# SPIRIT LAKES WATER QUALITY ASSESSMENT SUMMARY

(A 23 page full report is also available)

## Water quality basics

Phosphorus concentration in lake water is very important because it controls the amount of suspended algae that grows. Suspended algae are microscopic plants that turn the water green (or sometimes brown) and reduce water clarity. Chlorophyll concentration in lake water can be measured to determine how much algae is present. As more phosphorus is added to a lake, more suspended algae grows and chlorophyll concentrations increase. The increase in algae reduces the depth you can see in the water. Water clarity can be measured with a Secchi disk. This is a black and white disk that is lowered into the water and the depth of disappearance is recorded.

Much of the algae produced in a lake eventually settles to the bottom where it decomposes. The decomposition consumes the oxygen in the water near the bottom. When oxygen concentrations become very low, phosphorus that is bound to iron in the lake sediment is released back into the lake. This phosphorus can then grow more algae resulting in even worse conditions in the lake.

## Spirit Lakes water quality

The results from several years of monitoring of Spirit and North Spirit Lakes are summarized below:

| Parameter | Spirit Lake | North Spirit Lake |
|---|---|---|
| Mean Total Phosphorus (ug/l) (June-Aug.) | 115 | 77 |
| Mean Chlorophyll a (ug/l)(Jul.15-Sept.15) | 68 | 59 |
| Mean Secchi depth (ft) (June-Aug.) | 2.6 | 5.0 |
| True Color (Pt-Co units)(spring and fall, 2004) | 60 - 110 | 20 - 25 |

Both lakes have high phosphorus concentrations and are considered hypereutrophic. They are very fertile and produce an abundance of algae.

Spirit Lake has higher total phosphorus and chlorophyll a concentrations, and correspondingly lower Secchi depths. True color, which is due primarily to dissolved organic materials in wetland drainage, is high in Spirit Lake and low in North Spirit Lake. The dissolved organic materials produce a "tea" color to the water. The high color in Spirit Lake contributes to the lower Secchi depths.

## Reason for the 2010 study

The DNR has developed a process for identifying lakes that have much worse than average water quality. The intent is to make these lakes priorities for improvement efforts. All Wisconsin lakes with sufficient data were screened based on impairment threshold values for phosphorus and chlorophyll concentrations. Both Spirit and North

Spirit Lakes were identified as having both phosphorus and chlorophyll concentrations that exceeded the impairment threshold values.

Based on previous studies done nearby, it was suspected that conditions in the Spirit Lakes might be largely due to naturally occurring conditions. A study was done in 2010 to evaluate the lakes and their watersheds and to determine what the potential was for water quality improvement.

## Study components

- Water samples were collected on several dates from 9 stream sites in the watershed.
- Groundwater samples were collected from 12 residential wells, 3 springs, and one artesian well.
- Watershed boundaries and land uses were identified.
- All existing data for the 2 lakes was reviewed and assessed.
- Lake phosphorus models were used to estimate lake responses to reduced inputs of phosphorus.
- Lake sediment cores were collected and analyzed to compare lake water quality in recent years to that in pre-development times.

## Study results

### Watershed assessment and lake modeling

Ninety percent of the Spirit Lakes watershed is undeveloped woodland and wetland. Only 10% of the watershed is developed areas, such as farmland and residential areas. Drainage from an area of development typically contributes 5 to 10 times more phosphorus than drainage from an undeveloped area.

If an effort was made to reduce the phosphorus coming from the developed areas to the maximum extent feasible, phosphorus inputs to the lakes would only be reduced by about 11 to 15% or less. Summer phosphorus concentrations in the lakes would only be reduced by about 8 to 9 % or less. These reductions would not reduce phosphorus and chlorophyll concentrations in the lakes below the impairment threshold values.

### Groundwater and wetland assessment

Naturally occurring phosphorus concentrations in the local groundwater were found to be very high, about nine times higher than average Wisconsin groundwater phosphorus concentrations. This appears to be a major reason for the high phosphorus concentrations in the Spirit Lakes.

Wetlands, which are abundant in the watershed may also contribute more phosphorus to the lakes than is typical in Wisconsin. Wetlands are providing large inputs of phosphorus to Spirit Lake in late summer and may be significant phosphorus sources year-round.

Sediment and wetland phosphorus release

Phosphorus concentrations in both lakes increase substantially from spring to summer. North Spirit Lake shows a 40% increase. In that lake release of phosphorus from the sediment appears to be the primary source of this increase. Dissolved oxygen concentrations near the bottom have been shown to often become very low along with a corresponding buildup of phosphorus in near bottom lake water. Strong winds cause partial mixing of the lake and bring the phosphorus to the lake surface where it results in additional algae growth.

Spirit Lake shows a 62% increase in phosphorus concentrations from spring to summer. The increase appears to be due to a combination of lake sediment phosphorus release and wetland phosphorus release. Phosphorus released from wetlands in the summer is carried to the lake by the tributary streams.

Sediment cores

Dating of the sediment core collected from Spirit Lake found that it was not old enough to represent pre-development conditions. Another core will be collected in 2011.

The North Spirit Lake core was old enough to use. The core indicated that phosphorus concentrations in that lake have increased about 81% from pre-development conditions. Land use changes in the North Spirit Lake watershed could only account for a small portion of this increase. It appears likely that the construction of the dam at the Spirit Lake outlet has resulted in more water from the main tributary stream backflowing into North Spirit Lake. This has increased the amount of phosphorus entering the lake each year which results in higher lake phosphorus concentrations.

## Study Conclusions

Impairment thresholds are goals based on average statewide conditions. For the Spirit Lakes, the thresholds don't apply well because of the atypical naturally occurring high groundwater phosphorus concentrations and phosphorus from wetland drainage. This means that lake specific goals are better suited to efforts to protect and improve water quality in these lakes. Small water quality improvements can be achieved by controlling phosphorus sources in the watershed.

For North Spirit Lake there may be the potential to achieve more substantial water quality benefits by controlling sediment phosphorus release with an alum treatment. Alum treatments are expensive and have a limited life expectancy. Further investigation would be needed to determine if an alum treatment is feasible.