

# BIRCH LAKE

## PORTER TOWNSHIP

## CASS COUNTY

### 2009 WATER QUALITY STUDY

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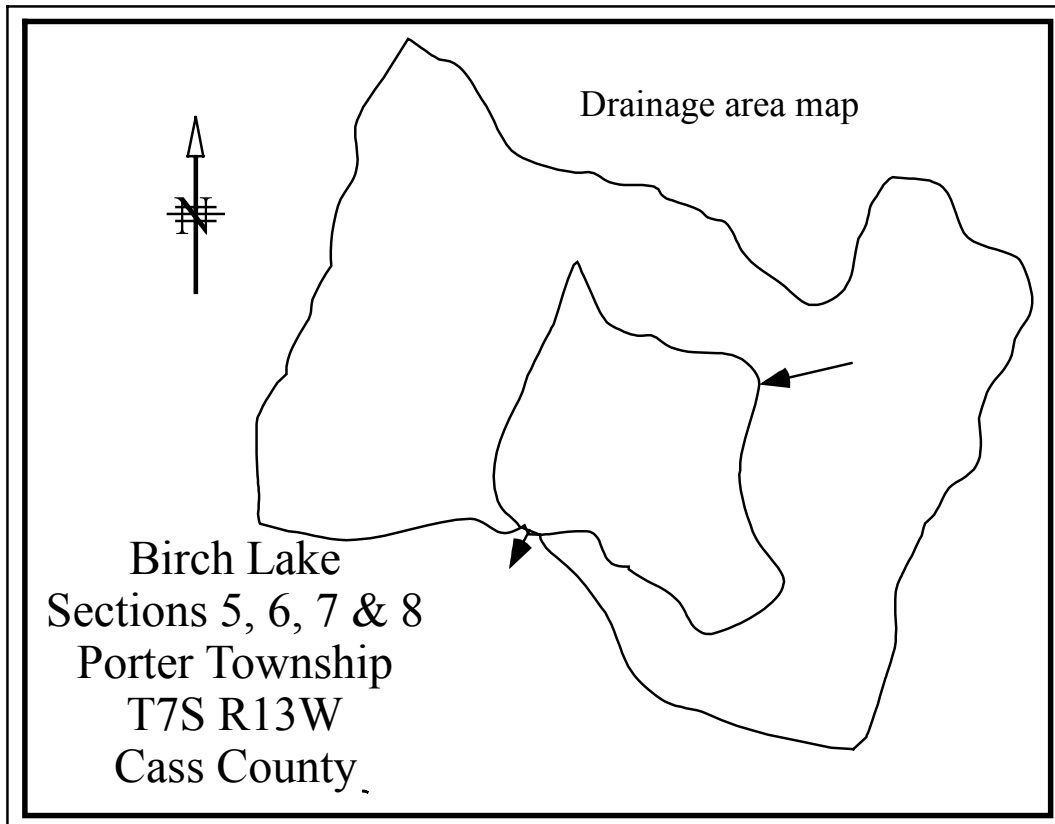
#### **BIRCH LAKE DATA**

Birch Lake is a 295-acre moderately hard water kettle lake located in Sections 5, 6, 7 and 8, Porter Township (T7S R13W), Cass County, Michigan. There are no islands in the lake. The lake has a maximum depth of 95 feet, a mean depth of 41.1 feet and contains 12121 acre feet of water. The lake has 15599 feet of shoreline.

The elevation is 853 feet above sea level. The size of the watershed, which is the area that collects water for the lake, but does not include the lake, is 1968 acres. The drainage area, which includes the lake and the watershed, is 2263 acres (See map below). The watershed to lake ratio is 6.7 to 1, which is on the high side of normal. The lake flushes about once every 5.5 years on an average. Although neither the USGS map or the Cass County soils map shows it, there is an intermittent inlet which flows into the lake on the east side.

The lake is in the St. Joseph River basin. The outlet is on the southwest corner. Water leaving the lake flows into Shavehead Lake. The outlet from Shavehead Lake, Mud Creek, flows from the lake on the south end. It joins the St. Joseph River north of Bristol, Indiana. The St. Joseph River discharges into Lake Michigan at St. Joseph.

The longitude and latitude of the 95-foot deep hole is 85° 51.385W and 41° 52.717N.



## **THE SAMPLE DATES**

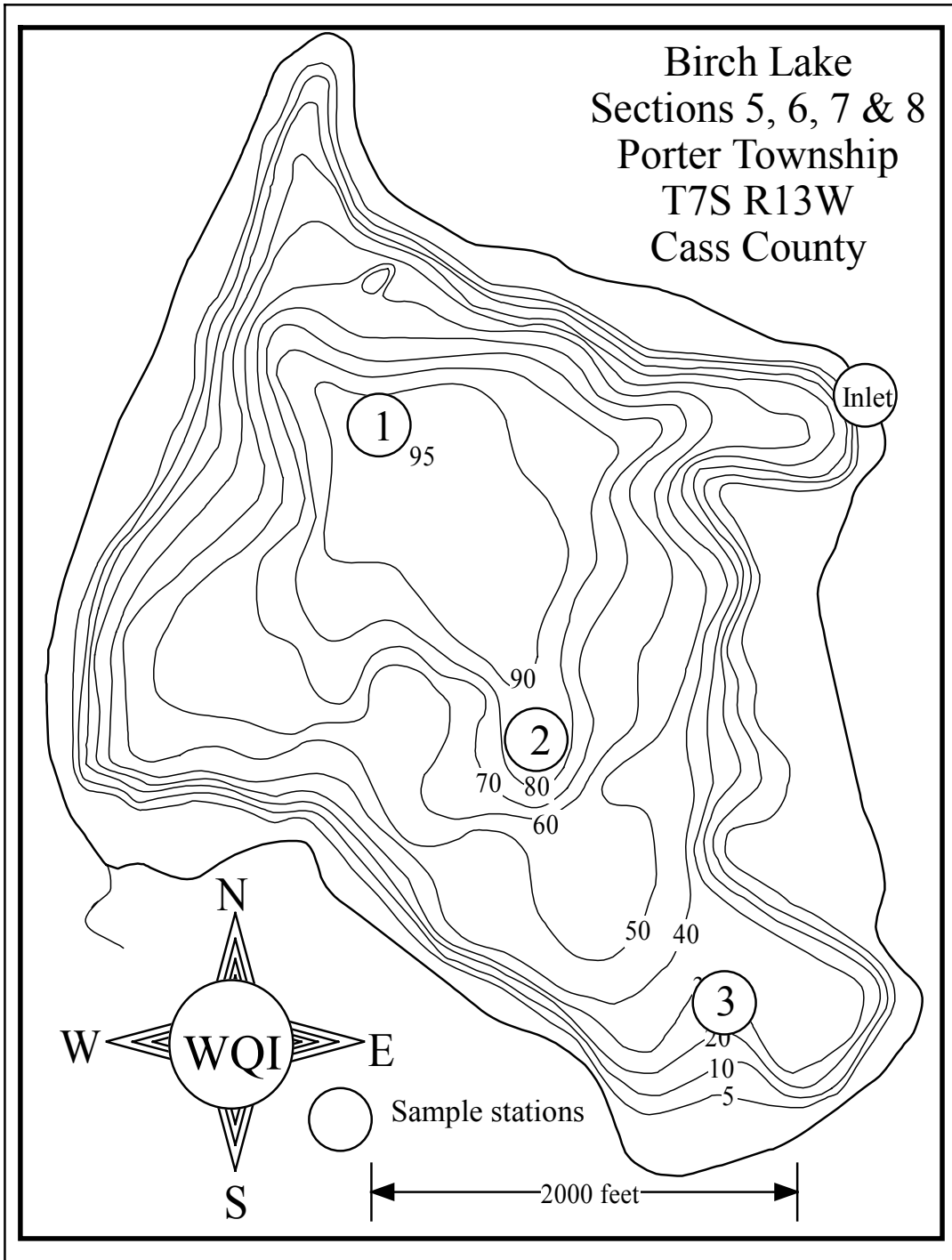
Dr. Terry Dugan collected three spring surface samples plus an inlet sample at the sites shown on the map March 21, 2009

WQI limnologists collected three late summer surface samples August 14, 2009 at the three in-lake sites. Temperature and dissolved oxygen profile data were collected at Station 1, the deepest part of the lake.

## **THE ANALYSES**

The tests performed on the samples included total phosphorus, total nitrate nitrogen, total alkalinity, pH, conductivity, chlorophyll a, Secchi disk depth, and in summer, 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 SAMPLE STATIONS



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

## THE WATER QUALITY STUDY

During certain periods of the year, Michigan lakes have poorer water quality than other parts of the year. The water quality sampling in this study was designed to look at two of those poor water quality periods, early spring soon after the lake mixes, and late summer when the water is warmest, and the lake is stratified. The rest of the year, the water quality is generally better. Thus if the lake gets high marks for water quality during early spring and late summer, it probably has pretty good water quality all year long.

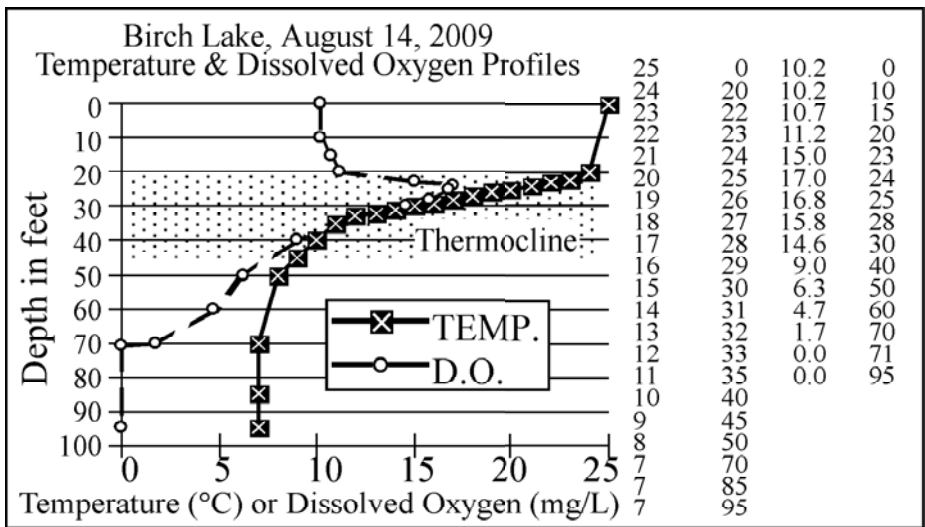
## THE TEST RESULTS

The results of the tests are shown in the text, in the table 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 gases, and biological activity.

Dissolved oxygen is the parameter most often selected by lake water quality scientists as being important. Besides providing oxygen for aquatic organisms, in natural lakes, oxygen is involved in phenomena such as phosphorus precipitation and release from the lake bottom sediments and decomposition of organic material in the lake.



In late summer 2009, the lake formed a 25-foot thick thermocline (defined as a layer of water in a lake where the temperature changes more than one

degree Centigrade per meter of depth, and shown shaded on the graph) from 20 to 45 feet.

Dissolved oxygen was plentiful above the thermocline (the dashed line with circles) and actually increased in the thermocline to a maximum of 17.0 mg/L at 24 feet. These deep dissolved oxygen maximums are usually the result of an algal bloom which settles in the thermocline. We could collect a sample and have the algae identified, but then all you would know would be the name of the algae.

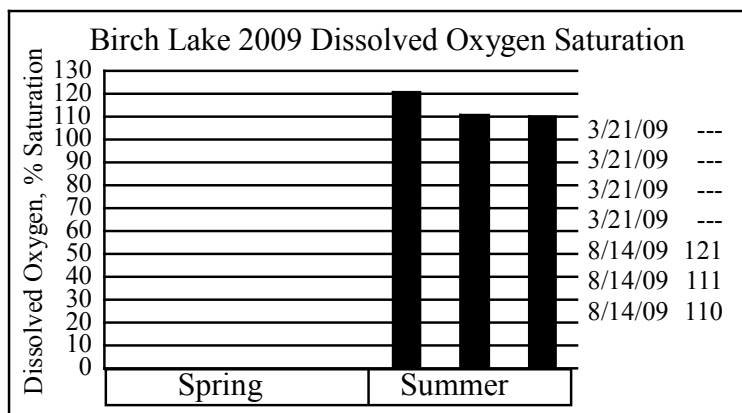
Does the algae indicate a problem? Slightly, in that it is an algal bloom in the lake. But more importantly the algae usually indicate a higher quality lake because the lake is clear enough for light to penetrate deep into the lake and into the thermocline, allowing the algae to grow at those depths.

Below 24 feet, the concentration of dissolved oxygen gradually decreased until it was zero at 71 feet, about 26 feet below the thermocline. That condition remained to the bottom at 95 feet. The hypsographic (depth-area) graph shows about 19 percent of the lake is deeper than 17 feet.

Dissolved oxygen in the deep water under the thermocline in late summer is one of the best indications of a high quality lake I know of. We only see this in about one to two percent of the lakes we study.

## DISSOLVED OXYGEN SATURATION

Since dissolved oxygen concentrations in water vary with temperature, with cold water holding more dissolved oxygen than warm water, dissolved oxygen saturation is often a better way to judge if the amount of oxygen dissolved in the water is adequate. Best is between 90 and 110 percent.



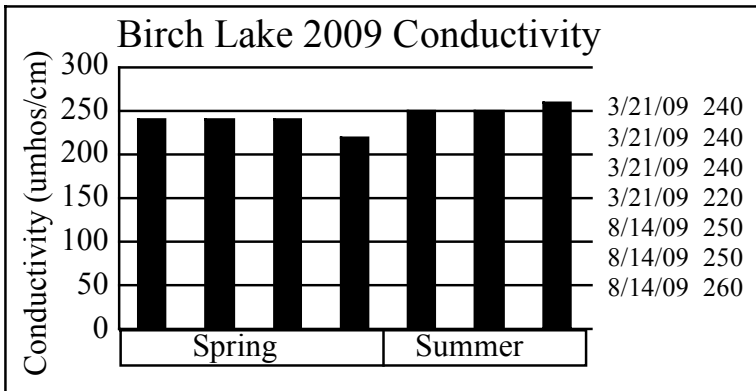
The graph shows the surface dissolved oxygen saturation values when the lake was sampled in late summer ranged from 110 to 121 percent. The chlorophyll a data (below) indicate the

supersaturated conditions were probably the result of an algal bloom. (Spring dissolved oxygen concentrations and temperatures were not measured.)

## 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.



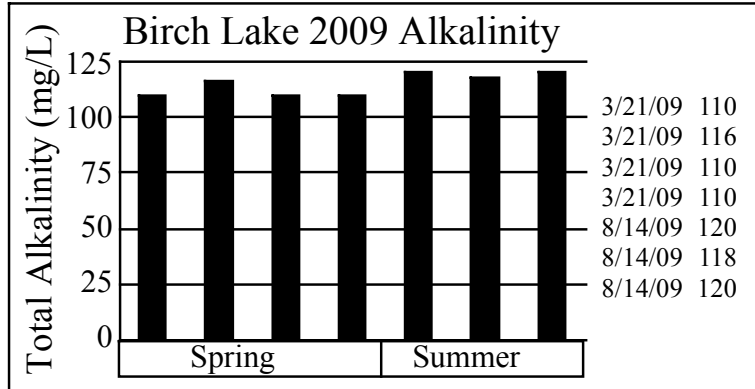
The graph shows 2009 surface conductivities of Birch Lake were 240 micromhos per centimeter in spring and 250-260 umhos/cm in summer. The inlet conductivity was lower, 220 umhos/cm.

These are lower than normal conductivities for a Michigan moderately hard water inland lake, and indicate salts are probably not entering the lake from road salting activities or water softeners. And the inlet does not appear to be causing a problem for the lake in terms of salt. Low lake conductivities are good.

## TOTAL ALKALINITY

Alkalinity is a measure of the ability of the water to absorb acids (or bases) without changing the hydrogen ion concentration (pH). It is, in effect, a chemical sponge. In most Michigan lakes, alkalinity is due to the presence of carbonates and bicarbonates which were introduced into the lake from ground water or streams which flow into the lake. In lower Michigan, acidification of most lakes should not be a problem because of the high alkalinity concentrations.

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 graph shows the alkalinities of Birch Lake ranged from 110 to 120 milligrams per liter in spring and summer. This indicates Birch Lake is a moderately hard water lake.

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. This pretty much ties that phosphorus up in the sediments.

It's a bit unusual for summer alkalinities to be higher than spring alkalinities, because carbonates and bicarbonates precipitate to the bottom in the warmer summer water.

The inlet alkalinity mimics the lake alkalinity. Not a surprise.

## NITRATE NITROGEN

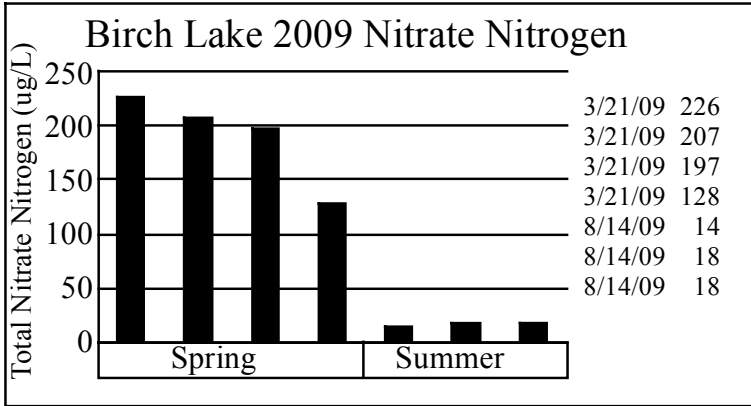
Nitrate, also measured in the parts per billion range, has traditionally been considered by lake scientists to also be a limiting nutrient. The experts felt any concentration below 200 parts per billion was excellent in terms of lake water quality. The highest value found by this author was 48,000 parts per billion in a river which flowed into an Ottawa County lake.

On the other hand, we've studied hundreds of Michigan inland lakes, and many times we find them nitrate limited (very low nitrate nitrogen concentrations), especially in summer.

Many lakes have lower nitrate nitrogen concentrations in summer than in spring. This is probably due to two factors. First, plants and algae growing in lakes as water warms can remove nitrates from the water column. And

second, bacterial denitrification (where nitrates are converted to nitrogen gas by bacteria) also occurs at a much faster rate in summer when the water is warmer.

Generally limnologists feel optimal nitrate nitrogen concentrations (which encourage maximum plant and algal growth) are about 10-20 times higher than phosphorus concentrations. The reason more nitrogen than phosphorus is needed is because nitrogen is one of the chemicals used in the production of plant proteins, while phosphorus is used in the transfer of energy, but is not used to create plant material. If the nitrate concentration is less than 10-20 times the phosphorus concentration, the lake is considered nitrogen limited. If the nitrate concentration is higher than 10-20 times the phosphorus concentration, the lake is considered phosphorus limited.



The graph shows Birch Lake nitrate nitrogen concentrations ranged from 197 to 226 micrograms per liter in spring and from 14 to 18 ug/L in summer. These are normal nitrates for a Michigan inland lake.

However water from this lake drains into Shavehead Lake a short distance south, and Shavehead is a high-nitrate lake, among several in that area. I don't know what happens to the water between the two lakes. I'm fairly sure the high nitrates in Shavehead are not coming from Birch Lake through the stream that connects the two lakes. I suspect it's something that gets into the groundwater between the two lakes, and is probably related to a combination of farming practices and soil types.

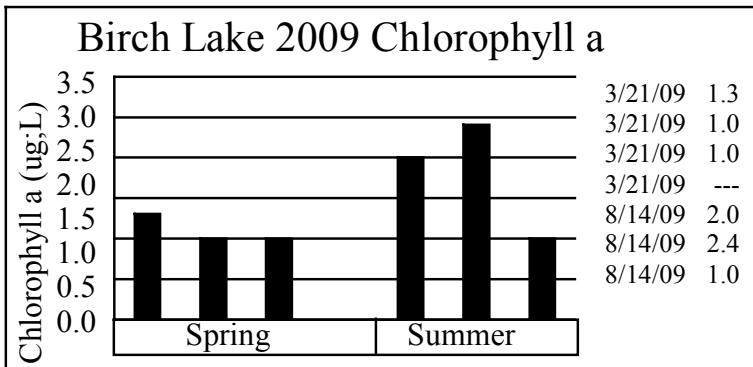
The inlet spring nitrate data do not indicate a nitrate problem from that stream.

These data indicate Birch Lake is probably phosphorus limited in spring and nitrogen limited in summer. It also means no fertilizers should be used on near-lake areas.

## CHLOROPHYLL A

Chlorophyll a is used by lake scientists as a measure of the biological productivity of the water. Generally, the lower the chlorophyll a, the better. High concentrations of chlorophyll a are indicative of an algal bloom in the lake, an indication of poor lake water quality.

The highest surface chlorophyll a concentration found by this writer in a Michigan lake was 216 micrograms per liter. Best is less than one microgram per liter.



The spring surface chlorophyll a concentrations were 1.0 and 1.3 micrograms per liter. In late summer, chlorophyll a concentrations ranged from 1.0 to 2.4 ug/L.

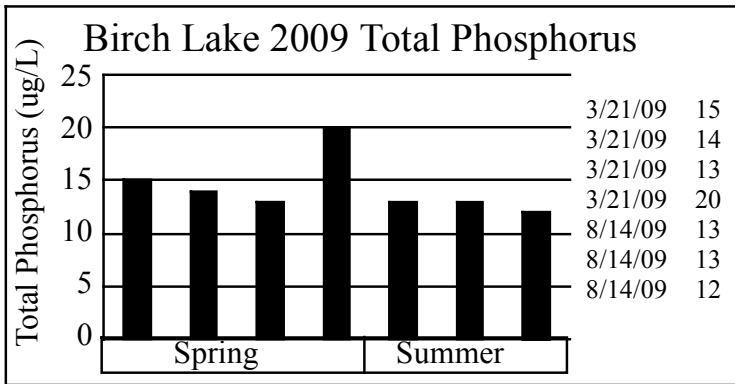
These data indicate Birch Lake had few algae in spring and small algal bloom in summer.

## 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 high by many limnologists.



The graph shows spring phosphorus concentrations ranged from 13 to 15 micrograms per liter, which is better than most lakes.

Summer phosphorus concentrations were

lower, 12 and 13 ug/L. These are also good, although best is less than 10.

The inlet phosphorus was 20 ug/L, which is slightly higher than the lake, but since the flow is small, its contribution to the lake is probably minimal. Plus it's only a single sample. Streams, because conditions constantly change, need to be sampled more often than lakes to arrive at meaningful information.

**pH (Hydrogen ion concentration) (No graph)**

pH has traditionally been a historical water quality test. It measures the amount of acid or base in water. Michigan inland lake pH values usually range from about 7.6 to 8.5. The pH of Birch Lake was 7.4-7.5 in spring and 8.4-8.5 in summer. These are normal pH values for a good quality Michigan inland lake.

It is not uncommon for lakes with algal blooms to have pH values which exceed 9.0. This is because the algae use the carbonates and bicarbonates in the water as a carbon source, which effectively removes them (and their buffering capacity), leaving only hydroxides. The hydroxides cause the pH to increase.

**SECCHI DISK TRANSPARENCY (originally Secchi's disk)**

In 1865, Angelo Secchi, an astronomer for the Pope, 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 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.

## BIRCH LAKE SECCHI DISK DATA

The following table is the Secchi disk data for Birch Lake from 1999 to 2009. It came from the DNR web site. The last line (in bold) is the average for the year.

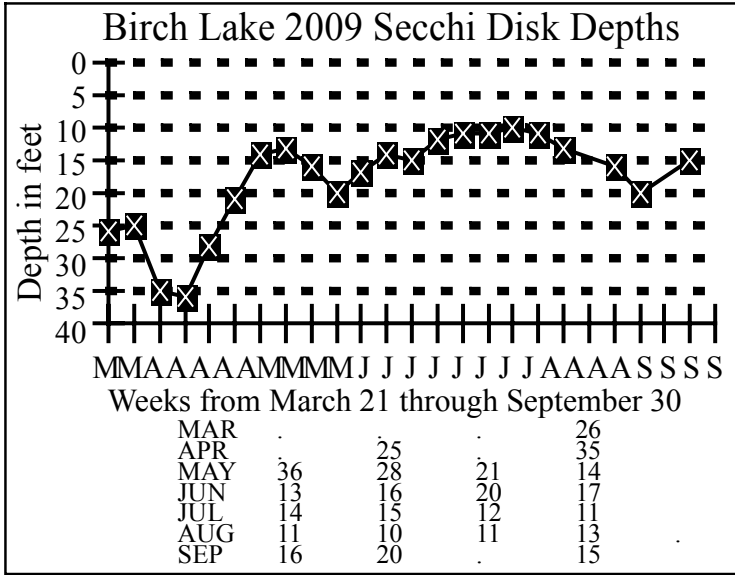
Birch Lake 1999-2009 DNR Secchi Disk Data

1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2009
	19								22		
	15	19							18		26
21.5	17.5	19	31		30	35			20		25
26.5	17	19	25		43	21		39	17		35
30	22	18	31	33	32	29		30	19		36
29	24	29	29	30	30	32		31	15		28
15.5	23.5	24	25	32	27	31	35	29	13.5	34	31
15.5	15.5	29	25	32	26	25	33	20	15	32	14
15.5	19	20	27	29	25	30	26	22	14	29	13
13	22	17	17	26	15	26	21	21	12	20	16
11	20	17	29	15	15	14	15	14	10	15	20
11	18	17	15	15	12	16	13	14	12	14	17
12	22	15	15	14	14	13	14	15	10	14	14
11	19.5	12	15	14	14	14	12	14	12	17	15
13	19.5	15	19	13	12	13	12	13	11	14	12
13	18.5	17	15	12	14	18	14	15	10	13	11
14	15.5	17	14	12	13	14	14	14	9	15	11
14	18.5	15	17	10	14	14	15	16	9	12	10
13	17	25.5	14	12	12	15	17	19	8	11	11
11	14	19	15	12	12	20	20	20	9	10	13
12	15.5	26	16	12	12	21	22	22	10	9	16
11	13.0	26	17	12	12	20	20	20	11.0	8	20
14	17.5	25.0	21	12	14	22	24	25	11.0	9	15
<b>15.5</b>	<b>18.4</b>	<b>20.0</b>	<b>20.6</b>	<b>18.3</b>	<b>19.0</b>	<b>21.1</b>	<b>19.2</b>	<b>20.7</b>	<b>12.9</b>	<b>16.2</b>	<b>18.6</b>

## 2009

In 2009 Dr. Terry Dugan did an excellent job taking Secchi disk readings through the warm months on a regular basis, beginning March 21<sup>st</sup>. The graph shows his data.

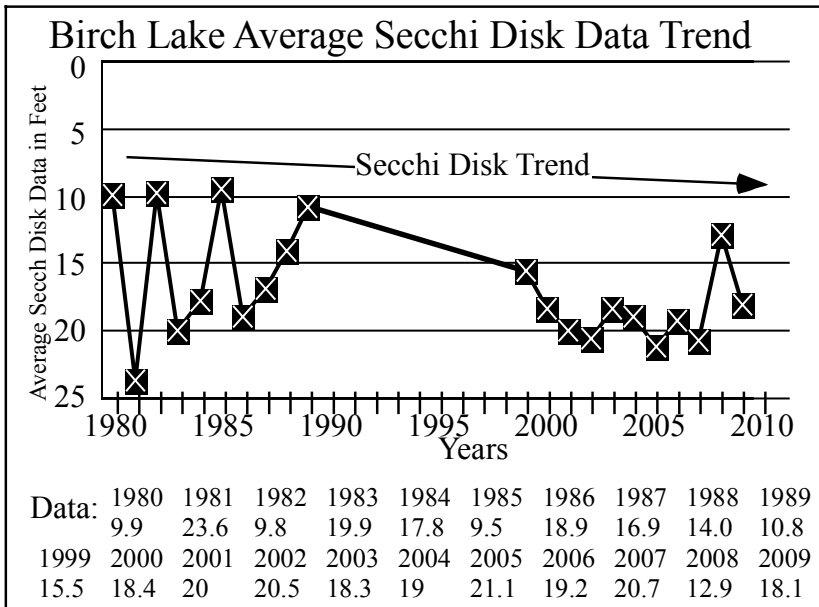
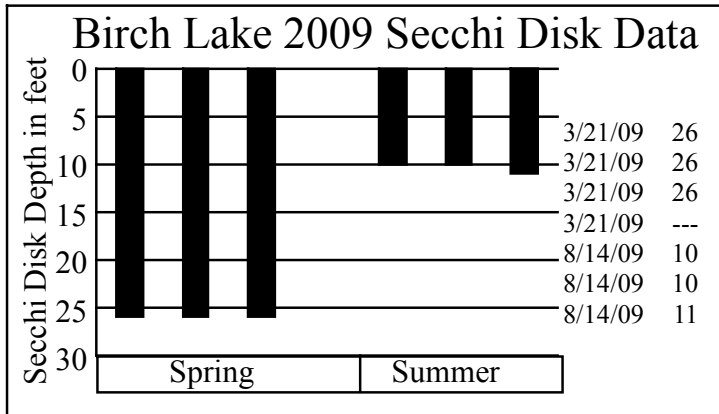
It shows early spring readings were 25 and 26 feet, increasing to 35 and 36 feet the end of April and the first part of May. Then as the water warmed, the clarity of the lake decreased to 10 to 11 feet in July and early August.



Secchi disk readings should be taken on a regular basis through the warm months every year.

### SECCHI DISK DATA COLLECTED WITH THE WATER SAMPLES

The graph shows the Secchi disk readings collected with the spring and summer water samples. The graph shows in spring the clarity of the water was 26 feet, which coincides with the low spring chlorophylls. In summer the water clarity was 10 and 11 feet, which again corresponds to the slightly higher summer chlorophylls.



### THE SECCHI DISK TREND GRAPH

Since Birch Lake residents have been collecting Secchi disk data since 1980 (with data missing from 1990 through 1998) we were able to construct a Secchi disk Trend Graph.

The Secchi Disk

Trend graph is interesting, especially the 1980 to 1989 data in that just about every other year there is a dramatic difference in the average Secchi disk readings, from 9.9 feet in 1980 to 23.6 feet in 1981 to 9.8 feet in 1982 to 19.9 feet in 1983 and so on. That's unusual and not easily explainable. A similar occurrence of that is found in the 2007-2008-2009 data as well.

## **THE LAKE WATER QUALITY INDEX**

The Lake Water Quality Index used in this study to define the water quality of Birch 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 invoked the use of 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 which 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 LQWI of 100. The lowest LWQI seen by this author was 16 in an Ottawa County lake.

## **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).

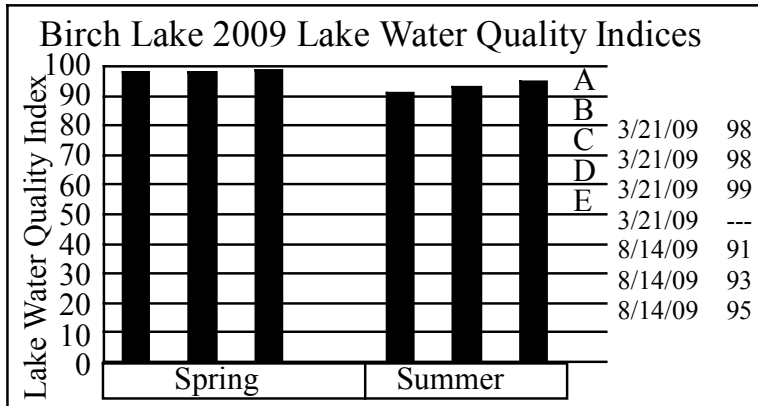
The calculation sheet permits calculation of the Lake Water Quality Index, using the results of all nine lake water quality tests.

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 LAKE WATER QUALITY INDICES FOR BIRCH LAKE



The graph shows the 2009 spring and summer Lake Water Quality Indices for Birch Lake.

In spring 2009 the Lake Water Quality Indices for Birch Lake were 98 or 99 at the three

stations, or in the A range.

In summer 2009 the LWQIs ranged from 91 to 95, again in the A range.

## THE LAKE WATER QUALITY INDEX CALCULATION SHEETS

Because the spring 2009 LWQIs from the three surface stations were similar (98 98 99) and the summer 2009 LWQIs from the three surface stations were also similar (91 93 95) only two LWQI calculation sheets are included in this report, one for the three spring 2009 surface samples, using averaged data, and a second for the three late summer 2009 surface samples, again using averaged data.

In the report marked MASTER, all six of the LWQI calculation sheets are included. That is the only difference between the MASTER and the other the reports.

## BIRCH LAKE BOTTOM SEDIMENTS

Bottom sediment samples were not collected in Birch Lake.

Wallace E. Fusilier  
 Consulting Limnologist  
 Water Quality Investigators  
 Dexter, Michigan  
 January 2010

Birch 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									
3/21/09	1	---	---	---	1.3	26	226	110	7.5	240	15	98	A
3/21/09	2	---	---	---	1.0	26	207	116	7.5	240	14	98	A
3/21/09	3	---	---	---	1.0	26	197	110	7.4	240	13	99	A
3/21/09	4	---	---	---	---	---	128	110	7.5	220	20	---	---
8/14/09	1	25	10.2	121	2.0	10	14	120	8.5	250	13	91	A
8/14/09	2	25	9.4	111	2.4	10	18	118	8.5	250	13	93	A
8/14/09	3	25	9.3	110	1.0	11	18	120	8.4	260	12	95	A