2001 Water Quality Monitoring Report

Clearwater River Watershed District

Prepared for

Clearwater River Watershed District

January 2002

2001
Water Quality
Monitoring Report

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Prepared for:

CLEARWATER RIVER WATERSHED DISTRICT
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January 2002

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Table of Contents

Table of Contents (Cont.)

TABLES

FIGURES

APPENDICES

1.0 Introduction

The Clearwater River Watershed District has conducted a stream and lake monitoring program since 1980. The overall approach to the annual monitoring program has been to conduct baseline monitoring for precipitation, stream monitoring on Clearwater River, and lake monitoring on a rotating basis. In addition, citizen volunteers collect secchi depth readings on numerous lakes.

The year 2001 program included stream flow gauging and water quality monitoring for total phosphorus, soluble reactive phosphorus, and fecal coliform and fecal streptococcus bacteria at three sites. Fecal coliform and fecal streptococcus bacteria were monitored at eight additional sites. Ten lake stations on nine lakes were monitored two times in July and August for water quality. See Figures 1 and 2 for monitoring locations and Appendix A for a summary of the 2001 monitoring plan.

2.0 Precipitation

For the watershed as a whole, precipitation for 2001 was higher than normal, averaging 31.28 inches (Table 1; Figure 3). Cumulative precipitation was higher than normal throughout the year. At the end of June, cumulative precipitation for the watershed overall was 7.05 inches above normal, due in part to an unusually wet April, but drier weather during late summer and fall resulted in a year-end value only 3.93 inches (14%) above normal (27.35 inches). The water quality monitoring on streams and lakes was performed through October, which was a cumulative 2.41 inches above normal for the watershed overall. Individual volunteer records are shown in Appendix B.

3.0 Streams

3.1 RUNOFF

Stream flow at the outlet of Clearwater Lake (station CR10.5) averaged 31.71 cubic feet per second (cfs) for the monitoring season. The monitoring flow was equivalent to 2.8 inches of runoff from the 155-square-mile upstream watershed. Throughout the summer, stream flows decreased from spring maximums to minor flow by late August. Flows for each site are given in Table 2.

3.2 TOTAL PHOSPHORUS

Phosphorus levels in the Clearwater River remained much improved, compared with conditions monitored in the early 1980s prior to the lake restoration project's main implementation. Upstream of the main-stem lake chain (station CR28.2), the average total phosphorus concentration was 0.51 mg/L (milligrams per liter, or parts per million), versus 0.74 to 1.40 mg/L in the early 1980s. Sites WR0.2 and CR 10.5 had very low average concentrations of 0.10 mg/L and 0.03 mg/L, respectively. Results for the three sites are given in Table 3A.

3.3 FECAL COLIFORM

Twelve sites were monitored for fecal coliform bacteria for five events. Five of the sites are along the Clearwater River, and seven are along Warner Creek, a tributary to Clearwater Lake East Basin. Values from the Clearwater River sites ranged from 2 colony forming units per 100 milliliters (cfu/100 mL) to 460 cfu/100 mL. Two sites, CR 28.2 and CR23.8, each had one exceedance of the state standard of 200 cfu/100 mL. Geometric means were calculated as is

typical for bacteria data. There were no mean exceedances of the 200 cfu/100 mL state standard. These sites are much improved from 2000. However, since two sites exceeded the state standard for one event, fecal coliform bacteria remain a concern. Results for all sites are given in Table 3B.

Values from the Warner Creek sites ranged from less than 2 cfu/100mL to 5,000 cfu/100mL Each site had at least one exceedance of the state standard of 200 cfu/100mL; WC-3 and WC-6 each had four exceedances; WC-1, WC-2, and WC-5 each had two; and WC-4 had one. In addition, the geometric mean for WC-3 exceeds the 200 cfu/100mL state standard, and the geometric mean for WC-5 and WC-6 are very close to the standard. Because of these exceedances, and the proximity of sites WC-3 and WC-5 to sewage disposal ponds, fecal coliform bacteria are a concern along Warner Creek. The presence of these bacteria might indicate contamination from the sewage disposal ponds is entering Warner Creek. Discussions with the City of Annandale regarding this concern are currently underway.

3.4 FECAL STREPTOCOCCUS

Six sites along Warner Creek were also monitored for fecal streptococcus bacteria during five events. All samples showed less than 2cfu/100mL (Table 3B). Fecal streptococcus bacteria do not appear to be a concern along Warner Creek.

Ratios of fecal coliform to fecal streptococcus have been used to attempt to determine the source of fecal contamination (Debby Sargeant, 1999). Suggestions that a ratio greater than four indicate contamination from a human source have drawn criticism because fecal coliform and fecal streptococcus bacteria do not die off at the same rate. However, the very large fecal coliform to fecal streptococcus ratios at WC-3, immediately downstream from the sewage disposal ponds, suggests that a human source is a strong possibility and should be investigated further.

4.0 Water Quality of Lakes Sampled in Year 2000

Most of the lakes sampled in 2001 showed good water quality (Table 5). Lakes were sampled for total phosphorus, chlorophyll-a, and secchi depth (a measure of clarity). These three parameters were used to determine each lake's Trophic Status Index (TSI) (Table 5), which is used to categorize the lake based on its productivity (R.E. Carlson, 1977). The TSI scale ranges from zero to 100, with a lower TSI indicating better water quality. The lakes sampled in 2001 fell into the oligotrophic or mesotrophic categories, which are nutrient poor, have clear water, and are relatively low in productivity (R.E.Carlson, 1977).

4.1 LAKE AUGUSTA

Lake Augusta's mid-summer water quality was **good**, with mean total phosphorus of 48 ug/L, chlorophyll-*a* of 6.4 ug/L, and secchi depth of 6.0 feet. A citizen volunteer also monitors secchi depths, which show the water clarity peaked in June at 19.5 feet, and averaged 7.5 feet from June through October (Figure D-1). Historical data (Figure 5) show that overall water quality has improved slightly since the early 1990s.

4.2 BASS LAKE

Bass Lake had **very good** mid-summer water quality, with mean total phosphorus of 25 ug/L, chlorophyll-*a* of 2.7 ug/L, and secchi depth of 13.8 feet. Citizen secchi data (Figure D-1) show an average secchi depth of 12.6 feet from May through October and a maximum of 16.0 feet in June. Bass Lake has been sampled in 1994, 1998, 1999, and 2001 (Figure 6).

4.3 LAKE BETSY

Lake Betsy's mid-summer water quality was **very poor**, although it has improved significantly since the late 1980s (Figure 7). Mean total phosphorus was 420 ug/L, chlorophyll-*a* was 4.3 ug/L, and sechhi depth was 1.5 feet. The citizen secchi data (Figure D-1) show the water clarity peaked in May at 5.0 feet, with an average of 2.7 feet from May through October. The extended period for citizen monitoring (early spring) accounts for the higher mean values.

4.4 LAKE CAROLINE

Mid-summer water quality in Lake Caroline was **fair**, with a mean total phosphorus of 30 ug/L, chlorophyll-a of 24.5 ug/L, and secchi depth of 4.5 feet. The citizen secchi data show an average of 6.0 feet from May through October, with a peak of 10.5 feet in June (Figure D-2). Chlorophyll-a levels and secchi depth have remained constant since the early 1980s, but total phosphorus levels show a significant decrease over the same period (Figure 8).

4.5 CEDAR LAKE

Cedar Lake showed **good** mid-summer water quality, with mean total phosphorus of 26 ug/L, chlorophyll-*a* of 5.9 ug/L, and secchi depth of 6.0 feet. Cedar Lake has been sampled in 1993, 1996, 1999, and 2001 (Figure 9). The citizen secchi data (Figure D-2) show an average secchi depth of 7.7 feet from May though October, with a maximum of 10.5 feet in June.

4.6 CLEARWATER LAKE

Clearwater Lake is sampled in both the West and East basins every year as part of the long-term monitoring plan. Data for 2001 show **very good** water quality for both basins.

West- Mean values for the West basin are 42 ug/L for total phosphorus, 7.5 ug/L for chlorophyll-a, and 4.5 feet for secchi depth. The citizen secchi data (Figure D-3) show a maximum clarity of 16 feet and an average of 8.7 feet from May through September. A citizen site on the very north portion of the West basin had an average secchi depth of 10.1 feet, more than double the average of the two measurements by District personnel. The extended period for citizen monitoring (early spring) and location on the lake may account for the higher mean values.

East - Mean values for the East basin are 40 µg/L for total phosphorus, 6.7 µg/L for chlorophyll-*a*, and 8.0 feet for secchi depth. No citizen monitoring of secchi depths occurred in the East basin.

The historical data (Figures 10 and 11) show very good water quality in recent years, with downward trends in total phosphorus and chlorophyll-a, and a slight improving trend in secchi depth.

4.7 LAKE LOUISA

Lakes Louisa and Marie are essentially one long lake with a narrows in the middle. The two lakes are generally monitored in alternate years, and in 2001 it was Lake Louisa. The summer water quality was **good**, with mean concentrations of total phosphorus and chlorophyll-*a* of 33 and 5.1 µg/L, respectively. No secchi depth was taken, but the citizen secchi data show a mean value of 5.4 feet (Figure D-3) from May through July on the downstream lobe of Lake Marie called Mill Pond. Historical data (Figure 12) show a dramatic reduction in total phosphorus since 1981. The chlorophyll-*a* data is less conclusive but shows a downward trend since 1995. The mean secchi depth has remained constant between 2 and 4 feet for 12 of the 16 years monitored.

4.8 NIXON LAKE

Nixon Lake's 2001 mid-summer water quality was **very good**, with mean concentrations of total phosphorus and chlorophyll-*a* of 21 and 5.6 µg/L, respectively. The secchi depth mean was 10.5 feet for the water quality events, and 11.7 for the citizen events from May through October (Figure D-4). Historical data (Figure 13) show stable concentrations for total phosphorus and chlorophyll-*a*. The secchi depth shows an improving trend.

4.9 OTTER LAKE

Otter Lake mean concentrations of total phosphorus and chlorophyll-*a* were 30 ug/L and 4.0 µg/L, respectively. These results represent **very good** water quality. Secchi depth was 9.3 feet for the two water quality events, and the citizen mean value was 10.1 feet from May through October (Figure D-4). Historical data (Figure 14) show a slightly increasing trend for total phosphorus and a constant trend for chlorophyll-*a*. The secchi depth has improved significantly since 1994.

5.0 Conclusions

1. Precipitation for the year was high, 31.28 inches (114% of normal) and was 2.41 inches above normal at the end of October and 3.93 inches at the end of the year.

2. The high precipitation resulted in wet spring and early summer conditions with 2.8 inches of runoff, a relatively low amount compared to previous years with similar precipitation amounts.

3. The Clearwater River phosphorus load was 9,500 pounds at CR 28.2, significantly higher than previous years with similar average flow values.

4. The water quality of Lake Augusta, Bass Lake, Cedar Lake, Clearwater Lake, Lake Louisa, Nixon Lake, and Otter Lake continued to be very good, while the water quality of Lake Caroline was fair and Lake Betsy was poor.

5. Fecal coliform bacteria were found at levels of concern in Clearwater River and Warner Creek. These findings confirm the 2000 fecal coliform monitoring results and raise concerns about the quality of Warner Creek. Bacteria levels in the Clearwater River have decreased since 2000.

6.0 Recommendations

1. Continue the District's water quality and hydrologic monitoring program.

2. Investigate the sources of fecal coliform bacteria in the District using identification methods and evaluate bacteria control methods.

3. Continue pursuing methods to improve the water quality of the District lakes.

7.0 References

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Carlson, R.E. A Trophic State Index for Lakes. Limnology and Oceanography, 22 (2): 361-369. 1977.

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Tables

TABLE 1

YEARLY PRECIPITATION AND RUNOFF TOTALS

Clearwater River Watershed District

	Precipitation (inches of water)									
YEAR	Watkins	Kingston		Maine Prairie		Corinna		Area-Weighted Average		Runoff (inches)
1981	--	--		--		--		19.76	(1)	3.6
1982	--	--		--		--		24.58	(1)	6.8
1983	46.54	--		42.32		35.02		41.78		17.4
1984	32.23	30.13		32.37		36.07		32.95		13.3
1985	40.72	39.49		45.28		--		42.22		12.0
1986	40.02	35.63		39.68		33.40		37.26		16.0
1987	18.97	15.40		19.41		16.16		17.52		1.4
1988	16.57	18.98		15.96		15.01		16.48		0.7
1989	22.13	22.68		21.80		16.96		20.68		3.0
1990	40.35	39.18		41.36		32.18		37.94		11.7
1991	41.30	45.11		43.41		36.28		41.01		20.7
1992	23.06	18.41		20.47		24.35		22.01		12.9
1993	40.17	35.27	(2)	37.54	(2)	33.33		36.71		15.5
1994	34.77	--		30.13		30.26		31.98		9.0
1995	33.80	--		33.65		28.66		32.21		8.8
1996	31.31	--		24.32	(2)	26.13	(2)	27.59		4.8
1997	24.18	--		21.90		27.37		24.43		6.3
1998	30.03	--		29.39		27.43	(2)	29.05		5.5
1999	22.08	--		22.31	(2)	27.71		23.84		3.9
2000	23.83	--		20.56		19.91		21.22		1.0
2001	31.00	--		33.56		29.57		31.28		2.8
							Mean	29.17		8.4
							Std. Dev.	8.2		5.9

NOTES:

Whole watershed runoff is based on time-weighted average flow at Clearwater Lake outlet (station CR 10.5), and total drainage area of 155 square miles.

(1) Data for single gauge in east-central part of watershed (Camp Heritage on Lake Caroline).

(2) Average values of other stations in District were used to fill in missing data.

TABLE 2
SUMMARY OF STREAM FLOWS

Clearwater River Watershed District

	Flow Values (cubic feet per second)		
	WR 0.2	CR 28.2	CR 10.5
10-May	10.20	30.28	112.11
12-Jul	0.57	3.41	8.96
16-Aug	0.39	2.20	1.22
22-Oct	0.34	1.93	4.56
Arithmetic Average:	2.88	9.46	31.71

TABLE 3A
2001 STREAM WATER QUALITY - TOTAL PHOSPHORUS

Clearwater River Watershed District

	Total Phosphorus (mg/L)		
	WR 0.2	CR 28.2	CR 10.5
10-May	0.086	0.16	0.044
12-Jul	0.13	0.90	0.023
16-Aug	0.098	0.77	0.026
22-Oct	0.066	0.22	0.026
2001 Arithmetic Average	0.10	0.51	0.03
2001 Flow Weighted Mean	0.09	0.27	0.04
2000 Flow Weighted Mean	0.07	0.30	0.04

TABLE 3B
2001 STREAM WATER QUALITY - FECAL COLIFORM AND FECAL STREPTOCOCCUS

Clearwater River Watershed District

Fecal Coliform (cfu/100 mL)						
	WR 0.2	CR 32.5	CR 30.0	CR 28.2	CR 23.8	CR 10.5
Notes	1			1	1	
7-May	2	12	180	410	460	Not Sampled
6-Jun	18	56	150	56	16	Not Sampled
11-Jul	280	Not Sampled	Not Sampled	34	Not Sampled	4
15-Oct	410	26	12	140	72	Not Sampled
Geometric Mean	45	26	69	102	81	4
2001 Average	178	31	114	160	183	4
2000 Average	624	134	225	489	343	Not Sampled

	WC-1	WC-2	WC-3	WC-4	WC-5	WC-6
Notes	1 and 2	1	1	1	1	1
16-Jul	52	22	360	24	240	130
1-Aug	2300	3400	5000	1100	1300	40
30-Aug	720	1400	360	100	200	230
12-Sep	8	200	270	20	34	360
10-Oct	2	10	240	180	540	400
17-Oct	< 2	4	2	28	36	360
Geometric Mean	67	97	209	80	186	199
2001 Average	514	839	1039	242	392	253

Fecal Streptococcus (cfu/100 mL)						
	WC-1	WC-2	WC-3	WC-4	WC-5	WC-6
Notes	2	2	2	2	2	2
1-Aug	< 2	< 2	< 2	< 2	< 2	< 2
30-Aug	< 2	< 2	< 2	< 2	< 2	< 2
12-Sep	< 2	< 2	< 2	< 2	< 2	< 2
10-Oct	< 2	< 2	< 2	< 2	< 2	< 2
17-Oct	< 2	< 2	< 2	< 2	< 2	< 2
Geometric Mean	1	1	1	1	1	1
2001 Average	1	1	1	1	1	1

Notes:

1. Exceeds State Standard of 200 cfu/100 mL.
2. Used 1 cfu/100 mL for lab value of < 2 cfu/100 mL.

TABLE 4
HISTORICAL SUMMARY OF STREAM FLOWS, PHOSPHORUS CONCENTRATIONS, AND LOADINGS

Clearwater River Watershed District

Station	Year	Average Stream Flow (cu m/sec)	Average Stream Flow (cfs)	Average Total Phosphorus Concentration (mg/l)	Total Phosphorus Load (kg)	Total Phosphorus Load (lb)
Main Stem:						
CR 28.2	1981 (1)	--	--	1.40	--	--
	1982 (1)	0.93	32.8	0.74	19,700	43,500
	1983	2.62	92.6	0.92	76,000	168,000
	1984	1.49	52.6	0.76	35,700	78,800
	1985	2.32	81.9	0.90	65,500	144,000
	1986	3.20	113	0.78	55,200	122,000
	1987	0.11	3.90	0.13	460	1,020
	1988	0.09	3.12	0.66	1,850	4,080
	1989	0.02	0.72	0.19	120	260
	1990	0.51	18.0	0.44	7,040	15,500
	1991	1.11	39.1	0.29	10,200	22,500
	1992	0.26	9.30	0.20	1,660	3,650
	1993	1.28	45.2	0.29	11,600	25,600
	1994	1.17	41.2	0.28	10,100	22,300
	1995	1.15	40.4	0.29	10,400	22,900
	1996	0.33	11.7	0.27	2,860	6,300
	1997	0.27	9.36	0.26	2,170	4,790
	1998	0.41	14.4	0.25	3,190	7,020
	1999	0.08	2.78	0.16	400	870
	2000	0.02	0.72	0.38	240	530
	2001 (4),(5)	0.27	9.46	0.51	4,309	9,500
CR 10.5	1981 (1)	1.15	40.6	0.05	2,060	4,550
	1982 (1)	2.20	77.8	0.07	4,990	11,000
	1983	5.64	199	0.10	18,500	40,800
	1984	4.28	151	0.05	6,620	14,600
	1985	3.88	137	0.14	16,700	36,800
	1986	5.52	195	0.15	23,700	52,300
	1987	0.46	16.2	0.04	600	1,320
	1988	0.23	7.95	0.04	260	580
	1989	0.97	34.2	0.08	2,340	5,150
	1990	3.77	133	0.03	3,060	6,750
	1991	6.68	236	0.05	10,500	23,200
	1992	4.16	147	0.06	8,090	17,800
	1993	5.01	177	0.04	6,330	14,000
	1994	2.92	103	0.03	2,850	6,290
	1995	2.83	100	0.03	3,040	6,710
	1996	1.53	54.2	0.04	1,970	4,350
	1997	2.06	72.8	0.04	2,690	5,940
	1998	1.78	63.0	0.04	2,330	5,120
	1999	1.25	44.1	0.04	1,520	3,350
	2000	0.31	10.8	0.03	280	610
	2001 (4),(5)	0.90	31.7	0.03	850	1,873

TABLE 4
HISTORICAL SUMMARY OF STREAM FLOWS, PHOSPHORUS CONCENTRATIONS, AND LOADINGS

Clearwater River Watershed District

Station	Year	Average Stream Flow (cu m/sec)	Average Stream Flow (cfs)	Average Total Phosphorus Concentration (mg/l)	Total Phosphorus Load (kg)	Total Phosphorus Load (lb)
Tributaries:						
WR 0.2 (2)	1981 (1)	0.07	2.60	0.17	390	860
	1982 (1)	0.23	8.20	0.16	780	1,720
	1983	0.47	16.50	0.09	1,270	2,800
	1984	0.60	21.20	0.05	950	2,100
	1985	0.48	17.10	0.14	2,130	4,700
	1986	0.86	30.40	0.20	4,630	10,200
	1987	0.04	1.50	0.07	100	230
	1988	0.01	0.40	0.17	60	130
	1989	0.03	1.19	0.14	80	180
	1990	0.06	2.28	0.37	750	1,660
	1991	0.26	9.22	0.11	860	1,900
	1992	0.11	4.02	0.05	170	370
	1993	0.24	8.59	0.10	760	1,670
	1994	0.18	6.34	0.06	320	700
	1995	0.12	4.27	0.05	210	460
	1996	0.05	1.78	0.11	180	380
	1997	0.09	3.15	0.08	220	480
	1998	0.09	3.11	0.11	290	650
	1999	0.06	2.03	0.07	130	280
	2000 (3)	0.01	0.44	0.06	25	56
	2001 (4),(5)	0.08	2.88	0.10	257	567

NOTES:

Flow values are time-weighted averages unless otherwise noted.
Total phosphorus values are flow- and time-weighted averages unless otherwise noted.

(1) Values in 1981 and 1982 are arithmetic means
(2) Station WR 0.2 was designated Station WC 0.2 in 1981-1983
(3) Phosphorus values in 2000 are flow-weighted and adjusted per log-log regression on flow so as to correspond to annual mean flows.
(4) 2001 Flow and total phosphorus values are arithmetic averages.
(5) 2001 total phosphorus loads estimated from arithmetic averages of flow and total phosphorus values.

TABLE 5
2001 SUMMARY OF LAKE SURFACE WATER QUALITY

Clearwater River Watershed District

	Total Phosphorus (micrograms/liter)			
	July 18 and 19	August 27 and 28	Mean	Std. Dev.
Lake Augusta	52	44	48	6
Bass Lake	27	22	25	4
Lake Betsy	680	160	420	368
Lake Caroline (SWCD) (1)	---	---	43	18
Cedar Lake	29	22	26	5
Clearwater Lake East	22	58	40	25
Clearwater Lake West	34	49	42	11
Lake Louisa	54	11	33	30
Nixon Lake	22	20	21	1
Otter Lake	13	41	27	22

	Chlorophyll-*a* (micrograms/liter)			
	July 18 and 19	August 27 and 28	Mean	Std. Dev.
Lake Augusta	6.4	6.4	6.4	0
Bass Lake	2.1	3.2	2.7	1
Lake Betsy	5.3	3.2	4.3	1
Lake Caroline (SWCD) (1)	---	---	12	10
Cedar Lake	5.3	6.4	5.9	1
Clearwater Lake East	6.4	6.9	6.7	0
Clearwater Lake West	8.5	6.4	7.5	1
Lake Louisa	2.5	7.6	5.1	4
Nixon Lake	3.7	7.5	5.6	3
Otter Lake	4.8	3.2	4.0	1

	Secchi Depth (feet)			
	July 18 and 19	August 27 and 28	Mean	Std. Dev.
Lake Augusta	6	6	6.0	0.0
Bass Lake	15	12.5	13.8	1.8
Lake Betsy	1.5	1.5	1.5	0.0
Lake Caroline (SWCD) (1)	---	---	5.8	2.7
Cedar Lake	5	7	6.0	1.4
Clearwater Lake East	8.5	7.5	8.0	0.7
Clearwater Lake West	4.5	4.5	4.5	0.0
Nixon Lake	10.5		10.5	
Otter Lake	9	9.5	9.3	0.4

TABLE 5
2001 SUMMARY OF LAKE SURFACE WATER QUALITY

Clearwater River Watershed District

	Trophic Status Index			
	TP	**Chl-*a***	**Secchi Depth**	**Average**
Lake Augusta	22.4	42.2	43.8	36.1
Bass Lake	21.8	41.4	42.9	35.4
Lake Betsy	24.6	41.8	45.2	37.2
Lake Caroline (SWCD) (1)	22.3	42.9	43.8	36.3
Cedar Lake	21.8	42.1	43.8	35.9
Clearwater Lake East	22.3	42.3	43.5	36.0
Clearwater Lake West	22.3	42.4	44.1	36.3
Lake Louisa	22.1	42.0	Not Sampled	32.0
Nixon Lake	21.6	42.1	43.2	35.6
Otter Lake	22.0	41.8	43.3	35.7

(1) Five sampling events

TABLE 6
HISTORICAL SUMMARY OF LAKE WATER QUALITY DATA
Summer (June-September) Epilimnetic Means

Clearwater River Watershed District

LAKE/ Year	Number of Samples	Total Phosphorous (ug/l) Mean (3)	Total Phosphorous (ug/l) Std. Dev.	Chlorophyll-a (ug/l) Mean	Chlorophyll-a (ug/l) Std. Dev.	Secchi Disk Transparency (m) Mean	Secchi Disk Transparency (m) Std. Dev.
AUGUSTA							
1981	7	260	400	25	14	1.4	0.3
1982	7	140	120	34	21	1.4	0.6
1983	7	300	90	4	3	1.8	1.0
1984	7	90	30	4	2	1.6	0.8
1985	7	120	120	23	12	1.2	0.2
1986	6	90	40	69	91	1.9	0.5
1987	7	30	10	20	12	1.3	0.3
1988	5	40	10	19	6	1.4	0.3
1989	6	80	30	26	40	1.5	0.4
1990	5	90	20	73	105	1.7	0.7
1991	3	80	40	56	73	1.1	0.4
1992	8	30	20	19	6	1.6	0.7
1993	4 (1)	68	20	42	19	1.2	0.4
1995	4 (2)	28 (4)	15	21	12	1.8	0.7
1997	4	46 (4)	13	20 (5)	1	1.7	0.2
1999	4(6)	37	4	8.5	2.7	1.6	0.2
2001	2	48	6	6.4	0.0	1.8	0.0
Mean		93	58	28	25	1.5	0.4
BASS							
1994	4	13 (4)	14	4.8	0.8	3.2	0.4
1998	4	28	11	2.0	1.0	3.1	0.6
1999	3	22	5	2.9	1.4	3.1	0.7
2001	2	25	4	2.7	1.0	4.2	1.8
Mean		22	9	3.1	1.1	3.4	0.9
BETSY							
1981	7	700	190	7.7	5.6	2.4	1.1
1982	7	650	90	59	50	1.3	0.7
1983	7	560	270	5	4	1.1	1.3
1984	7	350	160	7	5	0.8	0.2
1985	7	280	230	30	26	1.1	0.6
1987	2	120	0	74	35	0.87	0.41
1995	4 (2)	290	183	18	13	1.0	0.34
1997	4	245	108	100 (5)	98	0.83	0.05
1999	3(8)	247	110	170	85	0.8	0.2
2001	2	420	368	4.3	1	0.46	0.0
Mean		386	171	47	32	1.1	0.5
CAROLINE							
1981	7	220	100	39	33	1.3	0.3
1982	7	260	140	54	35	1.4	0.8
1983	7	300	140	3	3	1.8	1.1
1984	7	140	50	5	2	1.3	0.3
1985	7	170	150	41	46	1.5	0.6
1987	2	50	10	46	30	1.1	0.4
1994	4	40	18	55	16	0.8	0.2
1996	4	88	33	36	12	1.2	0.2
1998	4	86	24	55	43	1.2	0.1
2001 (SCWD)	5	43	18	12	10	1.8	0.8
Mean		140	68	35	23	1.3	0.5

TABLE 6
HISTORICAL SUMMARY OF LAKE WATER QUALITY DATA
Summer (June-September) Epilimnetic Means

Clearwater River Watershed District

LAKE/ Year	Number of Samples	Total Phosphorous (ug/l) Mean (3)	Total Phosphorous (ug/l) Std. Dev.	Chlorophyll-a (ug/l) Mean	Chlorophyll-a (ug/l) Std. Dev.	Secchi Disk Transparency (m) Mean	Secchi Disk Transparency (m) Std. Dev.
CEDAR							
1993	4	30	10	13.3	5.9	3.0	0.4
1996	4	33	8	12.9	6.5	2.4	0.3
1999	4	31	8	9.5	4.4	1.1	0.2
2001	2	26	5	5.9	1.0	1.8	1.4
Mean		30	8	10	4	2.1	0.6
CLEARWATER EAST							
1981	7	60	20	11	8	2.6	0.7
1982	7	60	30	12	9	2.7	1.6
1983	7	90	50	3	2	2.4	1.8
1984	7	90	40	4	2	1.4	0.2
1985	7	130	60	39	28	1.2	0.3
1986	6	80	40	85	132	2.1	0.8
1987	7	30	10	18	20	2.6	1.2
1988	5	40	10	10	5	2.9	1.8
1989	6	60	20	5	4	3.0	1.9
1990	5	90	100	18	9	2.0	0.6
1991	3	50	20	10	7	1.4	0.2
1992	8	30	10	20	10	2.0	0.6
1993	4 (1)	43	15	42	38	1.5	0.8
1994	4	23	5	14	9	1.4	0.2
1995	4 (2)	30	8	16	10	1.6	0.4
1996	4	33	8	10	3	2.1	0.3
1997	4	52	17	8 (5)	2	1.6	0.2
1998	4 (6)	36	18	11	3	1.9	0.4
1999	4	54	6	9.9	2.1	1.8	0.2
2000	4	33	18	10.3	3.4	2.3	1.0
2001	2	40	25	6.7	0.0	2.4	0.7
Mean		55	25	17.3	14.5	2.0	0.7
CLEARWATER WEST							
1981	7	60	20	45	71	2.6	0.9
1982	7	100	60	29	25	1.7	0.7
1983	7	160	100	4	5	1.8	1.4
1984	7	70	30	4	2	1.4	0.2
1985	7	110	80	24	17	1.9	1.3
1986	6	50	20	77	137	2.6	1.0
1987	7	40	10	20	12	2.0	0.4
1988	5	40	10	17	10	2.6	1.2
1989	6	70	10	8	4	2.3	0.9
1990	5	50	20	31	15	1.9	0.8
1991	3	60	40	18	12	1.5	0.0
1992	8	60	70	29	24	1.9	0.6
1993	4 (1)	40	0	29	6	1.4	0.3
1994	4	33	15	17	8	1.5	0.2
1995	4 (2)	35	11	21	10	1.4	0.3
1996	4	43	11	9	2	2.0	0.3
1997	4	44	3	13	6	1.5	0.1
1998	4 (7)	34	11	14	3	1.5	0.1
1999	4(6)	31	4	10.2	2.0	1.6	0.3
2000	4	41	31	9	2.9	1.9	0.4
2001	2	42	11	8	1.0	1.4	0.0
Mean		58	27	20.7	19.5	1.8	0.6

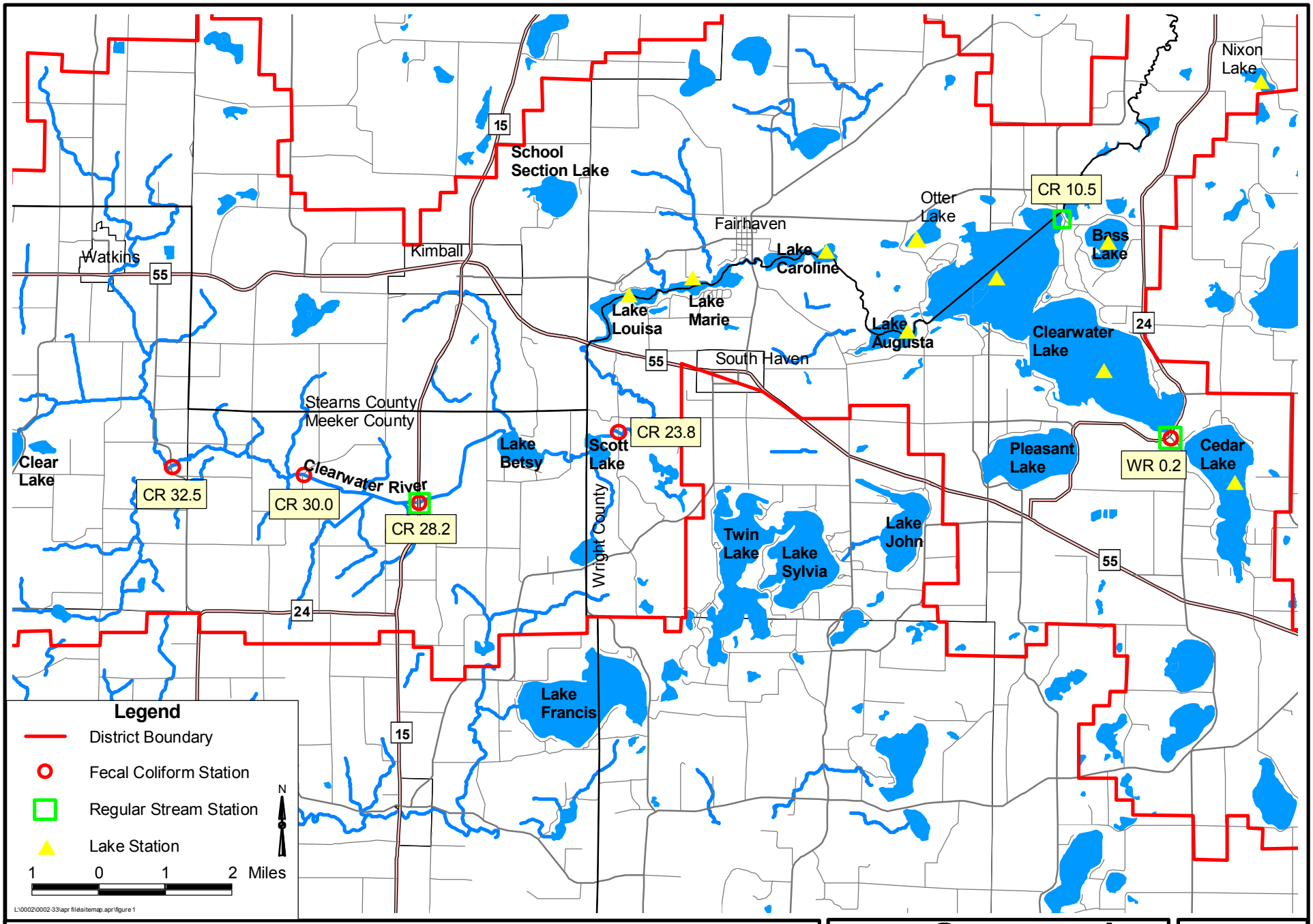
TABLE 6
HISTORICAL SUMMARY OF LAKE WATER QUALITY DATA
Summer (June-September) Epilimnetic Means

Clearwater River Watershed District

LAKE/ Year	Number of Samples	Total Phosphorous (ug/l) Mean (3)	Total Phosphorous (ug/l) Std. Dev.	Chlorophyll-a (ug/l) Mean	Chlorophyll-a (ug/l) Std. Dev.	Secchi Disk Transparency (m) Mean	Secchi Disk Transparency (m) Std. Dev.
LOUISA							
1981	7	440	110	39	29	1.4	0.4
1982	7	420	140	68	26	1.5	0.5
1983	7	410	170	4	4	1.4	1.4
1984	7	220	80	8	6	1.0	0.1
1985	7	160	100	26	17	1.1	0.3
1986	6	190	50	96	86	1.1	0.1
1987	7	100	10	70	44	0.8	0.2
1988	5	140	60	101	39	0.6	0.3
1989	6	110	40	69	78	0.8	0.5
1990	5	200	80	55	35	1.3	0.5
1991	3	160	70	31	18	1.5	0.3
1992	8	140	140	46	22	1.1	0.3
1993	4 (1)	170	40	35	13	1.2	0.2
1995	4 (2)	100	36	75	27	0.8	0.2
1997	4	68	7	59 (5)	8	0.9	0.2
1999	4	73	29	37.8	20	1	0.1
2001	2	33	30	5.1	4		
Mean		184	70	48.5	28.0	1.1	0.3
NIXON							
1994	4	25 (4)	25	5.0 (4)	3.4	1.8	0.7
1997	4	30	8	4.7 (5)	1.5	2.8	0.2
1999	4	39	17	7.0	8.7	3.3	0.5
2001	2	21	1	5.6	3.0	3.2 (8)	
Mean		28.8	12.8	5.6	4.2	2.8	0.5
OTTER							
1994	4	13 (4)	4	7.8	1.8	1.9	0.3
1997	4	23	10	3.7 (5)	1.5	2.1	0.3
1999	4	34	5	6.6	4.8	3.0	0.4
2001	2	30	22	4.0	1.0	2.8	0.4
Mean		25	10	6	2	2	0.4

Notes:
(1) The fourth sample was collected on October 6, 1993.
(2) The fourth sample was collected on October 2 or 3, 1995
(3) Starting in 1993, Total phosphorus means are rounded to two significant figures. Prior to 1993, the mean values were rounded to the nearest 10 ug/l.
(4) Values reported as "Less than" the detection limit were estimated as half of the detection limit.
(5) Three samples were analyzed for chlorophyll-a.
(6) Three samples were analyzed for total phosphorus.
(7) Three secchi disk readings were recorded.
(8) One secchi disk reading was recorded.

Figures



CLEARWATER RIVER WATERSHED DISTRICT

2001 Regular Stream and Lake Monitoring Locations

Wenck

Wenck Associates, Inc.
Environmental Engineers

1800 Pioneer Creek Center
Maple Plain, MN 55359-0429

JAN 2002

Figure 1

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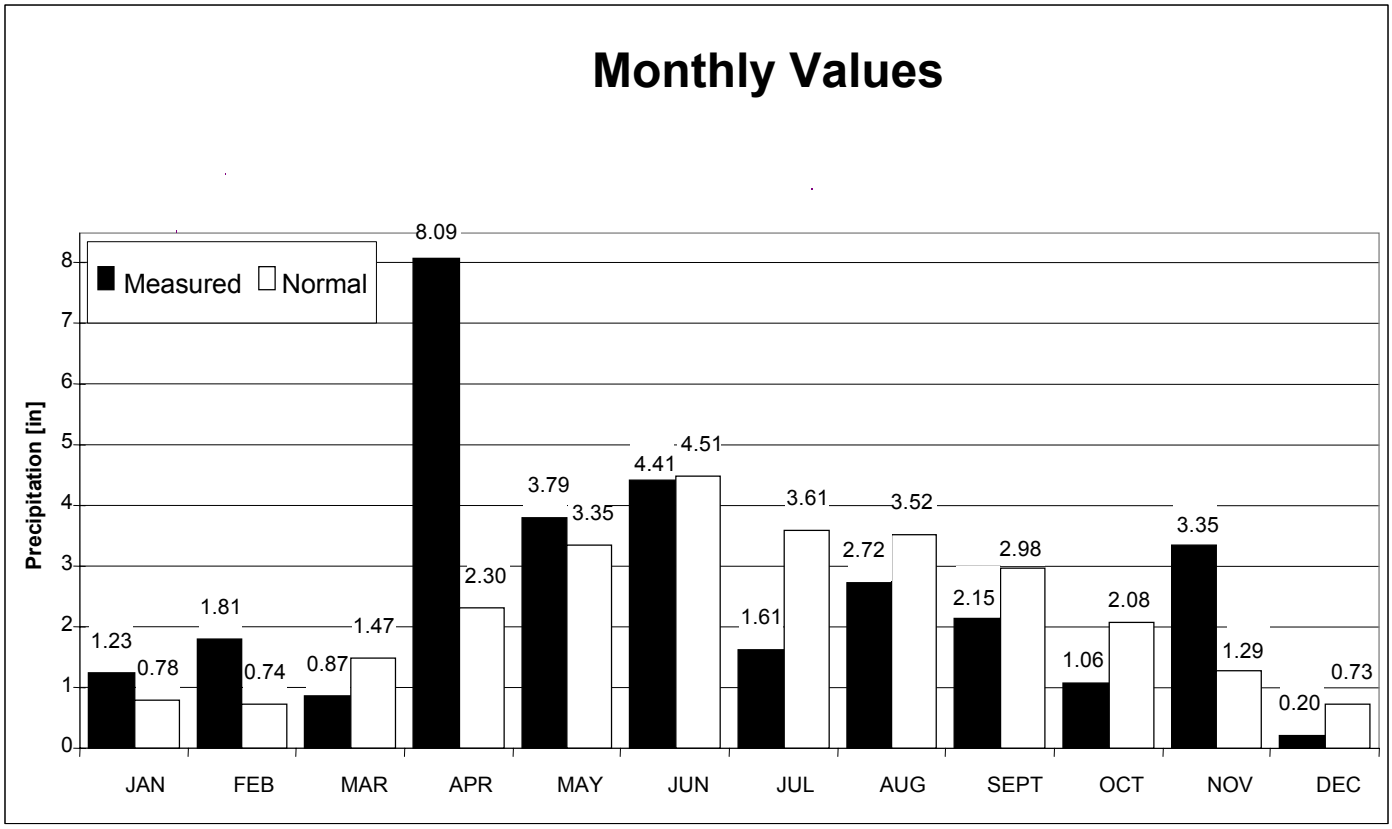
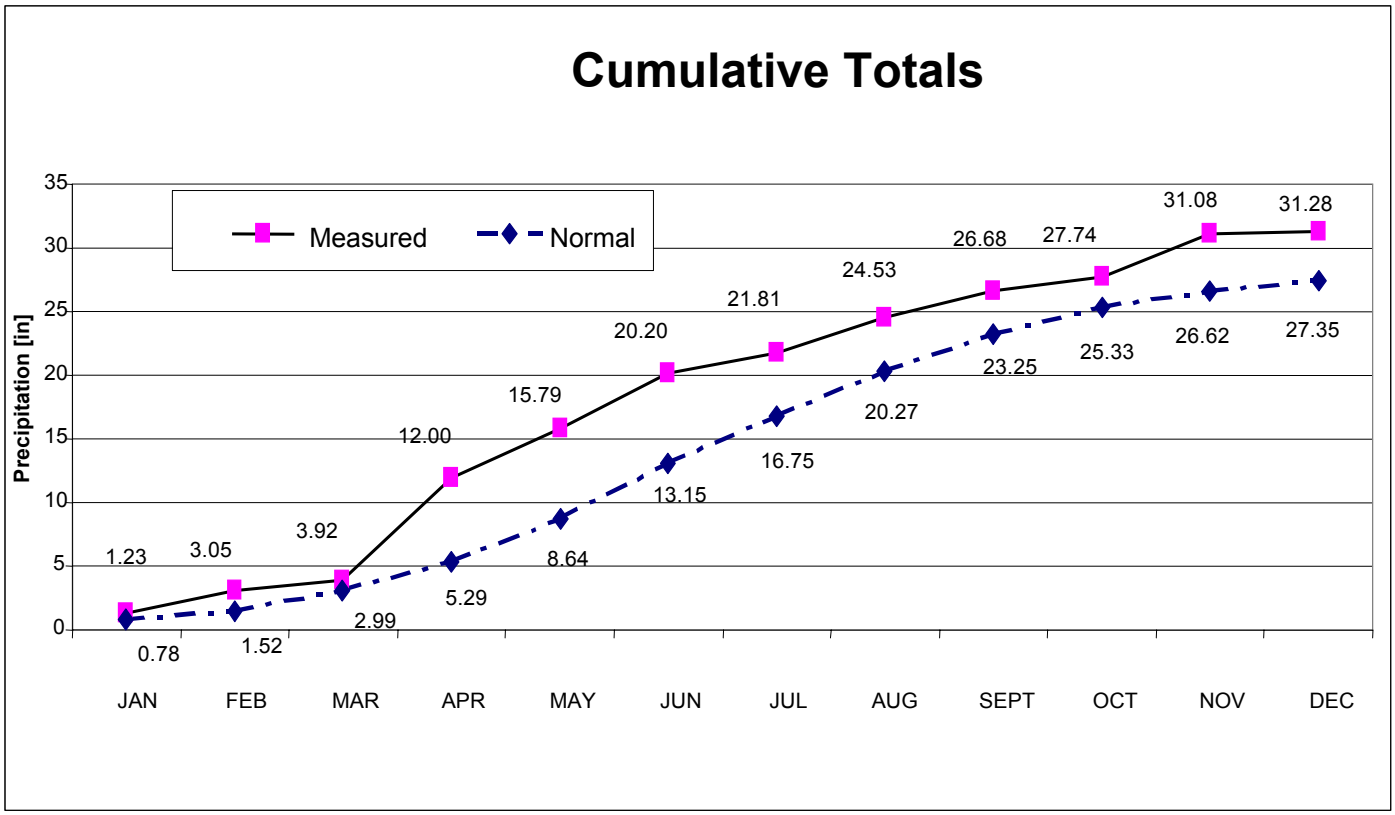
CLEARWATER RIVER WATERSHED DISTRICT	Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359-0249	JAN 2002
2001 Warner Creek Monitoring Locations		Figure 2





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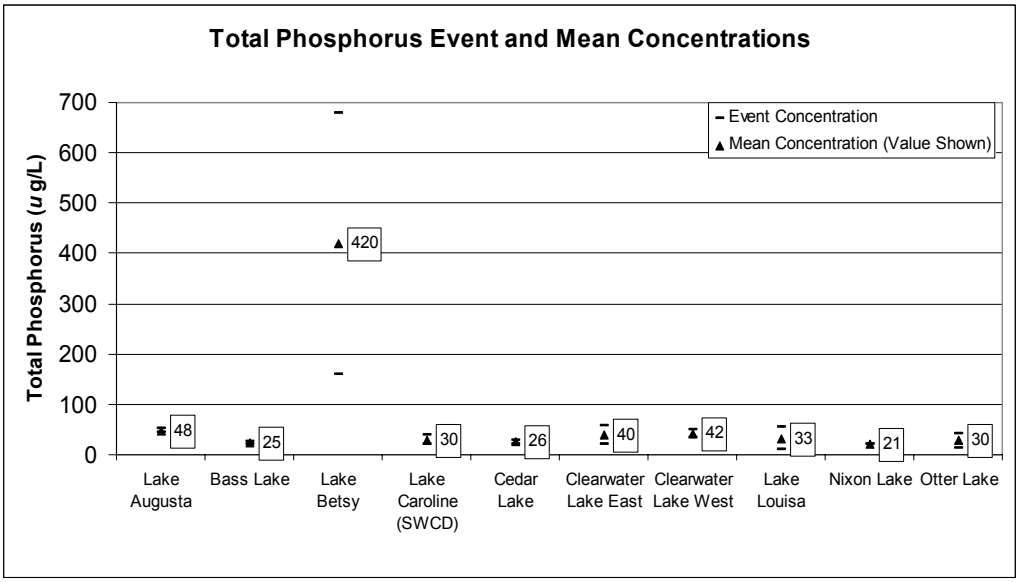
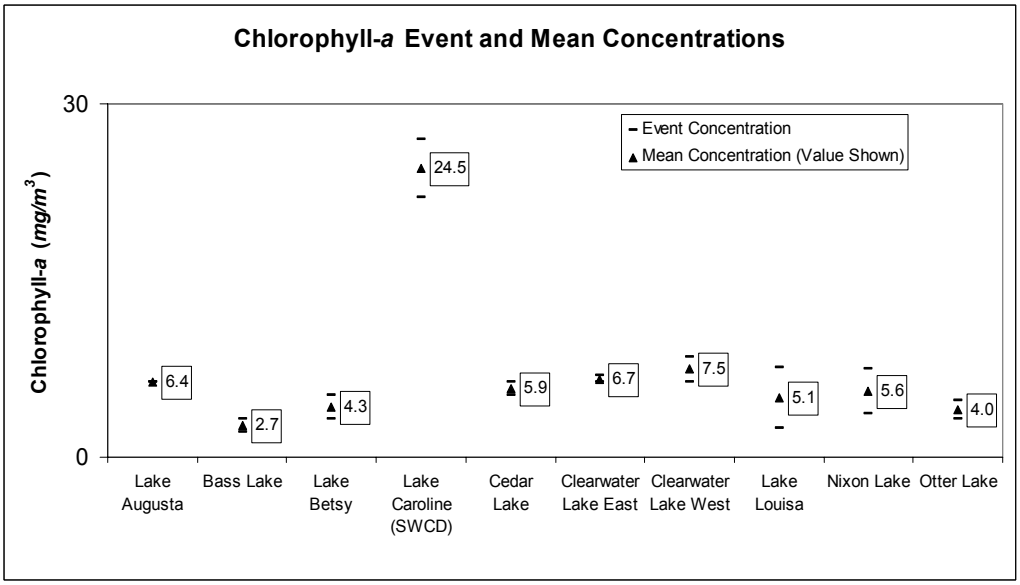
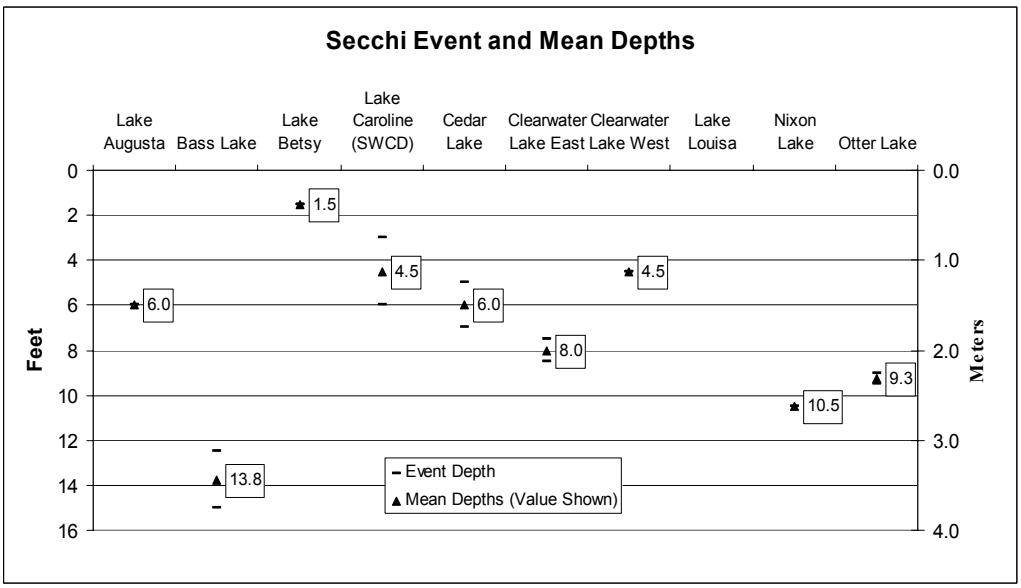
CLEARWATER RIVER WATERSEHD DISTRICT	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	JAN 2002
2001 Precipitation Data		Figure 3







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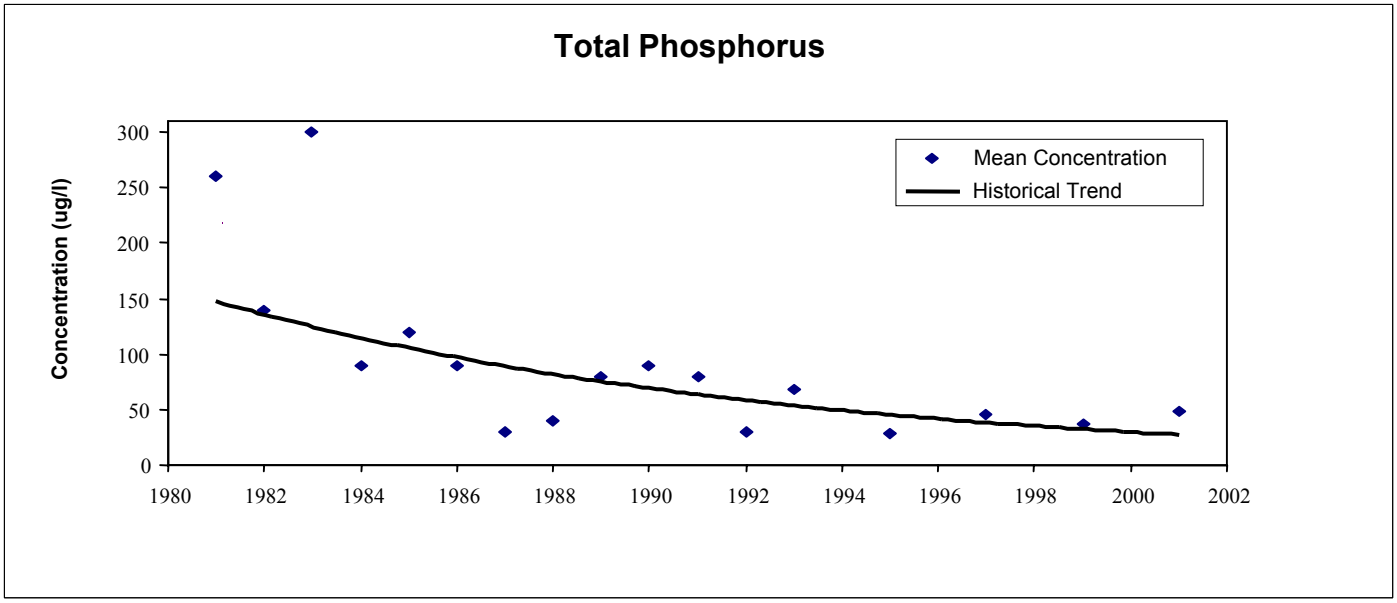
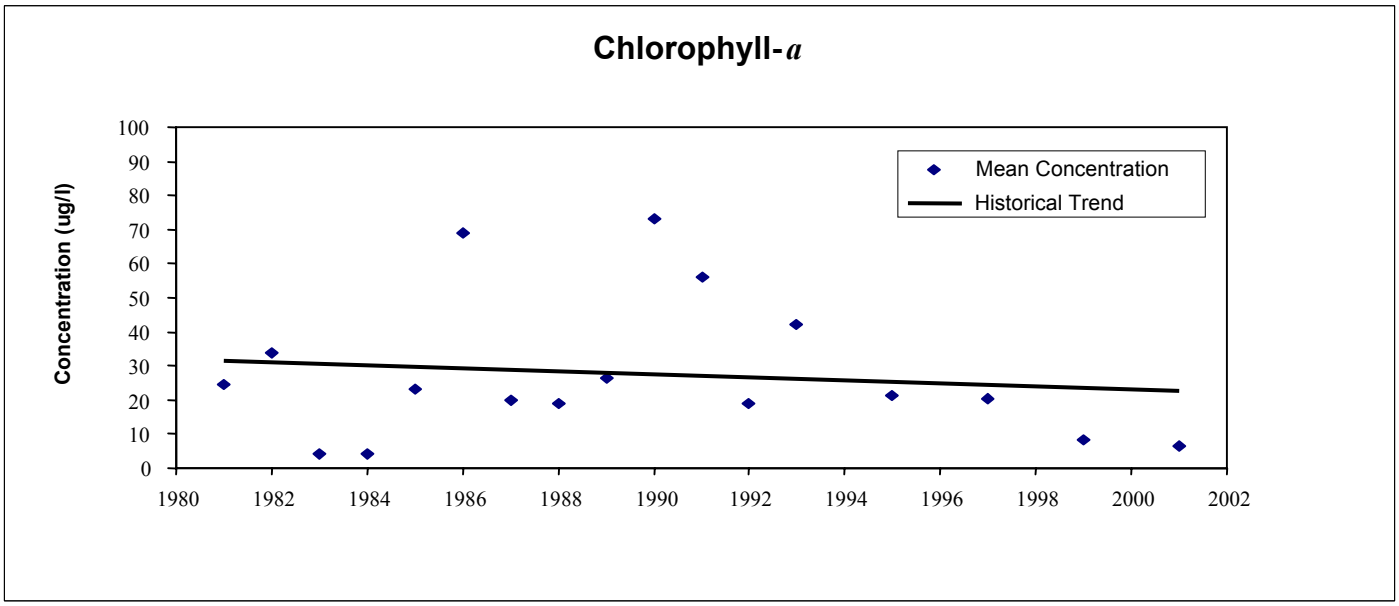
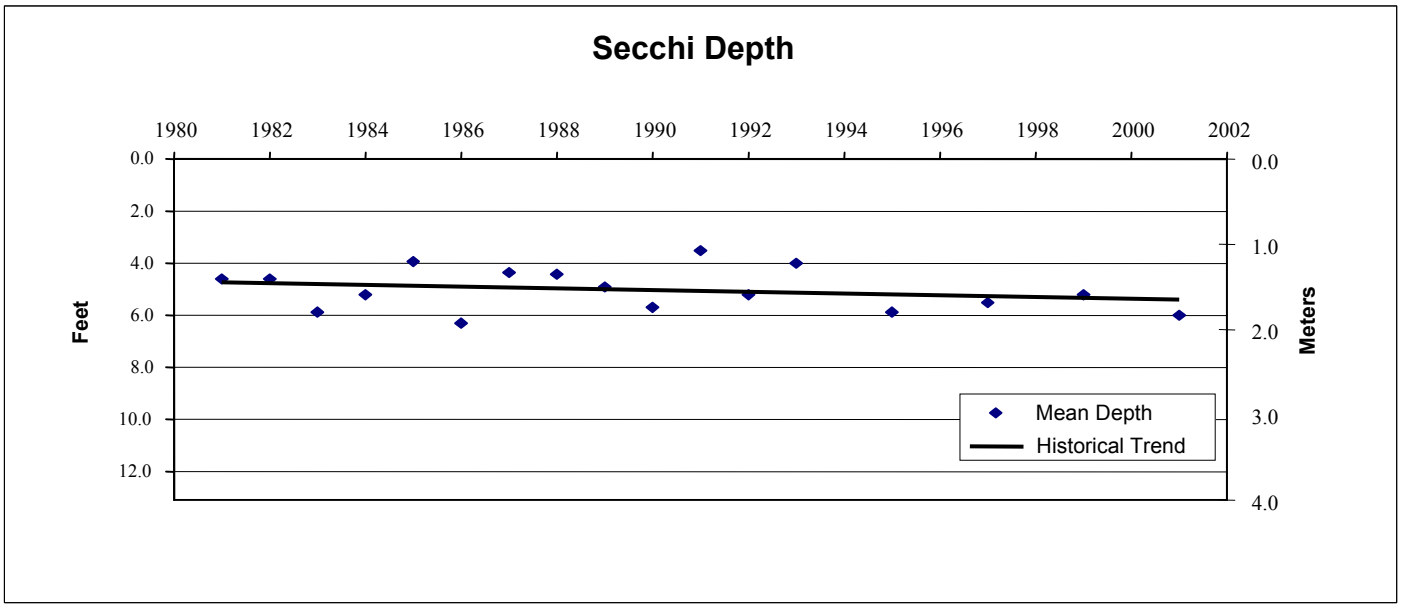
CLEARWATER RIVER WATERSHED DISTRICT	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	JAN 2002
2001 Graphical Summary of Lake Water Quality		Figure 4







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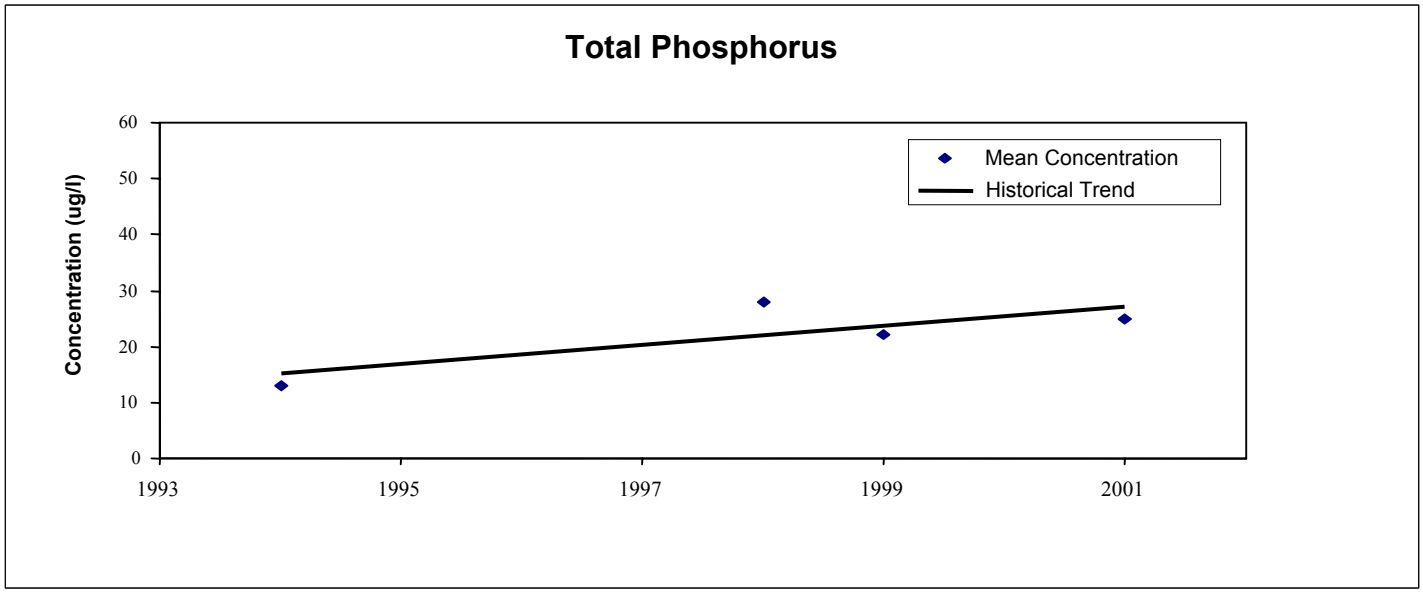
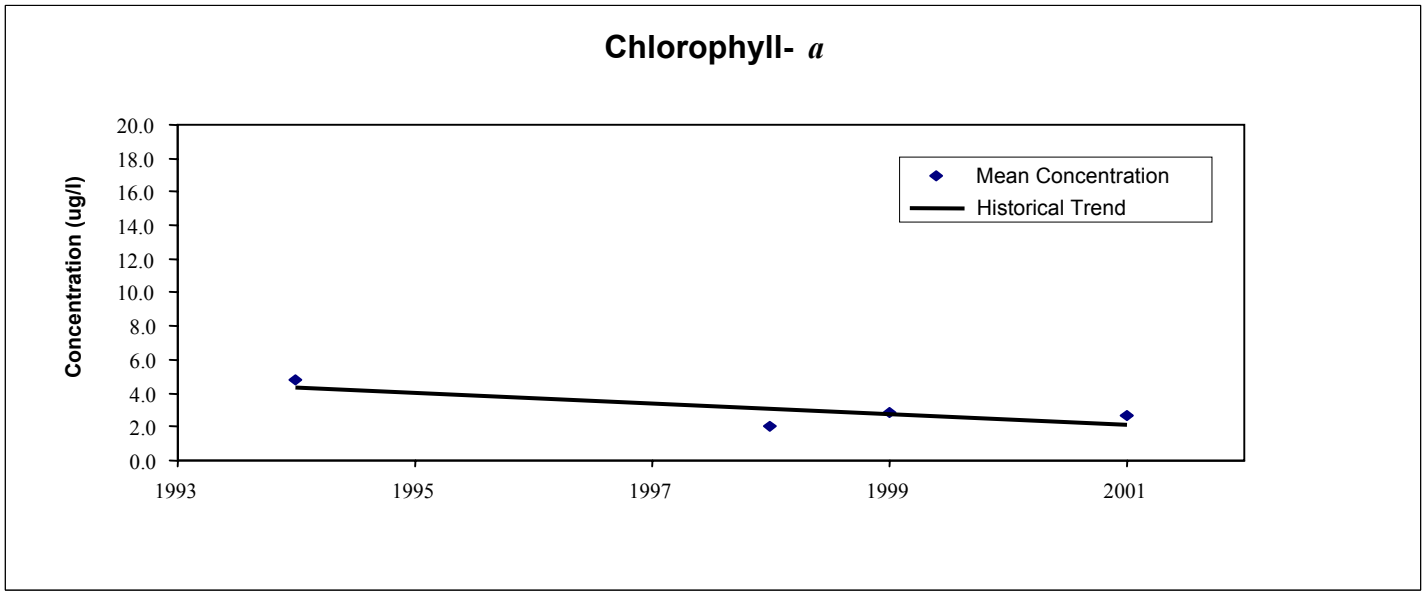
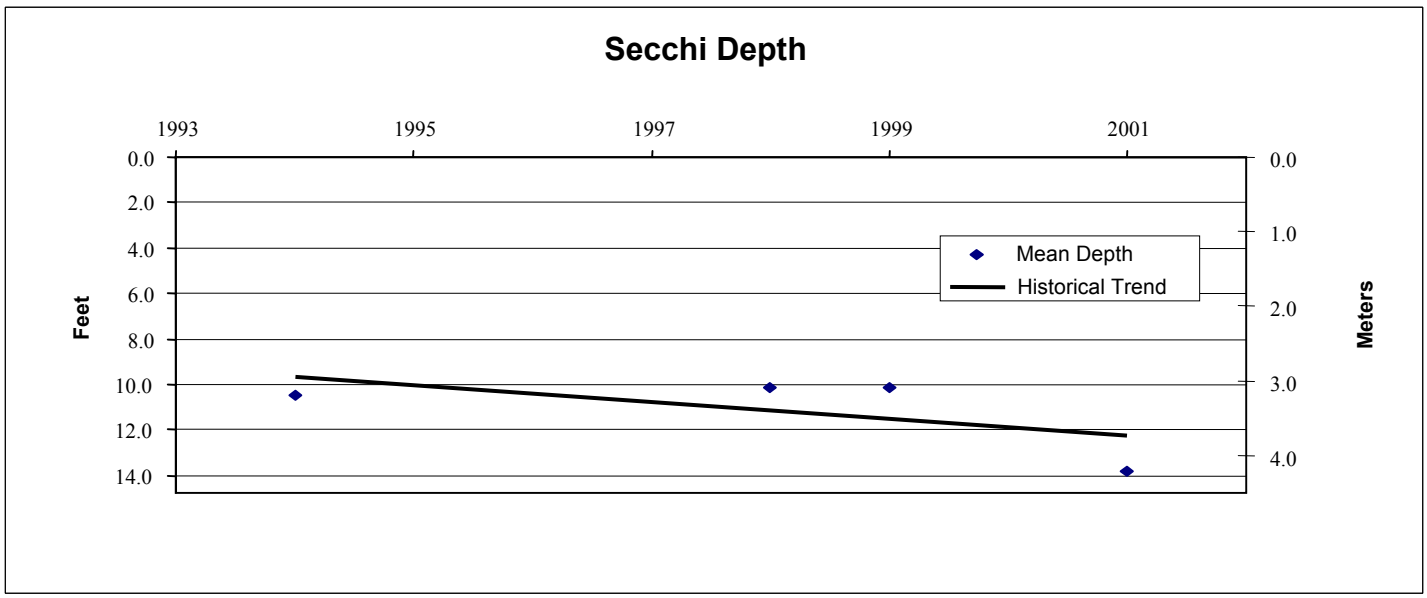
CLEARWATER RIVER WATERSEHD DISTRICT	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	JAN 2002
Lake Augusta Historical Data		Figure 5







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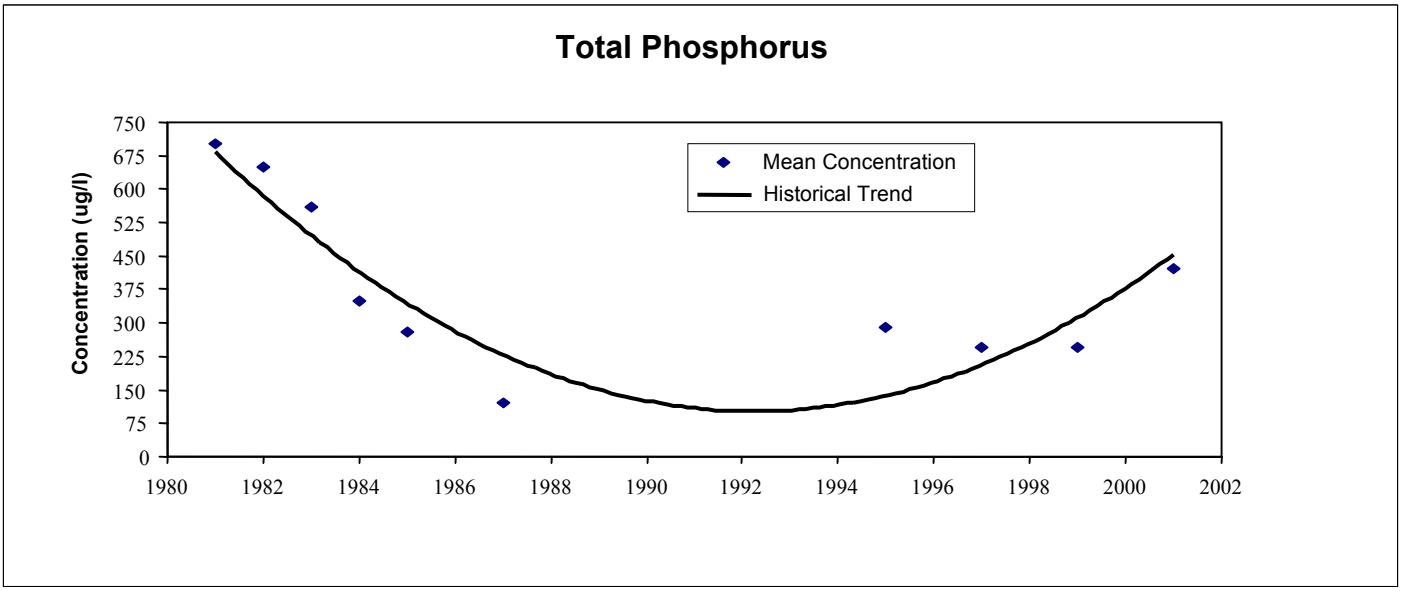
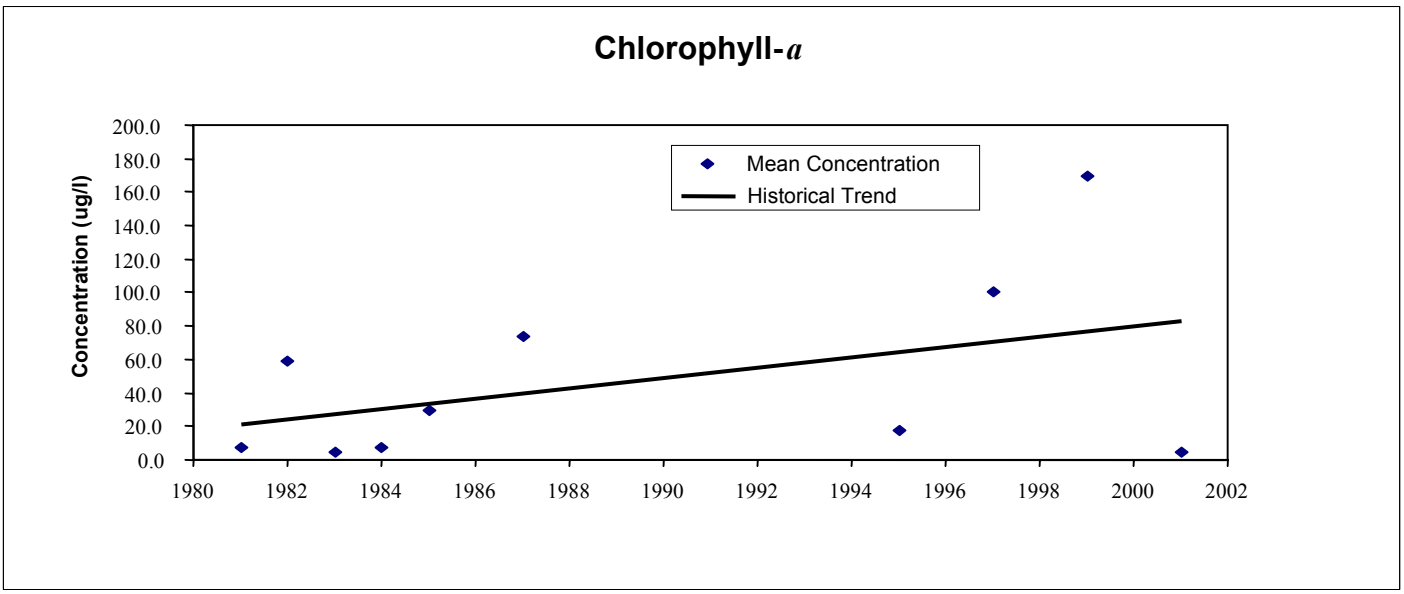
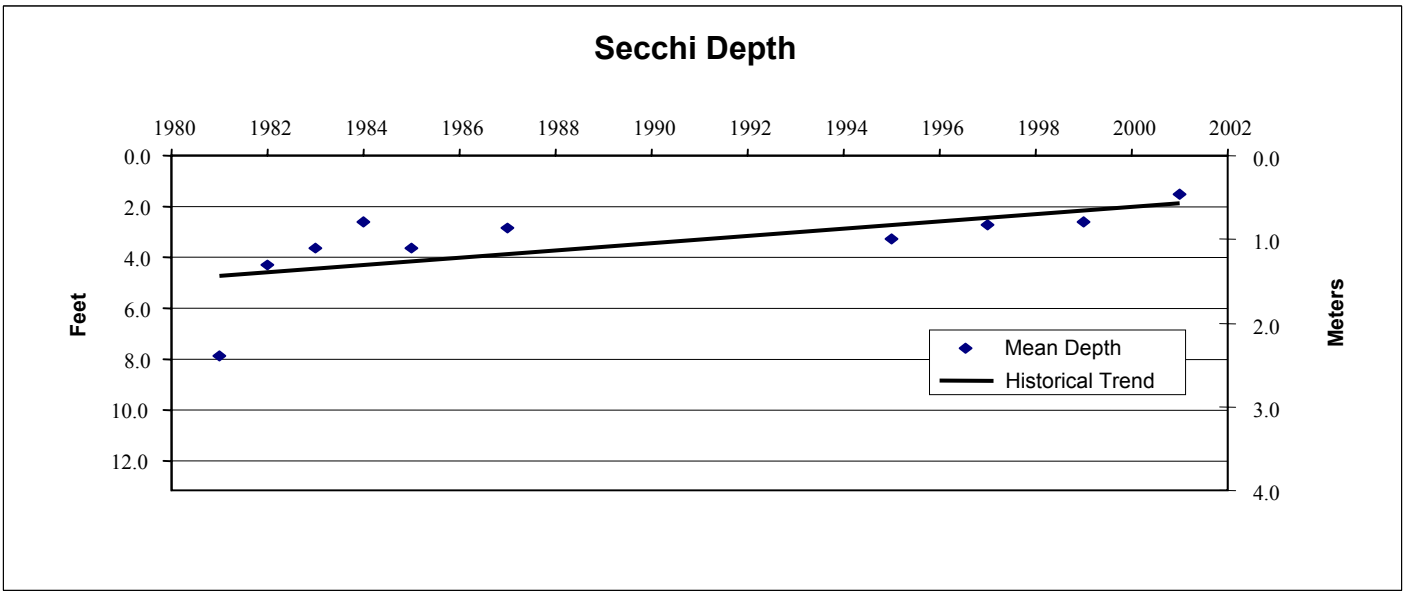
CLEARWATER RIVER WATERSEHD DISTRICT	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	JAN 2002
Bass Lake Historical Data		Figure 6







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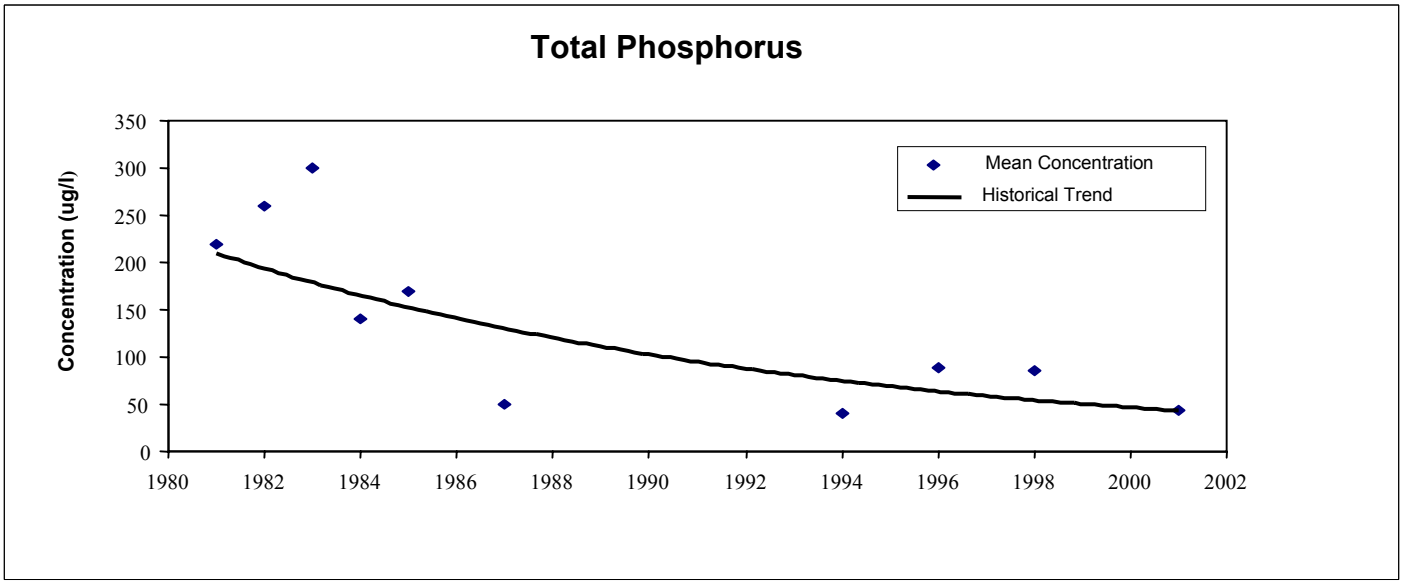
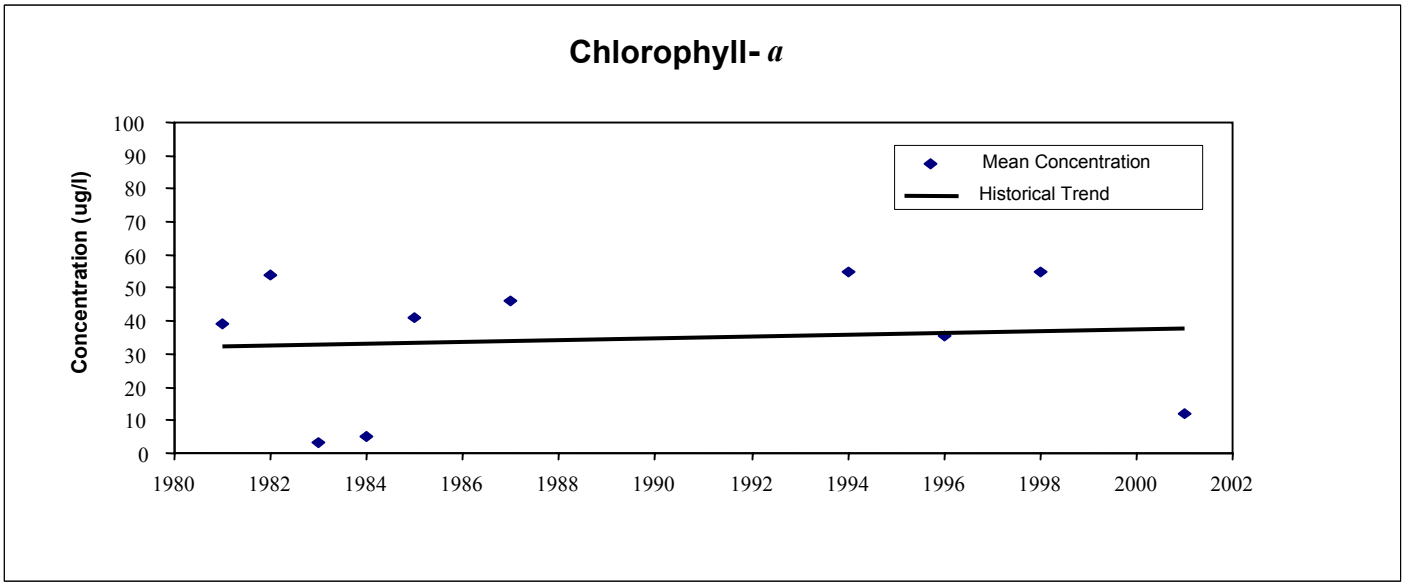
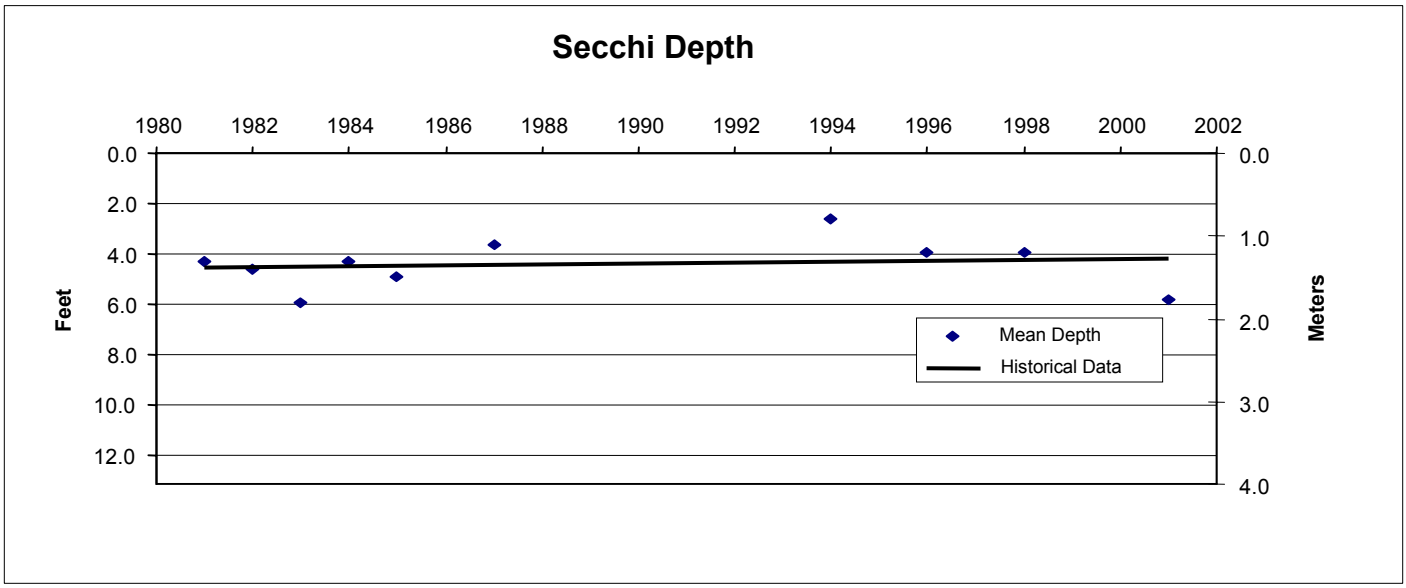
CLEARWATER RIVER WATERSEHD DISTRICT	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	JAN 2002
Lake Betsy Historical Data		Figure 7







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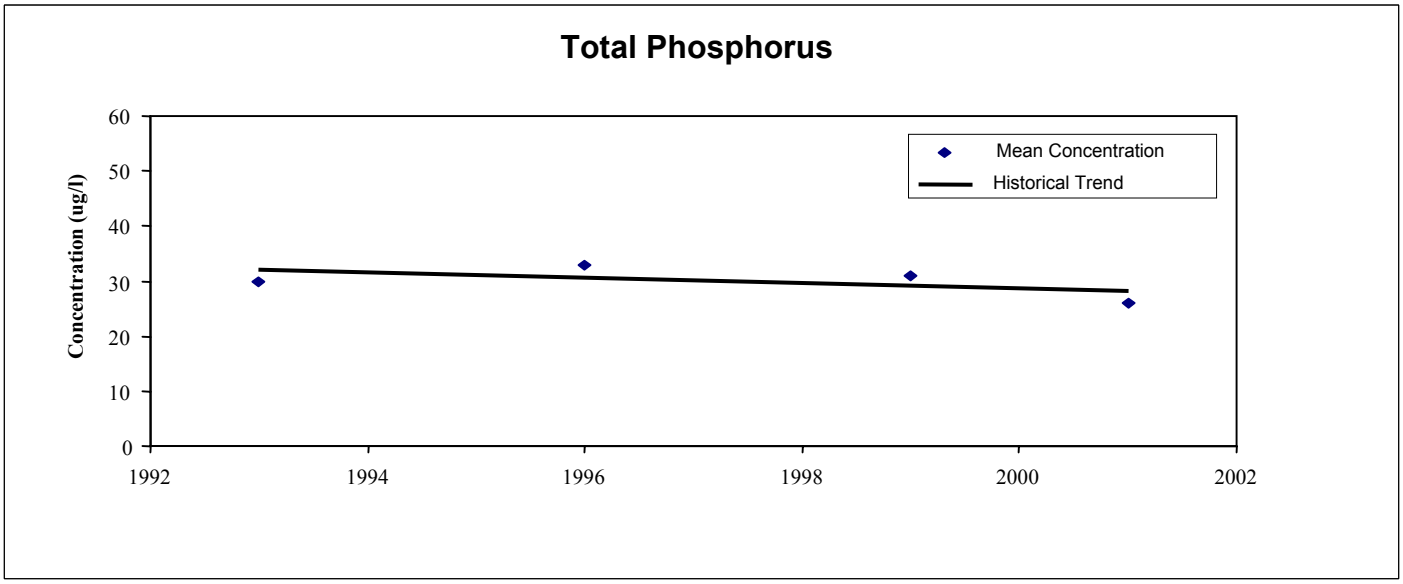
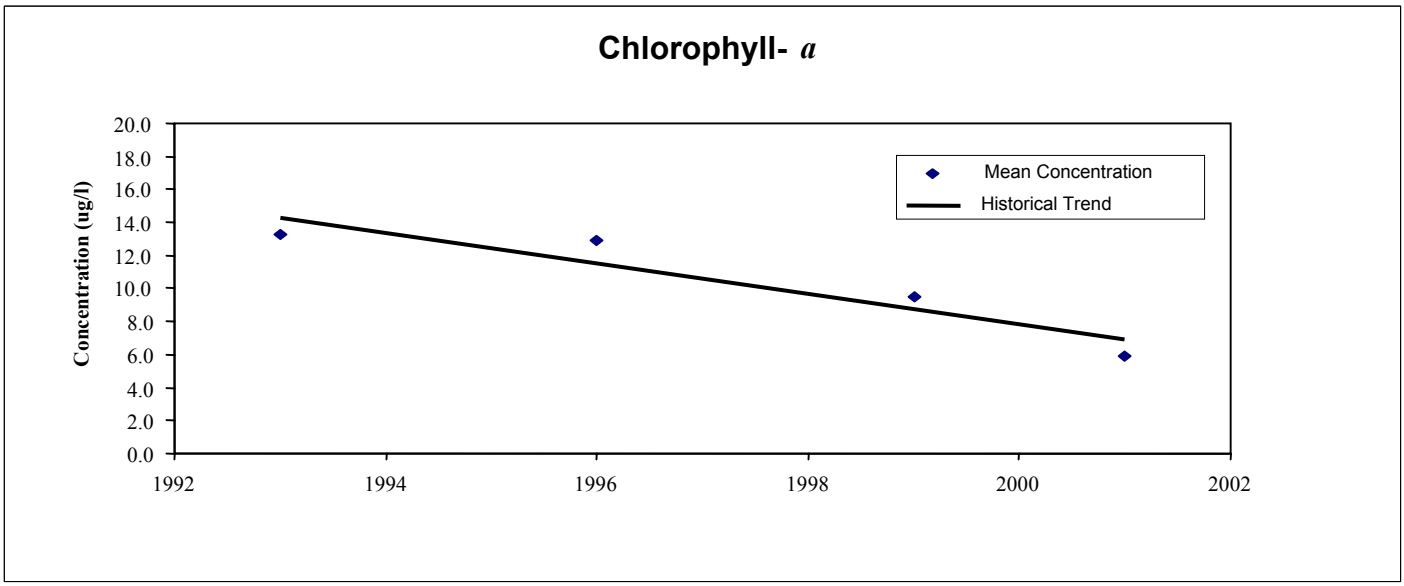
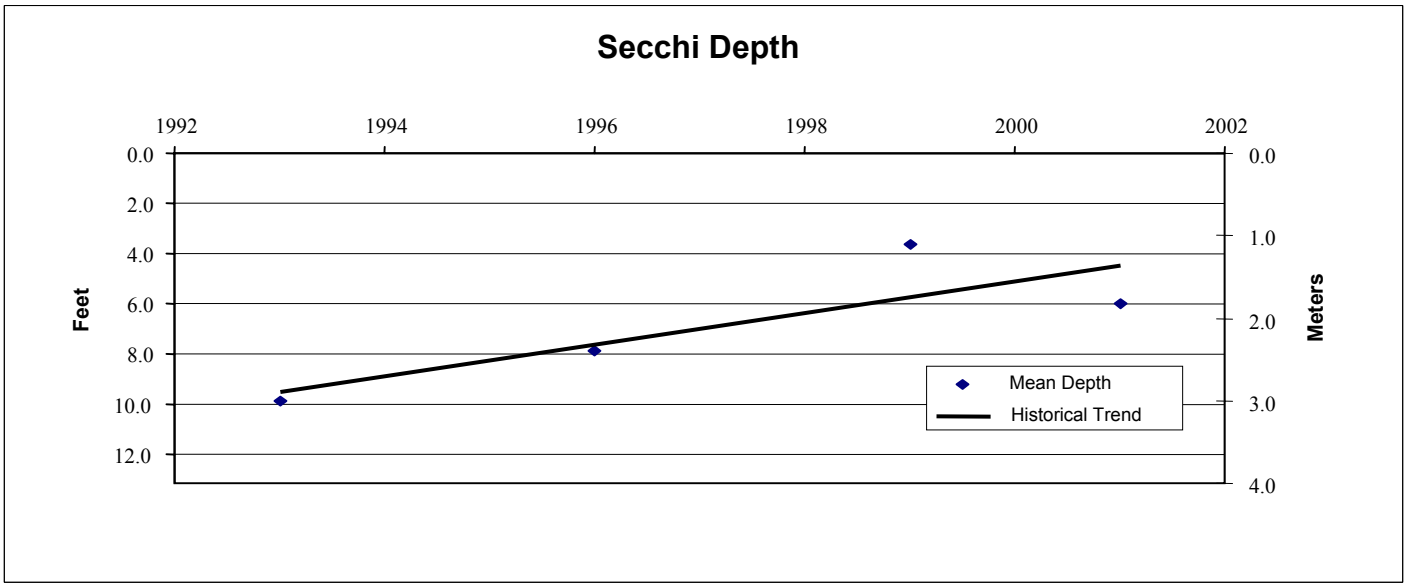
CLEARWATER RIVER WATERSEHD DISTRICT	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	JAN 2002
Lake Caroline Historical Data		Figure 8







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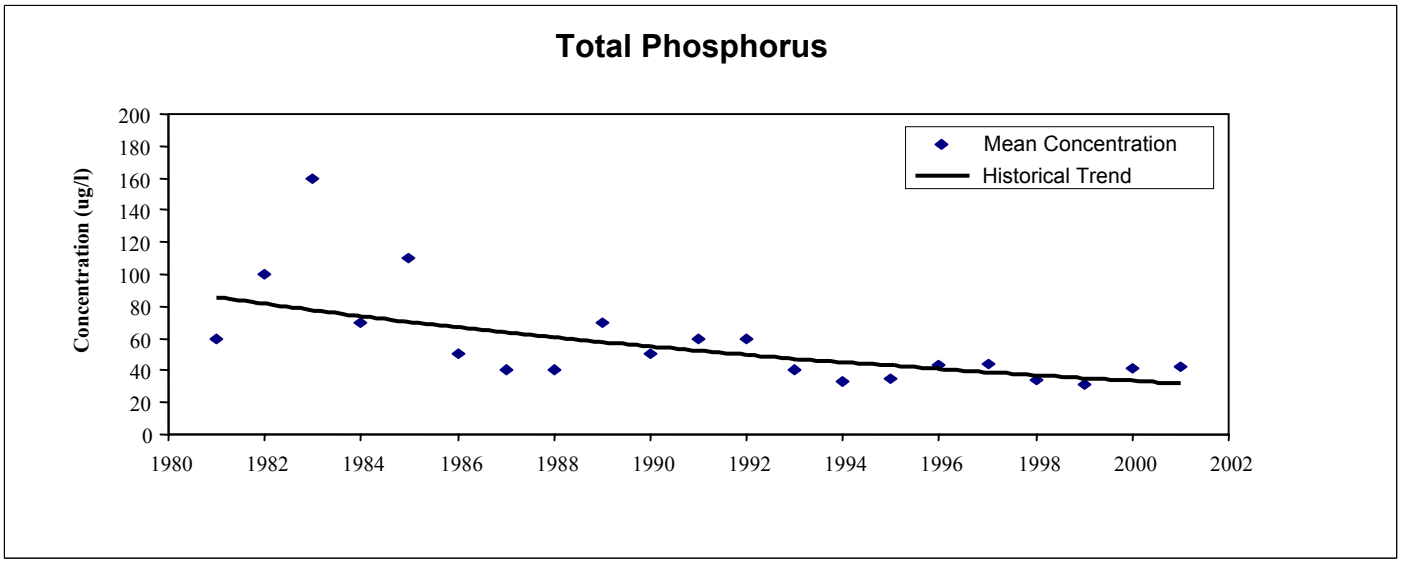
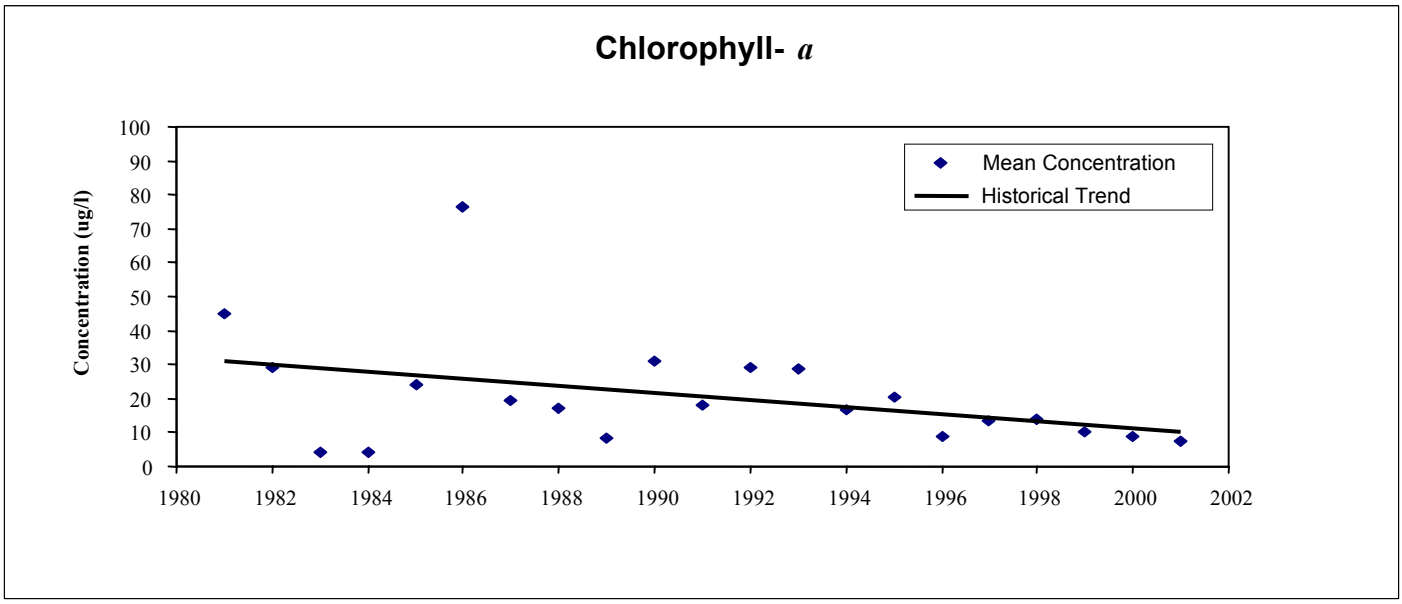
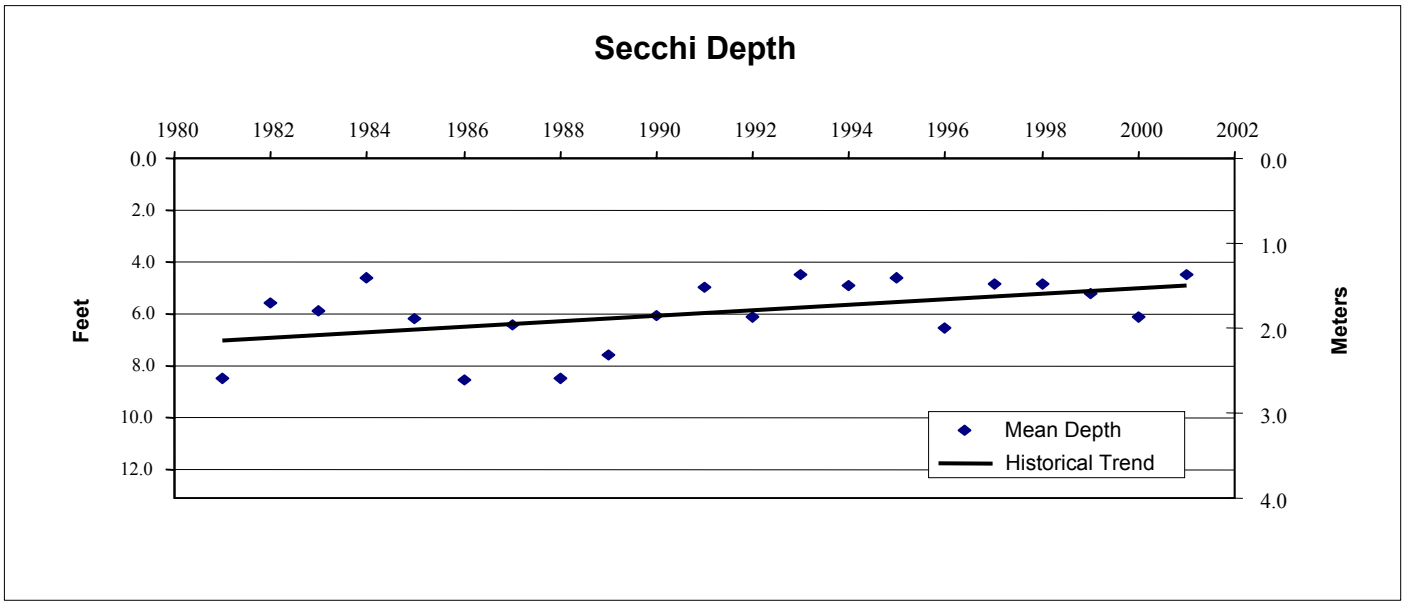
CLEARWATER RIVER WATERSEHD DISTRICT	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	JAN 2002
Cedar Lake Historical Data		Figure 9







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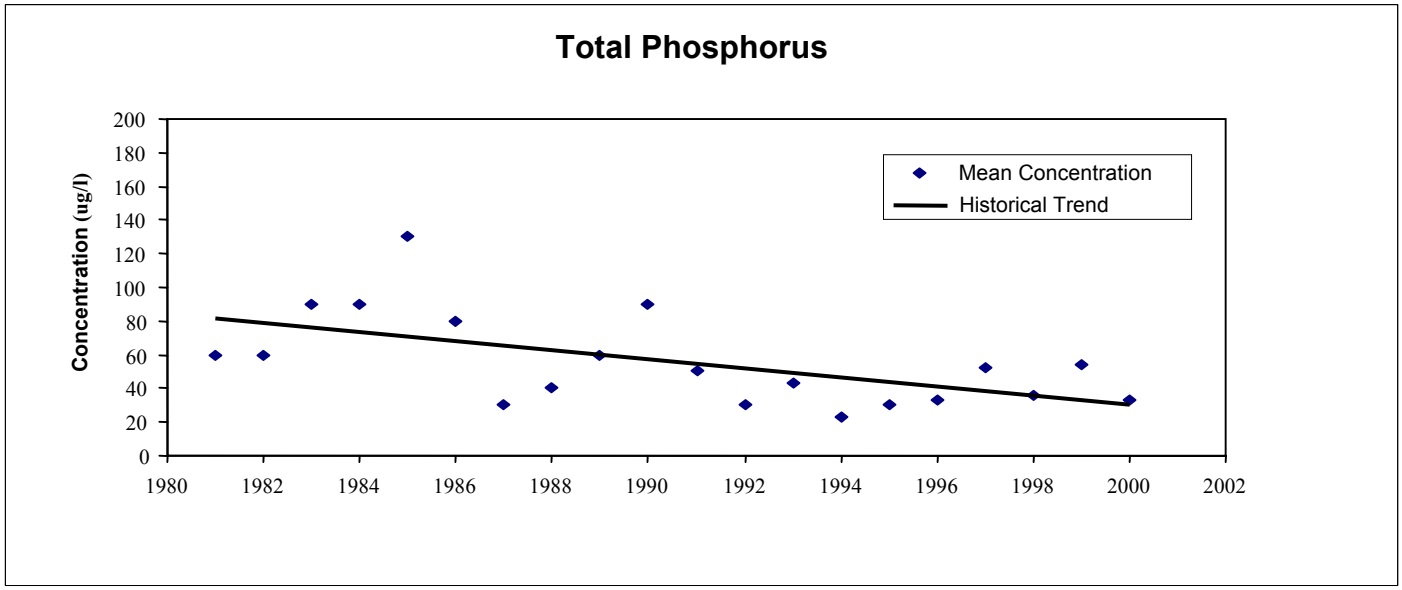
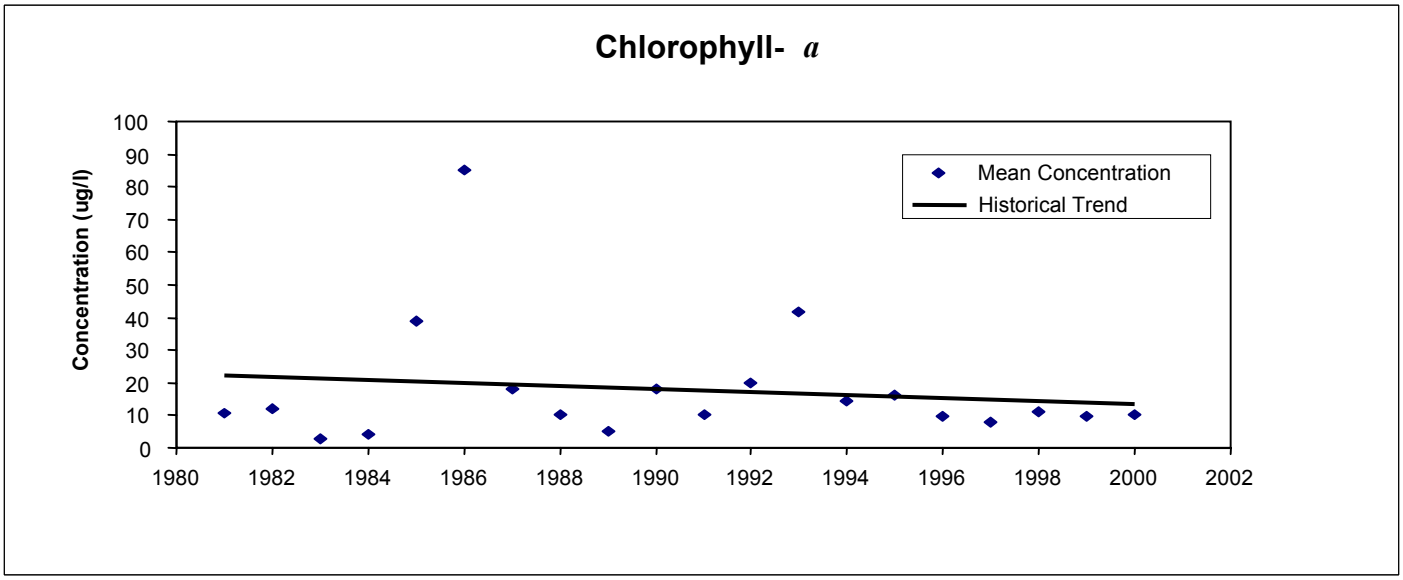
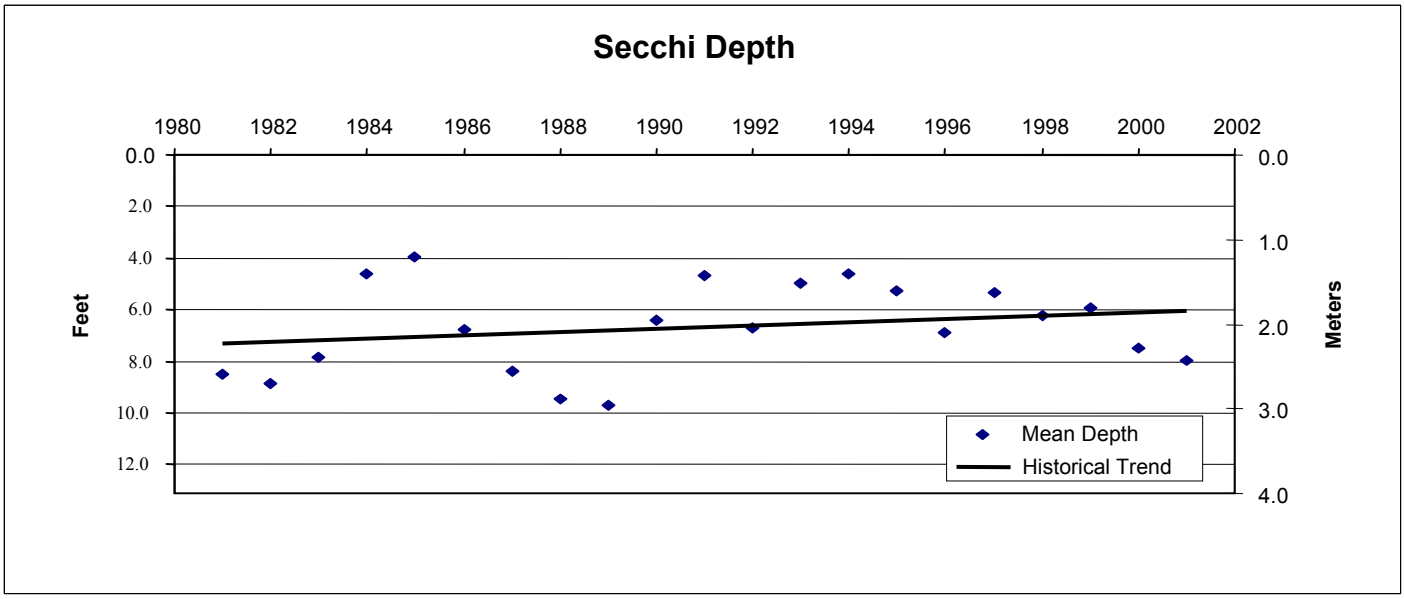
CLEARWATER RIVER WATERSEHD DISTRICT	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	JAN 2002
Clearwater Lake West Historical Data		Figure 10







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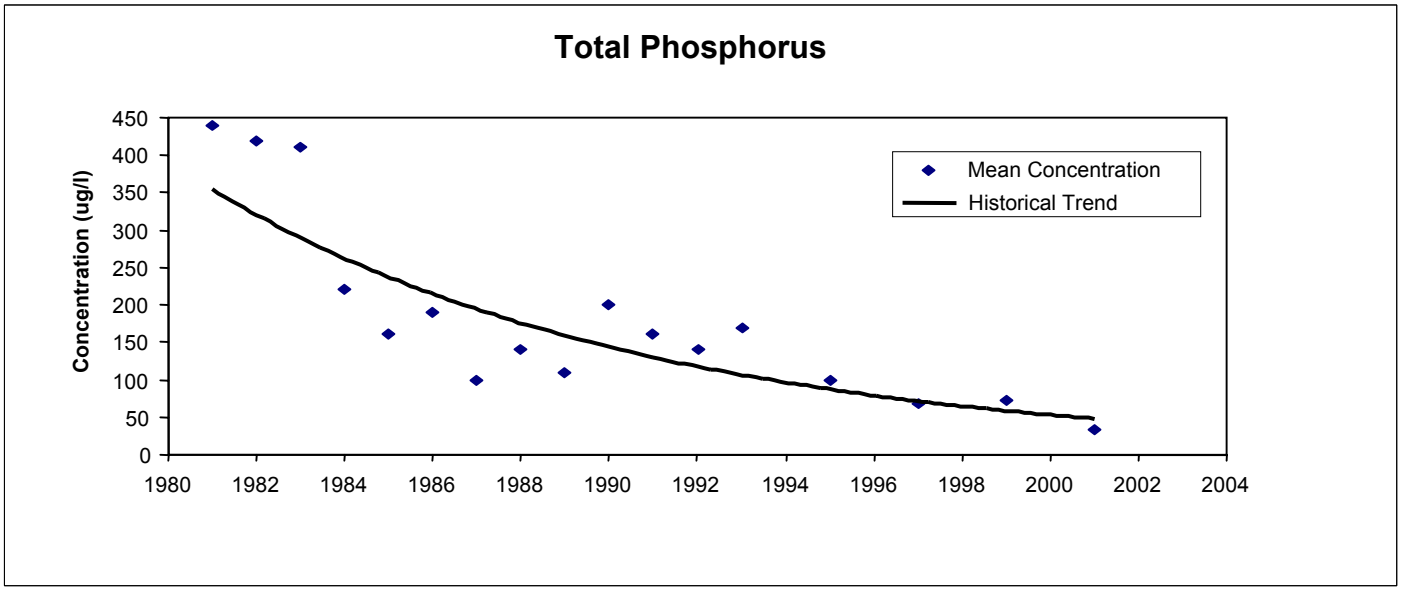
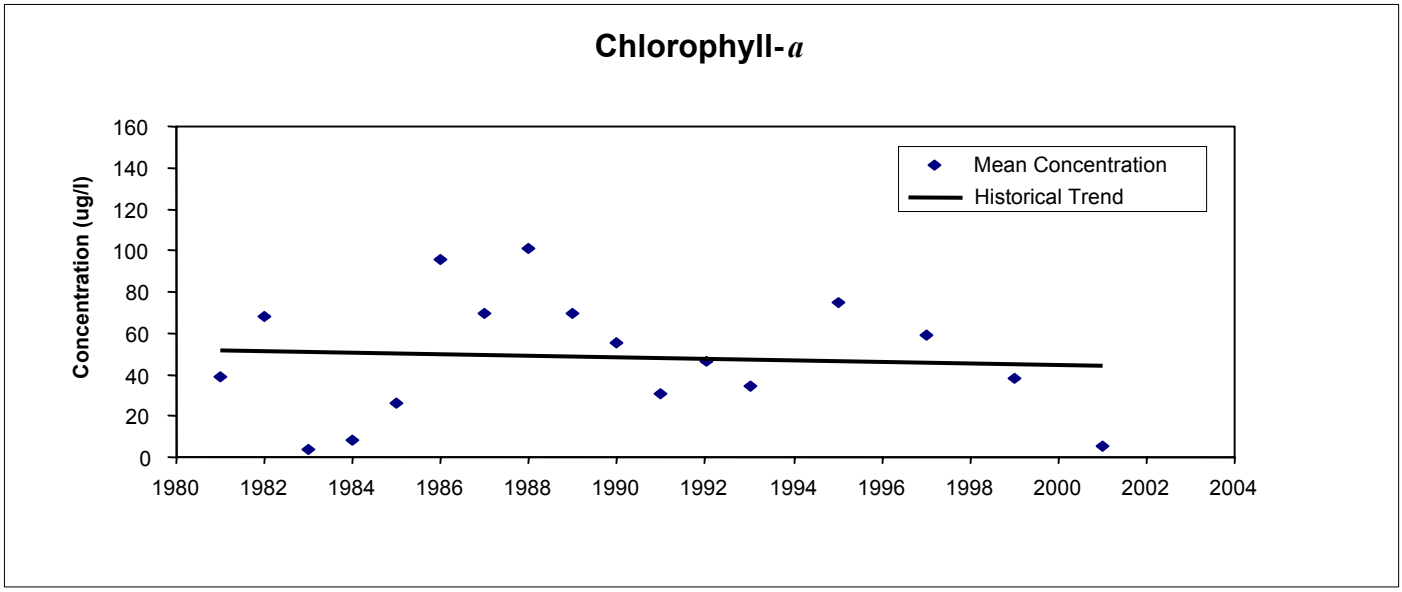
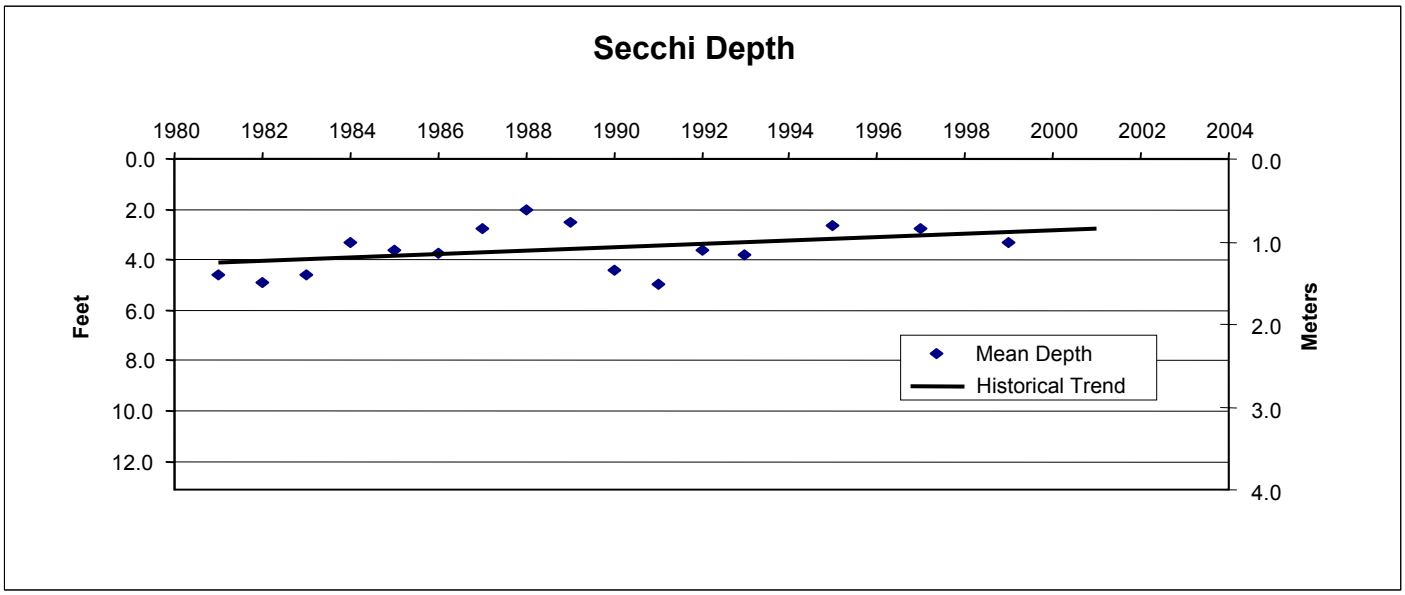
CLEARWATER RIVER WATERSEHD DISTRICT	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	JAN 2002
Clearwater Lake East Historical Data		Figure 11







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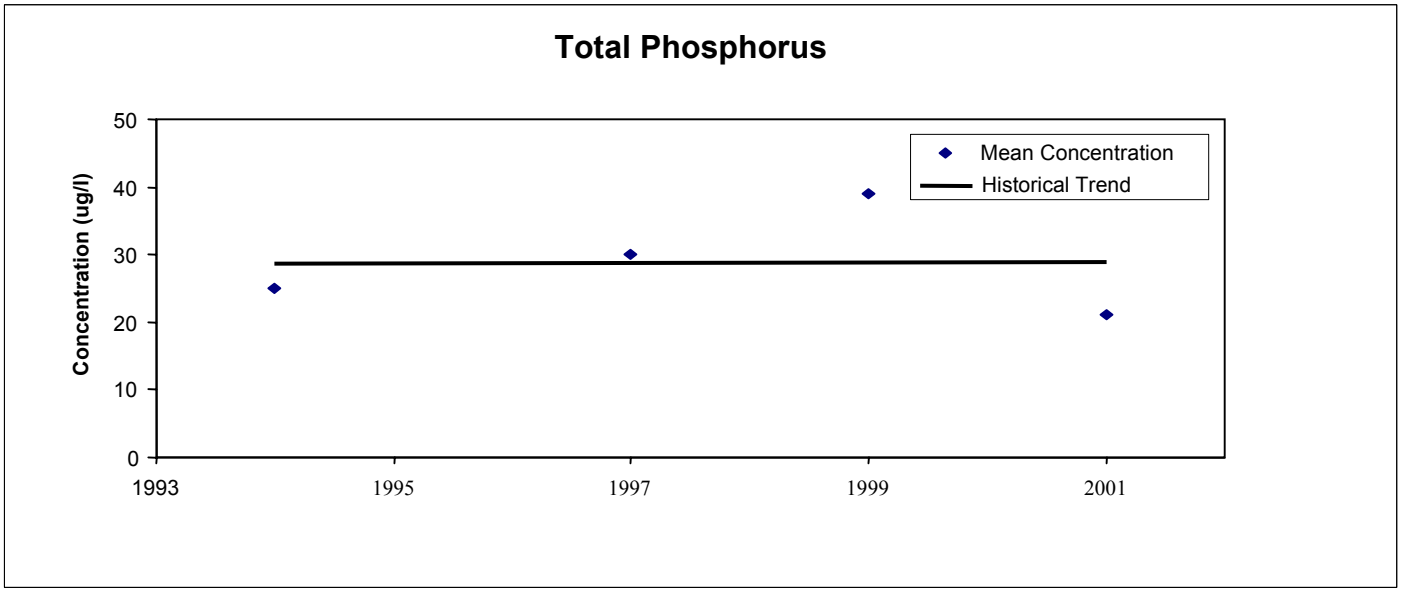
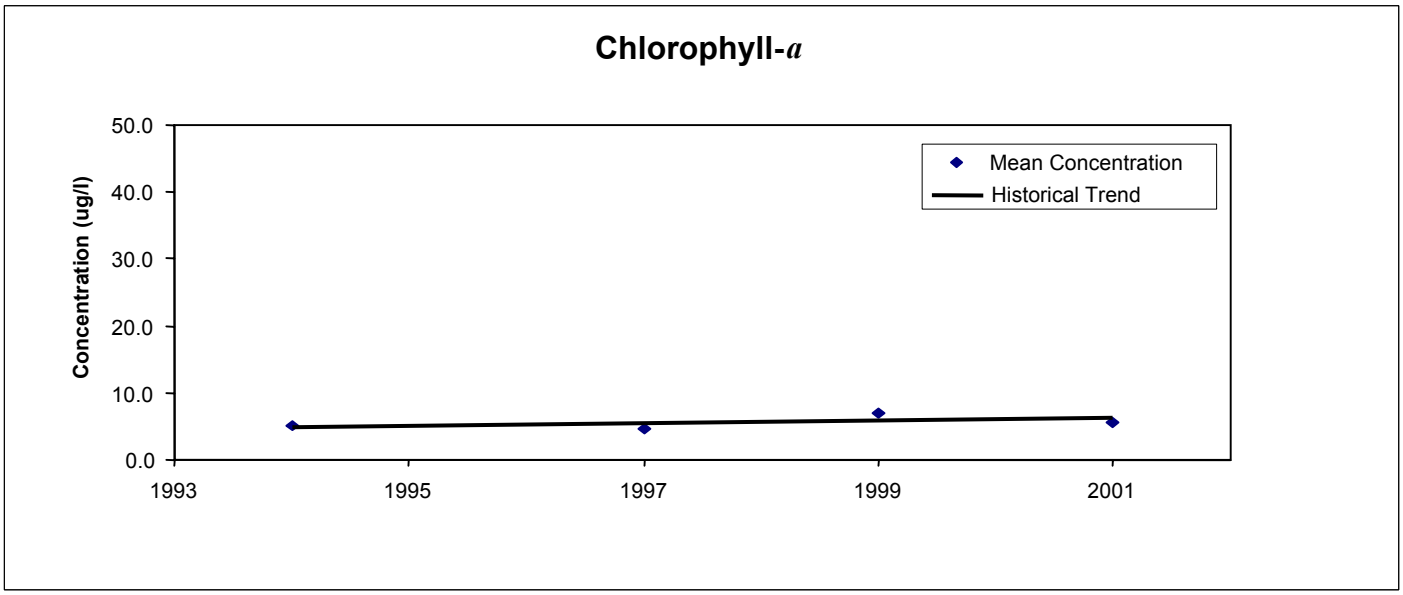
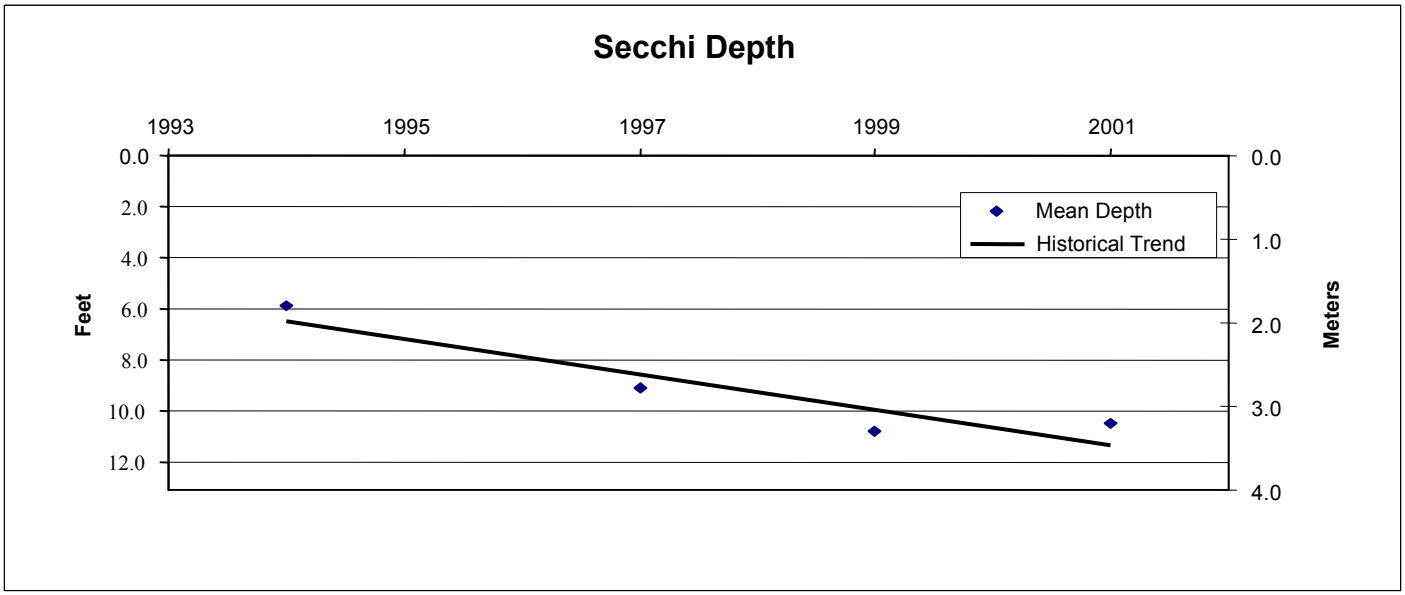
CLEARWATER RIVER WATERSEHD DISTRICT	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	JAN 2002
Lake Louisa Historical Data		Figure 12







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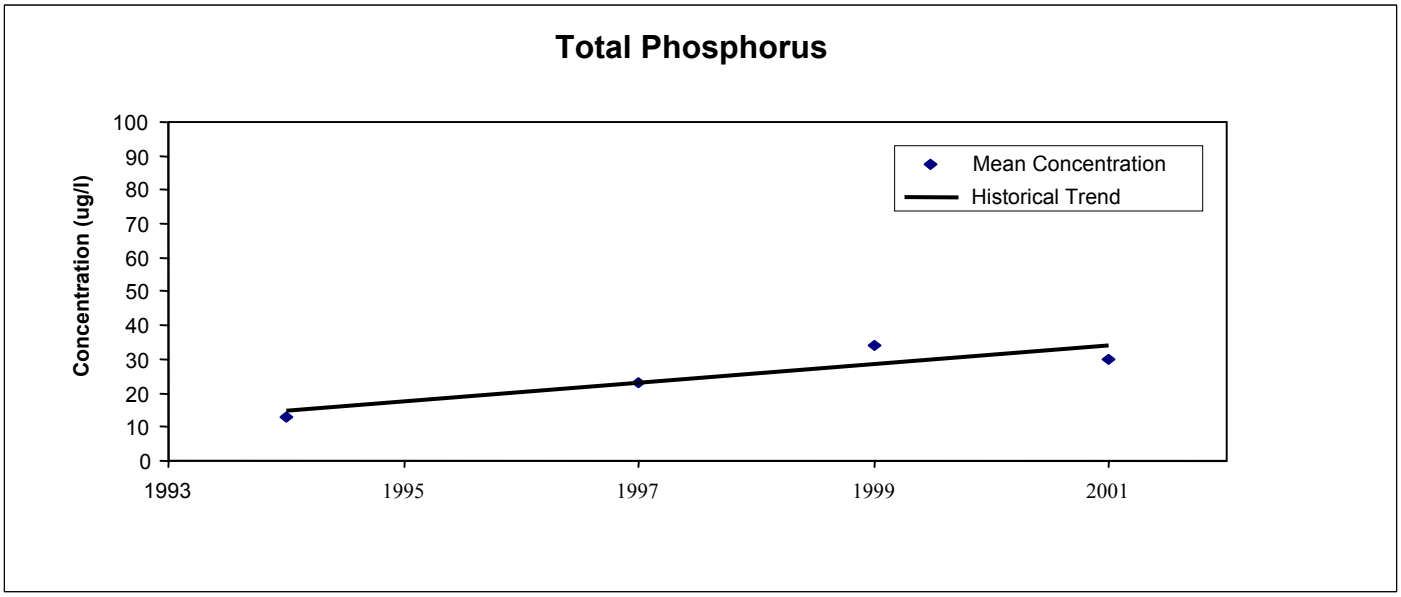
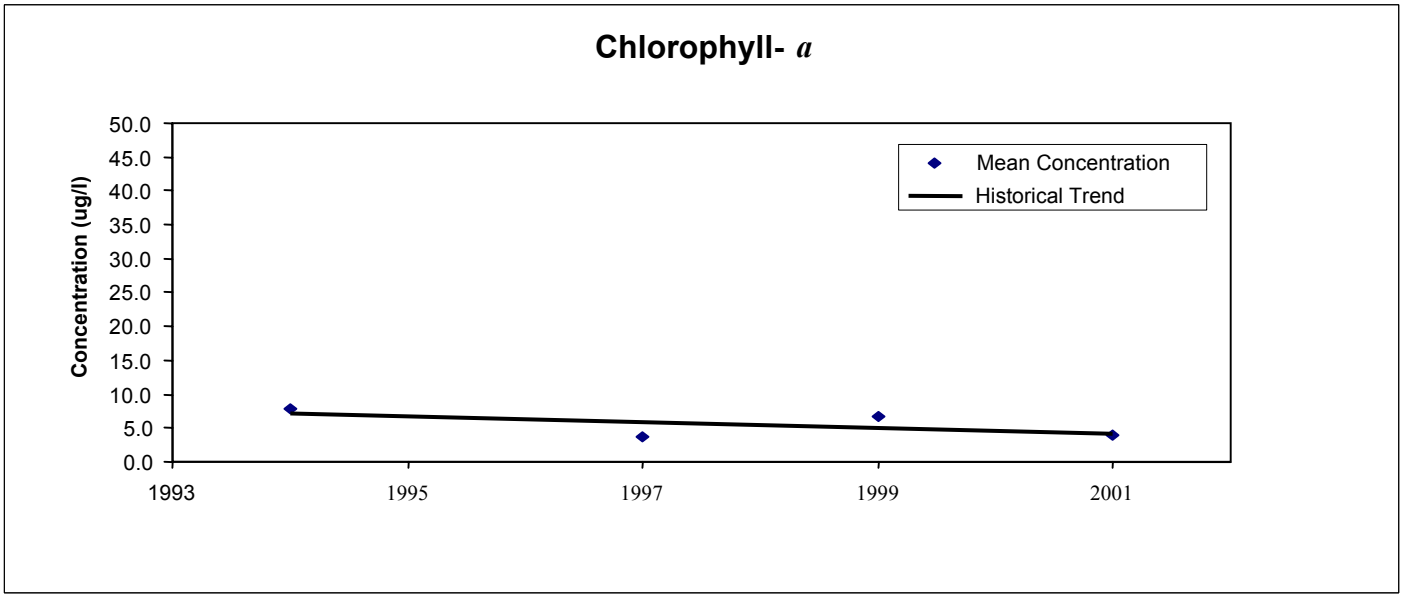
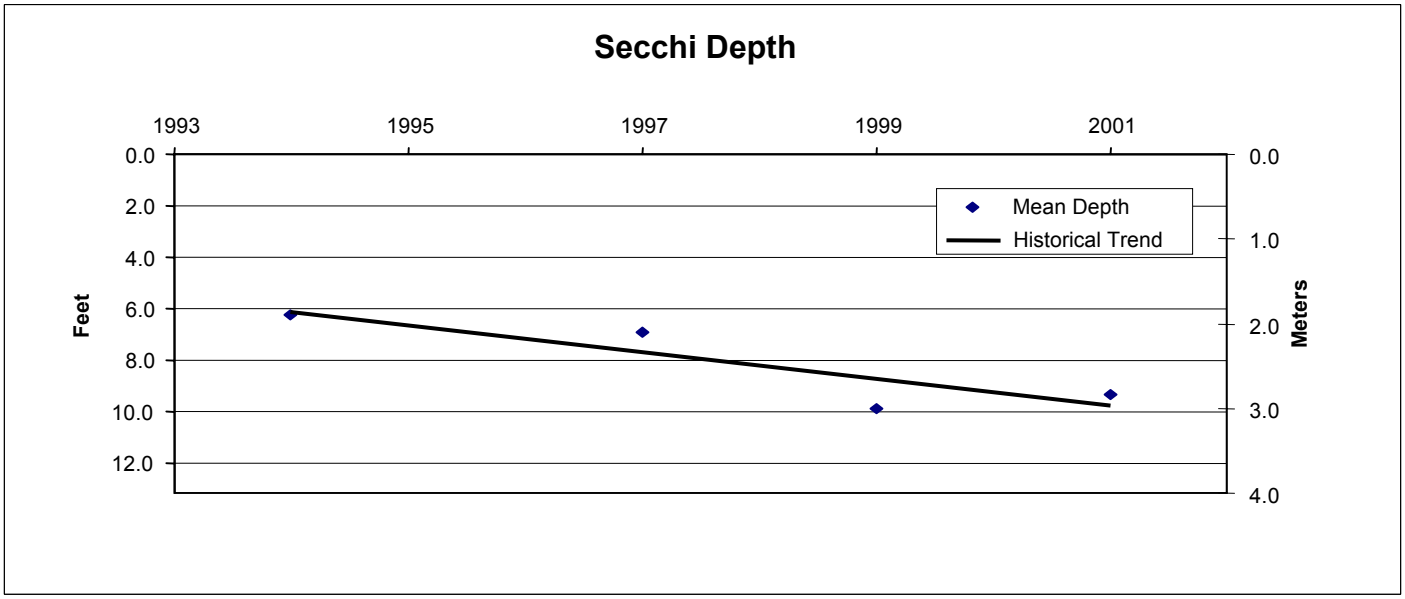
CLEARWATER RIVER WATERSEHD DISTRICT	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	JAN 2002
Lake Nixon Historical Data		Figure 13







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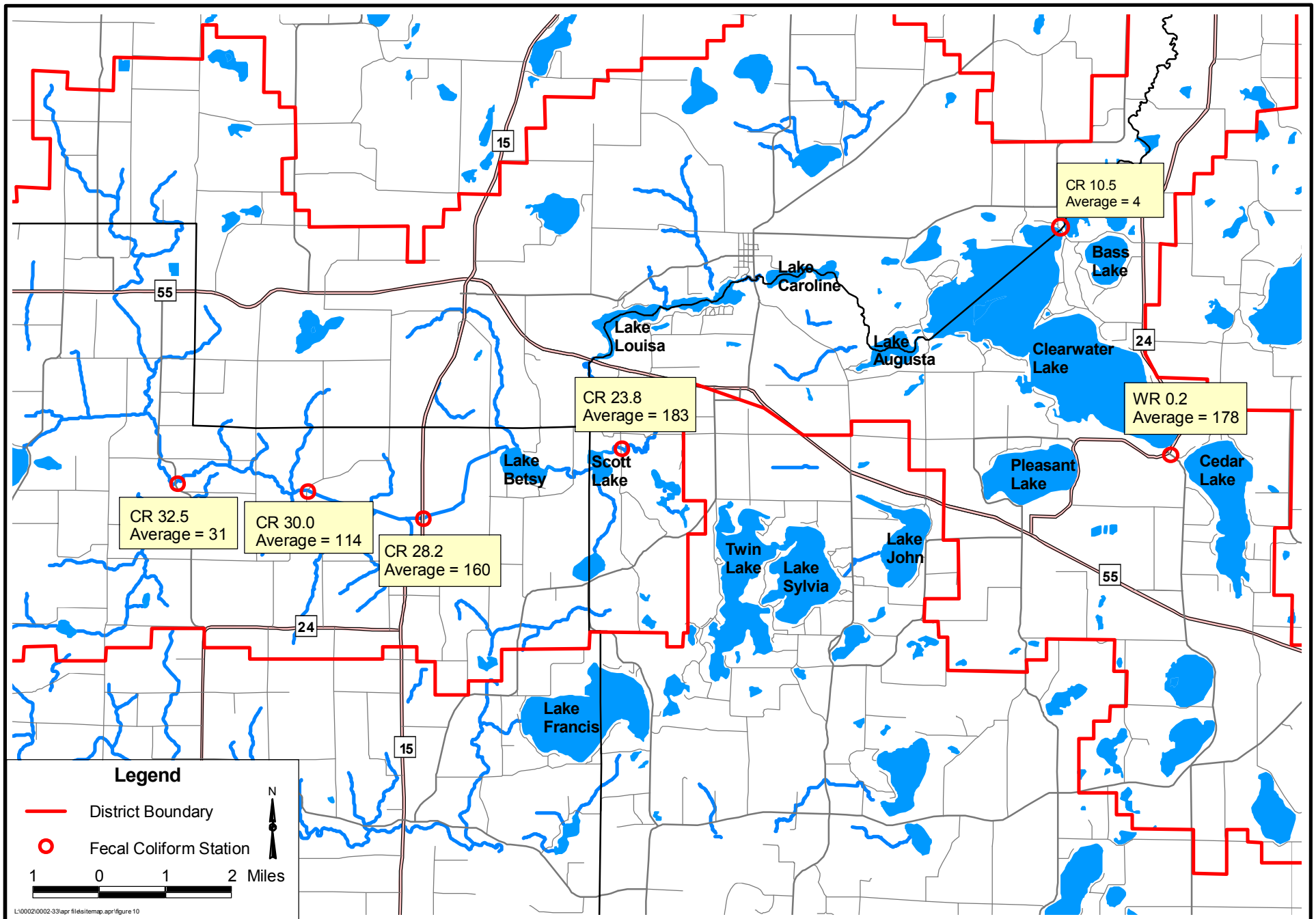
CLEARWATER RIVER WATERSEHD DISTRICT	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	JAN 2002
Otter Lake Historical Data		Figure 14



CLEARWATER RIVER WATERSHED DISTRICT

2001 Fecal Coliform Stream Monitoring Results

Wenck

Wenck Associates, Inc.
Environmental Engineers

1800 Pioneer Creek Center
Maple Plain, MN 55359-0429

JAN 2002

Figure 15

L:\0002\0002-34\apr file\fecalmap.apr\figure 16

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2001 Fecal Coliform and Fecal Streptococcus Stream Monitoring Results		Figure 16

Appendix A

2001 Monitoring Plan Summary

MEMORANDUM

TO: **Clearwater River Watershed District Board of Managers**

FROM: **Norman C. Wenck**
Engineer for the District

DATE: **March 9, 2001**

RE: **REVISED Proposed 2001 Water Quality Monitoring Program**

Introduction

The Clearwater River Watershed District conducts annual water quality monitoring at selected lakes and selected locations on streams. Lake monitoring follows the long-term plan shown in Table 1, and stream monitoring sites along with all laboratory and field parameters are shown in Table 2. Also shown in Table 2 are options for additional stream monitoring.

Lake Monitoring

The schedule for 2001 has Clearwater East and West being monitored and additional Main Stem Lakes of Augusta, Louisa, and Betsy. Cedar, Nixon, Otter, and Bass Lakes will also be monitored. The total number of lakes is eight but nine stations are monitored since Clearwater Lake has two stations. Citizens monitor approximately 14 lakes for secchi depth also.

Stream Monitoring

The Clearwater River will be monitored at stations CR 28.2, CR10.5 and Warner Creek will be monitored at WR 0.2. The stations are monitored six times for water quality and flow. Parameters are total phosphorus and soluble reactive phosphorus, which is new for 2001. The purpose of analyzing soluble reactive phosphorus is to determine what percentage of total phosphorus is in the dissolved phase to determine the feasibility of phosphorus removal by sedimentation basins or wetland treatment systems.

Cost

This proposed program is estimated to cost $11,800.00.

Option 1 – Fecal Coliform Monitoring
Coliform contamination was found at all stations monitored last year. Monitoring is again recommended at the same stations to investigate coliform levels for higher flows (assuming this year is not as dry). The cost of this option is $2,900.00.

For Warner Creek, the year 2000 Discharge Monitoring Reports for the Annandale Wastewater Treatment Plant were reviewed and showed levels <10 cfu/ml. This suggests that additional field reconnaissance would be the most practical method of discovering local sources for each monitoring station.

Option 2 – Fecal Strep Monitoring

Some research has shown that the ratio between fecal strep and fecal coliform gives an indication of the source of the coliforms, human versus animal. The research is not conclusive but results vary site by site. The addition of fecal strep analysis to Option 1 would cost an additional $1,500.00.

Option 3 – Expanded Annandale Fecal Coliform and Fecal Strep Monitoring

To further investigate the Warner Creek situation, it is proposed to sample six additional sites from Annandale to Clearwater Lake during six events and analyze for both fecal coliform and fecal strep. The cost of this option is $3,000.00.

Option 4 – Expanded Monitoring of the Other Four Sites

To further investigate coliform occurrence at the other stations along Clearwater River, (CR32.5, CR30.0, CR28.2 and CR23.8), it is proposed that six additional upgradient sampling locations be selected at each site and monitored for both fecal coliform and fecal strep during the six Option 1 events. The cost of this option is an additional $5600.00.

Summary

The basic monitoring program continues the program in place since 1981. The remaining options are progressive and additive and can be modified as desired after you have an opportunity to review this proposal. It is requested that a decision on the scope of the program be made at the March 14 meeting. Please feel free to call me with any questions or comments that you may have before the meeting.

TABLE 1
PROPOSED LONG-TERM WATER QUALITY MONITORING PLAN FOR CRWD LAKES

LAKE STATIONS[1]	1997	1998	1999	2000	2001	2002	2003	2004
Clearwater Lake:								
Clearwater East	X	X	X	X	X	X	X	X
Clearwater West	X	X	X	X	X	X	X	X
Main Stem Lakes:								
Augusta	X		X		X		X	
Louisa	X		X		X		X	
Caroline		X				X		X
Scott		X	X			X		X
Marie		X		X		X		X
Betsy	X		X		X		X	
Other Lakes:								
Cedar			X		X		X	
Pleasant	X		X	X				X
School Section	X		X	X				X
Nixon	X		X		X			X
Otter	X		X		X			X
Bass		X	X		X			
Clear		X	X	X			X	
Union		X	X			X		
Henshaw		X	X			X		
Little Mud			X			X		
Wiegand			X			X		
Swart Watts			X				X	
Albion			X				X	
Grass			X				X	

Note: [1]Lake selection based on total lake size ranking scores (Lake Priority Ranking, 1990)

TABLE 2

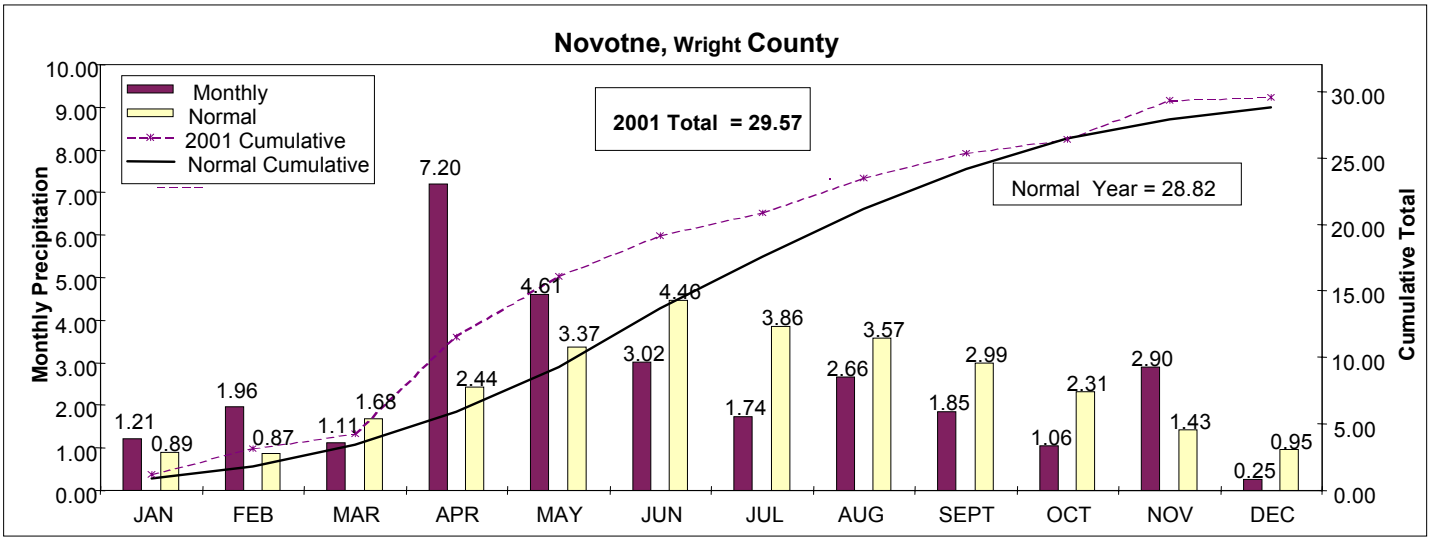
Proposed 2001 CRWD Monitoring Plan Summary

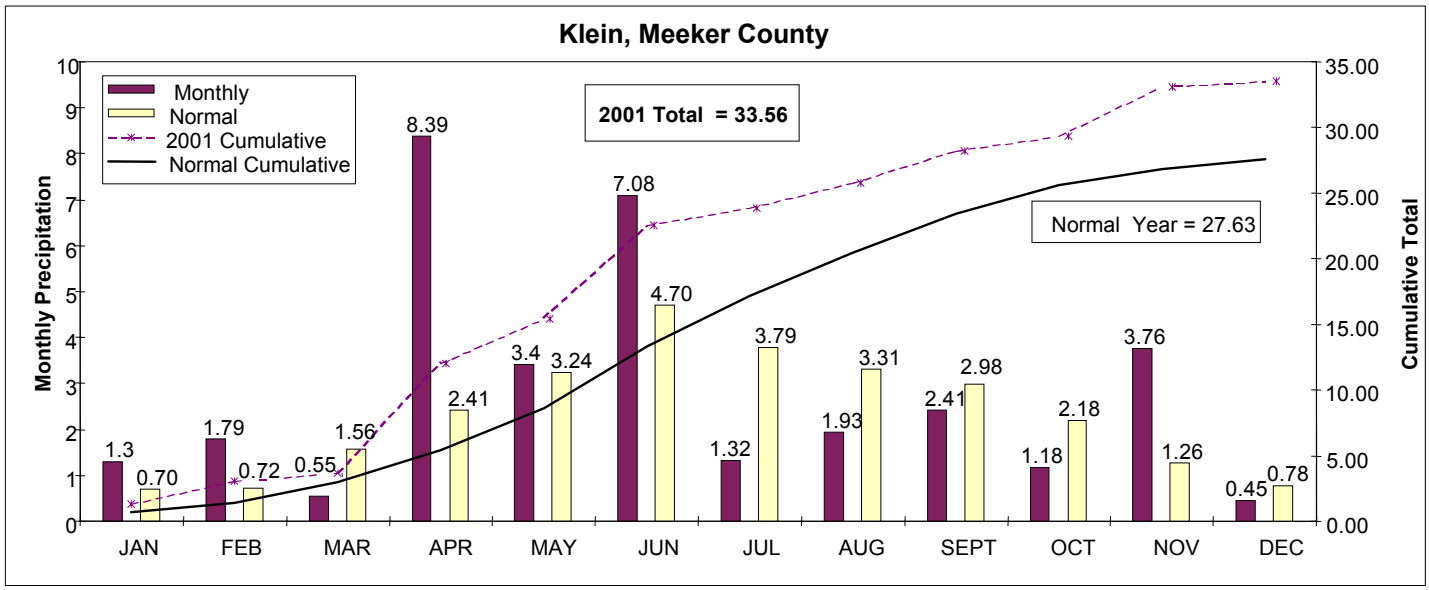
Category	Schedule	Station	Parameters
Lakes:	June 15 - July 5	Clearwater-East	Field: Secchi, DO and temperature profiles
	Jul 27 - Aug 4	Clearwater-West	
	Aug 26 - Sep 15	Augusta	
		Louisa	Lab: Total phosphorus and Chlorophyll-a
		Betsy	
		Cedar	
		Nixon	
		Otter	Citizen Secchi: Fourteen Sites
		Bass	
Streams:	April	CR28.2	Field: Flows, DO and temperature
	May	WRO.2	
	June	CR10.5	Lab: Total phosphorus, soluble reactive phosphorus
	July		
	August		
	September		
Precipitation:	Daily at three sites (Watkins, Maire Prairie and Corrinna)		
Option 1: Fecal Coliform Monitoring			
	April	5 River Stations	Lab: Fecal Coliform
	May	CR32.5	
	June	CR30.0	
	July	CR28.2	
	August	CR23.8	
	September	WR0.2	

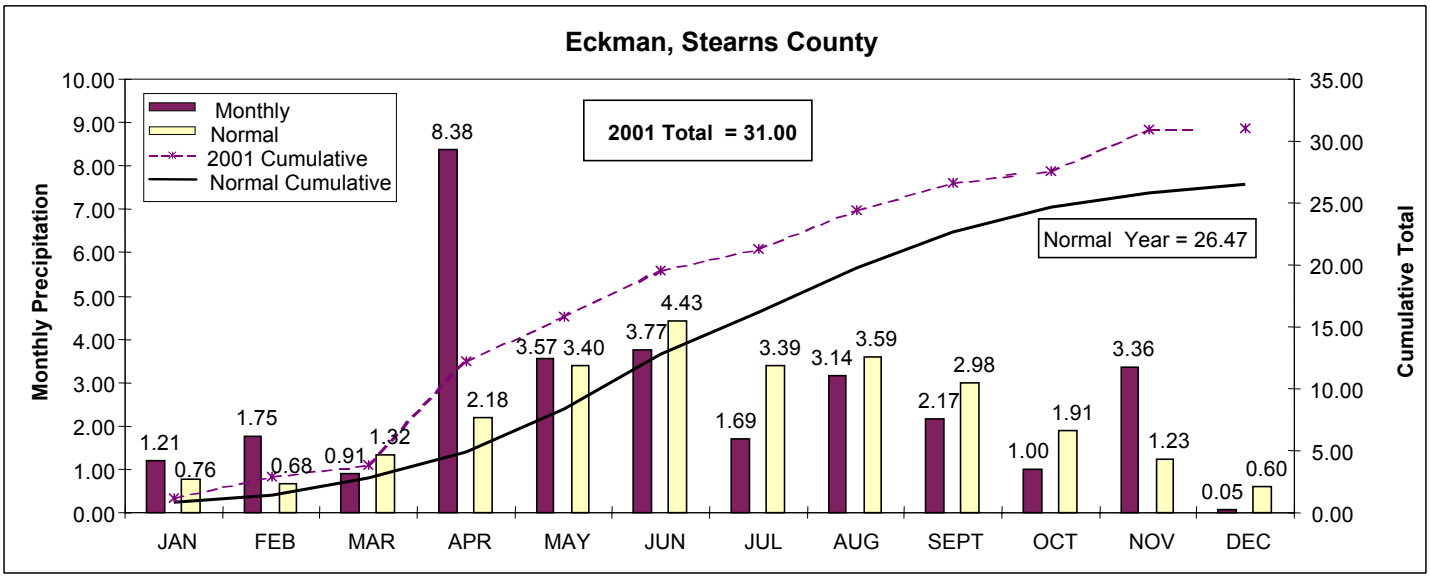
Appendix B

Volunteer Precipitation Data

Watershed Weighted Average is calculated by scoring Eckman double, Novotne and Klein single.







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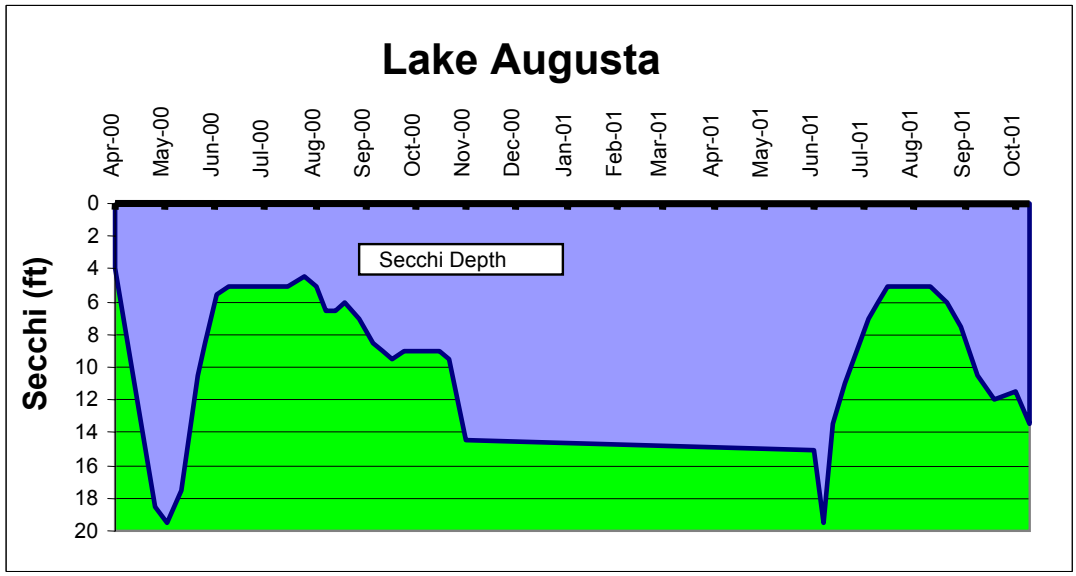
CLEARWATER RIVER WATERSEHD DISTRICT	Wenck Wenck Associates, Inc. Environmental Engineers 1800 Pioneer Creek Center Maple Plain, MN 55359	JAN 2002
Precipitation Data		Figure B-1

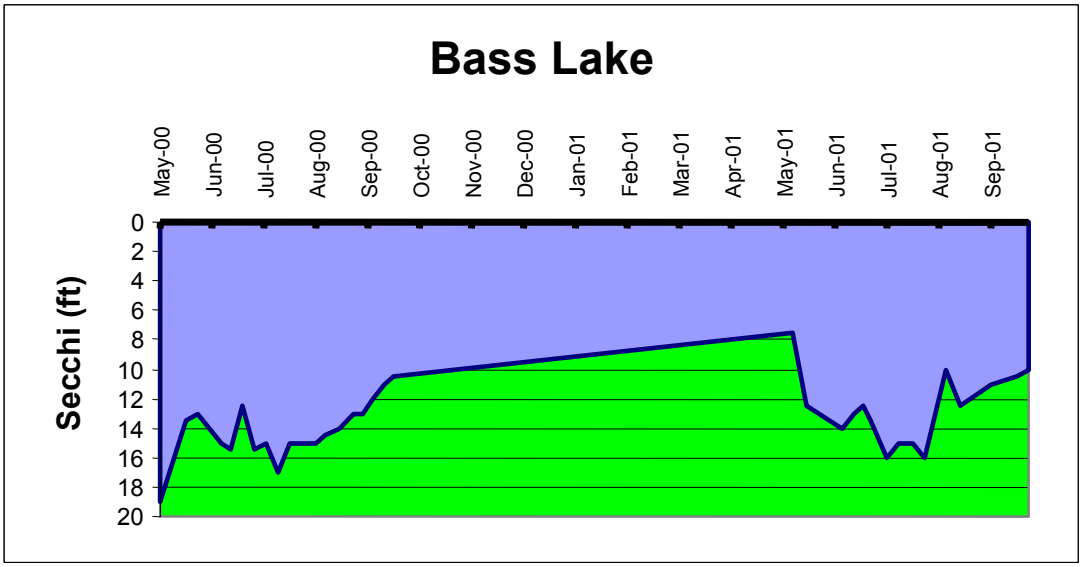
Appendix C

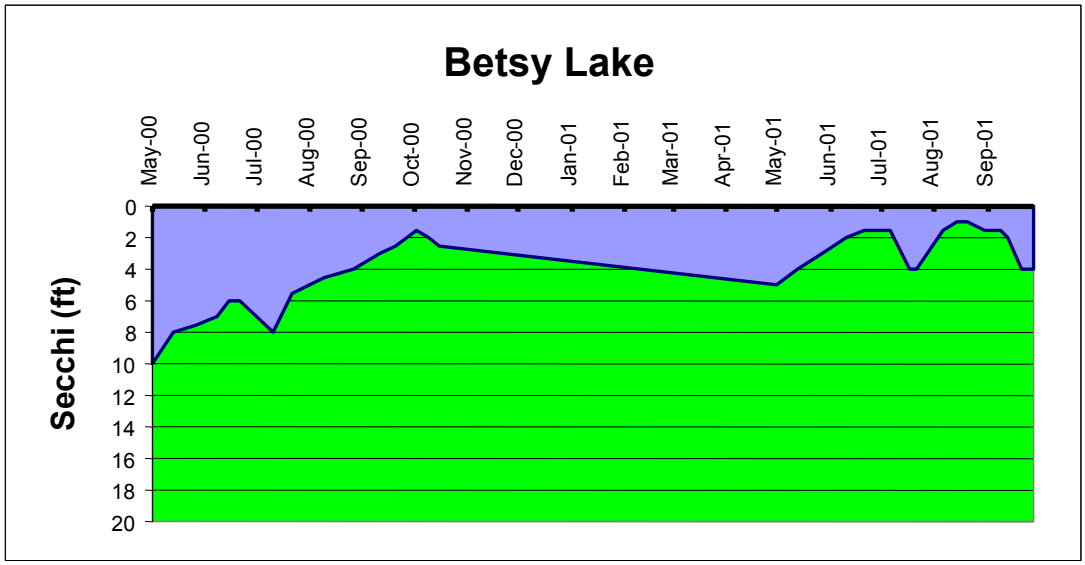
2001 Analytical Data
To review Analytical Data please contact
Norm Wenck at 763-479-4200

Appendix D

Citizen's Lake Monitoring Program – Secchi Data







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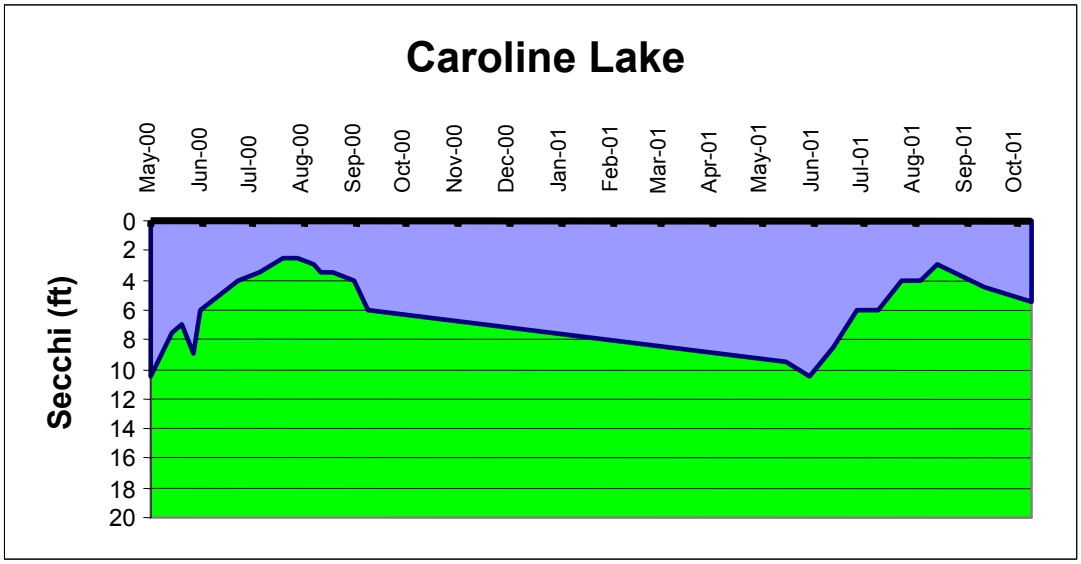
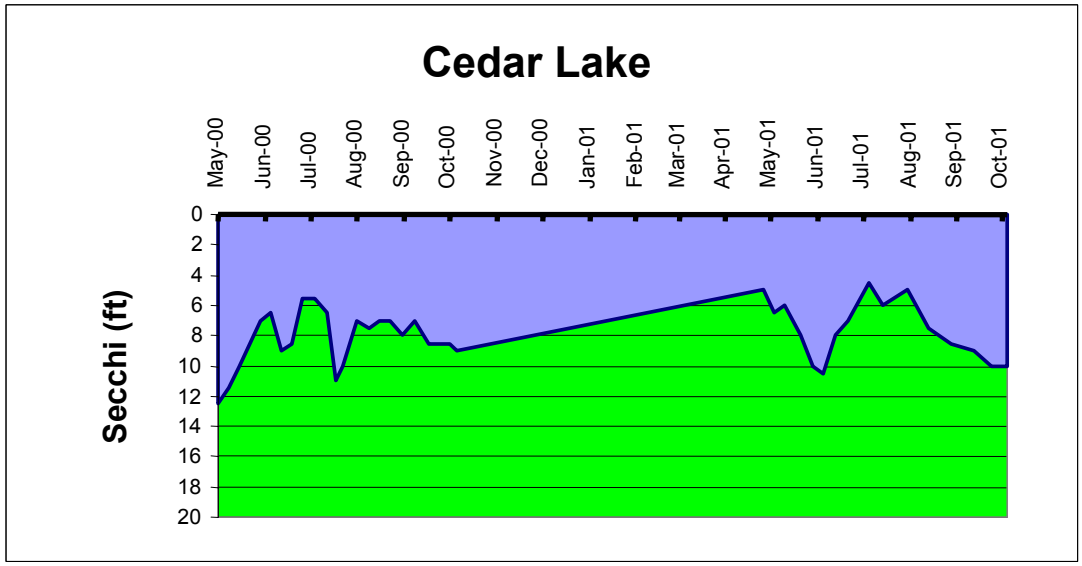
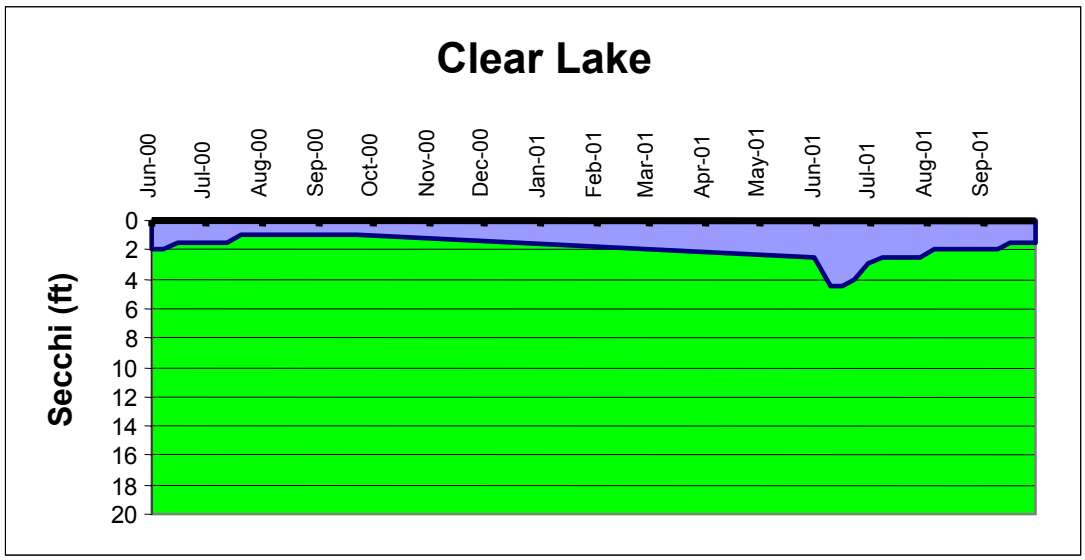
CLEARWATER RIVER WATERSHED DISTRICT	Wenck Associates, Inc. 1800 Pioneer Creek Center Environmental Engineers Maple Plain, MN 55359	JAN 2002
Citizen Secchi Data -- 2001		Figure D-1







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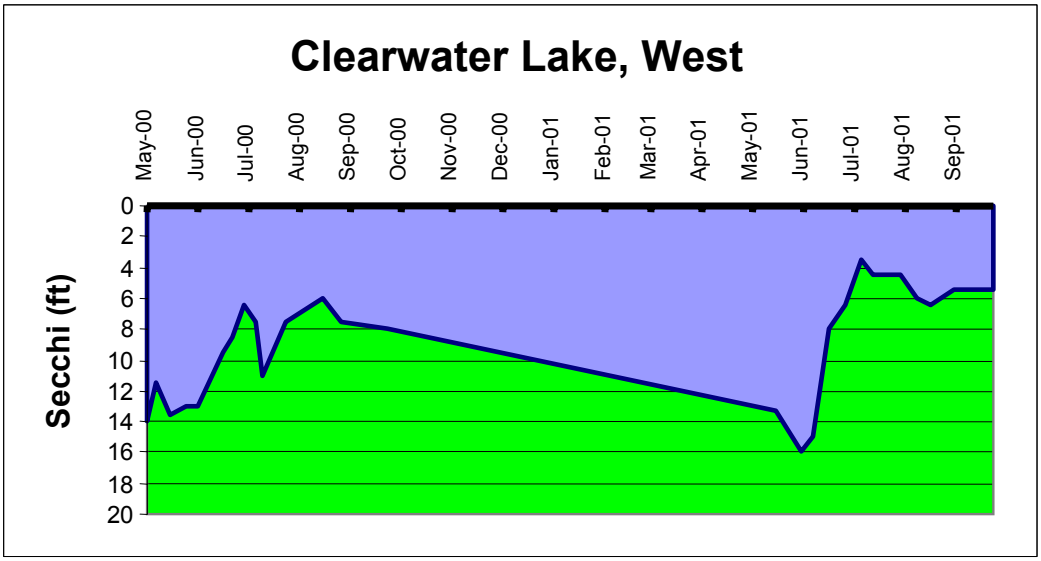
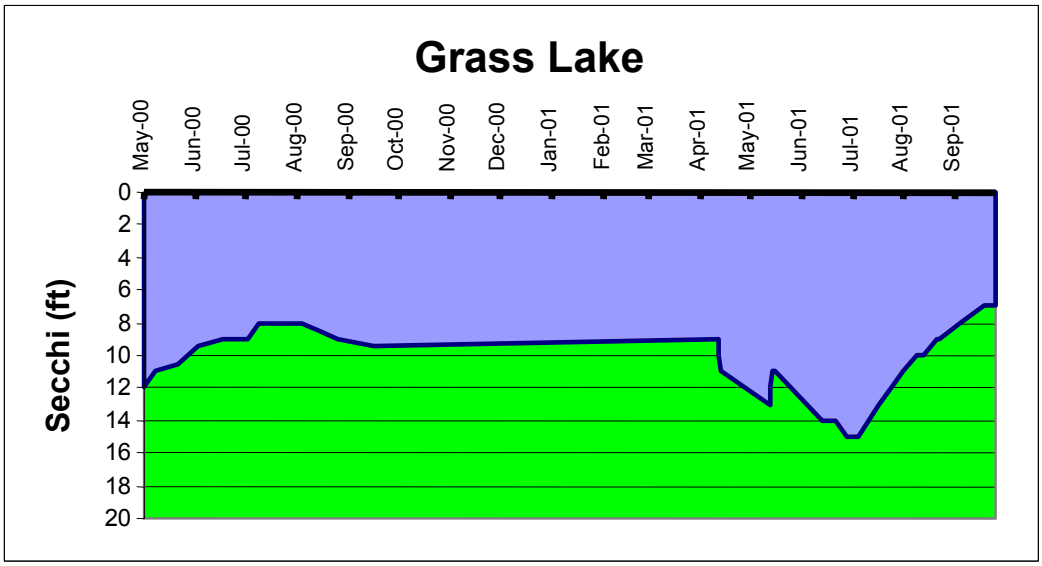
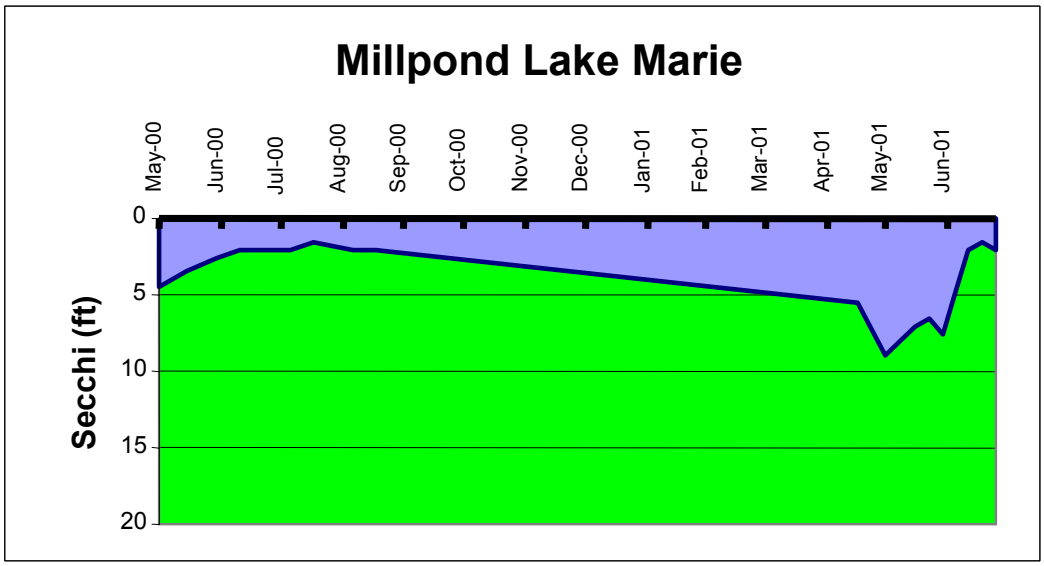
CLEARWATER RIVER WATERSHED DISTRICT	Wenck Associates, Inc. 1800 Pioneer Creek Center Environmental Engineers Maple Plain, MN 55359	JAN 2002
Citizen Secchi Data -- 2001		Figure D-2







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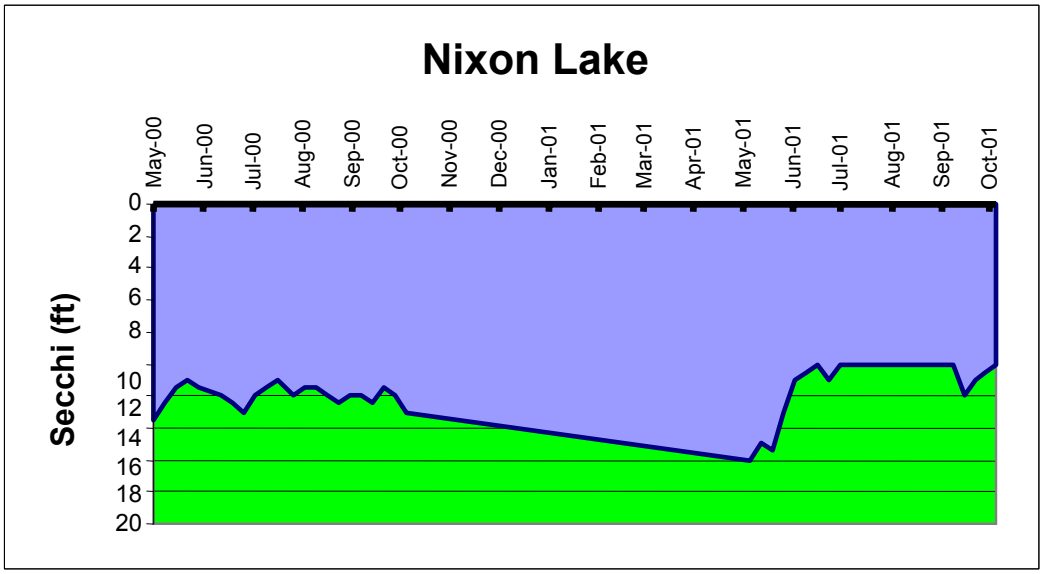
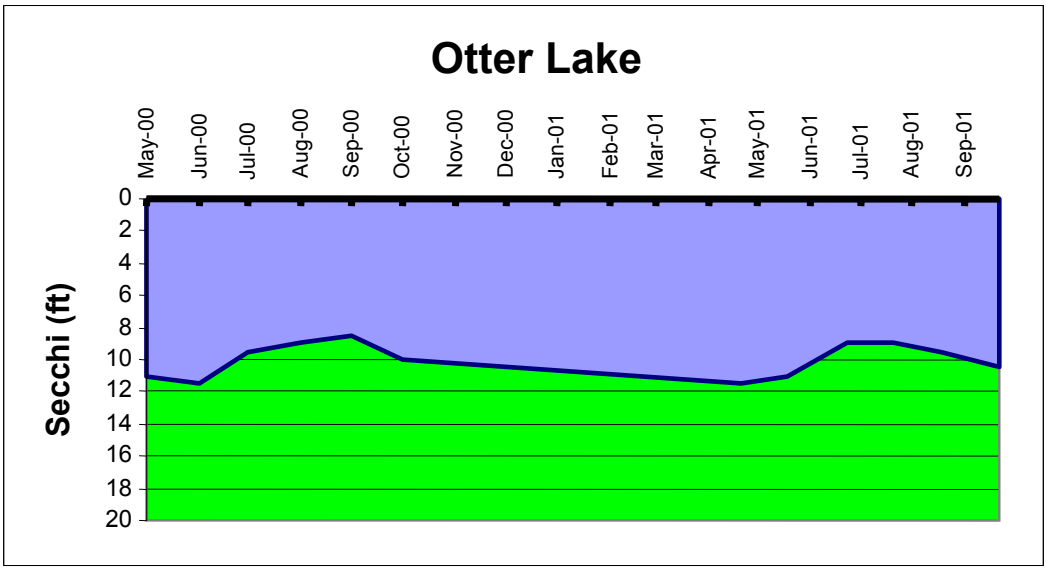
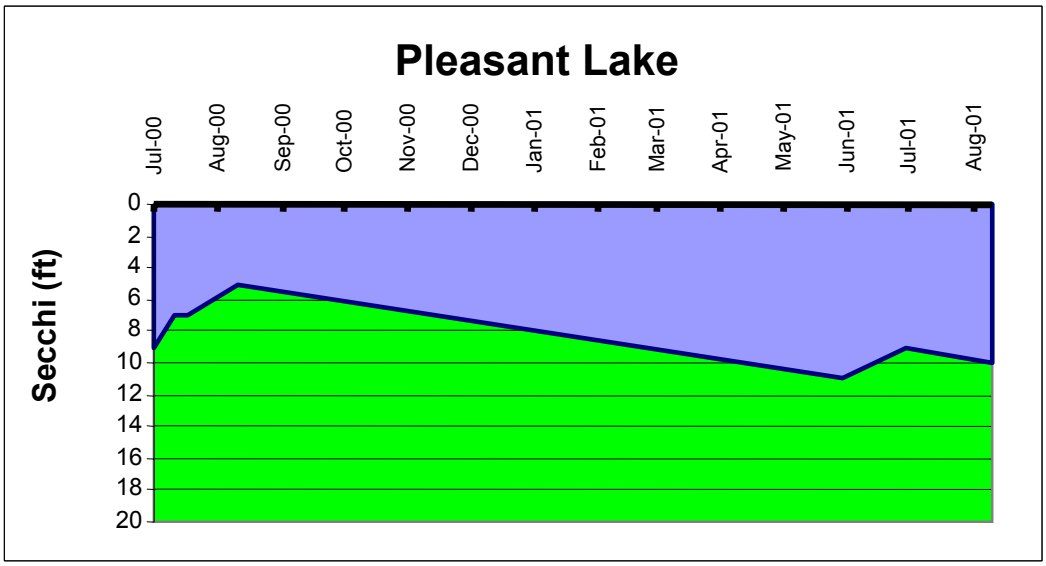
CLEARWATER RIVER WATERSHED DISTRICT	Wenck Associates, Inc. 1800 Pioneer Creek Center Environmental Engineers Maple Plain, MN 55359	JAN 2002
Citizen Secchi Data -- 2001		Figure D-3







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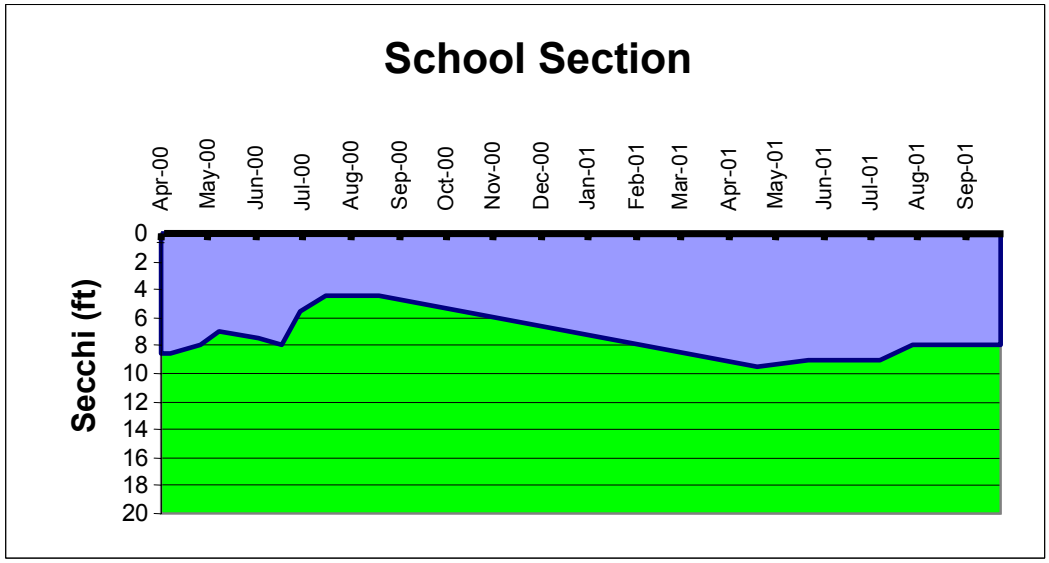
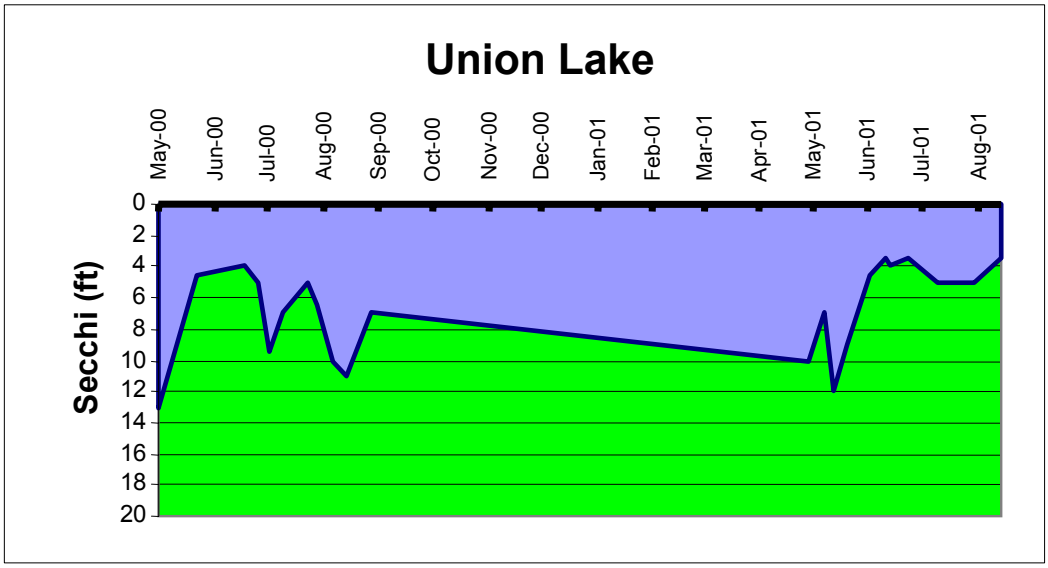
CLEARWATER RIVER WATERSHED DISTRICT	Wenck Associates, Inc. 1800 Pioneer Creek Center Environmental Engineers Maple Plain, MN 55359	JAN 2002
Citizen Secchi Data -- 2001		Figure D-4





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CLEARWATER RIVER WATERSHED DISTRICT	Wenck Associates, Inc. 1800 Pioneer Creek Center Environmental Engineers Maple Plain, MN 55359	JAN 2002
Citizen Secchi Data -- 2001		Figure D-5