Re-evaluation of Bone Lake Phosphorus Reduction Goal and Objectives

The Bone Lake phosphorus reduction goal was established in the Bone Lake Comprehensive Lake Management Plan 2009. Goals and objectives from the plan are shown in the text box below. The plan calls for gathering additional information to clarify sources of phosphorus to Bone Lake. Objectives were to be reassessed once this information is gathered.

The plan does not include a numerical improvement for water clarity.

From 38 ppb in 2008, this is a 21% reduction in in-lake phosphorus. Based on past measurements in Bone Lake, this would result in about a 25% (or 2 foot secchi depth) improvement in water clarity.

Studies to evaluate phosphorus loading from the watershed, curly leaf pondweed, and lake bottom sediments were completed by 2010.

Bone Lake Comprehensive Lake Management Plan 2009

Goal

Improve Bone Lake water clarity.

Objectives

Achieve an in-lake average summer phosphorus concentration of 30 ppb or less.

Reduce watershed phosphorus (P) loading by 25% or more.

- Reduce P loading from urban sources by lowering runoff from 25% of residential lots by 50%.
- Reduce P loading from cropland sources by reducing loading from 50 acres of row crop by 80%.
- Reduce tributary loading of phosphorus by 25%.

Further evaluate phosphorus loading from the watershed.

Evaluate in-lake sources of phosphorus.

Curly leaf pondweed

Lake bottom sediments

Reassess in-lake and watershed objectives in 2011. Objectives may need to be adjusted with better understanding from tributary monitoring and in-lake source evaluation.

The original water quality model results suggested that the watershed loading reductions from urban and cropland sources would reduce summer in-lake phosphorus concentrations by 11 percent. The in-lake result of tributary loading reduction was not calculated.

Phosphorus Loading to Bone Lake

Phosphorus comes from both outside (external) and within the lake (internal) including the following major sources:

- Precipitation on the lake (external)
- Water flow from two tributary streams (external)
- Runoff from the watersheds (remaining land which drains to the lake) (external)
- Die back of curly leaf pondweed (internal)
- Release from lake bottom sediments (internal)

With land use information, it is possible to estimate phosphorus loading from various areas within the watershed. Watershed loads are estimated by amounts of phosphorus delivered per acre for a particular land use. Septic system loads are estimated from the number of systems and amount of use. Tributary loads were measured with actual samples and flow rates. Above values were available in the original plan. Additional values were available in 2010 following a study of release of phosphorus from lake sediments in 2009 and 2010 and a study of release from dieback of curly leaf pondweed (CLP) in 2010. The updated 2010 estimates based on these studies are included below.

Table 1. Sources of Phosphorus to Bone Lake

Source	Kg/Year	Percent of P Load
Septic Systems	67	5
Prokop Creek	124.8	10
NW Tributary	122.7	10
Watershed	557	45
Lake Surface Precipitation	143	12
Lake Sediments	192	15
CLP	40	3
Total	**1246.5**	

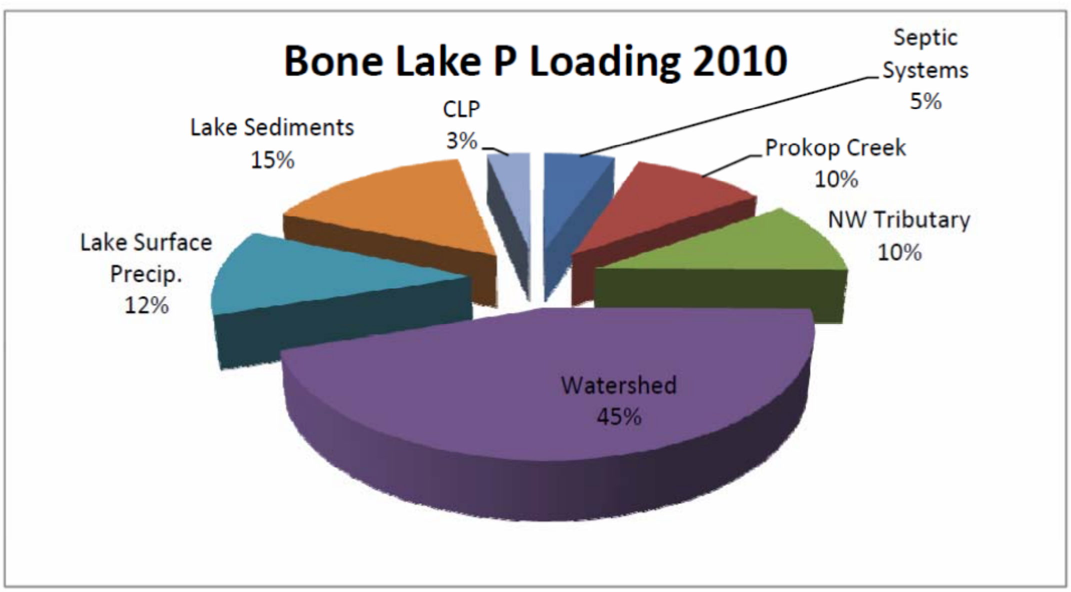

Figure 1. Phosphorus Sources to Bone Lake 2010

This is the best estimate that we currently have for managing phosphorus to reduce nuisance algae growth in Bone Lake. It shows a higher tributary load than the 2008 estimate. This is simply because there was more precipitation in 2010 than in 2008. Watershed and lake surface loads decreased in importance as the internal sediment and CLP loads were added.

Like precipitation and resulting tributary loading, sediment loading of phosphorus can vary from year to year in Bone Lake. Sediment loading of phosphorus is caused from phosphorus release when there is no oxygen at the bottom of the lake. During some summers this released phosphorus stays at the lake bottom because the water stratifies into temperature layers. Other years phosphorus is released from the bottom, then the lake mixes and phosphorus is brought to the surface. In fact, in 2008 the lake was mixed nearly throughout the entire growing season and total phosphorus averaged 38 ppm. In 2009, the lake also mixed with total phosphorus averaging 47 ppb. In 2010 and 2011 when temperature stratification was stronger, lower in-lake phosphorus concentrations were present with averages of 36 and 33 ppb respectively. In a given year, whether the lake stays stratified or mixes is likely to have the greatest impact on phosphorus levels and algae growth. Water clarity improvements from reductions in external loading would be evident when the lake does stratify.

Targeting Phosphorus Reduction[1]

Current phosphorus loading estimates will help to focus management efforts to improve Bone Lake water quality. Some sources of phosphorus are outside of immediate human control, so we focus on those sources which can be managed. These include watershed, tributary, septic, and CLP. Internal sediment loads are much more difficult and expensive to manage, especially when there is periodic mixing of the lake during the summer.

The WILMS water quality model was used to predict the impacts of changes in land management with the updated figures.

Updated numbers used in the WILMs model show the following result:

- Reducing 25% of residential P loading by 50% [32 kg] predicts a 2.5 % reduction in summer in-lake total phosphorus.

- Watershed projects which remove 6% of watershed phosphorus from non-residential areas [33 kg] will result in a 2.5% reduction in summer in-lake total phosphorus.

- These projects combined will lead to a 5% reduction in summer in-lake total phosphorus.

- Reducing the NW tributary load by 50% [61 kg] predicts a 5% reduction in summer in-lake total phosphorus. The NW tributary is targeted because pollutant concentrations are twice as high as those of Prokop Creek.

- Table 2 summarizes additional predicted results of phosphorus reductions.

[1] Information from Steve Schieffer, Ecological Integrity Services.

Table 2. Predicted In-Lake Phosphorus Reductions of Management Practices (WiLMS)

Watershed Reduction	No point source reduction	Northwest Tributary by 50% [61 kg]	+CLP by 50% [20kg]	+Septics by 20% [15 kg]
0%	0%	5%	7.5%	7.5%
10-12%*	5%	10%	12.5%	12.5%
20%	10%	15%	15%	15%
30%	12.5%	17.5%	20%	20%

*The predicted waterfront (32kg) and watershed (33 kg) reductions would reach 12% reduction in watershed loading.

Projects that currently appear realistic would bring a 13% reduction in total P loading. The WiLMS model predicts a 12.5% improvement in in-lake total P as a result. This would bring the growing season mean (GSM) total phosphorus to 31.5 ppm, a value which correlates to an 8 foot secchi depth in Bone Lake (based on past Bone Lake data). This is about a 1.5 foot increase in secchi depth.

Lake modeling is an inexact process, and the results above are from only one lake model. Bathtub, another lake water quality model, was also used to predict in-lake total P reductions. That model predicts an 8% improvement in in-lake total P with 13% reduction in total P loading. This would bring the GSM total P to 33 ppb, a value which correlates to a 0.6 foot increase in secchi depth.

Waterfront Property Reductions

With approximately 500 properties around the lake, 25% participation represents 125 properties. Early work to mitigate runoff from waterfront property around the lake has resulted in projects installed at 4 properties – only about 3% of the project goal. Participation in waterfront projects will need to increase dramatically to meet the residential reduction objective.

Property owner contacts were made for the owners with properties rated with a high or medium impact to the lake. This included 280 properties with one or more of the following characteristics:

- Moderate or steep slope to the lake
- Roads with direct access to lake
- Obvious erosion
- Structures close to the lake
- Lack of natural vegetation

Forty-six initial site visits conducted in 2010 and 2011 resulted in recommendations for 23 projects. Of these, 4 have been completed, 1 is partially complete, 3 designs are completed or in progress, and 4 are not interested. Designs for installation are recommended for the remaining 11 properties.

Septic Systems

Septic systems were estimated to load 67 kg of phosphorus to Bone Lake. This would mean that each system would contribute an average of 0.15 kg to the lake. A failing system might contribute twice the phosphorus of a functioning system. Therefore, 50 systems would need to be updgraded to meet the target of a 15 kg reduction in septic system loading.

An update of the septic system loading estimate is recommended. It is now possible to get a listing of the type of system at each lake district address. It would be reasonable to assume that newer holding tanks contribute no phosphorus to the lake. The type of system was not considered (and eliminated) in the original estimate.

Watershed Reduction

Priorities for reductions from watershed flow were developed by testing water in culverts that flow to Bone Lake. Test locations are shown on the map in Figure 2. Volunteers tested flow and grabbed samples from eight culverts. Samples were analyzed for total phosphorus, dissolved phosphorus, and total suspended solids. Testing and flow measurements were taken following storm events of at least 1 inch. This amounted to 5 times in 2010: once in March, once in May, twice in July, and once in August.

The objective of the culvert monitoring was to compare the relative contributions of phosphorus from culverts entering Bone Lake. Results were intended to be used to establish priorities for watershed practices. With limited data and flow collected, they were not intended to provide updated loading amounts for the watersheds.

None of the priority areas were found to have significant runoff from cropland. The area above culvert 3 has active crop fields. However, while culvert 3 had extensive flow and some high levels of phosphorus and sediment, this flow did not reach the lake (through culvert 4) when tested in 2010. However, culvert 4 was running during the snowmelt tour in 2012. Culvert 4 should be tested to assess TP concentrations reaching the lake. At this point, the initial objective to reduce phosphorus loading from cropland does not appear to be realistic.

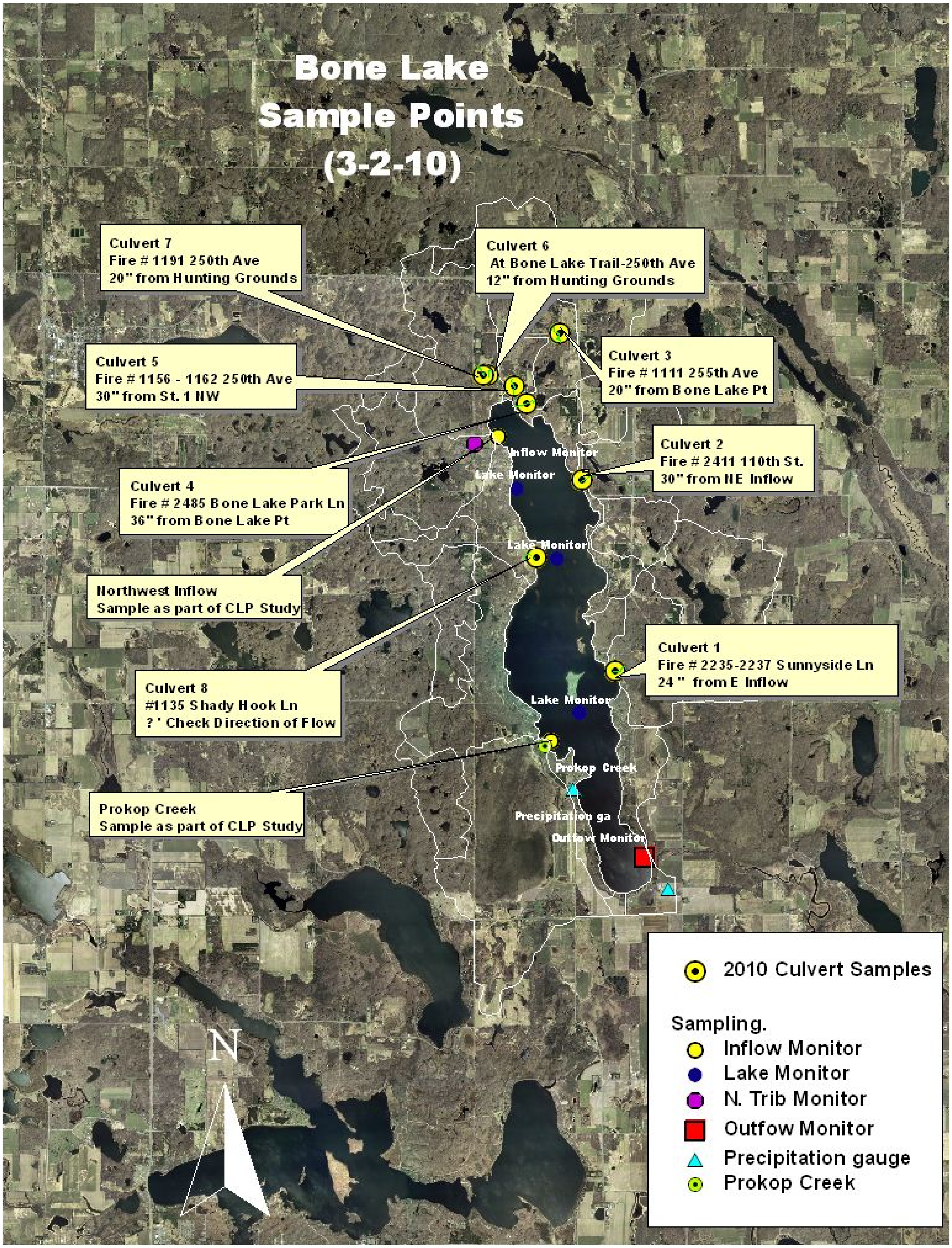

Figure 2. Culvert Sampling Locations 2010

Figure 3 compares overall phosphorus loading from the culverts on the days when sampling occurred. Figure 4 shows the loading of phosphorus (kg/day) each time sampling occurred.

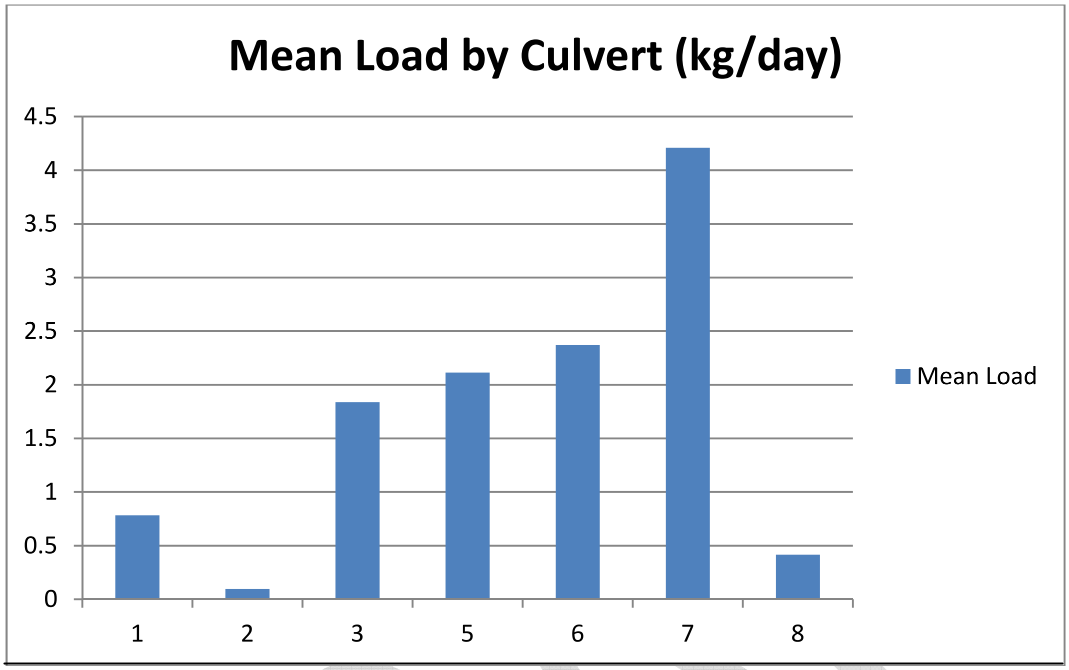

Figure 3. Mean phosphorus load (kg/day) for sampled culverts

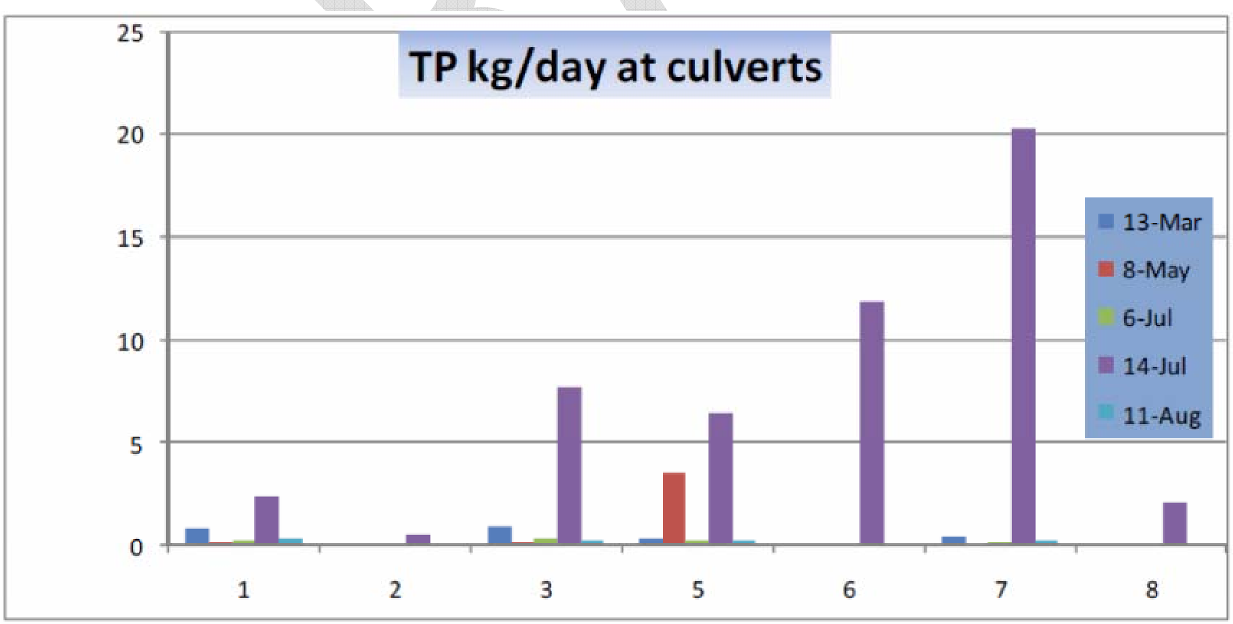

Figure 4. Storm event results (kg/day total phosphorus) for sampled culverts

Priorities for further investigation of project installation were recommended in early 2011 using the results of the culvert study. These priorities are updated in the table below with new information gathered during 2011.

Culvert number	Priority	Watershed	Description
5 (to Lagoon)	High	Station1NW (part)	Forest (57%), Crop (9%), Grass (17%)
7a/7 (E and W)	Medium	Hunting Grounds	Forest (74%), Wet (7%)
8 (Sandyhook)	Medium	Station 1W	Forest (56%), Urban (30%), Crop (6%)
1(Sunnyside)	Low	East Inflow	Forest (90%), Road (2.5%), Urban (2%)
2	Low	NE Inflow	Forest (59%), Crop (24%)
3 (doesn't reach lake)	Low	Bone Lake Point	
4 (no flow)	Low - watch	Bone Lake Point	
6 (no flow)			

Recommended Areas of Focus

Culvert 5 This is only the portion of the Station 1 NW watershed that flows to the Lagoon. High flows were reported by residents and streambank erosion is evident below this culvert.

A pond designed to capture water from this watershed is estimated to reduce 7 kg of phosphorus annually at a cost of $25,000. This is the best potential for a high level of phosphorus reduction identified to date. The owner is willing to install the practice. However, DNR permitting and grant staff are concerned about placement of the pond in an existing wetland and the impact of the practice for phosphorus reduction.

The owner along the streambank below culvert 5 is willing to consider efforts for stream stabilization. Polk County LWRD is authorized to proceed with a survey of this area and to propose solutions for erosion.

Culvert 7a/7 Much of this area that flows to this culvert is undeveloped. Water below the culvert flows through extensive wetlands before entering the lake. Some streambank erosion was identified in wooded areas above the culvert. Specific locations were not recorded. Data reported for 6 in Figures 3 and 4 is actually from a new culvert (7a) installed next to 7 when the previous single culvert blew out after a large storm event (over 3 inches in 24 hours) on July 14, 2010.

Culvert 1 A culvert in this area appeared to create flooding in wooded area of the watershed. This flooding was assumed to result in relatively high phosphorus loading from this area. The culvert was repositioned so that water flow was not impeded. Repeat total phosphorus and flow measurements are recommended prior to considering additional practices on this site.

Culvert 8 Crop field and farmstead (may not be active, check with owner) are very close to the culvert. Working with this farm should be a priority. Channelized flow comes from a wetland area which will present challenges for practice installation.

Crop fields along Dueholm Drive (**Station 2 SW**) The owner created a berm in 2008 or 2009. However, the berm was not functioning in the area of the snowmobile trail in 2012. Runoff carrying sediment was evident during the snowmelt tour in early 2012. Correcting the berm in this area should be a priority.

Figure 5. Culvert 5 drainage

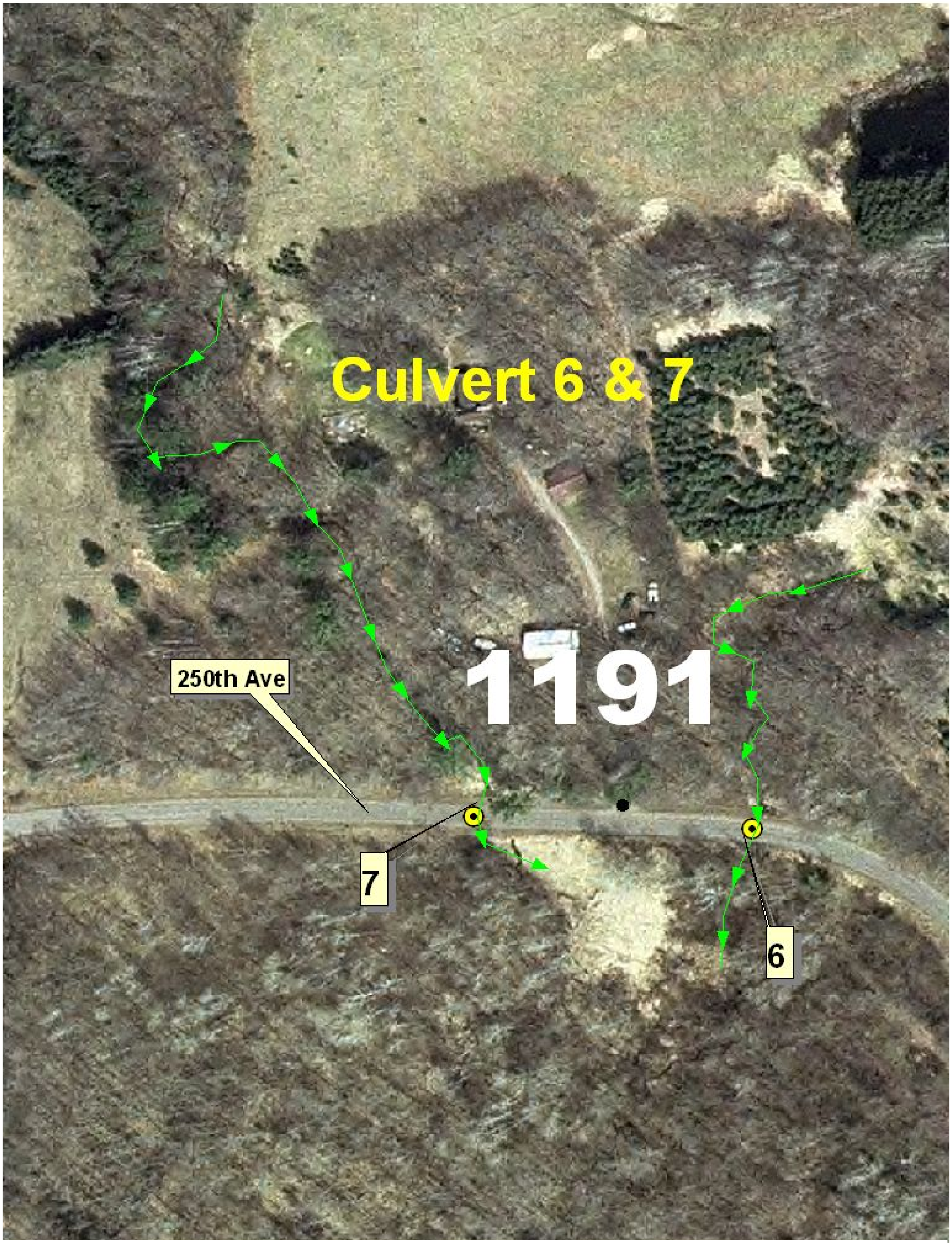

Figure 6. Culvert 7 drainage

Figure 7. Culvert 5 and 7 outlets

Figure 8. Culvert 8 flow

Tributary Reduction

The total loading of phosphorus and sediments from the two tributaries are quite similar. However, the water is much cleaner in Prokop Creek. Twice the volume of water carried in Prokop Creek results in very similar phosphorus loading. This was true in both 2008 and 2010. Extensive wetlands surrounding Prokop Creek likely help to remove pollutants from this stream. Therefore, practices to reduce total phosphorus are recommended for the northwest tributary but not for Prokop Creek.

Total phosphorus is made up of both dissolved (soluble reactive phosphorus) and particulate phosphorus. Dissolved phosphorus made up only 23-24% of the total phosphorus in both tributaries. This indicates that the source of phosphorus is not likely from highly soluble forms such as fertilizers, manure, sewage, etc. The total suspended solids (TSS) load was much higher in the northwest tributary, so this tributary contributes more sediment into Bone Lake. TSS values did increase (especially with the northwest tributary) with increased flow, as expected. As a result, practices which allow water to settle could effectively control the phosphorus in the northwest tributary.

A settling basin is an example of a practice which would allow particles to settle and remove phosphorus. A DNR permit would be required to install the basin. A permit may be difficult to obtain if the basin diverts all water from the main stream channel or is constructed in the stream channel.

Looking upstream, a potential source of sediments is the auto salvage operation just upstream of County GG. The owner has recently provided permission to walk the stream to look for streambank erosion. If corrective measures are suggested for the auto salvage yard, it may not be possible to pay for these measures with the lake protection grant. Instead, they may be required as part of the auto salvage stormwater permit. Another suggestion is to test phosphorus levels in the lake upstream of County GG. This sample will be collected at the time of the stream walk if the lake is accessible.

The northwest tributary flows through and adjacent to privately owned parcels with three landowners prior to reaching Bone Lake. These parcels are shown in following pages with ownership indicated. The auto salvage yard is located on the Fjorden parcel.

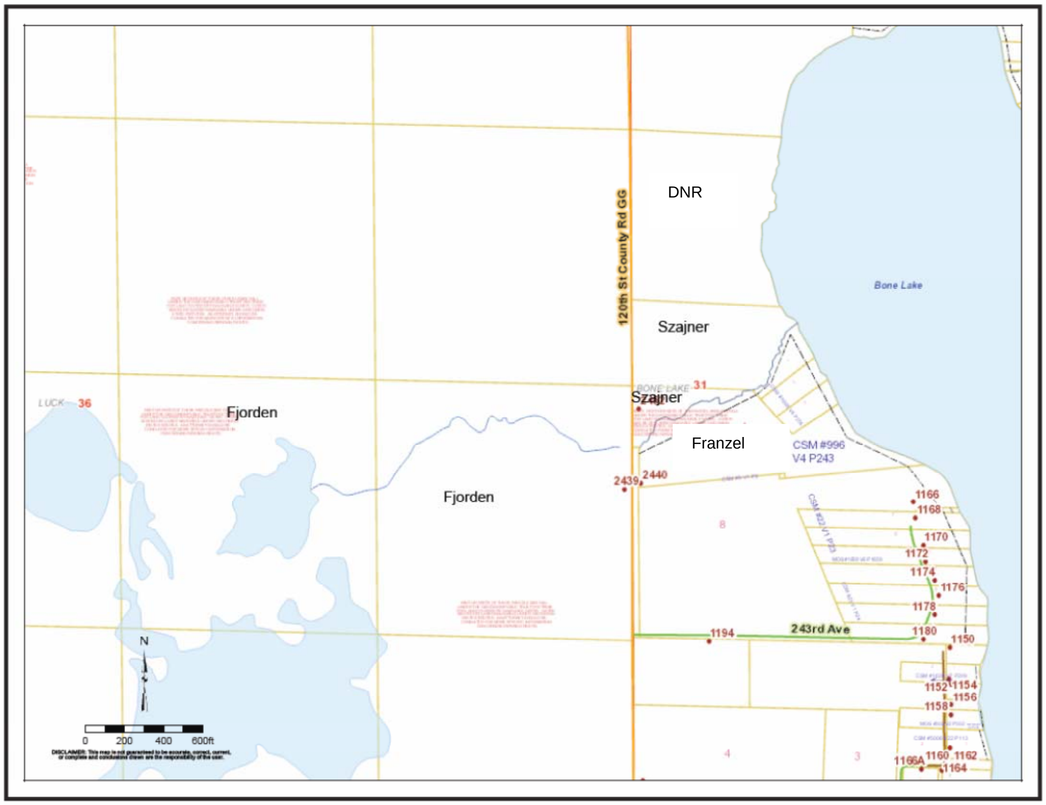

Figure 9. Parcels adjacent to the northwest tributary

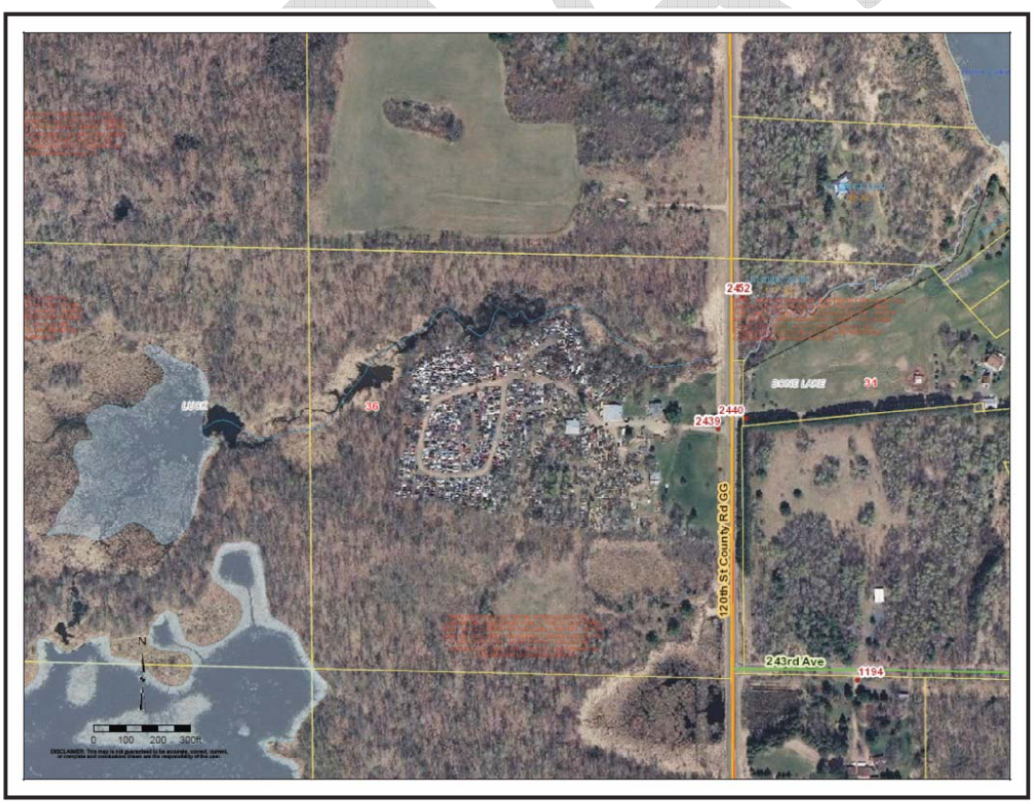

Figure 10. Aerial photo of northwest tributary parcels

Reductions from Curly Leaf Pondweed

A target of 20 kg/year assumes that there are 46 acres of CLP and half of that acreage is removed through an early season treatment. There are currently 14 acres treated each year, with varying degrees of success. We are working to improve success rates of CLP treatment. If consistent successful treatment occurs, it may be a good idea to expand treatment acreage. However, treatment areas must be selected carefully because site characteristics are important to treatment success. Areas with steep drop-offs are particularly difficult to treat successfully because concentration of herbicide may not be maintained above the plants.

Summary

Current information suggests that a 12.5% reduction in phosphorus loading to Bone Lake is within reach, and a 25% reduction probably is not. Even at the lower level of reduction, a extensive, combined effort in reductions from waterfront, remaining watershed, tributary, and CLP or septic sources would be needed. The predicted in-lake impact of such a reduction ranges from 0.6 to 1.5 foot increases in secchi depth from previous years. The impact would be seen most dramatically when the lake remains stratified all summer. In years when the lake mixes and P from sediments and deep water is brought to the surface, these results may be less evident. Priority areas for practice installation include the culvert 5 drainage on the north side of the lake and the northwest tributary.

Sources

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