Lake Puckaway Water Quality Monitoring 2011

Andrew Sabai
Grant Implementation Coordinator

Introduction

In 2011, 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. The type of water quality monitoring conducted at these stations is called trophic monitoring. Trophic refers to the state of the lake 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.

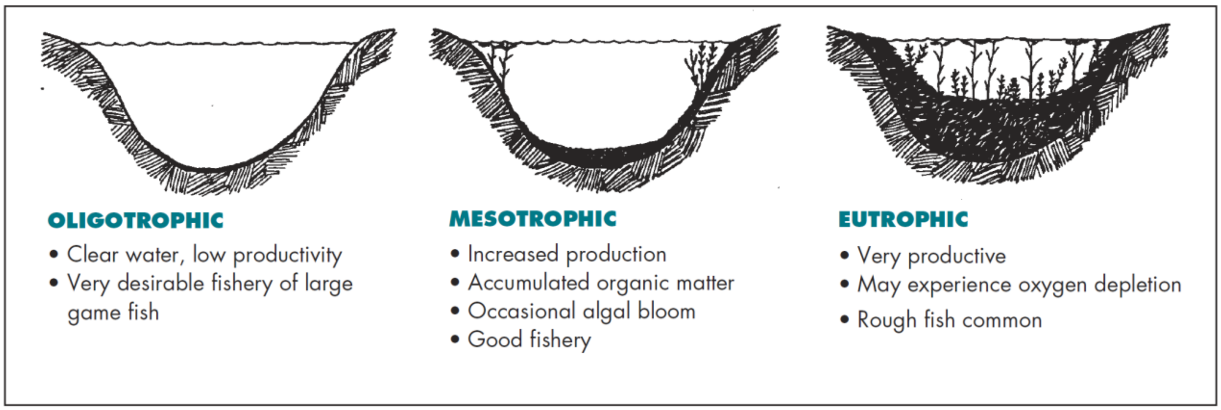


Figure 1. Description of trophic states (Mechenich, and Klessing 2004)

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 June 2nd and ending Sept 1. 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--were added for water clarity monitoring. Industrial pollutants were not monitored.

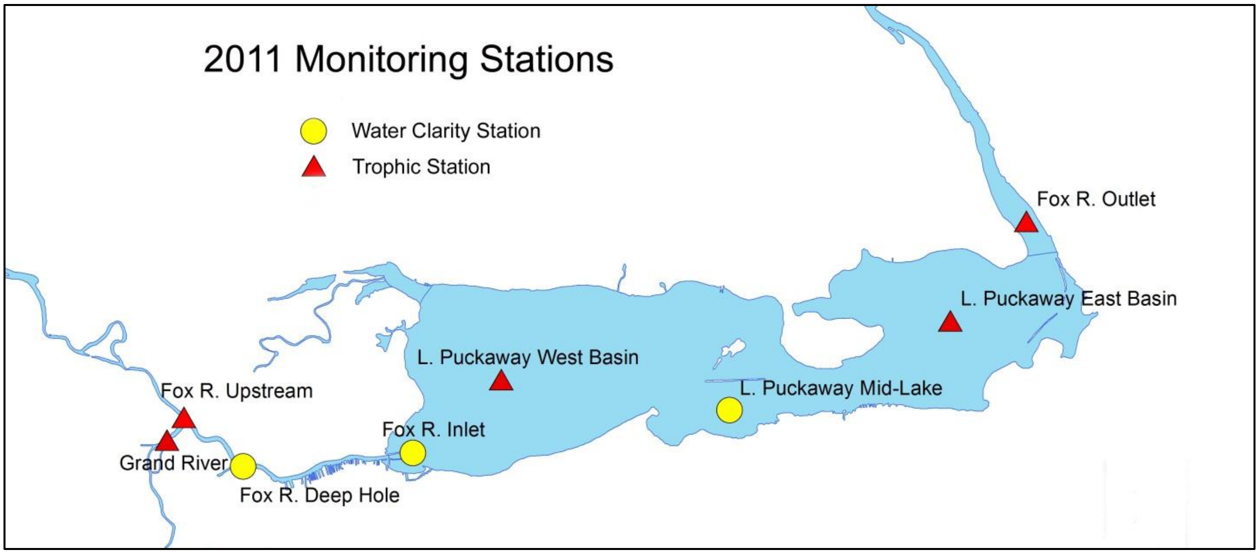


Figure 2. 2011 water quality monitoring stations.

Results Page

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 the results of the TSI Lake Puckaway was in a hypereutrophic state throughout the sampling period, and had an average TSI for July through August of 75.6.

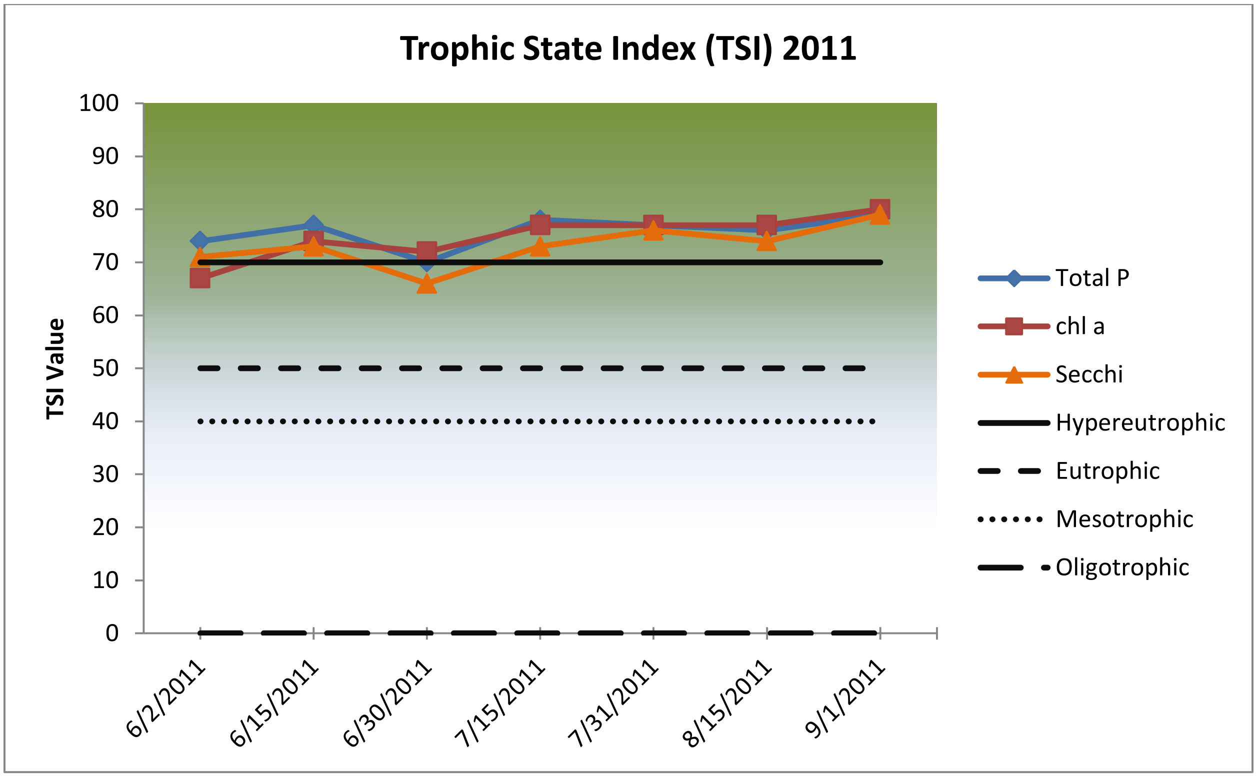


Figure 3. Average TSI for Lake Puckaway calculated using WDNR WiLMS software.

Water clarity (Secchi depth): An 8 inch diameter plate with alternating quadrants painted black and white (Secchi disc) is used to measure water clarity (light penetration). 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. Because of the relatively common occurrence of hitting the river bottom, an additional station was chosen for water clarity readings in a 9-11 foot deep section of the river downstream of the Fox/Grand confluence starting July 14th. As with other trophic indicators, conditions consistently became more eutrophic from west to east on the lake. Average water clarity for the lake through the sample period was 1.5 feet whereas the region averages 7.9 ft. A graph and table with readings from all stations is located in appendix A.

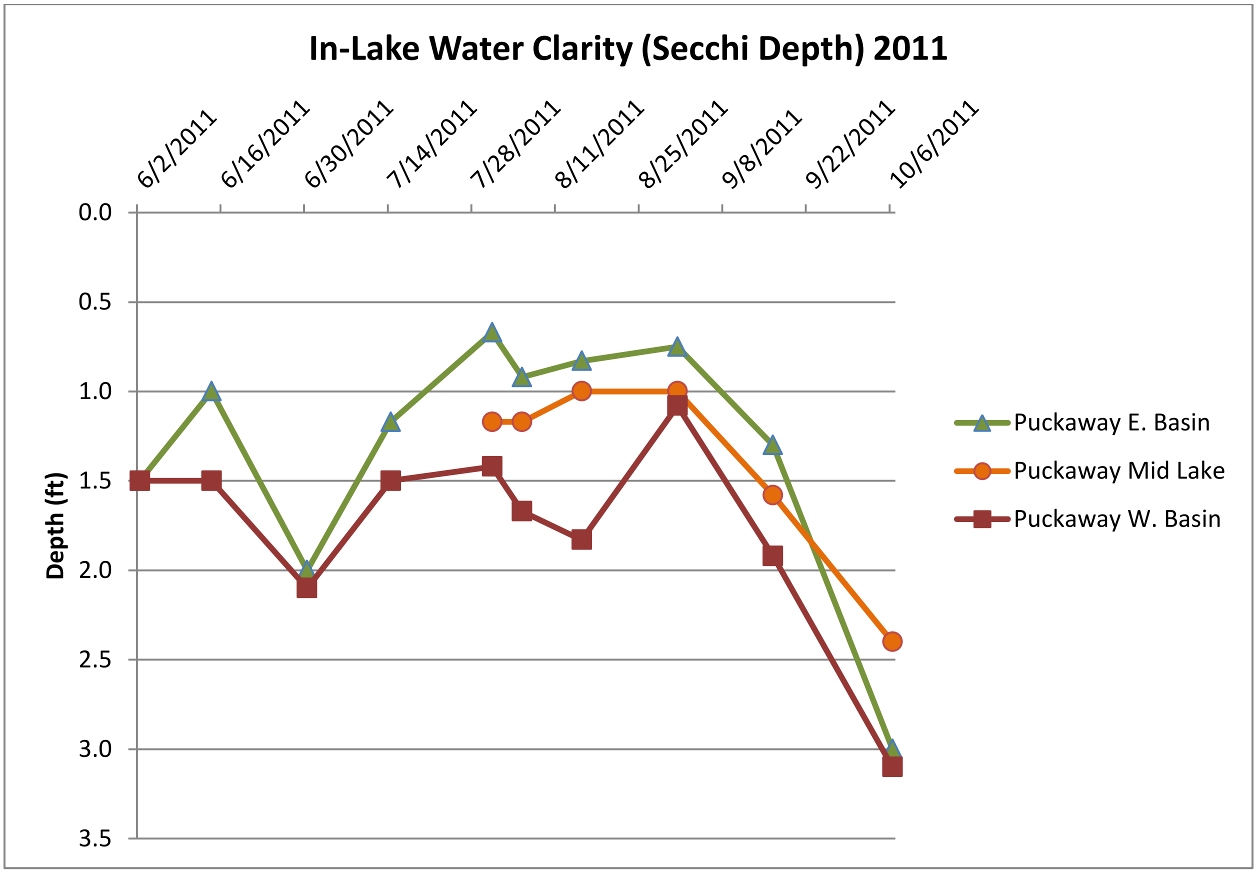


Figure 4. In-lake water clarity readings. Readings for all stations found in Appendix A

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 0.031µg/L, Lake Puckaway's summer average was nearly five times higher at 0.152 µg/L. Throughout the sampling period, total P concentrations exceeded that of a hypereutrophic system. At first glance it may appear that the Grand River is the largest source for P coming into Lake Puckaway. However, the levels are not the total amount of P coming into the system; rather it is a concentration of each unit of water. Therefore, since flow coming out of the Grand River is significantly less than that of the Fox River, this concentration is then diluted by the Fox River's water. The flow ratio between the Fox River and the Grand River is not known, and may be investigated.

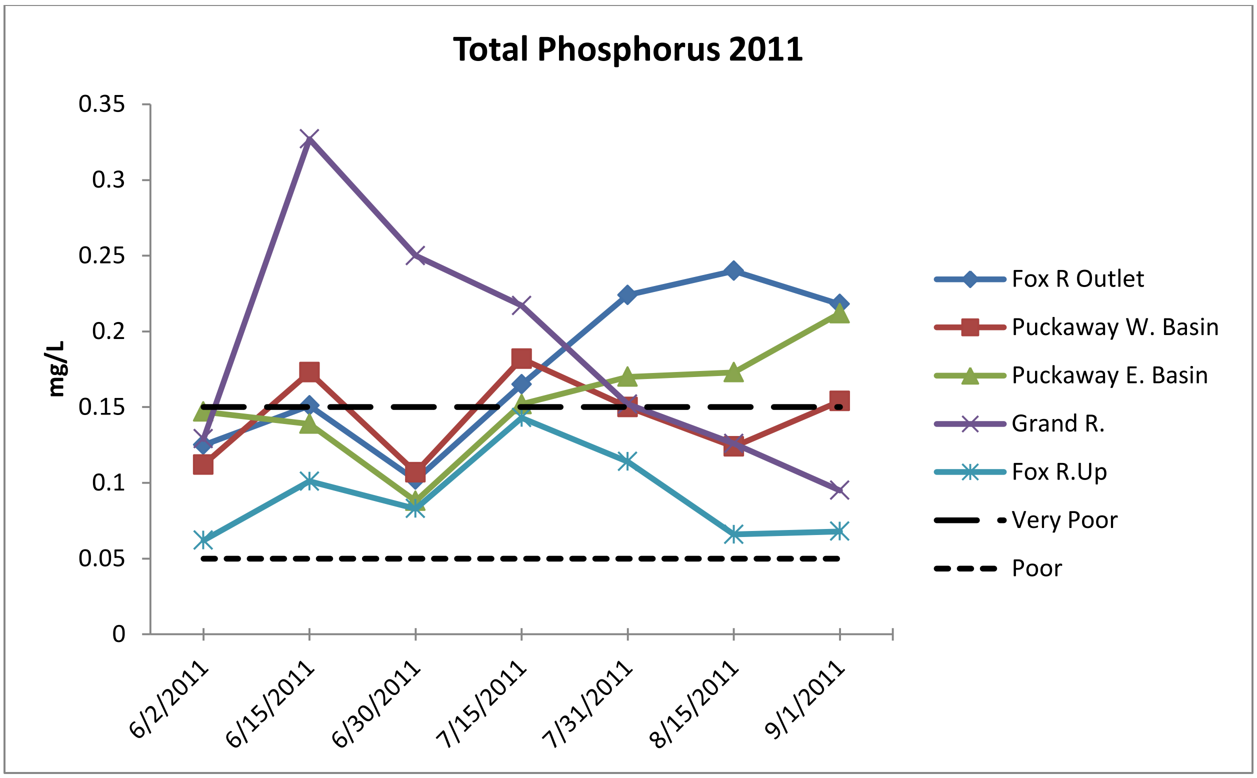


Figure 5. Total P concentrations are considered poor from 0.05 to 0.15 µg/L, and very poor greater than .15 µg/L (Lillie and Mason 1983).

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. Beginning in mid-June, Lake Puckaway entered an extended period of high algae concentrations that steadily increased throughout the sample period that ended September 1. Direct sampling of Chl a ceased on Sept. 1, but water clarity significantly increased by Oct. 6, indicating an algae die-off from mid to late September.

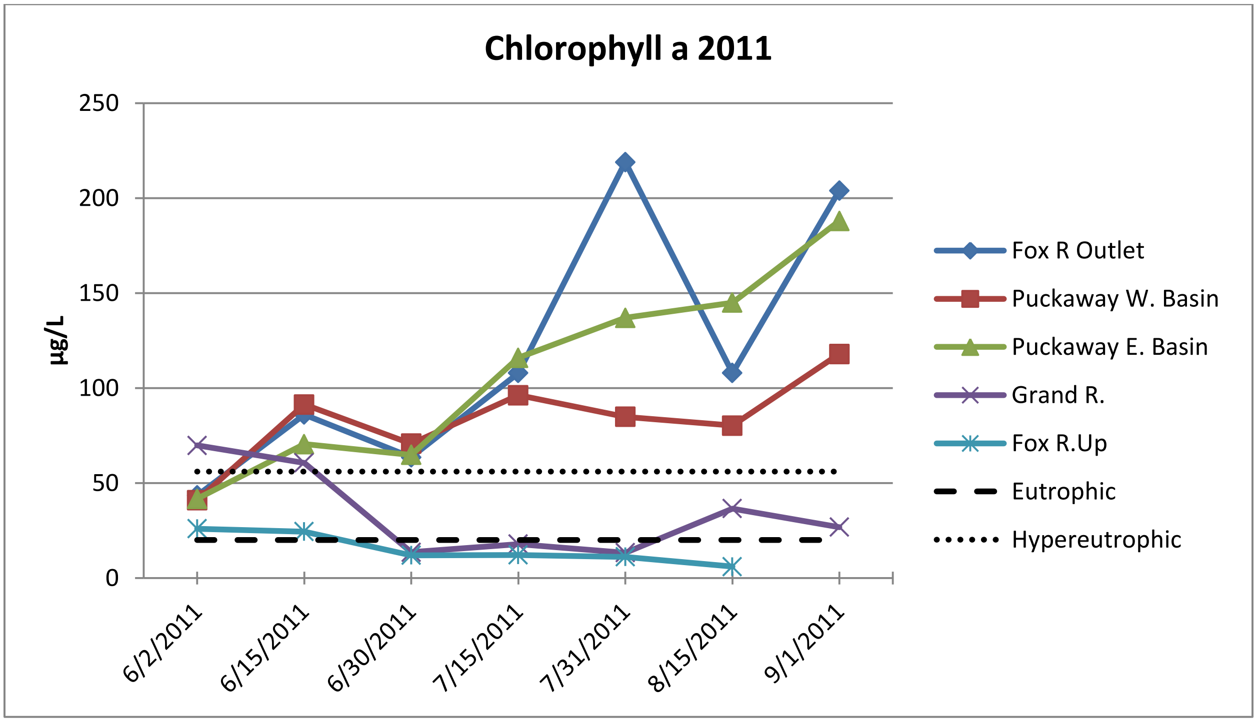


Figure 6. The Sept 1st Chl a sample for the Fox River upstream was erroneously high on Sept 1 (not plotted), and may have been due to contamination caused by water meal (a tiny free-floating plant) that was floating down the river in large numbers that day. Eutrophic and hyperutrophic levels after (Carlson 1996).

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 they produce excessive amounts of oxygen through photosynthesis and release it into the water, at night they take in that oxygen. 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. 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. DO levels at night were never tested. DO did reach supersaturated levels on several days during the sample period. To my knowledge there were no reports of fish being stressed or killed due to low or excessive oxygen levels.

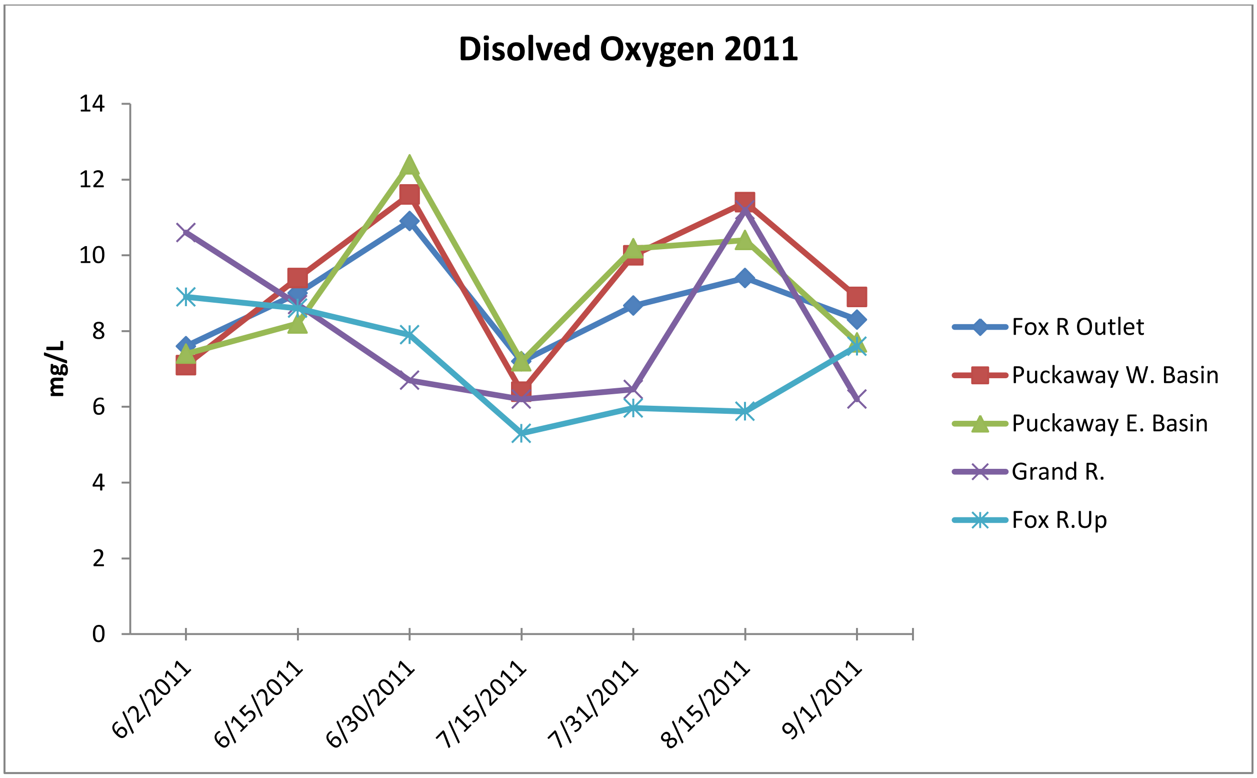


Figure 7. Dissolved oxygen

pH: A measure of acidity and alkalinity of a substance ranging from 1 (acid) to 14 (alkaline), ph must be within a range for the survival and reproductive functions of fish and other organisms. pH of 7 is neutral. pH for the monitoring period remained in the alkaline range, averaging 8.7. There were typically no significant differences based on location.

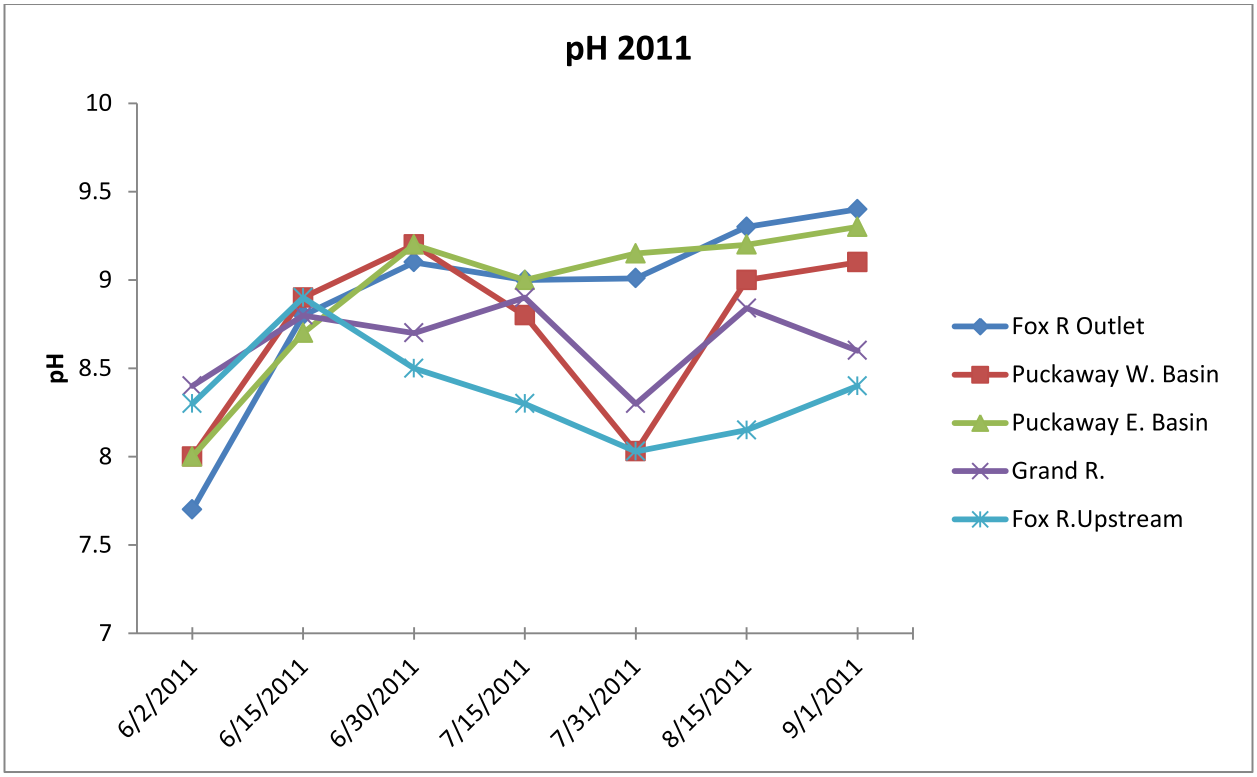


Figure 8. pH

Temperature:

For the sampling period, water temperatures were normal, but approached levels dangerous to fish upstream on July 31st. As temperatures increase, DO levels can become low and fish will move to deeper cooler water. These conditions can lead to summer fish kills. Luckily, temperatures were lower at the west end of the lake, and nowhere did daytime DO levels fall to dangerous levels. However, nighttime levels in shallow water may have become depleted (see DO section). High temperatures coupled with either extremely high or low DO can stress and kill fish.

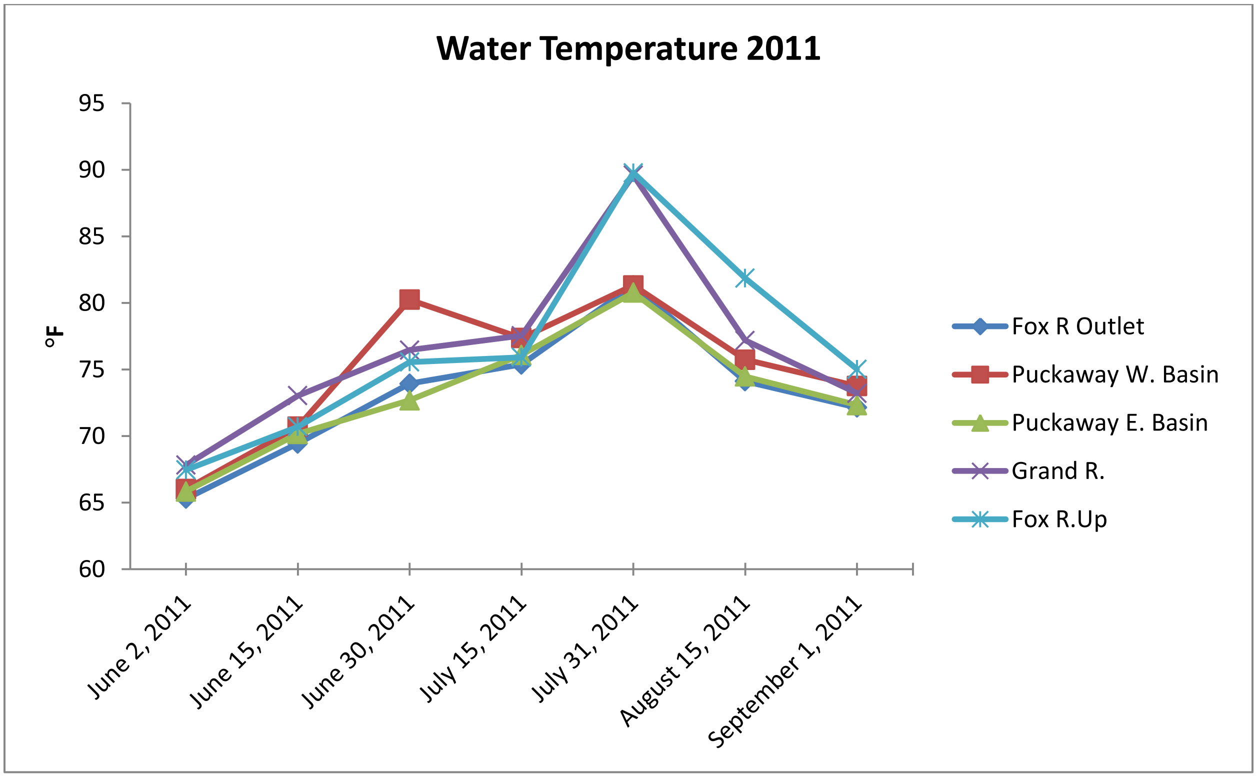


Figure 9. Water temperature

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 2011 did not indicate anything out of the ordinary. Higher conductivity in the Grand River could be due to water with naturally greater hardness, or iron content in that watershed.

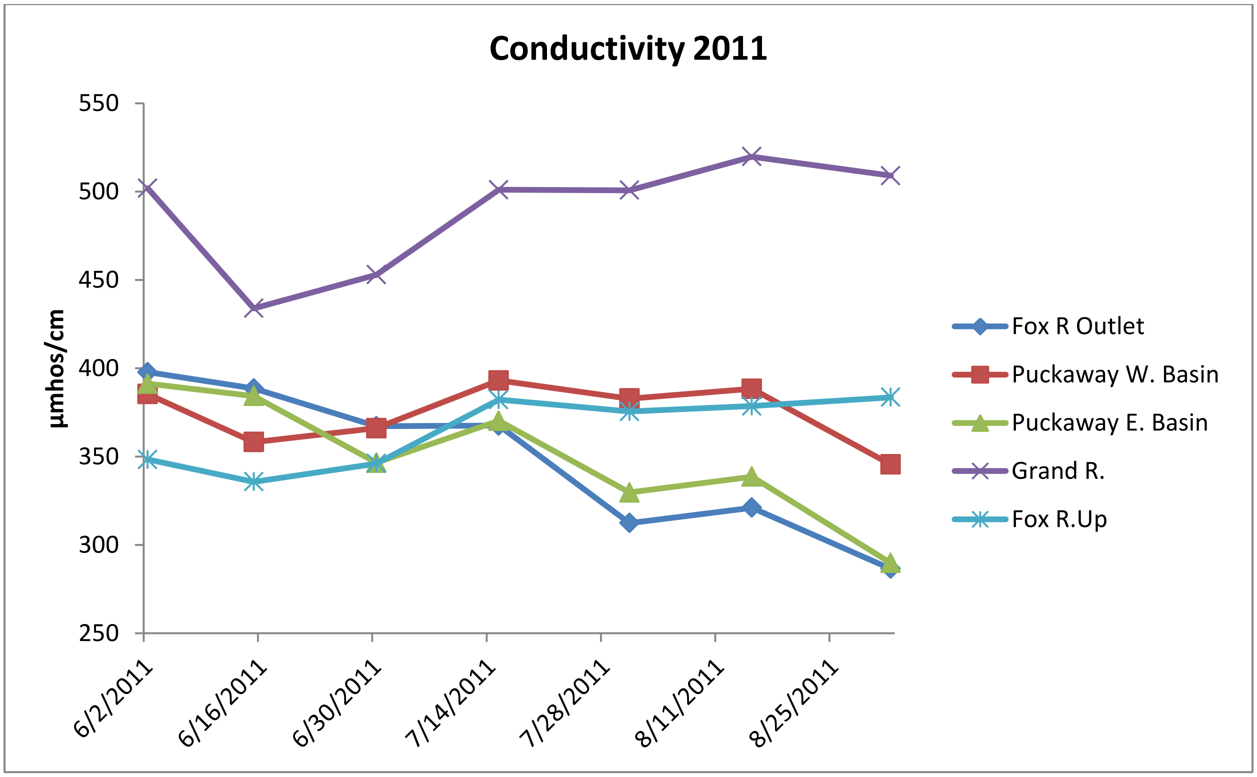


Figure 10. Conductivity

Trophic Monitoring Summary

As indicated by every measure of water quality, Lake Puckaway was in a hypereutrophic state throughout the 2011 monitoring. 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 concentrations. Also the east-west orientation of Lake Puckaway and prevailing west wind means waves will be larger on 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 2011 season saw hypereutrophic conditions throughout the lake. 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. However, 2011 was a poor year by recent standards and likely exacerbated by high water and a long, cold spring that did not give submergent aquatic plants a chance to establish. 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.

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.

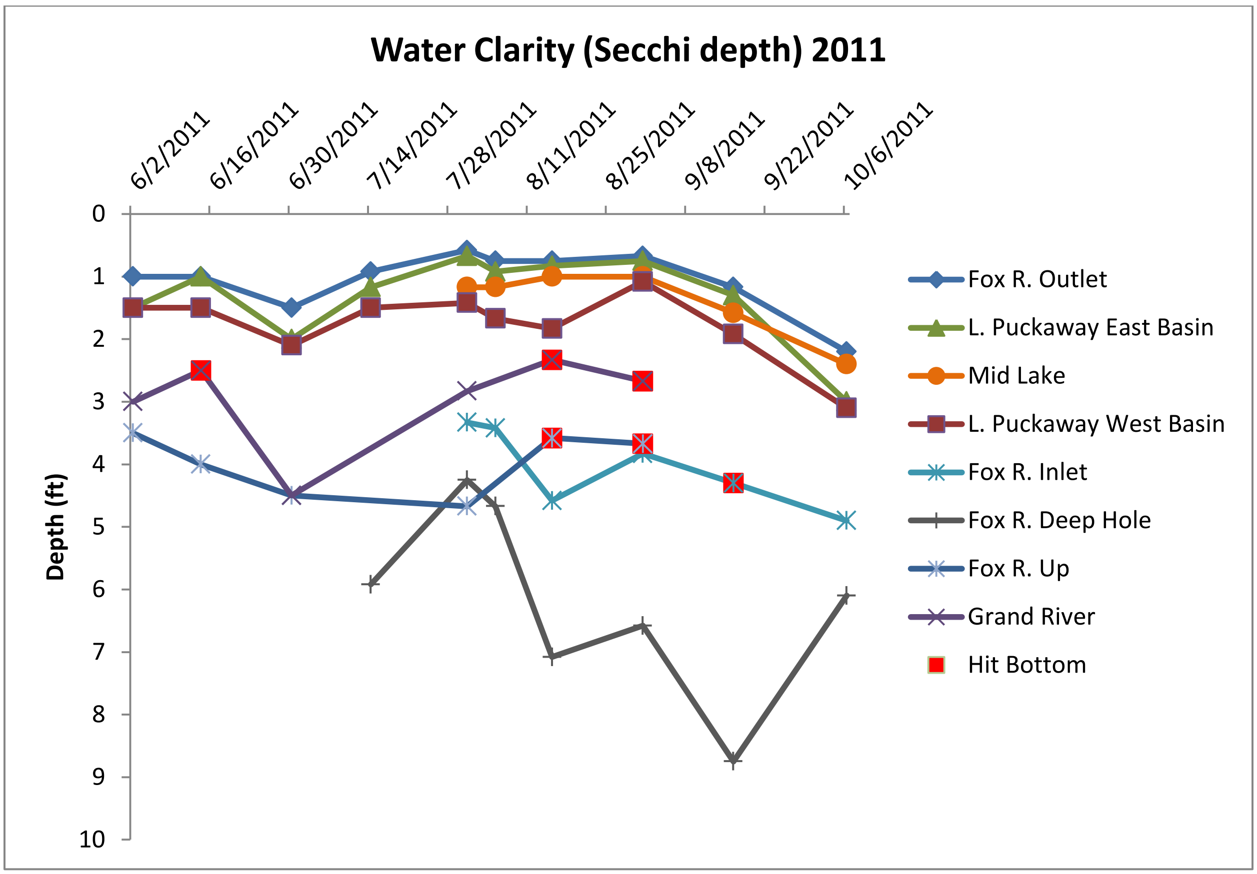
Lillie, R. A., Mason, J. W. 1983. Limnological Characteristics of Wisconsin Lakes. WDNR Technical Bulletin 138. Madison, WI

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

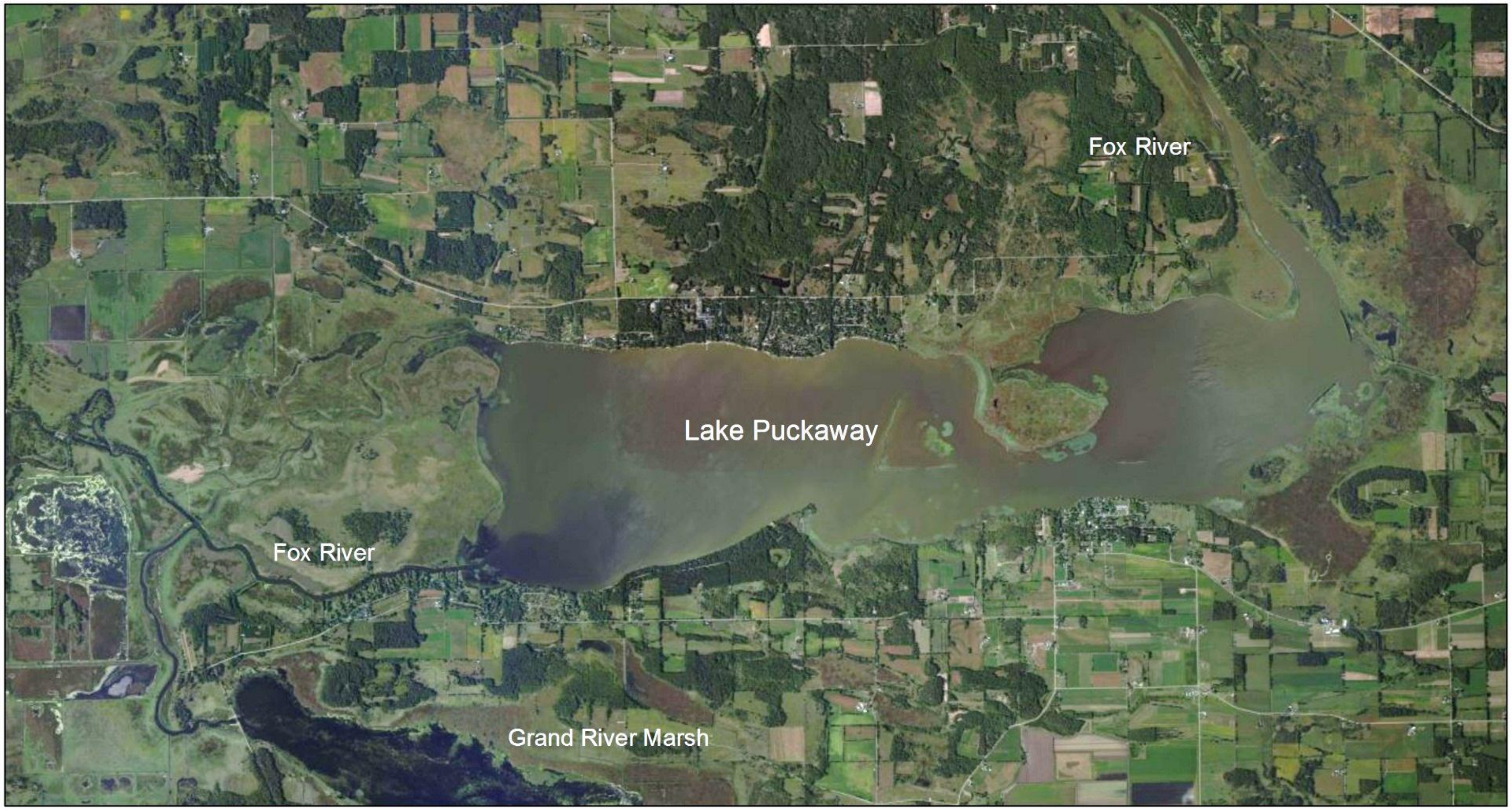
Appendix A

2011 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.

	2-Jun	14-Jun	30-Jun	14-Jul	31-Jul	5-Aug	15-Aug	31-Aug	16-Sep	6-Oct
Fox R. Outlet	1.0	1.0	1.5	0.9	0.6	0.8	0.8	0.7	1.2	2.2
L. Puckaway East Basin	1.5	1.0	2.0	1.2	0.7	0.9	0.8	0.8	1.3	3.0
Mid Lake	-	-	-	-	1.2	1.2	1.0	1.0	1.6	2.4
L. Puckaway West Basin	1.5	1.5	2.1	1.5	1.4	1.7	1.8	1.1	1.9	3.1
Fox R. Inlet	-	-	-	-	3.3	3.4	4.6	3.8	*4.3*	4.9
Fox R. Deep Hole	-	-	-	5.9	4.3	4.7	7.1	6.6	8.8	6.1
Fox R. Above Grand	3.5	*4.0*	4.5	-	4.7	-	*3.6*	*3.7*	-	-
Grand River	3.0	2.5	4.5	-	2.8	-	*2.3*	*2.7*	-	-
In Lake Average	1.5	1.3	2.1	1.3	1.1	1.3	1.2	0.9	1.6	2.8



Appendix B



2011 late summer water clarity transitions. Dark water in the Fox River, Grand River, and Grand River Marsh impoundment indicates clear water. In the south west corner of Lake Puckaway, clear water mixes with turbid water heavy with algae. This is a general trend observed over the years (2011 Bing aerial photography ©Microsoft Corporation).