

WHITEWOOD LAKES

HAMBURG TOWNSHIP

LIVINGSTON COUNTY

1996 - 2006 WATER QUALITY STUDIES

WHITEWOOD LAKE DATA

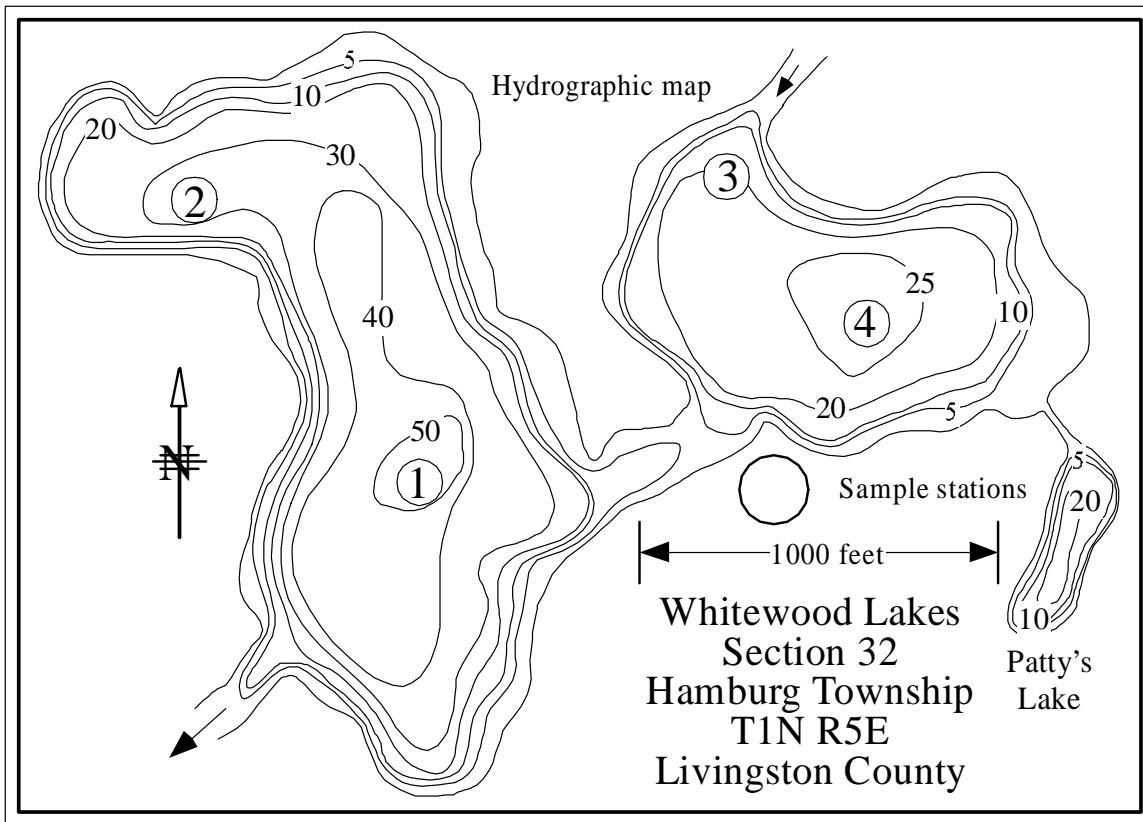
Whitewood Lake is a 62-acre natural hard-water kettle lake located in Section 32, Hamburg Township (T1N R5E) Livingston County, Michigan. The lake consists of a 40-acre downstream west basin and a 22-acre upstream east basin separated by a channel approximately 400 feet long. The channel depth between the two basins varies, but has a maximum depth of about 15 feet. The east basin has a maximum depth of 27 feet, a volume of 328 acre-feet, and a mean depth of 14.9 feet. The west basin has a maximum depth of 50 feet, a water volume of 1041 acre-feet, and a mean depth of 26.0 feet. The volume of both basins is 1369 acre-feet. Patty's Lake is a 2-acre, 20-foot-deep basin off the east basin. The elevation of the Whitewood Lake is 851 feet above sea level. The Huron River flows through both basins.

The size of the watershed, which is the land area that contributes water to the lake, but does not include the lake, is large, 243,138 acres. The drainage area, which includes the lake and the watershed, is 243,200 acres. The watershed to lake ratio is large, 3922 to 1. Because of this the basins flushes rapidly, about once every 2 or 3 days, on an average.

The longitude and latitude of the 50-foot deep hole is 83° 52.601W and 42° 26.004N.

THE SAMPLE STATIONS

The locations of the four in-lake sample stations are shown as circles on the map of the lake below.



THE SAMPLE DATES

WQI limnologists took three or four spring surface samples for water quality testing plus Secchi disk readings at the sites shown on the map June 9, 1996, May 12, 1997, April 19, 1998, April 25, 1999, April 15, 2000, May 13, 2001, April 15, 2002, April 28, 2003, April 16, 2004, April 18, 2005 and April 19, 2006.

WQI limnologists collected three or four late summer surface samples for water quality testing at the stations shown on the map August 7, 1996, August 25, 1997, August 10, 1998, August 28, 1999, August 4, 2000, August 3, 2001, August 2, 2002, August 1, 2003, August 2, 2004, August 3, 2005 and August 1, 2006.

Bottom sediment samples were collected at three stations in 1996 and four stations in 2005. Upstream, the Huron River and Davis Creek were sampled 11 times June 2005 through April 2006.

THE ANALYSES

The tests performed on the samples included total phosphorus, total nitrate nitrogen, total alkalinity, pH, conductivity, chlorophyll a, Secchi disk depth, temperature, and dissolved oxygen.

Temperature, dissolved oxygen and Secchi disk depths were measured in the field. Chlorophyll a, phosphorus, nitrate nitrogen, alkalinity, pH and conductivity tests were performed at the Water Quality Investigators laboratory in Dexter, Michigan. All test procedures followed those outlined in APHA's *Standard Methods for the Examination of Water and Wastewater* (1985).

THE TEST RESULTS

The results of the tests are found in the text, in the tables at the end of this report and on the enclosed atlas pages.

TEMPERATURE AND DISSOLVED OXYGEN

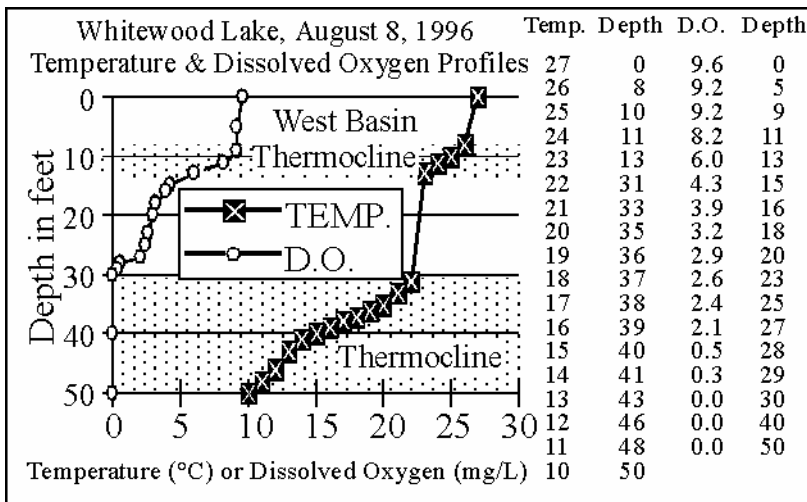
Temperature exerts a wide variety of influences on most lakes, such as the separation of layers of water (stratification), solubility of gasses and biological activity. In spring temperature generally doesn't need to be determined because we've found temperatures are low and dissolved oxygen is near saturation at that time.

Dissolved oxygen is the test most often selected by lake scientists as being important. Besides providing oxygen for aquatic organisms, in natural lakes oxygen is involved the capture and release of various chemicals, such as iron and phosphorus. In spring top to bottom dissolved oxygen concentrations were not measured. On the other hand, top to bottom dissolved oxygen and temperature profile data were collected in both basins when they were sampled in late summer.

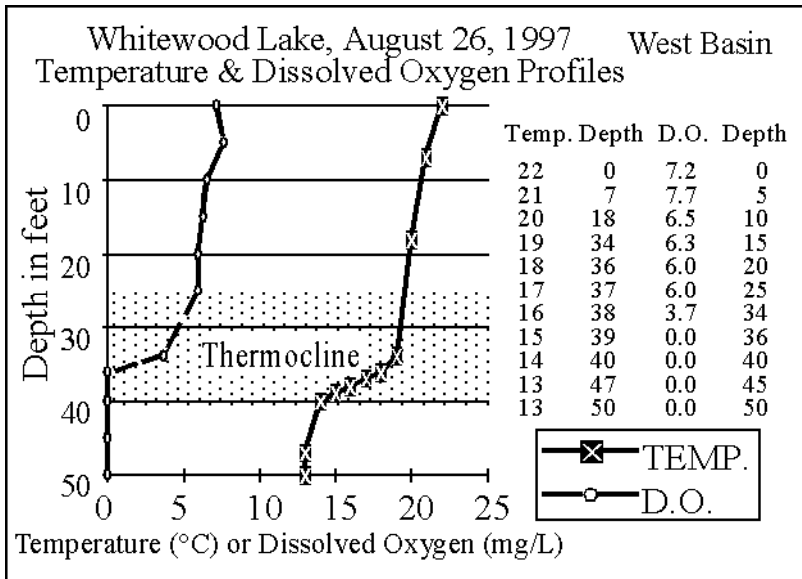
THE WEST BASIN

1996

In late summer 1996, the west basin formed two thermoclines (where the temperature changes rapidly with depth and shown shaded on the graphs), a



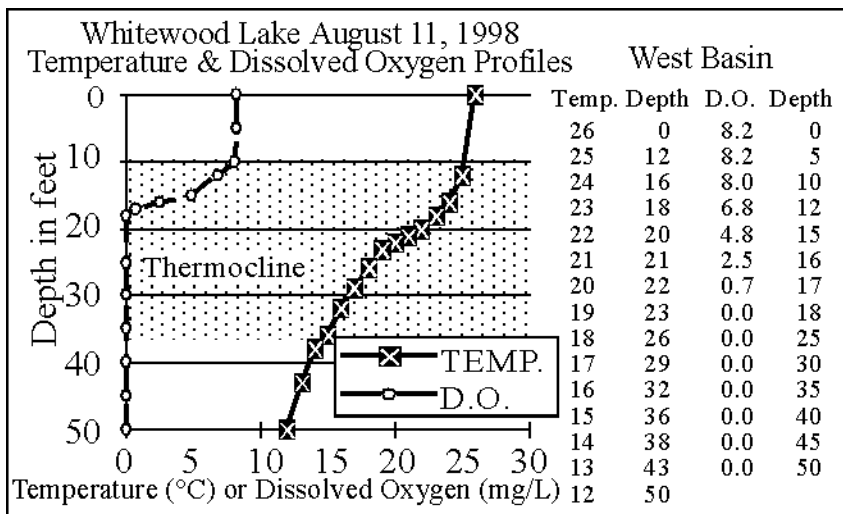
five foot thick one from 8 to 13 feet, and a second one 20 feet thick from 30 to 50 feet, which was the bottom of the lake. Dissolved oxygen was plentiful above ten feet and started to decrease at 10 feet in the upper thermocline. The



basin ran out of dissolved oxygen at 30 feet. That condition remained to the bottom. The hypsographic (depth-area) graph shows about 45 percent of this basin is deeper than 30 feet.

1997

In late summer 1997, the west basin formed a 15-foot-thick thermocline from 25 to 40 feet.



Dissolved oxygen was plentiful above 25 feet, and started to drop below that depth. The basin ran out of dissolved oxygen at 36 feet.

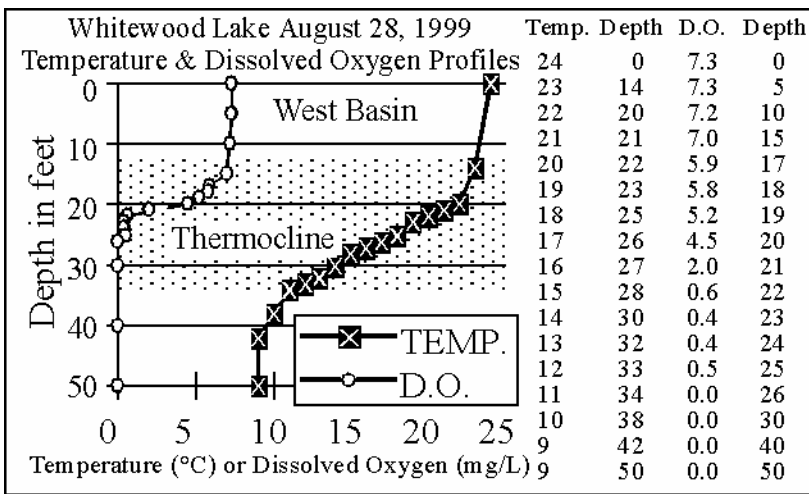
That condition remained to the bottom. About 30 percent of the basin

is deeper than 36 feet.

1998

In late summer 1998, the west basin formed a 27-foot-thick thermocline from 10 to 37 feet. Dissolved oxygen was plentiful above 10 feet and started to decrease below that depth. The basin ran out of dissolved oxygen at 18 feet, and that condition remained to the bottom. About 68 percent of the basin is deeper than 18 feet.

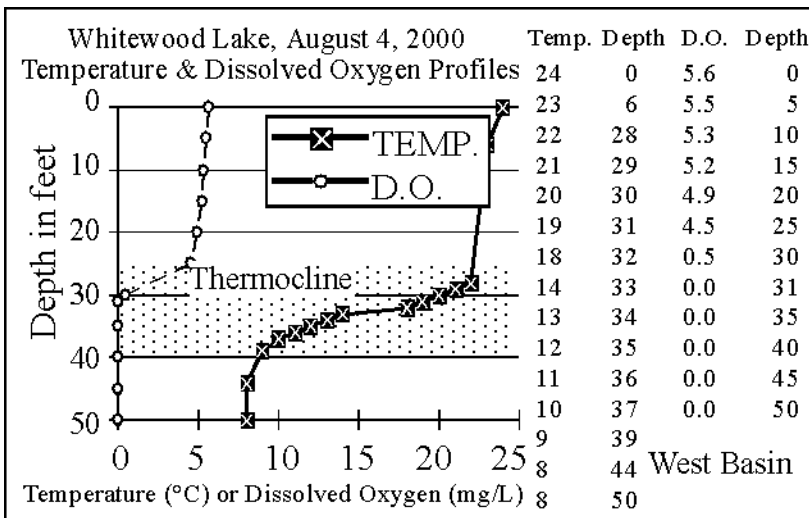
1999



In late summer 1999, the west basin formed a 20-foot-thick thermocline from 14 to 34 feet. Dissolved oxygen was plentiful above the thermocline. The basin ran out of dissolved oxygen at 26 feet. That condition remained

to the bottom. About 53 percent of the lake is deeper than 26 feet.

2000

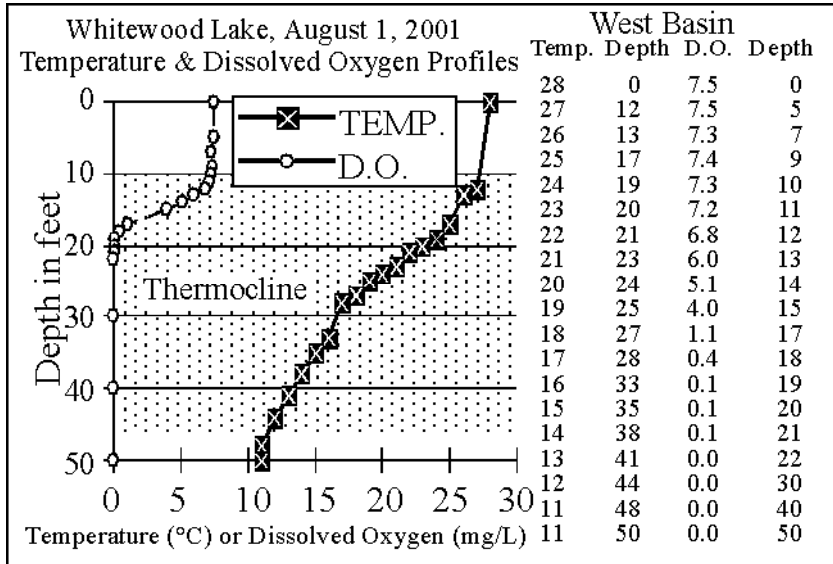


In late summer 2000, the west basin formed a 15-foot-thick thermocline from 25 to 40 feet. Dissolved oxygen was present, but low (5.6 milligrams per liter or less) above the thermocline. The basin ran out of

dissolved oxygen at 31 feet. That condition remained to the bottom. About 42 percent of the lake is deeper than 31 feet.

2001

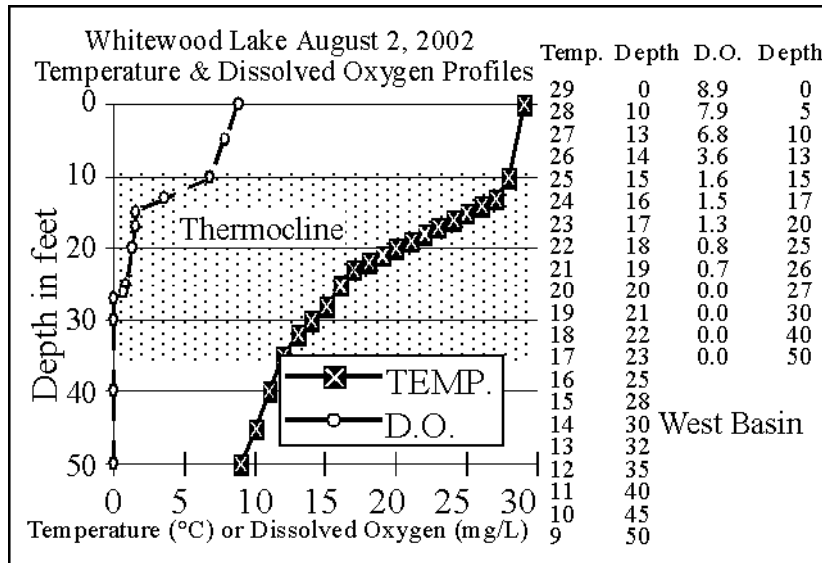
In late summer 2001, the west basin formed a 36-foot-thick thermocline from 10 to 46 feet. Dissolved oxygen was plentiful above the thermocline.



The basin ran out of dissolved oxygen at 22 feet. That condition remained to the bottom. About 60 percent of the basin is deeper than 22 feet.

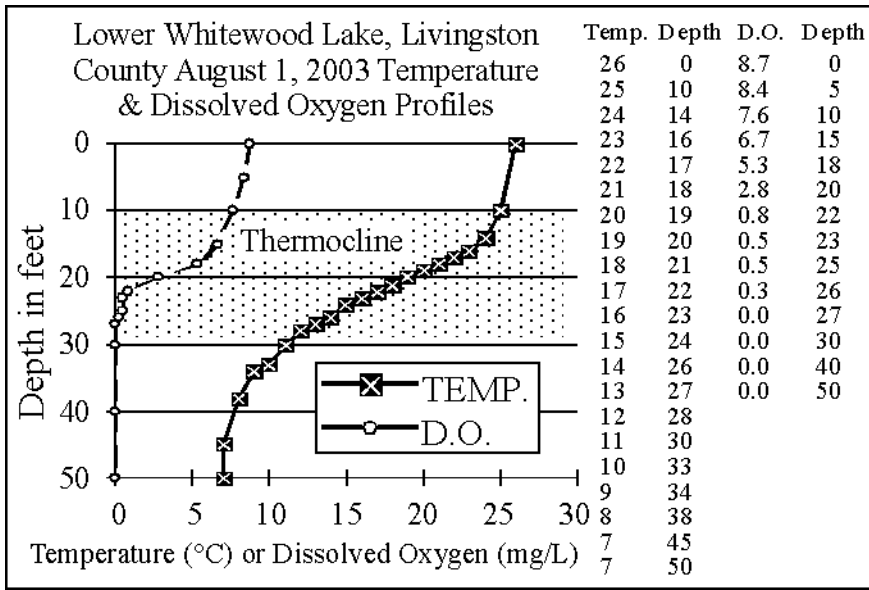
2002

In late summer 2002, the west basin formed a 26-foot-thick thermocline from 10 to 36 feet. Dissolved oxygen was plentiful above the thermocline. The basin ran out of dissolved oxygen at 27 feet. That condition



remained to the bottom. About 52 percent of the basin is deeper than 27 feet.

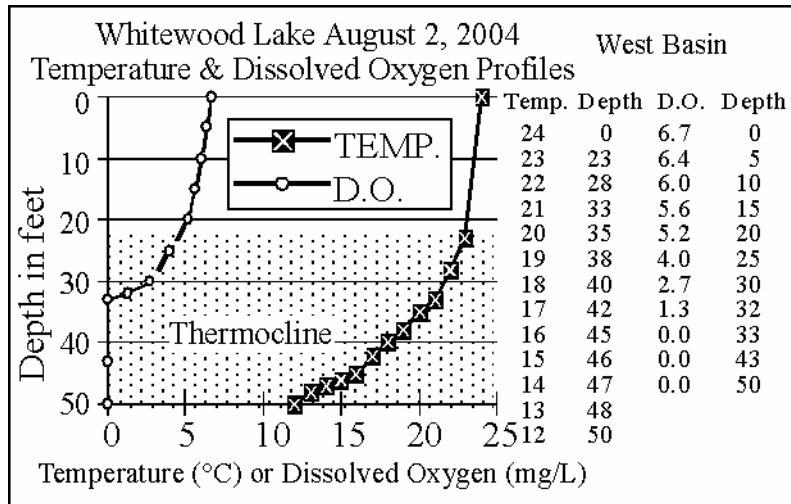
2003



In late summer 2003, the west basin formed a 20-foot-thick thermocline from 10 to 30 feet. Dissolved oxygen was plentiful above the thermocline. The basin ran out of dissolved oxygen at 27

feet. That condition remained to the bottom. About 52 percent of the basin is deeper than 27 feet.

2004



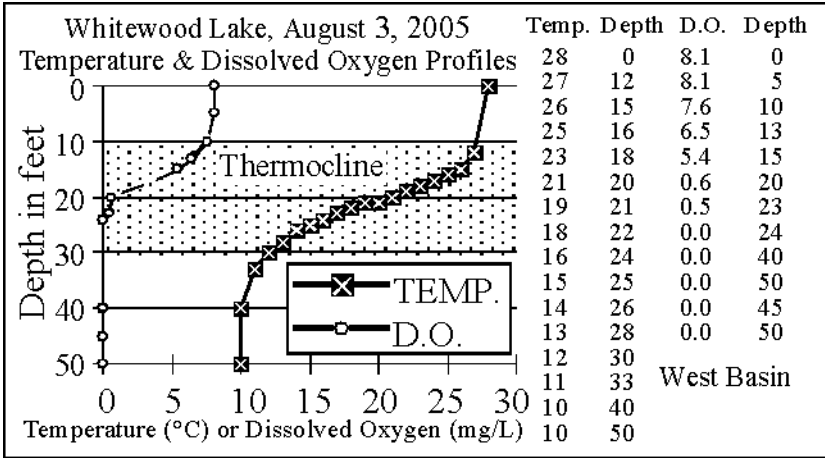
In late summer 2004, the west basin formed a 30-foot-

thick thermocline from 20 to 50 feet. Dissolved oxygen was plentiful above the thermocline. The basin ran out of dissolved oxygen at 33 feet. That condition remained to the bottom. About 37 percent of the basin is deeper than 33 feet.

2005

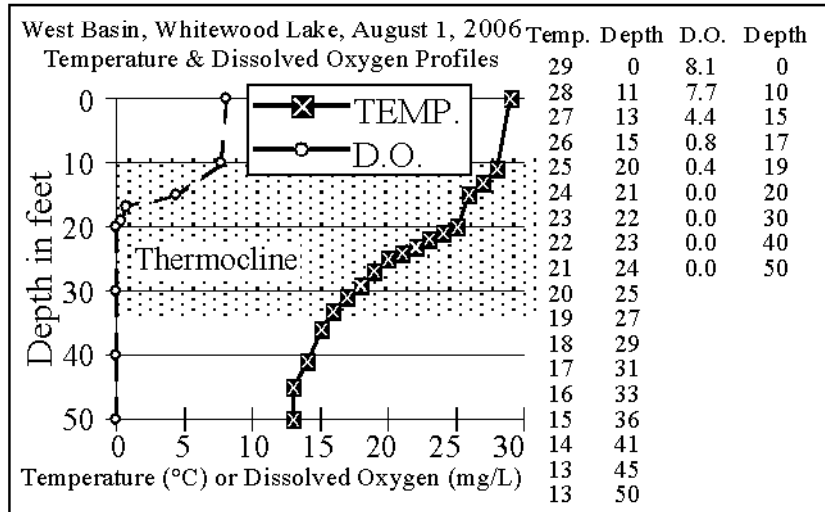
In late summer 2005, the west basin formed a 20-foot-thick thermocline from 10 to 30 feet. Dissolved oxygen was plentiful above the thermocline. The basin ran out of dissolved oxygen at 24 feet. That condition remained to the bottom.

About 60 percent of the basin is deeper than 24 feet.



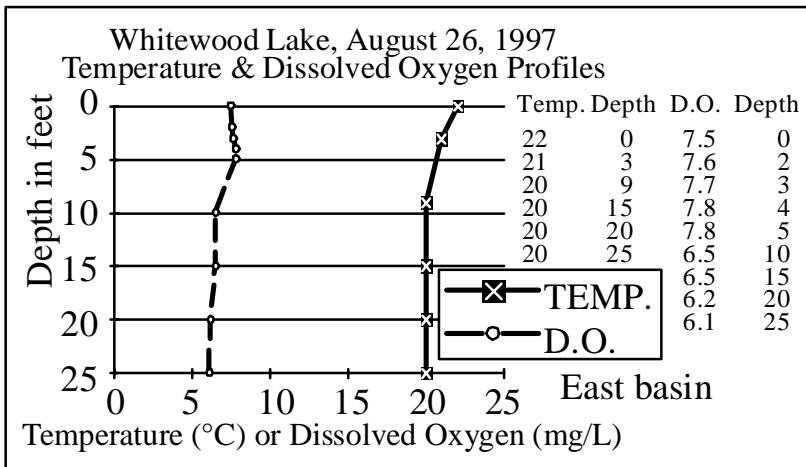
2006

In late summer 2006 the west basin formed a 23-foot thick thermocline from 10 to 33 feet. Dissolved oxygen supplies were adequate above 10 feet. Below that depth dissolved oxygen concentrations started to decrease, and were zero at 20 feet. That condition remained to the bottom. About 62 percent of the basin is deeper than 20 feet.



Late summer temperature and dissolved oxygen profiles show that no pattern is emerging in the west basin regarding the depth the lake runs out of dissolved oxygen. That's a plus.

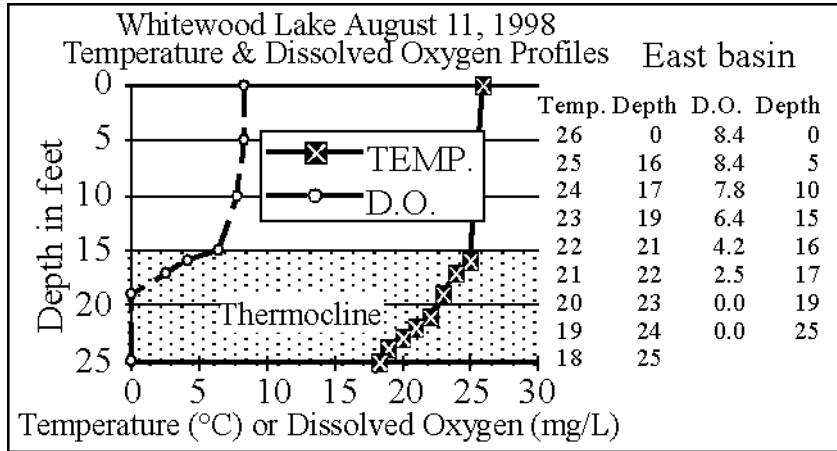
THE EAST BASIN



1997

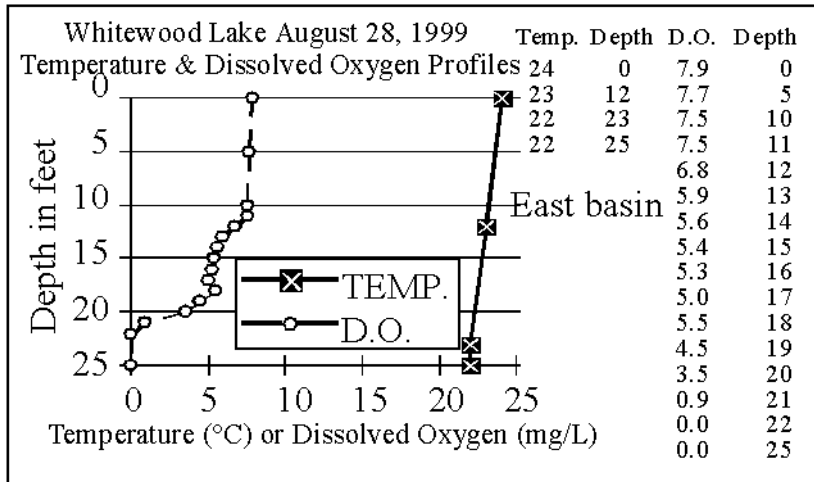
In late summer 1997, the east basin did not form a thermocline. Temperature was essentially uniform top to bottom. Since there was no stratification of layers of water in the

lake, dissolved oxygen was also uniformly mixed through the entire water column.



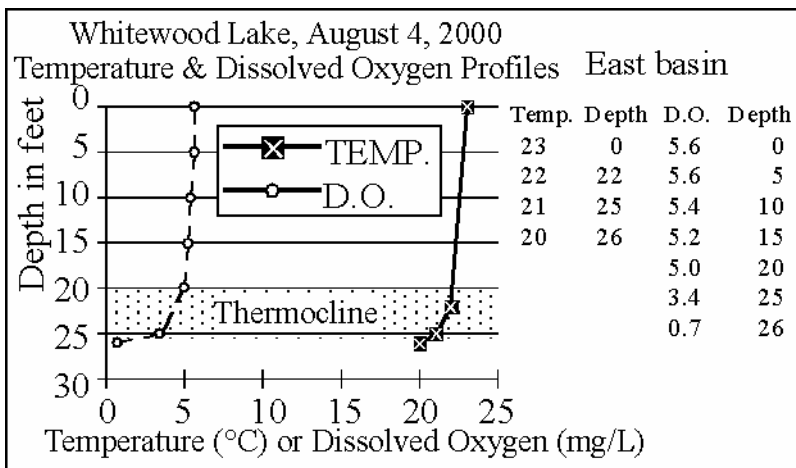
1998

In late summer 1998 the east basin formed a ten-foot-thick thermocline from 15 to 25 feet. Above the thermocline, dissolved oxygen was plentiful. The basin ran out of dissolved oxygen at 19 feet and that condition remained to the bottom. About 48 percent of the basin is deeper than 19 feet.



1999

In late summer 1999, no thermocline formed in the east basin. Temperature



was essentially uniform top to bottom. Dissolved oxygen was plentiful above 10 feet. From that depth the dissolved oxygen concentration gradually decreased. It was zero at 22 feet and that condition remained to the

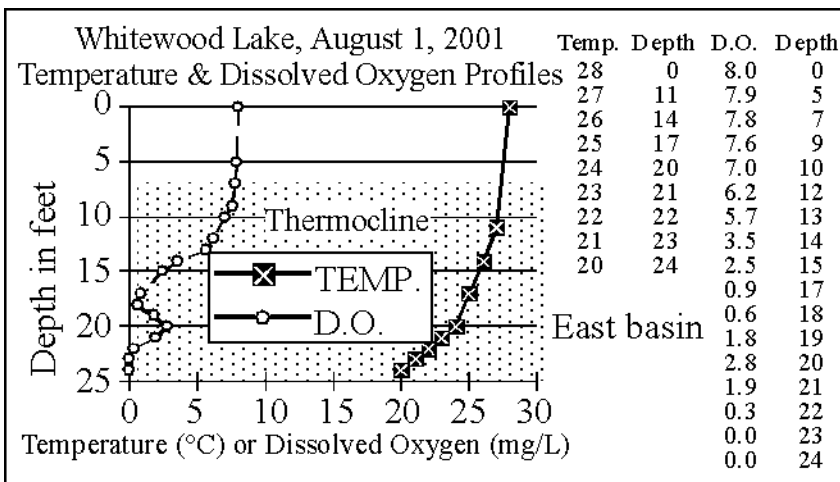
bottom. About 30 percent of the basin is deeper than 22 feet.

2000

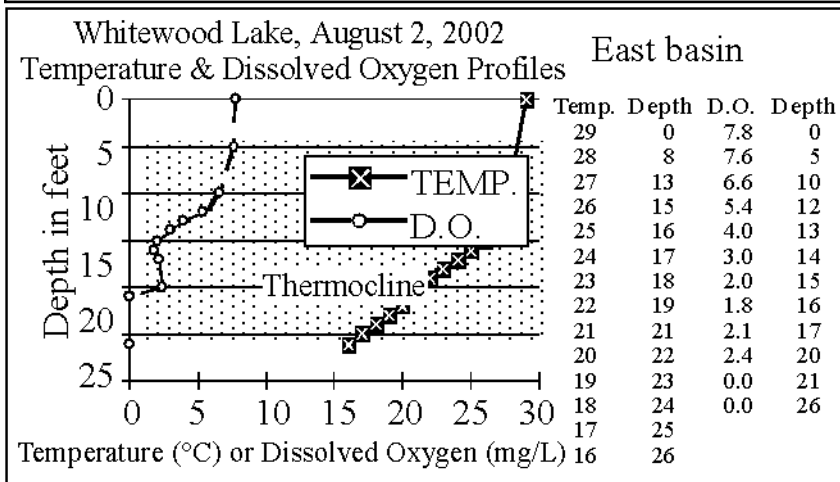
In late summer 2000, the east basin formed a 6-foot-thick thermocline from 20 to 26 feet (the bottom of the basin). The dissolved oxygen concentrations were low from the surface to 20 feet (less than 6 milligrams per liter). At 20 feet the dissolved oxygen concentration started to decrease. It reached 0.7 milligrams per liter at 26 feet, the bottom of the basin.

2001

In late summer 2001, the east basin formed a 16-foot-thick thermocline from 9 to 25 feet. In this case, dissolved oxygen concentration did a better job of defining the thermocline than did temperature. Dissolved oxygen was plentiful above 10 feet. From that depth the dissolved oxygen concentration gradually decreased to a low of 0.6 milligrams per liter at 18 feet. There was



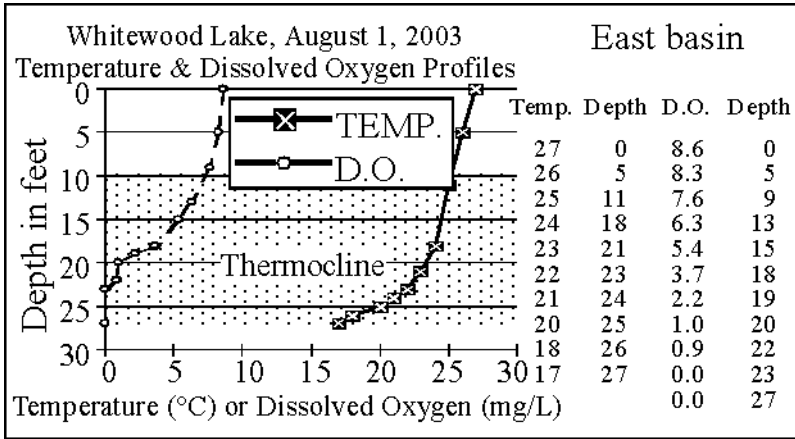
a small peak of dissolved oxygen at 20 feet, probably the result of an algal bloom which settled there. It was zero at 23 feet and that condition remained to the bottom. About 25 percent of the lake is deeper than 23 feet.



2002

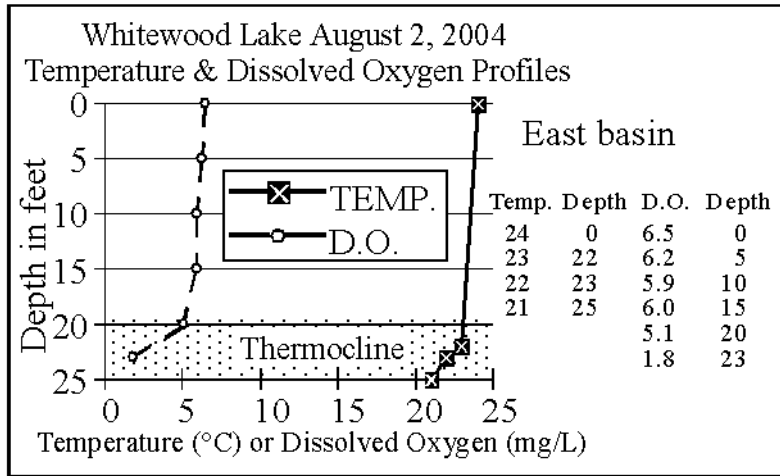
In late summer 2002, the east basin formed a 21-foot-thick thermocline from 5 to 26 feet. Dissolved oxygen

concentration again did a better job of defining the thermocline than did temperature. Dissolved oxygen was plentiful above 10 feet. From that depth the dissolved oxygen concentration gradually decreased to a low of 1.8 milligrams per liter at 16 feet, then increased to 2.4 mg/L at 20 feet. Dissolved oxygen was zero at 21 feet and that condition remained to the bottom.



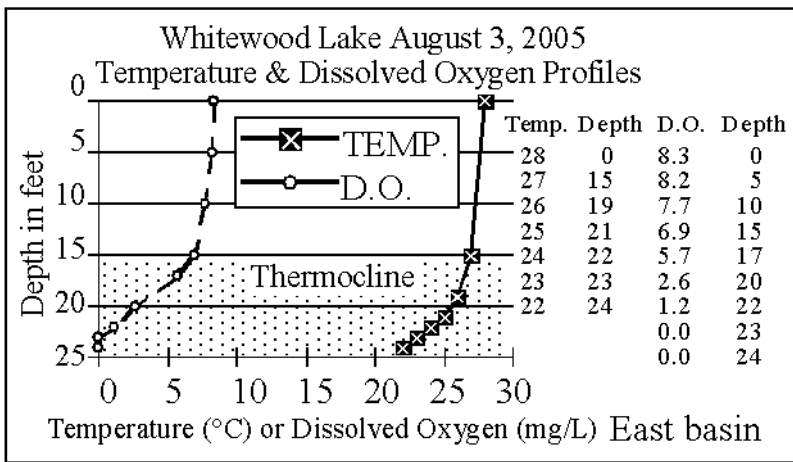
2003

In late summer 2003, the east basin formed a 17-foot-thick thermocline from 10 to 27 feet. Dissolved oxygen was plentiful above 10 feet. From that depth the dissolved oxygen concentration gradually decreased to zero at 23 feet and that condition remained to the bottom.



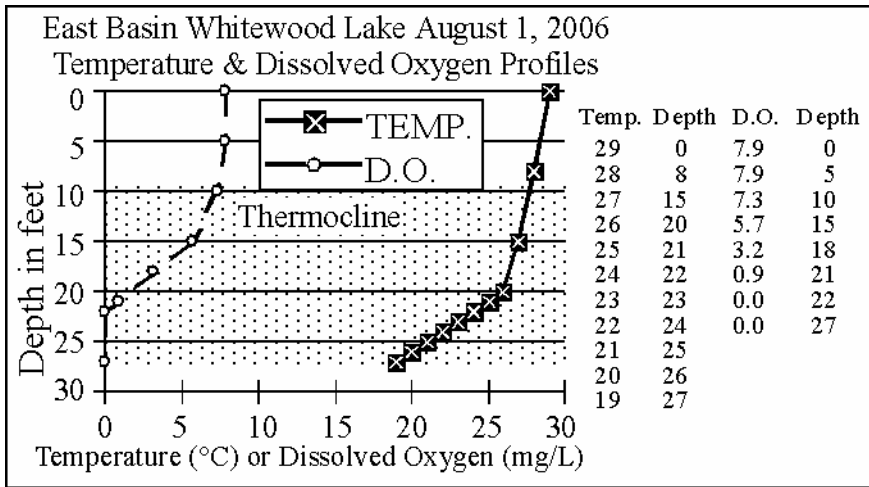
2004

In late summer 2004, the east basin formed a 5-foot-thick thermocline from 20 to 25 feet. Dissolved oxygen was plentiful above 20 feet. From that depth the dissolved oxygen concentration gradually decreased to 1.8 mg/L at 23 feet.



2005

In late summer 2005 the east basin formed a 10-foot thick thermocline from 15 to 25 feet. Dissolved oxygen was plentiful above 15 feet. This year the basin ran out of dissolved oxygen near the bottom, at 23 feet.



2006

In late summer 2006 the east basin formed an 18-foot thick thermocline from 10 to 28 feet. Dissolved oxygen was plentiful above 10 feet. This

year the basin ran out of dissolved oxygen near the bottom, at 22 feet.

The data show this basin has unusually variable temperature and dissolved oxygen conditions, probably the result of the high flushing rate.

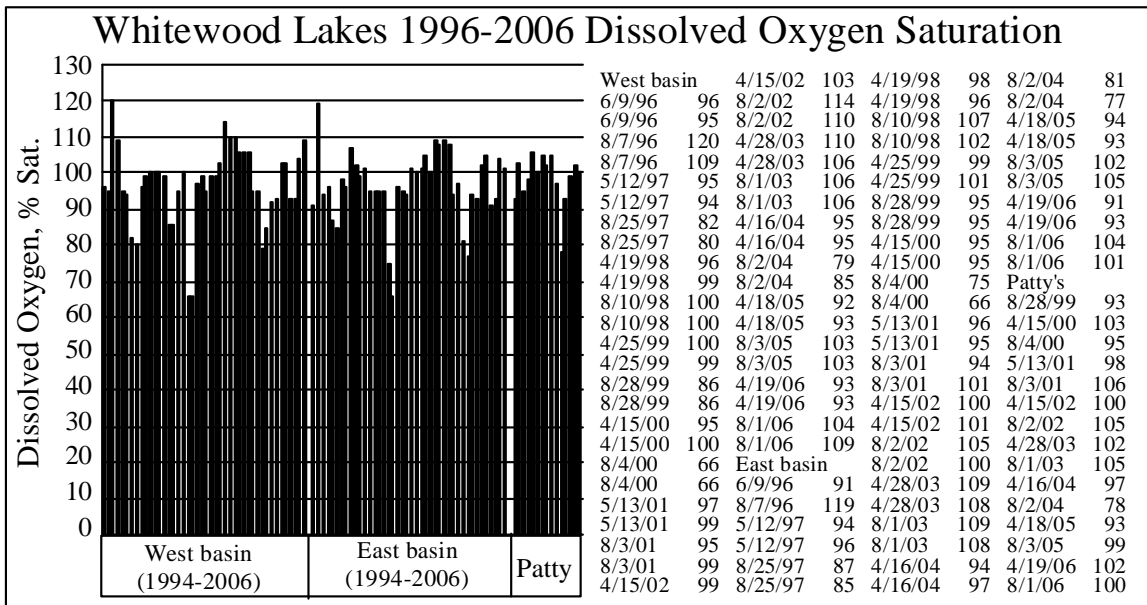
A NOTE ABOUT THE REMAINING GRAPHS

The graphs below are sorted first by east and west basin, then by date. The purpose is to see if there are any differences in the data between the two basins

DISSOLVED OXYGEN, PERCENT SATURATION

Because the amount of dissolved oxygen a water can hold is temperature dependent, with cold water holding more than warm water, percent saturation is often a better way to determine if surface oxygen supplies are adequate. Best is near 100 percent.

The graph shows the saturation of dissolved oxygen is usually less than 100 percent, with occasional higher values.

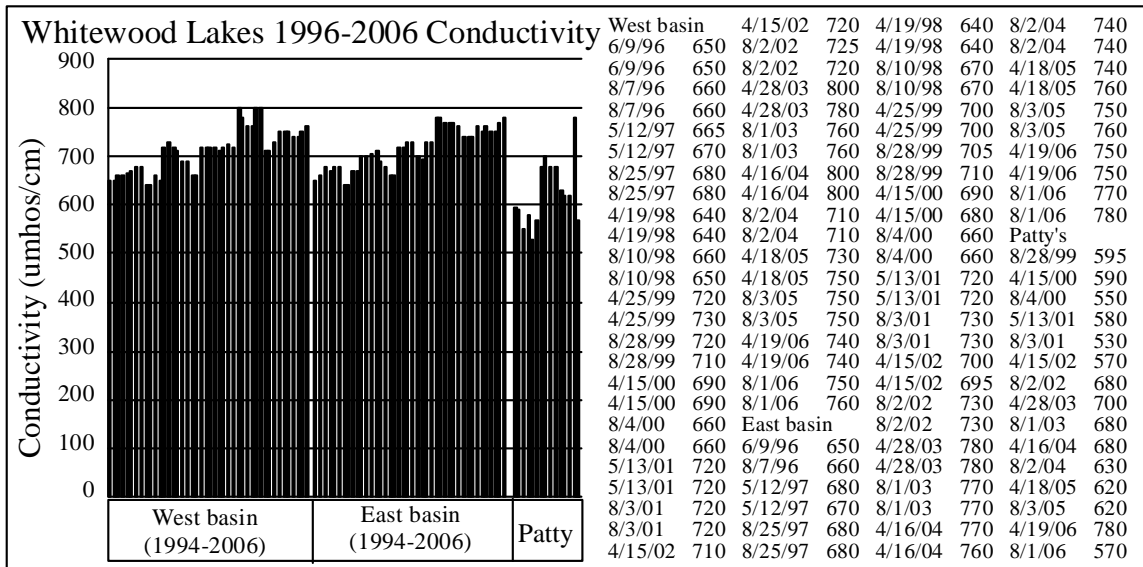


These data should indicate the lake does not have a lot of plants and algae, because plants and algae often create supersaturated conditions in lakes. However the high flushing rate may be keeping these high dissolved oxygen concentrations in check.

CONDUCTIVITY

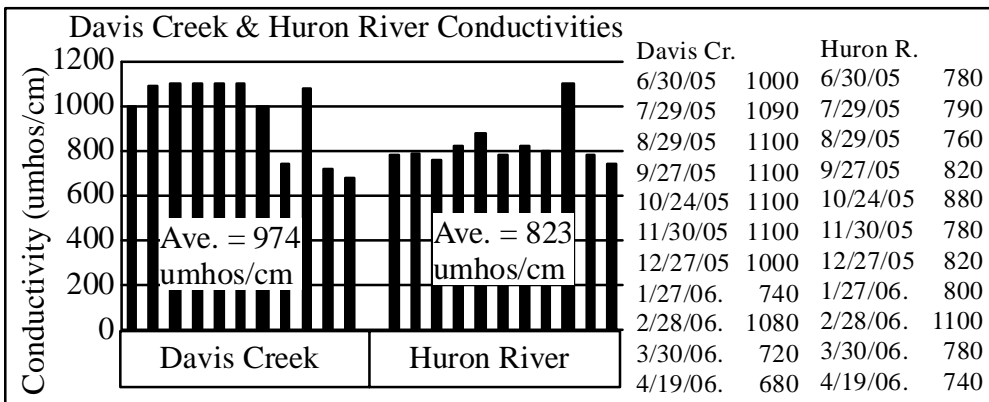
Conductivity, measured with a meter, detects the capacity of a water to conduct an electric current. More importantly however, it measures the amount of materials dissolved in the water (salts), since only dissolved materials will permit an electric current to flow. Theoretically, pure water will not conduct an electric current.

It is the perception of the experts that poor quality water has more dissolved materials than good quality water. I agree. Lower is usually better. The graph shows spring and summer conductivities ranged from 640 to 800 micromhos per centimeter, which is high for a Michigan inland lake.



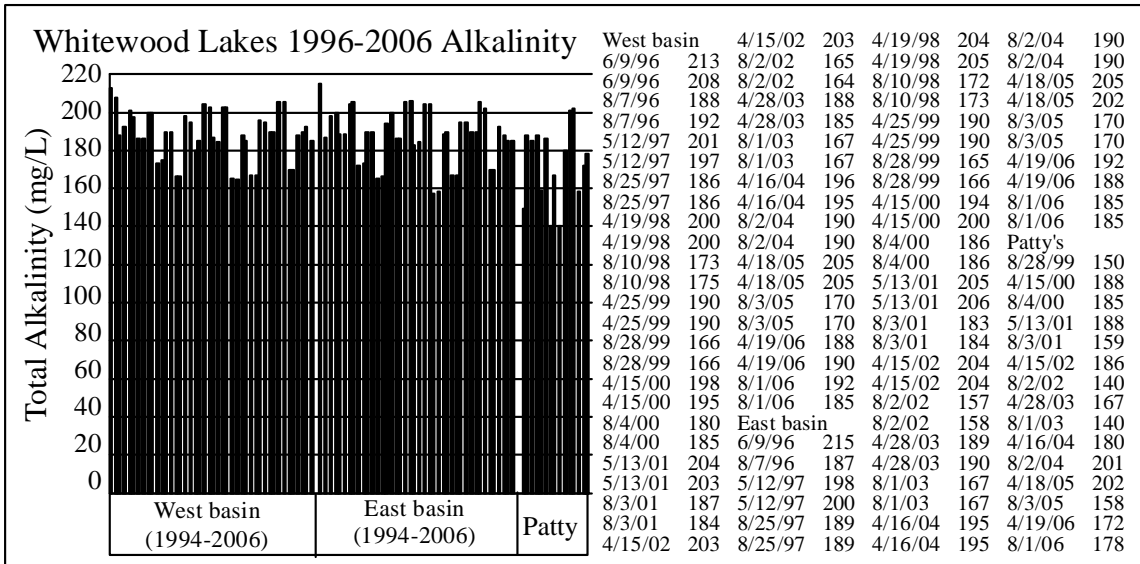
The graph shows conductivities are increasing in both basins, and that salts (probably from road salting operations or water softeners) may be affecting the lake. Some of the salts may be from upstream sources.

The graph shows the conductivities in Patty's Lake are less than those in Whitewood. This is probably because the salts that are causing the high conductivity are coming down the Huron River, and the Huron River doesn't pass through Patty's Lake. These are still high conductivities for a Michigan inland lake.



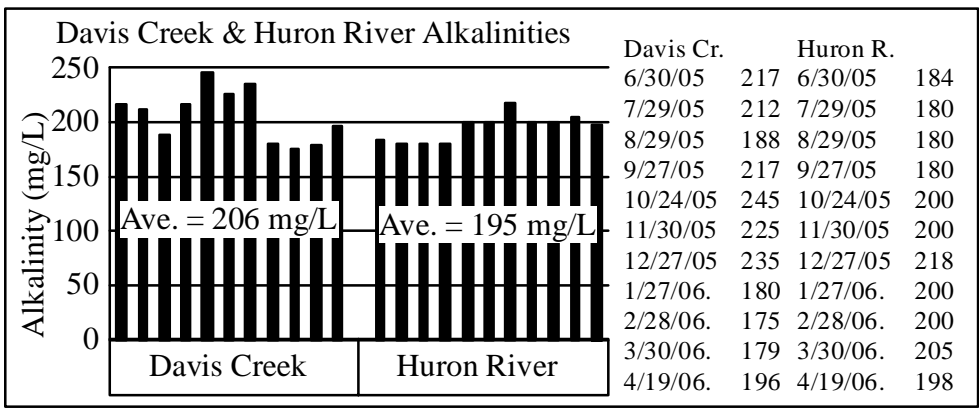
The conductivities of Davis Creek samples were higher than Whitewood Lake, while the conductivities of the Huron River samples were about the same.

TOTAL ALKALINITY



Alkalinity measures carbonates and bicarbonates in water. Soft water lakes have alkalinities below 75 milligrams per liter. Moderately hard water lakes have alkalinities between 75 and 150 milligrams per liter. Hard water lakes have alkalinities above 150 milligrams per liter.

The alkalinity of Whitewood Lake(s) ranges from 157 to 215 milligrams per liter. This indicates the lake is a hard water lake, not surprising given the Huron River flows through both basins. The graph shows summer alkalinities are lower than spring alkalinities, which is normal.



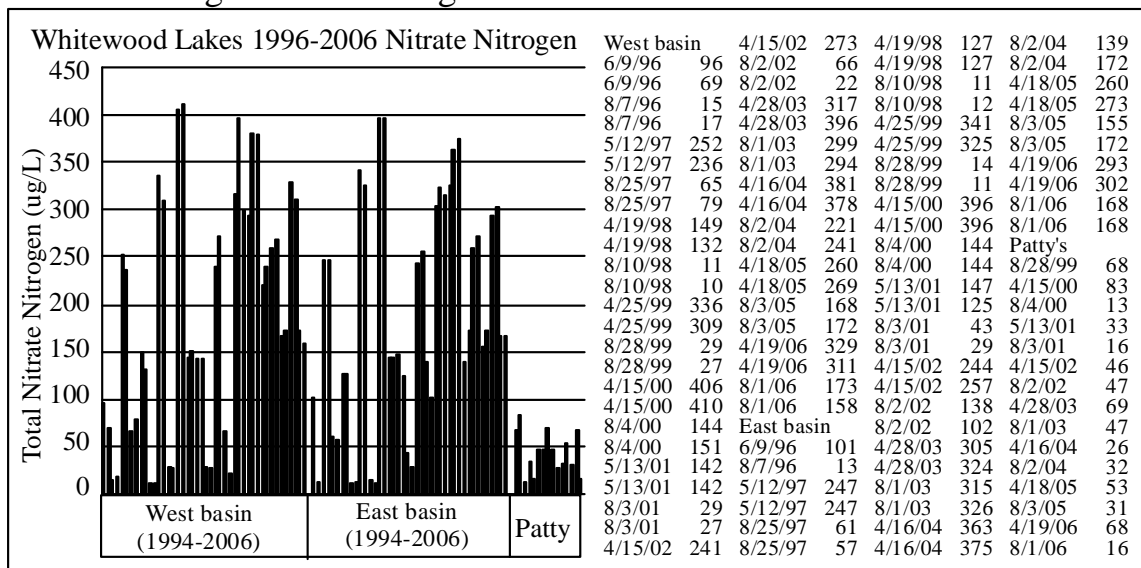
The alkalinities of the Davis Creek samples are slightly higher than Whitewood Lake water, but that's expected and normal. Huron River alkalinities are about the same as Whitewood Lake samples.

Hard water lakes are tougher than soft water lakes because they have the ability to precipitate some phosphorus to the bottom sediments as calcium phosphate. Soft water lakes lack this ability.

NITRATE NITROGEN

Most Michigan inland lakes have spring nitrate nitrogen concentrations around 200 micrograms per liter (or parts per billion). Summer nitrate nitrogen concentrations are generally much lower, in the 10 to 40 micrograms per liter range.

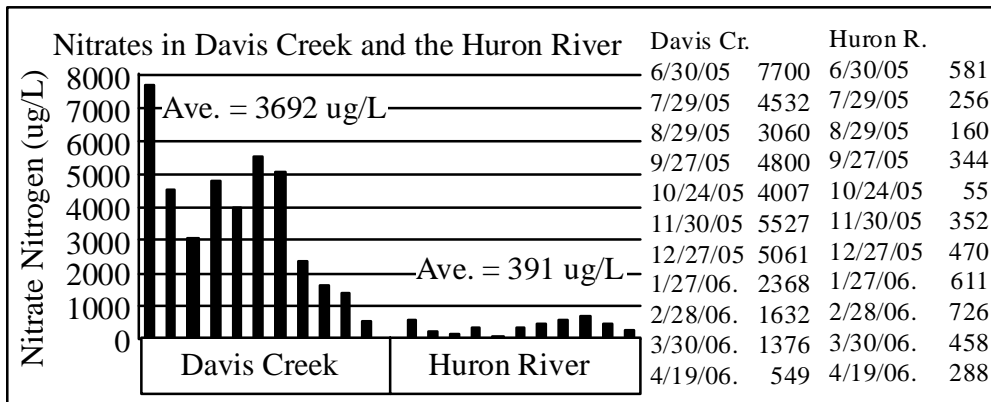
The graph shows spring nitrate nitrogen concentrations range from a low of 69 micrograms per liter (in 1996) to a high of 410 micrograms per liter (in 2000). Summer values are variable; sometimes low (less than 100 ug/L) and sometimes higher than 300 ug/L. The amount of variation is unusual.



The graph seems to show increases in nitrates in Whitewood Lake in summer since 2003. This may lead to increased aquatic plants growing in the lake.

The data from 2003, 2004, 2005 and 2006 indicate Whitewood Lake is probably phosphorus limited. It also means no fertilizers containing either nitrogen or phosphorus should be used on near lake areas.

The graph shows Patty's Lake seems to have low nitrates in both spring and summer.



The graph shows nitrate concentrations in the Davis Creek samples are about ten times higher than the Huron River samples. I suspect the source of these high nitrates in Davis Creek is the Northfield Township sewage treatment plant.

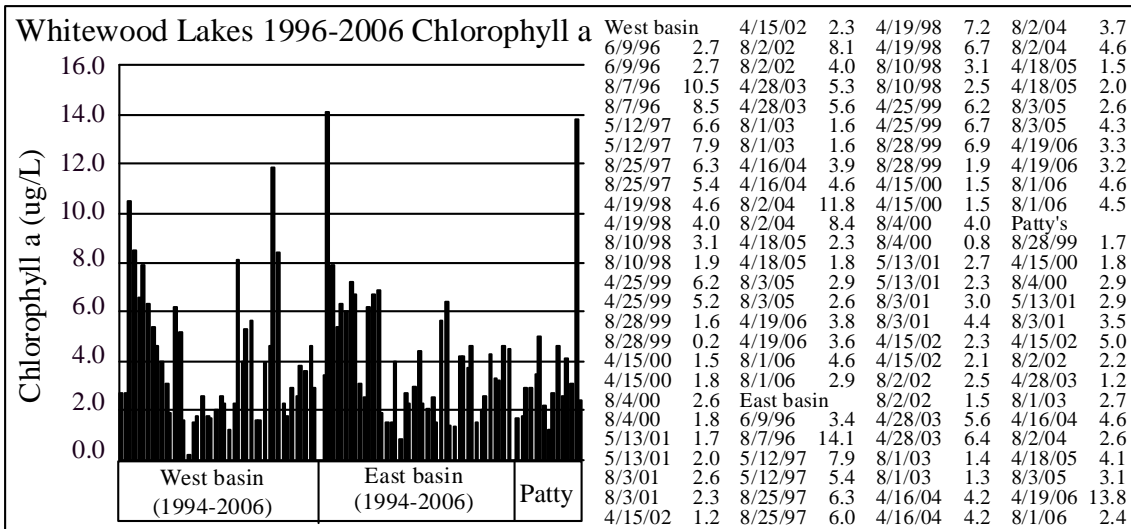
The DNR does not feel nitrates are a problem. In fact, they encourage nitrate production at sewage treatment plants.

I feel nitrates are a problem because although limiting the amount of phosphorus in the water may control algal communities in lakes, that is not the case with aquatic plants. Since aquatic plants have roots, and the bottom sediments of most lakes have plenty of phosphorus, the plants can get their phosphorus from the bottom sediments. Hence controlling phosphorus does little to limit aquatic plant growth. Therefore nitrogen needs to be controlled, because the aquatic plants get their nitrogen from the water, just like the algae do.

CHLOROPHYLL A

Chlorophyll a, reported in micrograms per liter (or parts per billion) generally gives an estimate of algal densities. Best is less than 1 microgram per liter.

The chlorophyll graph shows Whitewood Lake has had in the past significant algal blooms, and in the past several years, smaller algal blooms, although the 2004 spring and summer chlorophylls were higher than normal.



In 2005 summer chlorophylls (2.6-4.3 ug/L) were higher than spring chlorophylls (1.5-2.3 ug/L). 2006 spring and summer chlorophylls were about the same, ranging from 3.2 to 4.6 ug/L.

The algal blooms in Patty's Lake seem to pretty much mimic those in Whitewood.

pH (Hydrogen ion concentration) (no graph)

1996 through 2006 spring and summer surface pH values ranged from 7.4 to 8.4. These are normal pH values for a Michigan inland lake fed by a river.

Lakes with extensive plant communities often have high summer pH values (greater than 9) because the plants use the carbonates in the water as a carbon source. This causes a decrease in the buffering capacity of the water, and allows the pH to rise.

TOTAL PHOSPHORUS

Although there are several forms of phosphorus found in lakes, the experts selected total phosphorus as being most important. This is probably because all forms of phosphorus can be converted to the other forms. Currently, most lake scientists feel phosphorus, which is measured in parts per billion (1 part per billion is one second in 31 years) or micrograms per liter (ug/L), is the one nutrient which might be controlled. If its addition to lake water

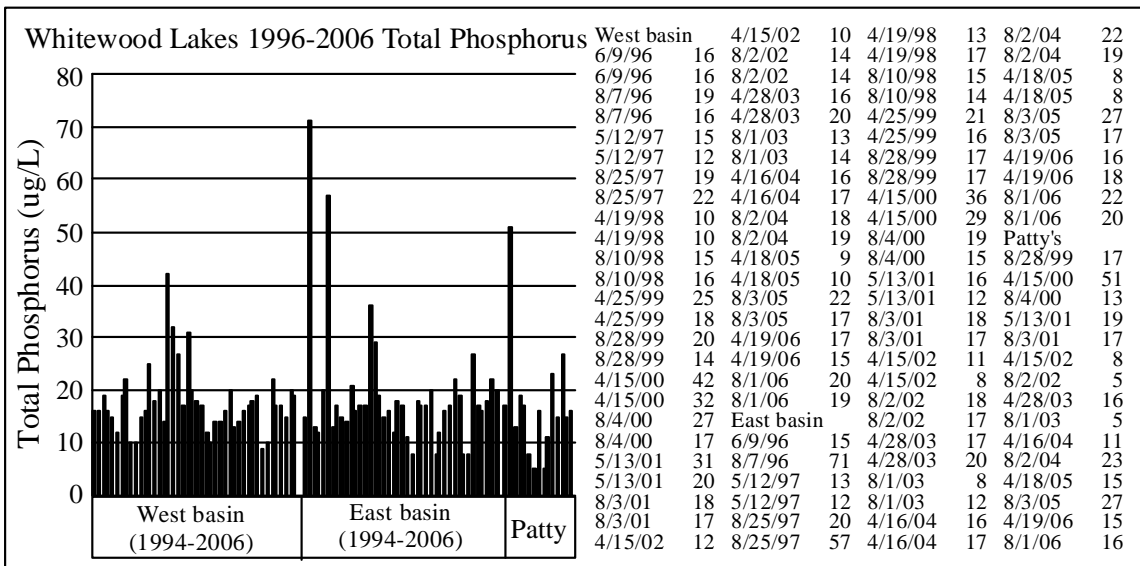
could be limited, the lake might not become covered with the algal communities so often found in eutrophic lakes.

However, based on our studies of many Michigan inland lakes, we've found many lakes were phosphorus limited in spring (so don't add phosphorus) and nitrate limited in summer (so don't add nitrogen).

10 parts per billion is considered a low concentration of phosphorus in a lake and 50 parts per billion is considered a high value in a lake by many limnologists.

The total phosphorus graph shows Whitewood Lake had phosphorus concentrations ranging from 8 to 71 micrograms per liter. Best is below 10 micrograms per liter.

The graph shows there is not a lot of difference between the phosphorus concentrations of the two basins. The west basin phosphorus concentrations range from 9 to 42 micrograms per liter, and average 18. The east basin phosphorus concentrations range from 8 to 71 ug/L and average 19.



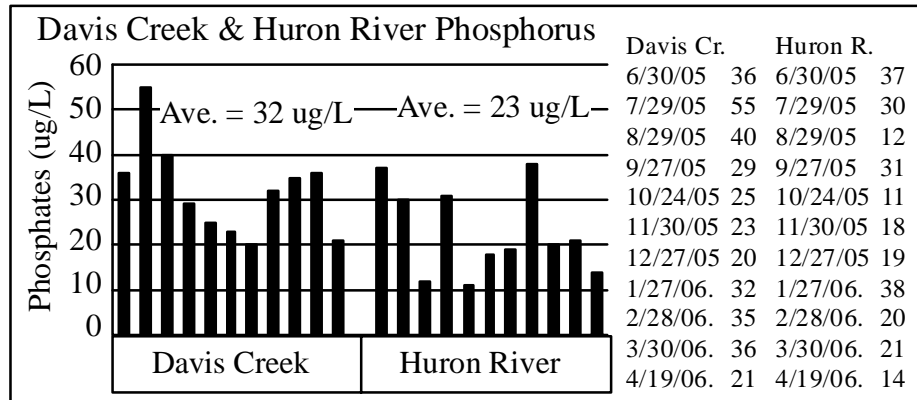
The graph shows most of the time, phosphorus concentrations are less than 20 ug/l. Once they start exceeding that value, if other nutrients are present in sufficient quantities, plants and algae will grow to nuisance levels.

It is a real plus that the Portage, Base and Whitewood Board passed a resolution recommending no fertilizers, containing either phosphorus or

nitrogen be used on lands within four hundred feet of the lakes, or from streams that feed the lakes. If residents heed this policy, the quality of their lakes should improve.

The graph however, does not seem to show an increase in phosphorus concentrations as the years pass.

Patty’s Lake phosphorus concentrations seem to mimic those of Whitewood.



The graph shows Davis Creek average phosphorus concentration is 32 ug/L while the average Huron River phosphorus concentration is 23 ug/L. Both are higher than the average Whitewood Lake phosphorus concentration of 18 ug/L. And Davis Creek has a phosphorus concentration about 50 percent higher than the Huron River. That’s not a plus for the lakes.

SECCHI DISK TRANSPARENCY (originally Secchi’s disk)

In 1865, Angelo Secchi, the Pope’s astronomer in Rome, Italy devised a 20 centimeter (8 inch) white disk for studying the transparency of the water in the Mediterranean Sea. Later an American limnologist (lake scientist) named Whipple divided the disk into black and white quadrants which many are familiar with today.

The Secchi disk transparency is a lake test widely used and accepted by limnologists. The experts generally felt the greater the Secchi disk depth, the better quality the water. However, one Canadian scientist pointed out acid lakes have very deep Secchi disk readings. Most lakes in southeast Michigan have Secchi disk transparencies of less than ten feet. On the other hand, Elizabeth Lake in Oakland County had 34 foot Secchi disk readings in

summer 1996, evidently caused by a zebra mussel invasion a couple of years earlier.

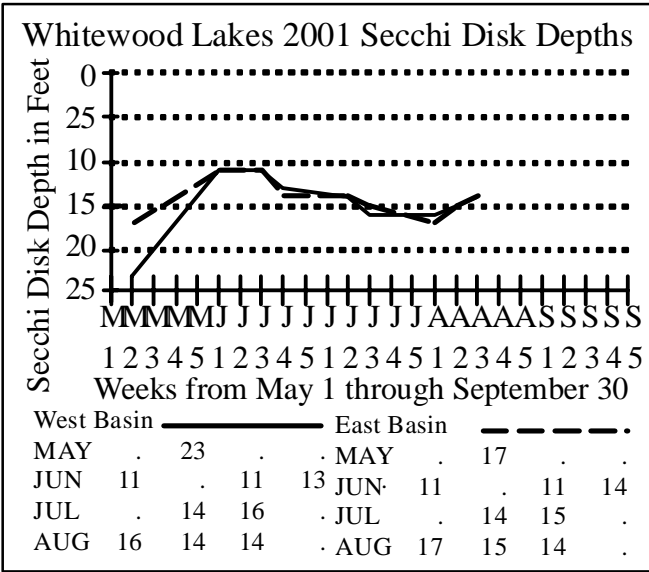
Most limnology texts recommend the following: to take a Secchi disk transparency reading, lower the disk into the water on the shaded side of an anchored boat to a point where it disappears. Then raise it to a point where it's visible. The average of these two readings is the Secchi disk transparency depth.

We do it slightly differently. We lower the disk on the shaded side of an anchored boat until the disk disappears, and note the depth, then report the depth to the next deepest foot. For example if the disk disappears at six and a half feet, we report the Secchi disk depth as 7 feet. The reason we do this is that some suggest using a water telescope (a device that works like an underwater mask and eliminates water roughness) to view the disk as it disappears. Since we don't use this device, we compensate for it by noting the slightly deeper depth.

We feel it is only necessary to report Secchi disk measurements to the closest foot. Secchi disk measurements should be taken between 10 AM and 4 PM. Rough water will give slightly shallower readings than smooth water. Sunny days will give slightly deeper readings than cloudy days. However, roughness influences the visibility of the disk more than sunny or cloudy days. Furthermore, it's been reported that most adults can see the Secchi disk disappear at about the same depth, but grand-children see it disappear 3-4 feet deeper than grand-parents.

If there are sample sites where the lake is too shallow and the disk is visible when resting on the bottom, the reading should be taken at a nearby deeper site. Since the sampling procedure is designed to obtain "representative samples" moving the boat to an area where a Secchi disk transparency reading can be properly taken is appropriate. In the case of Secchi disk readings, this procedure is more valid than reporting the disk is visible on the lake bottom.

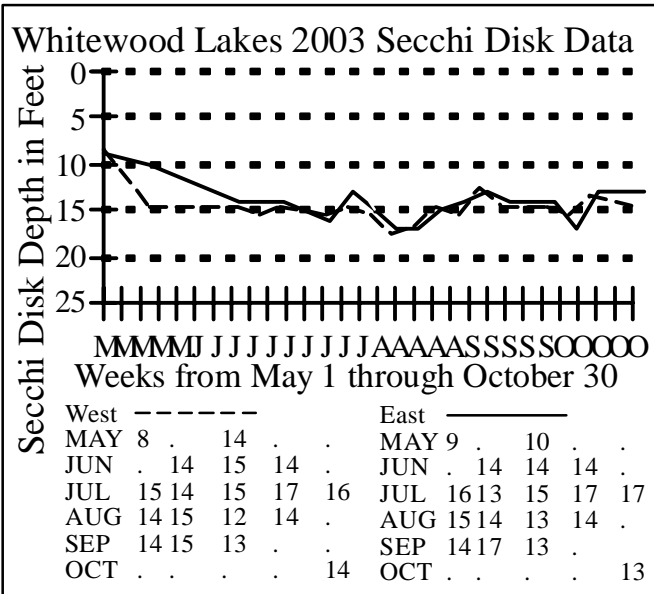
WHITEWOOD LAKES SECCHI DISK DATA



2001

Jerry and Stacy Porman did a good job taking Secchi disk readings in both basins of Whitewood Lake in 2001. The graph shows their data.

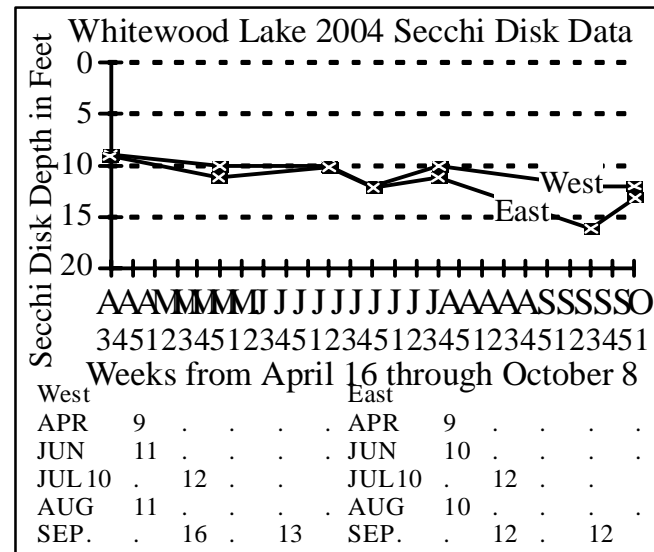
The graph shows in May, the clarity of the west basin was better (23 feet) than the east basin (17 feet). After that, the



Secchi disk readings in both basins were similar. The graph shows Secchi disk readings are shallowest in June, about 11 feet. From that point on, they gradually increase to 14 to 17 feet in July and August.

2003

Jerry and Stacy Porman collected Secchi disk data in 2003 from both basins. The graph shows their data from both basins, stacked.



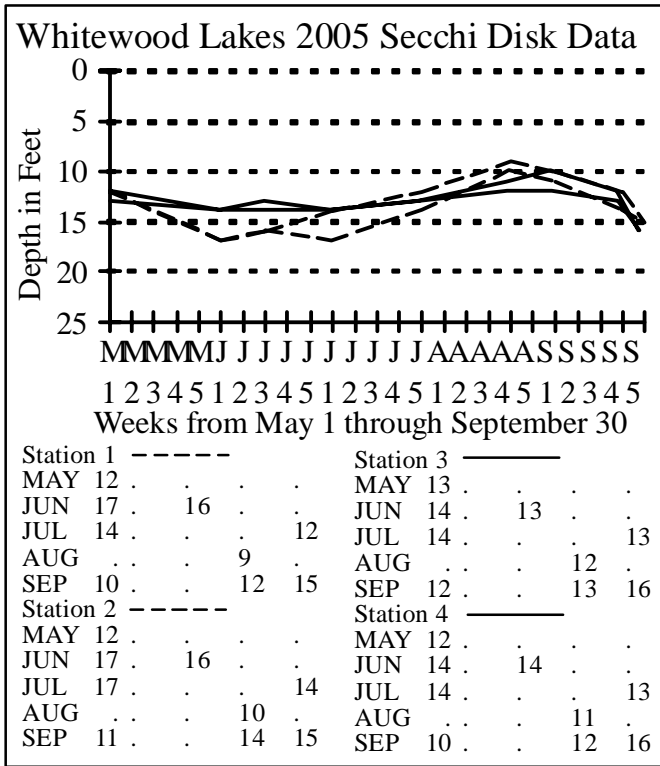
The graph shows little change in water clarity between spring when the water is cold, and summer when it is warm. This is probably due to the high flushing rate.

2004

Jerry and Stacy Porman again collected Secchi disk data in

2004 in both basins of Whitewood Lake. The graph shows their data.

The graph shows three things. First, there is not a lot of difference between the clarity of the water in east and west Whitewood lakes, two; the clarity doesn't change much between spring and summer, and three, in late summer 2004 the east basin was a bit clearer than the west basin.



2005

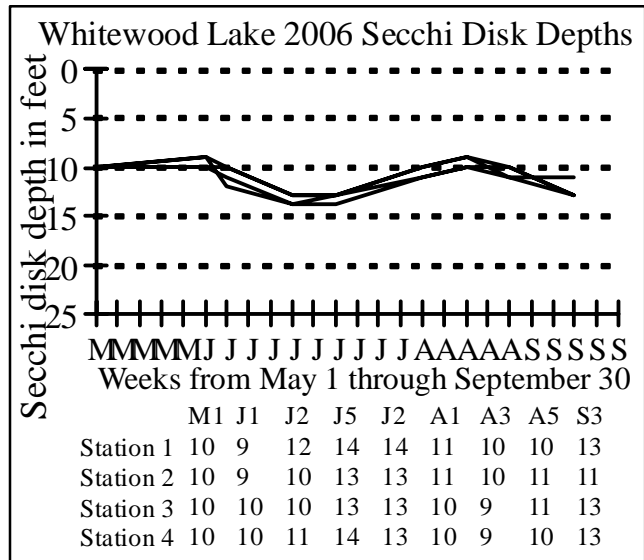
The Pormans collected Whitewood Lake Secchi disk data at all four stations in 2005. The graph shows the four data sets, stacked. The west basin data are represented by dashes, and the east basin data are represented by solid lines.

The graph shows the West Basin had slightly deeper readings than the East Basin in June and July, and slightly shallower readings in August. But all in all, the graph shows the clarity doesn't change much between spring and summer.

2006

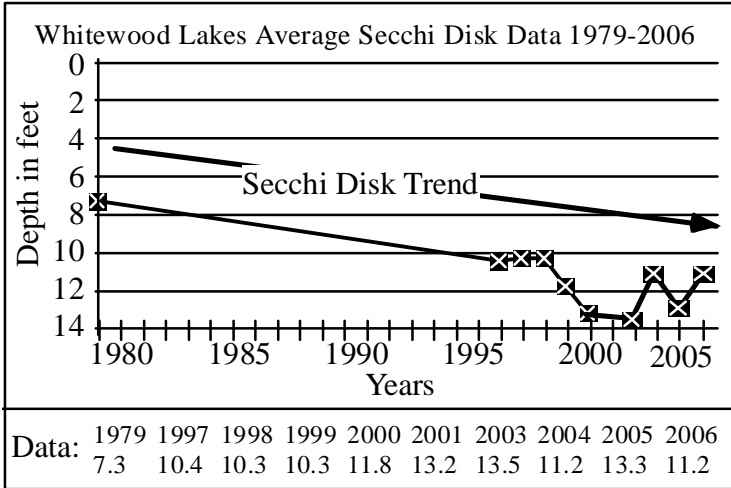
The Pormans collected 2006 Secchi disk data at all four stations on a regular basis through the warm months.

The graph shows little difference between the four stations.



It also shows little variation between spring, when the water is cold, and summer when the water is warm.

THE SECCHI DISK TREND GRAPH

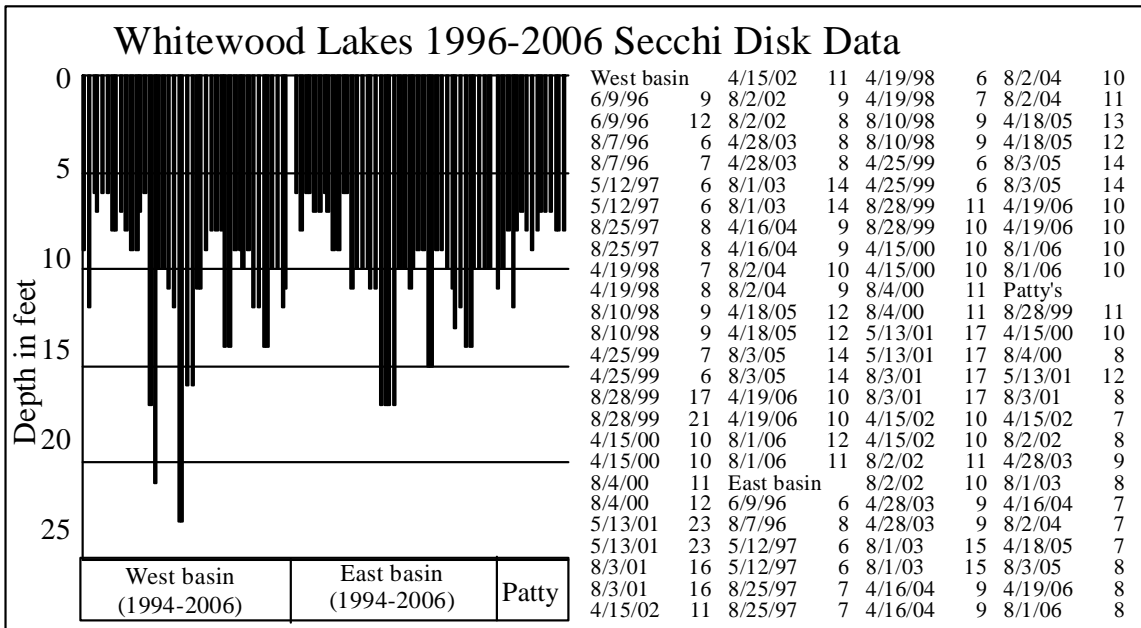


Since we have average Secchi disk data from 1979, plus 1997 through 2006, we were able to construct a Secchi disk trend graph. The graph shows Whitewood Lake is getting clearer as the years pass. However, it would be better if we had more readings from the

1980s and early 1990s.

SECCHI DISK READINGS TAKEN WITH THE SAMPLES

The graph shows the Secchi disk readings taken with the samples. It shows, at least through 2001 the water was getting clearer. The data show a decrease in water clarity in both basins since that time. It also shows the west basin had the deepest readings, 23 feet.



THE LAKE WATER QUALITY INDEX

The Lake Water Quality Index used in this study to define the water quality of Whitewood Lake was developed for two reasons. First, there was no agreement among lake scientists regarding which tests should be used to define the water quality of lakes, and second, there was no agreement among lake scientists regarding what the results of various tests meant in terms of lake water quality.

Development of the index used two questionnaires sent to a panel of 555 lake scientists who were members of the American Society of Limnology and Oceanography. The panel was specifically selected because they were chemists and biologists with advanced degrees who studied lake water quality.

The first questionnaire asked the scientists to select tests they felt should be used to define lake water quality. The tests most often selected by the panel became the index parameters (or tests). They were:

Dissolved oxygen (percent saturation)	
Total phosphorus	Total alkalinity
Chlorophyll a	Temperature
Secchi disk depth	Conductivity
Total nitrate nitrogen	pH

The second questionnaire, sent out after the first was returned, asked the scientists what the results of the tests they selected as good indicators of lake water quality meant.

After the responses to the second questionnaire were returned and tabulated, the nine parameters and the accompanying rating curves were combined into a Lake Water Quality Index.

The index ranges from 1 to 100 and rates lakes about the same way professors rate students: 90-100=A, 80-90=B, 70-80=C, 60-70=D, and below 60 = E. The lake with the highest LWQI was Long Lake in Grand Traverse County, with a spring LWQI of 100. The lowest was 16 at an Ottawa County lake.

THE LAKE WATER QUALITY INDEX CALCULATION SHEETS

The Lake Water Quality Index calculation sheets which follow were developed to show graphically what the results of the nine different lake water quality tests mean in terms of lake water quality.

HOW TO READ THE LAKE WATER QUALITY INDEX CALCULATION SHEETS.

Listed across the top of the calculation sheets are the tests selected by the panel of experts as being good indicators of lake water quality. The results of the tests are entered into the square boxes immediately under the names of the tests.

The figures which look like thermometers are actually graphs which convert the test results (the numbers found outside the thermometer) to a uniform 1-100 lake water quality rating (found inside the thermometer).

The calculation sheet permits calculation of the Lake Water Quality Index, using the results of all nine lake water quality tests.

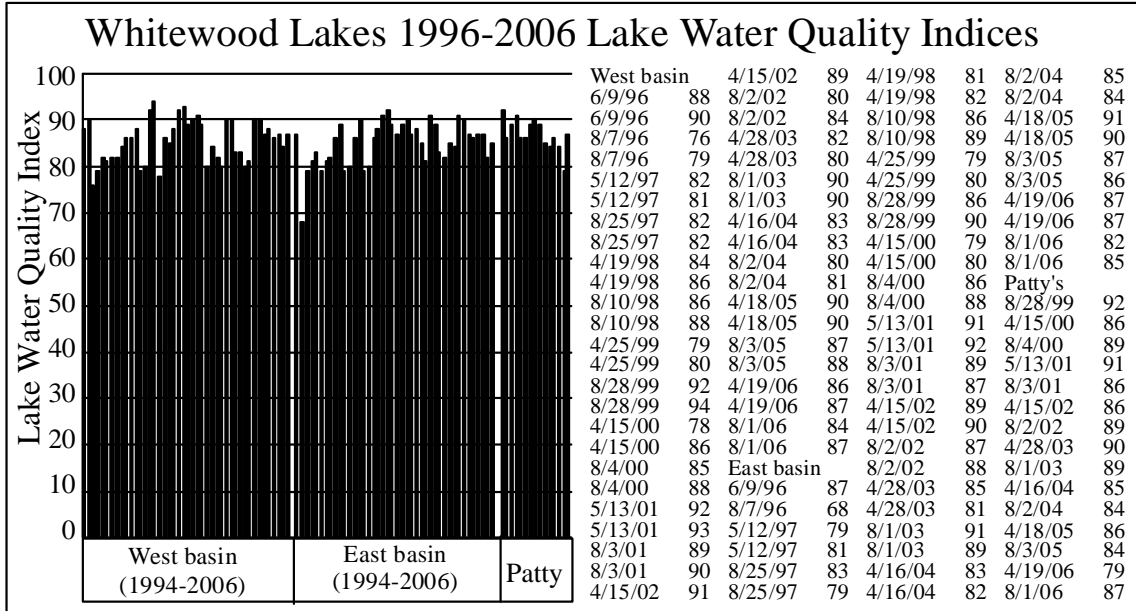
The position of the red lines across the thermometer indicates how the results of each test compare in terms of lake water quality. Test results indicating excellent water quality are indicated by red lines near the top of the thermometer. Test results indicating poor water quality are indicated by red lines lower on the thermometer. And the lower the red line on the thermometer, the greater the water quality problem. A glance at the top of the calculation sheet indicates the test and the actual test results.

The thermometer rating scales also allow you to determine what test results would be considered excellent in terms of lake water quality. They are the numbers found outside the thermometer near the top.

The index is shown three different ways, as a number between 1 and 100 in the circle marked LWQI, and by a color and position on the sheet edge scale. The purpose of the sheet edge scale is to review quickly large numbers of lakes or test sites within a lake, and determine how the water quality of the various lakes, or test sites within a lake compare.

THE 1996-2006 WHITEWOOD LAKES WATER QUALITY INDICES

The graph shows the Lake Water Quality Indices for Whitewood Lake ranges from a low of 68 (in summer 1996) to a high of 94 in summer 1999. It shows most of the time the Lake Water Quality Indices are in the 80s, or B range with a few in the 90s (A range). 2004 LWQIs were lower than most years (80-85), while 2005 LWQIs were better (86-91), especially in spring. 2006 LWQIs ranged from 82 to 87 in spring and summer.



Patty's Lake seems to have pretty uniform LWQIs in the 80s and low 90s (B to A). Although the graph does not appear to show any trend in either the east or west basins, the trend in Patty's lake appears to be to lower water quality.

THE LAKE WATER QUALITY INDEX CALCULATION SHEETS

Because the Lake Water Quality Indices were relatively uniform in spring 2006 (86 87 87 87) one Lake Water Quality Index calculation sheet is included in this report for those four surface samples, using averaged data.

In summer 2006, since the Lake Water Quality Indices were also relatively uniform, (84 87 82 85) a second LWQI calculation sheet is included for those four surface samples, again using averaged data.

In the report marked MASTER, all 8 of the 2006 Lake Water Quality Index calculation sheets are included. That is the only difference between the MASTER and the rest of the reports.

BOTTOM SEDIMENTS

Many times bottom sediments tell us more about what is happening in a lake than the water quality tests do. That's because bottom sediments provide sort of a history of what's been happening in a lake, while water testing just provides a snapshot.

Bottom sediments are collected with a Pederson dredge, transferred to pint freezer containers and allowed to air dry. Once they are dry, the (usually) shrunken block of material is measured to determine volume, then ground, placed in porcelain dishes, dried at 100 degrees C, weighed, burned at 550 degrees C, and weighed again. Color after air-drying and after burning is also noted.

Bottom sediments almost always come up from the lake bottom black, and many people consider these black sediments "muck". However that's not usually the case.

The bottom sediments are black because no oxygen penetrates them, so the decomposition processes which occur use sulfur rather than oxygen, and in this process, they produce iron sulfides, which are black. However once the sediments are exposed to air, they usually turn some other color.

If the sediments remain black after air drying it usually means they are less than about 65 percent mineral (or more than 35% organic material). Sediments also remain black if they are from soft water lakes, but there's a reason for that.

If the sediments turn gray after air drying it usually means they are made up primarily of carbonates. This is what we usually see in moderately hard water and hard water lakes.

If the sediments turn tan, it usually means they are made up primarily of clays. Further evidence of this occurs when we burn the sediments at 550 degrees C.

We determine how much bottom sediments shrink when they air dry because this information is useful when considering dredging a lake. Normal shrinkage after air-drying is in the range of 50 to 80 percent. However sands and gravels don't shrink at all. Excessive shrinkage is more than 95 percent. In other words, there is only five percent or less of the material remaining after air-drying.

If the gray bottom sediments remain gray after burning they are considered carbonates, and the loss of material during this process is considered organic material. The results are expressed in the percentage of minerals in the bottom sediments.

If the tan bottom sediments turn red after burning, it means the lake is filling with clay. Clay enters the lake from near-lake activities such as road building, home building or farming. Usually clay is not a material that makes up the bottom sediments of most inland lakes.

Highly organic sediments that remained black after air drying usually turn tan after burning, but the mineral content is usually quite low.

I consider high quality bottom sediments from natural lakes to be above 85 percent mineral. And I consider bottom sediments less than 50 percent mineral to be muck.

WHITEWOOD LAKE BOTTOM SEDIMENTS

Three bottom sediment samples (Stations 1, 2 & 3) were collected from Whitewood Lake in 1996. Four were collected from the lake in 2005. The graph shows the data.

STATION 1

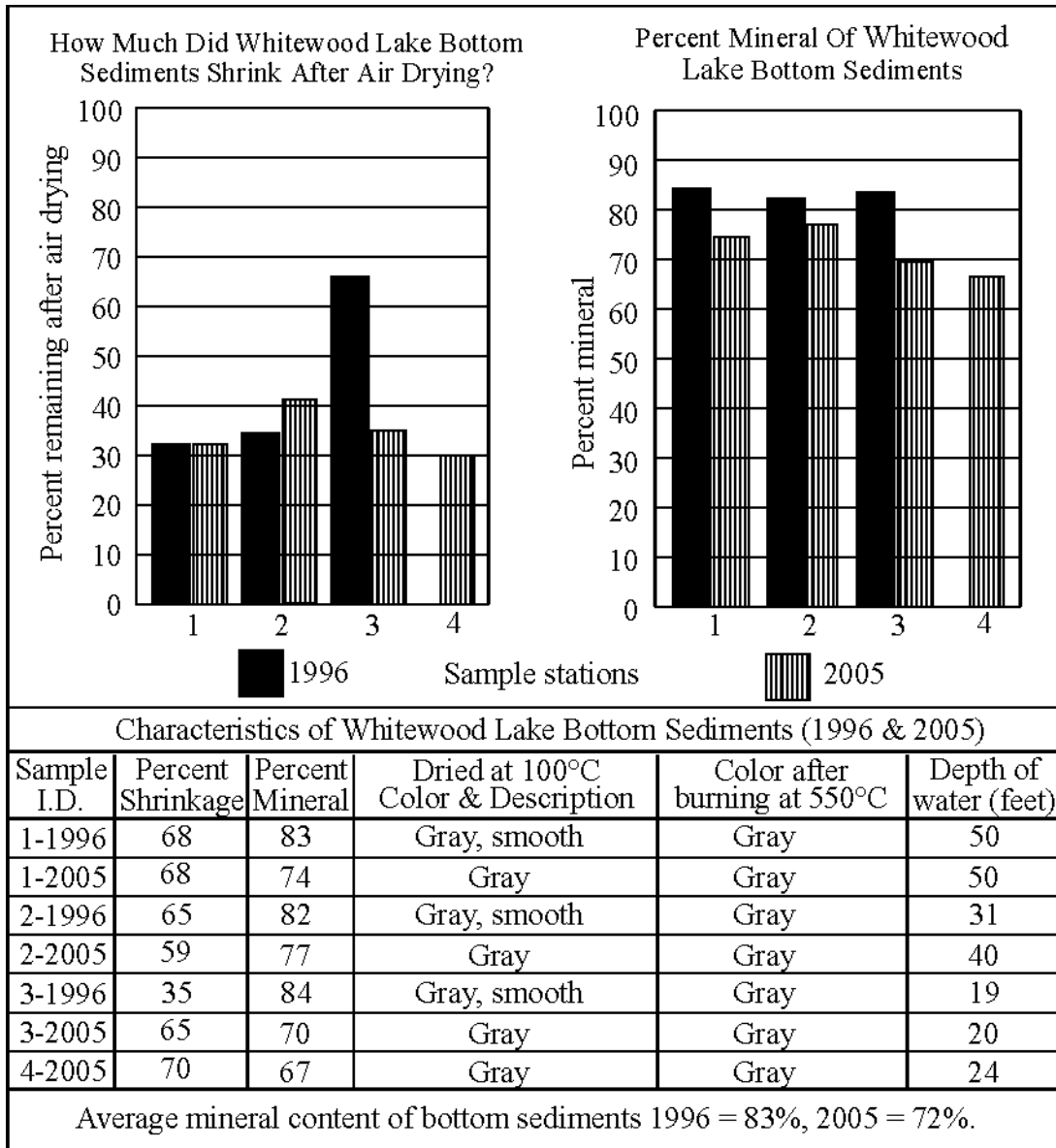
In 1996 the sediment sample from Station 1 collected in 50 feet of water was black when recovered, turned gray and shrunk 68 percent after air drying. It remained gray after burning at 550 degrees C, and was 83 percent mineral.

In 2005 the sediment sample from Station 1 collected in 50 feet of water was black when recovered, turned gray and shrunk 68 percent after air-drying. It remained gray after burning at 550 degrees C, and was 74 percent mineral.

STATION 2

In 1996 the sediment sample from Station 2 collected in 31 feet of water was black when recovered, turned gray and shrunk 65 percent after air-drying. It remained gray after burning at 550 degrees C, and was 82 percent mineral.

In 2005 the sediment sample from Station 2 collected in 40 feet of water was black when recovered, turned gray and shrunk 59 percent after air-drying. It remained gray after burning at 550 degrees C, and was 77 percent mineral.



STATION 3

In 1996 the sediment sample from Station 3 collected in 19 feet of water was black when recovered, turned gray and shrunk 35 percent after air-drying. It remained gray after burning at 550 degrees C, and was 84 percent mineral.

In 2005 the sediment sample from Station 3 collected in 20 feet of water was black when recovered, turned gray and shrunk 65 percent after air-drying. It remained gray after burning at 550 degrees C, and was 70 percent mineral.

STATION 4

A bottom sediment sample was not collected from Station 4 in 1996

In 2005 the sediment sample from Station 4 collected in 24 feet of water was black when recovered, turned gray and shrunk 70 percent after air-drying. It remained gray after burning at 550 degrees C, and was 67 percent mineral.

All of the samples shrunk a normal amount, indicating the bottom sediments of Whitewood Lake are fairly well consolidated, and not easily mixed into the water column by wind and wave, or boat action.

All sediments turned gray after air drying, indicating they are primarily carbonates and bicarbonates. This is not surprising given the high alkalinity of the lake. Carbonates are what Michigan inland lakes are normally filling with.

After burning at 550 degrees C, all sediment samples remained gray. If they had turned red, it would have indicated clay was being washed into the lake from near-shore activities such as home building or road building activities.

The three 1996 bottom sediment samples ranged from 82 to 84 percent mineral, and averaged 83 percent mineral.

The four 2005 bottom sediment samples ranged from 67 to 77 percent mineral, and averaged 72 percent mineral.

These data indicate Whitewood Lake is continuing to accumulate organic material in the bottom sediments at a rate faster than it can decompose it.

Wallace E. Fusilier, Ph.D.
 Consulting Limnologist
 Water Quality Investigators
 Dexter, Michigan
 May 2007

Surface Lake Water Quality Data

Date	Sample Station Number	Temperature °C	Dissolved Oxygen		Chlorophyll a ug/L	Secchi Disk Depth (feet)	Total Nitrate ug/L	Alkalinity mg/L	pH	Conductivity umhos per cm at 25°C	Total Phosphorus ug/L	Lake Water Quality Index	Grade
			(mg/L)	Percent Saturation									
6/9/96	1	21	8.6	96	2.7	9	96	213	8.2	650	16	88	B
6/9/96	2	22	8.4	95	2.7	12	69	208	8.2	650	16	90	A
6/9/96	3	21	8.2	91	3.4	6	101	215	8.2	650	15	87	B
8/7/96	1	27	9.6	120	10.5	6	15	188	8.3	660	19	76	C
8/7/96	2	27	8.7	109	8.5	7	17	192	8.3	660	16	79	C
8/7/96	3	27	9.5	119	14.1	8	13	187	8.3	660	71	68	D
5/12/97	1	13	10.1	95	6.6	6	252	201	8.2	665	15	82	B
5/12/97	2	12	10.2	94	7.9	6	236	197	8.2	670	12	81	B
5/12/97	3	12	10.2	94	7.9	6	247	198	8.2	680	13	79	C
5/12/97	4	13	10.2	96	5.4	6	247	200	8.2	670	12	81	B
8/25/97	1	22	7.2	82	6.3	8	65	186	8.2	680	19	82	B
8/25/97	2	22	7.0	80	5.4	8	79	186	8.2	680	22	82	B
8/25/97	3	21	7.8	87	6.3	7	61	189	8.2	680	20	83	B
8/25/97	4	22	7.5	85	6.0	7	57	189	8.2	680	57	79	C
4/19/98	1	13	10.2	96	4.6	7	149	200	8.3	640	10	84	B
4/19/98	2	13	10.5	99	4.0	8	132	200	8.3	640	10	86	B
4/19/98	3	13	10.4	98	7.2	6	127	204	8.3	640	13	81	B
4/19/98	4	13	10.2	96	6.7	7	127	205	8.3	640	17	82	B
8/10/98	1	26	8.2	100	3.1	9	11	173	8.5	660	15	86	B
8/10/98	2	26	8.2	100	1.9	9	10	175	8.5	650	16	88	B
8/10/98	3	26	8.8	107	3.1	9	11	172	8.5	670	15	86	B
8/10/98	4	26	8.4	102	2.5	9	12	173	8.5	670	14	89	B
4/25/99	1	13	10.6	100	6.2	7	336	190	8.3	720	25	79	C
4/25/99	2	13	10.5	99	5.2	6	309	190	8.3	730	18	80	B
4/25/99	3	13	10.5	99	6.2	6	341	190	8.3	700	21	79	C
4/25/99	4	14	10.5	101	6.7	6	325	190	8.3	700	16	80	B
8/28/99	1	24	7.3	86	1.6	17	29	166	7.9	720	20	92	A
8/28/99	2	24	7.3	86	0.2	21	27	166	7.9	710	14	94	A
8/28/99	3	24	8.1	95	6.9	11	14	165	8.0	705	17	86	B
8/28/99	4	24	7.9	95	1.9	10	11	166	8.0	710	17	90	A
4/15/00	1	11	10.6	95	1.5	10	406	198	8.2	690	42	78	C
4/15/00	2	12	10.8	100	1.8	10	410	195	8.3	690	32	86	B
4/15/00	3	11	10.6	95	1.5	10	396	194	8.3	690	36	79	C
4/15/00	4	11	10.6	95	1.5	10	396	200	8.3	680	29	80	B
8/4/00	1	24	5.6	66	2.6	11	144	180	8.0	660	27	85	B
8/4/00	2	24	5.6	66	1.8	12	151	185	8.1	660	17	88	B
8/4/00	3	24	6.4	75	4.0	11	144	186	8.0	660	19	86	B
8/4/00	4	23	6.4	66	0.8	11	144	186	7.9	660	15	88	B
5/13/01	1	20	8.9	97	1.7	23	142	204	8.2	720	31	92	A
5/13/01	2	20	9.1	99	2.0	23	142	203	8.3	720	20	93	A
5/13/01	3	20	8.8	96	2.7	17	147	205	8.2	720	16	91	A
5/13/01	4	20	8.7	95	2.3	17	125	206	8.2	720	12	92	A
8/3/01	1	28	7.5	95	2.6	16	29	187	7.9	720	18	89	B
8/3/01	2	28	7.8	99	2.3	16	27	184	7.8	720	17	90	A
8/3/01	3	28	7.4	94	3.0	17	43	183	7.8	730	18	89	B
8/3/01	4	28	8.0	101	4.4	17	29	184	7.8	730	17	87	B
4/15/02	1	14	10.3	99	1.2	11	241	203	8.2	710	12	91	A
4/15/02	2	14	10.7	103	2.3	11	273	203	8.3	720	10	89	B
4/15/02	3	14	10.4	100	2.3	10	244	204	8.2	700	11	89	B
4/15/02	4	14	10.5	101	2.1	10	257	204	8.2	695	8	90	A
8/2/02	1	29	8.9	114	8.1	9	66	165	7.5	725	14	80	B
8/2/02	2	29	8.6	110	4.0	8	22	164	7.6	720	14	84	B
8/2/02	3	29	8.2	105	2.5	11	138	157	7.4	730	18	87	B
8/2/02	4	29	7.8	100	1.5	10	102	158	7.4	730	17	88	B
4/28/03	1	15	11.3	110	5.3	8	317	188	8.3	800	16	82	B
4/28/03	2	15	10.8	106	5.6	38	396	185	8.3	780	20	80	B
4/28/03	3	16	10.9	109	5.6	9	305	189	8.3	780	17	85	B
4/28/03	4	15	11.0	108	6.4	9	324	190	8.3	780	20	81	B
8/1/03	1	26	8.7	106	1.6	14	299	167	8.4	760	13	90	A
8/1/03	2	26	8.7	106	1.6	14	294	167	8.4	760	14	90	A
8/1/03	3	26	8.9	109	1.4	15	315	167	8.3	770	8	91	A
8/1/03	4	27	8.6	108	1.3	15	326	167	8.3	770	12	89	B

Lake Water Quality Data

Date	Sample Station Number	Temperature °C	Dissolved Oxygen		Chlorophyll a ug/L	Secchi Disk Depth (feet)	Total Nitrate Nitrogen ug/L	Alkalinity mg/L	pH	Conductivity umhos per cm at 25°C	Total Phosphorus ug/L	Lake Water Quality Index	Grade
			(mg/L)	Percent Saturation									
4/16/04	1	11	10.6	95	3.9	9	381	196	8.2	800	16	83	B
4/16/04	2	11	10.6	95	4.6	9	378	195	8.2	800	17	83	B
4/16/04	3	11	10.5	94	4.2	9	363	195	8.2	770	16	83	B
4/16/04	4	11	10.8	97	4.2	9	375	195	8.3	760	17	82	B
8/2/04	1	24	6.7	79	11.8	10	221	190	8.0	710	18	80	B
8/2/04	2	25	7.1	85	8.4	9	241	190	8.0	710	19	81	B
8/2/04	3	24	6.9	81	3.7	10	139	190	7.9	740	22	85	B
8/2/04	4	24	6.5	77	4.6	11	172	190	8.0	740	19	84	B
4/18/05	1	15	9.4	92	2.3	12	260	205	8.1	730	9	90	A
4/18/05	2	16	9.3	93	1.8	12	269	205	8.1	750	10	90	A
4/18/05	3	16	9.4	94	1.5	13	260	205	8.2	740	8	91	A
4/18/05	4	16	9.3	93	2.0	12	273	202	8.1	760	8	90	A
8/3/05	1	28	8.1	103	2.9	14	168	170	8.1	750	22	87	B
8/3/05	2	28	8.1	103	2.6	14	172	170	8.1	750	17	88	B
8/3/05	3	28	8.0	102	2.6	14	155	170	8.1	750	27	87	B
8/3/05	4	28	8.3	105	4.3	14	172	170	8.1	760	17	86	B
4/19/06	1	14	9.7	93	3.8	10	329	188	8.1	740	17	86	B
4/19/06	2	14	9.7	93	3.6	10	311	190	8.0	740	15	87	B
4/19/06	3	14	9.5	91	3.3	10	293	192	8.0	750	16	87	B
4/19/06	4	14	9.7	93	3.2	10	302	188	8.1	750	18	87	B
8/1/06	1	29	8.1	104	4.6	12	173	192	8.3	750	20	84	B
8/1/06	2	29	8.5	109	2.9	11	158	185	8.4	760	19	87	B
8/1/06	3	29	8.1	104	4.6	10	168	185	8.3	770	22	82	B
8/1/06	4	29	7.9	101	4.5	10	168	185	8.3	780	20	85	B
8/28/99	Patty's	25	7.8	93	1.7	11	68	150	8.1	595	17	92	A
4/15/00	Patty's	14	10.7	103	1.8	10	83	188	8.2	590	51	86	B
8/4/00	Patty's	25	8.1	95	2.9	8	13	185	8.0	550	13	89	B
5/13/01	Patty's	20	9.0	98	2.9	12	33	188	8.2	580	19	91	A
8/3/01	Patty's	28	8.4	106	3.5	8	16	159	8.0	530	17	86	B
4/15/02	Patty's	18	9.5	100	5.0	7	46	186	8.2	570	8	86	B
8/2/02	Patty's	26	8.6	105	2.2	8	47	140	8.4	680	5	89	B
4/28/03	Patty's	18	9.7	102	1.2	9	69	167	8.1	700	16	90	A
8/1/03	Patty's	26	8.6	105	2.7	8	47	140	8.4	680	5	89	B
4/16/04	Patty's	13	10.3	97	4.6	7	26	180	8.2	680	11	85	B
8/2/04	Patty's	27	6.2	78	2.6	7	32	201	8.0	630	23	84	B
4/18/05	Patty's	18	8.8	93	4.1	7	53	202	8.1	620	15	86	B
8/3/05	Patty's	29	7.9	99	3.1	8	31	158	8.1	620	27	84	B
4/19/06	Patty's	16	10.2	102	13.8	8	68	172	8.1	780	15	79	C
8/1/06	Patty's	29	7.8	100	2.4	8	16	178	8.4	570	16	87	B