Long Lake Watershed
Soil Fertility and Phosphorus Index Assessment
December 2015
Polk County Land and Water Resources Department

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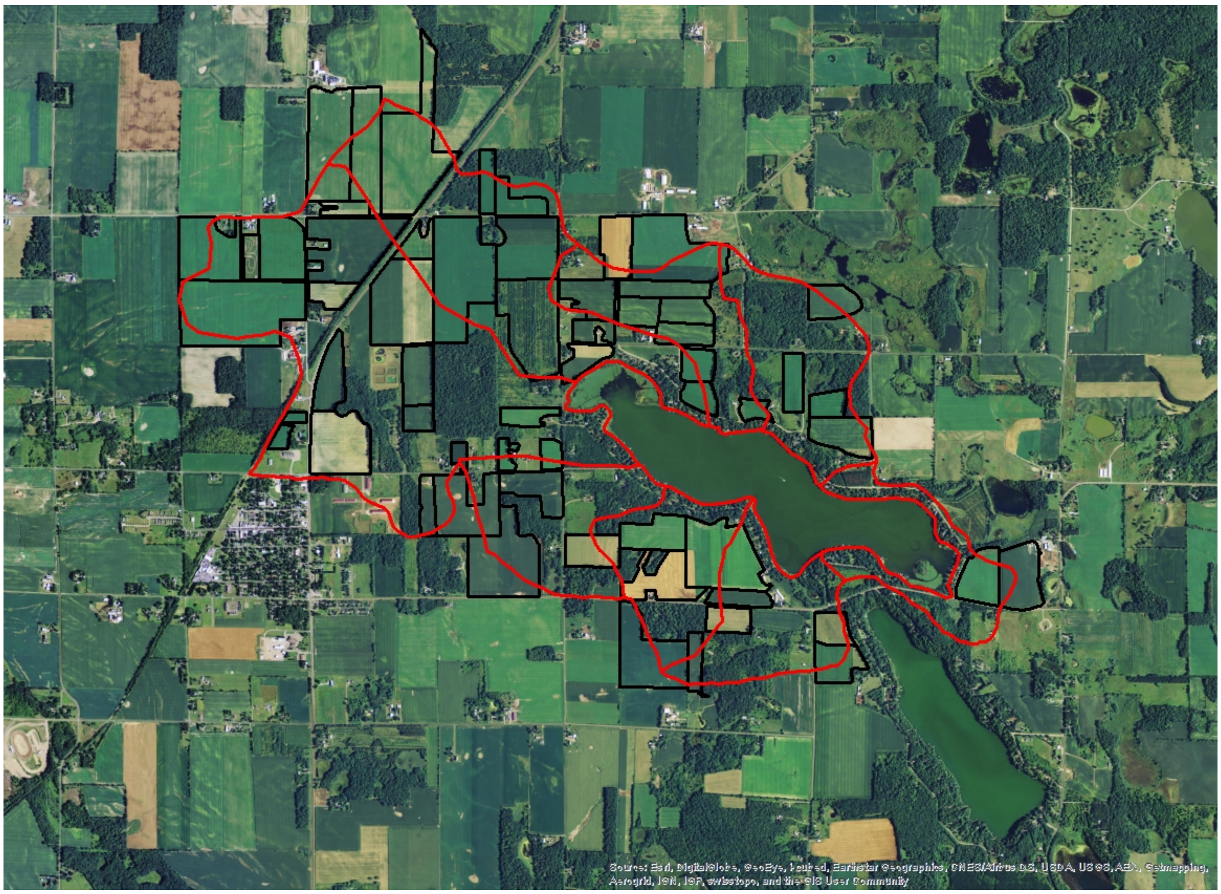


Project Overview

The Polk County Land & Water Resources Department (LWRD) conducted this evaluation to quantify the amount of phosphorus delivery from agriculture land uses to Long Lake at the request of the Long Lake Protection and Rehabilitation District. This project's objective was to work with the agricultural community to gather cropland soil test data, model estimated phosphorus delivery from fields, identify areas of concern, and identify strategies to reduce nutrient runoff from non-point sources in the watershed.

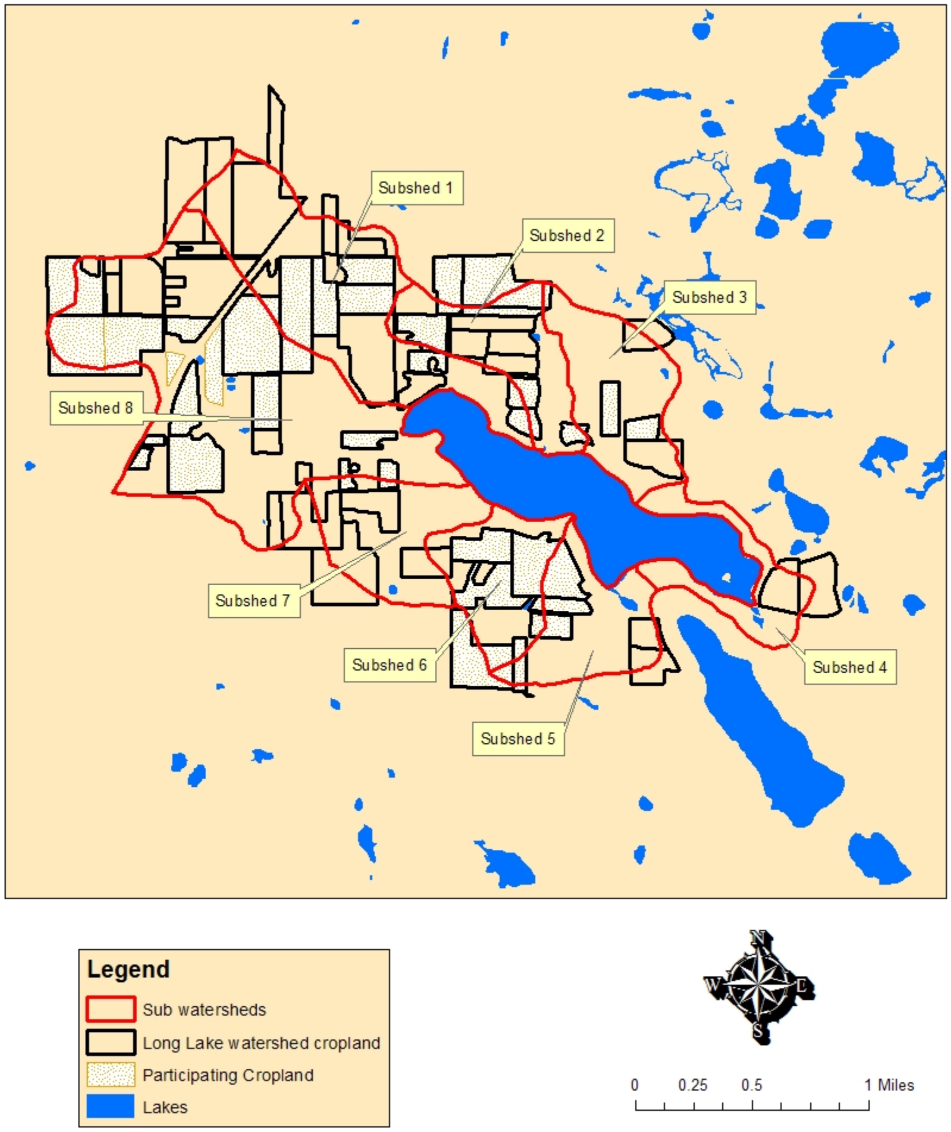


Figure 1

Project Area

The Long Lake watershed encompasses 2,343 acres (Figure 1). There is a diverse mix of land use in the watershed. Agriculture makes up 46% of the land use within the watershed. Row crop production makes up the majority of the farming practices within the project area. Dairy operations that were once common within the watershed have declined. However, there is still a presence of dairy farming, with two active dairy farms within the watershed, and three more that farm land within the watershed. Livestock from both operations do have access to pasture within the watershed project area. Manure applications are made to many of the fields within the watershed area. Poultry and dairy manure make up the majority of the manure applied within the watershed. Small hobby beef and/or horse operations do exist in the watershed, but these operations were not inventoried.

The Long Lake watershed is made up of eight sub watersheds (Figure 1). Polk County LWRD worked to gather as much soil fertility information from fields within each sub watershed in an effort to provide a representative sample of the entire watershed.

Methods

Collection of soil sample and crop management information for modeling estimates was the main focus of the project. With field soil tests, crop rotation, plant nutrient applications, and tillage system information, Polk County LWRD was able to determine an estimated Phosphorus Index (P Index) and soil loss for each field and averages for each watershed. The P Index is an estimate of a field's potential to deliver nutrients to the edge of the field and possibly beyond to surface waters. This value represents pounds of phosphorus delivered off the field per acre of cropland, per year.

Soil loss was calculated with an equation known as the Revised Universal Soil Loss Equation (RUSLE 2) (Figure 2). This equation produces a numeric value in tons of soil lost per acre, per year. RUSLE 2 uses factors such as soil type, slope steepness, slope length, tillage system, and other variables to calculate soil loss. All soils have an estimated amount of soil they can lose annually and still maintain productivity. This value is called "T" or tolerable soil loss. The RUSLE 2 equation produces a value (A) that can be compared to "T" to determine the rate at which soil is eroding. This calculation is helpful in evaluating phosphorus delivery because phosphorus bonds very strongly to soil particles. Therefore, if a producer minimizes soil erosion, phosphorus delivery off the field is also minimized.

Universal Soil Loss Equation

A = R K L S C P

- R - rainfall and runoff;
- K - soil erodibility;
- L - slope length;
- S -slope steepness;
- C - cover and management;
- P - support practice

~Equation used by SNAP Plus to calculate soil loss in this project

Figure 2 – Revised Universal Soil Loss Equation

To determine field P Indexes and soil loss values, all soil test information was entered into the Soil and Nutrient Application Planning software (SNAP Plus). SNAP Plus is a program that estimates P Index and soil loss per field using field characteristics, soil test analysis, crop rotation, and commercial or organic nutrient application information. This program requires a significant amount of information about the fields and the operation that must be obtained from the producer. Much of the information was collected by LWRD staff at farm visits interviewing agriculture producers in the watershed to obtain as much information to represent real management practices.

During the course of the project 14 agricultural producers were contacted to participate through multiple mailings and personal phone calls. Of the 14 possible participants, 4 agricultural producers were willing to participate and submitted soil test information and were interviewed. Of these four producers one is exclusively a row crop farmer and the other three are crop and dairy farms. All four producers provided useable soil test information covering 682.6 acres (47% of the total watershed cropland acres). Farmer participation was low in this study. However, the participation covered a significant portion of the watershed cropland acres.

Once data was compiled, entered, and modeled in SNAP Plus, results were entered into ArcMap GIS to spatially illustrate the findings. ArcMap is a geographic information system that can analyze data and illustrate it visually so that trends, patterns, and "hot spots" may appear. ArcMap GIS was used to make maps for reporting and creating the database where all information was stored.

Results

Soil test data was collected in 7 of the 8 watersheds within the Long Lake watershed. Soil test information allowed the calculation of average soil phosphorus levels. Soil test phosphorus throughout the entire watershed was quite consistent over all. Soil test phosphorus on all fields ranged from 7 parts per million (ppm) to 81 ppm. According to UW-Extension Publication A2809 *Nutrient Application Guidelines for Field, Vegetable, and Fruit Crops in Wisconsin*; 38% of the fields were low to very low soil test phosphorus (17 ppm or less), 35% of the fields reviewed were found to fall in the optimum category (18-35 ppm) for soil fertility, 27% of the fields fell into the high category (36-99 ppm), and no fields fell in the excessively high category (100+ ppm). It is important to mention that these fertility ranges pertain to the fertility needs of common row crops. Excessively high soil test phosphorus for crops does not mean there is an immediate threat to water quality. A fields potential to threaten water quality is dependent on a number of other factors including weather, topography, soil type, tillage, and crop management. Soil test levels are only one component of a very complex runoff risk equation.

Fields within the sub watersheds of Long Lake had very similar average soil test phosphorus, with averages falling between 17 and 47 ppm. This is not a lot of variation and falls very close to the optimum soil test level for row crop production. Another positive result of soil test collection was the absence of soil test levels greater than 100 ppm in participating fields. With soil test levels maintained closer to the optimum (18 to 35 ppm), runoff risk to surface water is decreased.

Sub watershed 7 had the highest average soil test phosphorus levels at 47 ppm (Figure 3). When the field information was modeled in SNAP plus with management practices, and field characteristics were factored into the equation, these fields resulted in a Phosphorus Index of 6 pounds of phosphorus contributed per acre, per year. This Phosphorus Index is exactly at the threshold for the State of Wisconsin. Average soil loss was moderate with an estimate of 6.5 tons/acre/year soil loss (Figure 5). This information is important, but may not be representative of the entire sub watershed. The sample size was very small and only represents a small amount of cropland within the sub watershed. These fields appear to be well buffered and though there may be higher levels of soil and nutrient loss we do not have the ability to quantify exact amounts reaching the lake. With the exception of the soil test phosphorus, soil loss, and Phosphorus Index being slightly elevated in sub watershed 7, all other estimates are within the nutrient management requirements and the Wisconsin Department of Natural Resource threshold levels for maintaining water quality. Additionally, some of these fields have been observed to have conservation or no till cropping practices and cover crops. Conservation practices recorded on fields within the Long Lake watershed showed much lower values than fields without when modeled. These numbers confirm the value of these practices in minimizing a crop field's potential to load sediment and nutrients to surface waters.

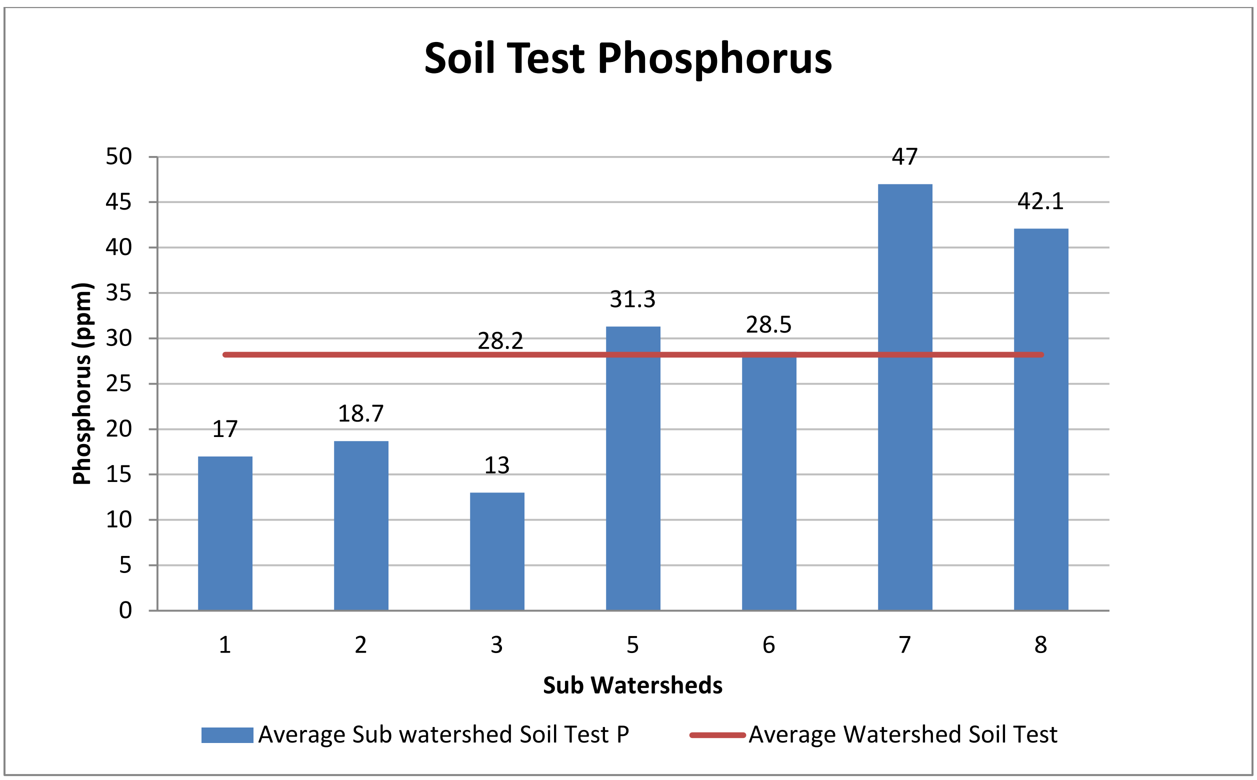


Figure 3

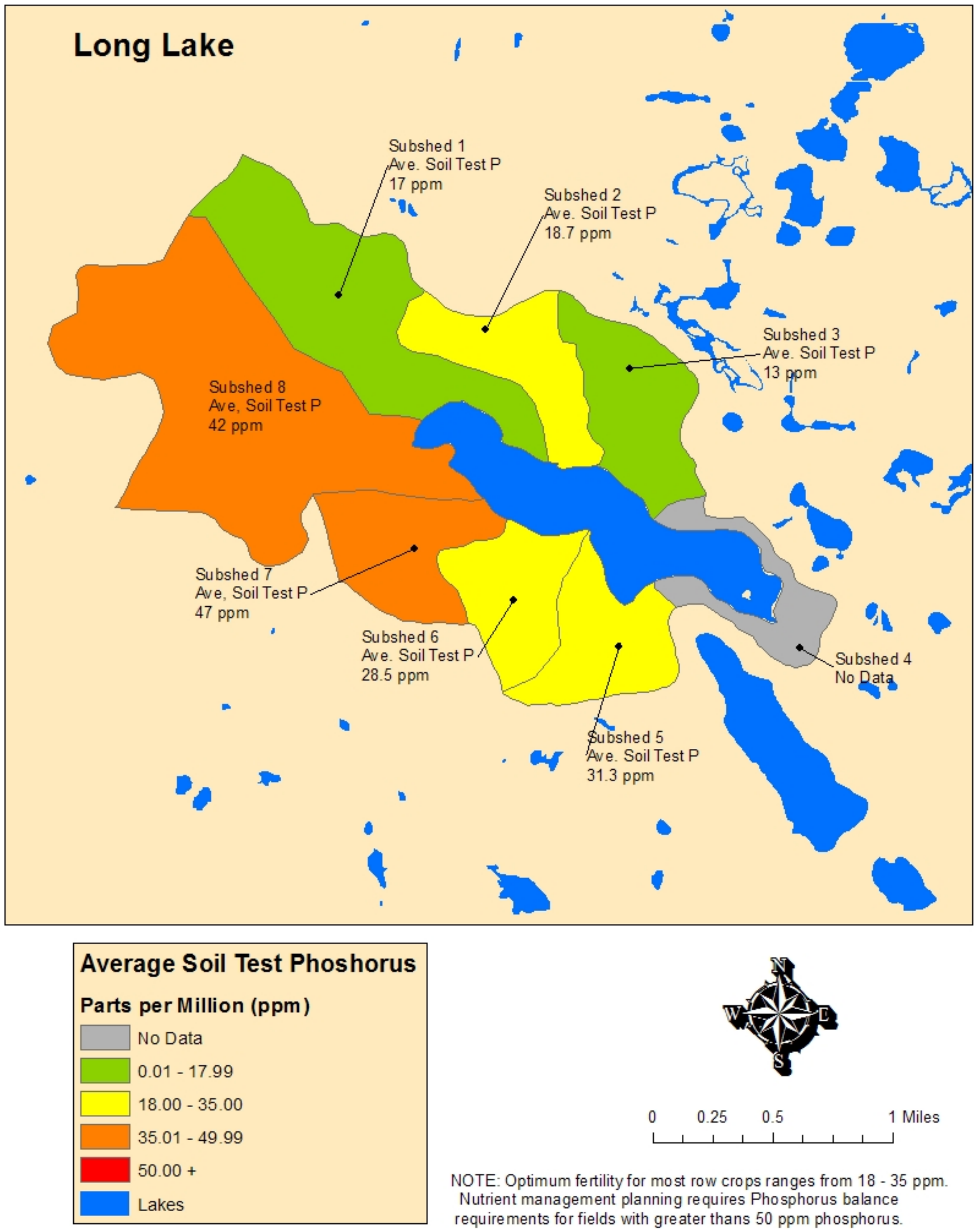

Long Lake
Subshed 1
Ave. Soil Test P
17 ppm
Subshed 2
Ave. Soil Test P
18.7 ppm
Subshed 3
Ave. Soil Test P
13 ppm
Subshed 4
No Data
Subshed 5
Ave. Soil Test P
31.3 ppm
Subshed 6
Ave. Soil Test P
28.5 ppm
Subshed 7
Ave, Soil Test P
47 ppm
Subshed 8
Ave, Soil Test P
42 ppm
Average Soil Test Phoshorus
Parts per Million (ppm)
No Data
0.01 - 17.99
18.00 - 35.00
35.01 - 49.99
50.00 +
Lakes
N
W
E
S
0 0.25 0.5 1 Miles
NOTE: Optimum fertility for most row crops ranges from 18 - 35 ppm.
Nutrient management planning requires Phosphorus balance requirements for fields with greater thans 50 ppm phosphorus.

Figure 4

The soil loss evaluation portion of this study yielded fairly consistent values across sub watersheds with adequate field participation. However, two watersheds did exceed the tolerable soil loss levels for the area soils. As shown on the graph and map of average soil loss, watershed averages for sub watershed 7 and 8 are above the watershed wide tolerable level (4 tons/acre/year) (Figure 5, page 7and Figure 6, page 8). However, when averaged, the collection of all sub watershed soil loss was 3.6 tons/acre/year, which is slightly lower than the watershed wide tolerable level.

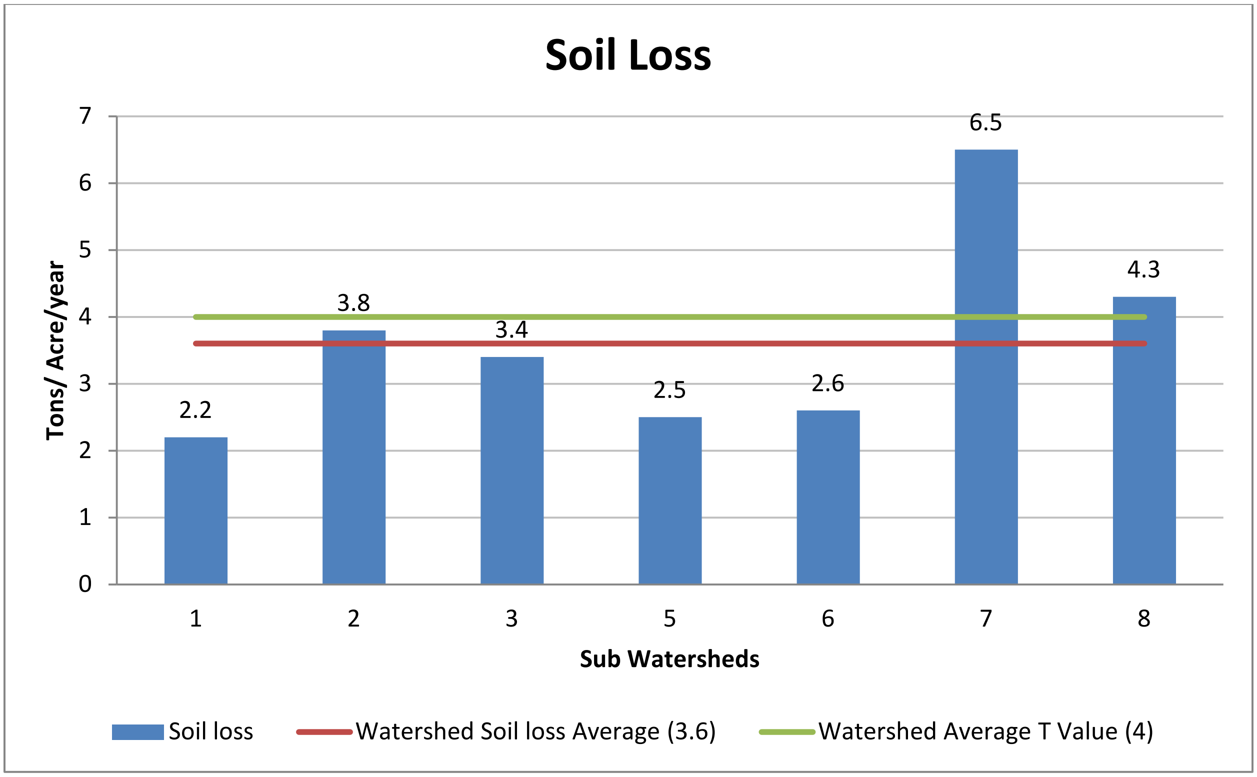
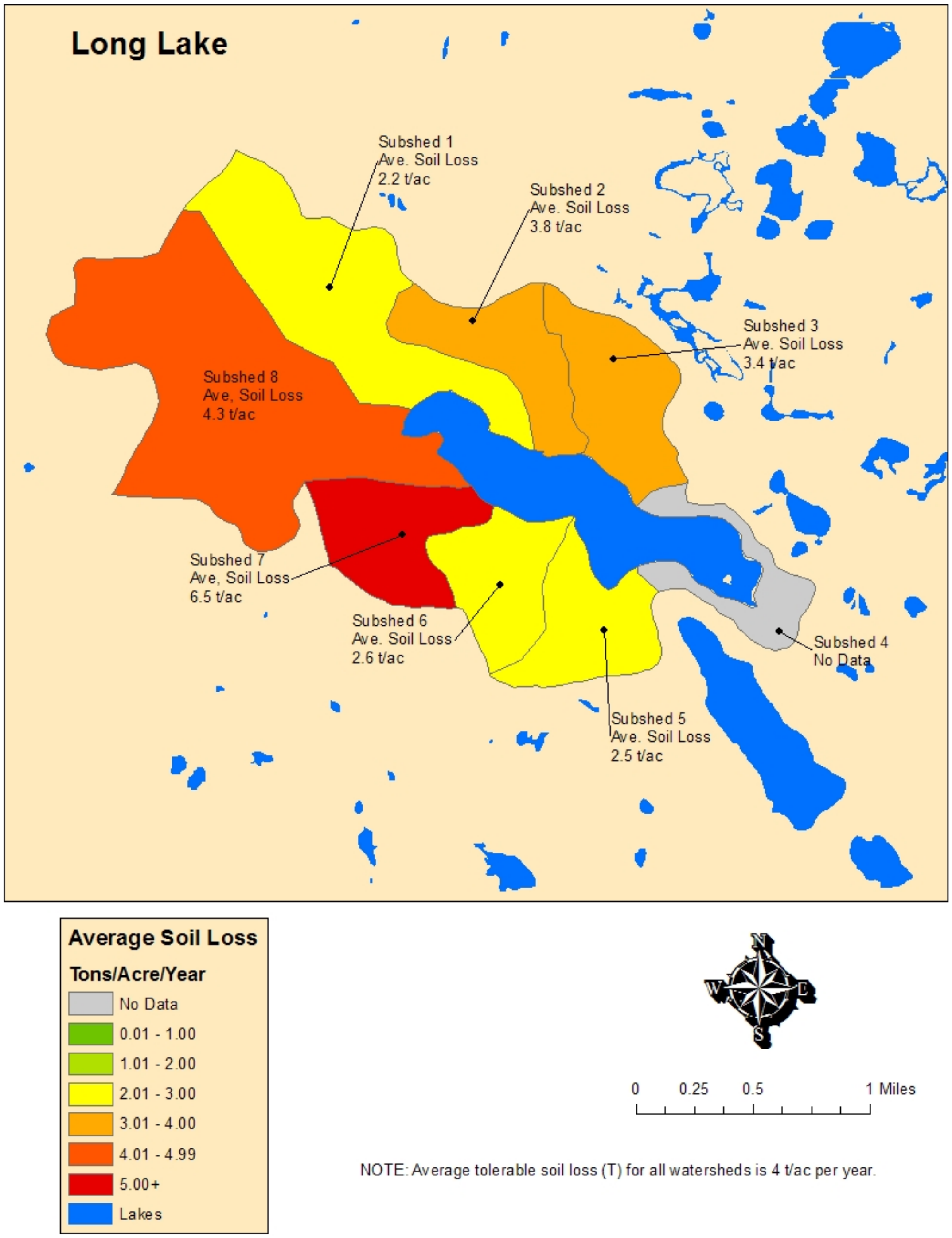


Figure 5

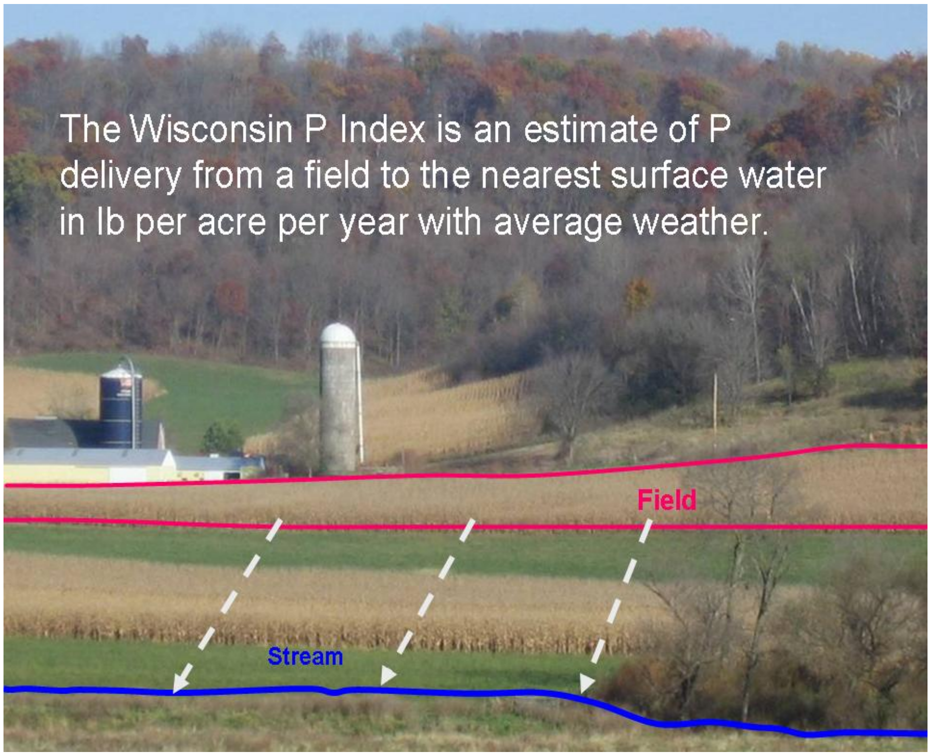
The estimates of soil loss should be fairly representative of the entire watershed. There has been enough data collected to achieve representative results, and all information collected during farm interviews used in the modeling process was as close to actual as possible. An average soil loss of 3.6 t/ac/yr in these eight sub watersheds is quite acceptable from a conservation planning standpoint. However, fields do exist in these areas that exceed the tolerable level for their soils. Seven fields within the Long Lake watershed exceed their soils respective tolerable soil loss. These fields range from 6.5 to 9.0 t/ac/yr and make up 14% of the total field acres evaluated.



Long Lake
Subshed 1
Ave. Soil Loss
2.2 t/ac
Subshed 2
Ave. Soil Loss
3.8 t/ac
Subshed 3
Ave. Soil Loss
3.4 t/ac
Subshed 8
Ave, Soil Loss
4.3 t/ac
Subshed 7
Ave, Soil Loss
6.5 t/ac
Subshed 6
Ave. Soil Loss
2.6 t/ac
Subshed 4
No Data
Subshed 5
Ave. Soil Loss
2.5 t/ac
Average Soil Loss
Tons/Acre/Year
No Data
0.01 - 1.00
1.01 - 2.00
2.01 - 3.00
3.01 - 4.00
4.01 - 4.99
5.00+
Lakes
N
W
E
S
0
0.25
0.5
1 Miles
NOTE: Average tolerable soil loss (T) for all watersheds is 4 t/ac per year.

Figure 6

The Phosphorus Index for the project area represents a collection of all field data obtained from soil test information and farmer interviews. The P Index represents a fields estimated potential to deliver phosphorus to nearby surface waters based on an agriculture producers planned management. The units for the P Index values are in pounds of phosphorus lost per acre, per year. The state of Wisconsin sets an upper threshold limit of 6 lbs/ac/yr. For nutrient management planning, anything over a P Index of 6 is unacceptable and may result in a change in crop management.



Graphic Courtesy, UW-Wisconsin Madison

During this project approximately 682.6 acres were evaluated totaling 30 separate fields within the Long Lake watershed. Phosphorus Index values range from 0 to as high as 8 lbs/acre/year, with a watershed wide average of 3 lbs/acre/year. As you can see from the graph below (Figure 8) only one sub watershed average P-Index level was elevated to, but did not exceed, the State of Wisconsin's threshold limit of 6 lbs/ac/year.

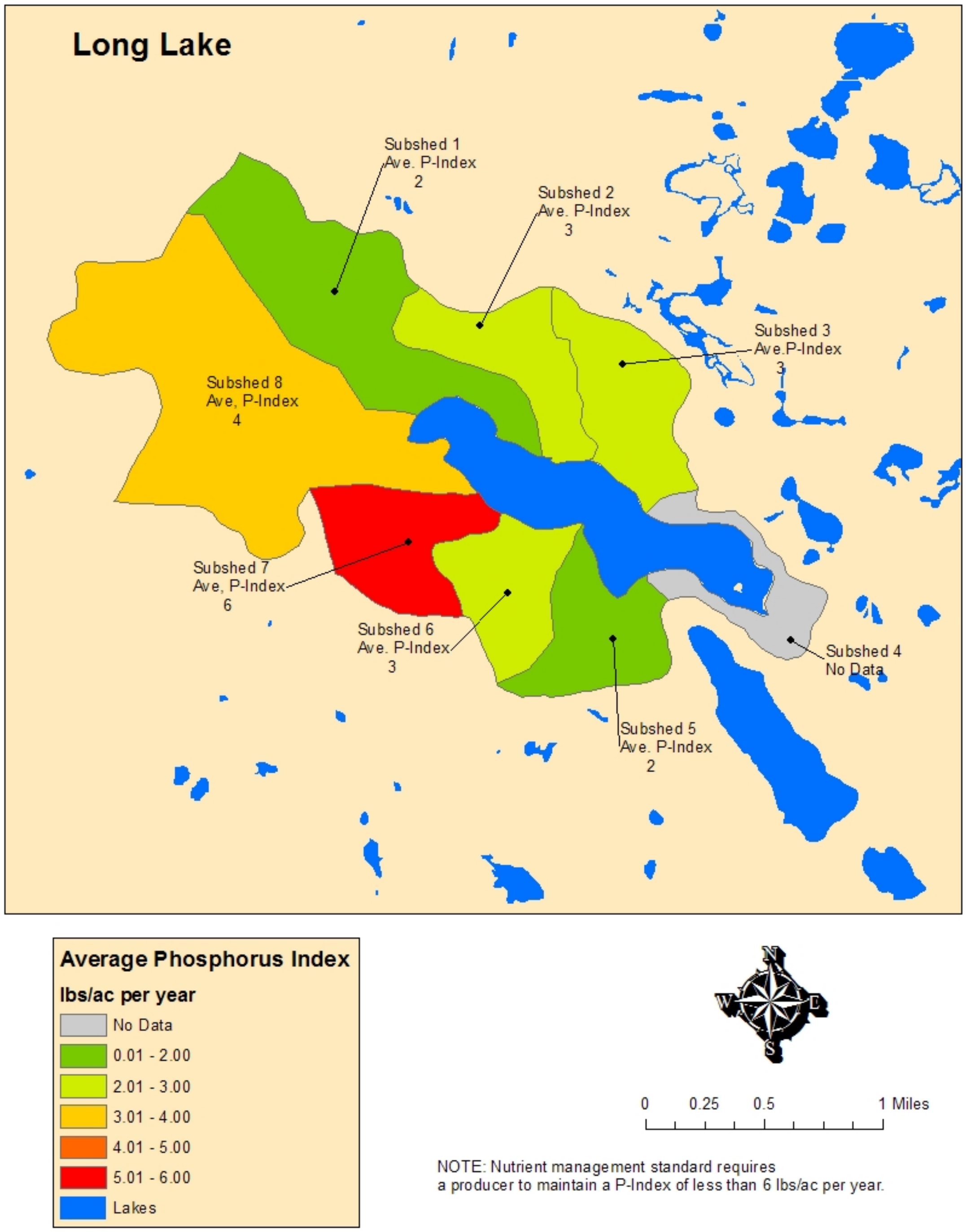

Long Lake
Subshed 1
Ave. P-Index
2
Subshed 2
Ave. P-Index
3
Subshed 3
Ave.P-Index
3
Subshed 8
Ave, P-Index
4
Subshed 7
Ave, P-Index
6
Subshed 6
Ave. P-Index
3
Subshed 4
No Data
Subshed 5
Ave. P-Index
2
Average Phosphorus Index
lbs/ac per year
No Data
0.01 - 2.00
2.01 - 3.00
3.01 - 4.00
4.01 - 5.00
5.01 - 6.00
Lakes
N
W
E
S
0 0.25 0.5 1 Miles
NOTE: Nutrient management standard requires
a producer to maintain a P-Index of less than 6 lbs/ac per year.

Figure 7

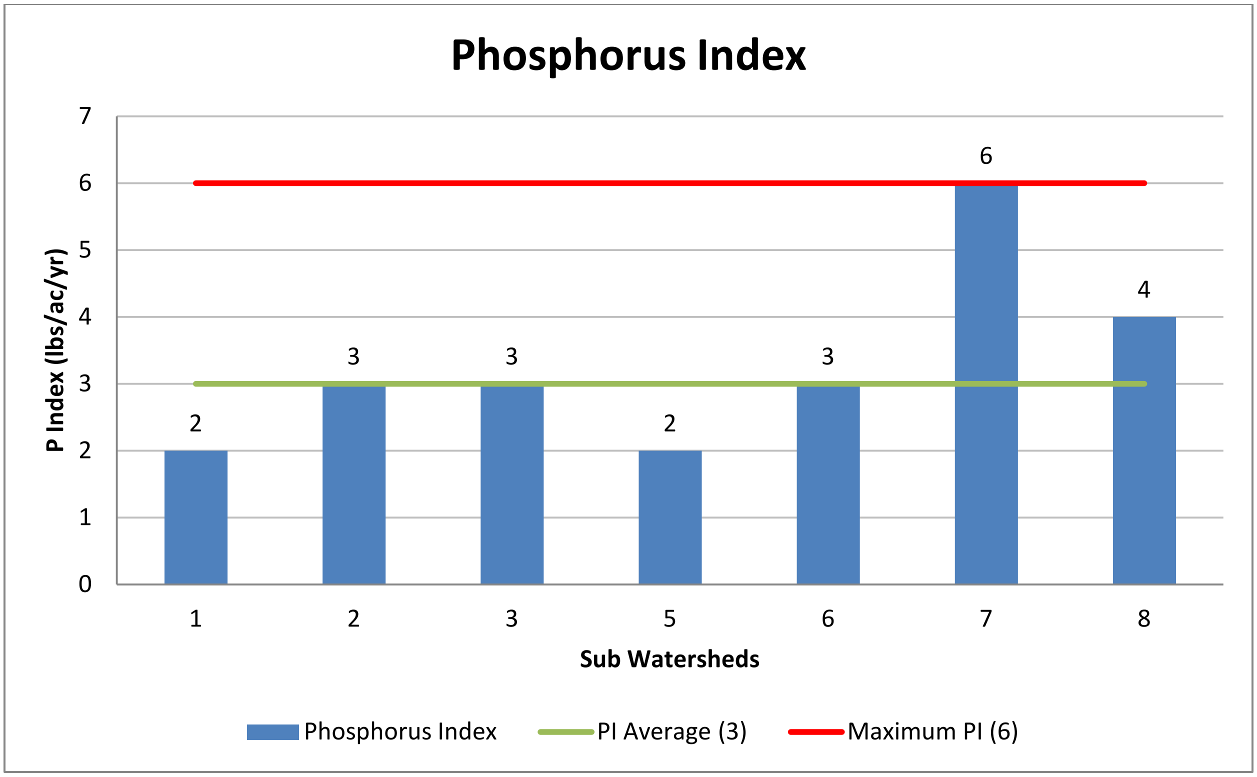


Figure 8

With the exception of a few fields, the P Index levels were low to moderate. Low to moderate P Index numbers in the watershed are important as these levels demonstrate surface water runoff risk. While SNAP plus models a fields potential to allow phosphorus movement to the fields edge, it does not accurately estimate phosphorus transport from the field edge to the nearby surface water. With the existence of undisturbed buffer area between much of the agricultural land and Long Lake, there is great potential to reduce the amount of phosphorus through natural processes between the field edge and the lake.

Conclusions and Recommendations

Overall this project went well. Time and farmer participation were limiting factors. Farmer participation in projects like this takes time. Project results would have greatly improved if this was a multiple year study. It was a challenge to connect with every operator in the watershed. As always, not everyone is willing to participate. For the size of the watershed area, we had good participation from producers that operated many acres within the watershed which was important in collecting enough field data to obtain good representative estimates.

Most of the information collected in this watershed project was not unlike what has been collected in similar studies where soil test and P Index information was estimated. Moderate to low P Index values were seen throughout. There were seven fields that had a P Index of greater than 6. These fields were elevated due to a combination of winter applications of animal waste, row crops planted on steeper slopes, and tillage systems that incorporate crop residue leaving more exposed soil on either side of the growing season.

With the estimated values seen from this assessment, a reduction in P Index is very likely and could be very simple with the adoption of a few specific conservation practices. However, for this reduction to be possible implementing the practices would be necessary and would result in significant changes in management for some operations. This could be challenging with some of the more expensive practices such as manure storage. However, some lower costs practices such as: nutrient management planning, proper placement of manure stacks, no till farming, contour farming and filter strips on all fields could help towards some reduction at a lesser cost to the producer.

While obtaining nutrient management plan information it was apparent that nutrient management planning efforts are happening within the watershed. However, there could be improvements. Only half of the producers that participated in this project had a current nutrient management plan. The majority of the non participating producers within the watershed are believed to not have nutrient management plans. Many have a cropping plan for nutrient applications, but only a few had 590 standard approved nutrient management plans that address water quality as well. Though a full 590 compliant plan is not entirely critical to achieve environmental and water quality benefit, it does help in most cases if the plan is implemented as written. Most of the growers who are actively engaged in nutrient management planning are following the plans to the best of their ability. Even though some of the recommendations are not compliant with 590, the basics of the plan are almost always understood and likely implemented. Awareness of sensitive areas, moving manure to fields that need nutrients, and soil testing are all basics of a plan. When these basics are implemented it is less likely that nutrients, including phosphorus, will be over applied to the land. With this, it appears that the educational aspect of nutrient management planning is almost more effective in minimizing risk than having a plan written.

Soil test levels within the Long Lake watershed are optimum according to University of Wisconsin - Extension recommendations. Even though the majority of the growers are doing well keeping sediment and particulate phosphorus on the land, Polk County LWRD recommends the producers in the watershed maintain these levels. With optimum soil test phosphorus on these fields the risk of impacting surface water is reduced when crop or tillage management practices change in the future. Knowing these fields are at the optimum levels for phosphorus is helpful alone. Knowing this, the producer only needs to apply enough phosphorus for what the crop will remove in that growing season. This is a cost savings for producers and can benefit water quality because the nutrients applied are used and there is very little excess to run off. Polk County LWRD will make efforts to promote practices in this watershed that will maintain optimum levels and minimize soil erosion.

Positive Project Outcomes

This project had many positive outcomes. Much of the challenge of implementing conservation practices is buy-in of those targeted to make a change. Polk County LWRD staff was pleased with the level of concern for soil and water quality by project participants. The agriculture producers that participated wanted to participate because they too are concerned about water quality and soil health.

This work promoted soil testing and obtained soil tests for those who may not routinely soil test. Knowing soil fertility alone can decrease fertilizer and manure applications. Once agricultural operators start soil testing they often times value the information and adjust fertilizer applications accordingly, resulting in a significant cost savings and less chance of over application of nutrients to fields. Polk County LWRD anticipates that some of the participating producers will continue to take routine soil tests as a result of this work.

In addition to soil testing, the farm interview process during this project promoted awareness of conservation practices and the value of conservation planning. Often agriculture producers were aware of soil conservation concerns on their operation and project staff were able to help with recommendations to address these concerns.

With very high costs to produce row crops and low commodity prices, agriculture producers are generally very careful in their nutrient management. The agriculture producers in the Long Lake watershed are quite concerned about the cost of their inputs. Having these concerns, they are less likely to over apply nutrients that pose a risk to surface waters.

With the information gathered from this study, the Polk County LWRD has identified areas that could be improved. As funding is available and affected producers are agreeable, financial and technical assistance will be offered to producers to address the areas of concern. This process is entirely voluntary. No guarantees can be made for improvements or producer participation. However, knowing improvements can be made that might have both financial and environmental benefits typically start the conversation and the process towards change.

References

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2. Wisconsin Phosphorus Index, http://wpindex.soils.wisc.edu/.

3. Mugaas, R.J, Angnew, M.L, and Christians, N.E. 2005. *Turfgrass Management for Protecting Surface Water Quality.* U of M Extension Publication, BU-05726. 2005.

4. Wisconsin. Department of Agriculture Trade and Consumer Protection. Plant Industry. Chapter 94 Wis. Stats s. 35.18. October 1. 2013. Print.