THE SHEBOYGAN RIVER AGRICULTURAL PROJECT

A PHOSPHORUS REDUCTION INITIATIVE PROJECT

FINAL REPORT

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INTRODUCTION

From 2011 thru 2016, a number of conservation partners have been working with farmers in the Otter Creek Watershed of the Sheboygan River basin to implement a pilot project to improve water quality in an effort known as the *Sheboygan River Agricultural Project (SRAP).* As a main component of this project, computer generated phosphorus loadings were compared to actual in-stream monitored phosphorus loadings in a paired watershed approach. One of the principle goals of the project was to focus phosphorus reduction efforts on the highest phosphorus loss fields by engaging the farmers that operated these fields to implement phosphorus reducing conservation practices. This would result in the most economical use of available conservation practice dollars, "biggest bang for the buck." Utilizing the results of the computer modeling, the Sheboygan County Planning and Conservation Department (Department) engaged farmers to implement practices on fields identified as high phosphorus contributors. Some SRAP accomplishments include: a **1,201 pound** or 15% reduction in modeled phosphorus, installing Wisconsin's first Denitrifying Bioreactor, and significant research on soil health thru the use of cover crops. This report primarily summarizes the role of the Department in the *SRAP* but, is also intended to highlight the achievements of all the partners that made this project successful.

BACKGROUND

In 2006, a pilot project was started utilizing computer modeling and a paired watershed approach to target sources of cropland phosphorus with the intent to achieve the greatest phosphorus reduction for the lowest possible cost. Known as the **Pecatonica River Project**, it was located in the unglacieated area of Dane, Green and Iowa counties. A collaborative effort involving many partners, the project enlisted farmers to implement conservation practices on fields targeted during an inventory phase as having high phosphorus runoff potential.

By 2010, The Nature Conservancy (TNC), one of the Pecatonica River Project partners, approached the Kohler Trust for Preservation and the Department to gauge their interest in starting another similar pilot project in Sheboygan County. The opportunity for participating in the pilot project was a good fit for the SCPCD as they have a long history of working in non-point pollution reduction projects having implemented 6 state non-point pollution abatement watershed projects throughout the county.

One unique element to the SRAP was the fact that the **Otter Creek** watershed had been part of the Sheboygan River Priority Watershed Project (SRPWP) during the 1990's. Thru this project most of the barnyards in the **Otter Creek** watershed had runoff control systems installed and several manure storage structures had been built. The construction of the aforementioned practices had already greatly reduced the impact of barnyard runoff and runoff from winter spread manure to Otter Creek and its tributaries. As a result of the conservation work installed thru the SRPWP the Department felt that this pilot project would truly be a test as to how much phosphorus reduction could be achieved targeting primarily cropland runoff vs. the combination of cropland runoff, manure runoff, and streambank erosion that had existed in the **Pecatonica River Project.**

With the funding secured through the Kohler Trust for Preservation the project, **The Sheboygan River Agricultural Project (SRAP)** began in 2011. A *SRAP Partners Group* was formed at the onset of the project consisting primarily of staff from organizations with specific tasks to complete throughout the project. The *Partners Group* had members from the following organizations: TNC, U.S. Geological Survey, USDA Natural Resource Conservation Service (NRCS), University of Wisconsin-Extension (UWEX), University of Wisconsin-Madison, Wisconsin Department of Natural Resources (WIDNR), and the Department. The *Partner Group* served as a forum to share progress updates, trouble shoot any problems that arose, and to keep the project moving forward in a timely fashion. The Project was planned to span the 6 years from 2011-2016 and consisted of **Monitoring, Inventory, and Installation** phases.

MONITORING

In order to compare phosphorus reductions as a result of implemented conservation practices rather than changes in weather, a **paired watershed approach** was used. The paired watersheds needed to be very similar in size, soil types, topography, and land use. In one of the watersheds conservation practices would be implemented (test watershed) and the other watershed would have no efforts made to implement conservation practices (control watershed). Through vetting carried out by USGS, WIDNR, TNC, and the Department, two watersheds were identified as meeting the above paired watershed criteria: **Otter Creek** (test watershed), a tributary to the Sheboygan River and **Fisher Creek** (control watershed) a tributary to the Pigeon River **(Figure 1).**

Figure 1

The Nature Conservancy

Both watersheds are rural in nature with no known point sources discharging into watershed streams. The estimated percentage of land cover types in both watersheds is shown in Table 1. Agricultural land use dominates both watersheds with the main enterprises being dairying and cash grain. Both watersheds have a flat to gently rolling topography with a predominance of silt loam soils formed in glacial deposits. Land use in both the Fischer Creek and Otter Creek watersheds is summarized in **Table 1.**

Table 1

SHEBOYGAN RIVER AGRICULTURAL PROJECT LAND USE SUMMARY			
	LAND USE	ACREAGE	PERCENT OF WATERSHED
FISCHER CREEK			
	Cropland	3971	65%
	Woodlot	663	11%
	Wetland	386	6%
	Miscellaneous	1076	18%
	TOTAL	**6096**	**100%**
OTTER CREEK			
	Cropland	3018	58%
	Woodlot	539	10%
	Wetland	330	6%
	Miscellaneous	1356	26%
	TOTAL	**5243**	**100%**

Once the paired watersheds were chosen, an in-stream monitoring station was installed in each watershed in May of 2011 (**Figure 2**). The Otter Creek monitoring station was installed just upstream of the confluence with the Sheboygan River and the Fisher Creek monitoring station was installed just upstream of the confluence with the Pigeon River.

Figure 2

OTTER CREEK MONITORING STATION

FISHER CREEK MONITORING STATION

Maintained by *Becky Carvin* of the USGS, these two monitoring stations recorded benchmark storm and base flow data for sediment, total phosphorus, dissolved phosphorus, and flow for each watershed. It was determined that between 40% - 60% of the annual suspended sediment and total phosphorus load was delivered to Otter Creek in 2-3 intense runoff events each spring. The monitoring of the both watersheds would continue for several years beyond the installation phase to determine how Otter Creek responded to the conservation practices installed in that watershed compared to the Fisher Creek watershed where no practices were installed. (See **Appendix A** for a summary of this data).

A sediment fingerprinting study by *Faith Fitzpatrick* of the USGS was also started during the monitoring portion of the project. This study continuing throughout the project would attempt to characterize the source of in-stream sediments (see **Appendix B** for a “snapshot” of this data).

In-stream fish and benthic macroinvertebrate as well as stream habitat benchmark surveys were conducted by *John Masterson* of the WI-DNR to gauge the benchmark biotic health of Otter and Fisher Creeks. These surveys were repeated after the conservation practice implementation period to gauge the impact of installed practices on the stream health. (see **Appendix C** for a summary of this data).

INVENTORY

The Department staff walked the main stem of Otter Creek and its tributaries during the inventory phase to verify any existing drainage tile line outlets. Twenty-two tile outlets were confirmed. The outlet size ranged from as small as 4 inch diameter to as large as 10 inch diameter. The type of tile systems existing in the Otter Creek watershed are considered “random systems“ where a tile is installed up a draw in a field to dry out the draw, or leading out of a closed depression in a field to dry out the depression in a timely manner so that crops survive. There are a few sites in the county that are flat enough that the landowner has installed a “grid pattern” tile system but none in the Otter Creek watershed. Tile systems will be discussed again in the conclusions section.

Streambank buffer needs were identified by Department staff during the inventory phase utilizing a two-fold process. Initial screening for cropland with less than 20 feet of existing buffer between the field edge and the streambank was carried out using high-resolution airphotos. Sites identified during this screening were then field validated. A 20 foot existing buffer width was chosen as these sites would then be the most critical to focus on As a result of this process 11 sites were identified as not having at least 20 of existing buffer.

During the inventory phase, the Soil Nutrient Application Planner (SNAP PLUS) computer program was used to calculate a number known as the **Phosphorus Index** (PI) for each crop field. The PI is an estimate of the amount of phosphorus that is leaving a crop field each year in pounds per acre. Using SNAP PLUS, the PI can be calculated as a yearly and/or a rotational value. For the purposes of this project the rotational PI was used. For each crop field, characteristics such as percent slope, slope length, distance to surface water as well as current management of a field must be collected along with tillage, crop rotation, yield goals, and applied nutrients such as commercial fertilizer, manure, and biosolids.

The data collected from both Otter Creek and Fisher Creek farmers for input into SNAP PLUS was gathered by Department staff and *John Nelson* of TNC thru on-farm interviews (see Appendix D for an example of the data sheets used for the on-farm interviews). Current soil test results (4 years old or newer) were also inputted into the SNAP PLUS program. Where current soil tests did not exist, *John Nelson* pulled soil samples that were subsequently analyzed by a state approved lab and the results inputted into SNAP PLUS.

The SNAP PLUS inventory summary for the Otter and Fisher Creek watersheds are shown in *Tables 2 & 3* respectively.

Table 2

FISHER CREEK PHOSPHORUS(P) INVENTORY		
TOTAL ACRES	3,971	
ACRES INVENTORIED	3,232	81% of cropland acres
TOTAL INVENTORIED P	9,286#	2.87 #/acre average cropland PI

Table 3

OTTER CREEK PHOSPHORUS(P) INVENTORY		
TOTAL ACRES	3018	
ACRES INVENTORIED	2900	96% of cropland acres
CROPLAND P	8243#	2.84 #/acre average cropland PI
DRYLOT P	188#	
PASTURE P	34#	
	8465#	
BARNYARD P	77#	
TOTAL INVENTORIED P	8542#	

The Fisher Creek drylots, pastures, and barnyards were not inventoried. The contribution of phosphorus to the watershed total from these sources was characterized by Department staff as being a rather small amount, similar to Otter Creek, which had only 3.5% of the inventoried phosphorus load coming from these sources.

The SNAP PLUS inventoried cropland phosphorus load was 8,243 pounds per year for an average PI of 2.8 pounds per acre per year. This was well under the state soil and water conservation standard of a maximum rotational PI of 6. Of the SNAP PLUS estimated phosphorus load, only 334 pounds, or 4% was coming from cropland with a PI over 6. Based on the SNAP PLUS inventory data, it was determined that *85% of the inventoried phosphorus load* was coming from land operated by 12 farmers. The SNAP PLUS inventoried load by source shows that 96% of the inventoried phosphorus is from cropland (**Table 4**). See **Appendix E** for maps showing the inventoried PI's for both the Otter and Fisher Creek watersheds.

Table 4

INVENTORIED SNAP PLUS PHOSPHORUS DELIVERY TO OTTER CREEK BY SOURCE	
SOURCE	**% OF TOTAL INVENTORIED PHOSPHORUS**
CROPLAND	96%
PASTURE	<1%
DRYLOTS	2%
BARNYARDS	1%

IMPLEMENTATION

The Otter Creek watershed portion of the inventory phase was completed in June of 2012. At the June 12, 2012 SRAP *Partner Group* meeting it was debated as to whether or not enough water quality base line data had been collected by the monitoring stations to warrant moving into the implementation phase in Otter Creek. Originally the plan was for conservation practice implementation to commence in 2013. It was concluded by the *Partner Group* that SCPCD staff should begin contracting with farmers to implement practices.

A strategy was recommended at the June 12, 2012 SRAP *Partner Group* meeting that SCPCD staff take a "whole farm" approach to reducing phosphorus runoff when working with Otter Creek farmers. This came from discussions with *Pat Sutter,* a Dane County Land and Water Conservation Department staff member that had worked on implementing the Pecatonica River Project. He felt we would have a greater likelihood of capturing phosphorus reductions from lower PI fields. (Otter Creek average watershed PI was (2.8#/acre/year). This seemed like a logical approach to SCPCD especially when practices like nutrient management are implemented on a "whole farm" basis. As was previously stated, the SNAP PLUS inventory data indicated that *85% of the inventoried phosphorus load* was coming from land operated by 12 farmers. The bulk of the implementation efforts were focused on land operated by these 12 farmers with additional outreach given to the remaining farmers as well.

By the fall of 2012, all of the landowners in Otter Creek had been contacted, and by October of that year the first two contracts for installation of conservation practices were signed. Conservation practices in Otter Creek were installed beginning in summer of 2013 with the last practices implemented by the summer of 2016.

In total, 11 farmers had implemented conservation practices in the Otter Creek watershed. Seven of the 12 farmers, with the highest total phosphorus loads, had implemented conservation practices. 590 nutrient management plans **(Figure 3)** were the most widely adapted practice in Otter Creek. At the time of the inventory, only 390 acres of cropland existed in the Otter Creek watershed that were operated under a 590 nutrient management plan After implementation there were 1,840 acres of cropland operated under a 590 nutrient management plan, an **increase of 1,450 acres or 370%**. Of these, five plans, totaling 1,198 acres were paid for through the project and achieved a SNAP PLUS phosphorus reduction of 755 pounds or 0.63 pounds/acre. See **Appendix D** for before and after implementation maps of 590 plan acres.

Figure 3

Following 590 nutrient management plans, the second most implemented practice in the project was grassed buffers **(Figure 4)**. A total of seven grassed buffers covering 6.6 acres were established on four farms. These 6.6 acres of buffers accounted for a phosphorus reduction of 132 pounds.

Figure 4

Intensive rotational grazing was implemented by one dairy farm as they transitioned their home farm from conventional dairying to grazing (Figures 5 & 6). Cattle lanes, fencing, water lines and waterers were installed. The transition to grazing accounted for a 136 pound phosphorus reduction. The county NRCS office was instrumental in making this project happen as they partnered with the Department on planning, construction, and cost sharing.

Figure 5

Figure 6

Shown below is a list of all of the practices implemented in Otter Creek through this project:

- **1,450 ACRES OF NUTRIENT MANAGEMENT PLANS**
- **56 ACRES OF CONSERVATION TILLAGE**
- **19 ACRES OF COVER CROPS**
- **4-GRASS WATERWAYS TOTALING 4,360 LINEAR FEET**
- **7-GRASS BUFFERS TOTALING 6.6 ACRES**
- **6,000 FEET OF PERMANENT PASTURE & LANE FENCE**
- **6,900 FEET OF CATTLE WATER PIPELINE**
- **1,380 LINEAR FEET OF CATTLE LANE**
- **1-PERMANENT CATTLE WATERER**
- **1-19 FOOT X 55 FOOT DENITRIFYING BIOREACTOR**
- **1-MILKHOUSE WASTE TREATMENT SYSTEM**

A total of 1201 pounds, or 15%, of phosphorus was reduced thru conservation practice implementation.

The most unique conservation practice implemented was a *denitrifying bioreactor* and **the first of its kind in Wisconsin**. The SRAP bioreactor reduces nitrate levels in drainage tile water thru bacterial action. Nitrates have long been known to play a key role in the Gulf of Mexico's hypoxia zone (dead zone); an area of little or no oxygen. While the thrust of the SRAP was to reduce phosphorus runoff, innovation was also a key component of the project so Department staff pushed for installation of a bioreactor. Already in use in all of the states surrounding Wisconsin, a bioreactor utilizes the denitrification process to strip the oxygen from the nitrate, eventually creating nitrogen gas. Naturally occurring bacteria carry out the denitrification using woody material as food and the nitrate oxygen for respiration.

The Department partnered with Matt Woodrow, DATCP Area Engineer, during the design and construction of the SRAP bioreactor. In designing the SRAP bioreactor a system design strategy from Iowa State University (ISU) was used. The basic design components are as follows: A water control box is installed on an existing drainage tile line and a smaller diverter pipe is installed perpendicular to the original tile; this diverter pipe is sized so that can it can carry up to 20% of the capacity of the original pipe. The diverter pipe delivers the nitrate laden water to the bark filled "bioreactor chamber"; the chamber is excavated and lined with plastic to keep seasonal soil water from entering the chamber and to keep the tile water from leaving the chamber before completing treatment. After the plastic liner is installed woody material is placed in the chamber. For the SRAP bioreactor a source of hardwood beech woodchips was sourced from a logging company in an adjoining county. After the bioreactor chamber is filled with wood chips, geotextile membrane is placed over the top of the wood chips. For the SRAP bioreactor, the membrane was then covered with 18 inches of soil, and seeded and mulched. As the water travels thru the woodchips, naturally occurring bacteria strip the oxygen molecules off of the nitrate and the nitrite rendering nitrogen gas which escapes to the atmosphere. The treated water leaves the bioreactor chamber and flows through the outlet water control box and then back into Otter

Creek via a non-perforated tile. The ISU design philosophy narrative and design worksheet are shown in **Appendix E** along with a plan view of the SRAP bioreactor.

Located on the Allen and Alyce Beeck farm, pictures of the SRAP bioreactor installation are shown below.

Site Prep Completed & Silt Fence Installed

Outlet Water Control Box & 4 Inch Outlet Pipe Installed

Excavated Bioreactor Chamber

Filling the Bioreactor with Woodchips

Capping the Bioreactor Chamber with Soil

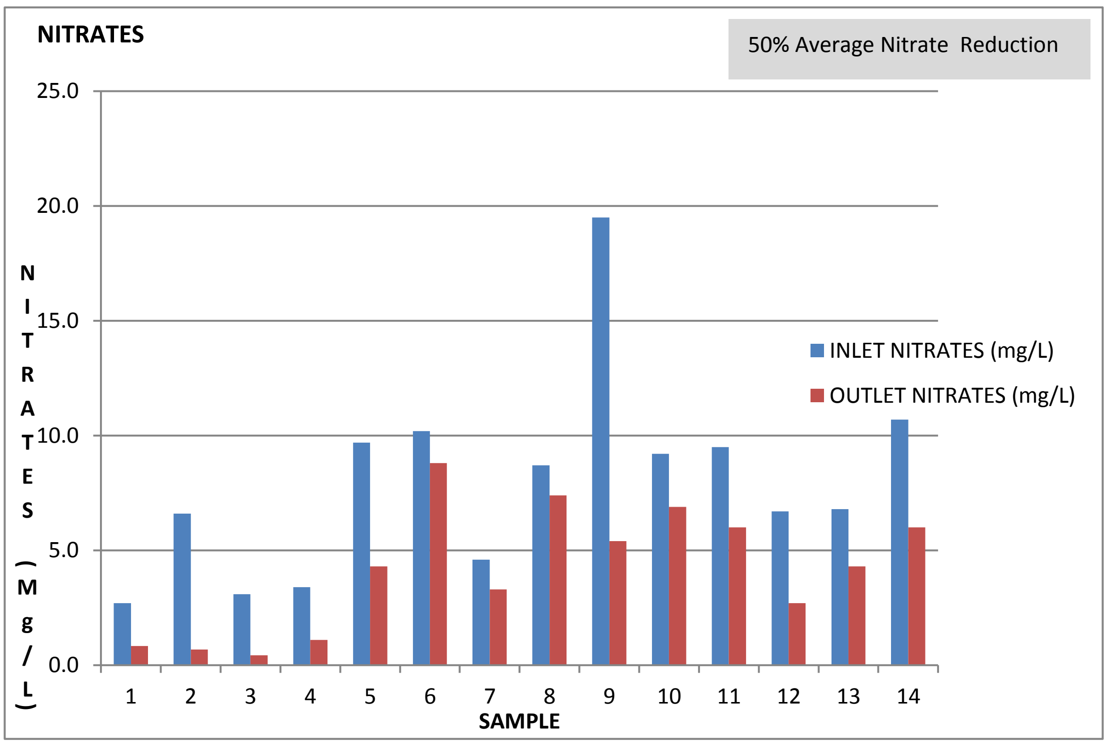
Completed Bioreactor with Boundary Fence

Bioreactor Sampling

Department staff began taking water samples at the bioreactor site in October of 2013. Water sampling was planned to done at least once a month in the time period between spring thaw and fall freeze-up. Additional sampling times were added, such as after a rainfall event that triggered a flow increase at the Otter Creek monitoring station lasting more than several hours. Samples were pulled from 3 locations each date of sampling. One sample was pulled from in the stream, upstream of the main bioreactor tile (reference sample), another sample was pulled from the bioreactor inlet water control structure (untreated sample), and the third sample was pulled from the bioreactor outlet water control structure (treated sample). Samples were delivered to a local state-certified laboratory for analysis, usually within an hour after being pulled. Three parameters were analyzed: Nitrates, Dissolved phosphorus, and Total Phosphorus.

By late September 2014, 14 sample runs had been analyzed. Figure 7 shows a graph of the nitrate levels from the 14 sample runs.

Figure 7

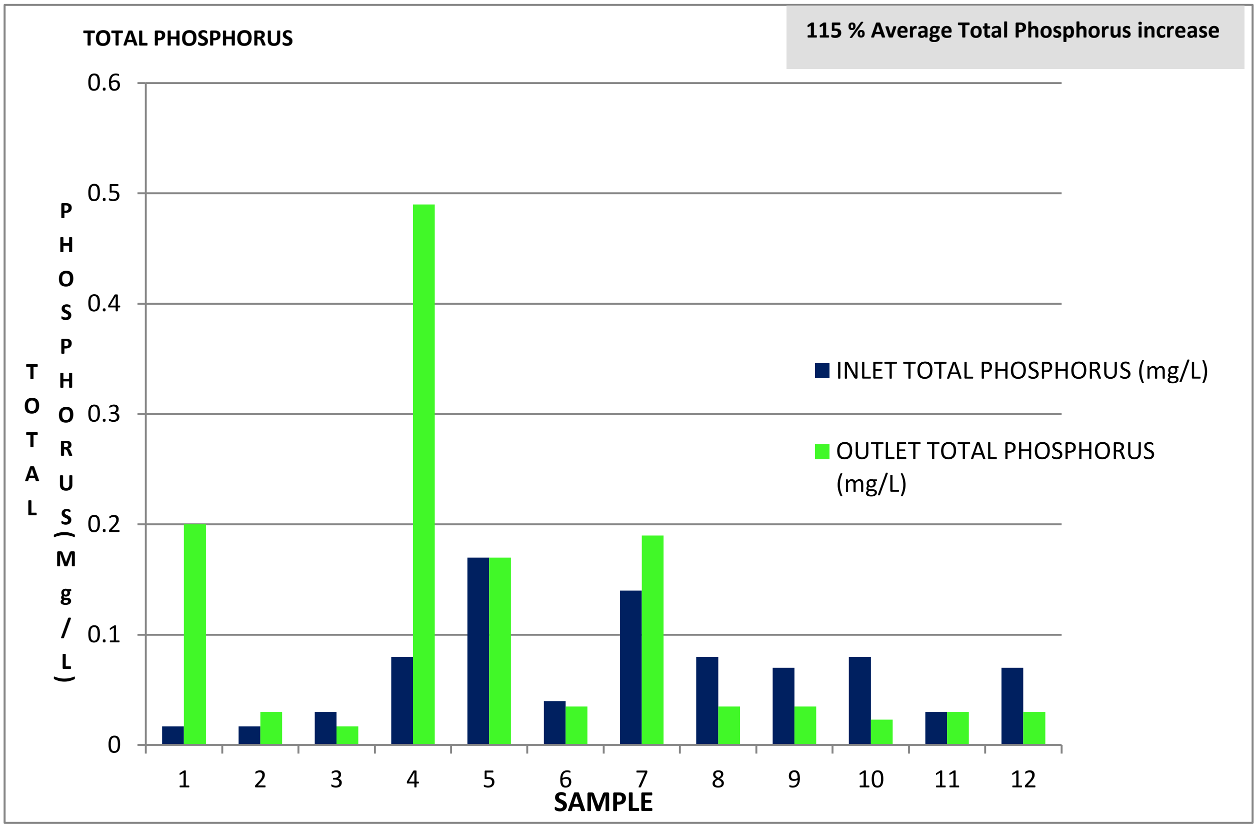


*Data derived from the SRAP bioreactor sampling is for information purposes only.

Taking an average of the 14 samples, **nitrate reduction averaged 50%** after flowing thru the bioreactor. The 50% nitrate reduction corresponded with a predicted 20%-70% reduction sited in a literature review of bioreactors installed in surrounding states previous to the SRAP bioreactor. Nitrate levels decreased in each of the 14 samples.

In regards to total phosphorus, the results from the water sampling were somewhat mixed. The total phosphorus concentrations in the tile water were very low, < 0.035 mg/L, which was the detection level calibrated by the laboratory used. It took until November of 2015 to obtain 12 samples that were above < 0.035 mg/L. **Figure 8** is a graph showing the 8 samples and the Total Phosphorus results.

Figure 8



*Data derived from the SRAP bioreactor does not adhere to the strict protocol of a scientific study. For information purposes only.

Taking the average of the 8 samples, the Total Phosphorus concentration increased an average of 115% by flowing thru the bioreactor. However, in 8 of the 12 samples, Total Phosphorus levels went down or stayed the same. In the other 3 samples the Total phosphorus levels increased dramatically. Taken as a whole the SRAP bioreactor appears to increase net Total phosphorus though more study would be needed to confirm this conclusion.

Another significant undertaking that occurred during the course of the SRAP was **cover crop research.** Dennis and Dan Roehrborn have cropland within and adjacent to the Otter Creek watershed. The Roehborns had been utilizing Tillage Radish© for several years as a cover crop when they were approached by Michael Ballweg, UW-Extension Sheboygan County Crops and Soils Agent, to see if they would be one of three farms to participate in UW-Extension research on Tillage Radish©. Originally developed in the climate and soils of the northeastern United States, not much was known as to its performance in the Wisconsin climate, and more specifically, how it would do in heavy Kewaunee "red clay" soils of east central Wisconsin. The Roehrborns agreed and were one of three sites to host the research. The other two sites were in Washington and Rock counties.

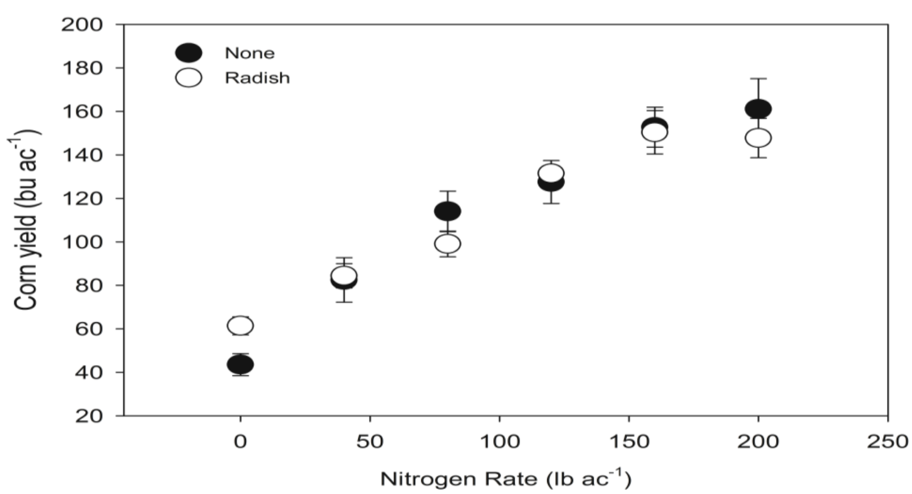
The Tillage Radish© research project spanned three years (2012-2014) in which Tillage Radish© was planted after winter wheat harvest with varying nitrogen rates at the time of radish planting. **Figure 9** is an example of the research results derived from the 3 farm research sites. It shows corn yields at various N rates following Tillage Radish© compared to no cover crop at 9 site years in Sheboygan, Washington, and Rock counties. Several tours and a field day were held over the course of the research project to explain the research to SRAP partners and area farmers.

The data shown in **Figure 9** illustrates that there was no corn yield difference and no nitrogen credit the following spring from the Tillage Radish ©cover crop vs. no cover crop scenarios. The Tillage Radish©, having been planted in late summer after the winter wheat harvest, had good biomass production both above and below ground before the onset of winter. However, due to the high water content of the Tillage Radish©, there was little or no residue left by spring planting time and whatever nitrogen the plant had taken up in the fall growth period had been released during decomposition in winter and early spring.

Figure 9

Cover crop – Tillage Radish©

Cover crop - none



Source: Research conducted by Matt Ruark (UW-Madison & Extension Soil Scientist), Michael Ballweg (UW-Extension Crops & Soils Agent, Sheboygan County), Richard Proost (UW-Madison, Nutrient & Pest Management Program), Megan Chawner (UW-Madison graduate student)

Figure 10 shows Tillage Radish© biomass harvest.

Figure 10

Michael Ballweg

As a result of the Tillage Radish© research, the question was posed whether or not a different cover crop would suit the growing conditions of southeast Wisconsin and provide a corn yield bump and nitrogen credit as well. Starting in 2013 and continuing thru the 2016 growing season, the Roehrborns again partnered with UW-Extension to conduct research on their farm. This research compared the performance of **Berseem clover, Crimson clover, and Barley** respectively as cover crops. The study utilized 8 nitrogen application rates from 0 lbs. N/acre to 280 lbs. N/acre (Michael Ballweg, UW-Extension Crops & Soils Agent, Sheboygan County). 2015 corn yields showed a *yield increase of 9%* following Berseem and Crimson clovers compared to no-cover crop and a 23% advantage when compared with corn following barley. These yield comparisons were averaged across all nitrogen rates except the zero N rate.

Figure 11

Berseem clover

Figure 12

Crimson clover

Michael Ballweg photos

Collaborating with NRCS and UW-Extension, the Roehrborns hosted several well-attended field days/tours during the research project whereby other farmers and agency staff got to see firsthand some of the research plots and learn about the results. A scientific paper is being developed as a result of the research. The abstract of the research paper is included in **Appendix F**.

DISCUSSION AND CONCLUSION

The Sheboygan River Agricultural Project (SRAP) was successful in targeting high phosphorus fields which was one of the key goals of the project. Additionally, based on the SNAP PLUS inventory data, it was determined that *85% of the inventoried phosphorus load* was coming from land operated by 12 farmers and the SRAP partners committee felt that engaging these 12 farmers was also an important goal. As a result of implementation efforts:

- 15 out of 18 fields (83%) with an inventoried PI $\geq$ 6 had conservation practices implemented.
- Of the 12 farmers with the highest total inventoried phosphorus load, 9 farmers (75%) implemented conservation practices.
- 1,201 pounds (15%) of modeled phosphorus load was reduced by all of the implemented conservation practices.

The SRAP was a project that was supposed to "think outside the box" and did so by installing Wisconsin's first denitrifying bioreactor. The SRAP bioreactor was successful in reducing tile water nitrate concentrations by an average of 50%.

There has been a recent emphasis nationwide regarding "soil health." Cover crops can play a major role in improving soil heath by providing erosion reduction, improving soil structure, and increase organic matter content. It is important to point out that two cover crop research projects were carried out during the SRAP. These two research projects looked at the suitability of Tillage Radish© and several clover varieties along with barley as cover crops in east-central Wisconsin climate and soils. The two research projects mentioned above provide information to help Wisconsin farmers examine how cover crops will work on their farms.

Another area of success for the SRAP was the emphasis of focusing mainly on cropland phosphorus runoff reductions. The Otter Creek watershed had been part of the Sheboygan River Priority Watershed Project (SRPWP) during the 1990s. That project's emphasis had been on reducing manure runoff. The farmers in the Otter Creek portion of the SRPWP had implemented many barnyard runoff control projects and constructed two manure storage structures. Only one farm at the time of the SRAP inventory had livestock with access to Otter Creek. The SRAP was successful in targeting cropland runoff reductions in that only one non-cropland conservation practice (milk house waste control) was implemented.

The amount of cost share dollars spent to implement conservation practices was $122,600. When dividing by the 1,201 pounds of phosphorus reduced, the cost sharing spent per pound reduced was $102. The amount of Department staff dollars spent on inventory and implementation was $88,200. The staff dollars spent per pound of phosphorus reduced was $73. Taken together the total cost per pound of phosphorus reduced was $175. This amount is significantly higher than the $50/pound of phosphorus being offered through the Multi-Discharger Variance. It is also significantly higher than the amount being used for looking at potential TMDL, Adaptive Management and Pollutant Trading projects.

Before the SRAP inventory was conducted there was a hypothesis that like the Pecatonica River Project (a previous WBI project), a few high PI fields were contributing a large share of the phosphorus load. However, the inventory data did not concur with this hypothesis. Unlike the Pecatonica River Project where 12% of the inventoried area was over a PI of 6 and contributing 60% of the phosphorus load, Otter Creek had only 2% of the inventoried area over a PI of 6 and contributed only 6% of the phosphorus load. As a result of the paired watershed monitoring between Otter Creek (implementation watershed) and Fisher Creek (control watershed), the USGS determined that it would take between a 40% and 50% reduction in *modeled* phosphorus reductions before a reduction would be evident in the water at the Otter Creek monitoring station. An analysis of the SNAP PLUS inventory results performed by the SCPCD utilizing decreasing target PI's for Otter Creek crop fields showed that even if all inventoried fields with a PI above 2 were reduced down to a 2, the mass reduction in phosphorus would be a 3,003 lbs or a 36% reduction in modeled phosphorus. This equates to one-third the state performance standard of a 6 PI and it still would not achieve the minimum modeled reduction needed to see a phosphorus reduction in the water.

It is important to note that every watershed setting has its own unique blend of nonpoint pollution sources and a person cannot make too many assumptions as to the magnitude of each source until an inventory is completed. One watershed may have a high number of untreated cattle lots, numerous sites where cattle have access to watershed streams, and relatively steep cropland slopes. The next watershed may have few cattle lots, few sites where cattle have access to watershed streams, and gently rolling cropland. Goals should be set after a thorough inventory is completed with careful attention given to what the inventory results are and what the current water quality conditions are in order to establish achievable goals for a project. When it comes to nonpoint pollution reduction, the temptation may be to use a "one size fits all" template, but this philosophy ignores the blend of agricultural and landscape, as well as the surface water aspects that make each watershed unique.

APPENDICES

APPENDIX A

Otter Creek Paired Watershed Study Partners Meeting 2/24/2016

US Geological Survey Stream Gaging and Water Quality Monitoring Summary for 2015

Narrative Summary for Otter Creek, 2015:

2015 was a drier year than 2014. The average flow rate in 2015 was 5.7 cfs, compared to 7.7 cfs in 2014.

There were 6 events in 2015, compared to 16 events in 2014.

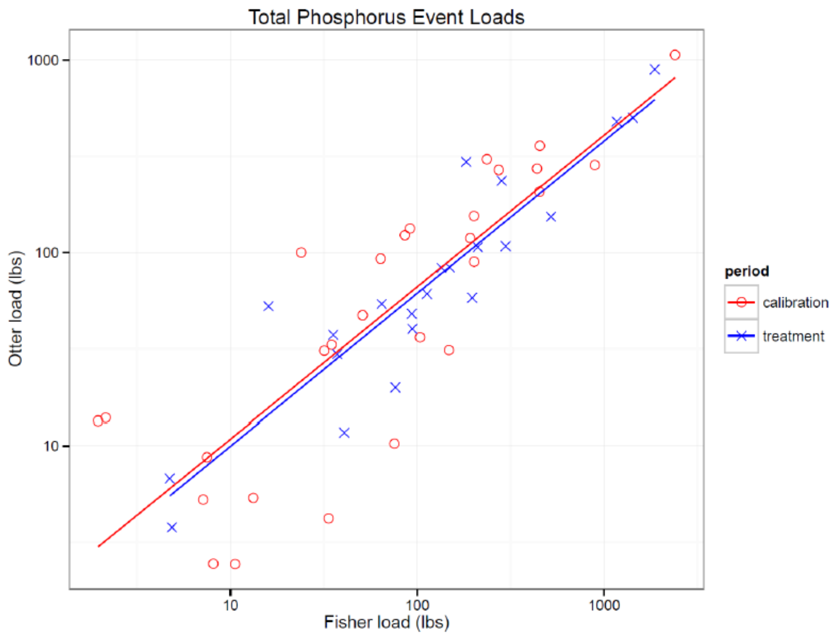
The largest event in 2015 was on April 9th and 10th. The rain gage at the outlet of Otter Creek measured 1.25 inches; an additional 0.5 inches fell in the 2 days prior to the event but didn't result in a stage rise. At the peak Otter was running at 121 cfs. For comparison, the highest peak flow ever measured at Otter was 327 cfs in April, 2013.

The total suspended sediment load for this event was 148 tons. Suspended sediment load for the year was 300 tons, so ~49% of the 2015 water year's annual sediment load washed through the system in two days. For the same event, the total phosphorus load was 500 pounds. This was ~30% of the annual total phosphorus load (~1,700 pounds annual load).

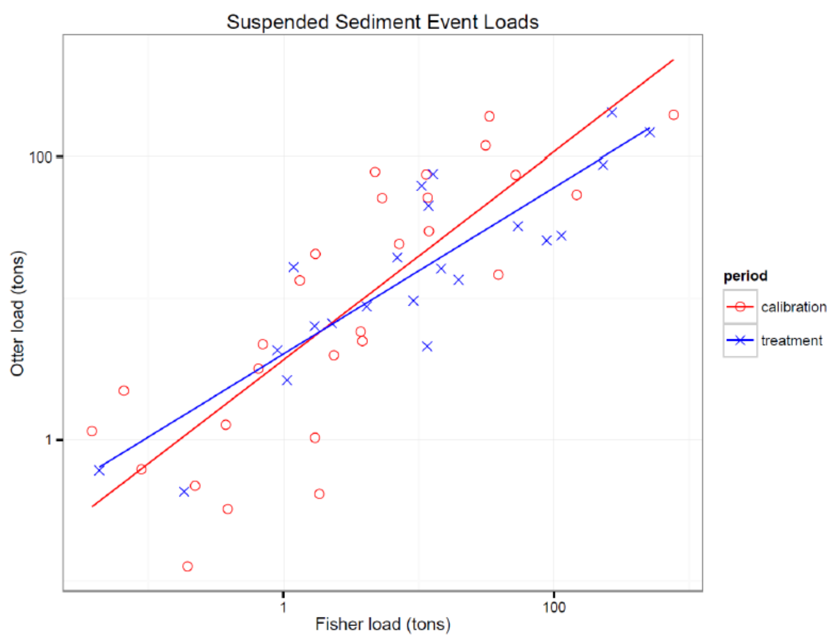
Otter Creek	July 2011-Sept 2013	October 2012 - September 2013	October 2013 - September 2014*	October 2014 - September 2015*
• Average Daily Flow				
– Max	65	201	186	60
– Mean	4.9	8.88	7.74	5.7
– Min	1.3	1.8	1.7	1.1
• TP Concentration [mg/L]				
– Max	0.91	0.88	0.69	1.15
– Mean	0.12	0.08	0.1	0.09
– Min	0.04	0.03	0.05	0.05
• Daily TP Load [lbs]				
– Max	321	719	556	327
– Mean	7.1	9.3	9.8	4.7
– Min	0.56	0.43	0.49	0.62
– Total	3,257	3,420	3568	1708
• Daily SS Load [tons]				
– Max	152	132	100	108
– Mean	2	1.8	2.19	0.83
– Min	0.02	0.01	0.01	0.03
– Total	941	651	800	300

*Some data are provisional and may change

Paired Watershed Analysis:



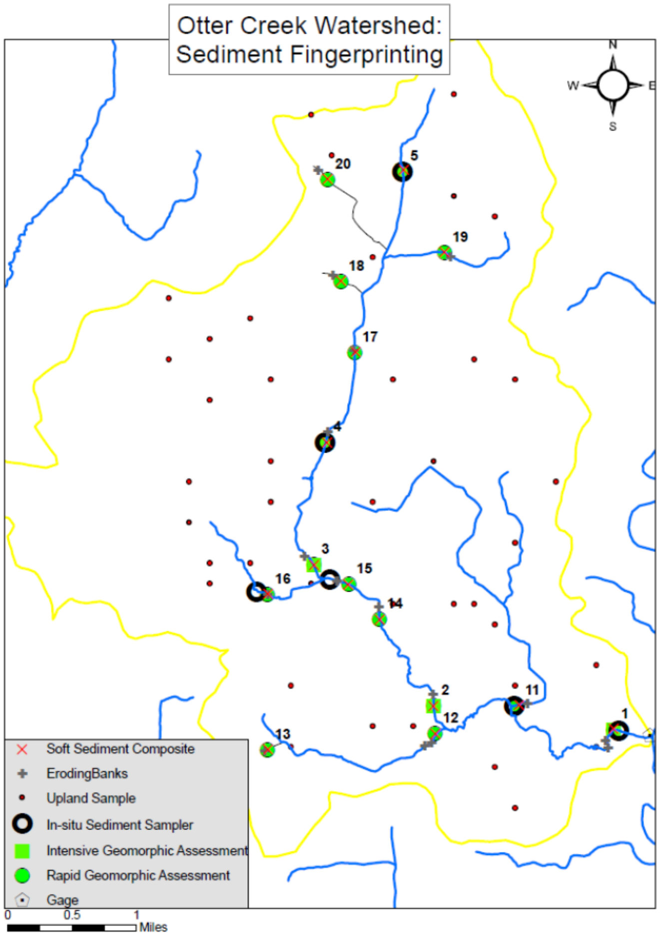
There is no observed difference in event total phosphorus loads between calibration (July 2011-September 2013) and treatment periods (October 2013-September 2015). There would need to be a 35% average decrease in loads for the difference to be statistically significant.



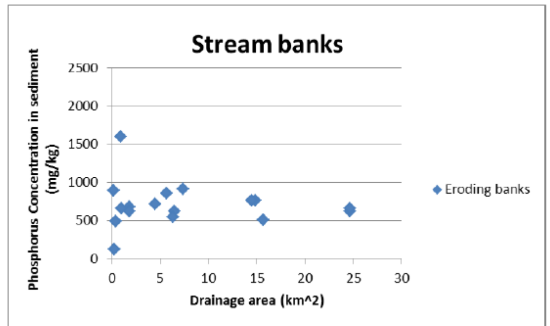
There is no observed difference in event suspended sediment loads between calibration and treatment periods. There would need to be a 50% average decrease in loads for the difference to be statistically significant. The slopes of these two lines are not statistically different either, but it does show the larger events at Otter Creek during the treatment period tend to have less sediment than in the calibration period.

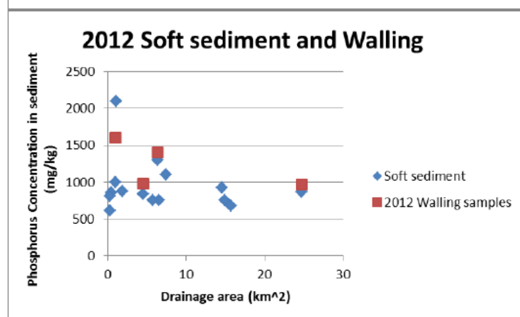
APPENDIX B

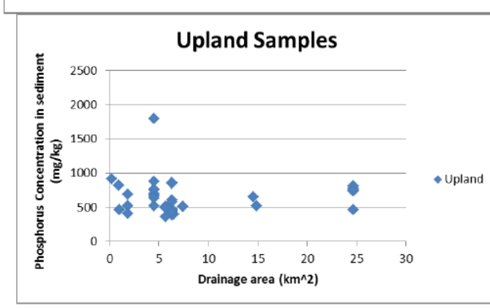
Sheboygan WBI Geomorphology Update May 2015
(Faith Fitzpatrick, USGS WI WSC fafitzpa@usgs.gov)



Otter Creek P Data







Currently working on:

- Sediment fingerprinting and apportionment
  - Having trouble distinguishing upland sources from banks in Otter Creek watershed, doing further data analyses
- Final 2012 sediment and P watershed budgets
  - Site comparison and QA to 2013/14 revisits
- EPA manual on sediment fingerprinting and budgets (region 3 and 5)
- Journal article of sediment budget/fingerprinting (prei-implementation)

APPENDIX C

Table 1. Scores, Fish IBIs, Macroinvertebrate IBIs (MIBI), and Stream Habitat Ratings for sites on Otter and Fisher Creeks before (2011) and after (2015 & 2016) implementation of BMPs within Otter Creek watershed.

	Fish IBI				MIBI				Habitat Rating			
	2011		2016		2011		2015		2011		2016	
Site #	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating
OC 01	90	Excellent	70	Excellent	5.07	Good	6.19	Good	68	Good	68	Good
OC 02	50	Fair	80	Good	5.93	Good	6.25	Good	55	Good	63	Good
OC 03	30	Poor	40	Fair	4.36	Fair	4.14	Fair	40	Fair	45	Fair
OC 04	40	Fair	40	Fair	4.8	Fair	5.52	Good	50	Good	45	Good
OC 05	80	Good	60	Fair	3.68	Fair	4.1	Fair	73	Good	68	Good
OC 06	0	Poor	70	Good	4.71	Fair	4.93	Fair	55	Good	63	Good
FC 01	100	Excellent	80	Good	2.81	Fair	5.98	Good	68	Good	68	Good
FC 02	50	Fair	80	Good	2.32	Poor	4.47	Fair	60	Good	58	Good
FC 03	50	Fair	40	Fair	3.57	Fair	3.86	Fair	48	Fair	72	Good
FC 04	70	Good	80	Good	4.43	Fair	4.09	Fair	55	Good	30	Fair
FC 05	50	Fair	20	Poor	0.2	Poor	3.36	Fair	78	Excellent	63	Good

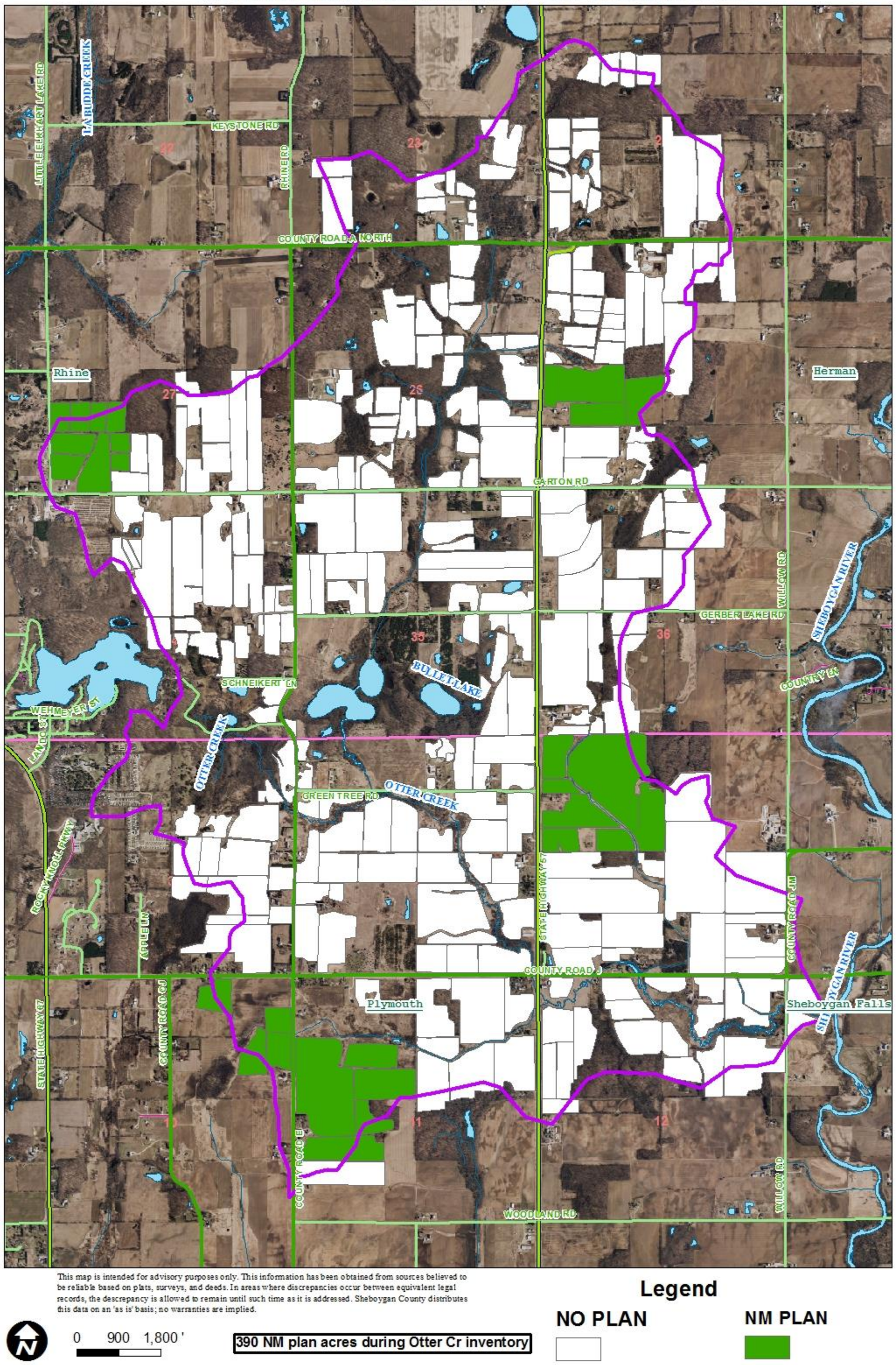
Table 2. Individual fish species from all sample sites within Otter and Fisher Creek watersheds during 2011 and 2016.

Species	OC 01		OC 02		OC 03		0C 04		0C 05		0C 06		FC 01		FC 02		FC 03		FC 04		FC 05	
	2011	2016	2011	2016	2011	2016	2011	2016	2011	2016	2011	2016	2011	2016	2011	2016	2011	2016	2011	2016	2011	2016
Black Bullhead	1						2		1													
Blackside Darter	1	6	1	1									1						3			
Bluegill							2			2												
Bluntnose Minnow	11	1																				
Brook Stickleback		4							1	2		9	3	22	1	137	12	72	4	162		
Central Mudminnow							17	2	17	1	3		87	103	15	20	33	60	24	24	60	5
Central Stoneroller									1				2	1								
Coho Salmon																		1				
Creek Chub	132	356	48	38	2	5	11	22	29	23			14	53	1	29	1	10	17	168	25	32
Common Shiner	173	60							49				99	20	19				44	6	10	

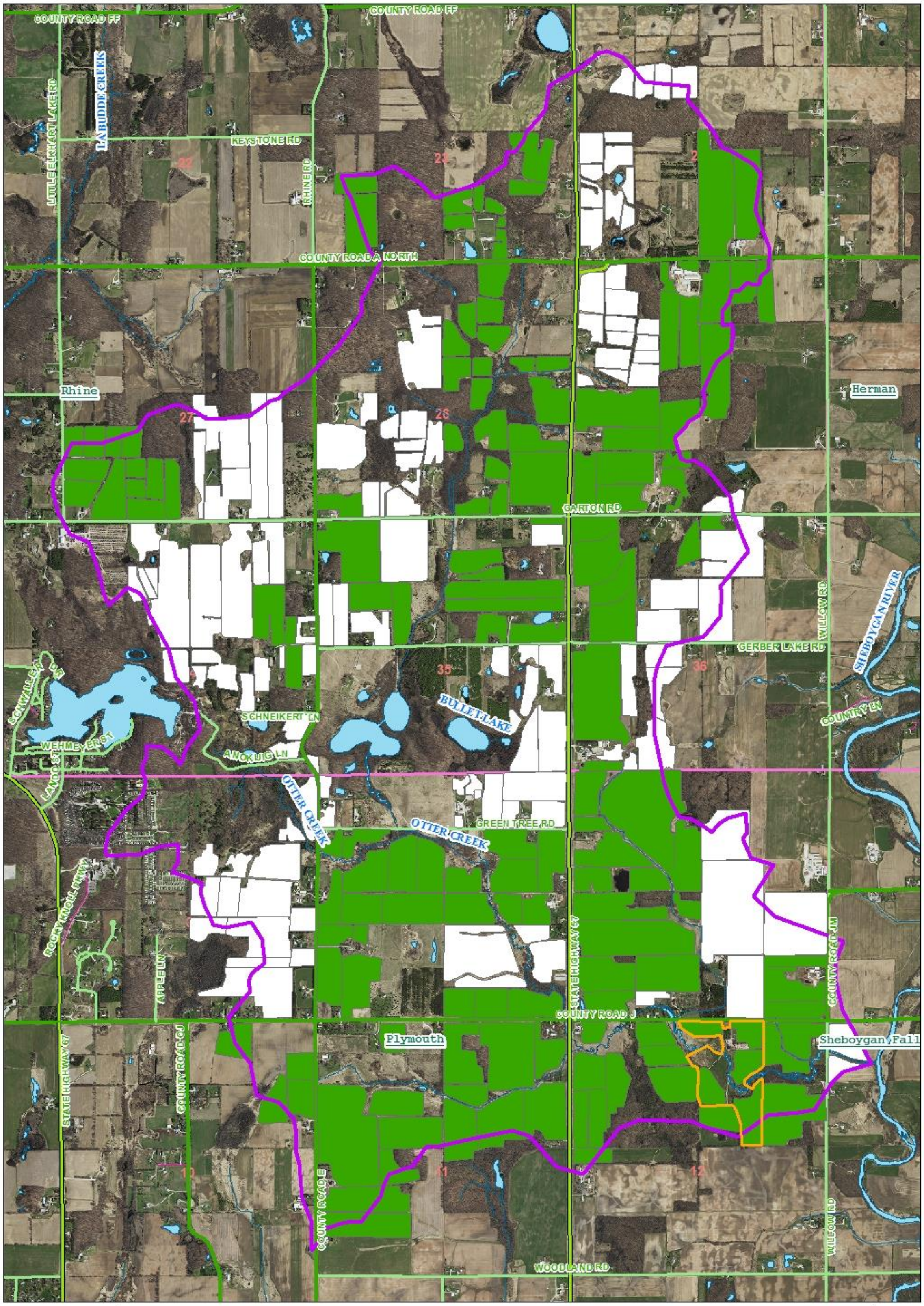
Fathead Minnow		3							6	1		3	2		37		8		3	16	10	
Green Sunfish	3		1		1		9				2	3		4	4	1	1	4	1			
Hornyhead Chub	17	7											8	2					1	4		
Johnny Darter	22	59	9	37		13	3	4	14	10			5	8	3	79		6	15	70	1	7
Largemouth Bass							1															
Longnose Dace	24	24	11	14	1	4		1														
Northern Pike	1																					
Northern Redbelly Dace												1										
Pearl Dace												1										
Pumkinseed Sunfish			2	1			13		1	1												
Rock Bass													1									
Round Goby														2						54		
Smallmouth Bass	7	22		1																		
Western Blacknose Dace	9	66	9	13	2	1		2					4	9	2	4			17	25	6	
White Sucker	20	170		11				1	12	4			3	3	3	1			7	29	1	4
Yellow Bullhead	1	1																				
Total Number of Fish	422	779	81	116	6	23	58	32	131	44	5	17	229	227	85	271	55	153	136	558	113	48
Number Individual Species	14	13	7	8	4	4	8	6	10	8	2	5	12	11	9	7	5	6	11	10	7	4
IBI Scores	90	70	50	80	30	40	40	40	80	60	0	70	100	80	50	80	50	40	70	80	50	20
IBI Ratings	Excellent	Excellent	Fair	Good	Poor	Fair	Fair	Fair	Good	Fair	Poor	Good	Excellent	Good	Fair	Good	Fair	Fair	Good	Good	Fair	Poor

APPENDIX D

OTTER CREEK NUTRIENT MANAGEMENT PLAN DURING INVENTORY



OTTER CREEK WATERSHED NUTRIENT MANAGEMENT FIELDS AS OF 2016



1823 Current NM plan acres - 390 NM plan acres during the inventory= A 1,433 acre or 367% increase

This map is intended for advisory purposes only. This information has been obtained from sources believed to be reliable based on plats, surveys, and deeds. In areas where discrepancies occur between equivalent legal records, the descrepancy is allowed to remain until such time as it is addressed. Sheboygan County distributes this data on an 'as is' basis; no warranties are implied.

0 900 1,800 '

Legend

NO PLAN

NM PLAN

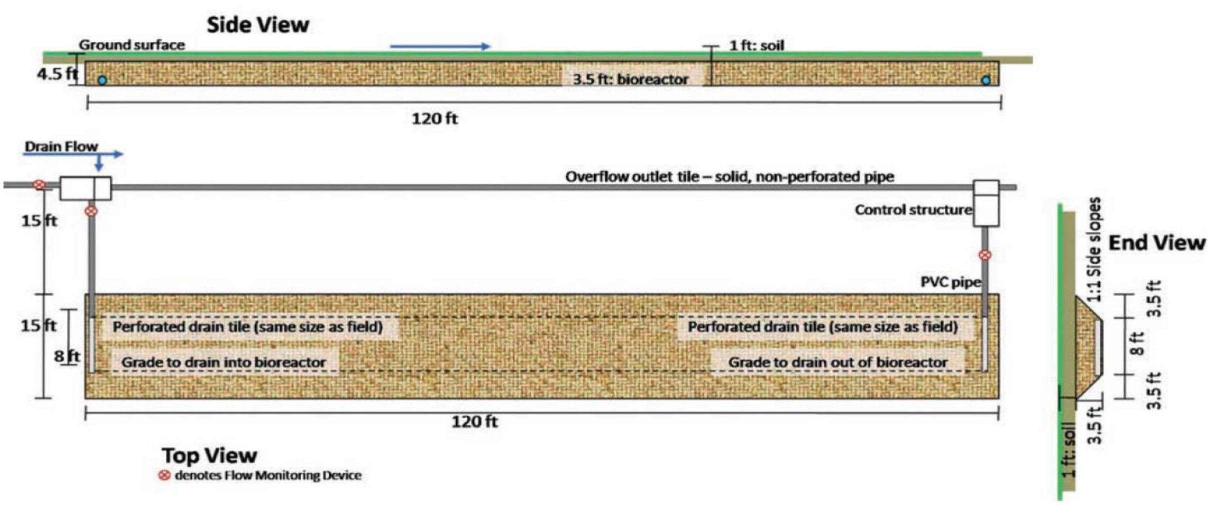
APPENDIX E

Iowa State University Bioreactor Design Philosophy

The Iowa template is based on treating a percentage of the maximum potential flow of the tile outlet pipe (depending on the diameter, slope and material of the drainage pipe) for a certain residence time. Residence time is estimated using the design inlet flow, the head drop between the upstream and the downstream control structures and the hydraulic conductivity of the media (typically woodchips) in the reactor. These quantities are normally known or can be determined using information about the tile system design and the topography where the bioreactor is to be installed. The hydraulic conductivity of the woodchips, however, is based on lab-scale testing of similar woodchips in Iowa. After defining these input parameters, the dimensions of the bioreactor are iteratively determined based on the desired residence time of the water in the reactor and the percentage of peak flow (i.e. the tile line is full) that should be treated. The chosen percentage of peak flow treated and hydraulic residence times are a balancing act among nitrate removal performance, practical and economic decisions (land area required, volume of excavation and woodchips needed, cost, level of management required, etc.) and avoidance of possible negative side effects (nitrous oxide emissions or methylation of mercury from the woodchips). Fine-tuning the design criteria is an area of continuing research. The currently recommended design criteria in Iowa are treatment of 20% of the peak flow at a retention time of 4-8 hours.

Source: South Dakota State University "Baltic, SD Bioreactor Overview"

Design Considerations



- ✓Tile Size
- ✓Tile Grade
- ✓Tile Depth
- ✓Available Land
- ✓Porosity of Fill Material
- ✓Fill Hydraulic Conductivity
- ✓Allowable Head Drop
- ✓% Peak Flow Accommodation
- ✓Retention Time @ Peak Flow

Source: Alok Bhandari-Ph.D., P.E., Iowa State University; Keegan Kult-Iowa Soybean Association "Denitrifying Drainage Bioreactors-Woodchip Bioreactors"

Design Considerations

Subsurface Drainage Bioreactor Design

Developed by M. Helmers, ABE Iowa State Unviersity

Instructions: Enter values in gray cells

Field Information:	
Tile Size (in)	6
Tile Grade (%)	1
Dual Wall	no
Velocity in Pipe (ft/s)	2.48
Peak Flow from Tile Size (cfs)	0.49
Media Information:	
Conductivity of Wood Media (ft/s) (K)	0.26
Porosity of Wood (ρ)	0.7
Bioreactor Inputs and Calculations:	
Flow Length (ft) (L)	120
Trench Width (ft) (W)	23
Depth of Trench below Inlet (ft) (d_t)	0
Head Drop (ft) (ΔH)	2
Flow Depth (ft) (d)	1
Hydraulic Gradient (i)	0.016667
Results:	
Bioreactor Flow Rate (cfs) (Q)	0.10
Hydraulic Retention Time (hours) (HRT)	**5.4**
% of peak flow that can be passed through bioreactor	**20.4**

15

Source: Alok Bhandari-Ph.D., P.E., Iowa State University; Keegan Kult-Iowa Soybean Association "Denitrifying Drainage Bioreactors-Woodchip Bioreactors"

APPENDIX F

Berseem Clover (Trifolium Alexandrinum), Crismon Clover (Trifolium Incarnatum) and Barley (Hordeum Valgare L.) Planted as Cover Crops Following Shorter Growing Season Crops in Wisconsin

Michael Ballweg[1], Matthew Ruark[2], Jamie West[3], Richard Proost[4]

Abstract
The benefit of using legumes in crop rotations is well established. This study explores a cover crop system utilizing annual clovers in Wisconsin that takes advantage of shorter season crops (i.e. winter wheat, vegetable crops), to enhance rotational impacts, to provide nitrogen credits to the next year's crop, and to grow additional biomass that potentially can provide a late season forage crop. Approximately 40% of annual precipitation and Growing Degree Days occur after August 1st in Wisconsin.

This study addresses four questions: (1) What dry matter (DM) yields can be obtained from Berseem Clover (Trifolium alexandrinum), Crimson Clover (Trifolium incarnatum) and Barley (Hordeum valgare L.) when planted following winter wheat in early to mid-August? (2) What nitrogen credit might be obtained from Berseem and Crimson clovers? (3) How well do these cover crops scavenge nitrates from the soil profile? (4) What are the potential late season uses of annual clovers for grazing, stockpiling or harvesting as forage?

Dry Matter yields from 2013 – 2015, showed that Berseem Clover yields ranged from 2.68 to 1.2 Tons/DM/Acre, averaging yields of 1.7 Tons/DM/Acre. Crimson Clover yields ranged from 3.32 to 1.06 Tons/DM/Acre averaging 1.8 Tons/DM/Acre. Barley yields from 2014 – 2015 ranged from 1.76 to 1.30 Tons/DM/Acre averaging 1.53 Tons/DM/Acre.

2015 corn yields showed a yield response of 9% following the Berseem and Crimson Clovers compared to no-cover crop and a 23% advantage when compared with corn following barley. These yield comparisons were averaged across all nitrogen rates except the zero N rate. The study utilized 8 nitrogen rates from 0 lbs. N/acre to 280 lbs. N/acre.

For more information contact: Mike Ballweg, UW-Extension Crops and Soils Agent, Sheboygan County at (920) 459-5910 or michael.ballweg@ces.uwex.edu.

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2 Matthew Ruark, UW-Madison & Extension Soil Scientist
3 Jamie West, UW-Madison Soil Science Research Specialist
4 Richard Proost, UW-Madison, Nutrient & Pest Management Program