Lake Puckaway
Water Quality Monitoring
2012

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Introduction

In 2012, water quality monitoring was conducted on Lake Puckaway and connecting rivers, funded by a State of Wisconsin Lake Management Grant and the Lake Puckaway Protection and Rehabilitation District. This is the second year of the monitoring project, but I will reserve most multi –year comparisons until the last year of the current project: 2013. The type of water quality monitoring conducted at these stations is called trophic monitoring. Trophic refers to the state of the lake, typically ranging from a turbid system dominated by algae and/or aquatic plants (Eutrophic) to a clear one with few nutrients (Oligotrophic). Mesotrophic condition marks a transition between oligotrophic and eutrophic. Hypereutrophic conditions have very high nutrients and frequent algae blooms. Excessive nutrients from the landscape--predominately in the form of phosphorous--drive the excessive growth of algae, as does the suspension of sediment due to waves and carp activity.

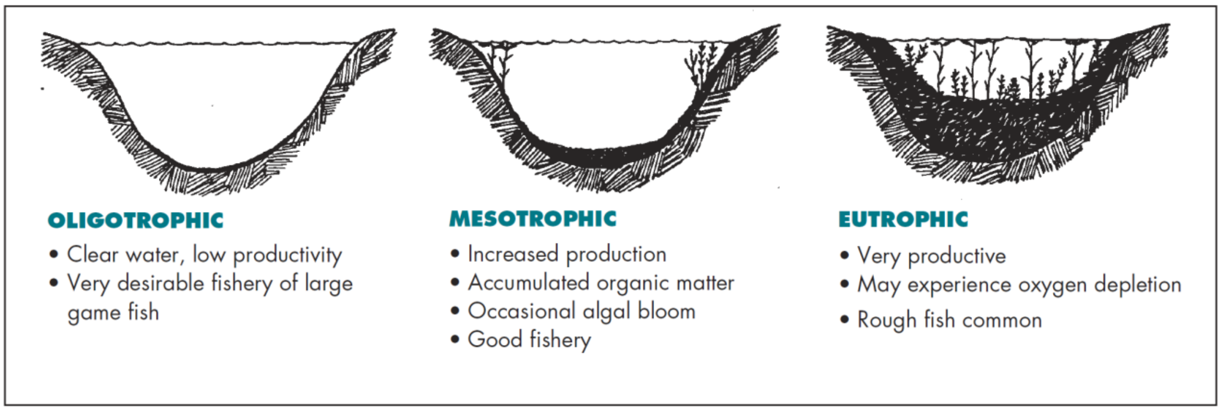

Figure 1. Description of trophic states (Mechenich, and Klessing 2004)

Methods and Location

Monitoring was conducted at two principal locations within the lake, roughly in the center of the West and East Basins. Samples were also taken on the Grand River, the Fox River above its confluence with the Grand River, and the Fox River as it exits the lake. In total, five stations were sampled for all parameters approximately every two weeks, beginning May 10th and ending November 15th. Samples were collected between 1030 and 1400 hours at a depth of 1.5 feet. Seven parameters were sampled at trophic stations. Total phosphorus and chlorophyll a samples were sent to the State Lab of Hygiene for testing. DO, conductivity, pH, and temperature were obtained with a YSI Professional Plus meter. In addition to the above stations, three sites--Mid-Lake, Fox Inlet and Fox River Deep Hole--are water clarity monitoring stations only. Industrial pollutants were not monitored at any sites.

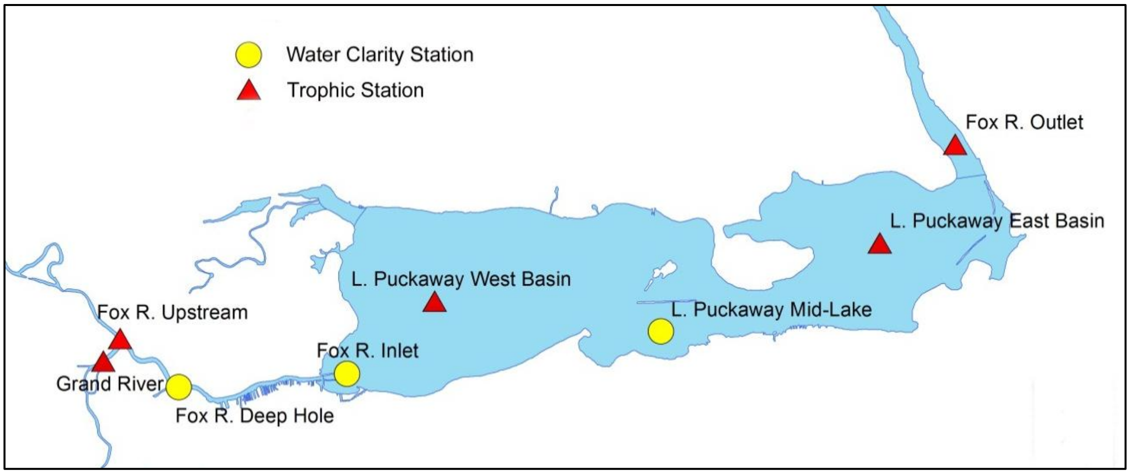

Figure 2. 2011-12 water quality monitoring stations.

Results Page

Figure 3. Water as it moves through the system during the worst water quality, July 17, 2012. Left to right: Fox R. Deep Hole, Fox R. Inlet, Puckaway West Basin, L. Puckaway mid-lake, L. Puckaway East Basin, Fox R. Outlet.

Results

Trophic State Index (TSI): Total phosphorus, water clarity, and algae concentration (in the form of chlorophyll a) are indicators of excess nutrients. These three factors can be assigned values in the TSI and compared together to indicate the trophic status of the lake. The TSI is probably the best single illustration of the nutrient condition of a lake. For every increase of 10 units of the TSI scale there is a doubling in algal mass. According to the results of the TSI, Lake Puckaway was in a hypereutrophic state throughout the sampling period, and had an in-lake average TSI for June through August of 76.5.

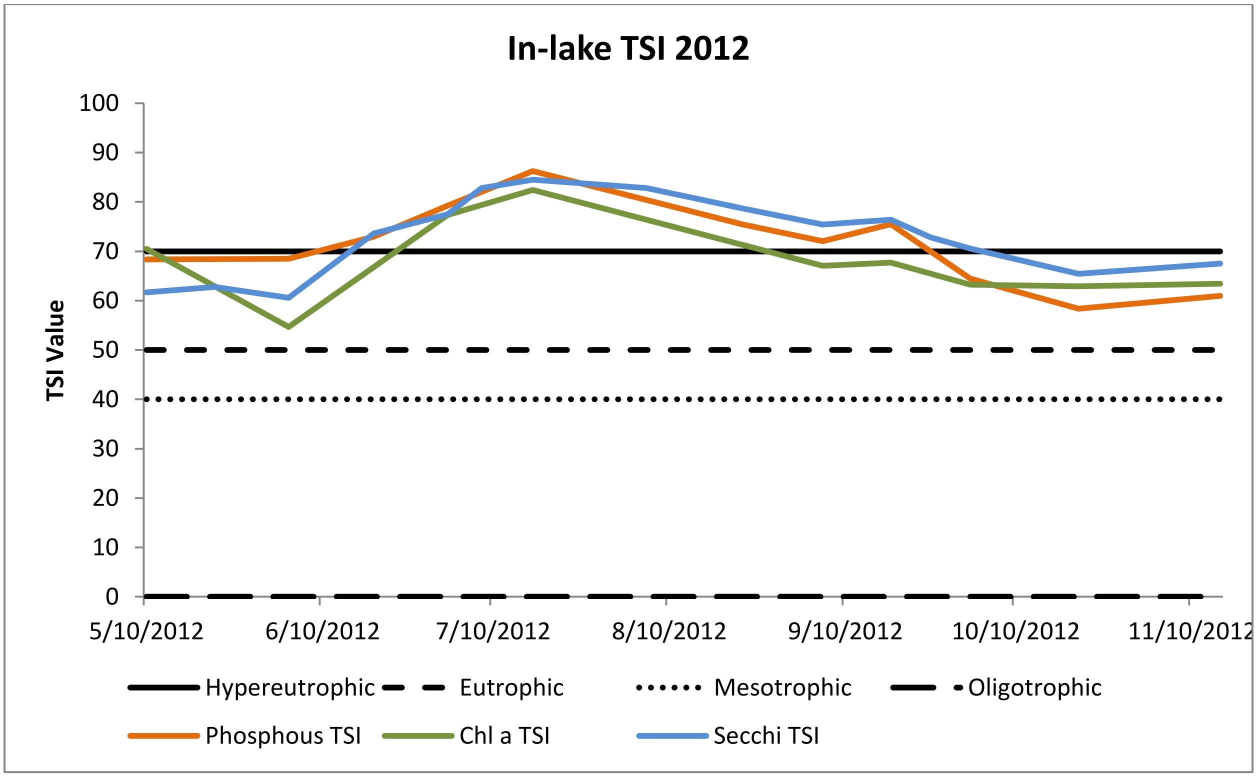

Figure 4. Average TSI for Lake Puckaway

Water clarity (Secchi depth): An 8 inch diameter plate with alternating quadrants painted black and white (Secchi disc) is used to measure water clarity (transparency). The disc is lowered into water until it disappears from view. It is then raised until just visible. The average of the two depths, taken from the shaded side of the boat, is recorded as the Secchi disc reading. For best results, the readings should be taken on sunny calm days (Shaw, Mechenich, and Klessing 2004).

Using Secchi discs to approximate water clarity is a common and inexpensive way to obtain data, as opposed to a light meter. True water clarity cannot be measured if the disc is still visible when it hits the lake or river bottom. This occurred nowhere in the lake east of the Fox River inlet during the sampling period, but did upstream. As with other trophic indicators, conditions consistently became less clear from west to east on the lake. Average water clarity for the lake through the summer sample period was 1.6 feet whereas the region averages 7.9 ft. A graph and table with readings from all stations is located in appendix A.

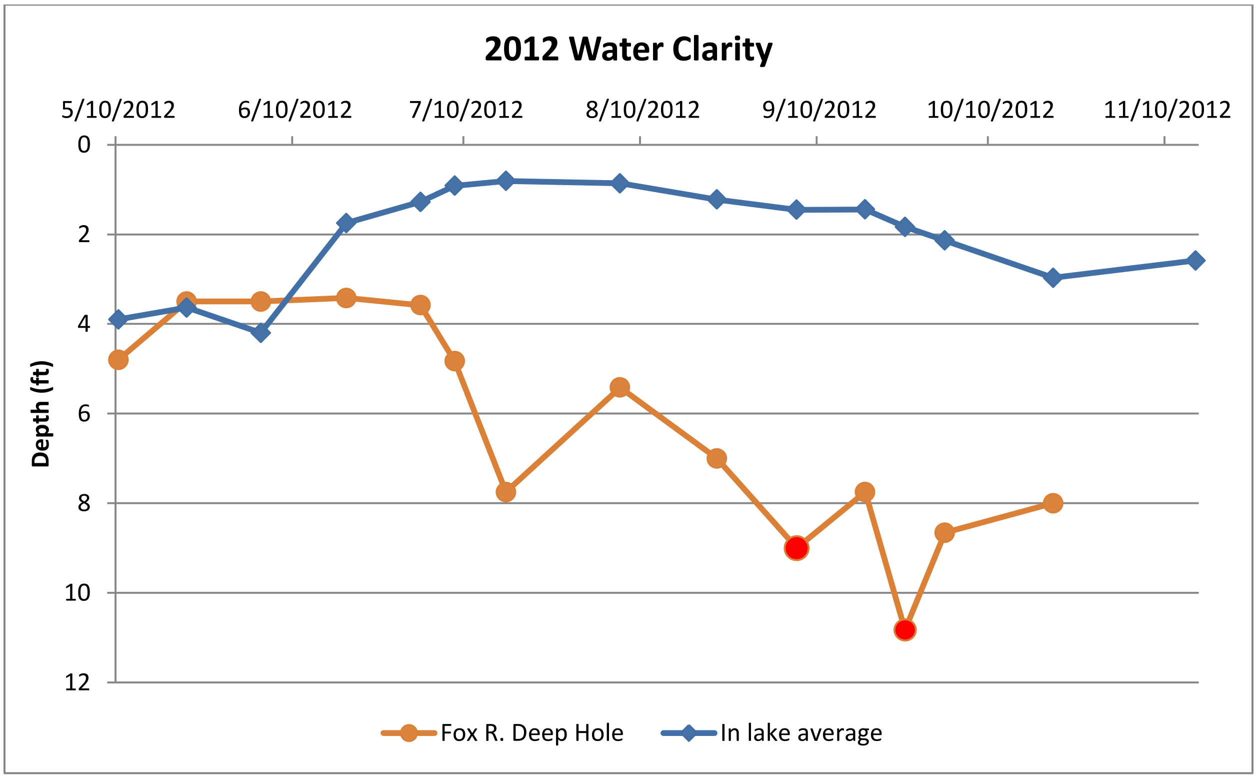

Figure 5. Fox River Deep Hole and average in-lake water clarity readings. Red dots indicate the Secchi disk hit bottom and true clarity could not be obtained.

Total Phosphorous (total P): A key nutrient influencing plant growth in more than 80% of Wisconsin lakes, total phosphorous includes the amount of phosphorous in solution (reactive) and in particle form (Shaw, Mechenich, and Klessing 2004).

While average total P for the region is 0.031mg/L, Lake Puckaway's 2012 summer average was five times higher at 0.165 mg/L. Throughout the summer, total P concentrations exceeded that of a hypereutrophic system.

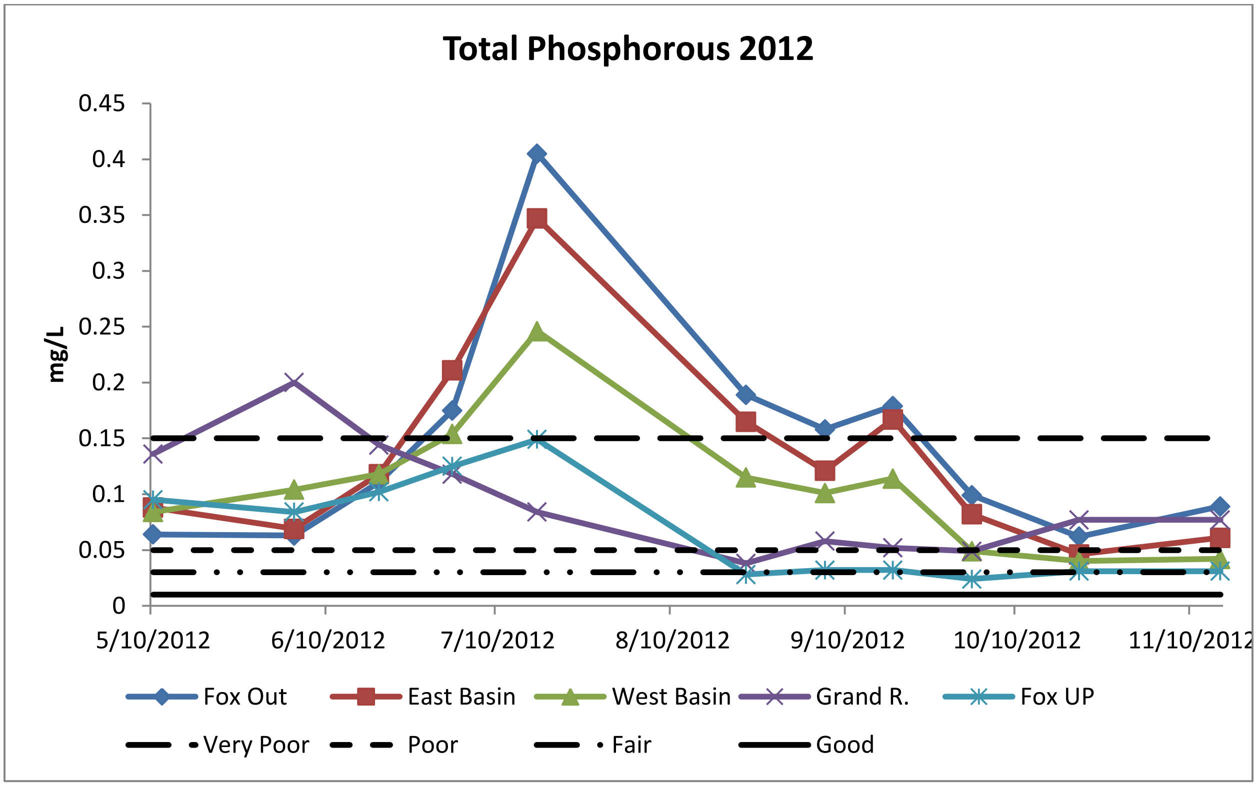

Figure 6. Total P concentrations are considered poor from 0.05 to 0.15 mg/L, and very poor greater than .15 mg/L (Lillie and Mason 1983).

Chlorophyll a (chl a): A green pigment present in all plant life and necessary for photosynthesis, the amount of chlorophyll present in lake water depends on the amount of algae and is therefore used as a common indicator of water quality (Shaw, Mechenich, and Klessing 2004).

Chl a followed the same general trend as other trophic indicators, upstream to downstream. As in past years Lake Puckaway suffered from intense algae blooms.

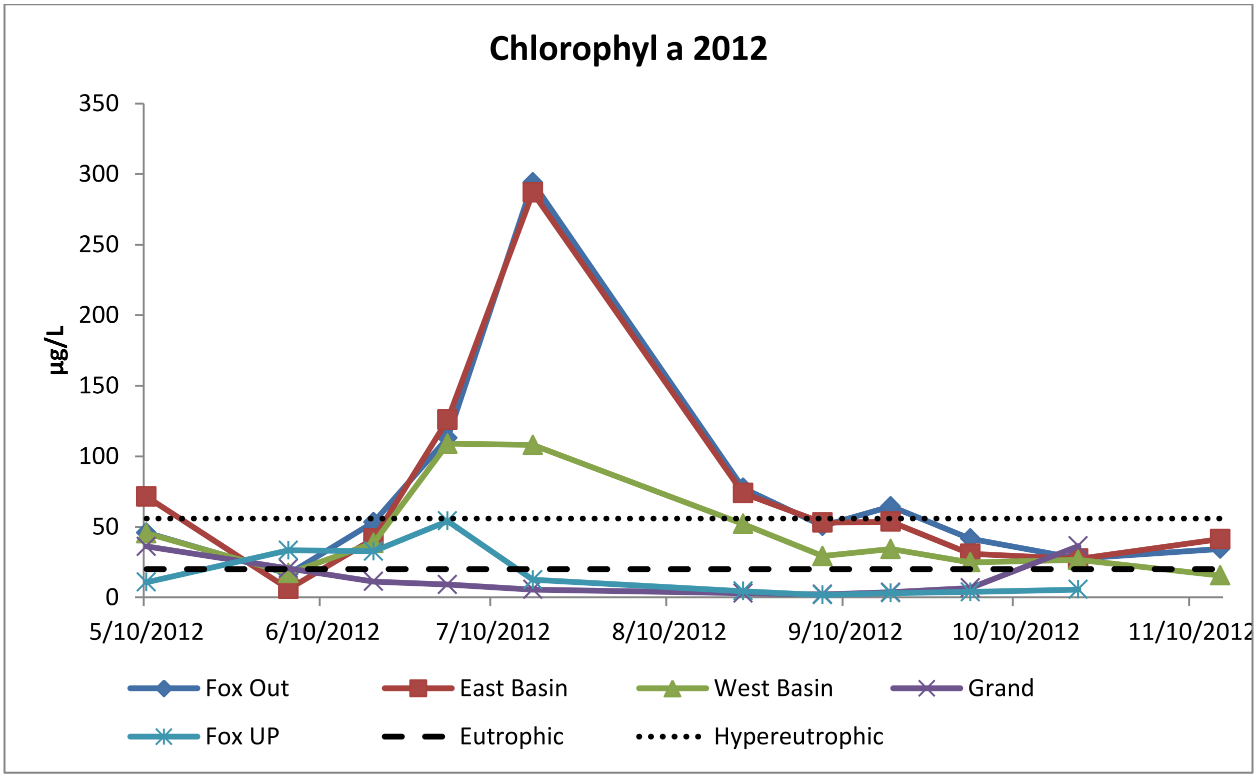

Figure 7. Eutrophic and hypereutrophic levels (Carlson 1996).

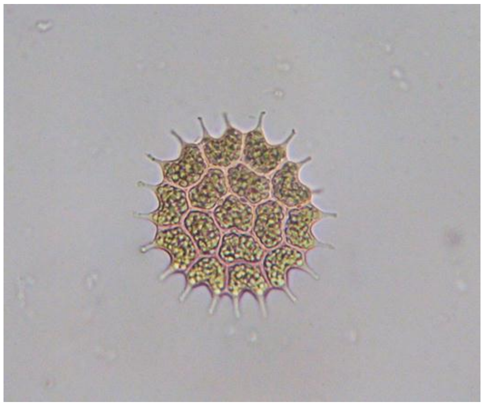

Figure 8. This *Pediastrum* from the West Basin, is one of the many green Algae phytoplankton found in Lake Puckaway

Dissolved Oxygen (DO): A gas required for most aquatic organisms to live, DO is produced by photosynthesis in plants and algae, and is exchanged with the atmosphere at the water's surface. Aquatic plants and algae require oxygen in their life processes just as animals do. During the daylight hours plants and algae produce excess oxygen through photosynthesis and release it into the water, at night they remove oxygen from the water. This leads to daily fluctuations in DO. In some circumstances, DO may fall to levels that may be harmful to aquatic life at night. Fueled by the right conditions, excessive algae or plant growth can produce so much oxygen it comes out of solution, supersaturating the water, bubbling like a can of soda. Water with supersaturated levels of oxygen has been known to kill black crappie, walleye and other species (Becker 1983).

Daytime DO levels never fell to those harmful to fish at monitoring sites. DO levels at night were never tested. DO did reach supersaturated levels on several days during the sample period.

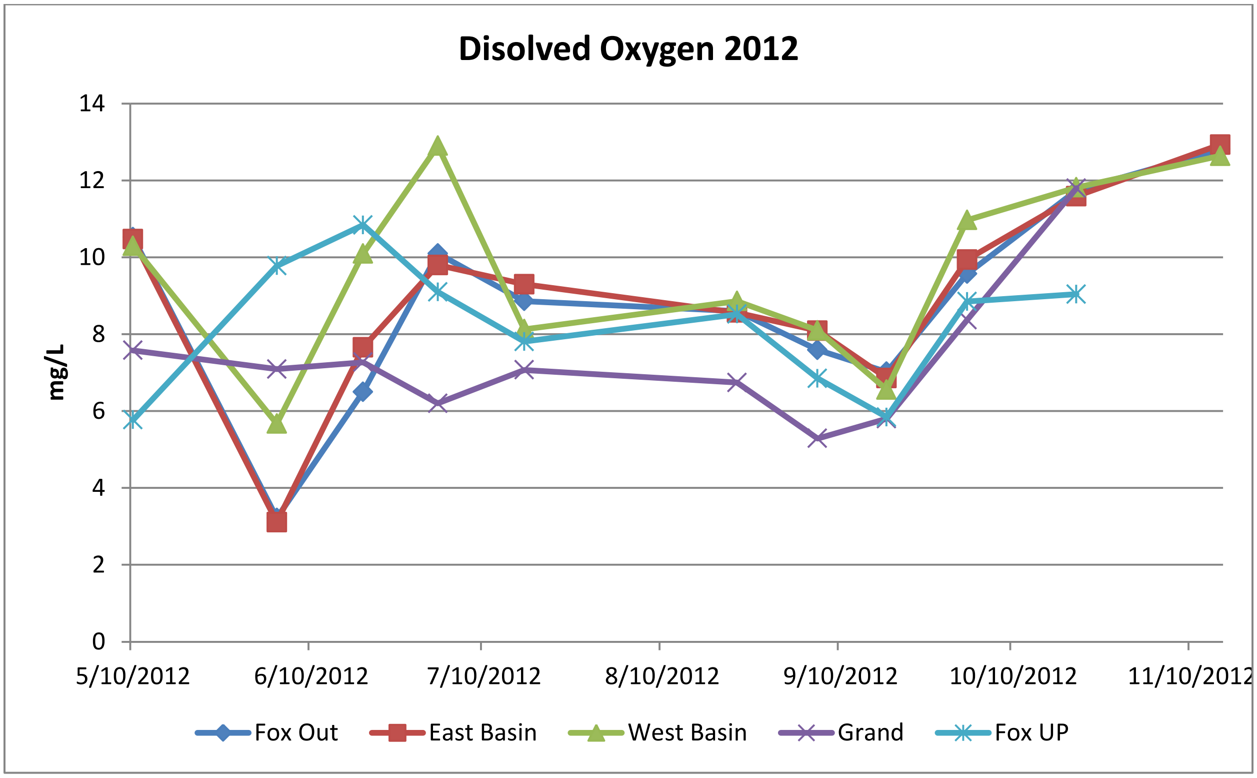

Figure 9. Dissolved oxygen

pH: A measure of acidity and alkalinity of a substance ranging from 1 (acid) to 14 (alkaline), a pH of 7 is neutral. pH must be within a range for the survival and reproductive functions of fish and other organisms. pH for the monitoring period remained in the alkaline range, averaging 9.0. There were typically no significant differences based on location.

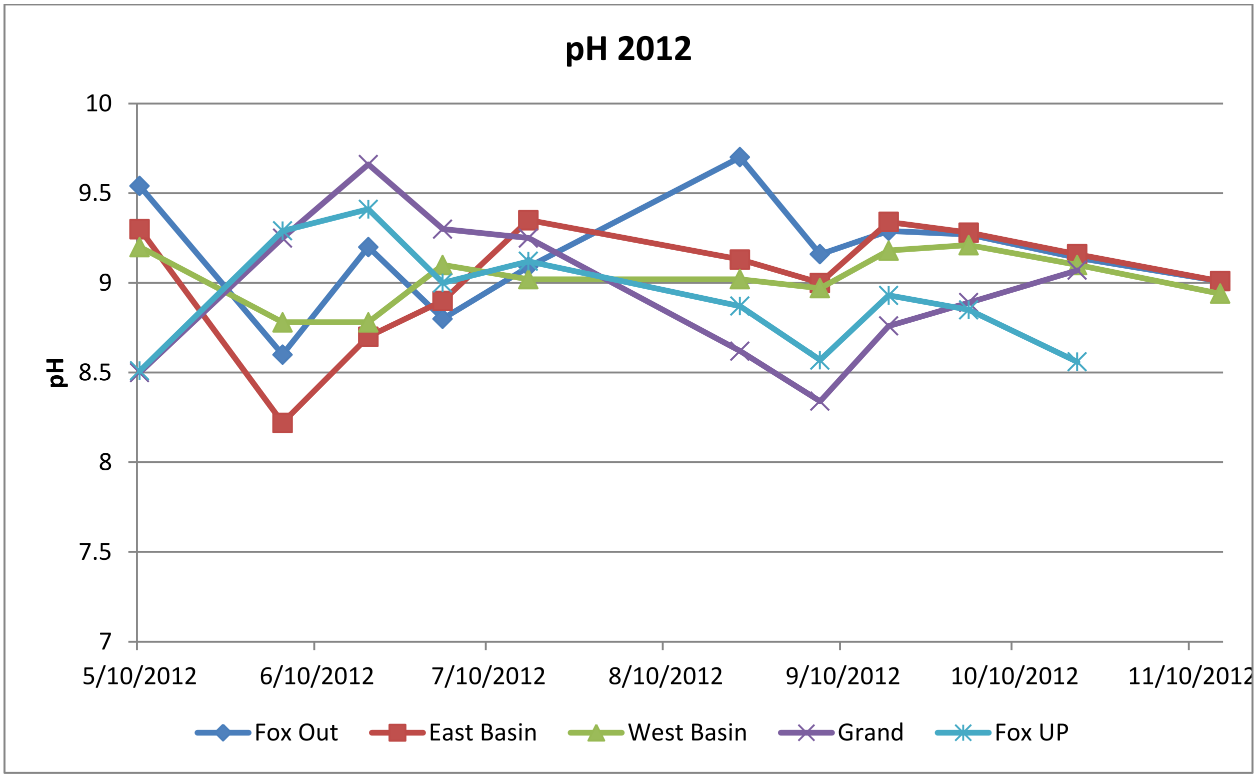

Figure 10. pH

Temperature: In mid-July water temperatures exceeded levels dangerous to some species of fish. This resulted in a die off of Northern pike. Although many pike died, Lake Puckaway's abundant Northern pike population was little affected according to WDNR fisheries biologist Dave Bartz. Water temperature was taken on the hottest day where it reached 95°F in mid-lake, and 100°F in water 1.5 feet or less; because those readings were not part of the routine sampling they do not appear in the following graph.

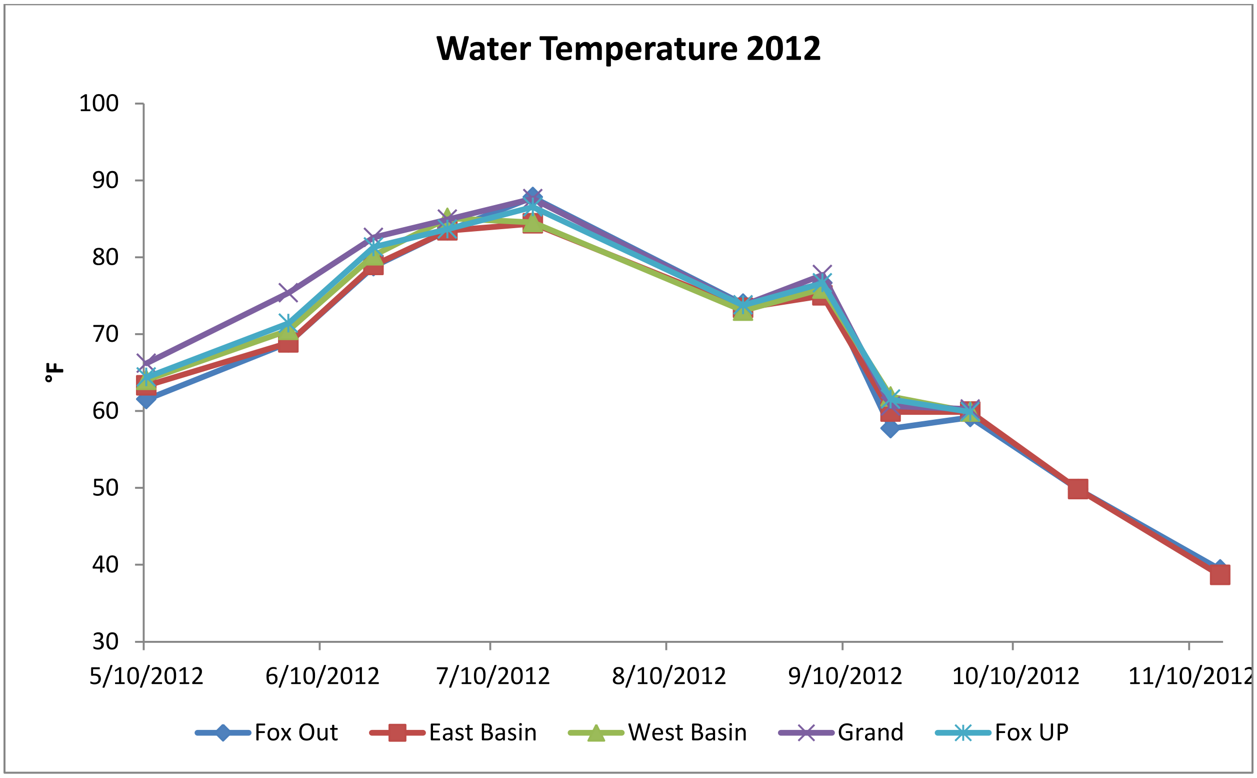

Figure 11. Water temperature

Conductivity (specific conductance) measures water's ability to conduct an electrical current. Conductivity is reported in micromhos per centimeter (µmhos/cm) and is directly related to the total dissolved inorganic chemicals in the water. Values are commonly two times the water hardness unless the water is receiving high concentrations of contaminants introduced by humans (Shaw, Mechenich, and Klessing 2004).

Conductivity levels in 2012 did not indicate anything out of the ordinary. Higher conductivity in the Grand River is likely due to water with naturally greater hardness, or iron content in that watershed.

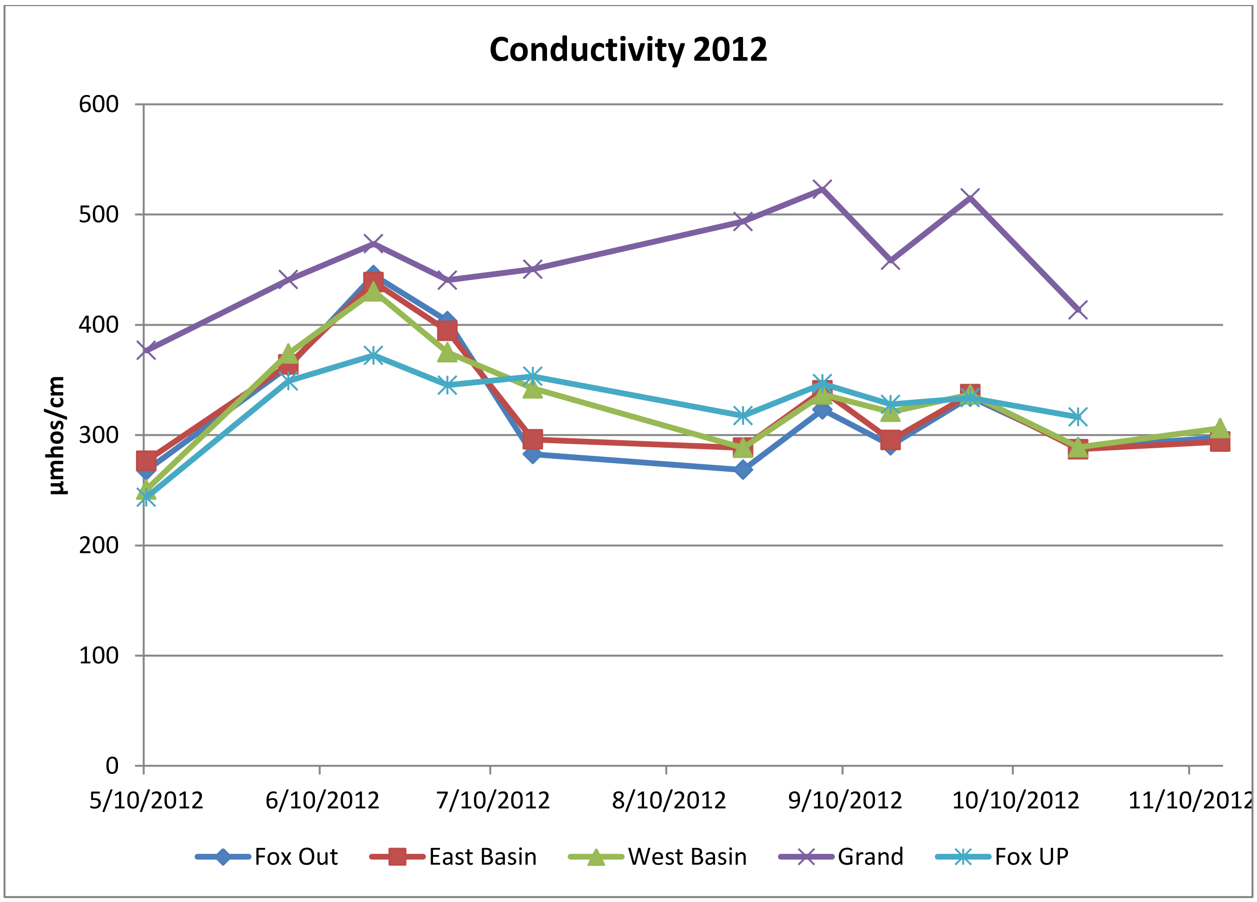

Figure 12. Conductivity

Conclusion

Conditions on Lake Puckaway beginning with low snowpack in the watershed were extreme. The lake was ice free by March 15th, the second earliest since records began in 1956. March saw record temperatures on multiple days, high temperatures lasted for weeks, and water levels were low. By late April, water levels had begun to creep up, but May 3 saw extremely heavy rain followed by yet more rain May 7. All the area's rivers and Lake Puckaway overflowed their banks, inundating wetlands. Water moving through the wetlands into the lake had a stained appearance, but the wetlands also helped filter out sediment and nutrients providing some protection for the lake. However, large amounts of nutrients still came off the landscape. Little rain fell for the next three months. As a result, lake levels plummeted four feet in less than 60 days despite flashboard placement on the Princeton Dam. Drought conditions then persisted for the rest of the summer. Once again, record high temperatures descended on Lake Puckaway in July, causing dangerous water temperatures that resulted in a fish kill consisting almost entirely of Northern pike.

Beginning September 12, water was drawn down from Buffalo Lake to prepare for repair of the dam there. Because of the draw down there was a concern that sediment and other pollution might be washed down if the river cut a channel through the lake bed, or exposed lake bed eroded. To observe any changes in water quality as a result of that drawdown, monitoring was extended beyond the summer season and ended on November 15. Monitoring showed no detectable increase in TP, chl a, or decrease in water clarity after the draw down began. Therefore, there have been minimal negative effects to Lake Puckaway as of November 15th, but conditions could change with extreme weather or spring runoff.

As indicated by every measure of water quality, Lake Puckaway was in a hypereutrophic state throughout the summer, and eutrophic in the spring and fall. The general trend of water clarity and other trophic indicators improves as one goes upriver. The reason for this is that once water spreads out over shallow Lake Puckaway, conditions for algae growth become optimal. The shallow water is easily heated. Wave action and carp disturb and suspend bottom sediments, clouding the water and bringing nutrients to algae in the water column, fueling their growth. Water in the east basin has been exposed to these conditions for a longer period of time and so contains higher algae and phosphorus concentrations. Also, the east-west orientation of Lake Puckaway and prevailing west wind means waves will be larger on average at the east end, disturbing more sediment. The end result is that the lake sends water downstream with higher concentrations of total P, chl a, and poorer water clarity than it received.

Discussion

The 2012 season saw hypereutrophic conditions throughout the lake, and a decrease in quality over 2011. A major cause of these conditions was the lack of healthy aquatic plant beds, particularly submergent plants. Submergent aquatic plants reduce algae by removing nutrients from the water column, dampening wave action, holding sediment in place with their roots, acting as a physical filter, and providing a hiding place for plankton that graze on algae. There is no single cause for the season's lack of plants. Over the long term, wave action, water level management, excessive nutrients, and an overabundant carp population are all to blame. In order to improve the trophic situation of Lake Puckaway, aquatic plant beds must be restored. Efforts to this end are underway in the form of shoreland restoration, nutrient management, large scale carp and rough fish removal, and state and federal regulations aimed to improve the water quality of Lake Puckaway and the rivers that feed it. Carp and rough fish removal by commercial fisherman continues, but due to extreme weather it is not possible to gauge the effectiveness of removal on water quality at this time. The lake's carp population is being addressed by a long-term study.

References

Becker, G. C. 1983. Fishes of Wisconsin. University of Wisconsin Press. Madison, WI

Carlson R.E., Simpson, J. 1996 A Coordinator's Guide to Volunteer Lake Monitoring Methods. *North American Lake* Management Society.

Lillie, R. A., Mason, J. W. 1983. Limnological Characteristics of Wisconsin Lakes. WDNR Technical Bulletin 138. Madison, WI

Shaw, B., Mechenich, C., Klessing, L. 2004. Understanding Lake Data. UW Extension publication G3582 http://learningstore.uwex.edu/assets/pdfs/G3582.pdf

Figure 13 The Wind can concentrate algae along the shore, and in channels, and make whole-lake blooms appear worse than they are. However localized algae pileups such as this can reduce the recreational use of shorelines.

Appendix A

2012 water clarity (Secchi depth) in feet for all monitoring stations. Numbers in red italics indicate the Secchi disk hit the lake or river bottom and true water clarity depth could not be obtained.

	5/10/2012	5/22/2012	6/4/2012	6/19/2012	7/2/2012	7/8/2012	7/17/2012	8/6/2012	8/23/2012	9/6/2012	9/18/2012	9/25/2012	10/2/2012	10/21/2012	11/15/2012		June - Augu
Fox R. Outlet	3.2	3.7	2.8	1.4	1.0	0.7	0.5	0.8	1.0	0.9	1.1	1.2	1.5	2.5	1.3		1.2
L. Puckaway East Basin	4.6	3.7	3.5	1.6	1.0	0.8	0.8	0.6	1.0	1.2	1.3	1.5	1.8	3.0	1.8		1.3
Mid Lake	3.2	3.6	4.5	2.3	1.1	0.8	0.8	0.9	1.2	1.3	1.3	2.0	1.8	3.0	1.9		1.7
L. Puckaway West Basin	3.9	3.6	4.6	1.3	1.8	1.1	0.9	1.1	1.5	1.9	1.7	2.0	2.8	2.9	4.1		1.8
Fox R. Inlet	4.4	3.8	2.9	3.4	2.8	3.2	**3.5**	3.5	**3.9**	**3.4**	**4.3**	**3.6**	**3.6**	4.5	**3.3**		**3.3**
Fox R. Deep Hole	4.8	3.5	3.5	3.4	3.6	4.8	7.8	5.4	7.0	**9.0**	7.8	**10.8**	8.7	8.0			5.1
Fox R. Above Grand R.	4.4		3.3	3.5	3.8		**3.6**	**4.1**	**4.6**	**4.0**	**4.2**		**4.0**	**4.5**			**3.8**
Grand R.	5.25		3.5	**2.6**	2.5		**2.1**	**2.7**	**2.8**	**1.8**	**2.6**		**2.6**	**3.8**			**2.7**
In lake average	3.9	3.6	4.2	1.7	1.3	0.9	0.8	0.9	1.2	1.5	1.4	1.8	2.1	3.0	2.6		1.6

Figure 14. Fish Camp Gauge – May 10, 2012. Heavy rain brought high water on the lake and on the Fox River concentrated with nutrients.