvements resulting from watershed projects such as wetlands, vegetated water treatment systems (VWTS), and grazing operations. If the project was part of a research endeavor, partner entities analyzed data and outcomes to provide to NEW Water through committee meetings and the annual stakeholder meeting (Section 2.5.2). By completing partner watershed projects as part of the Pilot Project, NEW Water strengthened connections with partner agencies, gained a greater understanding of different BMPs for implementation, and can assess the value of future watershed projects for the Full-Scale Program. Learning from and with project partners helped identify efficient and effective BMPs for the LFRB and strengthened the success of all regional watershed efforts.

4.2.1 Wetlands

NEW Water worked with agricultural landowners and partners TNC, the Oneida Nation, Ducks Unlimited, USFWS, and UWGB to convert 150 acres of agricultural land into seven different wetland complexes. Taking agricultural land out of production was not a primary goal of wetland implementation; however, these areas had low crop yield, hydric soils, and, in some cases, wetland indicator vegetation. Collectively, these seven basins drain 650 acres of the 4,800-acre watershed. The wetlands provided benefits such as sediment and phosphorus capture, contribution towards maintaining consistent base flow in the headwater reaches, water retention to reduce peak flow in Silver Creek, improved drainage, and improved habitat through extended buffers and establishment of native grasses.

A wetland in the headwater reach (Site 7, Figure 4-1) included three distinct basins with berms. A water control structure allowed for boards to be inserted after establishment of emergent vegetation to regulate water retention depth and duration. Native plantings were seeded on acreage adjacent to these three basins. By capturing and retaining some runoff in these basins, baseflow can be maintained downstream through the slower release of water from this wetland complex. This practice was installed in fall 2017, with emergent vegetation established in 2018.

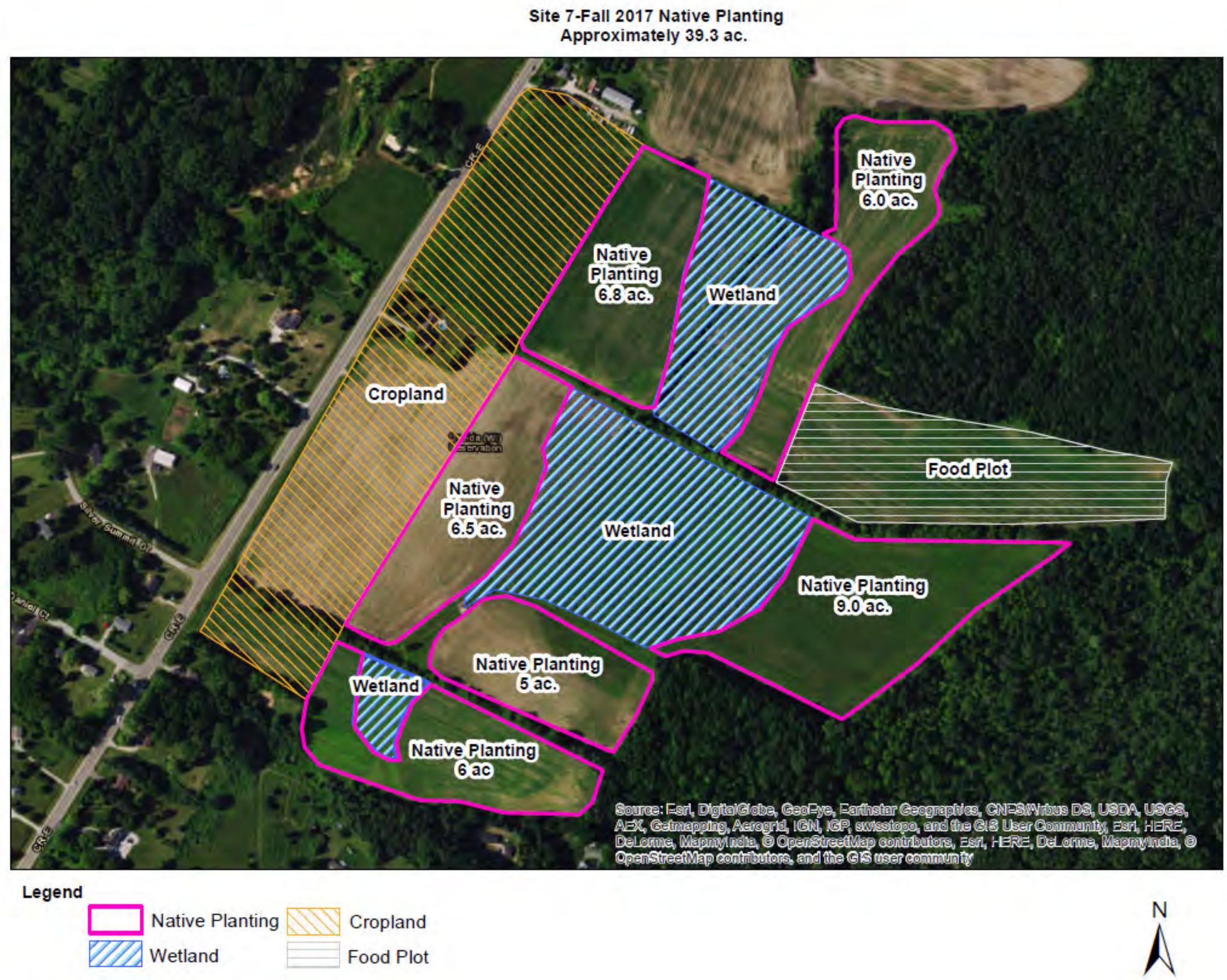


Figure 4-1. Site 7 Wetland

A wetland (Site 2, Figure 4-2) was placed on a small tributary of Silver Creek between agricultural fields by installing a small berm embedded with a water control structure to regulate water retention depth and duration after vegetation was established. Native plantings were seeded around the newly constructed wetland and a large field to the south. This practice was installed in fall 2017, with emergent vegetation established in 2018.

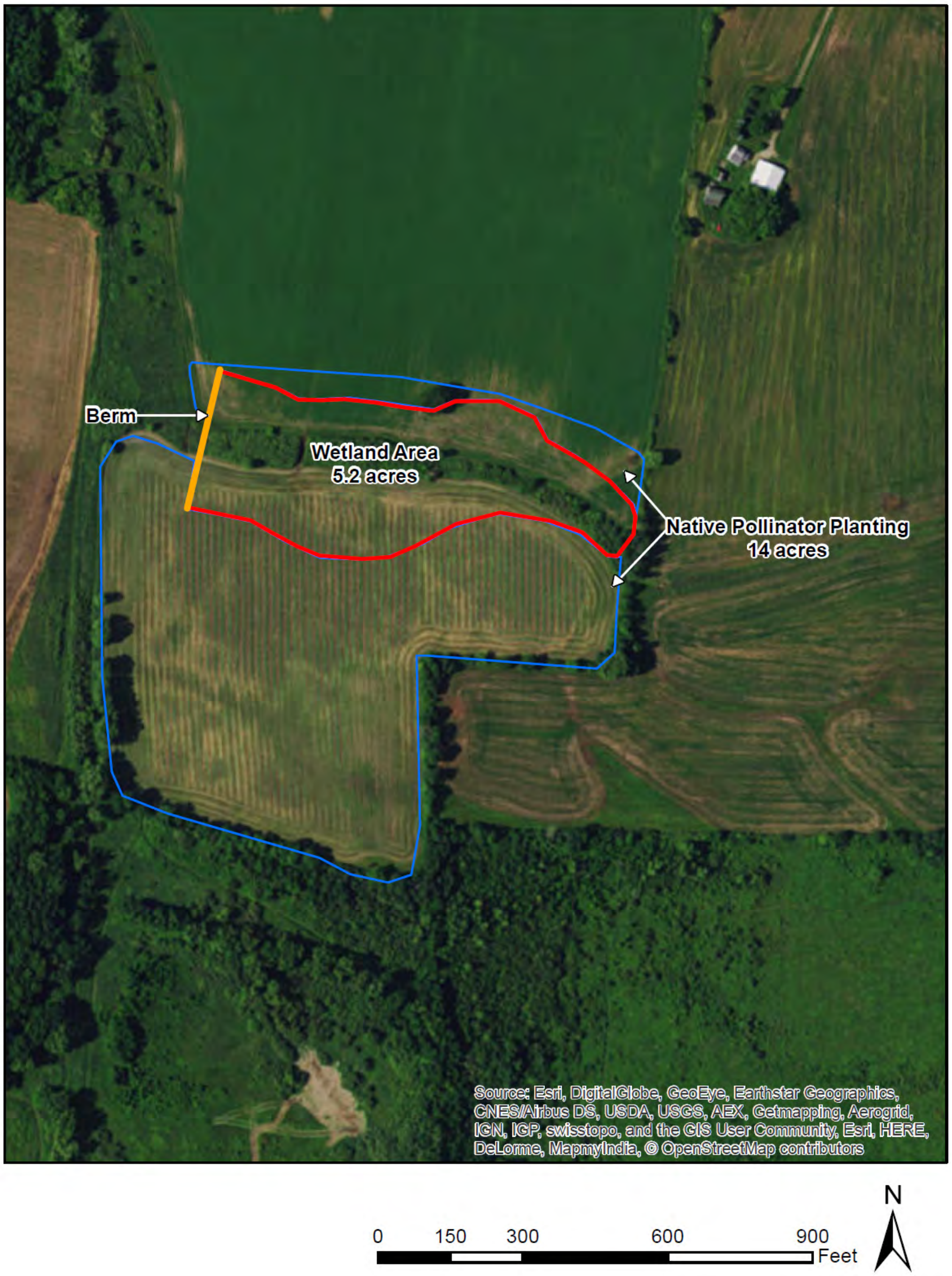


Figure 4-2. Site 2 Wetland

An experimental wetland (Figure 4-3) was funded through a grant obtained from the Fund for Lake Michigan with partners at USFWS, TNC, the Oneida Nation, and UWGB. A previously cropped field with high soil phosphorus was converted to forage to remove excess nutrients from the soil. A wetland basin was excavated and shaped, and an outlet was established to allow sheet flow through a neighboring fallow re-vegetated farm field before entering a tributary of Silver Creek. This practice was installed in fall 2017, with emergent vegetation established in 2018. Water quality weekly grab samples were taken at the outlet of this wetland complex. Control water samples were collected from an adjacent outflow area that did not receive a wetland addition but remained predominantly agricultural land use (Sites SL-ADR, wetland, and SL-OVR, control). A reduction in total phosphorus concentration was observed in the experimental wetland site between 2018 and 2019 (Figure 4-4), even though cumulative rainfall totals were greater in 2019 (see Section 4.3, Figure 4-10). This reduction may be partially due to greater post-construction vegetation establishment in 2019. In contrast to the increased phosphorus concentration, increased precipitation between 2018 and 2019 may explain the increased TSS concentration in the experimental wetland, potentially from past construction and vegetation material. Changes in cropping rotations on fields near the control sampling site may have contributed to the observed variability in phosphorus and TSS concentrations at the control site. Additional time is needed to better understand the water quality benefits, such as decreases in phosphorus concentration, from this established wetland system beyond 2019.

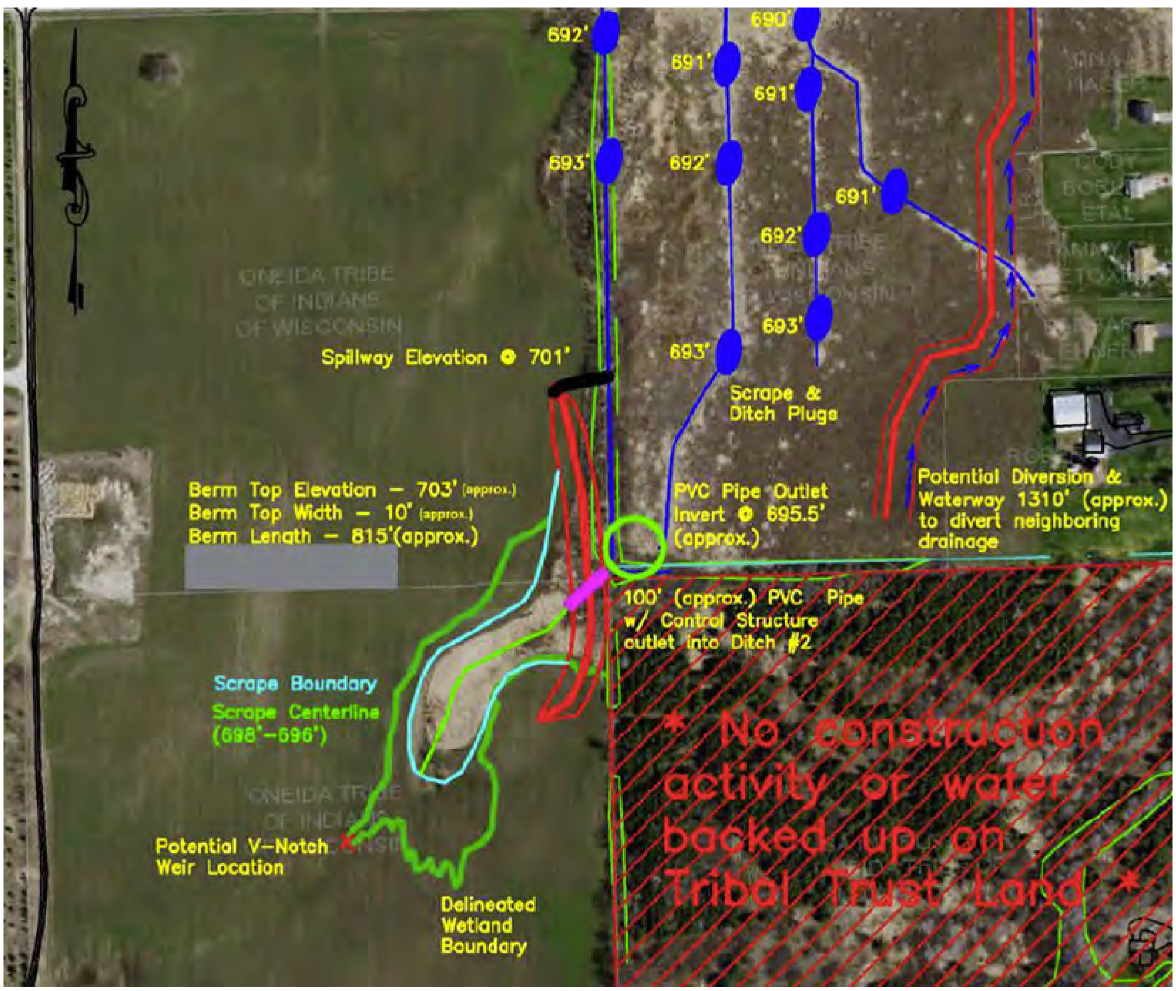
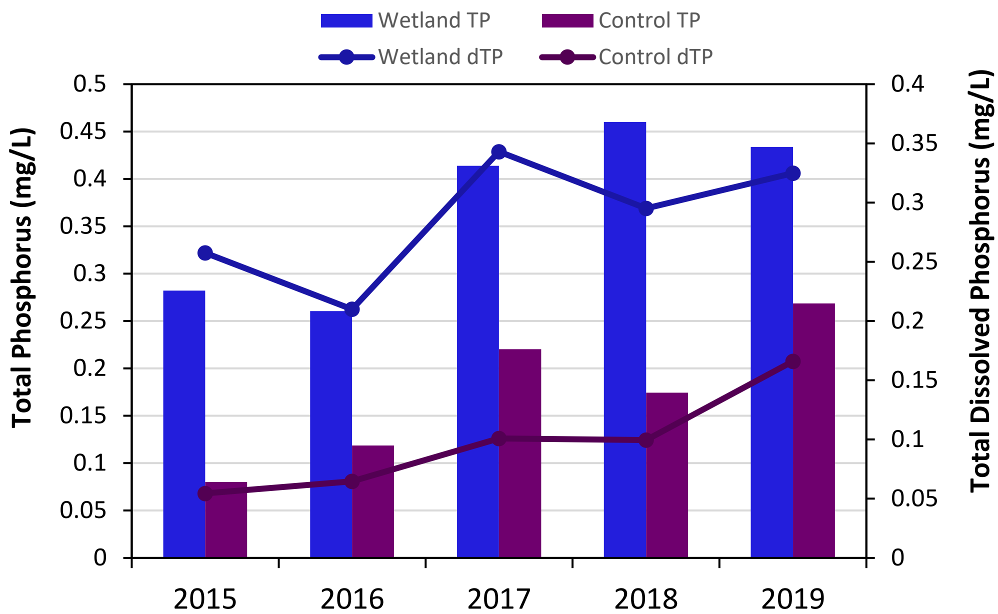


Figure 4-3. Fund for Lake Michigan Experimental Wetland Design Plans



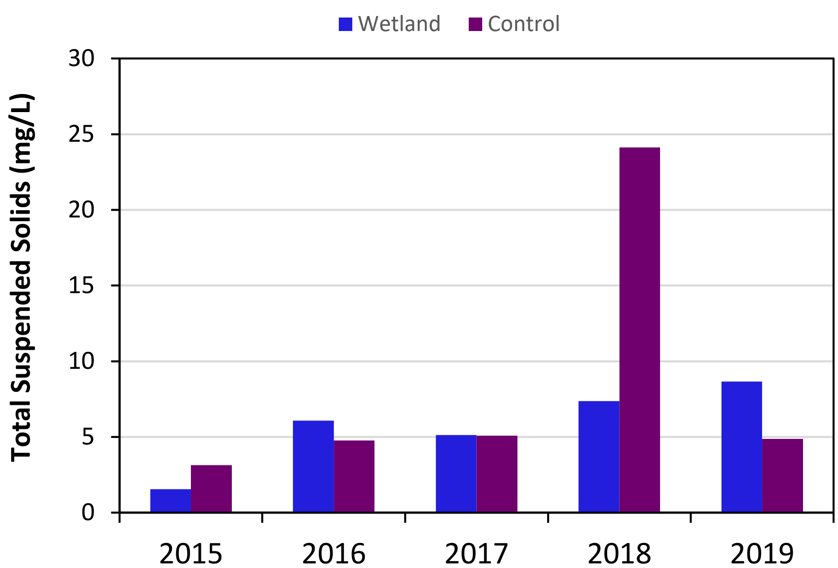


Figure 4-4. Fund for Lake Michigan Experimental Wetland Total Phosphorus and Total Suspended Solids Monitoring Results

The Pilot and project partners will continue to verify and maintain the wetlands installed in Silver Creek and monitor potential impacts to water quality. Continued observation will provide insight into watershed response time and serve as demonstration projects for other agricultural-based wetlands in the region. Unique aspects and lessons learned from the wetland projects included working with the regional Austin Straubel International Airport. Coordination with the airport, the Federal Aviation Administration, and Animal Plant Health Inspection Service ensured the wetland designs would not attract populations of nesting migratory waterfowl that could create potential hazards for aircraft in the area. Designs were completed using USFWS standards for wetland scrapes and altered so that water was held for 24 hours or less. An airport-certified biologist was engaged through the design, implementation, and monitoring process. Continued monitoring of the wetlands for migratory birds and other wildlife, funded through Ducks Unlimited and later the Oneida Nation, observed no adverse impact to airport operations. NEW Water and partners will evaluate future opportunities for wetland implementation as part of the Full-Scale Program and build on the lessons learned in Silver Creek. A consideration for the Full-Scale Program is to properly size wetlands according to their drainage areas and NRCS standards such that modeled reductions can be calculated and are applicable toward permit compliance goals. Future wetland sites considered within a 5-mile radius of the airport will build on the collaboration and experiences gained during the Pilot Project.

4.2.2 Vegetated Water Treatment Systems

The VWTS project was completed in partnership with UWGB, USFWS, and the Oneida Nation and had the following objectives:

- Evaluate spatial and temporal patterns of phosphorus sinks and biomass-based exports from warm-season grasslands.
- Evaluate the phosphorus content of existing grass-based BMPs and associated potential for phosphorus removal by grass harvesting at the watershed scale.
- Evaluate the effectiveness of the Sediment Basin with Warm-Season Grass Filter Strip BMP, a variation of the Nutrient and Sediment Control System.

The two-basin VWTS was designed to capture surface runoff and to promote infiltration and was established in summer 2017. It was installed downslope of a 160-acre agricultural field and was constructed by establishing a 2,000-foot berm parallel and adjacent to Silver Creek, with an additional 120-foot berm running perpendicular to Silver Creek to separate the two basins. The east basin is 2 acres, and the west basin is 3.5 acres; basin depth ranges from 0 to 2 feet. Figure 4-5 includes the design concept for the VWTS, which included removing a manure pit and installing WASCBs on the upslope agricultural field.

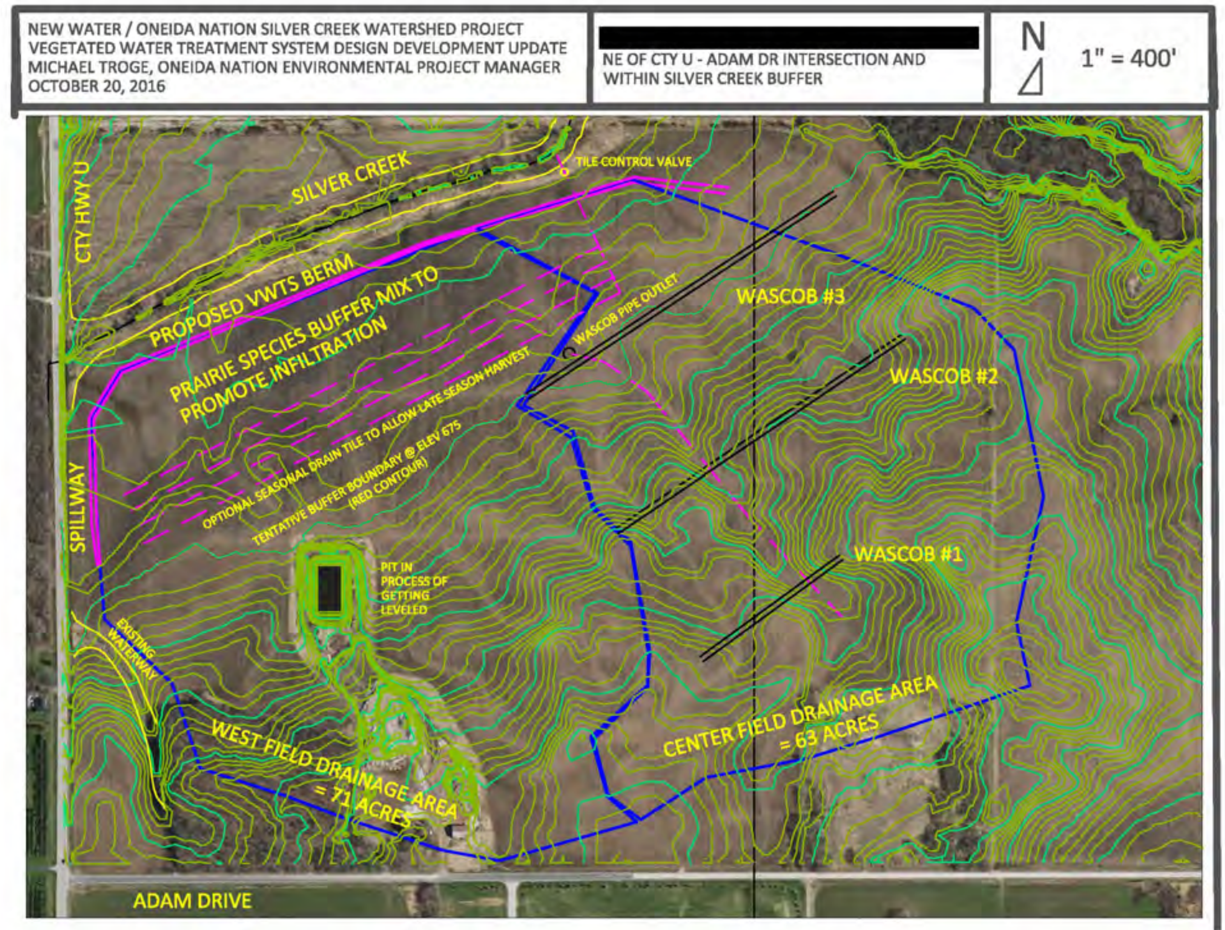


Figure 4-5 Design Concept for the VWTS Project

In November 2017, a native wetland species mixture was planted in the 4 acres directly adjacent to the 2,000-foot berm, and an additional 14.5-acre buffer was planted upslope with a native pollinator mix. The planting mixtures were designed with soil type, wildlife benefits, biomass production, and end-use constraints in mind (i.e., livestock toxicity). Figure 4-6 includes photos from construction and after vegetation was established.

Figure 4-6. Photos of the VWTS during Construction (top, view looking northeast) and After Vegetation Established (bottom, view looking southeast)

The VWTS project was part of a larger study completed by UWGB that included research on biomass plantings and managed grasslands in the Silver Creek watershed, some of which pre-dated the formal start of the Pilot Project. Results of the VWTS installation and the other components of the VWTS study completed by UWGB are summarized in a final report, included in Appendix O. Observations from the final report include:

- Warm-season grasses absorbed and held excess soil phosphorus, which could potentially be enhanced with frequent haying and removal.
- Areas with highly compacted, organic carbon-depleted, and phosphorus-enriched soils are likely to see the greatest improvements to overall soil health when converted to grasslands with annual harvest and removal. This approach may be a particularly effective short- and long-term option for managing excessive soil phosphorus within agricultural watersheds.
- There was no evidence that buffers accumulated phosphorus through time. There was also no correlation between buffer soil phosphorus content and buffer age.
- Buffers contributed to improved soil health with lower bulk densities and higher soil organic matter than neighboring fields. The older buffers appeared to indicate improved plant growth, which supports greater potential for harvesting phosphorus held in plant tissues. Although buffers were dominated by lower biomass cool-season grasses, aboveground biomass still held significant phosphorus.
- Although not commonly performed, annual harvesting of buffer biomass could significantly decrease soil phosphorus over time. Cool-season grasses may have the advantage of lower seed cost with more consistent establishment outcomes than native warm-season grasslands, although they are also likely to have lower biodiversity benefits.

The VWTS project provided the Pilot Project an opportunity to participate in ongoing research to test the uptake and storage of nutrients using native plantings in heavily impacted soils that are commonly found on agricultural land in the region. Working with these project partners strengthened relationships and developed a greater understanding of installing and maintaining VWTS to maximize potential benefits. Information gained through this research regarding siting and designing a VWTS project will be used to evaluate potential sites in the Full-Scale Program.

4.2.3 Grazing

The Oneida Nation and UWGB completed a 5-year Managed Grazing Project as part of the EPA GLRI Silver Creek grant. The Oneida Nation converted 97 agricultural acres to grazing acres, part of which included a study by UWGB. Figure 4-7 shows the grazing fields and the monitoring stations, facing west and upslope. The UWGB study involved monitoring, analyzing, and modeling runoff from a grazed field compared to a field of (conventional) corn row crops. Grazing allowed livestock to be rotated among designated fields to seasonally consume grasses and passively apply their manure in open fields. This is in contrast to the current practice of livestock confined in loafing barns requiring external, mostly liquid manure application to agricultural fields.

Figure 4-7. Grazing Fields and Monitoring Stations

While one of the paired fields was being grazed, the other field was planted in conventional corn row crops. Corn fields are routinely plowed after harvest, and the exposed soil is vulnerable to runoff and erosion. Figure 4-8 is output from a U.S. Department of Agriculture APEX model showing the general outlines of the two catchment basins.

Figure 4-8. APEX Model for Two Catchment Basins on the Grazing Project

In advance of fieldwork startup, NEW Water executed with UWGB a Memorandum of Agreement with Scope of Services and Budget, as well as an EPA-approved Quality Assurance Project Plan. The goals identified in the GLRI Work Plan were to reduce sediment (over 95%) and associated phosphorous (over 80%) on approximately 50 currently tilled acres by transitioning those acres to a continuous cover agriculture system (managed intensive grazing). Initially, the work plan identified 57 acres to be converted to grazing but was expanded to 97 acres, resulting in enhanced protection of approximately one mile of the Silver Creek riparian corridor. Other funding for the grazing project came from NRCS EQIP to install fencing, water lines, and a concrete pad for cattle to be kept on during winter and wet weather. A CSA (see description in Section 3.3) was signed between NEW Water and the Oneida Nation to install and maintain this grazing BMP in perpetuity.

The two catchments were located directly adjacent to each other (named South and North site) and were contained within a single agricultural field where corn was planted and then harvested as silage during the fall seasons of 2017-2018. The control part of the project began in June 2016 with the installation of two fully operational paired edge-of-field monitoring stations, accessed remotely via cell phone towers and modems. The monitoring stations were configured to collect continuous discharge and turbidity data as well as automated event samples from their respective catchments.

A No-Cost Time Extension was requested of EPA in August 2018 to provide more time to gather data and study the runoff comparison of the paired fields. A number of issues contributed to the need for an extension request. Delays early in the project resulted in less sampling data during critical spring runoff events. In addition, the dominant soil type in the catchment is Hortonville, which is more permeable than other dominant soils in the LFR basin (e.g., Kewaunee) and resulted in less measurable runoff events. Rainfall events in September and October 2018 delayed the intended transition of the catchments to grazing, as the soil was too wet to till and plant the grazing mixture following corn harvest.

In 2019, a transition in grazing operators from the previous non-Oneida lessee to the owner, the Oneida Nation, and fall rainfall events again prevented comparison of monitoring data between the grazing and control plots.

Conventional tillage, via a rotary tiller, was conducted in spring 2020 in the control plot (north catchment). Corn was planted to maintain comparable conditions to the previous farm operation. The grazed area was reseeded with pasture mix in the treatment plot in spring 2020: mostly no-till, but part of the grazing plot required tilling to remove ruts. Electric fencing was added to the control plot catchment shortly before grazing resumed in summer 2020. The Oneida Nation continued the non-treatment north plot in conventional farming by harvesting the corn crop and chisel-plowing the field by mid-November 2020. Another extension was requested and granted by EPA through September 2021 to allow time to obtain additional water quality data during the treatment phase of the study.

Cumulative rainfall in 2020 was higher than the long-term average, but fewer fall rainfall events and less cumulative precipitation was observed than in 2018 and 2019 (see Section 4.3, Figure 4-10), and no viable runoff events were able to be measured. A runoff event occurred in October 2020; however, it was just below the threshold for collecting viable water samples with the automated sampler. The Oneida Nation continued to keep the non-treatment north plot in conventional farming by harvesting the corn crop, and by mid-November the field was chisel-plowed. In December 2020, the remaining vegetation was removed by hand in the area above the outlet flumes that was "enclosed" by the berms, but the control plot was not plowed.

In 2021, both catchment basins were functioning as intended for the treatment phase of the study (i.e., ruts removed, control plot in conventional corn crop). Corn was planted in spring 2021 in the control plot for comparison between the control and grazed plots. By March 2021,18 paired runoff events had been recorded for the calibration/control period. Data from the grazing study will continue to be monitored and analyzed by project partners.

4.3 Water Quality

Water quality monitoring was completed through a joint partnership with NEW Water, UWGB, and USGS, with data and trend analyses led by NEW Water staff. Comparing the water quality data to changes in land use, farming practices, and implementation of BMPs was completed by the Project Team to determine if cause-and-effect relationships could be observed.

4.3.1 Hydrology

Silver Creek is a small and relatively flashy stream that drains an area of 5.01 square miles. The USGS gauge at Florist Drive has over 7 years of continuous flow records. Peak daily streamflow recorded at the Florist Drive gauge ranges from 40 to 266 cubic feet per second (cfs), and the peaks typically occur in April or May, except in December 2015 (Table 4-6, Figure 4-9). Daily mean streamflow at Florist Drive ranged from 2.38 to 9.79 cfs and is highly dependent on the amount, timing, and intensity of precipitation as rainfall. Monthly mean discharge peaked in spring and fall each year, typically before crop planting and after harvest, respectively.

Table 4-6. Florist Drive Flow

Calendar Year	Annual Rainfall (inches)	Daily Mean Flow (cfs)	Peak Daily Flow (cfs)	Month of Peak Flow
2014	32.12	3.69	47	April
2015	32.89	2.76	266	December
2016	33.11	3.57	101	March
2017	31.95	2.38	40	May
2018	39.21	4.98	101	April
2019	48.63	9.79	228	March
2020	34.01	4.66	130	May

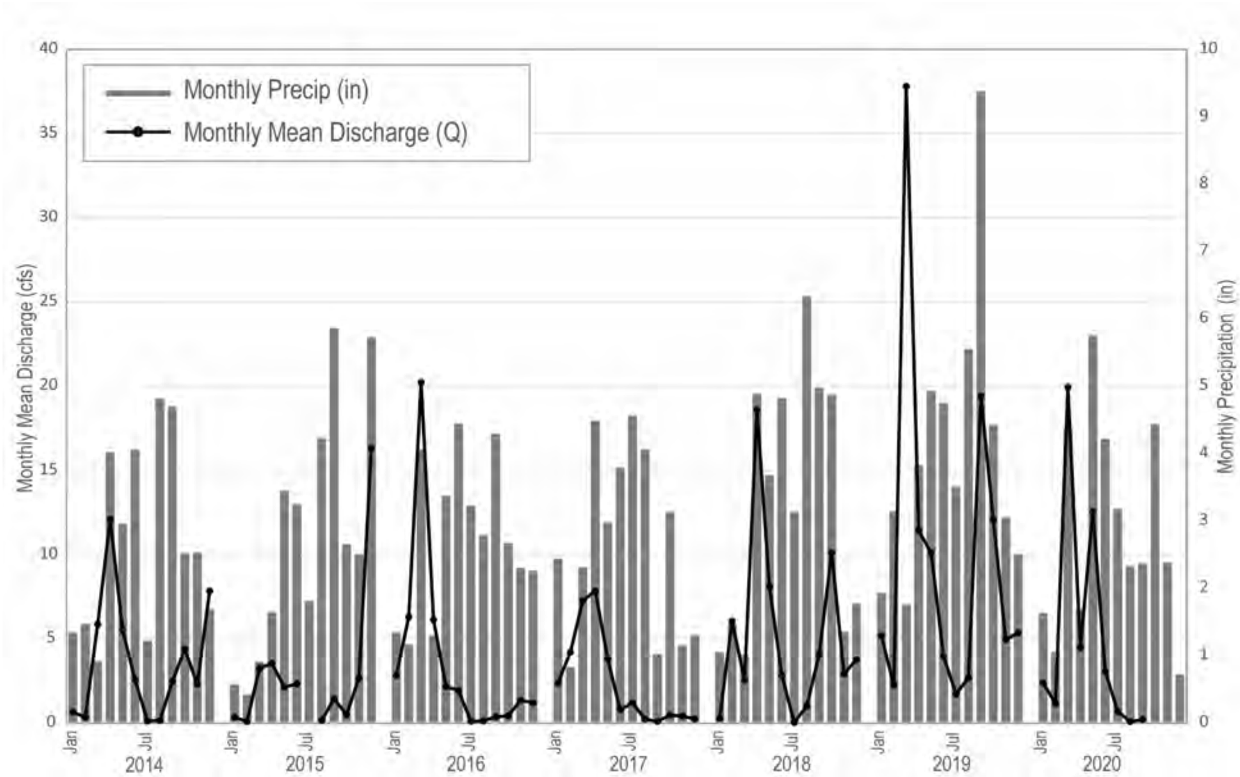


Figure 4-9. Monthly Precipitation and Discharge Data for Florist Drive USGS Gauge

Water quality trends in Silver Creek are influenced by the amount, timing, and intensity of rainfall. Precipitation is not directly measured at the Florist Drive location, so precipitation recorded 2.5 miles east of Silver Creek at Green Bay's Austin Straubel International Airport was used for analysis. The long-term average of annual precipitation for Green Bay is approximately 30 inches of rainfall (Figure 4-10). During the first 4 years of the Silver Creek Pilot Project from 2014-2017, annual precipitation was near the long-term average. However, in 2018, large individual storm events resulted in more than a 9-inch annual precipitation increase over the long-term average (26% increase). Larger and more intense individual storm events coupled with continuous precipitation continued, and 2019 was the wettest year on record in the Green Bay area with almost 14 inches of annual precipitation above the long-term average (47% increase). 2020 had less rainfall than 2018 and 2019 but was still 4 inches above the long-term average. Historic rainfall years in 2018 and 2019 show the need to implement BMPs that increase soil infiltration and water-holding capacity and slow the release of water from the landscape to the stream channel network.

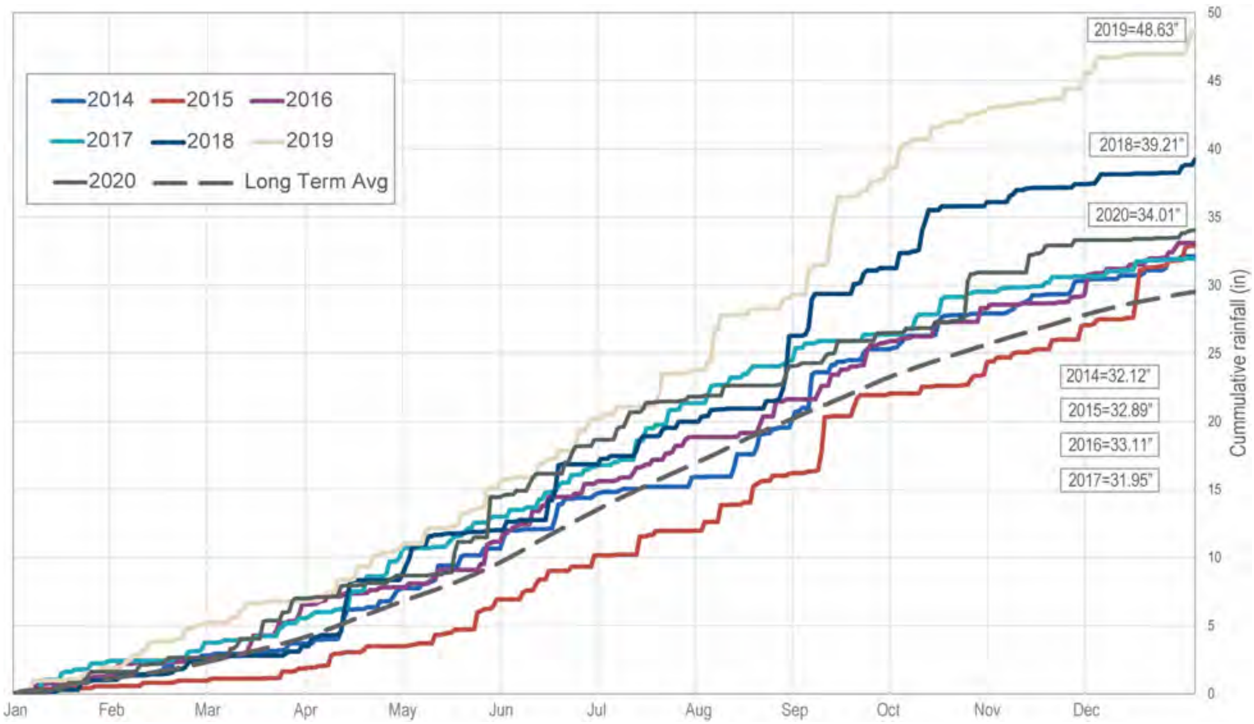


Figure 4-10. Cumulative Rainfall at the Austin Straubel International Airport

4.3.2 Phosphorus Concentration

Total phosphorus concentration from May through October varied by time and location throughout the Silver Creek watershed. Total phosphorous concentrations were also frequently elevated above the TMDL-identified tributary growing season water quality standard of 0.075 mg/L at all monitoring locations (Figure 4-11). Sites furthest upstream in the watershed (SL-CKR) and precipitation-driven events at SL-FLD had the highest concentrations of total phosphorus and the most variability over time. Total phosphorus increased at some sites (SL-COU, SL-FLD grab, and SL-172), likely attributed to heavy rainfall in 2018 and 2019. However, total phosphorus concentrations at both SL-CKR and event samples at SL-FLD have decreased over time, which is promising considering heavy rainfall in 2018 and 2019. In-stream phosphorus concentrations at SL-CKR were over an order of magnitude greater than the water quality standard of 0.075 mg/L set forth for total phosphorus. Significant reductions of in-stream phosphorus concentrations were observed at SL-CKR after widespread BMP implementation began in 2016. By 2019, even with 2019 being the wettest year on record and thus expected to drive higher phosphorus release and transport, the in-stream phosphorus content was more than 50% less than 2015. While only two grab samples were collected at SL-CKR in 2020 between May and October, future sampling efforts will help evaluate the water quality at this site.

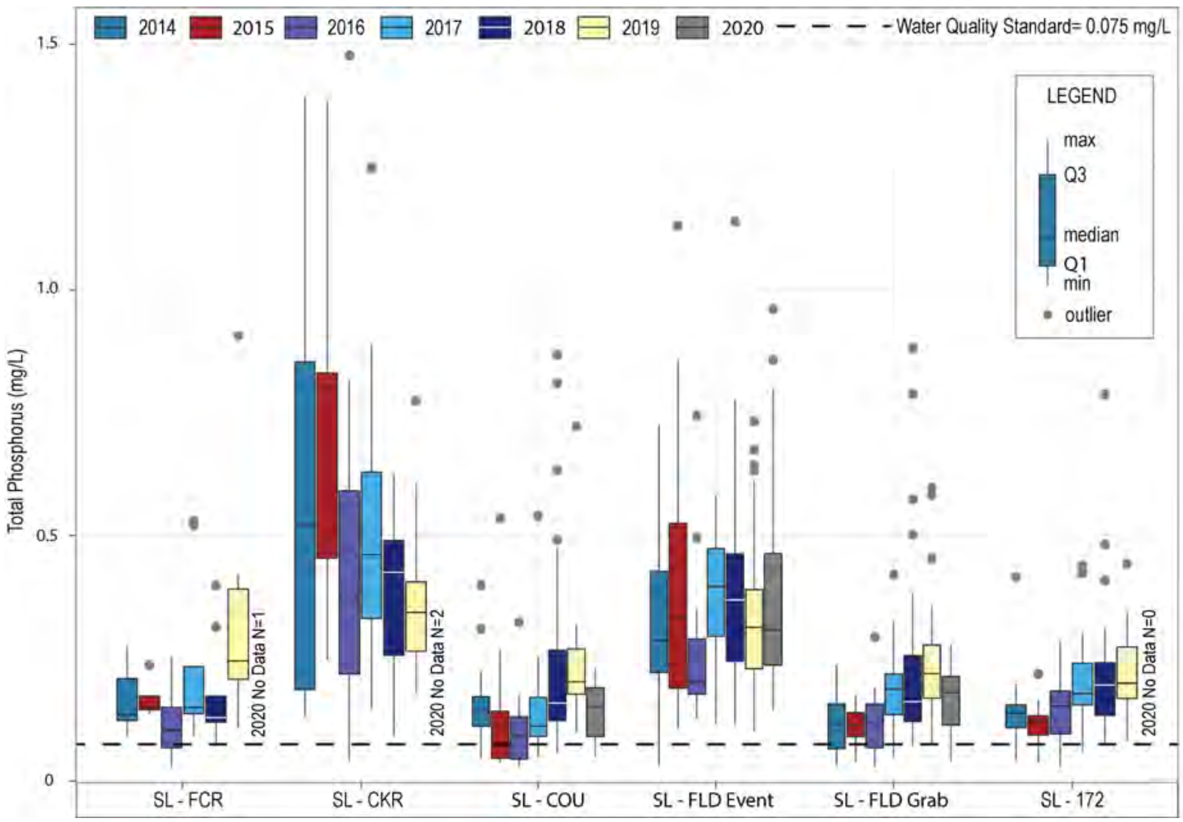


Figure 4-11. Total Phosphorus Concentration Monitoring Results from May through October 2014 – 2020

In-stream phosphorus concentrations varied at SL-FLD, depending in-part on the creek flow condition. Total phosphorus concentrations for both grab (independent of flow) and event samples at SL-FLD were elevated above the total phosphorus water quality standard. Total phosphorus concentrations during event samples at SL-FLD were higher than grab samples at the same site. A decrease in the median total phosphorus in event samples was observed from 2017 to 2020. The results for event flow phosphorus concentrations are promising, but more time is needed to fully understand water quality response to BMP implementation at SL-FLD during varying flow regimes.

Figure 4-12 shows the USGS Florist Drive phosphorus flow-weighted concentration as smaller orange bars above the columns depicting grab sample concentrations for each respective year. Flow-weighted concentrations were only calculated at SL-FLD due to the USGS gauge at this location. The flow-weighted concentrations are shown as median daily concentrations from May through October (n=183 days) and normalized to different flow regimes. Some flow-weighted phosphorus concentrations at SL-FLD showed both underestimating and overestimating when compared to normal grab sample concentrations that were not weighted by flow; however, most over- or under-estimation was within the standard error for each respective grab sample not weighted by flow.

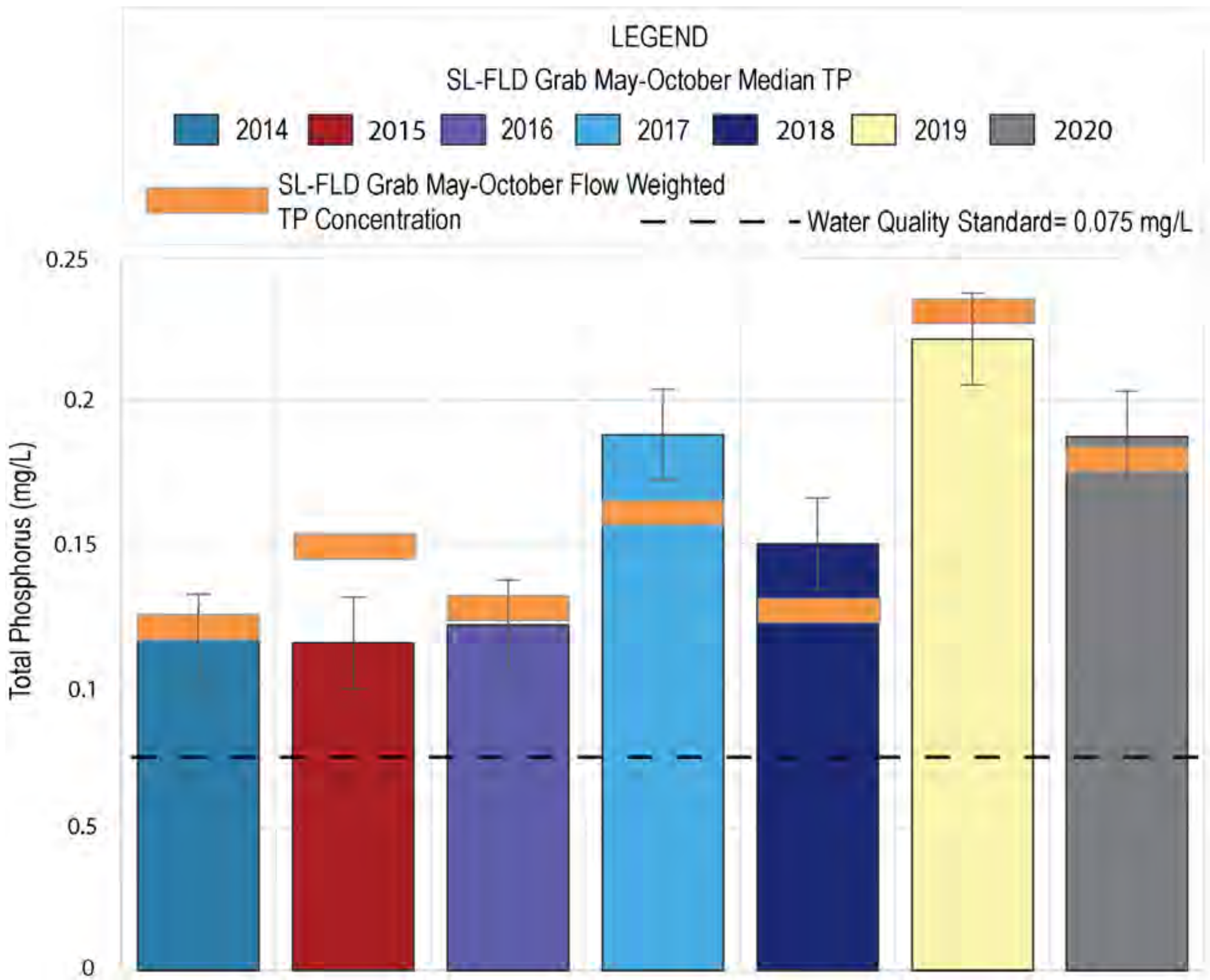


Figure 4-12. Flow-Weighted Phosphorus Concentration at Florist Drive

While it is important to examine water quality results at the watershed scale, it can be difficult to discern water quality improvements resulting from BMP implementation due to variables at the watershed scale and the short timeframe from post-BMP implementation (less than 5 years). Peer-reviewed literature shows that once BMPs are implemented, there is often a lag time of 5-10 years to observe water quality improvements.[6] However, the water quality response of SL-CKR, a site in the upper reaches of the Silver Creek watershed with a small contributing drainage area, demonstrated that benefits were becoming evident (Figure 4-13). Overall, more time is needed to monitor and analyze changes in water quality in the Silver Creek watershed.

[6] Meals, D. W., S. A. Dressing, and T. E. Davenport. 2010. "Lag Time in Water Quality Response to Best Management Practices: A Review." *Journal of Environmental Quality*. 39: 85-96. https://doi.org/10.2134/jeq2009.0108.

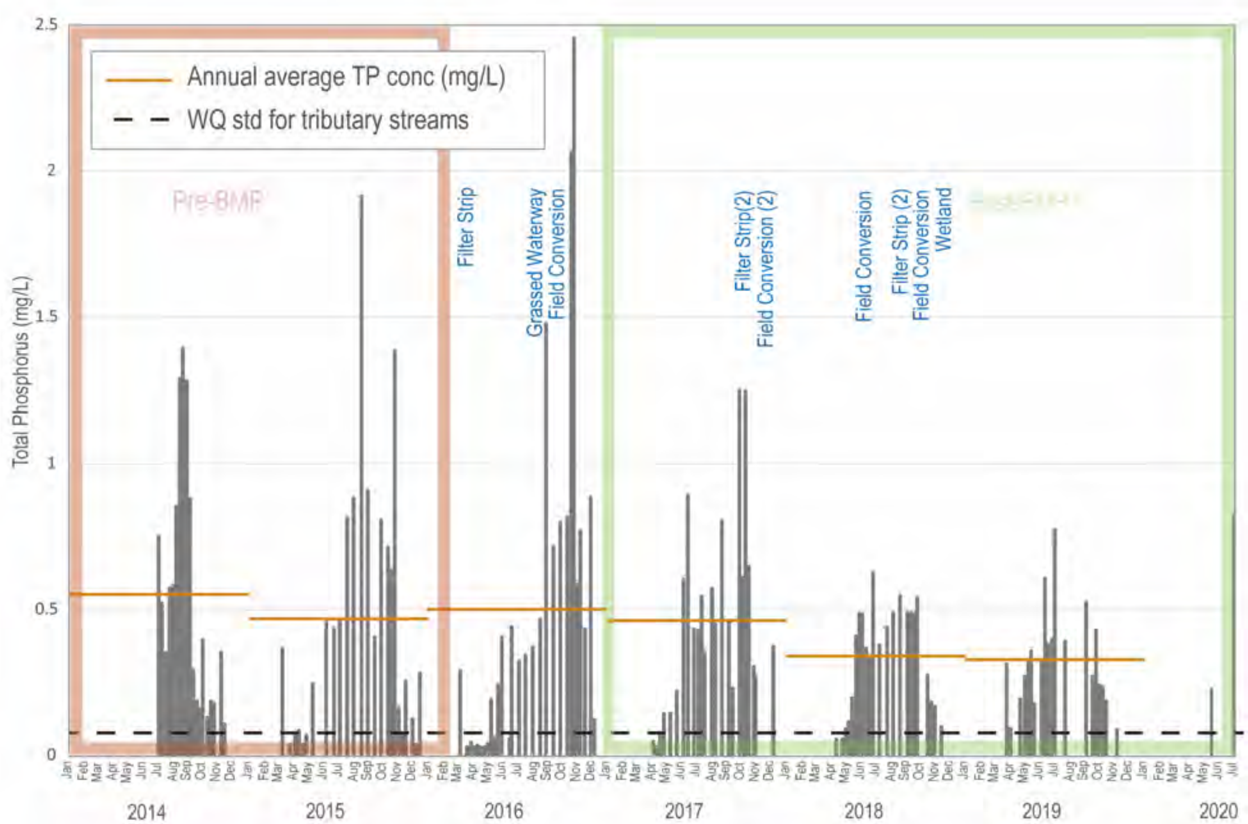


Figure 4-13. Total Phosphorus Monitoring Results at Crook Road Pre- and Post-BMP Implementation

Capturing changes in water quality at SL-FLD in a short period of time was difficult because of the large contributing drainage area and things that were out of the Pilot Project's control, such as subdivision development. Because changes in water quality were observed at SL-CKR, more detailed analyses were completed for these data. SL-CKR has a contributing drainage area of approximately 1.77 square miles (1,133 acres), or approximately 95% less drainage area, than at SL-FLD. Individual BMPs implemented upstream of SL-CKR included filter strips, grassed waterways, a field conversion, cover crops, reduced tillage, and a wetland complex. The timing of implementation is depicted in blue vertical text on Figure 4-13. In-stream phosphorus concentrations at SL-CKR have been decreasing since widespread BMP implementation began in 2016. It is likely that the implementation of these BMPs resulted in phosphorus concentration reductions; however, data to directly evaluate this cause-effect relationship was not obtained as part of the Pilot Project. The high phosphorus concentration peaks before BMP implementation were not observed in the post-BMP implementation years of 2017 through 2020, which likely decreased the annual average phosphorus concentrations shown in the orange horizontal lines on Figure 4-13. Only two grab samples were collected at this site in 2020 due to the pandemic and the resumption of what is considered normal flow conditions. SL-CKR will be considered as a continued location for water quality monitoring after the conclusion of the Pilot Project to observe additional changes in water quality and watershed response to implemented BMPs in the headwaters of the Silver Creek watershed.

4.3.3 TSS Concentration

TSS concentrations throughout Silver Creek varied over space and time during the Pilot Project. It was difficult to fully discern TSS trends throughout the Silver Creek watershed because sample collection in 2020 was minimal due to the pandemic combined with lower-than-normal flows; therefore, the sites

SL-FCR, SL-CKR, and SL-172 did not have any TSS data in 2020 (Figure 4-14). Unlike phosphorus, TSS concentrations in the upper reaches of the watershed did not show much variation from year to year and were low compared to the water quality recommendation for TSS. There is no approved in-stream seasonal water quality standard for TSS, and instead a recommendation at the mouth of the Fox River of 18 mg/L is used to compare water quality. Most sites throughout Silver Creek showed TSS concentrations below the recommendation of 18 mg/L, except for event samples collected by the USGS gauge at SL-FLD. As stream velocity increased during precipitation-driven event flow, stream power increased, which caused more sediment to be remobilized throughout the system as either suspended or bedload depending on particle size of the bed, banks, and floodplain. TSS concentrations were expected to be high with the amount of precipitation observed in 2019, but the highest TSS concentrations were in 2020 at Silver Creek SL-COU and SL-FLD, both in event samples collected by the USGS gauge and grab samples collected independent of flow. Spikes in 2020 TSS data in SL-COU and SL-FLD event and grab samples may have been due to inorganic sediment, organic plant material, detritus, animal waste, or other contributions to TSS. Organic matter may have contributed to more TSS during lower-flow periods observed in 2020 compared to previous years. In order to differentiate the organic and inorganic portion of a TSS sample, volatile suspended sediment analysis would also have to be analyzed in conjunction with TSS. Samples were not analyzed for volatile suspended sediment, so it was not possible to discern if organic matter accounted for observed spikes in TSS.

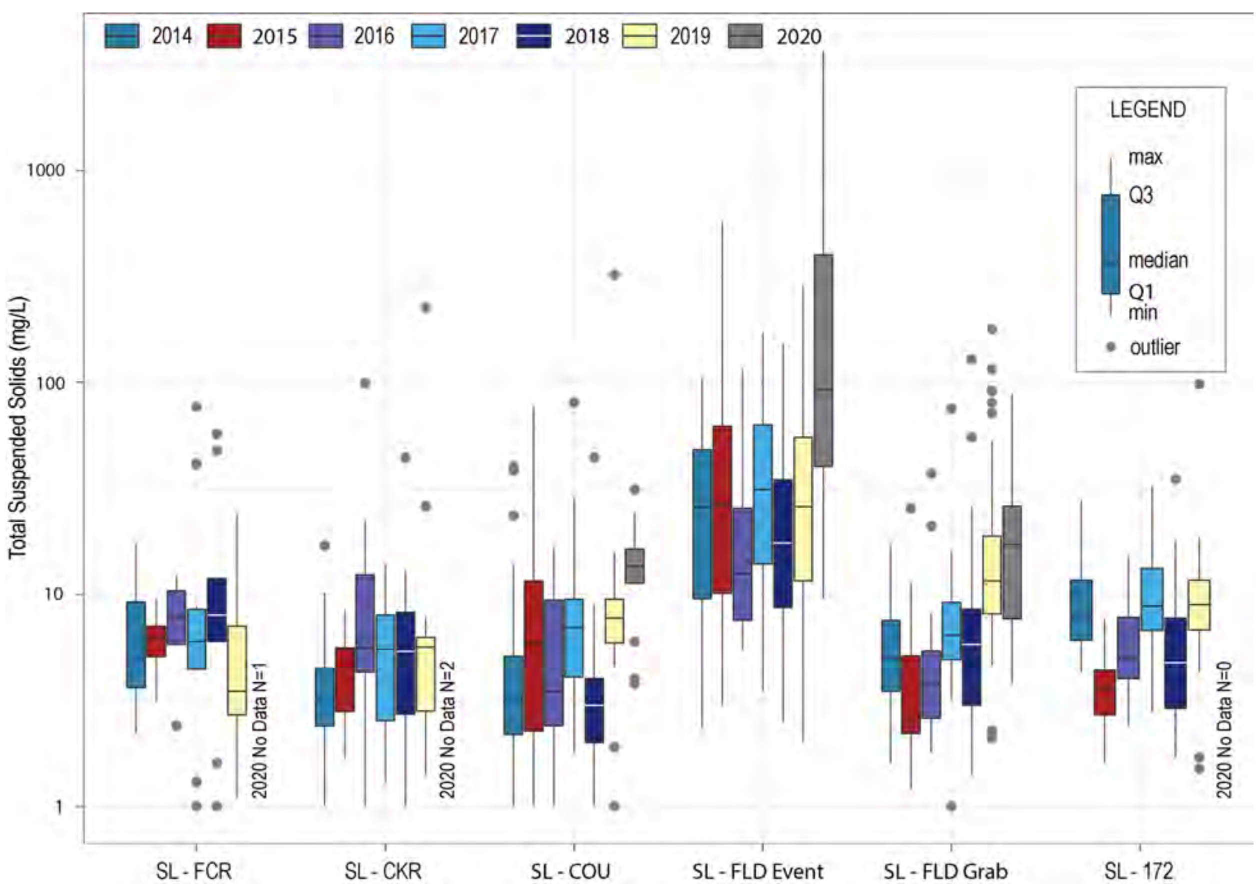


Figure 4-14. TSS Concentration Monitoring Results from May through October 2014 – 2020

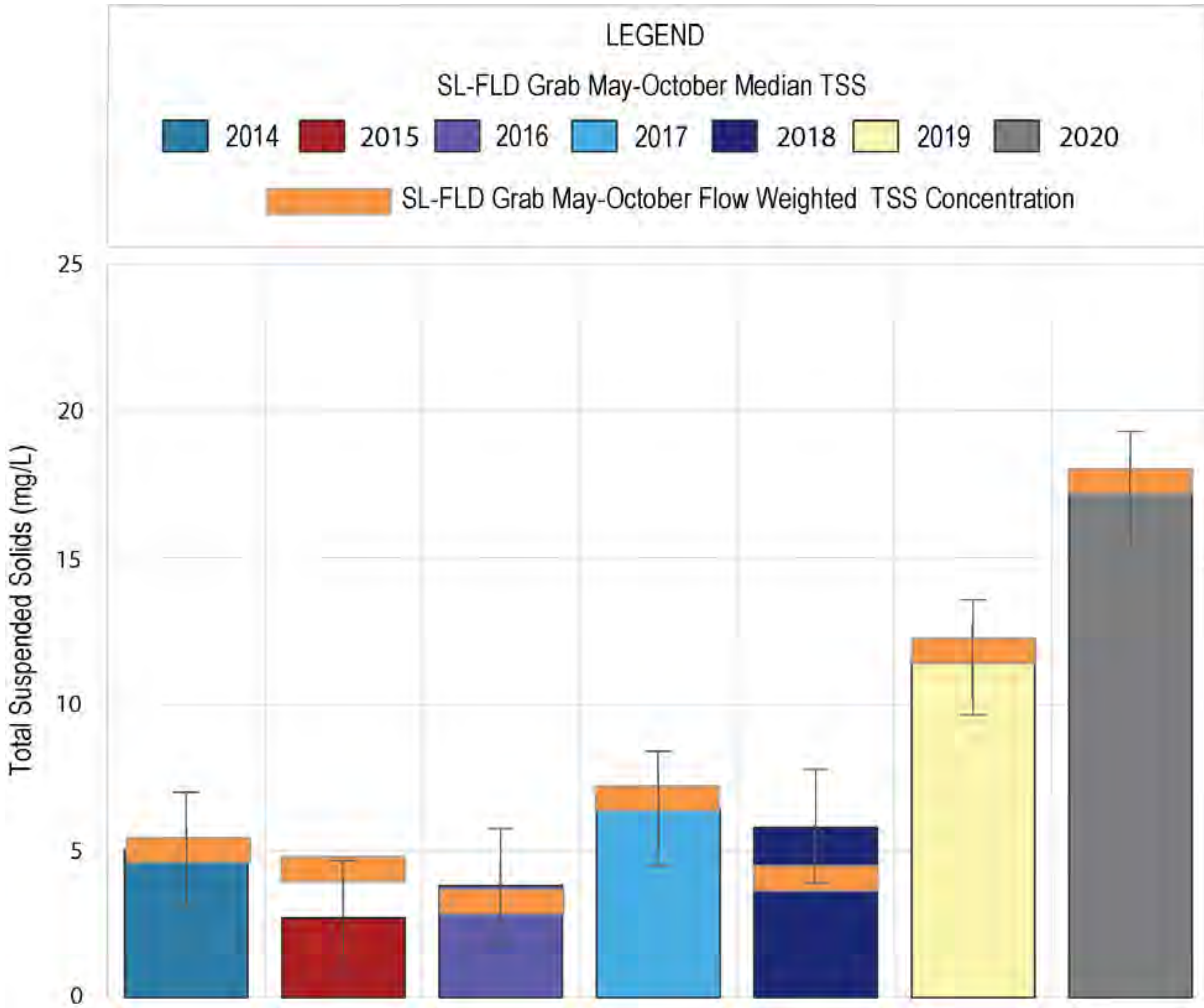


Figure 4-15. Flow-Weighted TSS Concentration at Florist Drive

4.3.4 Phosphorus Loads

Phosphorus loads were calculated by USGS using in-stream concentrations and flow to better understand overall watershed hydrology and water quality. Phosphorus loads are highly dependent on and correlate directly to the amount, timing, and intensity of precipitation. Phosphorus loading separation, or the amount of annual load that is considered base flow load versus the amount of annual load that is considered event flow load, showed annual phosphorus loads are dominated by event flow loads in Silver Creek (Figure 4-16). Precipitation-driven event flow makes up over 86% of annual phosphorus loads at Silver Creek at Florist Drive. A small number of events each year account for most of the annual phosphorus load exported through Silver Creek.

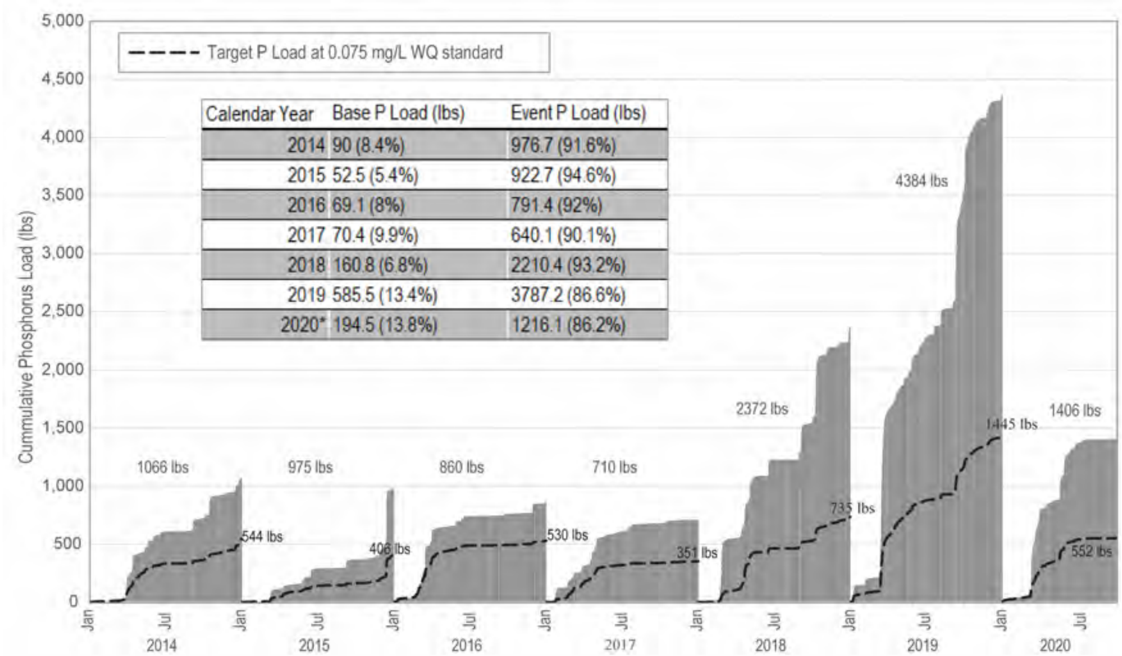


Figure 4-16. Phosphorus Loads at Florist Drive

Phosphorus loads at site SL-FLD ranged from approximately 700 to 1,000 pounds of annual phosphorus export in what are considered normal hydrologic years (2014-2017, 2020). Phosphorus loads during increased precipitation (2018 and 2019) ranged from 2,300 to 4,400 pounds per year. Regardless of the amount of rainfall, phosphorus loads in Silver Creek were often two to three times more than the target phosphorus load at the given water quality standard of 0.075 mg/L. The timing of phosphorus loading was driven by precipitation and vulnerability of the land, indicating it is important to have some form of annual cover to keep nutrient-rich land in place and minimize large individual loading events. Landscape vulnerability and large loading events usually occur in spring before or shortly after crops have been planted and in the fall after crop harvest. For example, in March 2019, the Green Bay area received an inch of rain over the course of one week, in addition to regular spring snowmelt. That event accounted for almost 900 pounds of phosphorus exported, more than 20% of the total annual load.

Fully established BMPs help keep cover on the ground, increase water-holding capacity and infiltration, slow the release of water, and sequester nutrients. The collective implementation of BMPs in Silver Creek will eventually lead to a more resilient landscape that can better and more efficiently handle larger precipitation events like those witnessed in 2018 and 2019. It is unknown how much more phosphorus and sediment would have been released during times of increased flow if BMP implementation was not widespread. Daily phosphorus loads both pre- and post-BMP implementation were further characterized by hydrologic condition (Figure 4-17). Flow duration interval, or the percent of time flow is exceeded, served as a general indicator of hydrologic condition. Post- BMP implementation (2019 and 2020) phosphorus loads were elevated above pre- implementation (2014 and 2015) phosphorus loads in every hydrologic condition (Figure 4-17). As expected, both pre- and post-implementation phosphorus loads decreased with flow, except for a slight increase in dry conditions or flow duration interval above 90%. The increase between pre- and post-implementation phosphorus loads in all hydrologic conditions is another example of how increased precipitation and flow skewed the data in the post-implementation years of 2019 and 2020. Results in high flow periods or flow duration intervals less than 10% are promising. Post-implementation phosphorus loads are elevated above pre-implementation loads. However, pre-implementation loads in high flows ranged from 1.59 to 359 pounds per day (lbs/day), with a median of 9.57 lbs/day. Post-implementation phosphorus load in that same high flow ranged from

7.21 to 268.5 lbs/day, with a median of 36 lbs/day. In summary, while the median post-implementation phosphorus load was higher than the pre-implementation loads in the same flow condition, the range and peak in post-implementation loads were lower despite higher flows. This further supports the hypothesis that implemented BMPs need time to fully establish, and more time is needed to observe water quality improvements.

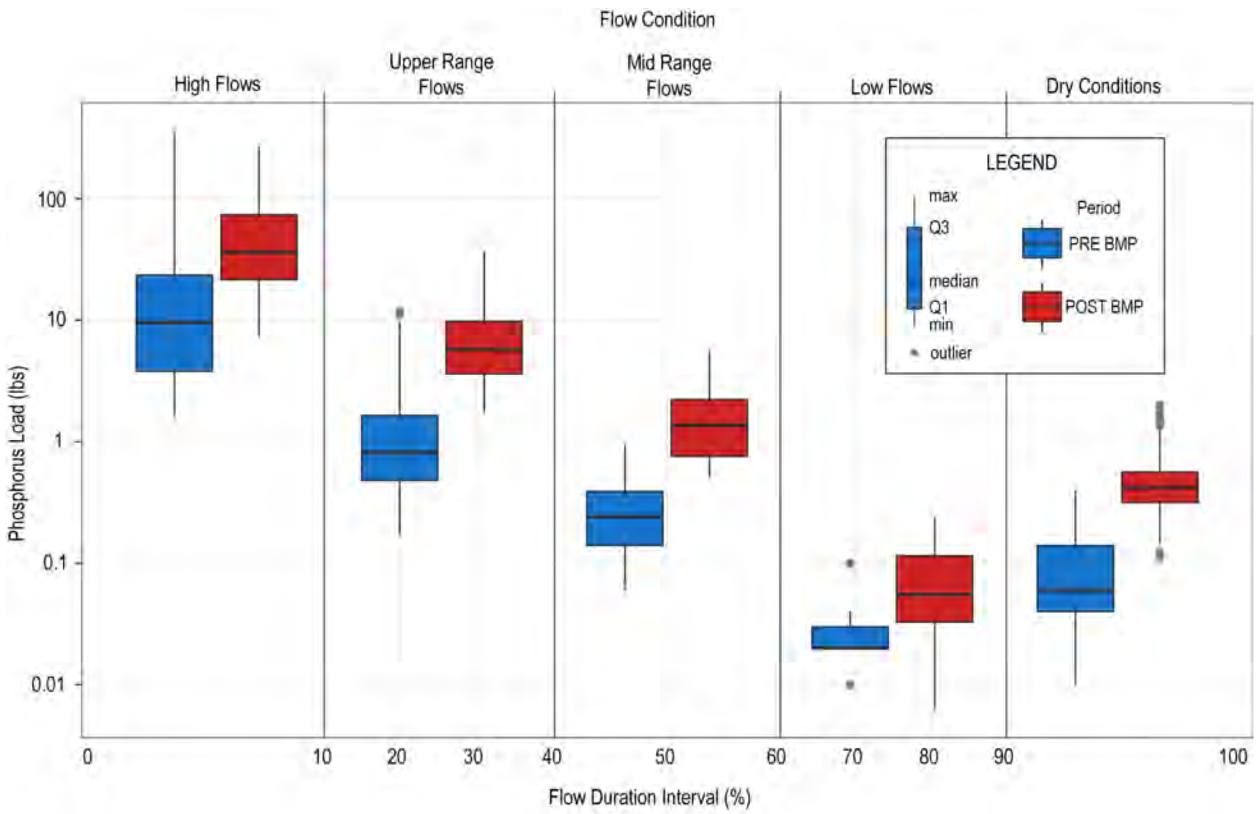


Figure 4-17. Phosphorus Loads by Hydrologic Condition
Note: 2014 and 2015 were considered "Pre-BMP" data, and 2019 and 2020 were considered "Post-BMP" data for this figure.

4.3.5 Total Suspended Solid Loads

TSS loads in Silver Creek ranged from 33 to over 150 tons per year between 2014 and 2020 (Figure 4-18). Precipitation-driven event flow makes up over 90% of the annual TSS load at SL-FLD. Unlike phosphorus, TSS has no approved in-stream water quality standard for tributary streams, but the value at the mouth of the Fox River of 18 mg/L TSS was used as a recommendation. Even given historic rainfall in 2018 and 2019, most TSS loads per year in Silver Creek were below the given annual load based on the criterion of 18 mg/L, except for 2015 and 2020. Annual TSS loads for 2015 were below the recommended load for most of the year until over 5 inches of rainfall fell during the second half of December, and flooding was observed throughout Silver Creek This event was representative of conditions prior to the implementation of BMPs where the landscape is vulnerable to precipitation and runoff. In 2020, TSS loading was observed well above the recommended load. While 2020 annual rainfall was considered closer to a normal hydrologic year, it was still more than 4 inches of annual rainfall above normal conditions and followed the two wettest years on record. In addition, organic material in low flows may have affected TSS loads.

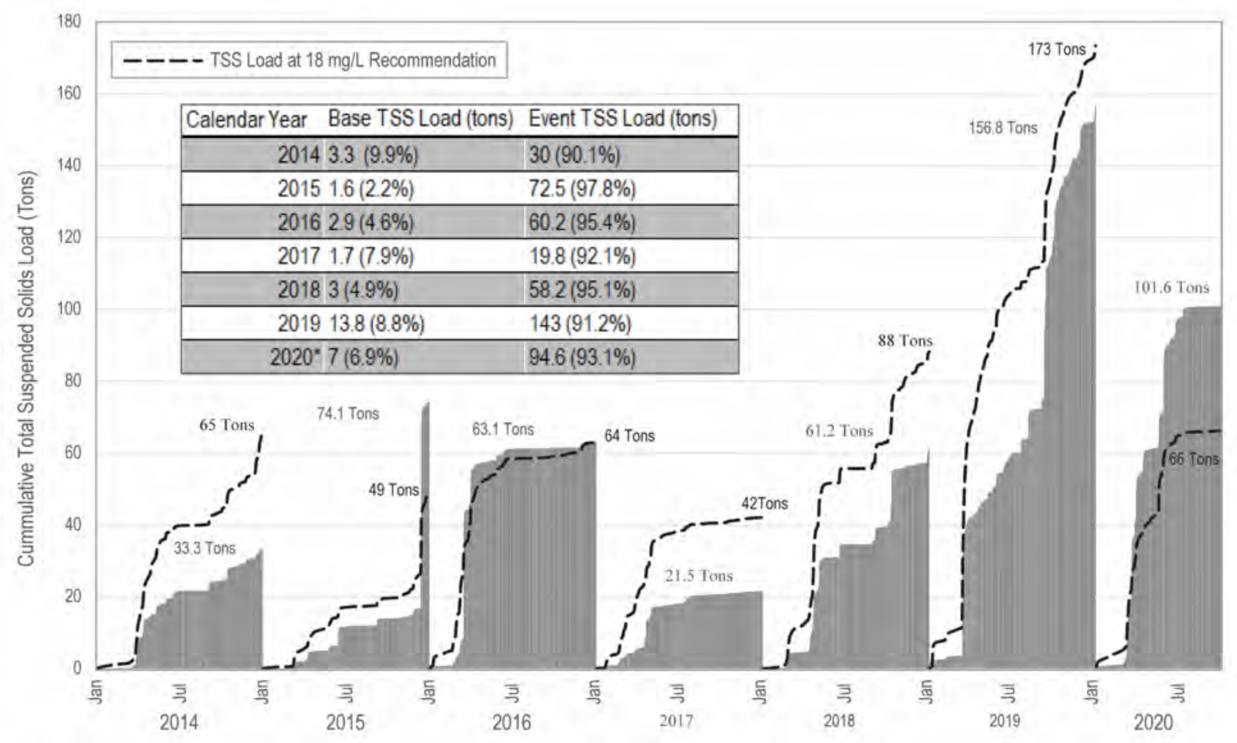


Figure 4-18. TSS Loads at Florist Drive

4.3.6 Land-Use Analysis

Water quality data were also analyzed in the context of land-use data from NMPs to see if there was a relationship between changes in land use and resulting water quality. Edge-of-field water quality samples were not collected; fields were grouped based on the approximate drainage area upstream of each water quality sampling location (Figure 4-19). The groupings of fields were analyzed as an additive group moving downstream for each sampling site. For example, SL-CKR considered all purple and red fields as the upstream drainage area.

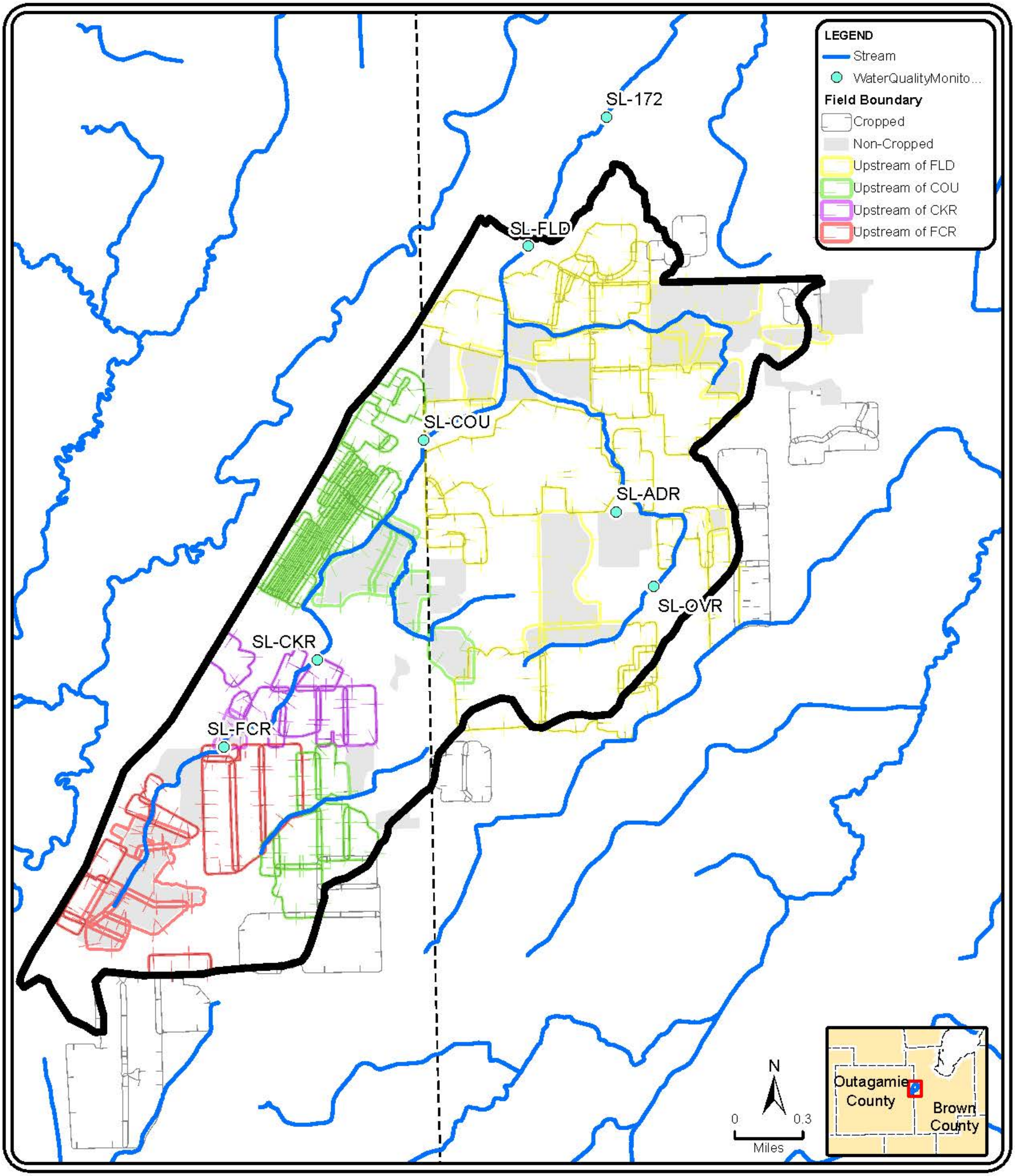


Figure 4-19. Water Quality Sampling Locations and Upstream Agricultural Fields

SL-CKR showed reduced variability in phosphorus concentrations, particularly high phosphorus concentrations observed in the second half of the growing seasons of 2014–2016. Figure 4-20 shows the phosphorus water quality results, the structural practice implementation timeline, and operational practice and land-use data for the fields upstream of Crook Road. Large rain events in 2018 and 2019 did not appear to have a corresponding increase in phosphorus concentration, potentially due to the increase of acres in alfalfa, non-cropped, and acres with an operational practice. In 2019, fields started coming out of the alfalfa rotation, and there was an increase in corn, similar to the composition of fields in 2014. However, in 2019, there were more acres in cover crop, which may have helped reduce nutrient runoff. There were not complete data on nutrient and manure application on these fields; however, C&ENMPs were completed for several fields and may have improved management over the course of the Pilot Project. Additionally, the installation of a large, grassed waterway network that spanned multiple fields upstream of SL-CKR may have contributed to improved phosphorus water quality results.

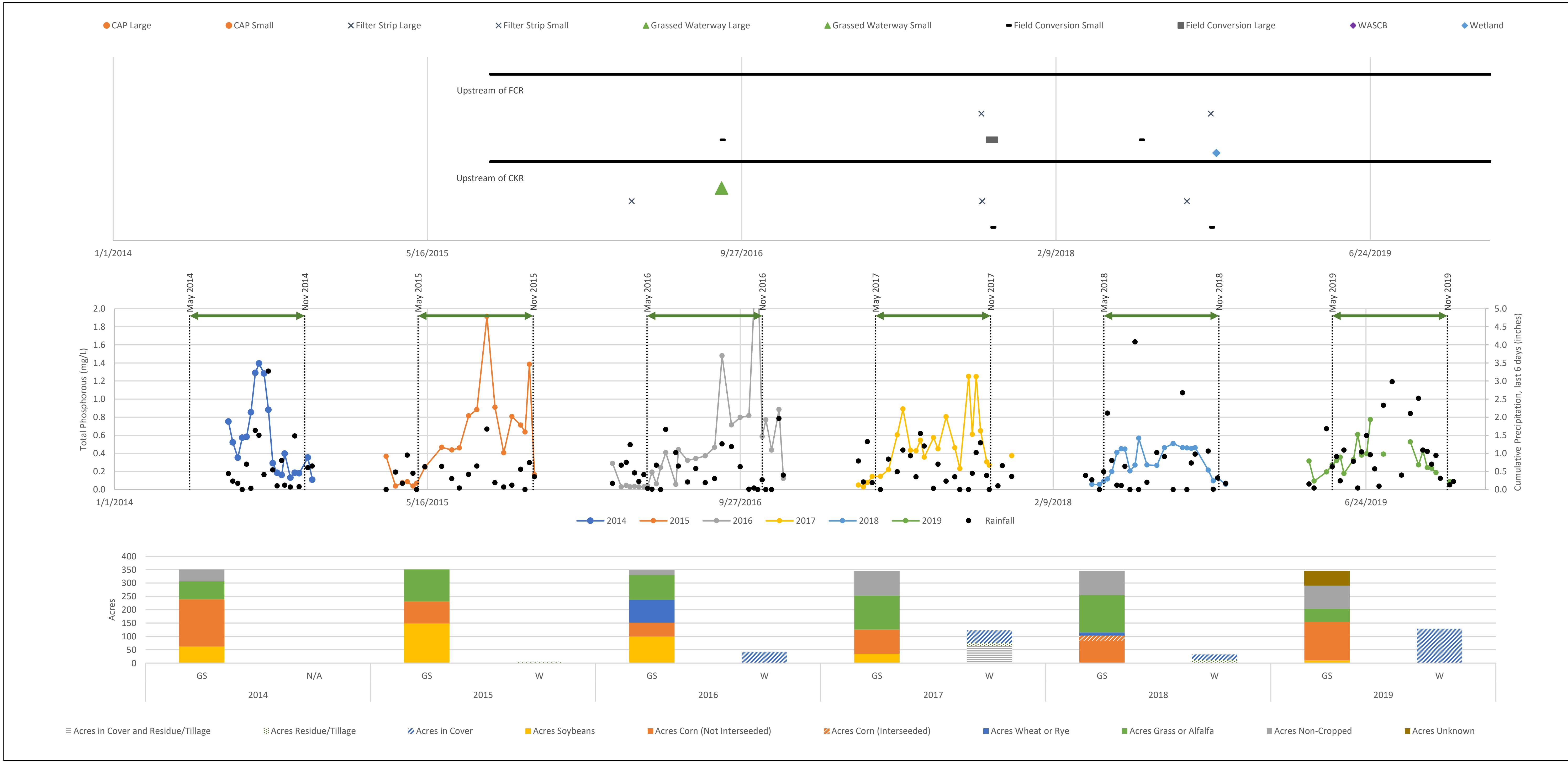


Figure 4-20. Phosphorus Water Quality Data and Land Use for Fields Upstream of SL-CKR

SL-FLD was sampled through 2020, but nutrient management planning data through the Pilot Project in 2020 was not available. Water quality results for 2020 are shown in Figure 4-21, with the assumption that the land-use composition was likely similar to previous years, with many fields in alfalfa or non-cropped and a mix of corn, soybeans, and wheat for the cropped acres. Land-use trends at Florist Drive were similar to Crook Road; many fields entered an alfalfa rotation that continued through 2019, and cropped acres started receiving cover crops and other operational practices in 2015. Operational practices were installed in the fall of a given year but also provided benefits during spring runoff events in the following calendar year. 2018 had a smaller number of operational practices installed, and the following spring and early growing season had elevated concentrations of phosphorus compared to previous years. Early 2020 exhibited a similar trend, even with the large number of acres in alfalfa, non-cropped, or those that had cover crops installed the previous fall.

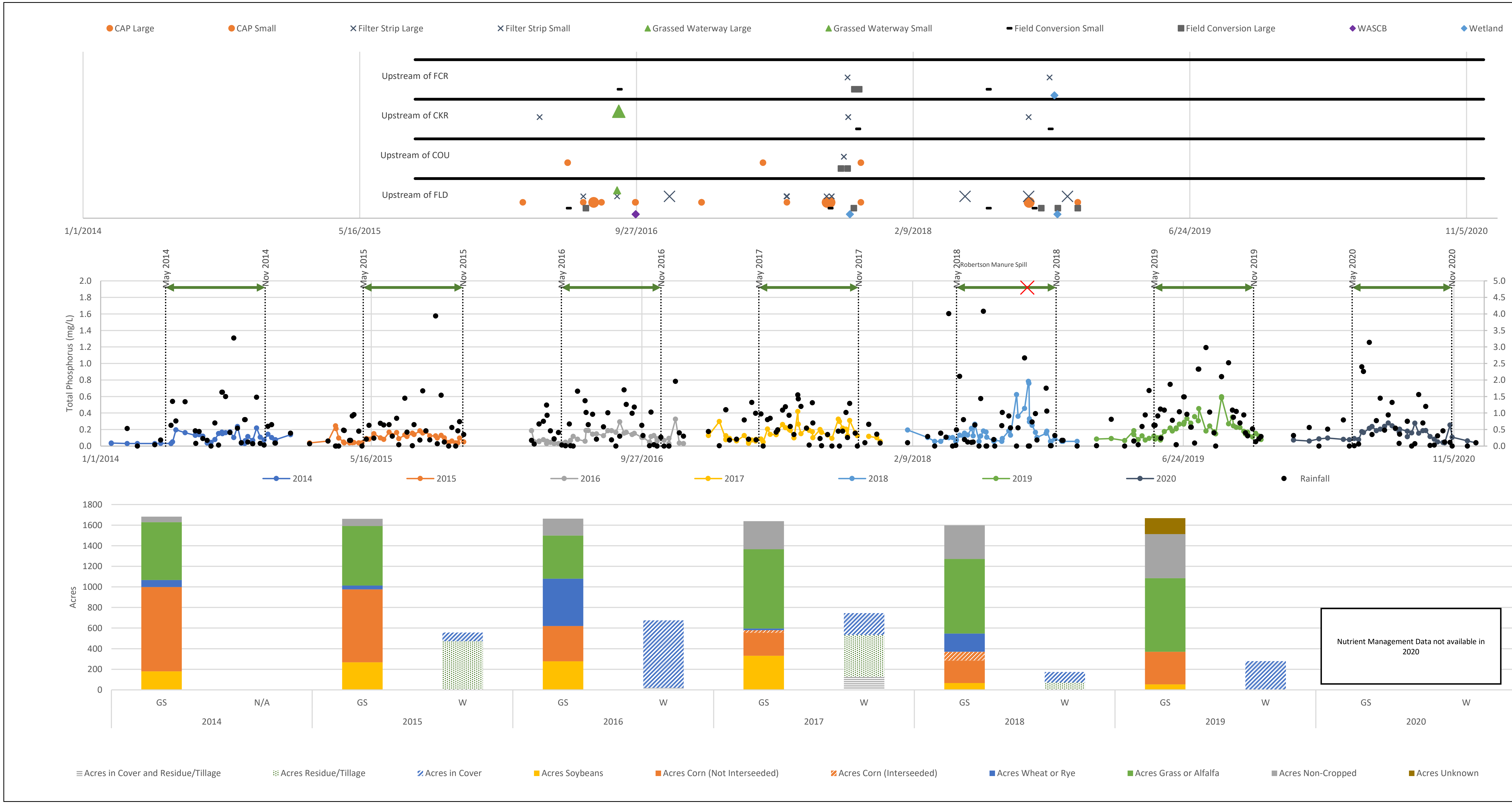


Figure 4-21. Phosphorus Water Quality Data and Land Use for Fields Upstream of SL-FLD

The figures in Appendix P include data for TSS and the other sampling sites. Overall, most sites exhibited the same trends in land use and resulting water quality. More time is needed for the watershed to respond to implemented BMPs. As more data is collected in Silver Creek, nutrient management data may be available through the counties to expand this analysis. Future statistical analyses could include incorporating soil sampling results, stream flow and nutrient load data, sediment core data from the streambed, and continuing to study the impact of structural BMPs and the stream re-meandering project.

4.3.7 In-stream Sediment

Sediment sampling took place in 2016 at four of the five water quality monitoring stations (SL-172, SL-FLD, SL-COU, and SL-CKR). The bulk-density values were lower at the two upstream sites compared to higher bulk-density values observed at the two downstream site locations (Figure 4-22). SL-CKR sediment had the highest total phosphorus and TKN values compared to the other sample sites downstream (Figure 4-23). This was consistent with the water-concentration data results. The highest total organic carbon was measured at the upstream site SL-CKR; however, this site had the lowest percentage of solids. The other sites downstream had lower total organic carbon, diminishing with each site moving downstream, while the percentage of solids increased as sites were sampled downstream (Figure 4-24).

These results indicate downstream movement where the percent solids increased as more suspended solids were introduced to the system and settled out. The amount of organic material decreased downstream as smaller clay particles were more likely to stay suspended and settled out downstream. These observations were further supported by heavier bulk-density values downstream as clay particles settle out and become more compact in the streambed. Visual observations during sampling included firm streambed with some small cobble downstream and loose mixed clay and organic soils further upstream in the watershed. These patterns support that nutrient-rich organic material likely coming from neighboring agricultural fields through surface runoff are observed higher up in the stream system.
The nutrient-rich sediment may be a source of phosphorus to the stream and may be a cause of higher total phosphorus concentrations observed pre-BMP implementation.

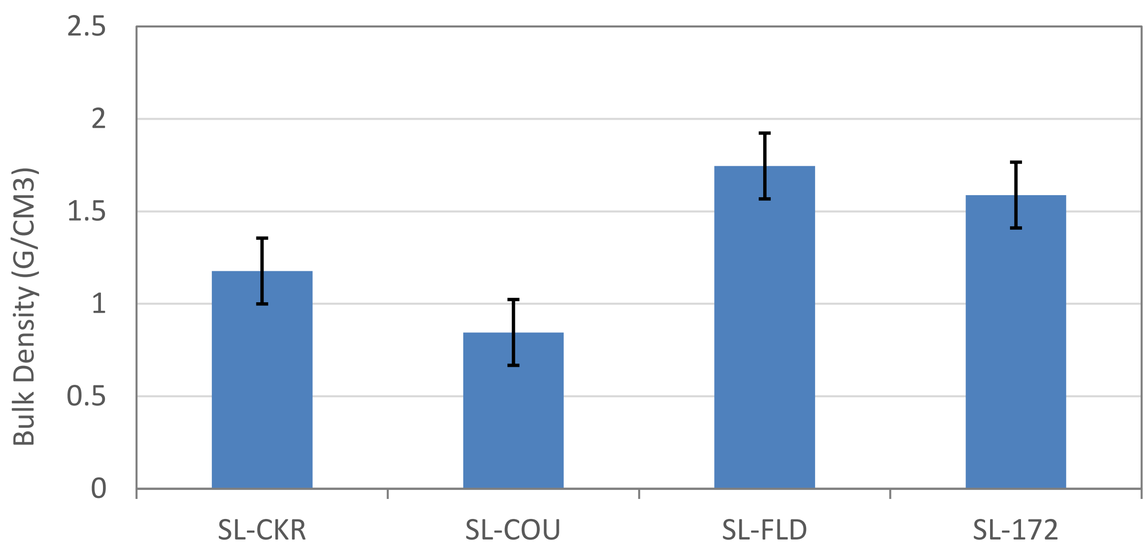


Figure 4-22. Streambed Bulk-Density Results
Note: Standard deviation bars were derived from replicate sample data.

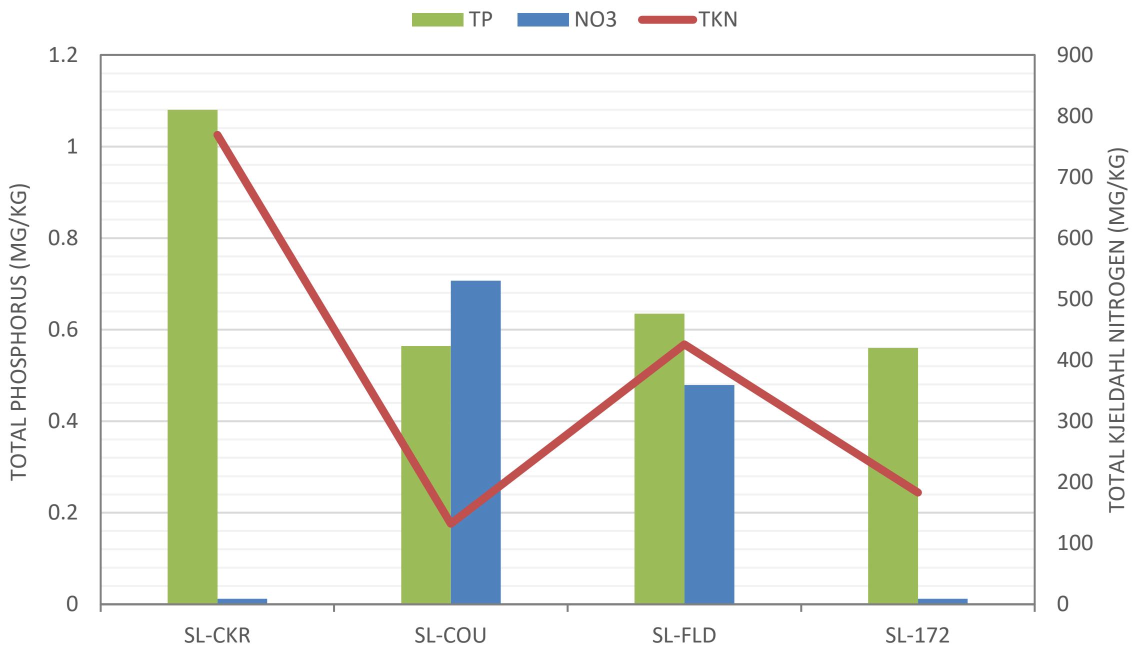


Figure 4-23. Streambed Nutrients

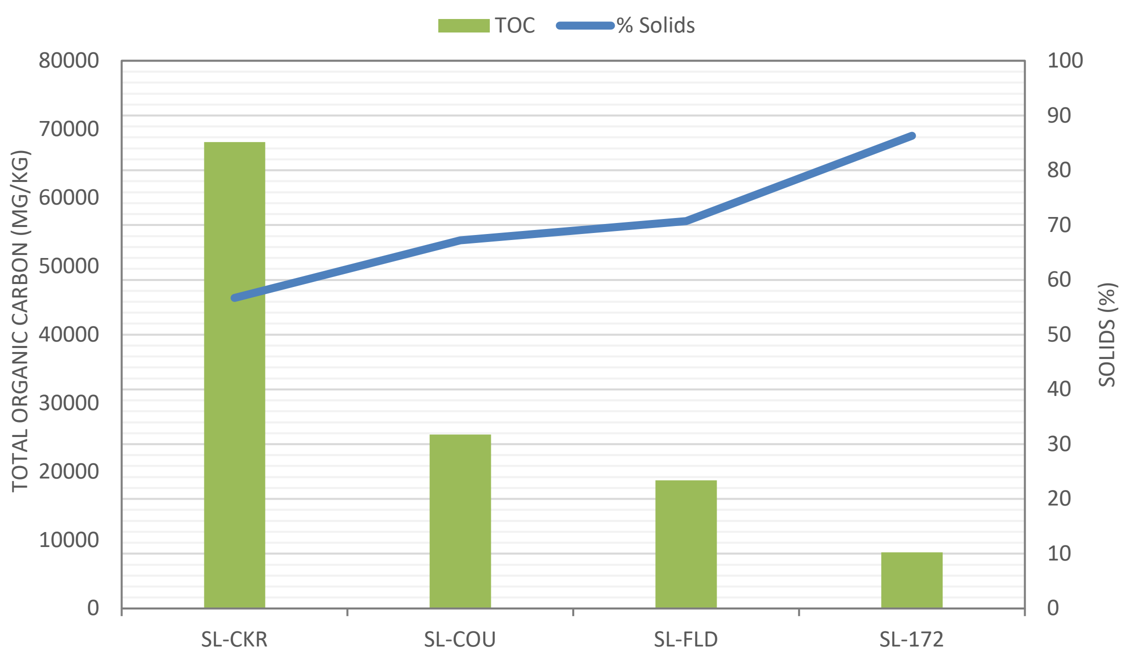


Figure 4-24. Streambed Solids

4.3.8 Summary

In-stream total phosphorus concentrations were elevated above the water quality standard throughout the Silver Creek watershed. Initial water quality improvements in Silver Creek are becoming evident and are promising, but more time is needed to fully understand the effects of widespread BMP implementation on water quality at the watershed scale. 2020 was the fourth full year after implementation began in Silver Creek. Some BMPs were just becoming established in that timeframe, while other BMPs may need more than 10 years to fully show in-stream water quality benefits. Furthermore, BMP establishment may have been hampered by high rainfall and flow in 2018 and 2019 and slightly above normal rainfall and flow in 2020. Regardless of which way the data were analyzed (over time, over space, concentration versus load, seasonality, etc.), precipitation was the driving factor in water quality analyses. Rainfall and increased flow had an important impact on water quality results and further phosphorus and sediment release. Elevated annual rainfalls in 2018 and 2019 show the need to build a resilient landscape through the implementation of BMPs that focus on increasing soil infiltration and water-holding capacity and slowing the release of water from the landscape to the stream channel network throughout Silver Creek. One unknown during these times of increased flow is how much more phosphorus and sediment, from a loading perspective, could have been released without widespread BMP implementation throughout Silver Creek.

Some sources of phosphorus and sediment were not addressed in this report but will need to be addressed in the future. These include the dissolved portion of total phosphorus, more detailed analysis of legacy sediment along the bed and banks that may release phosphorus back into the water column through erosion and/or sorption, and the relationship between organic matter and TSS. Water quality and flow monitoring will continue in Silver Creek, albeit at a reduced effort, to further quantify water quality reductions from BMP implementation. Lessons learned in Silver Creek will guide the water quality monitoring approach for the Full-Scale Program.

4.4 Biological

The Oneida Nation collected biological data from macroinvertebrate sampling conducted annually from 2014 through 2019 upstream of Silver Creek's crossing at Florist Drive. The data supported the water quality results and provided insight into how the system responded to the land-use changes through additions of structural and operational BMPs. The Pilot Project reviewed the biological data and prepared an analysis with the following objectives:

- Understand the baseline conditions and any subsequent biological trends in the watershed.
- Support the Oneida Nation biological sampling goals.
- Compare to WDNR biological assessment methods.
- Develop recommendations to enhance assessments and support the Pilot Project.

Results for the 2014 to 2019 samples were generally similar between sampling years, with a few exceptions. Overall, the number of species present was dependent on the specific sampling year; however, the variety of species present was a positive indicator that the benthic macroinvertebrate community is somewhat diverse. Other metrics that showed similar results between years included Proportions of Depositional Taxa, Diptera, and Chironomidae. An abundance of these taxa typically indicates poor water quality or a lack of available habitat for colonization of other pollution-intolerant organisms. However, it can be noted that the Proportions of Depositional Taxa, Diptera, and Chironomidae in 2019 were noticeably below the 6-year averages (91.1%, 87.8%, and 63.3%, respectively).

Two commonly used means of assessing biological water quality, the Hilsenhoff Biotic Index (HBI) and Proportion of Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (EPT), were used to characterize the health of Silver Creek. The HBI is calculated on a scale from 0 to 10 based on the number of individuals in each taxon identified and their assigned pollution-tolerance values. A high HBI score indicates a community containing pollution-tolerant species. In contrast, a low score indicates that organisms intolerant of organic pollution dominate the invertebrate community, implying good water quality. The EPT is the total number of taxa within the "pollution-sensitive" orders of EPT. Therefore, the higher the score, the better. In contrast to the HBI, the EPT index decreases with decreasing water quality.

Table 4-7 lists the HBI and EPT results for the last 5 years. In 2019, both the HBI and EPT values indicated the best conditions of all 6 years of monitoring at this site.

Table 4-7. HBI and EPT Results for Silver Creek

Metric	2014	2015	2016	2017	2018	2019
HBI	5.42 (good)	5.53 (fair)	5.76 (fair)	5.41 (good)	6.27 (fair)	5.25 (good)
EPT	3	3	5	3	4	6

Although there was not a consistent pattern to improvements in biological metrics, the biological monitoring data confirmed that monitoring the biology of the watershed can assist in determining the success of on-field conservation implementation and that additional time is needed for the watershed to respond to land-use changes. The impact of the stream re-meandering project implemented in 2020 will be of interest for future data collection. Appendix Q contains assessments of Silver Creek biological monitoring.

4.5 Soils

In 2014, 88 agricultural fields were sampled on 2.5-acre grids, resulting in 937 individual samples. In 2019, 74 agricultural fields were sampled on 2.5-acre grids, resulting in 838 individual samples. The difference in number of fields sampled between 2014 and 2019 was due to either not gaining permission for sampling or land conversion that removed the field from production. There were 811 individual points that were approximately comparable between 2014 and 2019 sampling, and the difference in soil phosphorus between events is shown on Figure 4-25. An increase in phosphorus (positive value) is shown in red, and a decrease (negative value) is shown in green.

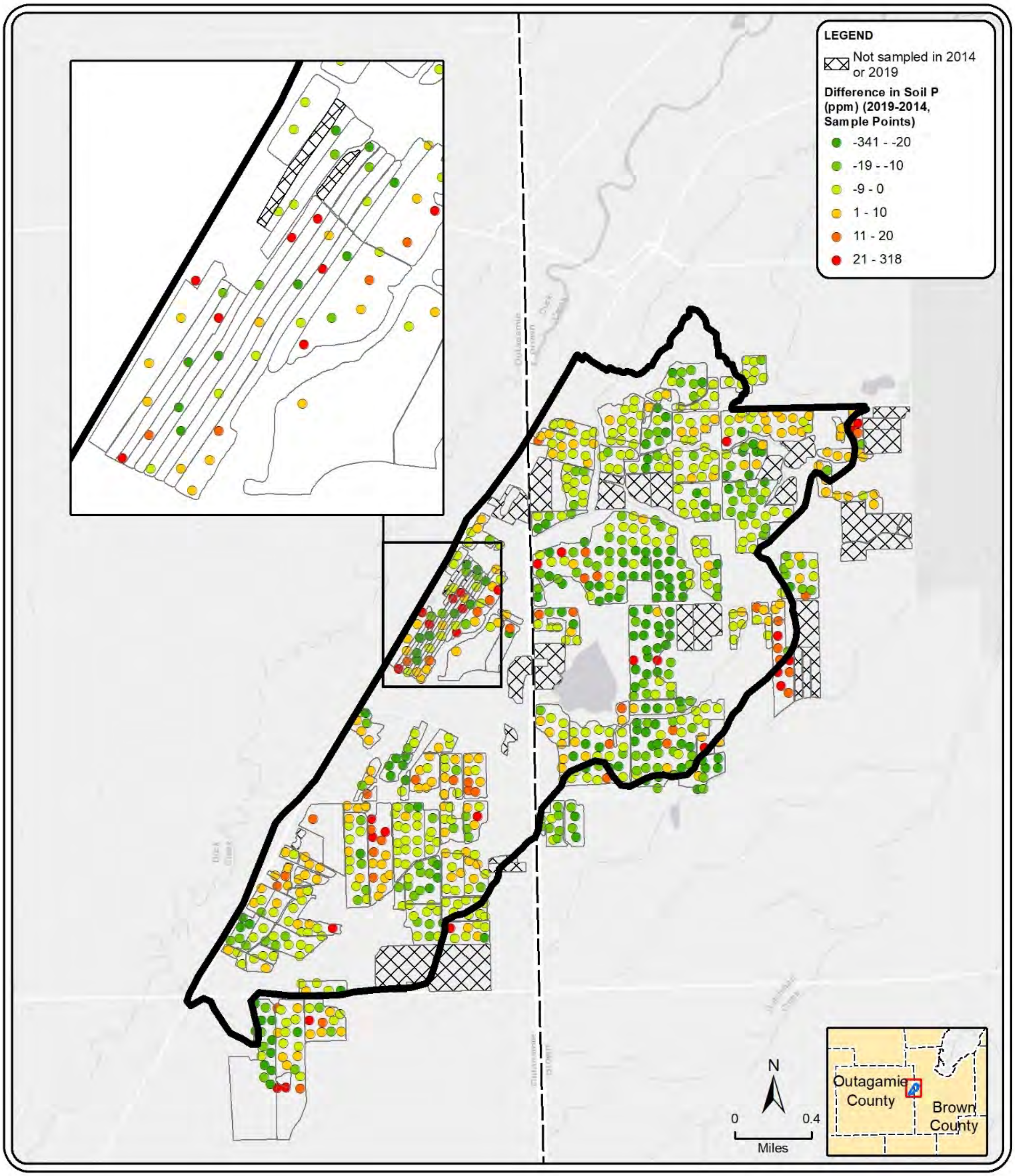


Figure 4-25. Comparison of Individual Sample Soil Phosphorus Values 2014 to 2019

Appendix E contains results for field averages and other parameters, including organic matter. Overall, fields that were already meeting nutrient management requirements in 2014 showed little to no change in soil phosphorus during the 2019 sampling event. There were 14 fields that were not meeting nutrient management code requirements in 2014, and several of those fields made improvements in soil phosphorus during the course of the Pilot Project, particularly the subset of fields that entered an alfalfa rotation.

Soil sampling completed as part of the Pilot Project resulted in a rich data set that could benefit from more fine-grained evaluation. The following types of analyses could be considered:

- Further test relationship between all fields entering an alfalfa rotation and resulting soil phosphorus.
- Investigate the relationship between nutrient application management (particularly manure) and resulting soil parameters.
- Analyze the spatial results on fields that used variable-rate technology.
- Group fields upstream of water quality and biological sampling locations to observe any correlation.
- Update the analysis comparing 2.5-acre and 5-acre grids (see Section 3.1.1).
- Consider sampling in 2024 to observe changes after the formal end of the Pilot Project.

4.6 Outreach

The education and outreach efforts of the Silver Creek Pilot Project were far-reaching and encompassed a variety of tools, such as print media, website, videos, stakeholder meetings, landowner luncheons, PowerPoint presentations, student monitoring days, tours, press releases, tweets, and television coverage.

The Pilot Project has generated several materials distributed to landowners, growers, project partners, and other external stakeholders and interest groups. An annual fact sheet was prepared for 2014-2015, 2016, 2017, 2018, and 2019 (Appendix R). The purpose of the fact sheets was to provide a 1-page summary of the Project to date, including major accomplishments, BMP installations, and water quality data. The fact sheets were distributed at the stakeholder meetings, landowner and grower meetings, and posted on the Project website.

Several Project "reflection" sheets were created for specific BMPs and lessons learned. Topics included Aerial Seeding Cover Crops, the InterSeeder™, No-Cost Critical Area Plantings (CAPs), and WASCBs. These 1-page documents summarized a specific challenge encountered during conservation planning, a proposed solution implemented by the Project, and lessons learned and future opportunities. For example, the WASCB reflection included background on a field that would have traditionally addressed gully erosion and poorly drained areas with a complicated network of CAPs and grassed waterways. The reflection sheet then summarized the installation of three WASCBs with side-by-side photos to illustrate how this conservation practice addressed resource concerns while still maintaining the ability to maneuver equipment on the agricultural field. The reflection sheets are included as Appendix S and were distributed at the stakeholder meetings and landowner and grower meetings, by field teams discussing potential opportunities with growers, and posted on the Project website.

Additional documentation and materials were created to promote the interseeder purchased in a partnership between NEW Water, Brown County Land and Water Conservation, and the Fund for Lake Michigan. In addition to a reflection sheet, a targeted fact sheet containing technical details was also created (Appendix M). The purpose of the InterSeeder™ fact sheet was to advertise the availability of the interseeder and provide more technical specifications on the equipment and how it could be used. The InterSeeder™ fact sheet was intended for a narrow target audience of growers and operators in the LFRB; whereas the InterSeeder™ reflection sheet provided fewer technical details and is applicable to a wider range of stakeholders in the region. The fact sheet was often used as a "leave-behind" material for field teams to remind landowners and growers of this available resource.

Student monitoring days, organized by the Pilot Project, were held during a spring event in 2014, 2015, 2016, 2017, and 2018. Dozens of students from Bayport High School in Green Bay and the Oneida Nation High School were invited to participate in hands-on learning experiences. The students rotated through stations collecting data on water quality, biological data, and assessing resources concerns through the use of technology.

A Pilot Project video *Water Knows No Boundaries* was produced and featured former U.S. Congressman Reid Ribble and Oneida Tribal Chairwoman Cristina Danforth speaking and sharing their support for this effort. This video and the Pilot Project have received numerous local and national awards to recognize the success and positive impact of the Pilot Project in northeast Wisconsin, most recently receiving the National Association of Clean Water Agencies 2022 National Environmental Achievement Award – Watershed Collaboration Award. A #WaterWednesday tweet series was started as part of the Pilot and continues, promoting Silver Creek efforts and NEW Water efforts in addition to local and national projects. A #LoveYourWatershed campaign was also started to help guide community members in Silver Creek and the LFRB on how they can do their part to reduce excess sediment and nutrient sources in urban areas.

Project Team members presented at several conferences, roundtable meetings, knowledge transfers, and other similar venues. Some of these include:

- American Society of Civil Engineers, Wisconsin Chapter
- American Water Resources Association, Wisconsin Section
- American Water Works Association, Wisconsin Section
- Brown County Conservation Alliance
- Clean Rivers Clean Lakes
- Central States Water Environment Association
- Central States Water Environment Association; Government Affairs Seminar
- Dairy Education Conference
- Fox Wolf Watershed Alliance
- Great Lakes Commission Knowledge Transfer
- International Association of Great Lakes Research
- Iowa Agricultural Water Alliance
- Land and Water Conservation Association, Wisconsin Section
- Marquette University Continuing Education
- New York Department of Environmental Protection
- Northeastern Wisconsin Technical College
- Pacific Northwest Clean Water Association
- University of Wisconsin – Green Bay
- University of Wisconsin – Platteville Continuing Education
- Water Environment Federation
- Wisconsin Association for Floodplain, Stormwater, and Coastal Management
- Wisconsin Lakes Association
- Wisconsin Rural Water Association
- Wisconsin Wetlands Association

5. Budgetary Review

In 2013, NEW Water began planning efforts for the Pilot Project to explore the adaptive management watershed approach to WPDES permit compliance. Knowing this would be a significant effort that would impact permit compliance and operational costs in the future, a reorganization took place, and a new division was created—Environmental Programs Division. At that time, a Director of Environmental Programs was hired with many years of experience working with agricultural conservation practices at a local land conservation office. 2014 was the first year that NEW Water budgeted significant funds for a USGS gauge, consultant costs, and cost share funding for the Pilot Project. NEW Water leadership understood that the cost of a pilot watershed project would be a good investment and opportunity to experiment with partnering in the watershed to achieve future phosphorus and TSS limits. The alternative of more traditional plant upgrades were expected to be more costly, ranging in cost from $100 million to $200 million. The Pilot Project was established to demonstrate that working toward water quality improvements in a watershed would be a more cost-effective approach to meeting WPDES permit requirements, while also achieving greater environmental and community benefits. Early in the project, there was a significant effort put toward educating NEW Water's Commission and customers about the potential benefits of a watershed adaptive management approach and the value of the Pilot. NEW Water staff received support and commitment from the Commission to conduct a 5-year Pilot Project using NEW Water funds.

In 2014, NEW Water submitted an EPA GLRI grant application to help offset some costs of planning and implementation of the Pilot Project, along with some additional studies in the watershed. In 2015, NEW Water was awarded an EPA GLRI grant for $1,686,669. This grant supplemented NEW Water funds to fully explore watershed conservation and conduct additional research, at a reduced cost to NEW Water. Throughout the Pilot Project, NEW Water continued to seek additional grant funds as well as leverage existing NRCS EQIP opportunities and partner funding. NEW Water was successful in securing a $100,000 grant from the Natural Resource Damage Assessment to establish grasslands and enhance habitat on sensitive areas and $58,850 from the Fund for Lake Michigan to purchase an innovative new piece of farm equipment to interseed cover crops into standing corn fields. The equipment was donated to the Brown County Land and Water Conservation Department for growers to use across county lines throughout the LFRB. NEW Water was also able to leverage over $100,000 in NRCS EQIP funding to install BMPs and $112,000 in partner funds for wetland restoration efforts.

The Pilot Project extended beyond the initially planned 5-year period as a result of the timing of the GLRI grant and some delays throughout the project. The total investment in the Silver Creek Pilot Project from 2013 through 2021 was $4,713,965. Of that total cost, 52%, or $2,467,761, was funded by NEW Water (Figure 5-1).

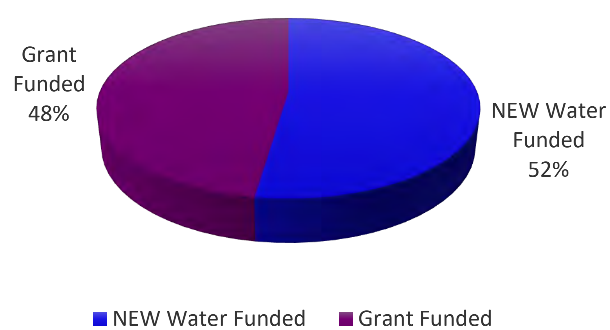


Figure 5-1. Silver Creek Project Funding

A review of the Pilot Project expenses identified four main categories of expenditures: labor-in-kind costs, consultant and contractor fees, BMP implementation and equipment, and research studies (Table 5-1, Figure 5-2).

Table 5-1. Silver Creek Project Cost Summary

NEW Water Labor	$1,053,713
Consultant/Contractor	$2,185,533
BMPs and Equipment	$1,196,034
Research/Studies	$278,685
Total	**$4,713,965**

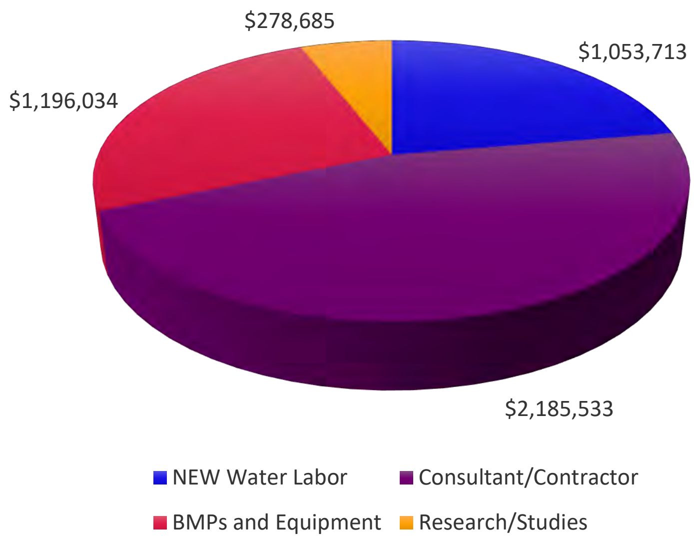


Figure 5-2. Silver Creek Project Cost Summary

A financial model was developed that used observed costs from the Pilot to project the 30-year Net Present Value (NPV) of a full-scale, 20-year watershed adaptive management effort in a watershed large enough to achieve future permit compliance. A 30-year period was used to allow for additional costs, including building plant upgrades and resulting capital, operation, and maintenance costs, to be captured within the adaptive management alternative. A 30-year period also allowed NEW Water to evaluate longer compliance options if adaptive management were to be extended beyond 20 years, such as if permit renewals are not effective immediately following the expiration of a current permit. A 30-year NPV of approximately $61 million was estimated for the adaptive management compliance option that included building tertiary treatment at the end of the watershed program; approximately $37 million was estimated for the adaptive-management-only portion of this alternative. Treatment-only alternatives ranged from $92 million to $122 million. Figure 5-3 shows a comparison of the ranges of 30-year NPVs for the compliance options.

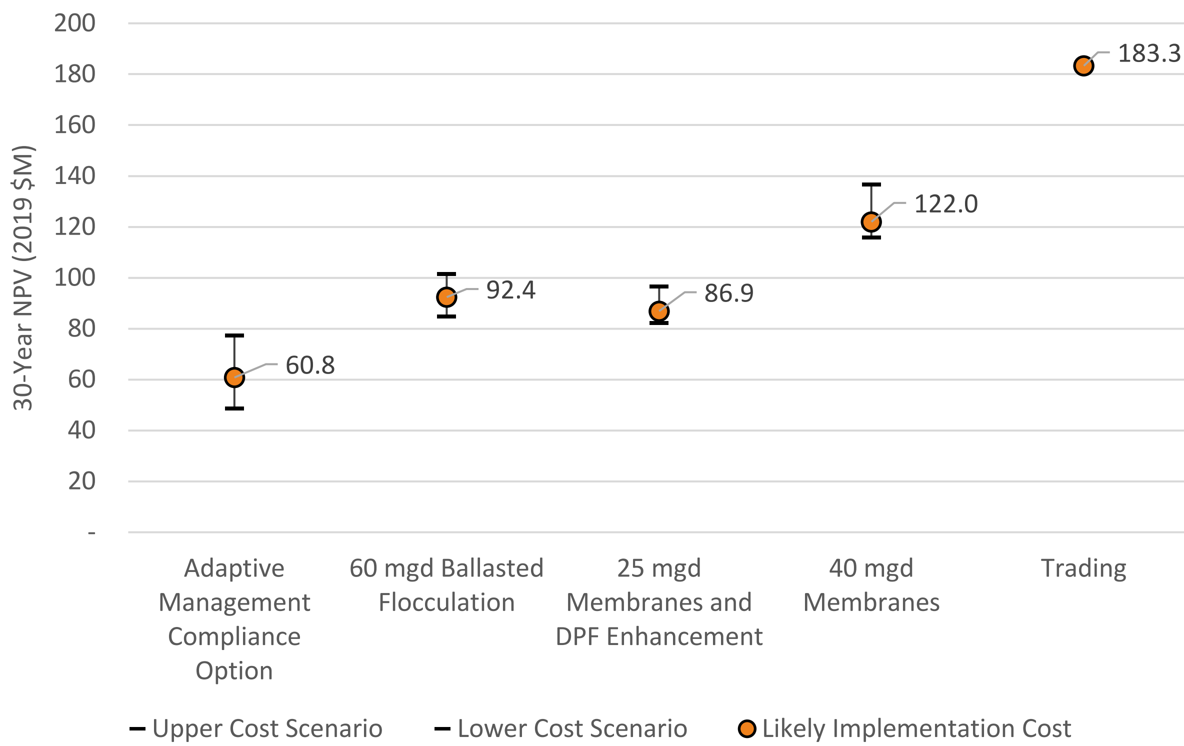


Figure 5-3. 30-Year NPV Costs for WPDES Permit Compliance Options

The financial model was used to support a request for Commission approval of a watershed approach, the selection of the adaptive management compliance alternative in the Preliminary and Final Phosphorus Compliance Plans submitted to WDNR, and the eventual Adaptive Management Plan submittal as part of the WPDES permit application process. A summary of the financial model versions and results is documented in Appendix T. Appendix U contains the Final Compliance Alternatives Plan.

The cost evaluation included assumptions that the costs observed in the Pilot Project were not completely representative of a future full-scale approach to watershed work. In Silver Creek, efforts were made to install every possible BMP on every possible field to complete maximum implementation rates to determine the response in water quality over time. Larger watershed efforts will require more prioritization of BMP opportunities. The Pilot Project focused almost exclusively on agricultural lands. There will be a need to work with both agricultural and urban partners to achieve improved water quality in a larger watershed area. Cost-sharing practices and budgeting will be adjusted for a 20+ year effort, with an effort to dedicate funding towards educating landowners and growers to assist them in getting through the learning curve of soil health and conservation measures, while also educating them on long-term funding options already provided by programs such as NRCS EQIP.

6. Conclusions

6.1 Pilot Observations

The Pilot Project provided invaluable learning opportunities for NEW Water regarding partnering with agricultural producers to encourage conservation and soil health practices to improve water quality. Some landowners and growers would not accept funding from the Pilot Project, but greatly appreciated the technical assistance provided by the team so they could implement measures on their own. Throughout the course of the Pilot Project, there was a noticeable cultural shift, where growers saw benefits to their fields, soil health, cropping practices, reduced labor and equipment inputs, and other factors that made this change desirable.

The Pilot Project has taken an in-depth and hands-on approach to planning and implementing structural and operational BMPs. The following tools and lessons learned will be used to implement the Adaptive Management Program:

- Partnership agreements for project partners, chartering a diverse and knowledgeable implementation team, and overall organizational outlines to map each stakeholder's and partner's contributions.
- Baseline soil phosphorus and C&ENMPs for determining success and identifying conservation opportunities and barriers to implementation.
- Mobile data-collection tools and planning, designing, implementing, and maintaining BMPs using tracking tools to ensure BMPs are installed correctly and continue to function for reducing phosphorus and TSS in agricultural runoff.
- Structuring mobile data collection to allow for identifying efficiencies between team members through enabling appropriate workflow and identifying BMPs that require maintenance.
- Water quality and biological data provide a more comprehensive assessment of changes that result from BMP implementation when compared with baseline conditions.
- Partnerships with neighboring watershed projects for equipment sharing, expertise, and assisting with implementation keeps stakeholders engaged and encourages implementation.
- Obtaining equipment that has not been available to growers and that needs proof-of-concept to support broader implementation, such as the cover crop interseeder, will allow greater implementation of conservation opportunities.
- C&ENMPs allow Project Team members to simply communicate the need for implementing BMPs with growers and show how BMPs could fit within their existing agricultural operations. Automating these reports with the other digital tools allows team members to work efficiently to capture the needed information and communicate to the broader Project Team.
- Maintaining a partnership and collaboration with the LFR Demonstration Farm Network to share lessons learned and implementation successes across a broad and diverse region of growers and landowners. Communicating those successes and lessons learned with area growers and landowners through informational handouts also proved to further collaboration between the team and area growers.

Other successes from the Pilot Project include:

- Meetings with growers or landowners on 100% of the agricultural fields to discuss conservation opportunities.
- Desktop conservation planning and erosion vulnerability analysis on 100% of the watershed's agricultural fields.
- Increases in winter cover from 35% in 2015 to 70% in 2016 and 85% in 2017.

- Updated nutrient management and conservation plans beyond the minimum requirements of the State.
- Execution of a robust water quality monitoring program.
- Commitment of a diverse core team of agronomists, County conservationists, and consultants who worked directly with landowners to encourage implementation and build strong relationships.
- Support from the Oneida Nation, which demonstrated a strong partnership through providing access to land, project implementation, monitoring assistance, and various other tasks.
- Support from a diverse group of project partners.

The Pilot Project provided an opportunity for NEW Water to be engaged at the ground level on agricultural-based watershed conservation. With this engagement, the Pilot observed the following items that will require continued attention to achieve goals of adaptive management:

- Farm field boundary delineations are important for land management, including C&ENMPs, and are the basis of demarcation for SnapPlus modeling. Field delineations follow a "field" and often are bordered along ditches. Sometimes however the ditches are not used to segregate fields when two adjacent fields are farmed the same way and considered; instead, they are modeled and managed as one field by the grower. This is not a consistent practice and creates challenges within a GIS environment when two polygons have the same name. SnapPlus also does not require unique demarcation of fields if a ditch crosses a field and therefore splits it into two.
- Agronomists were critical team members because of their relationship to the landowner and/or grower. Communication was often completed through mobile devices, and other modes of direct contact since routine office hours are unpredictable. This requires adaptability and flexibility in integrating the agronomists within the Project Team.
- There can be significant variability in nutrient concentrations across a field; however, variable-rate nutrient application is not widely used. Nutrient application rates are instead planned for a field average basis. Nutrient application, either synthetic fertilizer or manure, should more broadly consider variable-rate technologies to eliminate excess nutrient application.
- There are desires in some fertilizer companies to minimize custom fertilizer blends that may be recommended in an ENMP. Consequently, this can result in over application of nutrients.
- Nutritionists should be part of the discussion about crops and livestock feed so conservation practices are more widely adopted by the dairy industry. Better communication between nutritionist and conservationists could allow some conservation practices to be more desirable and effective.
- Many farms are practicing conservation farming, including no-till, residue management, cover crops, and low-disturbance manure injection. Watershed programs must balance technical support for progressive farms with existing practices, while cost sharing and educating other farms to implement basic conservation practices. Cost sharing all conservation would not be sustainable for an Adaptive Management Program.
- Leased agricultural land has a varying range of lease requirements, if at all. Incorporating conservation requirements into a lease agreement, with inspection to verify lease requirements are being followed, is a low-effort mechanism to further encourage (or require) conservation practices.
- Existing regulations (e.g., *Wisconsin Administrative Code* NR 151) as they are currently enforced are insufficient to achieve water quality needs of a TMDL. The full implementation of NR 151 may still not achieve water quality goals. Universal application and enforcement of NR 151 is required, and enhancing the requirements will be needed if voluntary actions are not broadly implemented.
- An Adaptive Management Program, implemented by a municipal entity, can only be completed with voluntary participation by agricultural stakeholders. Without environmentally protective regulations, more incentive is needed to encourage the agriculture sector to participate if TMDL requirements are to be achieved.

- Crop rotations change over time and some change within days of planting. When planning for conservation opportunities, the fields must be viewed as a 'bare' field so that conservation is applied conservatively and irrespective of the crop. This will allow conservation to function under the highly variable nature of the crop rotations.
- When faced with an opportunity to implement multiple different types of BMPs for a single resource concern, the most conservative (i.e., most protective of water quality) practice should be installed.
- Annual leases leave uncertainty at the end of a term, which is commonly at the end of a calendar year or after harvest, but the end of the term may be the most critical part in terms of establishing a cover or preparing the field for overwintering and spring planting. For example, a lease should require, especially if it is annual, that a cover crop be established. Without some end-of-term requirement, there is little incentive for the grower to maintain conservation.
- There is much variability in supporting growers in the planning, documentation, implementation, and verification of NMPs. Some growers have thorough support, such as from consultant agronomists, because the grower contracts directly with the agronomist. Conservation implementation and improving water quality could be improved if all parties, including agronomists and the WDNR/Wisconsin Department of Agriculture, Trade, and Consumer Protection and County, were to consistently verify NMP implementation.
- Challenging conventional thinking and agricultural approaches are needed to improve water quality from the status quo. Asking "why not" will help to inform and identify barriers to BMP implementation.
- Drainage tile is being installed on fields that are poorly drained, generally lower, and wet. Some fields would be wetland areas if left to naturalize and would not be considered farmable land today if the field were to be developed. Removing portions of fields from production must be a consideration for conservation.
- County conservationists are often the most direct enforcement entity. Having consistency between county and statewide requirements could improve compliance with basic conservation practices.
- Active gullies in fields are a violation of *Wisconsin Administrative Code* NR 151. Creating a manmade drainage furrow is permitted, but the manmade furrow and gulley can result in the same negative water quality impact. Gullies, whether naturally forming or manmade, should not be allowed per NR 151.
- Greater coordination and oversight for manure application will improve its application and reduce environmental impacts. There are many perceived disconnects between the plan developed (often by agronomists) for the manure generators, the manure haulers, and the fields and exclusion areas of the field(s) receiving the manure. Greater collaboration and accountability among all involved parties could reduce manure impacts to waterways.
- Agronomists are often the most knowledgeable about field conditions across a grower's many fields because they perform field walks for crop scouting and assisting with planting and harvesting decisions with the grower. Completing field walks with the added purpose of identifying resource concerns could further reduce water quality impacts. Training in conservation and resource concerns may be needed. One agronomist during the Pilot Project commented "I have walked this field for over 10 years, and I never looked at it for the purpose of identifying resource concerns."
- Soil health is a critical aspect of successful farming and is commonly talked about. However, assessment of soil health is somewhat subjective, and common metrics are not unified.

6.2 Challenges and Opportunities

The Pilot Project experienced the following challenges that provide opportunities for improvement of future watershed work:

- The Pilot Project employed a "shotgun" approach to BMP implementation because the Pilot was intended for a short 5-year duration for achieving as much BMP implementation as possible. This approach will not be repeatable for a Full-Scale Program that is much larger with more entities involved. Lessons learned from the Pilot Project must be used to create a prioritization process that will achieve the interim and end goals of a 20-year watershed program.
- Strategies for modeling nutrient reductions in the watershed changed over the course of the Pilot Project. Challenges included identifying the best modeling software, using consistent model versions over the course of the Pilot Project, and identifying appropriate inputs and assumptions. Future watershed modeling should consider the need for flexibility given the changing nature of preferred modeling software, the speed of updated versioning, and the rapid pace of technological change.
- Several iterations occurred for the Collector Apps as technology and the program evolved. The Pilot Project tried several approaches to find the right balance between the level of detail needed and streamlining the user experience, particularly for the agronomists. Lessons learned from the Pilot Project will be used to shape the structure of future databases so that information does not need to be input multiple places, streamlining the apps for particular users (e.g., an agronomist-focused application), and critically screening for data necessary and critical to the Program.
- NEW Water's ability to access data was limited during the Pilot Project. The complexity and security of the centralized geodatabase limited access for end users outside of Jacobs. This led to the development of several automated email reports and the generation of PDFs containing summarized data from the GIS. In the future, dashboards and other reporting software will be considered to better export data frequently needed by program staff, in addition to email reports and other data-reporting methods used in the Pilot Project.
- Collecting NMP data from agronomists was laborious and was not used by the Project Team as originally envisioned. Future efforts should explore the automation of this process and screen for the data most used that would directly support a function of the program. For example, crop rotation information can assist with planning the use of the InterSeeder™ and may be valuable to collect.

6.3 Elements for the Full-Scale Program

NEW Water engaged in a 2-year process to review and select an action area in which to meet the requirements of a Settlement Agreement, Memorandum of Understanding, and to develop a program consistent with NEW Water's Strategic Plan. The Ashwaubenon and Dutchman creeks sub-basins were chosen for the Action Area in an Adaptive Management Program. Together, the Ashwaubenon and Dutchman creeks sub-basins require a total phosphorus load reduction of 18,911 pounds per year according to the TMDL, with 16,816 pounds per year of reductions assigned to agricultural and unregulated urban nonpoint sectors. These two sub-basins are immediately adjacent, to the east, from Silver Creek and drain to the LFR.

The Pilot Project has provided valuable insight into how collaborating with nonpoint source stakeholders can bring about reductions in phosphorus and sediment. The implementation strategy for Ashwaubenon and Dutchman creeks sub-basins builds on the successes of the Pilot Project by leveraging existing partners and programs that promote conservation and watershed management, sharing collected data and information, collaborating on overlapping regional and local BMPs, and monitoring performance through water quality and biological measurements. Adaptive management tasks and strategies are expected to include the following:

- Write the Adaptive Management Plan that outlines the implementation strategy, goals, and measures of actions.
- Develop an organizational chart and charter partnerships with participating counties, municipal separate storm sewer systems, nongovernmental organizations, the regional airport, the Oneida Nation, and others.
- Identify any need for soil testing on agricultural fields. Leverage lessons learned from the Pilot Project to execute higher-density soil sampling when needed.
- Execute field walks and other watershed inventories to identify opportunities for BMPs early in the Program. Use a centralized GIS database to track opportunities and assist with workflows.
- Collect a comprehensive data set for water quality and biological monitoring that includes water chemistry, flow monitoring, fish surveys, macroinvertebrate surveys, and habitat surveys. These data will help support nutrient load calculations and an assessment of potential watershed improvements over the life of the Program.
- Develop a methodology to prioritize implementation of BMPs that considers grower relationship, BMP type, modeled phosphorus and TSS reductions, and costs.
- Develop a robust modeling strategy that includes watershed-wide modeling and modeling of individual BMPs for demonstrating phosphorus and TSS reductions.
- Create a centralized GIS database to collect, store, and report data and support the implementation and maintenance of BMPs.
- Develop conservation plans for participating growers in the watershed. Developing ENMPs will also be considered.

7. Continuing Work in Silver Creek

NEW Water has committed significant resources over the past 7 years so that the Pilot Project could be successful in improving land-use management, water quality, assessing biological impacts, and developing and fostering partnerships. Partnerships are a critical component of any watershed program, particularly in adaptive management, because NEW Water does not have regulatory authority over watershed stakeholders for meeting state and local requirements. Given that many growers and landowners are expected to overlap between the Pilot Project area and a full-scale adaptive management area, the fostering of partnerships and maintaining commitments established in the Pilot Project will be important in implementing the Program.

NEW Water has developed tools and completed conservation and enhanced nutrient management planning throughout the Pilot Project area to provide a framework for variations in crop rotations independent of land ownership or individual grower operation of leased lands. The information collected and the planning framework developed for implementation of structural and operational BMPs can exist within Silver Creek for many years into the future with significantly reduced efforts, as compared to early years of the Pilot Project. NEW Water has worked closely with the counties, agronomists, and other conservation planners within Silver Creek, so the planning framework provides a blueprint for continued BMP implementation. This was an intentional approach at the onset of the Pilot Project because it was expected that a period longer than 5 years would be needed to observe sustained improvements in in-stream water quality and biological metrics. The framework and tools will allow NEW Water to leverage project partners to sustain implementation in Silver Creek. To achieve these goals and support partners for continued work in Silver Creek, NEW Water anticipates performing the following tasks:

- Continue to host GIS and database systems that include the C&ENMPs and allow conservation planners to plan, install, verify, and monitor BMP implementation. This includes enforcing NEW Water CSAs with the Oneida Nation and other landowners and growers to ensure that contractual obligations are maintained.
- Conduct periodic meetings with conservation planners to develop a BMP implementation schedule and activities and to assess actual implementation.
- Support use of interseeding to encourage cover crop installation on corn fields.
- Coordinate with neighboring watershed projects, such as the Demonstration Farms Network and other grant projects, to encourage cross-participation in educational events, equipment demonstrations, field days, and other watershed collaboration activities, in order to support continued growth of conservation stewardship within Silver Creek.
- Host partner and Project coordination meetings with the Oneida Nation, TNC, Ducks Unlimited, and USFWS to coordinate BMP implementation and special projects, such as wetlands and vegetated treatment systems, as needed.
- Host periodic grower and landowner information meetings to review accomplishments, BMP monitoring information, and water quality results.
- Track changes to soil health by evaluating soil testing data for metrics, such as organic matter.

Water quality monitoring efforts will continue in Silver Creek while working in the Adaptive Management Program. It is unlikely that all five sampling locations will be retained (Figure 3-1); however, the Florist Drive site will continue to be sampled to monitor the long-term response to in-stream water quality from the conservation practices installed in the watershed. For the sites that are sampled, monitoring will continue at least twice per month during the growing season and once per month during the non-growing season. Total phosphorus and TSS will continue to be the key parameters analyzed along with additional basic water quality parameters from the multiparameter probe.

Biological monitoring is planned to continue within Silver Creek through collaboration with the Oneida Nation. As with the water quality results, biological results are expected to improve and are likely to require more than 5 years to respond to watershed BMPs implemented in the watershed. The Oneida Nation is planning habitat improvements within the watershed, most notably through a stream re-meandering project upstream of the current monitoring location. The project could have a significant impact on water quality and biological metrics because a significant limitation to the biological community, along with current water quality, is the availability of functional habitat.

Continuing BMP verification, implementation, and water quality and biological monitoring in Silver Creek will provide insight to NEW Water on how to manage the Adaptive Management Plan. While not directly beneficial to the water quality of a full-scale Adaptive Management Program, continued work within Silver Creek provides the following benefits to the Program and NEW Water's phosphorus compliance strategy:

- Continued improvement of water quality to the bay of Green Bay and progress toward the TMDL goals. A local long-term record of a watershed's response to BMP implementation, to provide insight into how adjacent watersheds could respond to similar watershed programs.
- A local understanding of site-specific conditions that allow for assessing compliance with phosphorus and TSS water quality standards, such as delisting the waterway for phosphorus and TSS following the Wisconsin's Consolidated Assessment and Listing Methodology (WisCALM).
- Demonstration of NEW Water's commitment to the growers, landowners, and partners who have operations in the full-scale area. This, in turn, will improve long-term partnership opportunities and BMP implementation in the full-scale area.
- Confidence that implementation strategies have been successful through long-term partnerships.
- Ability to evaluate benefits and commitments of partnerships and to assess partnerships with the greatest or longest-lasting potential, to allow NEW Water to focus efforts on the most impactful partnerships.
- Allowing NEW Water to pilot tools, communications, etc. at a small scale first, before full-scale rollout.
- Providing unique insight to NEW Water on how adaptive management could be improved in future permit renewals, such as through statutory changes or updates to the Adaptive Management Plan.
- Consistency with the requirements of the full-scale Adaptive Management Program under which structural BMPs are maintained and annual operational BMPs, such as cover crops, continue to be implemented, allowing BMPs to continue to reduce phosphorus and TSS for maintaining in-stream water quality.

The success of the Silver Creek Pilot Project was possible in large part because of the numerous stakeholders, partners, collaborators, and funders that participated throughout its duration. The positive watershed work in northeast Wisconsin is a direct result of the wonderful watershed programs, connected stakeholders, and engaged landowners. These programs and staff continue to share successes, work together to overcome challenges, and share lessons learned from each other—all to better serve the community.