

## U.S. Geological Survey's Update on the Water Quality of Delavan Lake

By: Ryan Simons, Chair; Town of Delavan Lake Committee

On Wednesday January 8, Dr. Dale Robertson, Research Hydrologist with the U.S. Geological Survey (USGS), made a detailed presentation to the Town of Delavan's Lake Committee to update its membership on the In-lake Water Quality Monitoring Program conducted by the USGS in conjunction with the Town of Delavan during 2012. The USGS, under Dr. Robertson's direction, has gathered data on our Lake since 1983. Dr. Robertson put the data collected during 2012 into a historical context, which in turn, enabled him to describe long term trends in water quality. The detailed monthly sampling data is readily available on the Town's website under the Lake Information link.

Dr. Robertson used the Trophic State Index to summarize, in general terms the data collected. Trophic State Indices (TSIs) are an attempt to provide a single quantitative index for the purpose of classifying and ranking lakes, most often from the standpoint of assessing water quality. In recent years the Index appears to have attained general acceptance in the limnological community as a reasonable approach to this problem. This is a measure of the trophic status of a body of water using several measures of water quality including: transparency or turbidity (using Secchi disk depth recordings), chlorophyll-a concentrations (algal biomass), and total phosphorus levels (usually the nutrient in shortest supply for algal growth).

TSI ranges along a scale from 0-100 that is based upon relationships between Secchi depth and surface water concentrations of algal chlorophyll, and total phosphorus for a set of North American lakes. Its major assumption is that suspended particulate material in the water controls secchi depth and that algal biomass is the major source of particulates. A set of equations were then derived to describe these relationships with higher values corresponding to increased fertility, that is, more eutrophic. An increase in TSI of 10 units corresponds to a halving of Secchi depth and a doubling of phosphorus concentration.

Phosphorus, Chlorophyll-a (algae concentration) and Secchi depth are related. When phosphorus increases, that means there is more food available for algae, so algal concentrations increase. When algal concentrations increase, the water becomes less transparent and the Secchi depth decreases. The resulting numbers from these three measurements cover different units and ranges and thus cannot be directly compared to each other or averaged. In order to standardize these three measurements to make them directly comparable, we convert them to a trophic state index using an equation. You can find the equations online at: <http://dipin.kent.edu/tsi.htm>. The overall trophic state index (TSI) of a lake is the average of the TSI for phosphorus, the TSI for chlorophyll-a and the TSI for secchi depth; therefore, it can be thought of as the lake condition taking into account phosphorus, chlorophyll-a and secchi depth.

It is important to understand that Trophic States are defined divisions of a continuum in phosphorus and algal concentration. The TSI ranges from 0-100. 0-30 is Oligotrophic, where water is very clear, phosphorus is low, and algae is sparse. 30-50 is an in-between stage where the number of aquatic plants algae increase due to more available phosphorus.

A TSI of over 50 describes a lake that is eutrophic, with a high density of plants and algae that could be unpleasant for swimming at certain times in the summer. Some lakes may be naturally eutrophic, having a TSI of 50 or greater for the last 100 years. Other lakes have gradually increased in TSI as a result of human activities.

Trophic State Index is not necessarily interchangeable with water quality. Water quality is subjective and depends on how you intend to use the water body. A lake that is good for duck hunting is not necessarily good for water skiing. In turn, a lake that is great for swimming may not be great for bass fishing.

The Chlorophyll and phosphorous numbers are reported as u/gl. Ug/l is micrograms per litre, which measures one millionth of a gram per litre. In more understandable terms, a litre equals 1.05 quarts and there are 454 grams to a pound. The Secchi depth is measured in meters and there are approximately 39.4 inches in a meter.

TSI	Chl-a(ug/L)	SD (ft)	TP (ug/L)	Attributes	Fisheries & Recreation
<30	<0.95	>26.2	<6	<b>Oligotrophy:</b> Clear water, oxygen throughout the year at the bottom of the lake, very deep cold water.	Trout fisheries dominate
30-40	0.95-2.6	13.1-26.2	6-12	Bottom of shallower lakes may become anoxic (no oxygen).	Trout fisheries in deep lakes only. Walleye, Tullibee present.
40-50	2.6-7.3	6.6-13.1	12-24	<b>Mesotrophy:</b> Water moderately clear most of the summer. May be "greener" in late summer.	No oxygen at the bottom of the lake results in loss of trout. Walleye may predominate.
50-60	7.3-20	3.3-6.6	24-48	<b>Eutrophy:</b> Algae and aquatic plant problems possible. "Green" water most of the year.	Warm-water fisheries only. Bass may dominate.
60-70	20-56	1.6-3.3	48-96	Blue-green algae dominate, algal scums and aquatic plant problems.	Dense algae and aquatic plants. Low water clarity may discourage swimming and boating.
70-80	56-155	0.8-1.6	96-192	<b>Hypereutrophy:</b> (light limited productivity). Dense algae and macrophytes.	Water is not suitable for recreation.
>80	>155	<0.8	192-384	Algal scums, few aquatic plants	Rough fish (carp) dominate; summer fish kills possible

Overall, the summer average Trophic State Index values for Delavan Lake (based on Secchi disk depth, total phosphorous, and Chlorophyll a) during 2012 classifies the lake on the border of being eutrophic and mesotrophic (Below) and near the water-quality goals established for the lake. He, however, was quick to point out that 2012 was not truly representative of typical hydrologic conditions because of the drought conditions experienced in southeastern Wisconsin. The yellow swath in this slide marks the period of the Delavan Lake Rehabilitation project.

### Trophic State of Delavan Lake

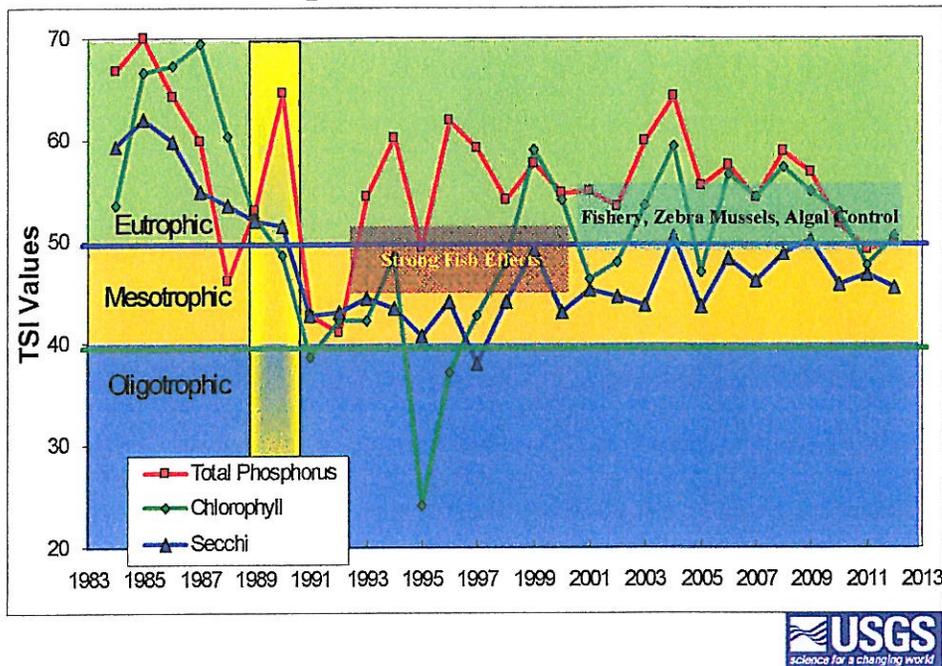
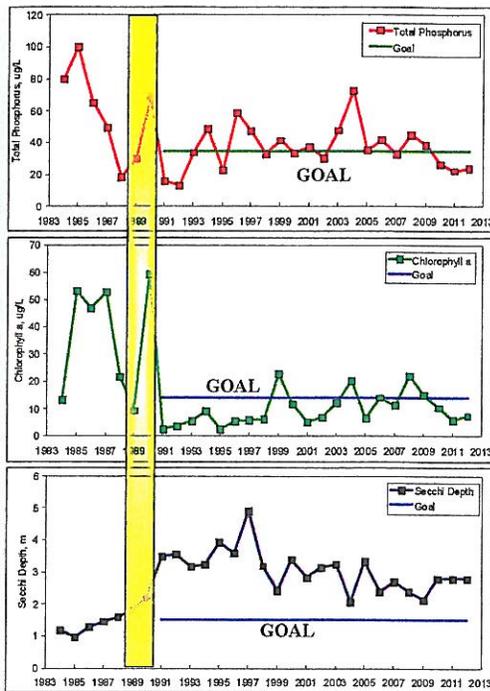


Figure 1. Summer average Trophic State Index values for Delavan Lake.

Data collected in 2012 indicate that the summer average phosphorus concentration was 24 ug/L, which is below the goal set for the lake of 35 ug/l (Figure 2). Phosphorus concentrations spiked in mid-September (Figure 3), caused by the predictable turnover in the lake that typically brings water with elevated phosphorus concentrations to the surface. The seasonal changes in phosphorus concentrations prompted a discussion about the advisability of lowering lake levels in fall as a means of releasing phosphorus from the lake. This option may be worth pursuing.

**In-lake  
Water Quality**

**Summer Average  
June - August**



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Figure 2. Summer average water quality in Delavan Lake, with goals established by the Community.

**2012 Water Quality – Total Phosphorus      Intra-Lake Variability**

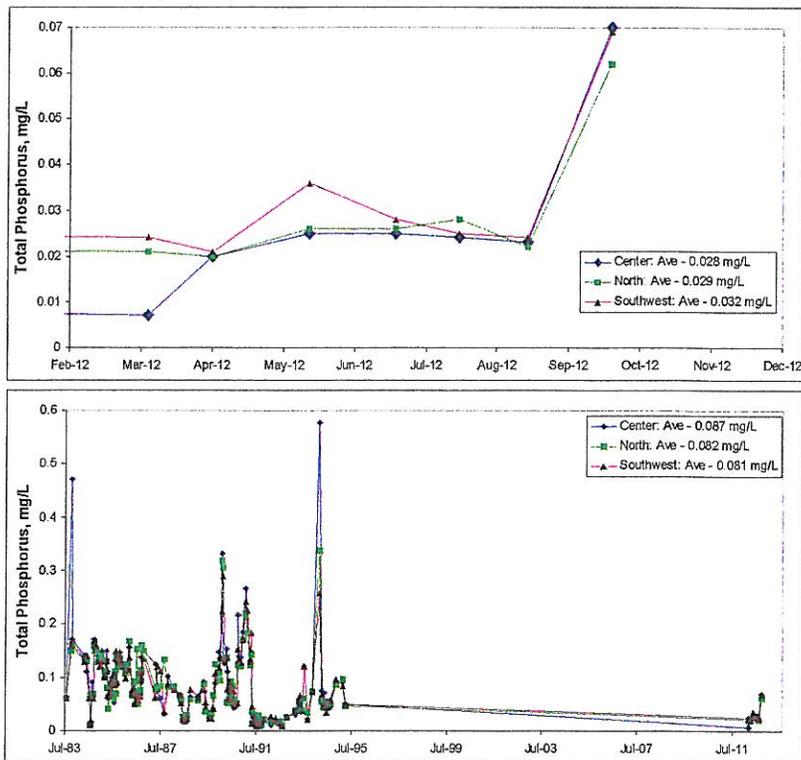


Figure 3. Phosphorus concentrations measured in Delavan Lake.

The summer average chlorophyll a concentration during 2012 was 8 ug/L, which was lower than the goal set for the lake of 14 ug/L (Figure 2). Chlorophyll a concentrations were low throughout most of the summer, but increased in fall (Figure 4).

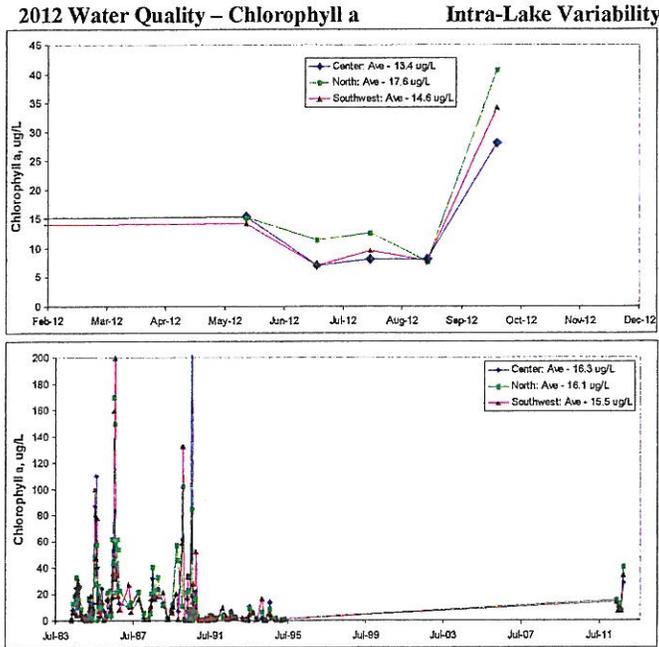


Figure 4. Chlorophyll a concentrations in Delavan Lake.

The summer average Secchi depth during 2012 was 2.8 m, which exceeded the 1.5 m goal set for the lake (Figure 2). Secchi depths generally declined throughout the summer (Figure 5).

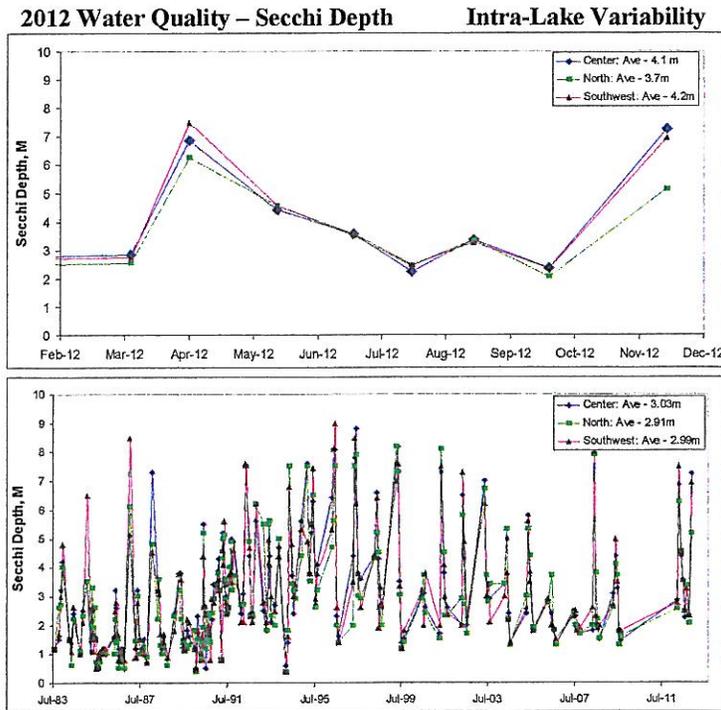


Figure 5. Secchi depths in Delavan Lake.

Robertson cautioned that a year with typical hydrology may have much different water quality than that measured in 2012 and that drawing conclusions from a single year's information is not advised. Instead, he urged that the Committee consider a few years of recent data in any assessment of water quality. The total phosphorous concentration graph (Figure 6) illustrates the variability in concentrations that have occurred in the lake since 1943 and the need to consider any individual measurements or year of data in a longer-term context that results from actions to improve lake water quality and hydrologic variability. It is important to point out that ALL monitoring results are routinely posted on the Town's website.

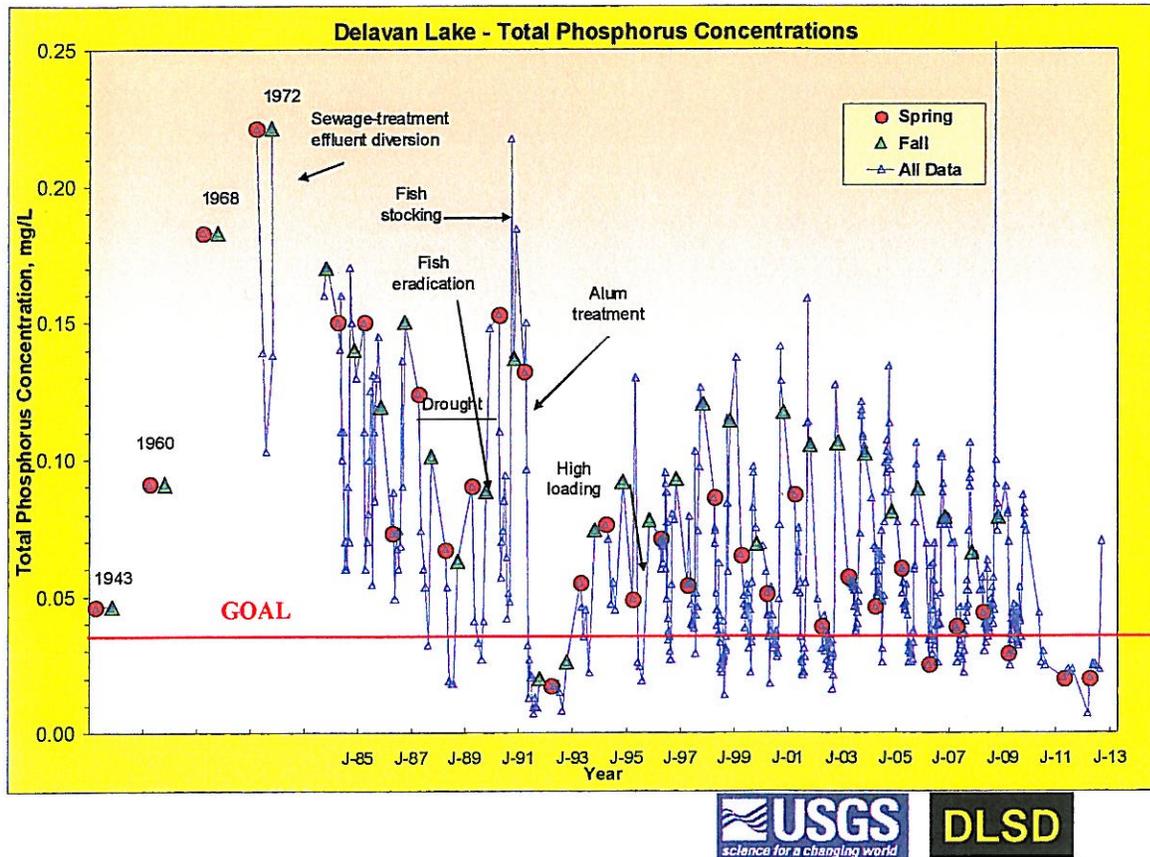


Figure 6. Phosphorus concentrations measured in Delavan Lake from 1943-2012.

Robertson suggested that the historic goals of the lake management program could be refined. Using the Secchi disk depth data as an illustration (Figure 7): The original goal for June through August average Secchi depth was 1.5 meters, established in the 1980s. Typical Secchi depths in June often exceed 4 meters while depths in July and August often decrease to 1-2 meters. On average then, he pointed out, the Secchi depth goals can be met and or exceeded by just averaging increased clarity in early summer with decreased clarity generally observed in mid to late summer. Further, he pointed out that the phosphorus loading goals have not been met, other than in very dry years. There was a discussion on whether the overall goals for the lake could be expanded to include phosphorus loading, water clarity, and fish community structure. The Lake Committee will continue the discussion on goals for the lake at its February meeting. The Committee intends to solicit thinking and suggestions from the widest possible range of stakeholders in developing any new goals for the lake.

## Does the 1.5 m Secchi Depth Goal Make Sense Anymore?

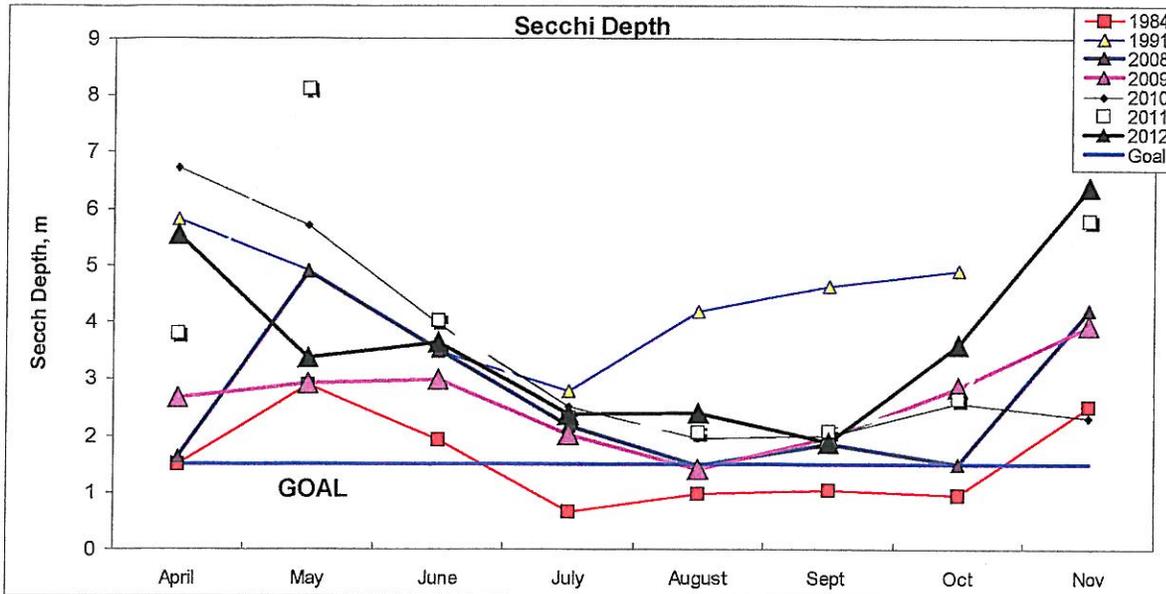


Figure 7. Monthly average Secchi depths in Delavan Lake.

Prior to the USGS presentation, the Town Chair, Ryan Simons, convened a meeting of many experts active in understanding the water quality of the lake to review the Watershed Monitoring Program to be implemented by the DLSD beginning this spring. This was one of the few times since the Delavan Lake Rehabilitation Project began that a group of experts all met at one time. In addition to Dr. Robertson and his colleague Ben Siebers of the USGS, the group included: Jim Deluca - Delavan Lake Sanitary District (DLSD) Administrator, Charlie Handel - DLSD's Lake Manager, Dr. Jeff Thornton - Lake Planner for the Southeast Wisconsin Regional Commission (SEWRPC), Tom Slawski - SEWRPC, Roy Carlson and Jeff Stelzer - Lake and Pond Solutions (the firm that does much of the chemical weed control work on the Lake), and Greg Igl and Eric Allness - U.S. Department of Agriculture's Natural Resource Conservation Service. In the aggregate the assembled group has had more than 80 years collective experience with the Lake. Overall, the discussions served to get everyone "on the same page" with regard to a host of issues for Delavan Lake. One of those issues was to come some agreement as to the locations and methods to be used in the watershed monitoring program. The group settled on methodology and agreed to begin the watershed monitoring effort at the locations identified in Figure 8, below. Hopefully the group can gather again this summer to participate in establishing and finalizing the new management goals discussed above for Delavan Lake.

During the first week of January, the USGS reactivated its gaging station on Jackson Creek at Mound Rd and began data collection at Highway 50. The gaging site is now fully operational, with real time stream flow information available at: [http://waterdata.usgs.gov/wi/nwis/uv?site\\_no=05431016&PARAMeter\\_cd=00065,00060](http://waterdata.usgs.gov/wi/nwis/uv?site_no=05431016&PARAMeter_cd=00065,00060). Data from these sites will again provide information to quantify phosphorus loading to the lake and evaluate how the sedimentation ponds and Inlet affect this loading. In addition to the monitoring on Jackson Creek, data will be collected throughout the watershed as part of the DLSD Watershed Monitoring Program, which incidentally was developed by Robertson and Peter Berrini, HDR Engineering, Inc. Data collected as part of this Program will help identify potential problem areas throughout the watershed.

Figure 8

