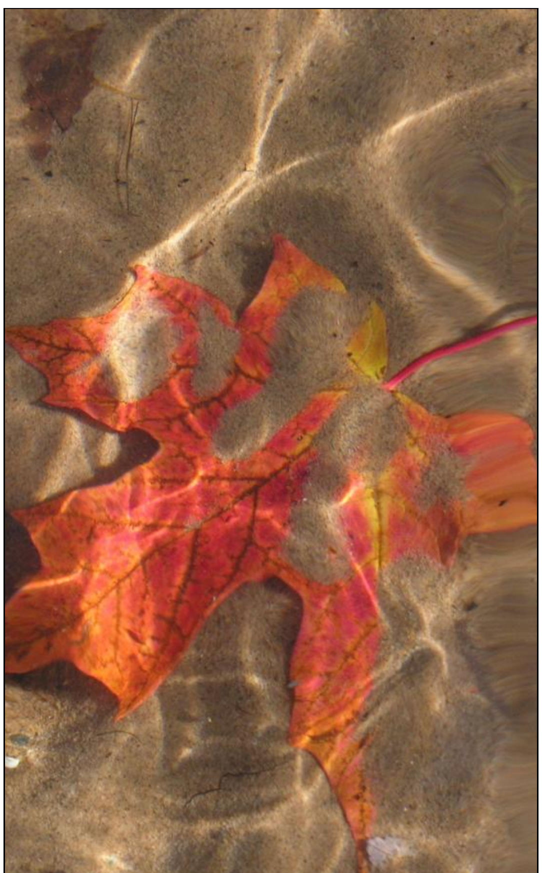
Black Oak Lake Watershed Protection Program (Phase 5): Planning & Implementation of Long-term Water Quality & Stage Monitoring

The Black Oak Lake Preservation Foundation



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Report for a WDNR Lake Planning Grant (Phase 5)

Submitted to:

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Introduction

The Black Oak Lake Watershed Protection Program is an ongoing endeavor composed of annual phases that progress toward the overall vision. The Black Oak Lake Preservation Foundation (formerly, Black Oak Lake Riparian Owners Association) is the lead organization in this long-range effort. White Water Associates, Inc. has been the organization's consultant throughout the history of the program.

Five project phases have been undertaken over the course of the Watershed Protection Program. Phase 5 sought to plan for long-term water quality and stage monitoring at Black Oak Lake and (in concert with Phase 4) continue the ongoing Clean Boats, Clean Waters effort. This report presents these activities and becomes part of the overall adaptive management plan for the Black Oak Lake Watershed Protection Program. It is a required report to the Wisconsin Department of Natural Resources (WDNR) Lake Planning Grants Program. A planning grant partially funded this project.

Project participants continue to embrace the concept of "adaptive management" in their approach to the Black Oak Lake Watershed Protection Program. Simply stated, adaptive management uses findings from planned monitoring activities to inform future management actions and periodic refinement of the plan. An adaptive management plan accommodates new findings by integrating this information into successive iterations of the comprehensive plan (Walters 1986). The plan is therefore a dynamic entity, successively evolving and improving to fit the needs of the Black Oak Lake watershed. A central premise of adaptive management is that scientific knowledge about natural ecosystems is uncertain and therefore a practical management plan allows for ongoing adjustments in management designed to "adapt" to changing conditions and new information or understanding. Monitoring the outcomes of plan implementation is essential to the process of adaptive management.

Besides this introductory chapter, this report contains three additional chapters. Chapter 2 describes the background and study area. Chapter 3 lays out the methods we followed in carrying out this project. Chapter 4 presents and discusses the results of Phase 5

Chapter 2

Background

Black Oak Lake is a 584 acre lake located near the town of Land O'Lakes in northern Vilas County, Wisconsin. It is a deep lake (more than 80 feet in places) and has a high diversity of aquatic habitats (from shallow to deep water). Black Oak Lake can be best described as a "Groundwater Drainage Lake" although the outflow stream has been dry for many years. It is an oligotrophic lake. Its outflow stream is small. Black Oak Lake has remarkable water quality and associated native biotic community. There is a public park with swimming beach, picnic area, and boat landing. Black Oak Lake is an important resource used by the public.

Phases 1 and 2 assembled existing water quality information on Black Oak Lake and Phase 5 has conducted further analysis of this data as well as more recently collected data. This analysis and consultation with Wisconsin water quality professionals has helped the development of a water quality monitoring program that informs The Black Oak Lake Preservation Foundation members and other stakeholders about the status of Black Oak Lake water quality. It will help reveal trends in water quality measures such as water transparency.

The recent years of draught conditions in northern Wisconsin have resulted in low lake levels in Black Oak Lake. Since widely varying lake level represents a possible stressor on the Black Oak Lake ecosystem, it is important to document the extent of this variation. Measurements of Black Oak Lake water levels have taken place since 2001. In fact, this kind of stage height monitoring is rarely done for lakes and generally prevents us from determining how current lake levels compare to historic values and whether the current drought and coincident low lake levels is having an unusual duration. Phase 5 has endeavored to establish an accurate, repeatable, and standardized approach to lake level monitoring in Black Oak Lake.

Chapter

3

Methods

There were three principal goals of the Phase 5 project: (1) institute a system that detects changes in water quality, (2) establish a scientifically acceptable method for monitoring lake stage height (lake level), and (3) prevent establishment of AIS. The approaches we used to accomplish these goals are described in this chapter.

Part 1 — Long-range Water Quality Monitoring

Our approach with long-range water quality monitoring was to review and analyze historical water quality data available for Black Oak Lake to see if long-term trends were evident. We consulted with Wisconsin-based limnology professionals regarding Black Oak Lake water quality issues to glean other ideas about approaching long-range monitoring. Members of the Black Oak Lake Preservation Foundation have consulted with Tim Kratz (former Trout Lake Director) and Susan Knight (Trout Lake Research Scientist). We also consulted with Tim Asplund (WDNR) and Kevin Gauthier (WDNR).

The Citizen Volunteer Water Quality Monitoring Program was ongoing throughout Phase 5. In addition, White Water Associates collected a mid-summer 2011 water quality sampling to evaluate additional water quality parameters.

One outcome of our data review, analysis, and discussion with other scientists was the preparation of a water quality sampling plan for Black Oak Lake that will monitor for changes in water quality. Black Oak Lake Preservation Foundation Board members asked that water quality plan allow the determination of a Black Oak Lake water quality "report card" on an periodic basis. This will help identify areas of quality or concern for Black Oak Lake stakeholders. In order to "grade" the lake, we consider attributes on which to base such an evaluation.

Part 2 — Long-term Stage Monitoring

In the process of establishing a scientifically acceptable method for monitoring Black Oak Lake stage height (lake level), we consulted Preservation Foundation Board member Walt Bates regarding the lake stage monitoring that he has conducted for several years on Black Oak Lake. He has begun an important long-term record of lake level. We also consulted with Tim Asplund (WDNR) regarding lake stage monitoring protocols for Wisconsin, training for lake stage monitors, and disposition of lake stage data. In addition, we consulted with the U.S. Geological Survey (USGS) for advice on protocols for lake stage monitoring. Early on, we spoke with Dr. Carl Watras (University of Wisconsin, Center for Limnology, Trout Lake Station) regarding a program of lake level monitoring in which he was involved (now being managed by the North Lakeland Discovery Center).

Part 3 — Clean Boats / Clean Waters

Phases 4 and 5 shared the goal of preventing establishment of AIS in Black Oak Lake. Phase 5 included (in part) volunteer monitoring of watercraft traffic into Black Oak Lake through the Clean Boats, Clean Waters Program. This monitoring serves to minimize the opportunities for introduction of AIS propagules on recreational watercraft. Since 2004, watercraft inspection has been a significant part of Wisconsin's AIS prevention efforts. Black Oak Lake has participated in the Clean Boats, Clean Waters Program since 2008. The WDNR and University of Wisconsin Extension (UWEX) have developed a well-defined protocol for carrying out this program. In 2011 BOLROA carried out the CBCW program and submitted data collected by boat landing monitors to the SWIMS database.

Part 4 — Education

As part of the Phase 5 project, we had numerous direct interactions and correspondences with Preservation Foundation board members that, in part were educational in nature. Aspects of these discussions were presented on the foundation website. The Phase 5 report and the adaptive management plan that houses it are educational documents intended for Black Oak Lake stakeholders to become more knowledgeable about the Black Oak Lake ecosystem and watershed.

Chapter

4

Results and Discussion

In this Chapter, we describe the results of the Phase 5 effort under two corresponding parts: (1) long-range water quality monitoring and (2) long-term stage monitoring.

Part 1. Long-range Water Quality Monitoring

The adaptive management plan for Black Oak Lake summarizes and interprets water quality data collected in Black Oak Lake from two sources: (1) Conserve School classes from 2000 through 2002 and (2) WDNR Self-Help Monitoring Program data from 2002 through 2006. In this Phase 5 report, we update the data analysis (including more recently obtained data) and focus on measures of trophic status (specifically, Secchi depth, phosphorus concentration, and chlorophyll α concentration).

As has been previously documented, a dramatic increase was observed in Black Oak Lake water clarity beginning in 2005. Secchi depths went from an annual average of around 15 feet to an annual average of about 28 feet in 2005 and 2006 (Exhibit 1). Since 2007, average Secchi depth readings in Black Oak Lake have not been less than 31 feet (and most are higher). Black Oak Lake has long been known for its high water clarity, but this increase was noteworthy.

The reasons for this greater than doubling of water transparency are generally unknown. One might guess that the presence of some sort of filtering organism such as the AIS zebra mussel would be behind the phenomenon, but in fact zebra mussel are not present in Black Oak Lake (in fact, lake's calcium concentration is sufficiently low so as to be unsuitable for zebra mussels). Small changes in chlorophyll α concentration may lead to more noticeable changes in an already clear lake. In fact, average chlorophyll α concentration in Black Oak Lake was lower beginning in 2005 (coincident with the high Secchi transparency). This is graphically displayed in Exhibit 2. For a few years, chlorophyll α concentration was measured at several times during the ice free season. When these data are examined graphically (Exhibit 3) the variability of chlorophyll α concentration was higher in 2002 and 2003 (varying about 5 μ/L over the course of each of those years. Starting in 2004, however, the variability of chlorophyll α varied less than 1.5 μ/L (and often less than 1.0 μ/L) over the course of any given year. More dramatic algal "blooms" apparently took place in 2002 and 2003, but less so since then.

Exhibit 1. Average annual Secchi depth (in feet)

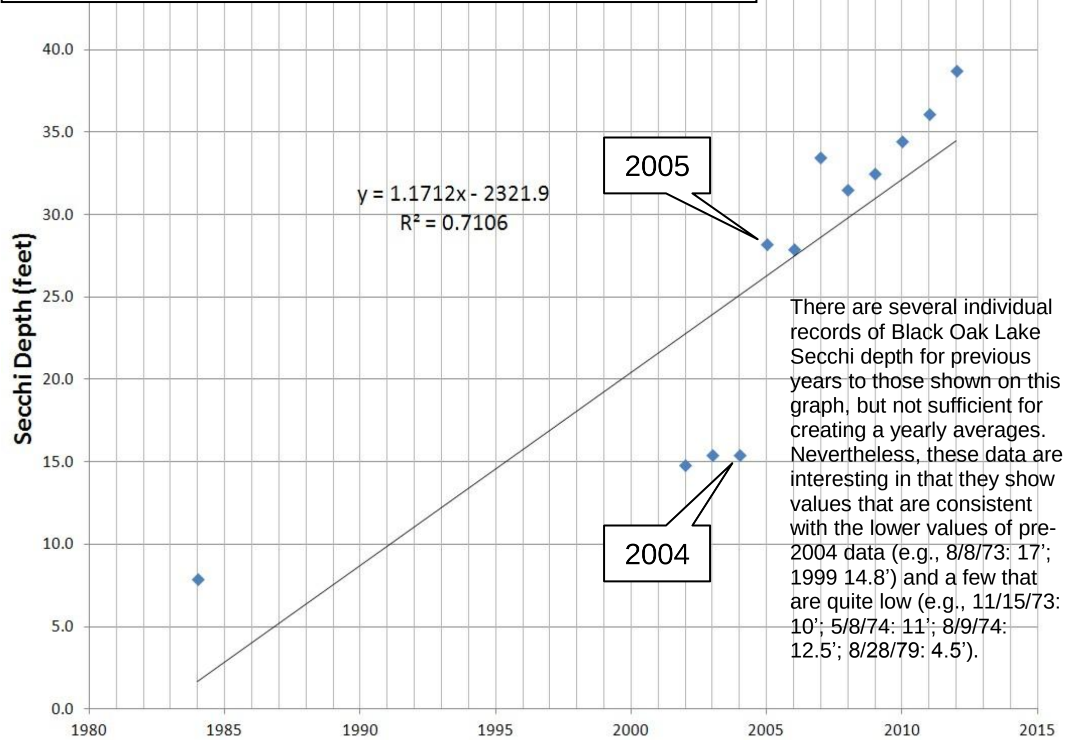


Exhibit 2. Average annual Chlorophyll α

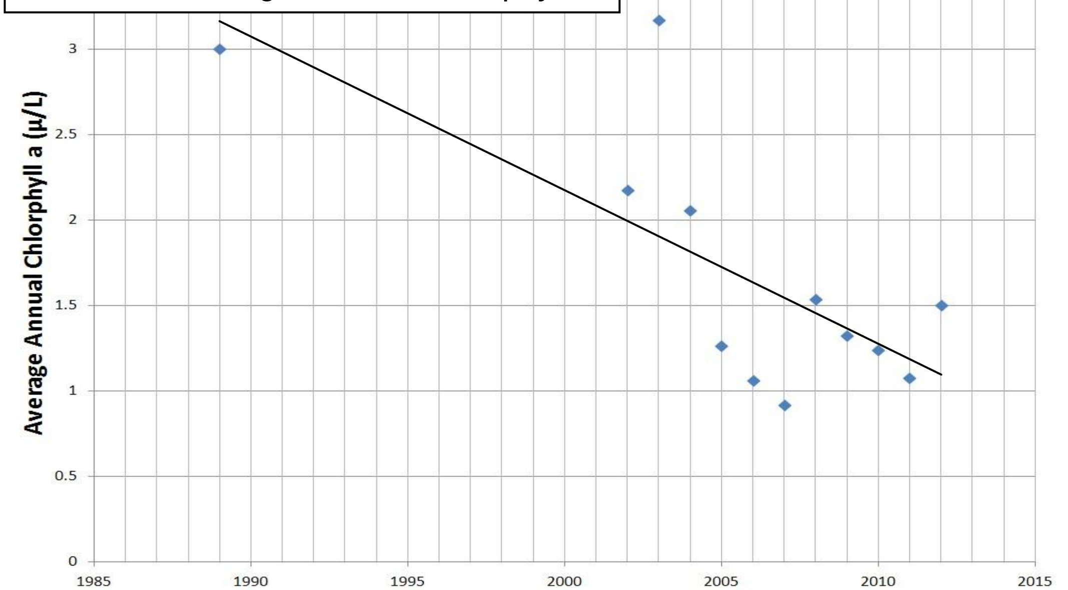
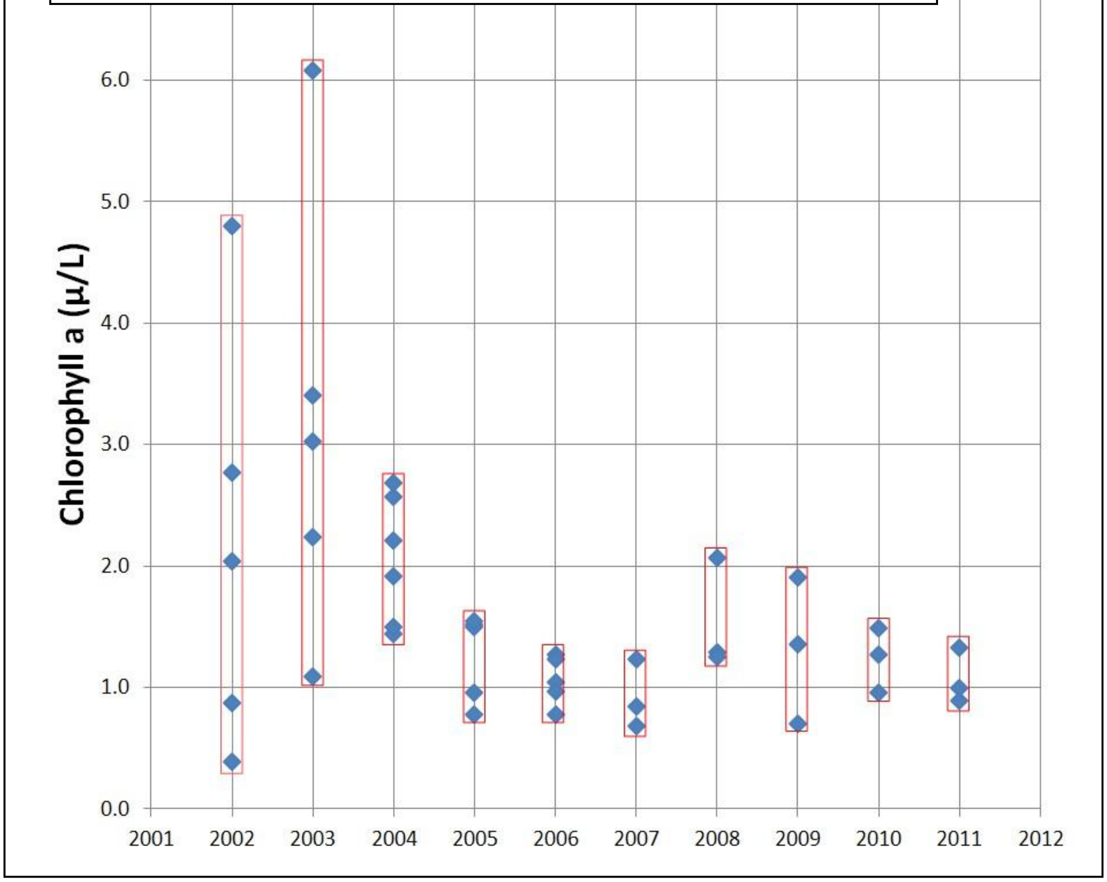
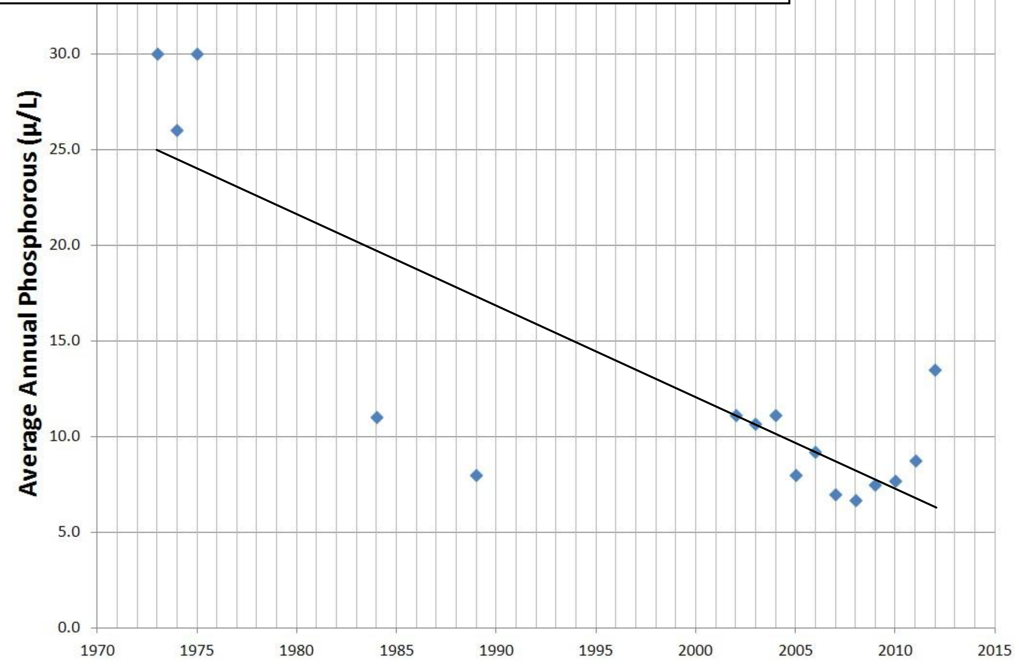


Exhibit 3. Chlorophyll α concentration within year variability



Chlorophyll α and water transparency are often related to concentration of the nutrient phosphorus. The annual average concentration of phosphorus measured in Black Oak Lake over the past 39 years is shown in Exhibit 4. Values in 1973, 1974, and 1975 were more than twice what has been observed since 1984. This could be a real phenomenon or perhaps a different laboratory or field sampling methodology. In the last 28 years (since 1984) the average phosphorous concentration has remained between 6 and 11 µ/L. The single phosphorus value for 2012 was 14 µ/L. The average annual phosphorus concentrations were about 11 µ/L in 2002, 2003, and 2004. In the first year of the high water transparency the average annual phosphorus concentration was 8 µ/L.

Exhibit 4. Average annual phosphorus concentration



Dr. Susan Knight, WDNR and UW Research Scientist and Aquatic Biologist at the University of Wisconsin Center for Limnology Trout Lake Station, has had a long time interest in Black Oak Lake. Dr. Knight examined Secchi depth data to document and understand the increased water clarity phenomenon. She prepared and interpreted the graphs displayed in Exhibit 5. This multi-year set of graphs shows the large increases (more than doubling) of Black Oak Lake's Secchi depths starting in 2005. Dr. Knight notes that the intra-summer changes of Secchi depth are of scientific interest in the Exhibit 5 graphs of annual Secchi depth (Knight, 2012, unpublished). The worst clarity is right after ice-out. Clarity continues to increase and eventually more than doubles the initial reading. Peak clarity is reached at about 55 days after ice-out. Over the next 40 or so days it drops back to about half way between the two values and stays there until fall. Also of interest is how tightly the Secchi peaks cluster at that 55 days since ice-out point, especially considering that the actual calendar ice-out date varied by more than a month over the six years covered by these graphs. This would indicate that a lake's biotic year is far more affected by ice-out than by sun angle. Indeed, many significant things happen at ice-out such as the first infusion of fresh oxygen, spring turnover, first solar illumination, first wind mixing, first rainfall turbulence, and more.

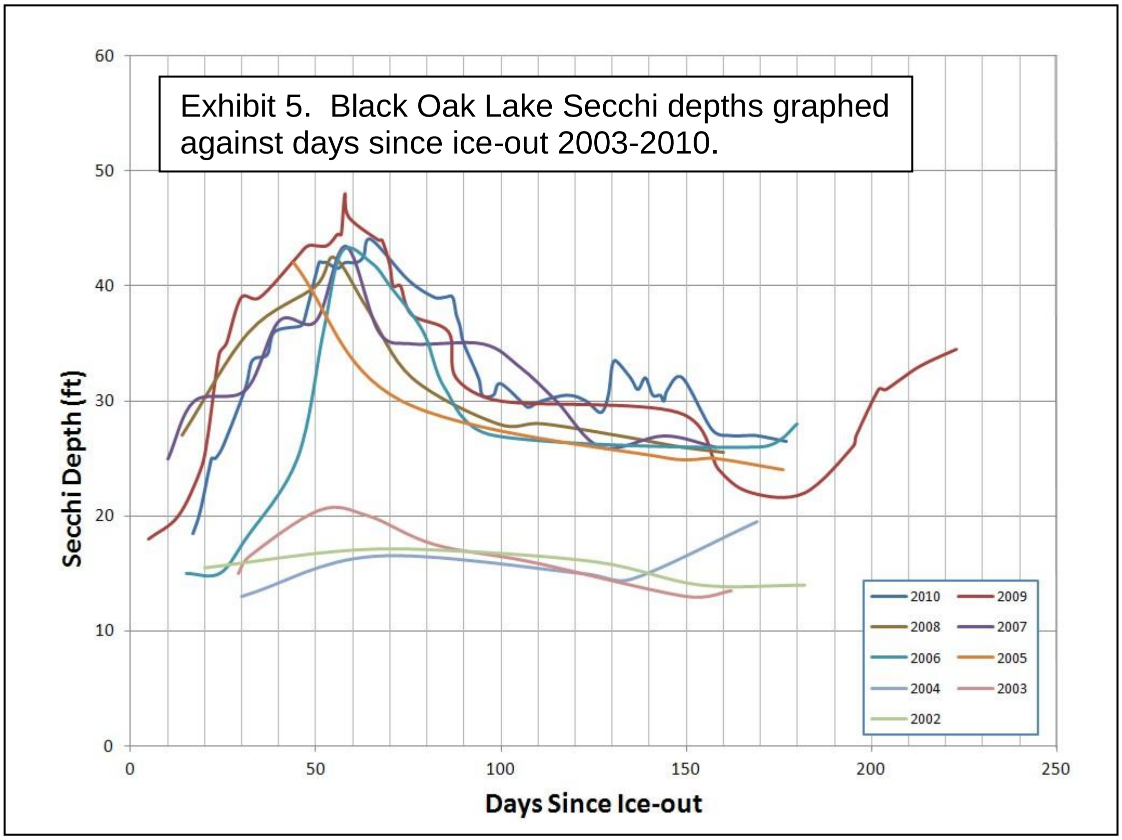


Exhibit 5. Black Oak Lake Secchi depths graphed against days since ice-out 2003-2010.

Dr. Knight interprets the seasonal variability in Secchi depths by describing the trophic interactions between algae and zooplankton (nearly microscopic organisms that eat single-celled algae). In the early spring, right after ice-out, lake turnover brings up nutrients from the bottom and this spurs algal growth in the lake. Zooplankton benefit from the increasing numbers of algae and consume more and more. Consequently the numbers of zooplankton also go up as they reproduce and prosper from the rich food source. As more algae are eaten the water clarity increases. When the zooplankton numbers are at their peak and they are eating the most algae, Secchi readings will also be at their peak. This is known as the “clear water phase.” As the graphs in Exhibit 5 show, this peak clarity seems to happen in Black Oak Lake data about 55 days after ice-out. After this, the algae numbers will start to fall, and the zooplankton numbers will also fall. The interactions between algae, zooplankton, nutrients and fish become more complicated as the summer moves on and thus a more intermediate water clarity results.

By any standard, the water clarity of Black Oak Lake would be considered an indicator of excellent lake water quality. Recent measures of phosphorus and chlorophyll α reinforce this conclusion. Like any ecosystem, Black Oak Lake is complex and an absolute determination of cause for the increased water clarity in 2005 and thereafter remains elusive. Has it reached a new equilibrium or will it continue to change? This can only be learned through the efforts of devoted lake stewards and their ongoing lake monitoring.

Future sampling should continue with the frequent Secchi depth measures (weekly would be good). For a period of five years, Chlorophyll α and phosphorus should be measured close to the time of ice-out, at 55 days after ice out and at 130 days after ice-out. Dissolved oxygen/temperature profiles should be done as time permits, but at least monthly. Stage height measurements should be taken in spring and fall. Sampling efforts are coordinated by Walter Bates. These parameters and sampling frequency are outlined in the bulleted list below:

- Secchi depth – weekly during ice-free season;
- Chlorophyll α – three times: ice-out, 55 days after ice-out, 130 days after ice-out;
- Phosphorus – three times: ice-out, 55 days after ice-out, 130 days after ice-out;
- Dissolved oxygen/temperature profiles - at least monthly during ice free season;
- Stage height (lake level) – Twice per year: early spring and late fall.

Water quality data should be input into the SWIMS database from which it should be periodically accessed for analysis. Once per year the water quality data should be compared to values to previous years to see if unexpected changes have become evident. This data review should be conducted by a committee of the Black Oak Lake Preservation Foundation. Past foundation president, Tom Allman, recommends that two people from each current board (one senior board member and one freshman member) form this committee and complete the annual review with needed assistance from a professional consultant. As future understanding or observations dictate, additional parameters can be added to the monitoring plan. A Phase 6 project will be proposed in 2013 and will incorporate these new water quality sampling recommendations.

In addition to the ongoing water monitoring, members of the Foundation Board and their consultant are considering additional studies to help understand the trophic status and dynamic nature of the Black Oak Lake ecosystem. These possible studies include:

- Analysis of a 2011 point-intercept aquatic plant survey and comparison to the previous survey to determine changes in composition, density, and distribution of the aquatic Macrophytes in Black Oak Lake;
- Analysis of sediment core sample taken in Black Oak Lake in July 2012;
- Algae and zooplankton studies to understand these communities, their trophic interactions, and influence on water clarity.

Foundation board member, Bob Pierce has expressed an interest in developing a Black Oak Lake "report card" that would reflect the health status of the lake. One of the actions anticipated in the 2012 iteration of the Black Oak Lake Adaptive Management Plan is to develop such an evaluation process based on lake monitoring data. Also involved in this process is to establish standards for what constitutes various ratings (in other words, the grading scale). For example, what Secchi transparency value would be considered as the ideal? Perhaps a more integrated evaluation of parameters that results in a rating of the lake as oligotrophic or mesotrophic would be preferred. The board committee should consider these and other topics. Good candidate factors to consider when evaluating the lake include: clarity, phosphorous, chlorophyll α, temperature, dissolved oxygen, water level, aquatic plant community, presence of AIS, and the fish community.

Part 2. Long-term Stage Monitoring

In August of 1969, the WDNR created a "Lake Survey Map" for Black Oak Lake. This included the lakes bathymetric contours and water level. At that time a benchmark was established as an "X" on the top of the lake side of the first culvert under the park access road at the south end of the lake. This is labeled in Exhibit 6. The benchmark was assumed to be 100.00 feet in elevation. A water level obtained at that time was 98.66 feet. That culvert still exists on Black Oak Lake although it, and the road that travels over it, are old and replacement in the near future is likely.

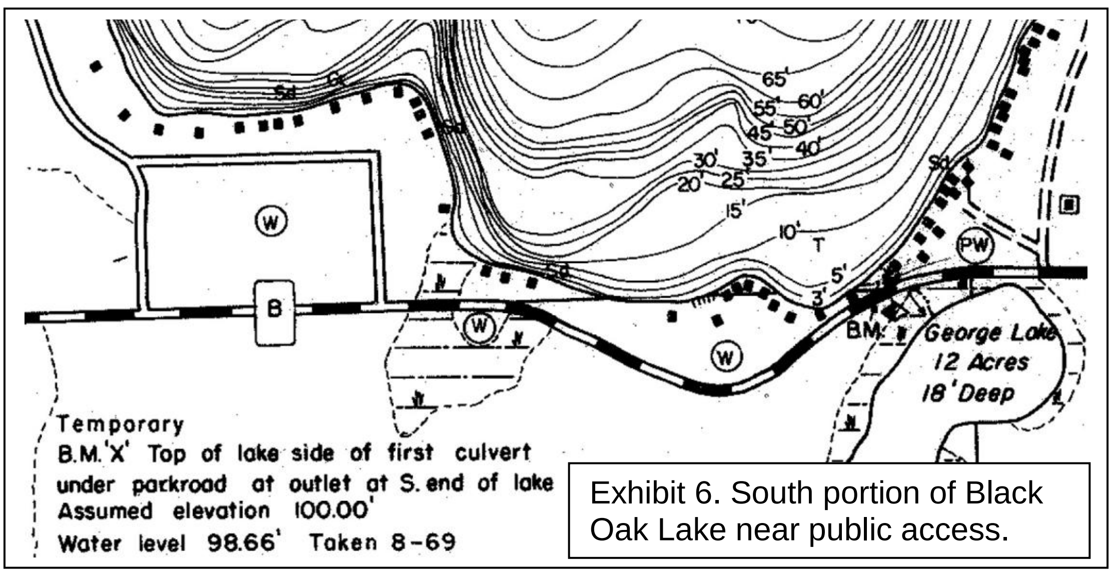


Exhibit 6. South portion of Black Oak Lake near public access.

Black Oak Lake water level has been accurately recorded since early spring of 2001, by lake volunteer Walt Bates. On flat calm water, Mr. Bates measures vertical height from a submerged concrete block that exists in front of his property near the west end of North Black Oak Lake Road (this is one mile northwest from the bench mark described in the previous paragraph and within a line-of-sight from the benchmark). Actually, two blocks of concrete are used in the determination of lake level. One is a very large block whose surface is approximately seven feet underwater. The second is a smaller block located in shallower water. The shallower block is more convenient to measure stage height from and the larger block is used to document the stability of the shallower block. From 2001 to 2010 the relative measurements of these two concrete blocks remained unchanged. Low water in winter of 2010 caused ice to break up the shallow concrete piece. A new one was installed in slightly deeper water. The deeper water concrete block was used to standardize the new shallow block's elevation measurement. In the years since the new block was installed, its position relative to the deeper block has remained stable.

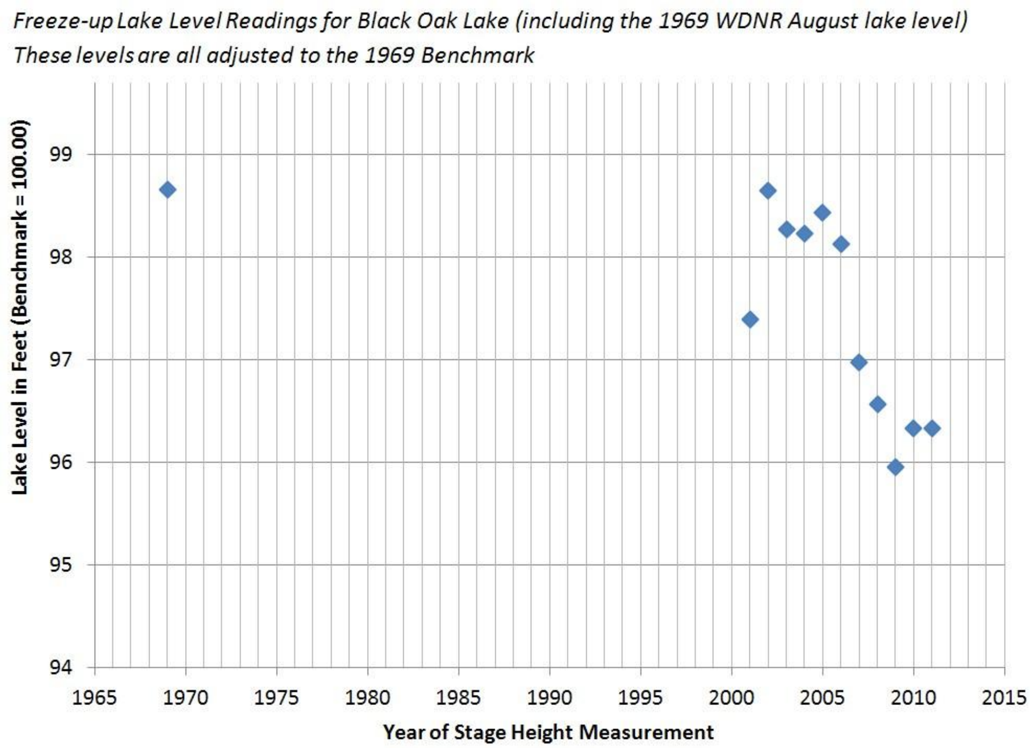
On August 22, 2011 (a very calm, windless day), Mr. Bates and an assistant used a transit to determine that the top of the culvert (the 1969 benchmark for lake level) was 3.27 feet above Black Oak Lake water surface (in other words the lake level was at 96.73 feet (relative to the BM). Mr. Bates next took the measurement from the top of the large concrete block to the water surface. Using the survey technique of "water level transfer" it was possible to establish that the vertical distance from the top of the large concrete block to the top of the culvert benchmark (=100.00 feet) was 130.25 inches (=10.85 feet). Relative to the 100.00 BM, the elevation of the top of the large concrete block is 89.15 feet. Using this datum we are able to report the entire history of Black Oak Lake level at the same scale and relative to the original bathymetric map of the lake in 1969 when the benchmark was established. These data are presented in Exhibit 7. Exhibit 8 displays the water level elevations for the fall measures. Over the course of these records, fall water level readings have ranged from a high of 98.66 feet (in 1969 and 2004) to 95.96 feet (in 2009). This is a 2.7 foot (32.4 inch) range.

Exhibit 7. Black Oak Lake water level elevations (in feet) relative to the 1969 benchmark established by the WDNR.

Note: measures are made at the time of ice out in spring and freeze-up in fall. The 1969 bathymetric survey was conducted in August.

Year	Ice-Out	Freeze-Up
1969 (August)		98.66
2001	97.60	97.40
2002	97.81	98.65
2003	98.77	98.27
2004	98.65	98.23
2005	98.19	98.44
2006	98.69	98.12
2007	98.17	96.98
2008	97.15	96.56
2009	96.62	95.96
2010	95.77	96.33
2011	96.87	96.33
2012	96.48	

Exhibit 8. Black Oak Lake fall water level elevations.



As part of the Phase 5 effort, we have been in contact with Tim Asplund (WDNR) and Paul Juckem (USGS) regarding the status of the Wisconsin lake level monitoring program. This program is in its early stages. They are currently developing the portion of the program called "train the trainers" which gets a core group of people trained locally who can work with lake associations to create a lake level monitoring program that the lake association will follow and enter lake level data into the SWIMS database. Since Black Oak Lake has several years of monitoring and has tied the lake level elevation data to the 1969 benchmark, the advice we glean from the WDNR at this time is to continue with the Black Oak Lake protocol and enter the data into SWIMS as it becomes available. Black Oak Lake stewards will remain informed regarding the status of the WNDR-UWEX Lakes train the trainer program.

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Walters, C. 1986. Objectives, constraints, and problem bounding. In W.M. Getz, ed., Adaptive Management of Renewable Resources. Macmillan Publishing Company. New York. p. 13+.