TEE LAKE

GREENWOOD TOWNSHIP

OSCODA COUNTY

1992-2010 WATER QUALITY STUDIES

TEE LAKE DATA

Tee Lake, called T Lake in the past, is a 229-acre natural soft to moderately hard-water kettle lake located in Sections 2, 3. 10 and 11, Greenwood Township (T28N R1E), Oscoda County, Michigan. There are three islands in the lake totaling 6 acres, hence the surface area is 223 acres. Tee Lake is V-shaped, and consists of a northwestern 70-foot-deep 157-acre basin and a southern 20-foot deep 72-acre basin. The lake has a water volume of 3717 acre-feet, and a mean depth of 16.7 feet.

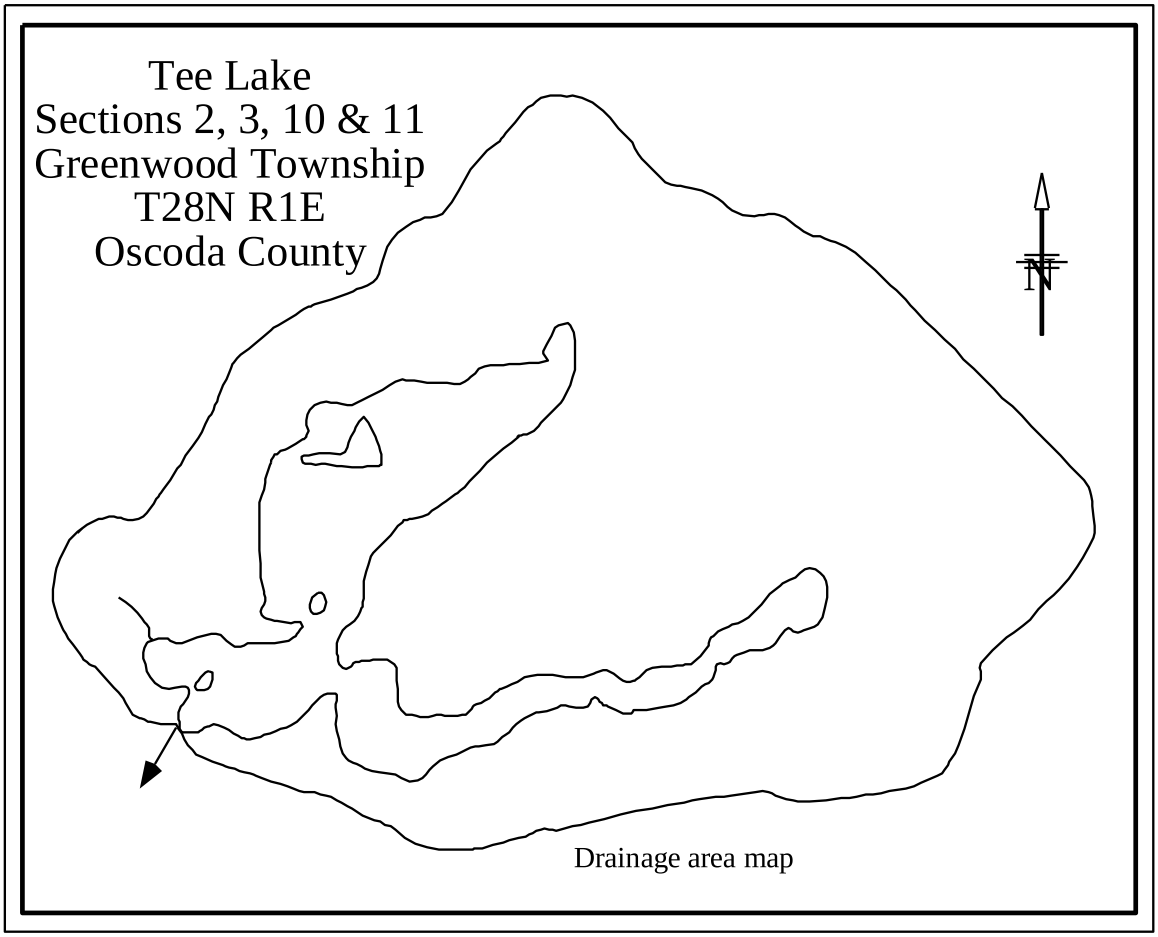
Tee Lake has 32311 feet of shoreline, not including the shorelines of the islands. The elevation of the lake is 1213 feet above sea level.

The size of the watershed, which is the land area that contributes water to the lake, but does not include the lake, is 1051 acres. The drainage area, which includes the lake and the watershed, is 1274 acres. (See map below.) The watershed to lake ratio is 4.71 to 1, which is normal for a Michigan inland lake. The lake flushes about once every 2.8 years, on an average.

There are no inlets.

Water leaves the lake through the outlet on the southwest corner and flows into the East Branch of Big Creek, which flows into the North Branch of the AuSable River, then the AuSable River. The AuSable River discharges into Lake Huron at Oscoda.

The longitude and latitude of the 70-foot deep hole at is 84° 17.333W and 44° 50.743N.



THE SAMPLE DATES

In spring three surface samples for water quality testing were collected by Tee Lake residents June 10, 1992, May 18, 1993, May 3, 1994, April 25, 2001, May 30, 2002, June 2, 2003, June 15, 2004, May 5, 2006, May 13, 2007, May 17, 2009 and May 31, 2010 at the stations shown on the map below.

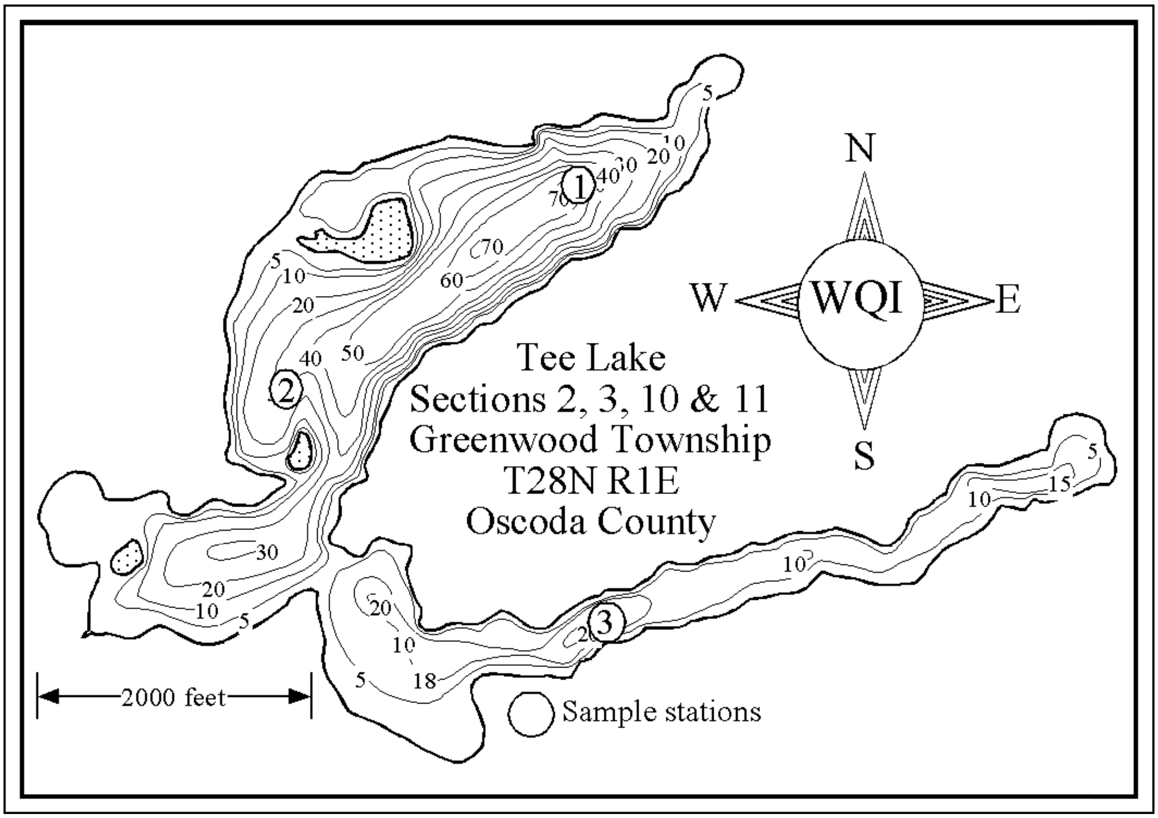
In late summer WQI limnologists collected three surface samples for water quality testing plus Secchi disk readings at the sites shown on the map October 5, 1992, August 31, 1993, August 28, 1994, August 25, 1995, August 14, 2001, August 15, 2002, August 29, 2003, August 25, 2004, August 24, 2005, August 9, 2006, August 27, 2007, August 24, 2009 and August 23, 2010. Top to bottom temperature and dissolved oxygen profile data were collected at Station 1 (the 70-foot deep hole) each time the lake was sampled in late summer.

Tee Lake residents collected two fall samples October 21, 2005.

Bottom sediment samples were collected at the three in-lake sites in late summer 2004.

THE SAMPLE STATIONS

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

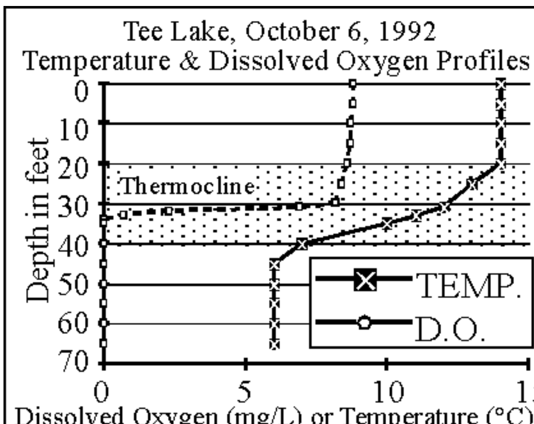
The results of the tests are found in the text, in the table at the end of this report, and on the enclosed atlas pages.

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 gasses and biological activity. In spring temperature (and dissolved oxygen) generally don't need to be measured because 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 its importance in providing oxygen for aquatic organisms, in natural lakes oxygen is involved the capture and release of various chemicals, such as iron and phosphorus.

In late summer, temperature and dissolved oxygen were measured top to bottom at Station 1, the 70-foor deep hole. The graphs show those data.

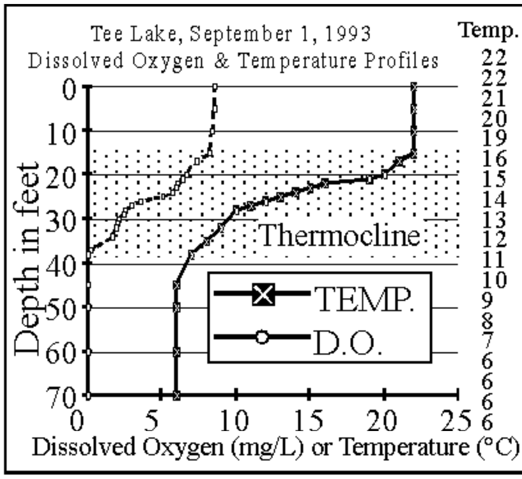


Temp.	Depth	D.O.
0	14	8.8
5	14	8.8
10	14	8.7
15	14	8.7
20	14	8.6
25	13	8.4
30	13	8.2
31	12	6.9
32	11	2.3
33	11	0.7
34	11	0
35	10	0
40	7	0
45	6	0
65	6	0

1992

In late summer 1992 the lake was sampled in early October, so it had started to cool. Even so, the lake had a 20-foot-thick thermocline (where the temperature changes more than one degree C per meter of depth and is shown shaded on the graphs) from 20 to 40 feet. The lake started to run out of dissolved oxygen in the middle of the thermocline, and at 34 feet it was zero. That condition remained to the bottom.

The hypsographic (depth-area) graph shows about 16 percent of the lake is deeper than 34 feet.

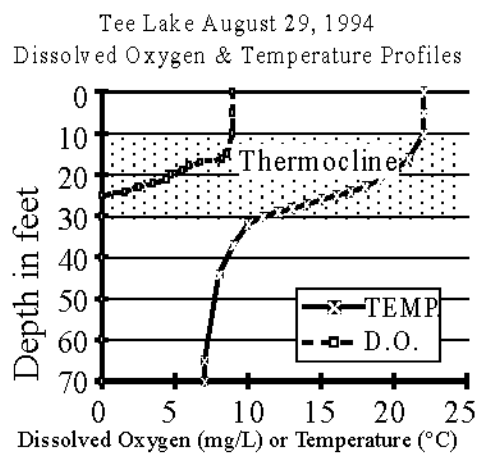


Temp.	Depth	D.O.	Depth
22	0	8.6	0
22	10	8.4	10
21	17	7.4	17
20	20	6.7	20
19	21	6.4	21
16	22	6.1	22
15	23	6.0	23
14	24	5.7	24
13	25	5.1	25
12	26	3.6	26
11	27	3.0	27
10	28	2.6	28
9	32	2.4	29
8	35	2.1	30
7	38	2.0	31
6	45	1.9	32
6	50	1.7	34
6	60	0.2	37
6	70	0	38
		0	50
		0	70

1993

In late summer 1993 the lake was again stratified, and formed a 23-foot-thick thermocline from 15 to 38 feet. The lake ran out of dissolved oxygen at the bottom of the thermocline (38 feet), and that condition again remained to the bottom.

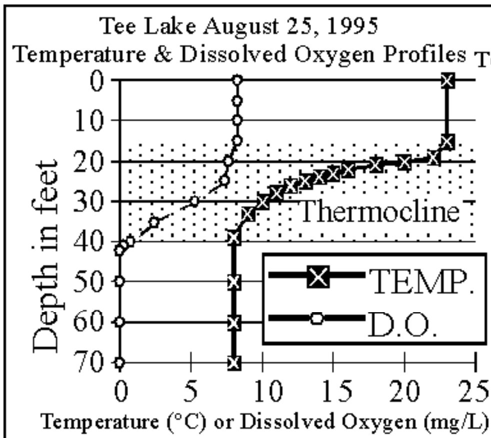
About 12 percent of the lake is deeper than 38 feet.



Temp.	Depth	D.O.	Depth
22	0	8.9	0
22	5	8.9	5
22	10	8.9	10
21	16	8.5	15
20	19	8.2	16
19	21	6.7	17
18	23	5.9	18
17	24	5.5	19
16	25	4.7	20
15	26	4.4	21
14	27	3.5	22
13	28	2.5	23
12	29	1.5	24
11	30	0	25
10	32	0	30
9	37	0	40
8	44	0	50
7	65	0	60
7	70	0	70

1994

In late summer 1994 the lake was stratified, and formed a 22-foot-thick thermocline from 10 to 32 feet.



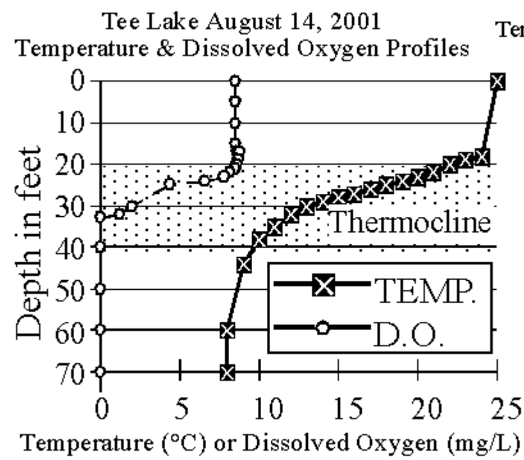
Temp.	Depth	D.O.	Depth
23	0	8.3	0
23	15	8.3	5
22	19	8.3	10
20	20	8.3	15
18	21	7.7	20
16	22	7.4	25
15	23	5.3	30
14	24	2.5	35
13	25	0.8	40
12	26	0.3	41
11	28	0.0	42
10	30	0.0	50
9	33	0.0	60
8	39	0.0	70
8	70		

Dissolved oxygen was plentiful above the thermocline. The lake ran out of dissolved oxygen at 25 feet, and again that condition remained to the bottom.

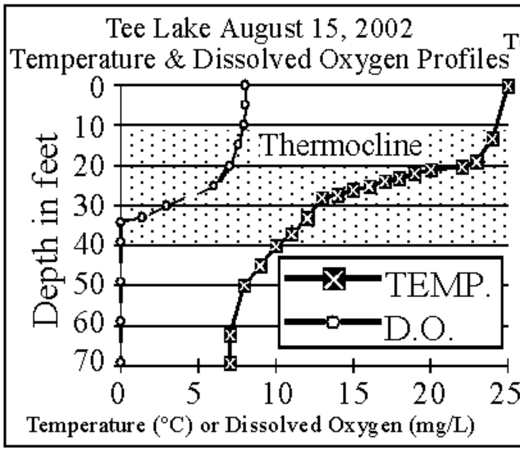
About 22 percent of the lake is deeper than 25 feet.

1995

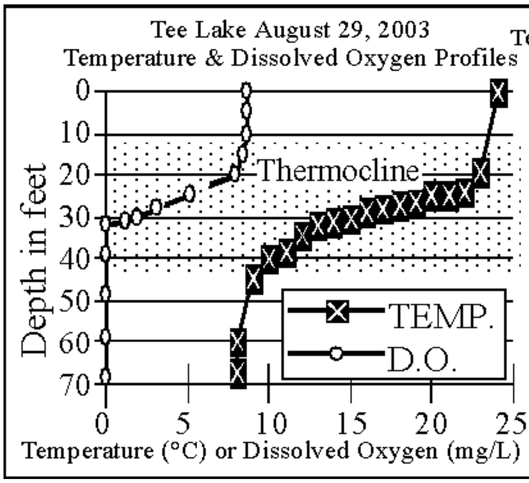
In late summer 1995 the lake formed an 18-foot thick thermocline from 15 to 33 feet. Dissolved oxygen was plentiful above the thermocline. The lake ran out of dissolved oxygen at 42 feet, and that condition remained to the bottom. About 9 percent of the lake is deeper than 42 feet.



Temp.	Depth	D.O.	Depth
25	0	8.5	0
24	18	8.5	5
23	19	8.5	10
22	20	8.5	15
21	22	8.6	17
20	23	8.8	17
19	24	8.7	19
18	25	8.6	20
17	26	8.5	21
16	27	8.2	22
15	28	7.8	23
14	29	6.6	24
13	30	4.4	25
12	32	2.0	30
11	35	1.2	32
10	38	0.0	33
9	44	0.0	40
8	60	0.0	50
8	70	0.0	70



Temp.	Depth	D.O.	Depth
25	0	8.1	0
24	13	8.1	5
23	19	8.0	10
22	20	7.6	15
20	21	7.0	20
19	22	6.0	25
18	23	3.0	30
17	24	1.4	33
16	25	0.0	34
15	26	0.0	39
14	27	0.0	49
13	28	0.0	59
12	33	0.0	69
11	37		
10	40		
9	45		
8	50		
7	62		
7	69		



Temp.	Depth	D.O.	Depth
24	0	8.6	0
23	19	8.6	5
22	24	8.6	10
21	25	8.4	15
20	25	7.9	20
19	26	5.2	25
18	27	3.1	28
17	28	1.9	30
16	29	1.2	31
15	30	0.0	32
14	31	0.0	39
13	32	0.0	49
12	34	0.0	59
11	38	0.0	69
10	40	0.0	79
9	45		
8	60		
8	70		

2001

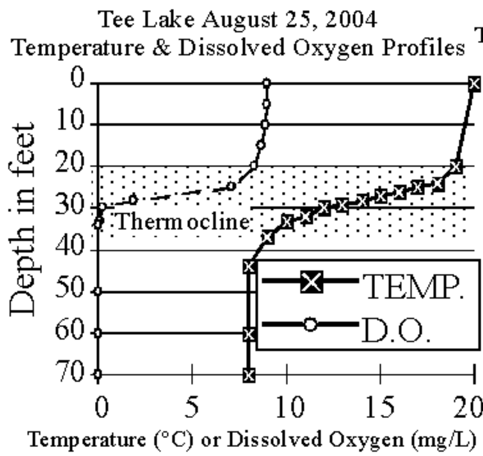
In late summer 2001 the lake was stratified, and formed an 18-foot-thick thermocline from 20 to 38 feet. The lake ran out of dissolved oxygen at 33 feet, and that condition remained to the bottom. About 15 percent of the lake is deeper than 33 feet.

2002

In late summer 2002 the lake was stratified and formed a 21-foot-thick thermocline from 19 to 40 feet. The lake ran out of dissolved oxygen at 34 feet, and that condition remained to the bottom. About 14 percent of the lake is deeper than 34 feet.

2003

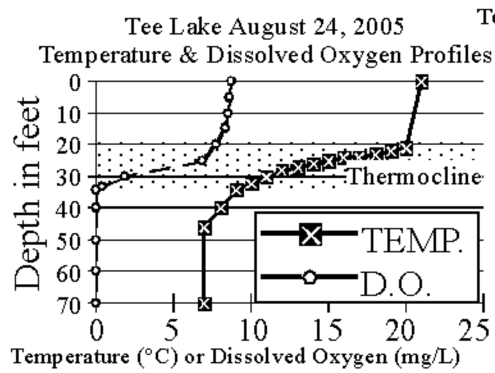
In late summer 2003 the lake was stratified, and formed a 14-foot-thick thermocline from 20 to 34 feet. The lake ran out of dissolved oxygen at 32 feet, and that condition remained to the bottom. About 16 percent of the lake is deeper than 32 feet.



Temp.	Depth	D.O.	Depth
20	0	9.0	0
19	20	9.0	5
18	24	8.9	10
17	25	8.7	15
16	26	8.3	20
15	27	7.1	25
14	28	1.9	28
13	29	0.2	30
12	30	0.1	33
11	32	0.0	34
10	33	0.0	50
9	37	0.0	60
8	44	0.0	70
8	60		
8	70		

2004

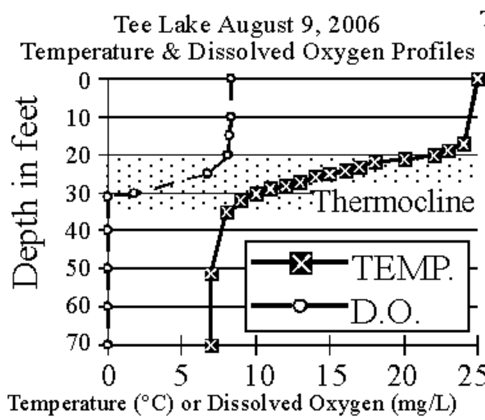
In late summer 2004 the lake was stratified, and formed a 13-foot-thick thermocline from 20 to 33 feet. The lake ran out of dissolved oxygen at 34 feet, and that condition remained to the bottom. About 16 percent of the lake is deeper than 34 feet.



Temp.	Depth	D.O.	Depth
21	0	8.7	0
20	21	8.6	5
19	22	8.5	10
18	23	8.3	15
17	24	7.7	20
15	25	6.9	25
14	26	1.9	30
13	27	0.4	33
12	28	0.0	34
11	30	0.0	40
10	32	0.0	50
9	34	0.0	60
8	40	0.0	70
7	46		
7	70		

2005

In late summer 2005 the lake was stratified, and formed a 14-foot-thick thermocline from 20 to 34 feet. Dissolved oxygen was plentiful above the thermocline. The lake ran out of dissolved oxygen at 34 feet, and that condition remained to the bottom.



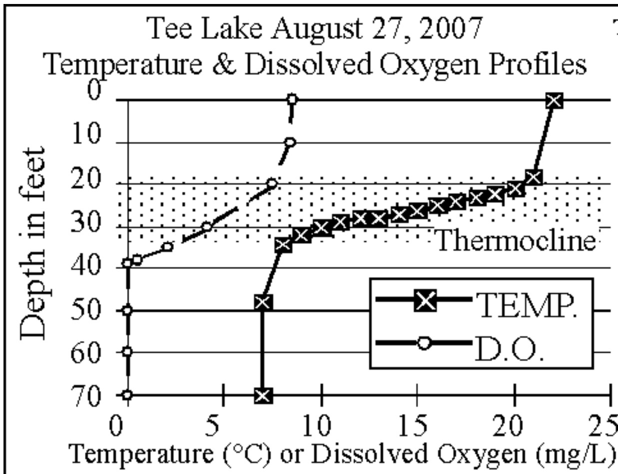
Temp.	Depth	D.O.	Depth
25	0	8.3	0
24	17	8.3	10
23	19	8.2	15
22	20	8.1	20
20	21	6.8	25
18	22	1.8	30
17	23	0.0	31
16	24	0.0	40
15	25	0.0	50
14	26	0.0	60
13	27	0.0	70
12	28		
11	29		
10	30		
9	32		
8	35		
7	51		
7	70		

2006

In late summer 2006 the lake formed a 15-foot thick thermocline from 20 to 35 feet. Dissolved oxygen concentrations were plentiful above the thermocline and started to decrease at the top of the thermocline. They were zero at 31 feet and that condition remained to the bottom. About 17 percent of the lake is deeper than 31 feet.

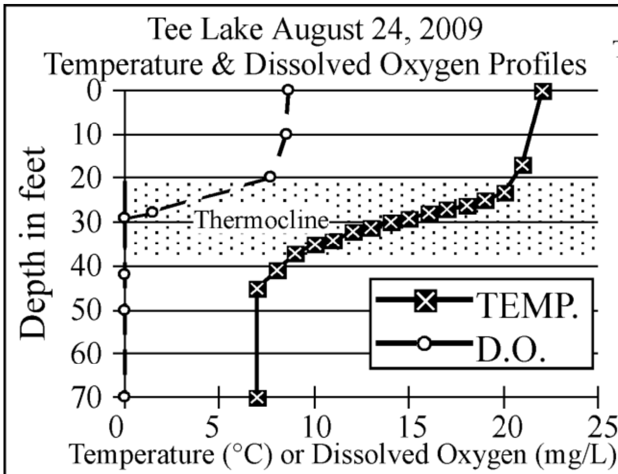
2007

In late summer 2007 Tee Lake formed a 15-foot thick thermocline from 19 to 34 feet. Dissolved oxygen was plentiful above the thermocline and started to decrease below 10 feet. It was zero at 39 feet, and that condition remained to the bottom. About 12 percent of the lake is deeper than 39 feet.



Temp.	Depth	D.O.	Depth
22	0	8.5	0
21	18	8.4	10
20	21	7.5	20
19	22	4.1	30
18	23	2.1	35
17	24	0.5	38
16	25	0.0	39
15	26	0.0	50
14	27	0.0	60
13	28	0.0	70
12	28		
11	29		
10	30		
9	32		
8	34		
7	48		
7	70		

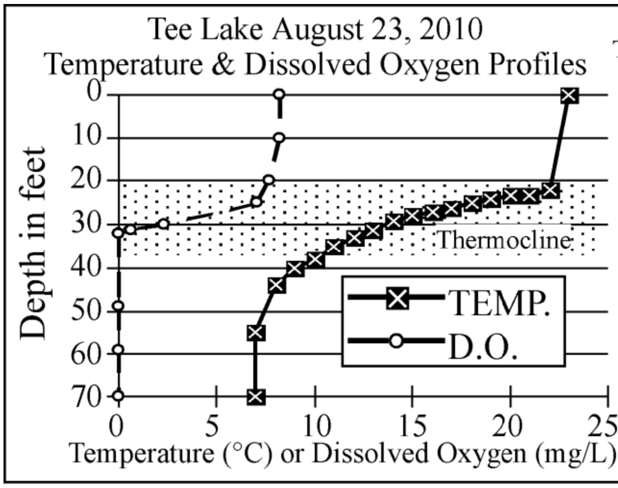
2009



Temp.	Depth	D.O.	Depth
22	0	8.6	0
21	17	8.5	10
20	23	7.7	20
19	25	1.5	28
18	26	0.0	29
17	27	0.0	41
16	28	0.0	50
15	29	0.0	70
14	30		
13	31		
12	32		
11	34		
10	35		
9	37		
8	41		
7	45		
7	70		

In late summer 2009 the lake formed a 17-foot thick thermocline from 20 to 37 feet. Dissolved oxygen was adequate to support fish life above 20 feet, and started to drop below that depth. It was zero at 29 feet and that condition remained to the bottom. About 20 percent of the lake is deeper than 29 feet.

2010



Temp.	Depth	D.O.	Depth
23	0	8.2	0
22	22	8.2	10
20	23	7.7	20
19	24	7.1	25
18	25	2.3	30
17	26	0.6	31
16	27	0.0	32
15	28	0.0	49
14	29	0.0	59
13	31	0.0	70
12	33		
11	35		
10	38		
9	40		
8	44		
7	55		
7	70		

In late summer 2010 the lake formed a 15-foot thick thermocline from 20 to 35 feet. Dissolved oxygen supplies were adequate above the thermocline and started to decrease below 20 feet, the top of the thermocline. They were zero at 32 feet, and that condition remained to the bottom.

A NOTE ABOUT THE FOLLOWING GRAPHS

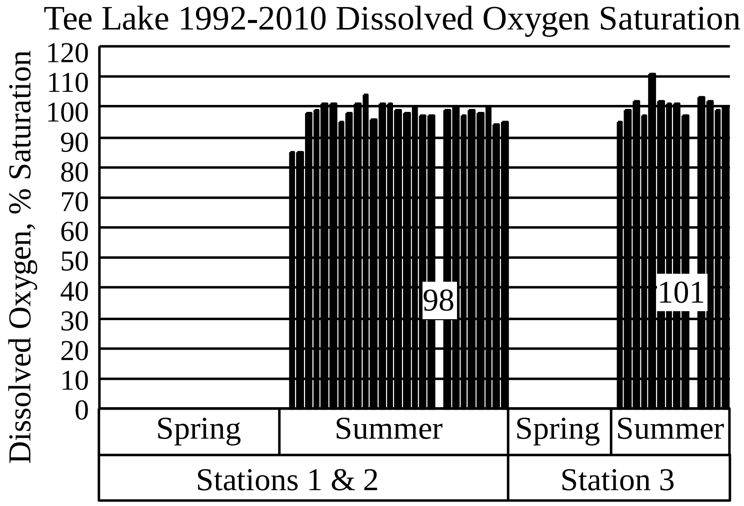
The graphs below were first sorted by sample station then by spring and summer, then by date and show Stations 1 and 2 data together and Station 3 data separately.   The purpose of this is to see if there are difference between the deep arm of the lake and the shallow arm and if there are differences between the spring and summer data in each arm. Averages for each data set are shown on the bars.

LATE SUMMER SURFACE DISSOLVED OXYGEN SATURATION

Since the amount of dissolved oxygen a water can hold varies with temperature, with cold water holding more than warm water, dissolved oxygen saturation is often a better method to use to determine if dissolved oxygen supplies are adequate.

The graph shows most of the time late summer surface dissolved oxygen concentrations were near 100 percent, which is good.

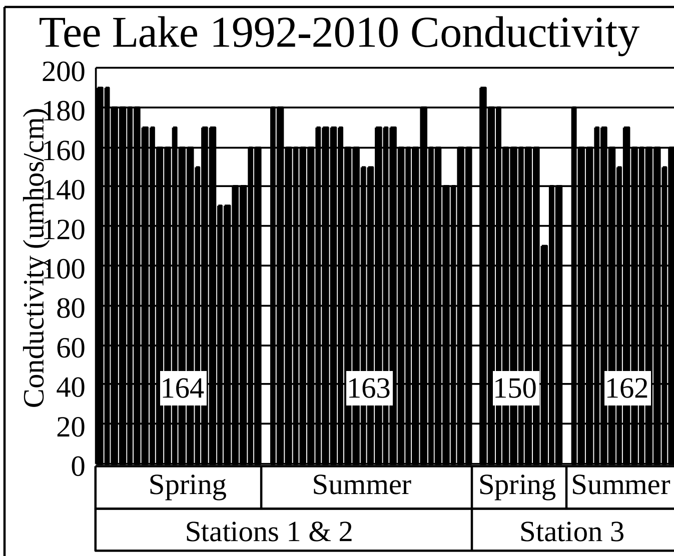
The saturation values of dissolved oxygen at Stations 1 and 2 range from 85 to 104 percent and average 98 percent. The saturation values of dissolved oxygen at Station 3 range from 95 to 111 percent and average 99 percent. Statistically, the difference is not significant. These are good values.



Stations 1&2		8/9/06	99
Spring		8/9/06	100
10/5/92	85	8/27/07	97
10/5/92	85	8/27/07	99
8/31/93	98	8/24/09	98
8/31/93	99	8/24/09	100
8/28/94	101	8/23/10	94
8/28/94	101	8/23/10	95
8/25/95	95	Summer Sta 3	
8/25/95	98	10/5/92	95
8/14/01	101	8/31/93	99
8/14/01	104	8/28/94	102
8/15/02	96	8/25/95	97
8/15/02	101	8/14/01	111
8/29/03	101	8/15/02	102
8/29/03	99	8/29/03	101
8/25/04	98	8/25/04	101
8/25/04	100	8/24/05	97
8/24/05	97	10/21/05	---
8/24/05	97	8/9/06	103
10/21/05	---	8/27/07	102
8/9/06	99	8/24/09	99
8/9/06	100	8/23/10	100

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, since only dissolved materials (salts) 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.



Stations 1&2		8/31/93	160	Spring Sta. 3	
Spring		8/31/93	160	6/10/92	190
6/10/92	190	8/28/94	160	5/18/93	180
6/10/92	190	8/28/94	160	5/3/94	180
5/18/93	180	8/25/95	170	4/25/01	160
5/18/93	180	8/25/95	170	5/30/02	160
5/3/94	180	8/14/01	170	6/2/03	160
5/3/94	180	8/14/01	170	6/15/04	160
4/25/01	170	8/15/02	160	5/5/06	160
4/25/01	170	8/15/02	160	5/13/07	110
5/30/02	160	8/29/03	150	5/17/09	140
5/30/02	160	8/29/03	150	5/31/10	140
6/2/03	170	8/25/04	170	Summer	
6/2/03	160	8/25/04	170	10/5/92	180
6/15/04	160	8/24/05	170	8/31/93	160
6/15/04	150	8/24/05	160	8/28/94	160
5/5/06	170	10/21/05	160	8/25/95	170
5/5/06	170	8/9/06	160	8/14/01	170
5/13/07	130	8/9/06	180	8/15/02	160
5/13/07	130	8/27/07	160	8/29/03	150
5/17/09	140	8/27/07	160	8/25/04	170
5/17/09	140	8/24/09	140	8/24/05	160
5/31/10	160	8/24/09	140	10/21/05	160
5/31/10	160	8/23/10	160	8/9/06	160
Summer		8/23/10	160	8/27/07	160
10/5/92	180			8/24/09	150
10/5/92	180			8/23/10	160

The graph shows spring and summer conductivities appear to be decreasing in the north basin and in spring in the south basin. Stations 1 and 2 have higher conductivities than station 3 in spring.

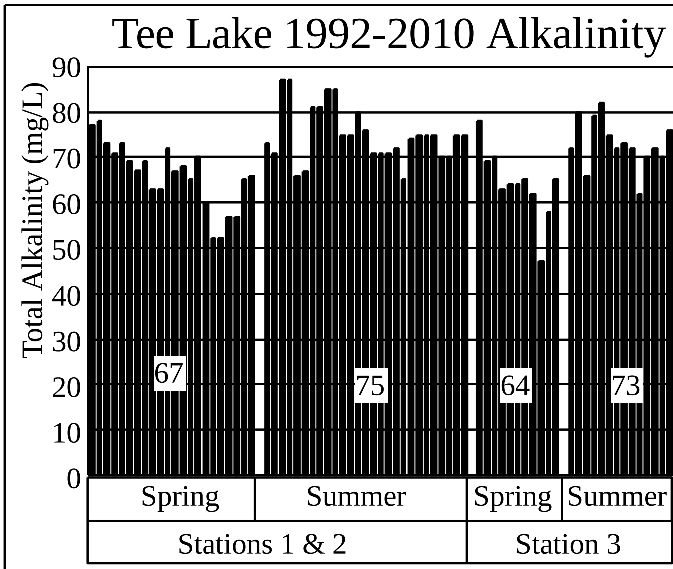
Stations 1 and 2, conductivities range from 130 umhos/cm 190 umhos/cm in spring (average 164 umhos/cm) and from 140 to 180 umhos/cm (average = 163 umhos/cm) in summer. At Station 3, spring conductivities range from 110 to 190 umhos/cm (average = 150 umhos/cm) and summer conductivities range from 150 to 180 umhos/cm (average = 162 umhos/cm). These are normal conductivities for a soft water Michigan inland lake.

The graph also shows the conductivity is decreasing, especially in spring. This is unusual. Usually salts build up in lakes because they are used for ice control on roads in winter and in water softeners around the lake. The above data seems to indicate salts from road salting operations or water softeners are probably not affecting Tee Lake at this time.

All in all the conductivity data do not show salts are entering the lake to any great extent in either spring or summer in either basin.

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.



Stations 1&2		8/31/93	87	Spring Sta 3	
Spring		8/31/93	87	6/10/92	78
6/10/92	77	8/28/94	66	5/18/93	69
6/10/92	78	8/28/94	67	5/3/94	70
5/18/93	73	8/25/95	81	4/25/01	63
5/18/93	71	8/25/95	81	5/30/02	64
5/3/94	73	8/14/01	85	6/2/03	64
5/3/94	69	8/14/01	85	6/15/04	65
4/25/01	66	8/15/02	75	5/5/06	62
4/25/01	69	8/15/02	75	5/13/07	47
5/30/02	63	8/29/03	80	5/17/09	58
5/30/02	63	8/29/03	76	5/31/10	65
6/2/03	72	8/25/04	71	Summer	
6/2/03	67	8/25/04	71	10/5/92	72
6/15/04	68	8/24/05	71	8/31/93	80
6/15/04	65	8/24/05	72	8/28/94	66
5/5/06	70	10/21/05	65	8/25/95	79
5/5/06	60	8/9/06	74	8/14/01	82
5/13/07	52	8/9/06	75	8/15/02	75
5/13/07	52	8/27/07	75	8/29/03	72
5/17/09	57	8/27/07	75	8/25/04	73
5/17/09	57	8/24/09	70	8/24/05	72
5/31/10	65	8/24/09	70	10/21/05	62
5/31/10	66	8/23/10	75	8/9/06	70
Summer		8/23/10	75	8/27/07	72
10/5/92	73			8/24/09	70
10/5/92	71			8/23/10	76

The graph shows the spring and summer alkalinity data at the three stations. It shows at Stations 1 and 2, spring alkalinity concentrations range from 52 to 78 milligrams per liter and average 67 mg/L while summer alkalinities range from 65 to 87 milligrams per liter and average 75 mg/L.

At Station 3 spring alkalinities range from 47 to 78 milligrams per liter and average 64 mg/L while summer alkalinities range from 62 to 82 mg/L and average 73 mg/L.

These data indicate Tee Lake is right on the border between a soft water lake and a moderately hard water lake but heading to a soft water lake.   The graph seems to show alkalinity is decreasing in both arms in spring but not in summer.

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.

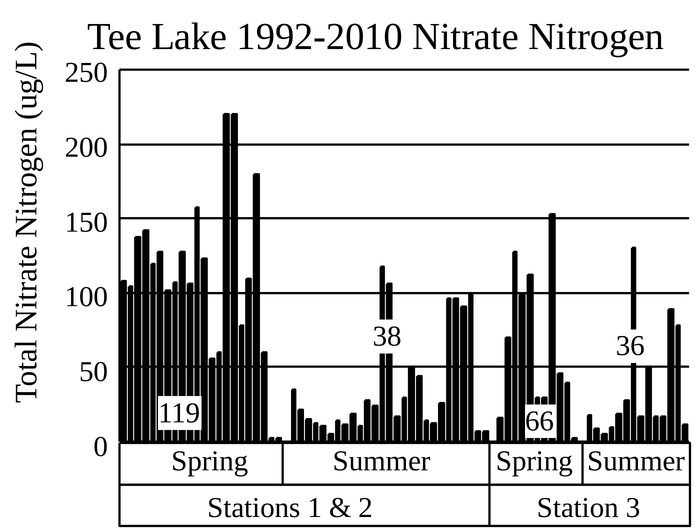
The graph also shows summer alkalinities are higher than spring alkalinities, which is unusual because carbonates and bicarbonates, which are what the alkalinity test measures, precipitate to the bottom sediments when the water warms.

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 at Stations 1 and 2, spring nitrate nitrogen concentrations (range 3 to 220 ug/L and average 119 ug/L) were generally higher than summer nitrates (range = 5 to 118 ug/L, and average 38 ug/L).

Station 3, spring nitrates range from 3 to 153 ug/L and average 66 ug/L while summer nitrates range from 5 to 130 ug/L and average 36 ug/L. Both spring and summer nitrates are within the normal range for a Michigan inland lake.



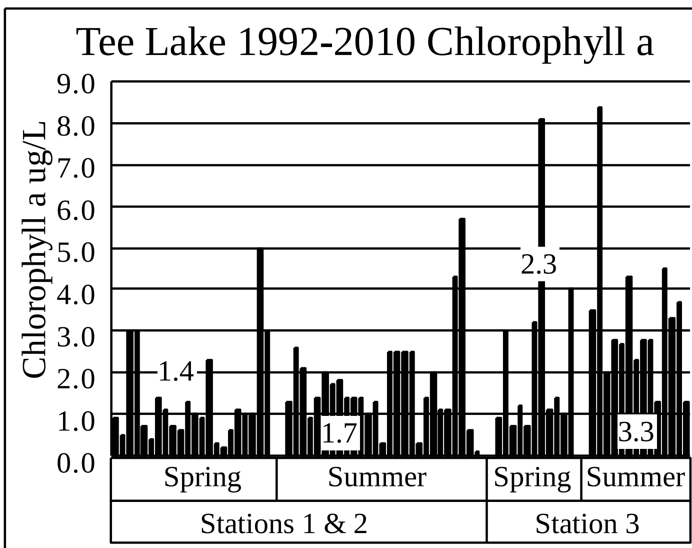
Stations 1&2		8/31/93	15	Spring Sta 3	
Spring		8/31/93	13	6/10/92	16
6/10/92	108	8/28/94	11	5/18/93	70
6/10/92	104	8/28/94	5	5/3/94	128
5/18/93	138	8/25/95	14	4/25/01	99
5/18/93	142	8/25/95	12	5/30/02	112
5/3/94	120	8/14/01	19	6/2/03	30
5/3/94	128	8/14/01	11	6/15/04	30
4/25/01	102	8/15/02	28	5/5/06	153
4/25/01	107	8/15/02	24	5/13/07	46
5/30/02	128	8/29/03	118	5/17/09	40
5/30/02	106	8/29/03	106	5/31/10	3
6/2/03	157	8/25/04	17	Summer	
6/2/03	123	8/25/04	30	10/5/92	18
6/15/04	56	8/24/05	50	8/31/93	9
6/15/04	60	8/24/05	44	8/28/94	5
5/5/06	220	10/21/05	14	8/25/95	10
5/5/06	220	8/9/06	13	8/14/01	19
5/13/07	78	8/9/06	26	8/15/02	28
5/13/07	110	8/27/07	96	8/29/03	130
5/17/09	180	8/27/07	96	8/25/04	17
5/17/09	60	8/24/09	91	8/24/05	50
5/31/10	3	8/24/09	100	10/21/05	17
5/31/10	3	8/23/10	7	8/9/06	17
Summer		8/23/10	7	8/27/07	89
10/5/92	35			8/24/09	78
10/5/92	22			8/23/10	12

The graph shows the nitrates at Stations 1 and 2 are higher than those at Station 3 in spring.

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

CHLOROPHYLL A

Chlorophyll a, reported in micrograms per liter (or parts per billion) generally gives an estimate of algal densities. Best is below 1 microgram per liter. The graph shows the spring and summer 1992-2010 chlorophyll a data.



Stations 1&2		8/31/93	2.1	Spring Sta 3	
Spring		8/31/93	0.9	6/10/92	0.9
6/10/92	0.9	8/28/94	1.4	5/18/93	3.0
6/10/92	0.5	8/28/94	2.0	5/3/94	0.7
5/18/93	3.0	8/25/95	1.7	4/25/01	1.2
5/18/93	3.0	8/25/95	1.8	5/30/02	0.7
5/3/94	0.7	8/14/01	1.4	6/2/03	3.2
5/3/94	0.4	8/14/01	1.4	6/15/04	8.1
4/25/01	1.4	8/15/02	1.4	5/5/06	1.1
4/25/01	1.1	8/15/02	1.0	5/13/07	1.4
5/30/02	0.7	8/29/03	1.3	5/17/09	1.0
5/30/02	0.6	8/29/03	0.3	5/31/10	4.0
6/2/03	1.3	8/25/04	2.5	Summer	
6/2/03	1.0	8/25/04	2.5	10/5/92	3.5
6/15/04	0.9	8/24/05	2.5	8/31/93	8.4
6/15/04	2.3	8/24/05	2.5	8/28/94	2.0
5/5/06	0.3	10/21/05	0.3	8/25/95	2.8
5/5/06	0.2	8/9/06	1.4	8/14/01	2.7
5/13/07	0.6	8/9/06	2.0	8/15/02	4.3
5/13/07	1.1	8/27/07	1.1	8/29/03	2.3
5/17/09	1.0	8/27/07	1.1	8/25/04	2.8
5/17/09	1.0	8/24/09	4.3	8/24/05	2.8
5/31/10	5.0	8/24/09	5.7	10/21/05	1.3
5/31/10	3.0	8/23/10	0.6	8/9/06	4.5
Summer		8/23/10	0.1	8/27/07	3.3
10/5/92	1.3			8/24/09	3.7
10/5/92	2.6			8/23/10	1.3

Stations 1 and 2 spring chlorophylls range from 0.2 to 3.0 micrograms per liter and average 1.4 ug/L. Summer chlorophylls at the two stations range from 0.1 to 5.7 ug/L and average 1.7 ug/L.

Station 3 in the south arm of the lake has the highest chlorophylls and the most variation, ranging from 0.7 to 8.1 ug/L and averaging 2.3 ug/L in spring and ranging from 1.3 to 8.4 ug/L and averaging 3.3 ug/L in summer.

The graph does not show chlorophylls are increasing. That's a plus.

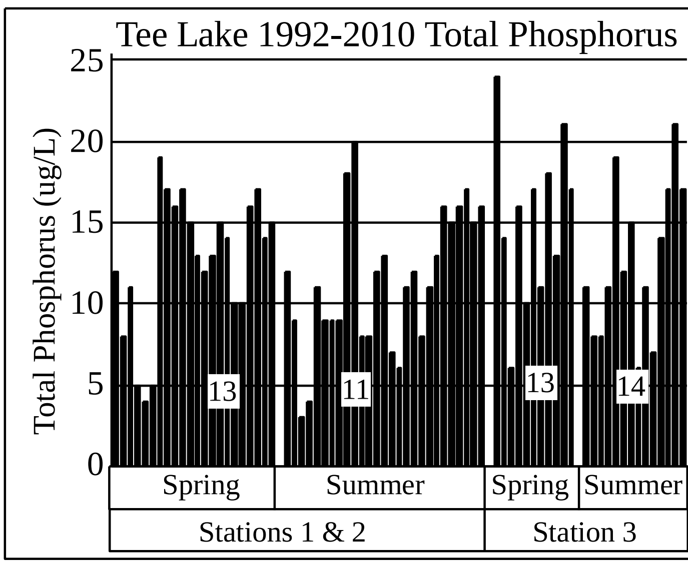
pH (Hydrogen ion concentration) (no graph)

Spring and summer surface pH values ranged from 7.4 to 8.8. These are normal pH values for a soft to moderately hard water Michigan inland lake.

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 increase.

TOTAL PHOSPHORUS

Phosphorus is a major nutrient in lakes. There are many forms, but they can all be converted to the other forms. Because of this, the experts selected



Stations 1&2		8/31/93	3	Spring Sta 3	
Spring		8/31/93	4	6/10/92	24
6/10/92	12	8/28/94	11	5/18/93	14
6/10/92	8	8/28/94	9	5/3/94	6
5/18/93	11	8/25/95	9	4/25/01	16
5/18/93	5	8/25/95	9	5/30/02	10
5/3/94	4	8/14/01	18	6/2/03	17
5/3/94	5	8/14/01	20	6/15/04	11
4/25/01	19	8/15/02	8	5/5/06	18
4/25/01	17	8/15/02	8	5/13/07	13
5/30/02	16	8/29/03	12	5/17/09	21
5/30/02	17	8/29/03	13	5/31/10	17
6/2/03	15	8/25/04	7	Summer	
6/2/03	13	8/25/04	6	10/5/92	11
6/15/04	12	8/24/05	11	8/31/93	8
6/15/04	13	8/24/05	12	8/28/94	8
5/5/06	15	10/21/05	8	8/25/95	11
5/5/06	14	8/9/06	11	8/14/01	19
5/13/07	10	8/9/06	13	8/15/02	12
5/13/07	10	8/27/07	16	8/29/03	15
5/17/09	16	8/27/07	15	8/25/04	6
5/17/09	17	8/24/09	16	8/24/05	11
5/31/10	14	8/24/09	17	10/21/05	7
5/31/10	15	8/23/10	15	8/9/06	14
Summer		8/23/10	16	8/27/07	17
10/5/92	12			8/24/09	21
10/5/92	9			8/23/10	17

total phosphorus as the most meaningful test. Best is below 10 micrograms per liter.

The graph does not show a lot of difference between the spring and summer surface phosphorus concentrations at Stations 1 and 2. They range from 3 to 20 ug/L in spring and summer and average 13 ug/L in spring and 11 ug/L in summer.

Station 3 phosphorus concentrations range from 6 to 24 ug/L and average 13 ug/L in spring and 14 ug/L in summer. That's not a lot of difference.

The graph seems to show phosphorus is increasing in spring and summer in both basins. If this is indeed occurring, it is not a plus.

Residents should try to keep phosphorus concentrations around 10 ug/L or less. That is ideal.

SECCHI DISK TRANSPARENCY (originally Secchi's disk)

In 1865, Angelo Secchi, an astronomer for the Pope 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 grandchildren see it disappear 3-4 feet deeper than grandparents.

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.

TEE LAKE SECCHI DISK DATA

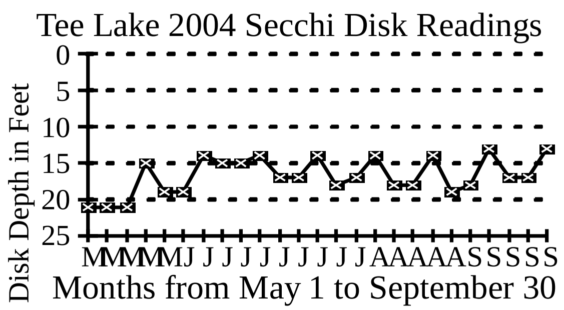
Raymond Lingle did a good job taking Secchi disk readings through the warm months in 2004, 2005 and 2006.

2004

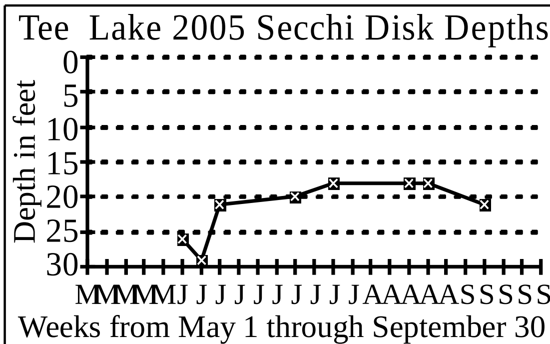
The graph of Lingle's 2004 data shows Tee Lake had early spring readings of 21 feet, and then as the water warmed in summer they got shallower, 14 to 18 feet. For some reason the water clarity varied two to three feet in a saw toothed pattern during the warm months. This is unusual, but not a concern.

2005

Lingle's 2005 data shows early June readings are 26 and 29 feet. From mid-June on, the Secchi disk readings range from 18 to 21 feet. These are very good Secchi disk readings for a Michigan inland lake.

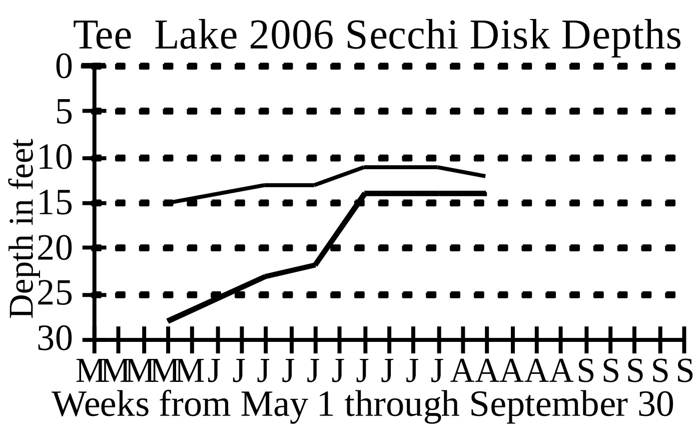


MAY	21	21	21	15	19
JUN	19	14	15	15	14
JUL	17	17	14	18	17
AUG	14	18	18	14	19
SEP	18	13	17	17	13



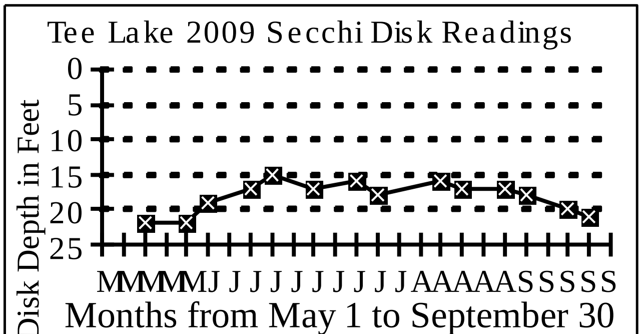
JUN	26	29	21	.
JUL	.	20	.	18
AUG	.	.	18	18
SEP	.	21	.	.

2006



Station 1					
MAY	.	.	.	28	.
JUN	.	.	23	.	22
JUL.	14	.	.	14	
AUG	.	14	.	.	.
Station 2					
MAY	.	.	.	28	.
JUN	.	.	23	.	22
JUL.	14	.	.	14	
AUG	.	14	.	.	.
Station 3					
MAY	.	.	.	15	.
JUN	.	.	13	.	13
JUL.	11	.	.	11	
AUG	.	12	.	.	.

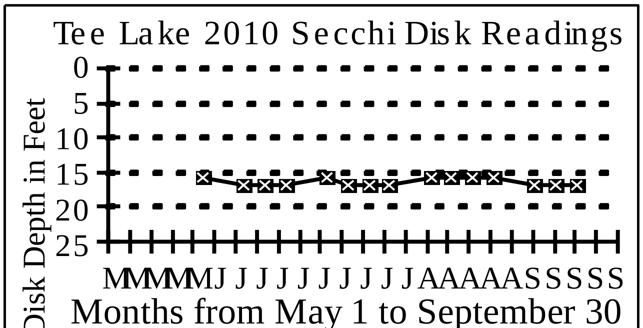
Lingle collected Secchi disk readings at all three stations in 2006. The graph shows his data, stacked. It shows water clarity at Stations 1 and 2, were similar, and were deep (28 feet) in late May. They gradually decreased to 14 feet in July and August. Station 3 Secchi disk readings were shallower, starting at 15 feet in late May and decreasing to 11 to 13 feet in July and August. Lingle noted several of these readings were resting on the bottom.



MAY	.	.	22	.	22
JUN	19	.	17	15	.
JUL	17	.	16	18	.
AUG	.	16	17	.	17
SEP	18	.	20	21	.

2009

Paul White did a good job collecting Secchi disk data in 2009. The graph of his data below shows deepest readings in spring, 22 feet, and late summer, 21 feet. During the warm part of the summer the water clarity was slightly less, ranging from 15 to 18 feet.

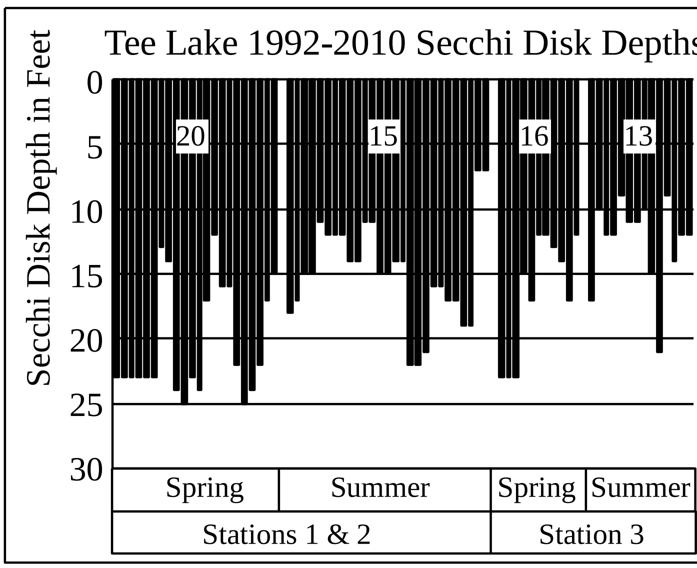


MAY	.	.	.	.	16
JUN	.	17	17	17	.
JUL	16	17	17	17	.
AUG	16	16	16	16	.
SEP	17	17	17	.	.

2010

White collected Secchi disk data again in 2010. The graph shows his data. In 2010 there was very little variation between the spring readings when the water was cold and summer when the water was warm.

SECCHI DISK READINGS TAKEN WITH THE SAMPLES



Stations 1&2		8/31/93	15	Spring Sta 3	
Spring		8/31/93	15	6/10/92	23
6/10/92	23	8/28/94	11	5/18/93	23
6/10/92	23	8/28/94	12	5/3/94	23
5/18/93	23	8/25/95	12	4/25/01	15
5/18/93	23	8/25/95	12	5/30/02	17
5/3/94	23	8/14/01	14	6/2/03	12
5/3/94	23	8/14/01	14	6/15/04	12
4/25/01	13	8/15/02	11	5/5/06	13
4/25/01	14	8/15/02	11	5/13/07	14
5/30/02	24	8/29/03	15	5/17/09	17
5/30/02	25	8/29/03	15	5/31/10	12
6/2/03	23	8/25/04	14	Summer	
6/2/03	24	8/25/04	14	10/5/92	17
6/15/04	17	8/24/05	22	8/31/93	10
6/15/04	12	8/24/05	22	8/28/94	12
5/5/06	16	10/21/05	21	8/25/95	12
5/5/06	16	8/9/06	16	8/14/01	9
5/13/07	22	8/9/06	16	8/15/02	11
5/13/07	25	8/27/07	17	8/29/03	11
5/17/09	24	8/27/07	17	8/25/04	10
5/17/09	22	8/24/09	19	8/24/05	15
5/31/10	17	8/24/09	19	10/21/05	21
5/31/10	15	8/23/10	7	8/9/06	9
Summer		8/23/10	7	8/27/07	14
10/5/92	18			8/24/09	12
10/5/92	17			8/23/10	12

The graph of Secchi disk readings taken with the samples shows spring readings are generally quite a bit deeper summer readings in the large basin. This indicates the decrease in water clarity in summer is probably due to an algal bloom.

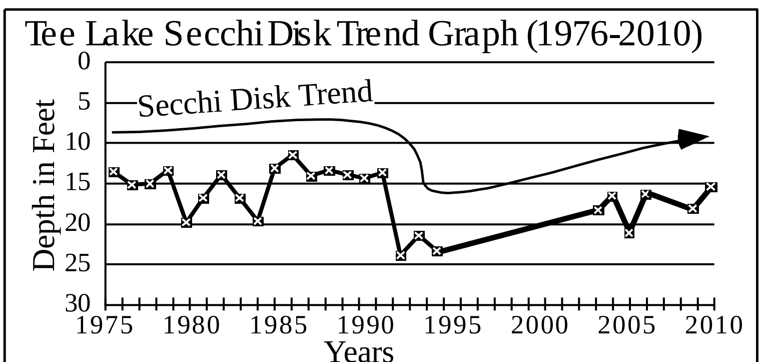
The graph shows a lot of variation between the spring data at Stations 1 and 2, ranging from 12 to 25 feet and averaging 20 feet in spring and from 7 to 22 feet in summer and averaging 15 feet. The summer readings appear to be getting better as years pass at these two stations.

Station 3 Secchi disk readings in spring water ranged from 12 to 23 feet in spring (average = 16 feet) and from 9 to 21 feet in summer (average = 13 feet). Spring readings at Station 3 appear to be getting shallower but summer readings appear to be stable.

Secchi disk readings should be taken on a regular basis through the warm months to follow the clarity of Tee Lake. This is important.

THE SECCHI DISK TREND GRAPH

In the past, Secchi disk readings were taken on a regular basis, so we have in our files a graph showing average Secchi disk readings from 1976 through 1994, and in 2003, 2004, 2005, 2006, 2009.and 2010.



Data:

1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	
13.5	15.1	15.0	13.4	19.8	16.8	13.9	16.8	19.7	13.1	11.4	14.1	
1988	1989	1990	1991	1992	1993	1994	2003	2004	2005	2006	2009	2010
13.3	13.9	14.3	13.6	23.9	21.4	23.3	18.3	16.9	21.3	16.7	18.0	15.4

The graph shows the clarity of the lake was fairly stable from 1976 through 1991, then increased dramatically in 1992, 1993 and 1994.

Since that time the water clarity is decreasing. That trend continued in 2010. The reason for this decrease is unknown. Let’s hope this decrease doesn’t continue.

THE LAKE WATER QUALITY INDEX

The Lake Water Quality Index used in this study to define the water quality of Tee 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
Chlorophyll a
Secchi disk depth
Total nitrate nitrogen
Total alkalinity
Temperature
Conductivity
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 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 thermometers. Test results indicating poor water quality are indicated by red lines lower on the thermometers. 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.

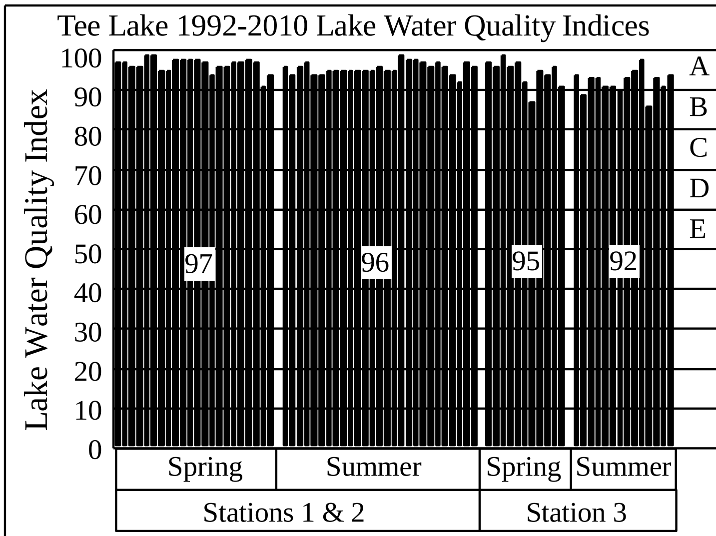
The index is shown three different ways, as a number between 1 and 100 in the circle marked LWQI, and by a color and position on the sheet edge scale. The purpose of the sheet edge scale is to review quickly large numbers of lakes or test sites within a lake, and determine how the water quality of the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

THE TEE LAKE WATER QUALITY INDICES

The graph below shows the 1992-2010 Lake Water Quality Indices for Tee Lake at the three in-lake sample stations in spring and summer.

The graph shows the Lake Water Quality Indices for Stations 1 and 2 in spring ranged from 91 to 99 (average = 97) (A) and in summer ranged from 92 to 99 (average = 96) (A).

Station 3 spring LWQIs ranged from 87 to 99 (average = 95) (B to A) and summer LWQIs ranged from 86 to 98 (average = 92) (B to A). There is more variation in the Station 3 LWQIs. The graph shows Stations 1 and 2 have slightly higher LWQIs than Station 3 in both spring and summer, but only by a slim margin.



Stations 1&2		8/31/93	96	Spring Sta 3	
Spring		8/31/93	97	6/10/92	97
6/10/92	97	8/28/94	94	5/18/93	96
6/10/92	97	8/28/94	94	5/3/94	99
5/18/93	96	8/25/95	95	4/25/01	96
5/18/93	96	8/25/95	95	5/30/02	97
5/3/94	99	8/14/01	95	6/2/03	92
5/3/94	99	8/14/01	95	6/15/04	87
4/25/01	95	8/15/02	95	5/5/06	95
4/25/01	95	8/15/02	95	5/13/07	94
5/30/02	98	8/29/03	95	5/17/09	96
5/30/02	98	8/29/03	96	5/31/10	91
6/2/03	98	8/25/04	95	Summer	
6/2/03	98	8/25/04	95	10/5/92	94
6/15/04	97	8/24/05	99	8/31/93	89
6/15/04	94	8/24/05	98	8/28/94	93
5/5/06	96	10/21/05	98	8/25/95	93
5/5/06	96	8/9/06	97	8/14/01	91
5/13/07	97	8/9/06	96	8/15/02	91
5/13/07	97	8/27/07	97	8/29/03	90
5/17/09	98	8/27/07	96	8/25/04	93
5/17/09	97	8/24/09	94	8/24/05	95
5/31/10	91	8/24/09	92	10/21/05	98
5/31/10	94	8/23/10	97	8/9/06	86
Summer		8/23/10	96	8/27/07	93
10/5/92	96			8/24/09	91
10/5/92	94			8/23/10	94

2010 LAKE WATER QUALITY INDEX CALCULATION SHEETS

Because the 2010 Lake Water Quality Indices were relatively uniform at all three stations in spring (91 94 91) and in late summer (97 96 94), two Lake Water Quality Index calculation sheets are included in this report, one for the three spring 2010 surface samples, using averaged data and a second for the three late summer 2010 surface samples, again using averaged data.

In the report marked MASTER, all 6 of the 2010 LWQI 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.

TEE LAKE BOTTOM SEDIMENTS

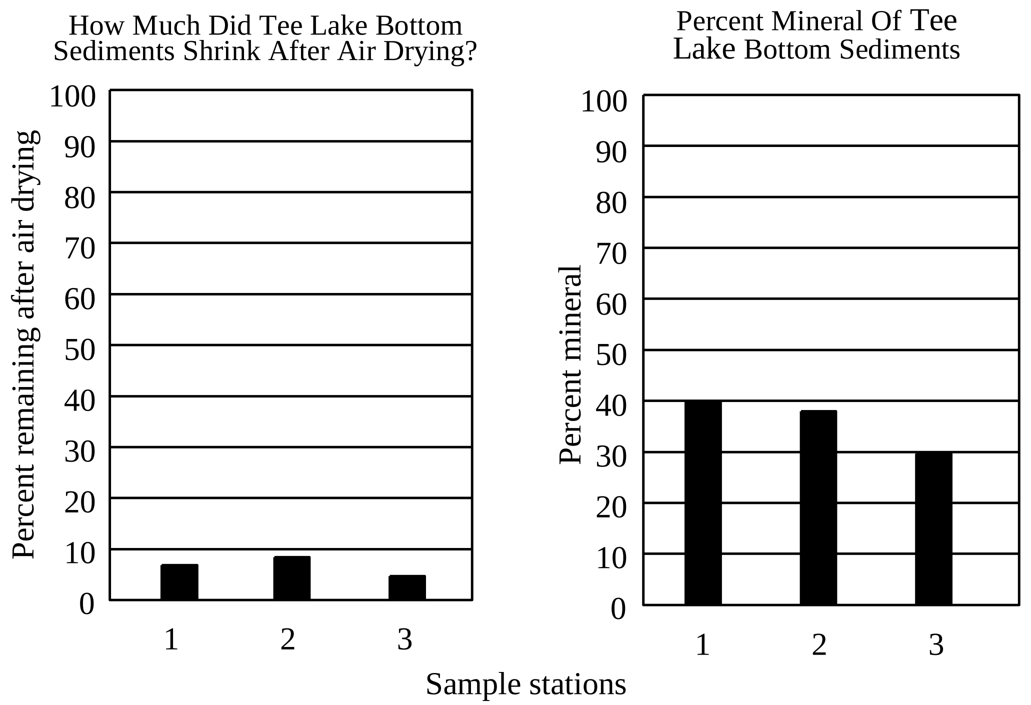
Bottom sediments were collected from Tee Lake in 2004. The graph shows the data.

The sample from Station 1 collected in 70 feet of water was black when recovered, remained black after air drying, shrank 93 percent and turned red after burning at 550 degrees C. It was 40 percent mineral.

The sample from Station 2 collected in 37 feet of water was black when recovered, remained black after air-drying, shrank 91 percent and turned red after burning at 550 degrees C. It was 38 percent mineral.

The sample from Station 3 collected in 13 feet of water was black when recovered, remained black after air drying, shrank 96 percent and turned red after burning at 550 degrees C. It was 30 percent mineral.

All of the sediments shrank excessively, greater than 90 percent. This means they are light and fluffy and easily mixed into the water column by wind, wave and boat action, which also means any nutrients in the sediments can also be mixed into the water column.



Characteristics of Tee Lake Bottom Sediments (2004)

Sample I.D.	Percent Shrinkage	Percent Mineral	Dried at 100°C Color & Description	Color after burning at 550°C	Depth of water (feet)
1	93	40	Black	Red	70
2	91	38	Black	Red	37
3	96	30	Black	Red	13

Average mineral content of bottom sediments = 36%

All remained black after air-drying. This indicated they were greater than 35 percent organic, and indeed they were, averaging only 36 percent mineral (or 64 percent organic). This is normal for a soft water lake because that’s all there is in the water column.

All the samples turned red after burning at 550 degrees C. This indicates clay in the lake sediments. Clay is not a normal constituent of lake bottom sediments. It is generally washed into the lake from road or home building activities or farming.

It looks like there are slightly more organic materials in the sediments at Station 3 than the other two. If we had data from earlier years (1992-3, etc.) which we could use to compare the present data, we probably would have been able to tell whether the bubblers were effective in reducing the amount of organic material in that arm of the lake.

That being said, soft water lakes generally have highly organic sediments because there are few carbonates and bicarbonates in the soft water to precipitate to the sediments. My impression is the bubblers are never going to get rid of the organic sediments in the lake because that's what the sediments of Tee Lake, and other soft water lakes consist of.

Wallace E. Fusilier, Ph.D.
Consulting Limnologist
Water Quality Investigators
Dexter, Michigan
May 2011

Surface 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									
6/10/92	1	---	---	---	0.9	23	108	77	8.2	190	24	97	A
6/10/92	2	---	---	---	0.5	23	104	78	8.2	190	8	97	A
6/10/92	3	---	---	---	0.9	23	16	78	8.5	190	24	97	A
10/5/92	1	14	8.8	85	1.3	18	35	73	7.9	180	12	96	A
10/5/92	2	14	8.8	85	2.6	17	22	71	8.0	180	9	94	A
10/5/92	3	14	9.9	95	3.5	17	18	72	8.0	180	11	94	A
5/18/93	1	---	---	---	3.0	23	138	73	7.8	180	11	96	A
5/18/93	2	---	---	---	3.0	23	142	71	7.8	180	5	96	A
5/18/93	3	---	---	---	3.0	23	70	69	7.8	180	14	96	A
8/31/93	1	22	8.6	98	2.1	15	15	87	8.5	160	3	96	A
8/31/93	2	22	8.7	99	0.9	15	13	87	8.5	160	4	97	A
8/31/93	3	22	8.7	99	8.4	10	9	80	8.3	160	8	89	B
5/3/94	1	---	---	---	0.7	23	120	73	7.9	180	4	99	A
5/3/94	2	---	---	---	0.4	23	128	69	7.8	180	5	99	A
5/3/94	3	---	---	---	0.7	23	128	70	7.8	180	6	99	A
8/28/94	1	22	8.9	101	1.4	11	11	66	8.2	160	11	94	A
8/28/94	2	21	9.1	101	2.0	12	5	67	8.1	160	9	94	A
8/28/94	3	21	9.2	102	2.0	12	5	66	8.3	160	8	93	A
8/25/95	1	23	8.3	95	1.7	12	14	81	8.3	170	9	95	A
8/25/95	2	23	8.5	98	1.8	12	12	81	8.4	170	9	95	A
8/25/95	3	22	8.5	97	2.8	12	10	79	8.4	170	11	93	A
4/25/01	1	---	---	---	1.4	13	102	66	7.9	170	19	95	A
4/25/01	2	---	---	---	1.1	14	107	69	7.4	170	17	95	A
4/25/01	3	---	---	---	1.2	15	99	63	7.5	160	16	96	A
8/14/01	1	25	8.5	101	1.4	14	19	85	8.1	170	18	95	A
8/14/01	2	25	8.7	104	1.4	14	11	85	8.1	170	20	95	A
8/14/01	3	25	9.3	111	2.7	9	19	82	8.4	170	19	91	A
5/30/02	1	---	---	---	0.7	24	128	63	8.5	160	16	98	A
5/30/02	2	---	---	---	0.6	25	106	63	8.2	160	17	98	A
5/30/02	3	---	---	---	0.7	17	112	64	7.9	160	10	97	A
8/15/02	1	25	8.1	96	1.4	11	28	75	8.0	160	8	95	A
8/15/02	2	24	8.6	101	1.0	11	24	75	8.1	160	8	95	A
8/15/02	3	25	8.6	102	4.3	11	28	75	8.1	160	12	91	A
6/2/03	1	---	---	---	1.3	23	157	72	8.2	170	15	98	A
6/2/03	2	---	---	---	1	24	123	67	8.1	160	13	98	A
6/2/03	3	---	---	---	3.2	12	30	64	8.2	160	17	92	A
8/29/03	1	24	8.6	101	1.3	15	118	80	8.6	150	12	95	A
8/29/03	2	23	8.6	99	0.3	15	106	76	8.6	150	13	96	A
8/29/03	3	23	8.8	101	2.3	11	130	72	8.6	150	15	90	A
6/15/04	1	---	---	---	0.9	17	56	68	7.8	160	12	97	A
6/15/04	2	---	---	---	2.3	12	60	65	7.7	150	13	94	A
6/15/04	3	---	---	---	8.1	12	30	65	7.9	160	11	87	A
8/25/04	1	20	9.0	98	2.5	14	17	71	8.0	170	7	95	A
8/25/04	2	20	9.2	100	2.5	14	30	71	8.0	170	6	95	A
8/25/04	3	20	9.3	101	2.8	10	17	73	8.1	170	6	93	A
8/24/05	1	21	8.7	97	2.5	22	50	71	8.5	170	11	99	A
8/24/05	2	21	8.7	97	2.5	22	44	72	8.4	160	12	98	A
8/24/05	3	20	8.9	97	2.8	15	50	72	8.5	160	11	95	A
10/21/05	1	---	---	---	0.3	21	14	65	7.7	160	8	98	A
10/21/05	3	---	---	---	1.3	21	17	62	7.6	160	7	98	A
5/5/06	1	---	---	---	0.3	16	220	70	7.7	170	15	96	A
5/5/06	2	---	---	---	0.2	16	220	60	7.5	170	14	96	A
5/5/06	3	---	---	---	1.1	13	153	62	7.8	160	18	95	A
8/9/06	1	25	8.3	99	1.4	16	13	74	8.5	160	11	97	A
8/9/06	2	25	8.4	100	2.0	16	26	75	8.3	180	13	96	A
8/9/06	3	25	8.7	103	4.5	9	17	70	8.8	160	14	86	B
5/13/07	1	---	---	---	0.6	22	78	52	7.8	130	10	97	A
5/13/07	2	---	---	---	1.1	25	110	52	7.8	130	10	97	A
5/13/07	3	---	---	---	1.4	14	46	47	7.7	110	13	94	A
8/27/07	1	22	8.5	97	1.1	17	96	75	8.2	160	16	97	A
8/27/07	2	22	8.7	99	1.1	17	96	75	8.1	160	15	96	A
8/27/07	3	22	9.0	102	3.3	14	89	72	8.3	160	17	93	A
5/17/09	1	---	---	---	1.0	24	180	57	7.9	140	16	98	A
5/17/09	2	---	---	---	1.0	22	60	57	7.8	140	17	97	A
5/17/09	3	---	---	---	1.0	17	40	58	7.9	140	21	96	A
8/24/09	1	22	8.6	98	4.3	19	91	70	8.1	140	16	94	A
8/24/09	2	22	8.8	100	5.7	19	100	70	8.1	140	17	92	A
8/24/09	3	22	8.7	99	3.7	12	78	70	8.1	150	21	91	A
5/31/10	1	---	---	---	5.0	17	3	65	7.8	160	14	91	A
5/31/10	2	---	---	---	3.0	15	3	66	7.7	160	15	94	A
5/31/10	3	---	---	---	4.0	12	3	65	7.6	140	17	91	A
8/23/10	1	23	8.2	94	0.6	7	7	75	8.3	160	15	97	A
8/23/10	2	23	8.3	95	0.1	7	7	75	8.2	160	16	96	A
8/23/10	3	23	8.7	100	1.3	12	12	76	8.4	160	17	94	A