MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER BUREAU
SEPTEMBER 2007

STAFF REPORT

MONTHLY WATER QUALITY ASSESSMENT OF LAKE MACATAWA AND ITS TRIBUTARIES 2006

INTRODUCTION

Water quality monitoring of Lake Macatawa is planned on an annual basis, as resources allow, through 2009, to document the effectiveness of phosphorus reduction efforts. Walterhouse (2006) presented water quality monitoring results from 2005 and contrasted them with recent lake and tributary water quality results. This report presents the results of sampling efforts in 2006, and compares the results with previous sampling results collected in conjunction with development of the phosphorus total maximum daily load (TMDL) in 1997, and annual sampling results collected subsequent to TMDL development.

Lake Macatawa is a 1,780 acre drowned river mouth lake located along the southeastern shoreline of Lake Michigan near the city of Holland, Michigan. The lake and its watershed encompass 179 square miles (114,560 acres) in Ottawa and Allegan Counties. Lake Macatawa is a relatively shallow lake with an average depth of 12 feet and a maximum depth of 40 feet in the western basin. The water level of Lake Macatawa changes along with the fluctuations in Lake Michigan water levels. Consequently, the water level of Lake Macatawa was approximately three feet lower in 2006 than 1997 when the TMDL was developed and Lake Michigan water levels were above the long-term average levels. A man-made shipping channel about 5 miles in length is maintained at a depth of 22 feet from Lake Michigan to the eastern basin of the lake. The width of the lake varies from less than 0.25 miles to slightly more than 1 mile.

Major tributaries to Lake Macatawa are the Macatawa River and Pine Creek. The Macatawa River enters the shallow eastern basin of Lake Macatawa after passing through a several hundred acre wetland. Recent low-water levels have decreased the wetted surface area of the wetland exposing vast mud flats that have developed lush stands of wetland vegetation. The shoreline of the eastern basin is dominated by industrial development. The remainder of the lake's shoreline consists of residential development, city and township parks, or commercial marinas. A small portion of the middle basin in Pine Creek Bay in 1997 was natural and undeveloped, but recent home construction has drastically reduced the extent of natural shoreline.

The Michigan Department of Environmental Quality (MDEQ) is required by Section 303(d) of the federal Clean Water Act to biennially develop and submit to the United States Environmental Protection Agency (USEPA) a list of water bodies that do not attain water quality standards (WQS). Lake Macatawa and all tributaries within the watershed were included on this list submitted to the USEPA because of nutrient enrichment. Lake Macatawa displays the classic symptoms of a hypereutrophic lake, including: extremely high nutrient and chlorophyll a levels, excessive turbidity, periodic nuisance algal blooms, low dissolved oxygen (D.O.) levels,

and a high rate of sediment deposition. Lake Macatawa was included in a 1971 publication entitled, "Problem Lakes in the United States" (Ketelle and Uttormark, 1971). Thirty-five years later the lake is still considered to be one of the most nutrient enriched lakes in Michigan. Federal, state, and local agencies, as well as several universities, have documented Lake Macatawa's water quality, sediment chemistry, watershed resources, and various specifics of the dynamics that impact water quality. Historic published literature available for Lake Macatawa is compiled in the references section of a past report prepared by the MDEQ (Walterhouse, 1998).

The MDEQ received a Section 104(b)(3) grant from the USEPA in October 1996 to develop a phosphorus TMDL for Lake Macatawa, and used some of the funding to quantify phosphorus loading throughout the Lake Macatawa Watershed and relate the loading to Lake Macatawa's in-lake phosphorus concentration. Walterhouse (1998) summarized the sampling efforts, sampling results, and outlined the methods used to develop a phosphorus TMDL that will result in Lake Macatawa meeting WQS. The TMDL document was public noticed on November 23, 1998, and submitted to the USEPA on January 27, 1999 (Walterhouse, 1999b). USEPA approval of the TMDL required the submission of additional documents on June 30, 1999, October 22, 1999, and February 24, 2000. Final approval from the USEPA was received on April 13, 2000. The MDEQ dedicated the remainder of the USEPA funds to the Macatawa Area Coordinating Council (MACC), a local organization that accepted the challenge of coordinating the development of a locally derived watershed management plan to achieve the goal of the TMDL. The MACC finalized a plan on September 16, 1999, entitled "Phosphorus Reduction Implementation Plan for the Macatawa Watershed, 1999-2009" (Higgins and Kosky, 1999). A voluntary agreement to reduce phosphorus loading to Lake Macatawa was signed on May 1, 2000, by representatives of all government units within the watershed, point sources that contribute phosphorus, and the MDEQ. As per the agreement, the MACC is responsible for preparing a report on an annual basis summarizing the progress made toward meeting the phosphorus goals identified in the TMDL. The following table provides a summary of the best management practices (BMPs) implemented throughout the 114,000-acre watershed to reduce nonpoint source (NPS) phosphorus loading prior to sampling in 2006 (MACC, 2007).

Best Management Practice	**Area Impacted**	
Agricultural	**2005**	**Project to Date**
Filter Strips		45.6 acres
Grassed Waterway		73,602 linear feet
Crop Residue Management-No Till		1,307.5 acres
Crop Residue Management-Minimum Till		384.1 acres
Hayland Planting		62.3 acres
Cover Crop		52.6 acres
Critical Area Planting		26.4 acres
Grass Stabilization Structure		40 linear feet
Wetland Creation/Restoration		2.12 acres
Livestock Crossing		1 unit
Fence Exclusion		2,002 linear feet
Urban	**2005**	**Project to Date**
Rain gardens		62,364 ft^3
Wetlands	4.8 acres	5.0 acres
Stream Bank Stabilization	950 linear feet	950 linear feet

In addition to the BMPs, numerous efforts and actions have been taken to reduce NPS loading from urban and agricultural sources throughout the watershed. The point sources in the watershed have reduced phosphorus loading to Lake Macatawa from over 14,000 pounds in 2000, to less than 14,000 pounds in 2005, and are well below the phosphorus wasteload allocation of 20,000 pounds per year established in the TMDL.

METHODS

Sampling was conducted once per month from April through September 2006, at five stations in Lake Macatawa (Figure 1). Grab samples were collected at the surface, bottom, and mid-depth at each station. A depth integrated sample of the photic zone was also collected at each station for chlorophyll a analysis. Additional sampling at each station included a measurement of secchi transparency and a profile at five-foot increments of temperature, D.O., conductivity, and pH from the surface to the lake bottom using a calibrated Yellow Springs Instruments 6 series environmental monitoring system.

Grab samples were also collected once per month, on the same day the lake sampling was conducted, at the six tributaries where annual loads were determined during development of the TMDL (Figure 2). Flow at the time of sampling was obtained from the United States Geological Survey (USGS) Web site for the gage station located on the Macatawa River. Flows at the time of sampling for the other five tributaries were calculated using the stage height at the time of sampling and the stage discharge curves previously developed by the MDEQ's Land and Water Management Division.

All of the samples from the lake and tributaries were collected, preserved (if necessary), stored at four degrees Celsius, and transported to the MDEQ's Environmental Laboratory for chemical analysis using standard protocols (Michigan Department of Natural Resources, 1994). The samples were analyzed for total and ortho-phosphorus, nitrate + nitrite, Kjeldahl nitrogen, nitrite, ammonia, suspended solids, and chlorophyll a. The MDEQ's Environmental Laboratory analyzed all of the water samples except for part of the samples collected in August. Tri-Matrix Laboratories analyzed the August samples for total phosphorus, nitrate + nitrite, ammonia, and Kjeldahl nitrogen, and the MDEQ's Environmental Laboratory analyzed the samples for the remainder of the parameters.

SAMPLING RESULTS

Monthly water quality sampling results for Lake Macatawa and the tributary sites are presented by month in Tables 1 through 6. The 2006 average monthly sampling results for total phosphorus are displayed in Figures 3 and 4 for Stations 1, 2, and 4, along with historic data that was collected at the same three locations (Creal and Walterhouse, 1997; and Walterhouse, 1998, 1999a, 2000, 2001, 2002, 2003, 2004, 2005, and 2006). The 1997 monthly sampling results used to develop the TMDL suggested that conditions might be improving in Lake Macatawa compared to the previous years. The 2000 data demonstrated that conditions were not improving. Average phosphorus concentrations in April, May, and September 2000 were the highest recorded since reliable and comparable data collection began in 1982. All of the monthly average phosphorus concentrations in 2006 were within the historic range of values for each month. The average phosphorus concentration of 165 micrograms per liter (ug/l) in April was the lowest value recorded for the month since 2000, but during May the concentration increased to nearly 200 ug/l. The average phosphorus concentration dropped to the lowest

value of the year in June at 142 ug/l. However, the phosphorus concentration increased dramatically in July to 251 ug/l, the highest value recorded in 2006. Phosphorus concentrations decreased in August to 173 ug/l and decreased again in September to 160 ug/l.

The spring (April and May) average phosphorus levels at the three locations where additional historic, comparable data was available (USEPA, 1975) are presented in Figure 5. The spring overturn phosphorus concentration of 181 ug/l in 2006 was slightly higher than the concentration of 148 ug/l in 2005, but is consistent with historic levels before and after implementation of the TMDL. The 2006 spring phosphorus concentration was more than three times greater than the TMDL interim goal of 50 ug/l. The total nitrogen (nitrate + nitrite and Kjeldahl nitrogen) to total phosphorus ratios in April, May, and June of 2006 were once again greater than 15:1 indicating that phosphorus continues to be the limiting nutrient in Lake Macatawa. The primary conclusion of the data analysis to date continues to be that phosphorus levels are consistently unacceptable, and phosphorus concentrations are extremely variable on a monthly and annual basis.

The historic monthly average chlorophyll a concentrations are presented along with the results from monthly sampling at the five stations in 2006 in Figure 6. Chlorophyll a measurements provide an indication of the amount of algae present in the lake. Michigan lakes with chlorophyll a concentrations greater than 22 ug/l are generally considered to be hypereutrophic. Monitoring during 2006 demonstrated once again that chlorophyll a levels were greater than 22 ug/l during every month from April through September. The highest monthly average recorded during 2006 was 114 ug/l in July, while the lowest monthly average was 51 ug/l in September. The 2006 monthly averages for April through September were within the range of values that have been documented with previous monitoring efforts. The lowest chlorophyll a concentration recorded in 2006 was in the east basin (Station 1) during September (33 ug/l). The highest values (220 ug/l) during 2006 were also documented in the east basin (Station 1) in July and August. Like the phosphorus data collected to date, the chlorophyll a concentrations are consistently high, three to four times greater than desirable, and variable on a monthly and annual basis.

The monthly average Secchi depth readings for 2006, along with comparable historic data, are presented in Figure 7. Secchi depth readings provide a measurement of water clarity that is related to the chemical and physical properties of a lake. While water clarity is not a direct measurement of the chemical properties of lake water, it is an easy-to-understand indicator of a lake's water quality. Lakes in Michigan with secchi depth readings less than three feet are normally considered to be hypereutrophic. Secchi depth monitoring on an annual basis in Lake Macatawa has shown that water clarity is normally less than two feet (Figure 8). The June 2002 and 2003 average secchi depth readings exceeded 2.5 feet and were the highest values recorded since comparable data collection began in 1982. This relatively high level of water clarity, at least for Lake Macatawa, corresponded with the relatively low total phosphorus levels that were recorded in June 2002 and 2003. The 2006 monthly average secchi depths were never greater than 2.0 feet. The lowest secchi depths in 2006 were recorded in the east basin during April, August, and September when secchi depth was only 1.25 feet. The largest secchi depth value recorded in 2006 was 2.5 feet in the west basin during June. It is well documented that Michigan lakes normally exhibit a strong correlation between total phosphorus, chlorophyll a, and water clarity. Consequently, it is not surprising that the water clarity data for Lake Macatawa demonstrates monthly and annual variability consistent with phosphorus and chlorophyll a results that are consistently less than desirable.

Water quality parameters in the west basin were once again generally better than those measured in the east basin. Secchi depth readings in the east basin ranged from 1.25 to 1.50 feet compared to a range of 1.5 to 2.5 feet in the west basin during the 2006 monitoring. Chlorophyll a concentrations in 2006 were higher in the east basin, ranging from 33 to 220 ug/l, than the west basin, ranging from 44 to 120 ug/l, during all months, except May and September. Visible surface blooms of algae were not present during any of the periods of sample collection despite the high chlorophyll a concentrations all year. Surface total suspended solids ranged from 9 milligrams per liter (mg/l) to 22 mg/l in the west basin and 24 mg/l to 34 mg/l in the east basin. Similar differences in the water quality of the basins were also noted for ortho phosphorus, nitrite, ammonia, nitrate + nitrite, and Kjeldahl nitrogen with higher concentrations in the east basin during all months.

D.O. was depressed in 2006 to less than 5.0 mg/l near the lake bottom during July and August in the west basin, during June and August in the east basin and from June through September in the central basin. All other D.O. readings were above 5.0 mg/l. Thermal stratification of the water column was not apparent anywhere in the lake until June when all three basins were thermally stratified to varying degrees. The west basin was the only basin to remain at least weakly thermally stratified throughout July and August. Phosphorus concentrations were slightly elevated in several, but not all of the water samples collected near the bottom when D.O. was depressed and the water column was thermally stratified. Suspended solids were also slightly elevated in several of those samples relative to the overlaying water column suggesting that the sample gear may have disturbed the lake bottom. Monitoring since 1995 has revealed that thermal stratification can and does occur in all three basins of Lake Macatawa on a periodic basis during the summer months. D.O. depletion near the lake bottom occurs sporadically, but the release of phosphorus from the sediments during anaerobic conditions does not appear to be a problem that occurs on a regular basis.

A significant observation of the 2006 sampling events was the continued presence of rooted aquatic vegetation, primarily milfoil, in the west basin in three to four feet of water. The vegetation, which became established during the summer of 2002, flourished during the summers of 2002 and 2003, and weed beds were present in a large portion of the shallow water throughout the west basin both years. The growth of aquatic vegetation might be considered undesirable by boaters, but is typically an indication of improved lake quality due to increased water clarity. However, since water clarity has not improved in Lake Macatawa, the continued presence of aquatic vegetation is probably a product of lower lake levels. The lower lake levels have created large areas of water that are three to five feet deep allowing sunlight to reach the lake bottom and stimulate the growth of aquatic plants. These areas were previously six to eight feet deep and beyond the extent of sunlight penetration. Water levels have remained relatively low since 2003 but the abundance of the aquatic vegetation has been lower during the summers of 2004, 2005, and 2006 as compared to 2003.

The results of the 2006 tributary sampling results for total phosphorus concentration and stream flow at the time of sampling, along with previous data collected during low flow conditions, is presented in Figures 9 through 14. Average daily flow at the USGS gage on the Macatawa River from spring through fall 2006 is presented in Figure 15. The extensive sample results from 1996/1997 showed a strong positive correlation between flow and total phosphorus concentrations. The 2006 samples were collected as scheduled and low flow conditions were encountered during all of the sample events at all six sites. The May samples were collected just after the largest storm event during the monitoring period but stream flows were back to normal when the samples were collected. The September samples were collected after a minor

storm event and stream flows were still elevated slightly when the samples were collected. The lowest phosphorus concentrations of the year at five of the six stations were recorded in April. The highest phosphorus concentrations of the year at the Macatawa River (620 ug/l), North Branch Macatawa River (193 ug/l), Bosch & Hulst Drain (210 ug/l), and the Railroad Tributary (670 ug/l) were recorded during the September storm event. The highest phosphorus concentration of the year at Pine Creek (270 ug/l) was recorded flowing the May storm event. The highest phosphorus concentration at Maplewood Drain (340 ug/l) was recorded in August following an extended period of dry weather when the concentration of total suspended solids (200 mg/l) was also elevated possibly from construction activities upstream in the watershed. The phosphorus concentrations measured at all of the sites in 2006 were similar to concentrations that were measured during similar flow conditions in previous years. The results indicate that total phosphorus concentrations during various flow conditions throughout the watershed have not changed since sampling began in 1996/1997. The Macatawa River at the gage station and the sample site on Bosch & Holst Drain continue to have higher levels (normally greater than 100 ug/l) of total phosphorus during periods of low flow than the other sample sites in the watershed, while the site on Maplewood Drain typically has the lowest concentrations (less than 50 ug/l) during periods of low flow. The 2006 sampling results from throughout the watershed continue to demonstrate that when flows increase even minimally during storm events, total phosphorus concentrations increase substantially and phosphorus loading to Lake Macatawa increases dramatically.

In order to demonstrate the impact storm events have on the water quality of Lake Macatawa, an analysis of the water quality data collected at Lake Macatawa from 1997 to 2003 was regressed against peak and average daily stream flow of varying durations at the USGS gage on the Macatawa River (Walterhouse, 2005). The best statistically significant relationship was found between the average phosphorus concentration in Lake Macatawa and the average flow at the USGS gage, during the ten-day period prior to the sampling date. The 2004 and 2005 monitoring results were included in the analysis producing a similar correlation to what was obtained with the 1997-2003 monitoring data (Figure 16). The 2006 monitoring results are also included in Figure 16 demonstrating that phosphorus concentrations in Lake Macatawa are lower after extended periods of low stream flow prior to sampling. The relationship between flow and phosphorus concentrations in Lake Macatawa demonstrates that the water quality of Lake Macatawa continues to be strongly influenced by nonpoint source inputs during periods of higher flow (storm events). BMPs that are designed to reduce peak flows and improve water quality during storm events need to continue to be pursued aggressively throughout the watershed.

Fieldwork by: Christine Aiello, Marissa Burghdoff, Mike Walterhouse
Sarah Wolf, Matt Wesner, and Jamie Zbytowski
Surface Water Assessment Section
Water Bureau

Report by: Mike Walterhouse, Aquatic Biologist
Surface Water Assessment Section
Water Bureau

REFERENCES

Creal, W. and M. Walterhouse. 1997. Biological and Chemical Assessment of Lake Macatawa and its Tributaries, Allegan and Ottawa Counties, Michigan, 1979-1983. MDEQ, Surface Water Quality Division, Report No. MI/DEQ/SWQ-97/080.

Higgins, S. and K. Kosky. 1999. Phosphorus Reduction Implementation Plan for the Macatawa Watershed, 1999-2009. September 16, 1999. MACC, Holland, Michigan.

Ketelle, M. and P. Uttormark. 1971. Problem Lakes in the United States, University of Wisconsin for USEPA, Project No. 06010EHR.

Macatawa Area Coordinating Council. 2007. Macatawa Watershed Voluntary Agreement, Annual Report Covering 2005/2006, Lake Macatawa 2005/2006.

Michigan Department of Natural Resources. 1994. Quality Assurance for Water and Sediment Sampling. Environmental Protection Bureau, Lansing, Michigan, Publication No. 3730-0028.

USEPA, National Eutrophication Survey. 1975. Report on Lake Macatawa, Ottawa County, Michigan, USEPA Region V, Working Paper No. 200.

Walterhouse, M. 1998. Phosphorus Loading Assessment for Lake Macatawa, 1995 through 1997. MDEQ, SWQD, Report No. MI/DEQ/SWQ-98/015.

Walterhouse, M. 1999a. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 1998. MDEQ, SWQD, Report No. MI/DEQ/SWQ-99/084.

Walterhouse, M. 1999b. Total Maximum Daily Load for Phosphorus in Lake Macatawa, January 20, 1999. MDEQ, SWQD, Submittal to U.S. Environmental Protection Agency.

Walterhouse, M. 2000. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 1999. MDEQ, SWQD, Report No. MI/DEQ/SWQ-00/035.

Walterhouse, M. 2001. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2000. MDEQ, SWQD, Report No. MI/DEQ/SWQ-01/021.

Walterhouse, M. 2002. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2001. MDEQ, SWQD, Report No. MI/DEQ/SWQ-02/060.

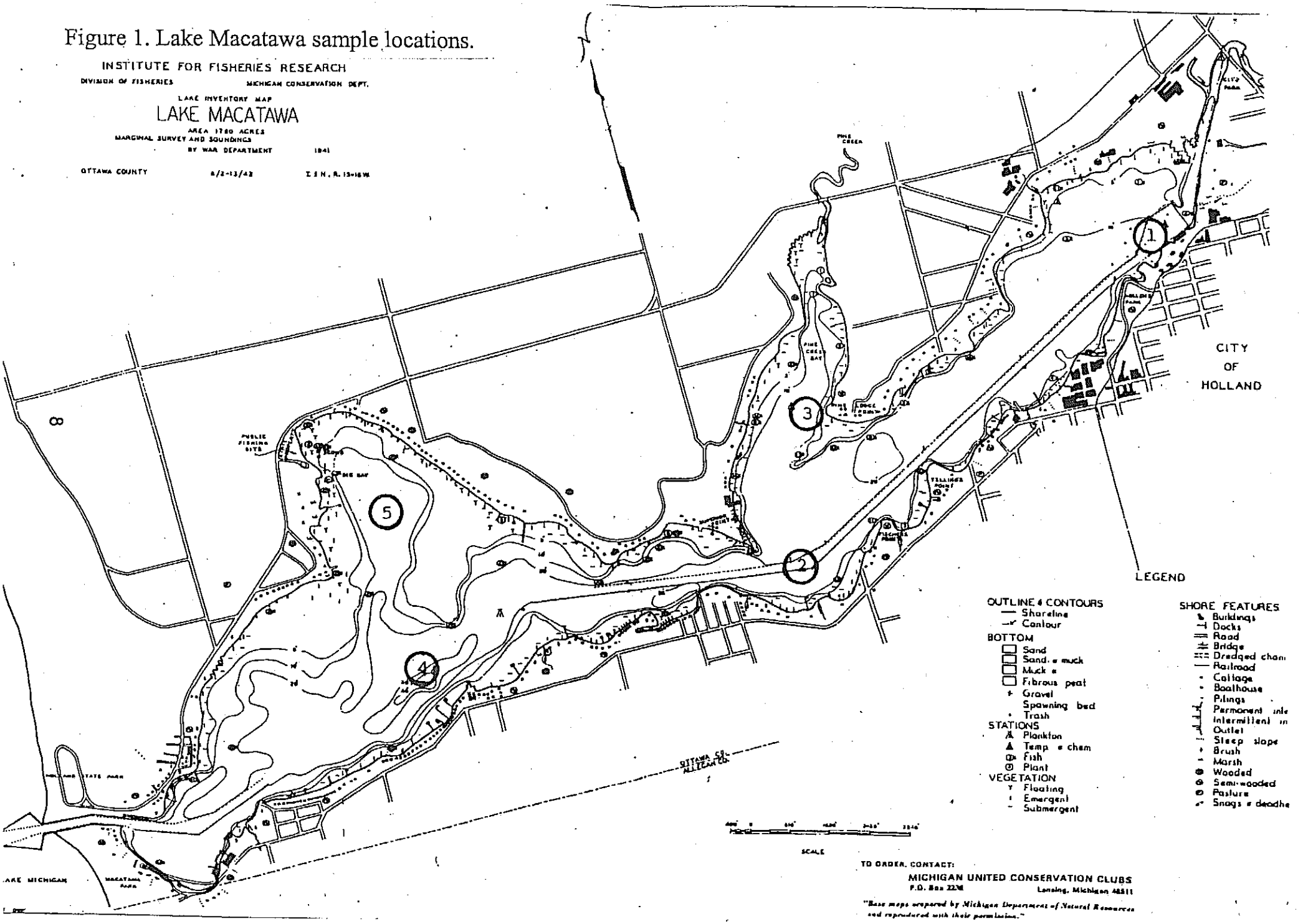
Walterhouse, M. 2003. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2002. MDEQ, WD, Report No. MI/DEQ/WD-03/015.

Walterhouse, M. 2004. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2003. MDEQ, WD, Report No. MI/DEQ/WD-04/022.

Walterhouse, M. 2005. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2004. MDEQ, WB, Report No. MI/DEQ/WB-05/039.

Walterhouse, M. 2006. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2005. MDEQ, WB, Report No. MI/DEQ/WB-060/070.

Figure 1. Lake Macatawa sample locations.



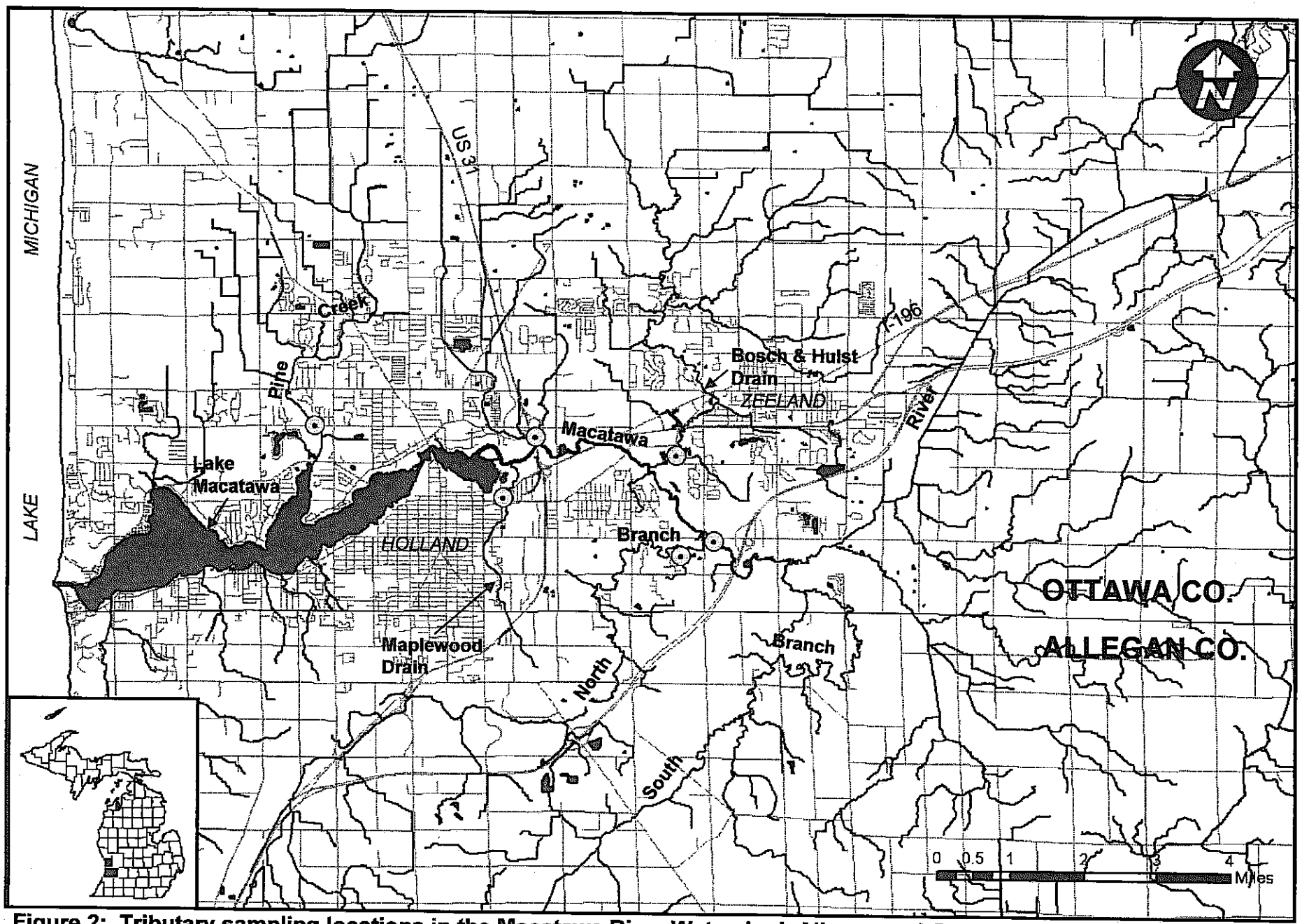


Figure 2: Tributary sampling locations in the Macatawa River Watershed, Allegan and Ottawa Counties, 2006.

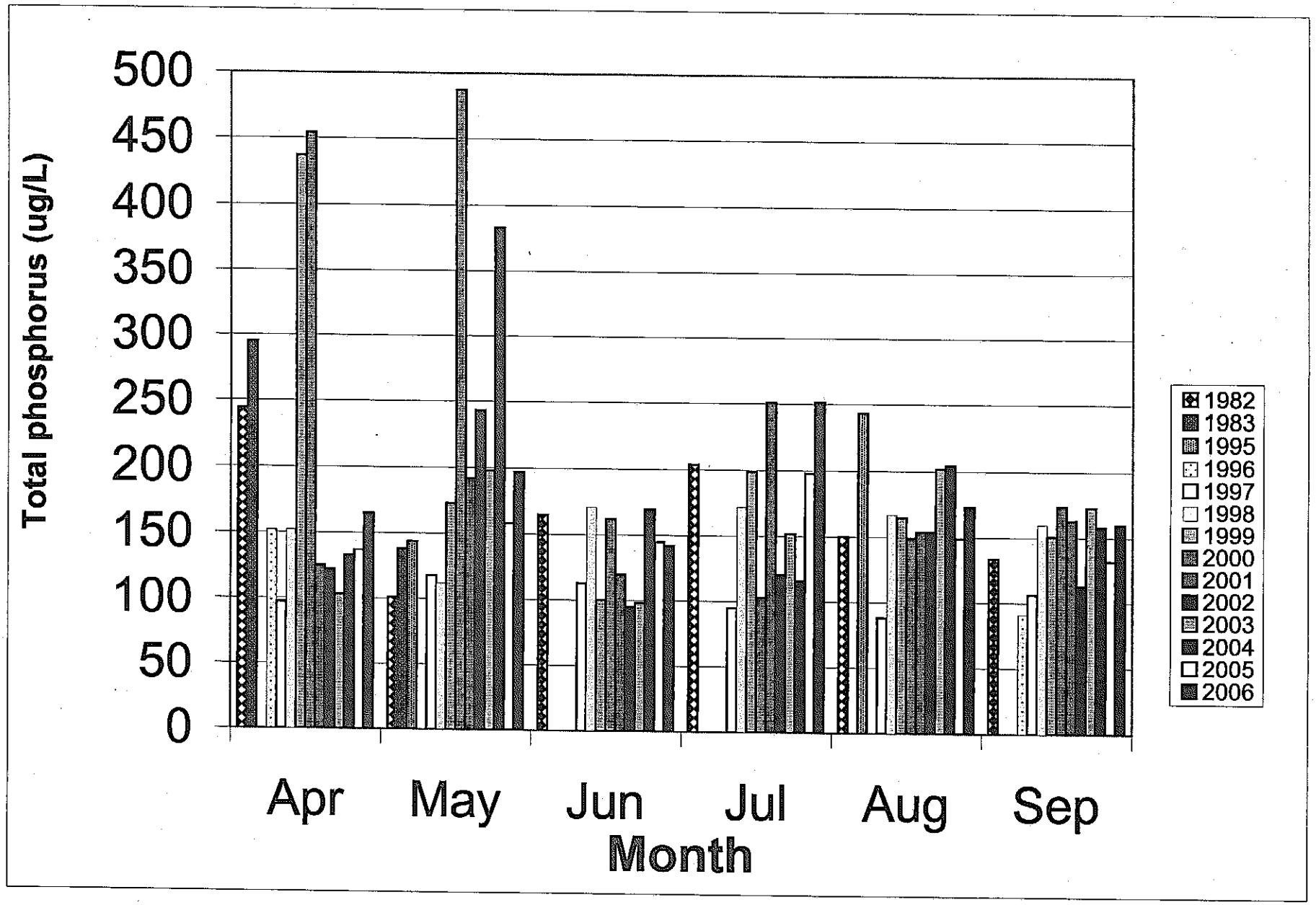


Figure 3. Historic monthly average phosphorus concentrations by month in Lake Macatawa at stations 1, 2, and 4, Ottawa County, Michigan,

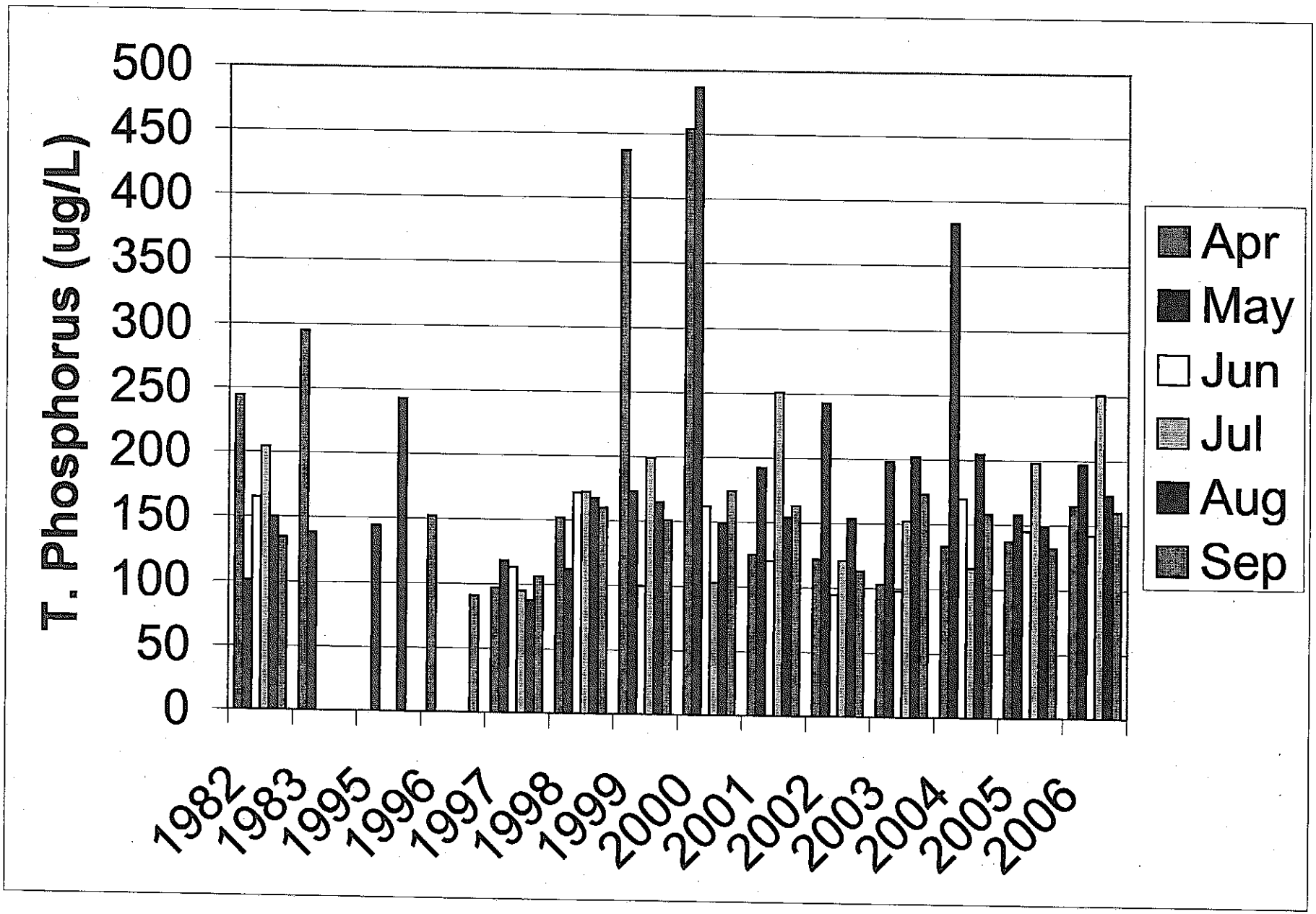


Figure 4. Monthly average phosphorus concentrations in Lake Macatawa at stations 1, 2, and 4, Ottawa County, Michigan.

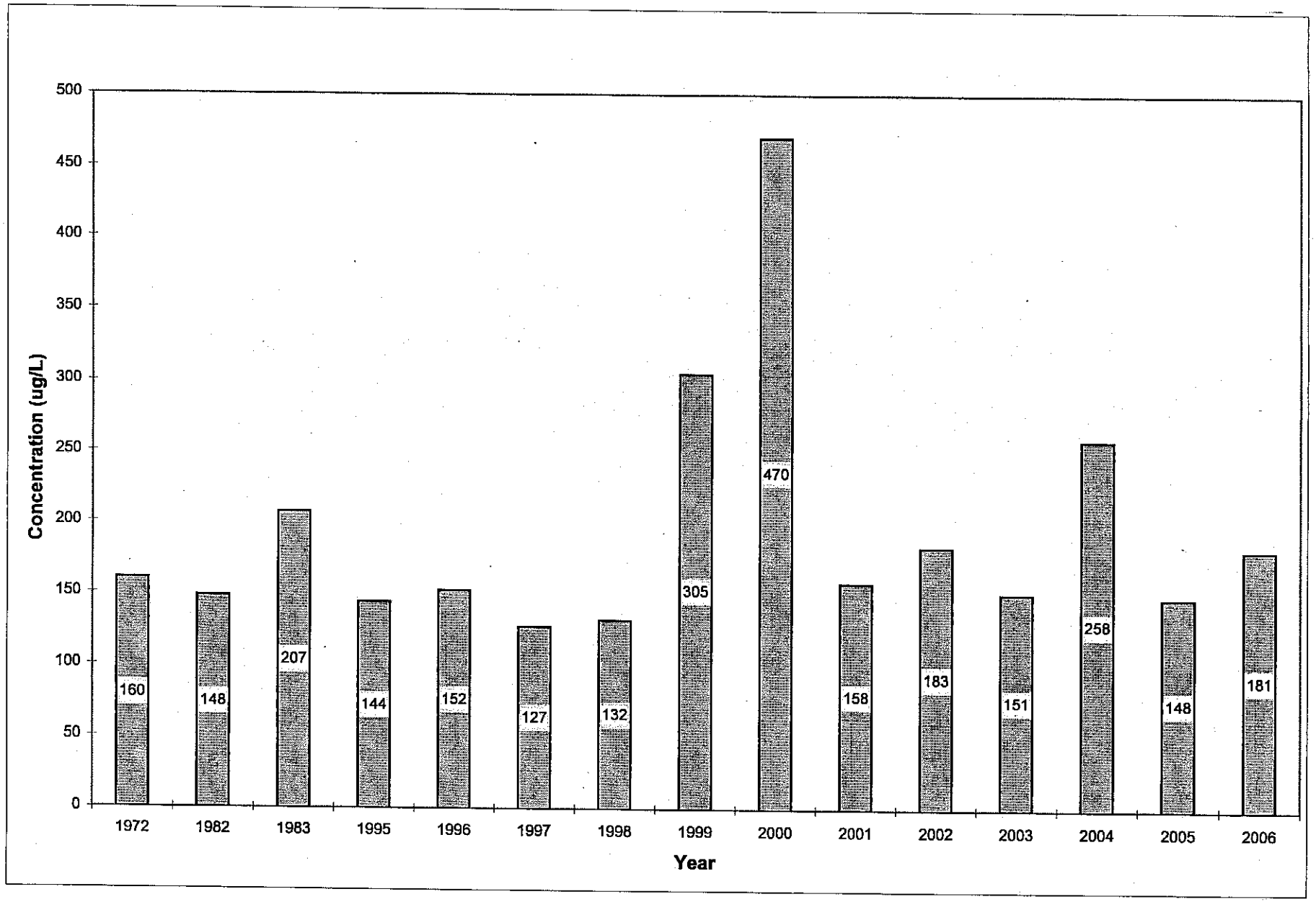


Figure 5. Average historic spring phosphorus concentrations at stations 1, 2, and 4 in Lake Macatawa, Ottawa County, Michigan.

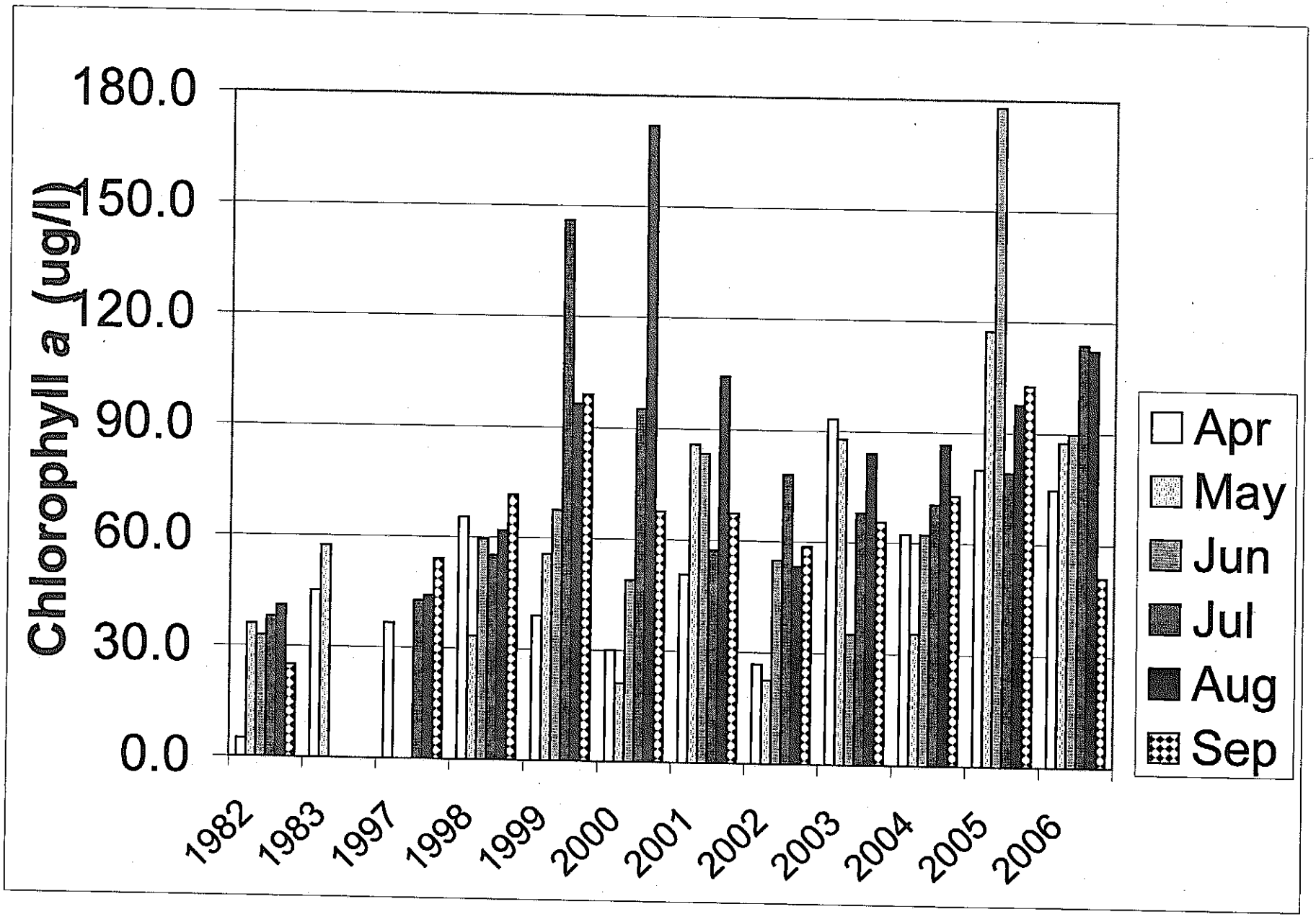


Figure 6. Historic monthly average chlorophyll *a* concentrations at stations 1-5 in Lake Macatawa, Ottawa County, Michigan.

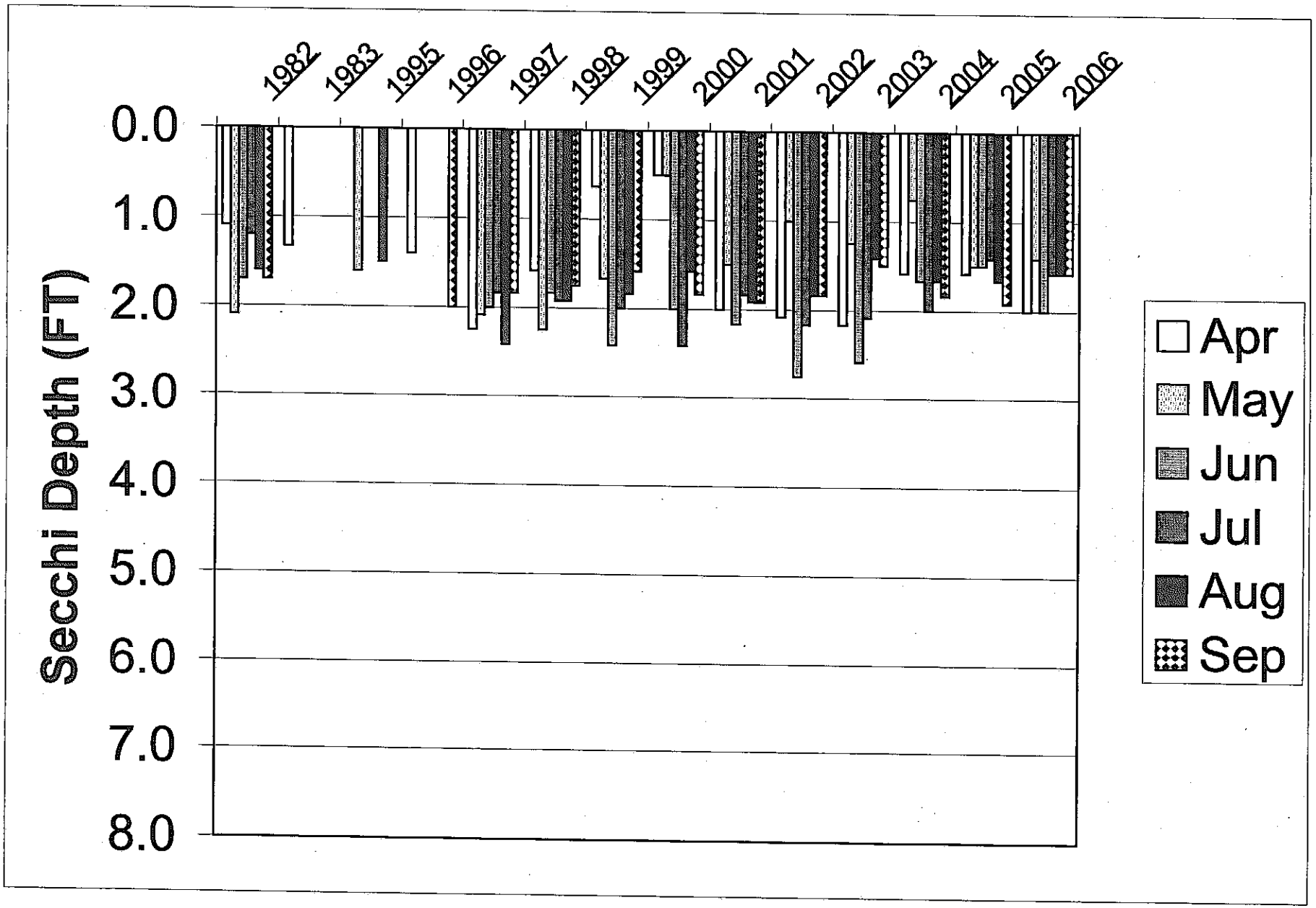


Figure 7. Monthly average secchi depths in Lake Macatawa at stations 1, 2, and 4, Ottawa County, Michigan.

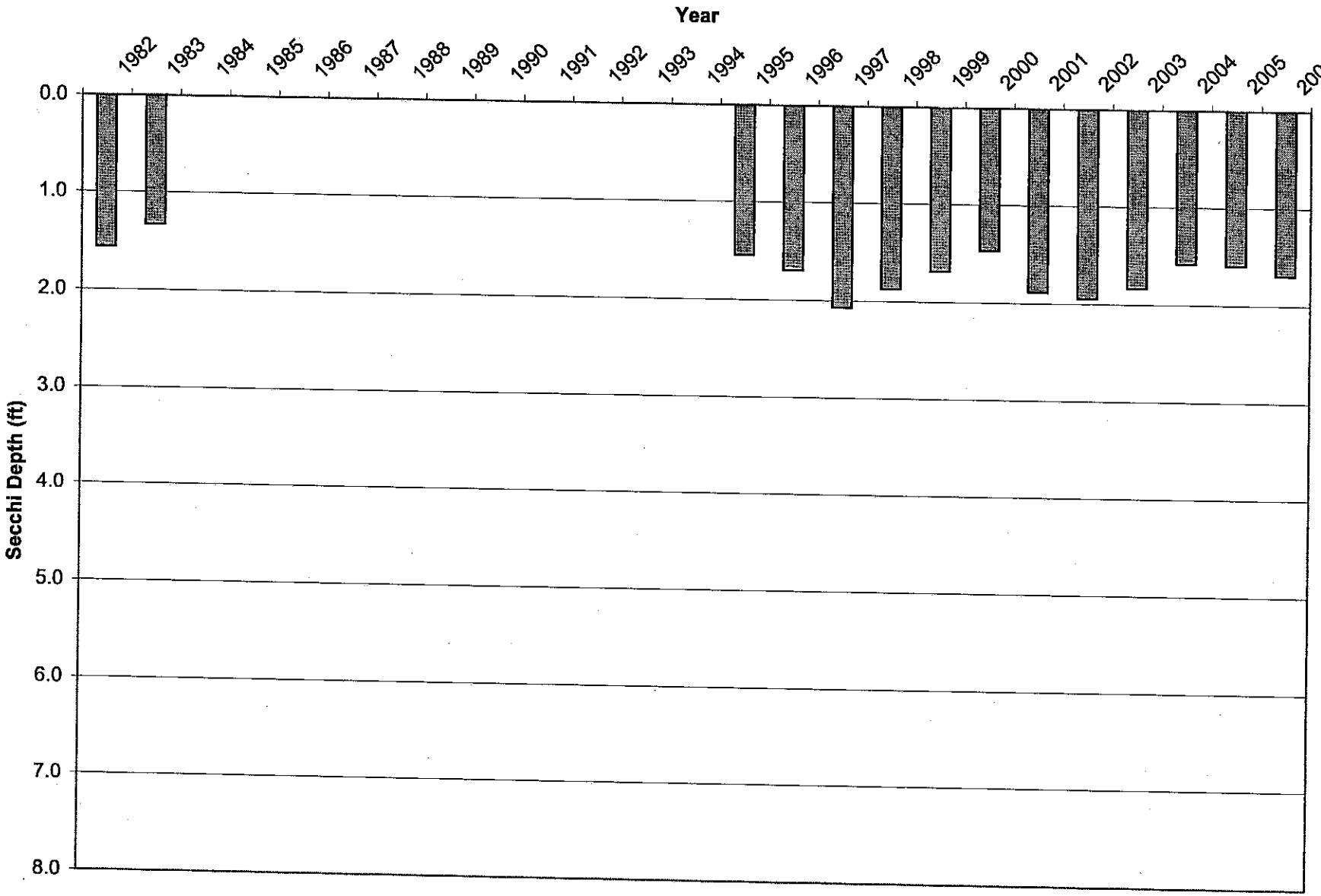


Figure 8. Annual Average secchi depth from April through September at stations 1, 2, and 4 in Lake Macatawa, Ottawa County, Michigan.

Figure 9. Phosphorus Sampling Results In Relation To Flow At The USGS Gage On The Macatawa River

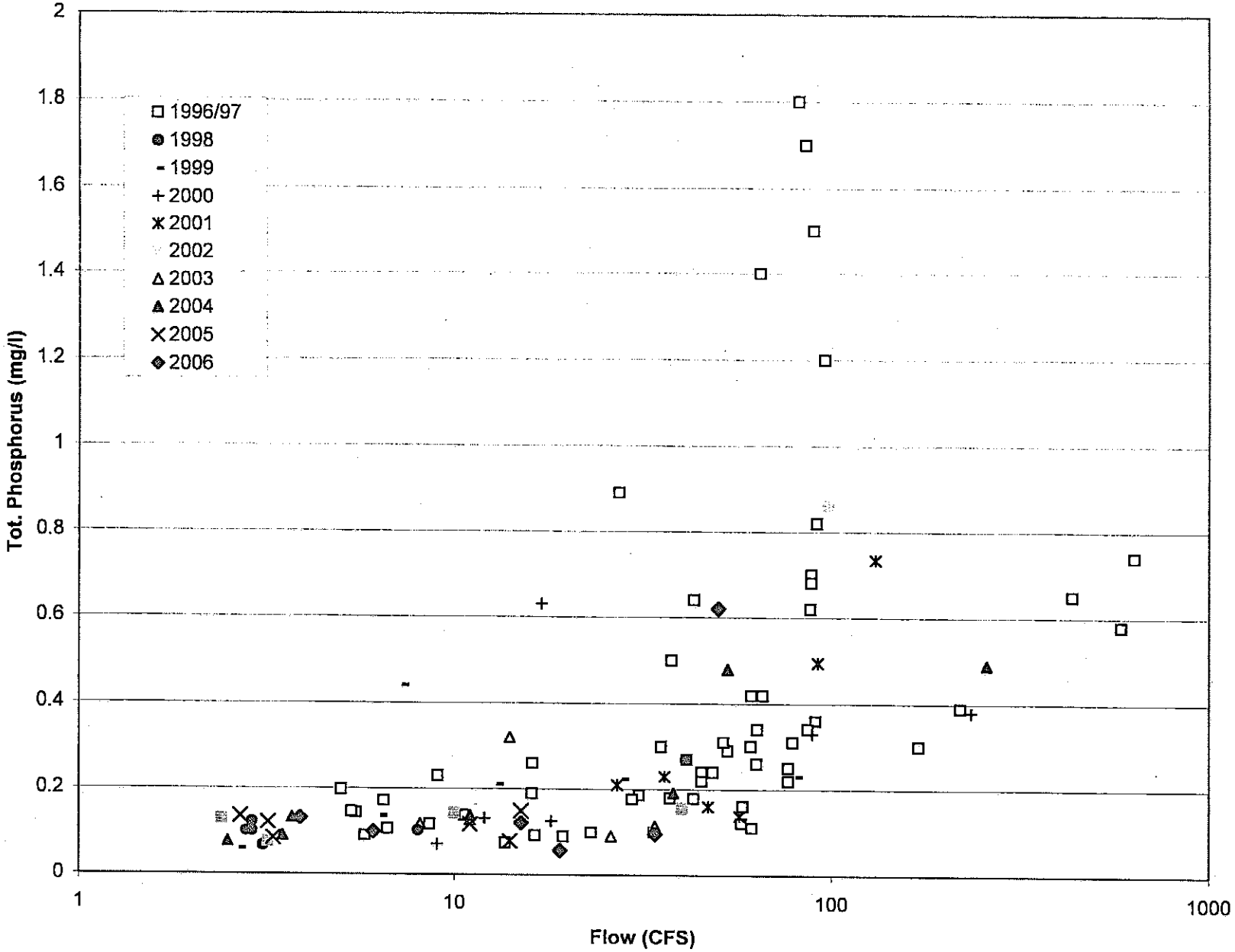


Figure 10. Phosphorus Sampling Results In Relation To Flow In The North Branch Macatawa River

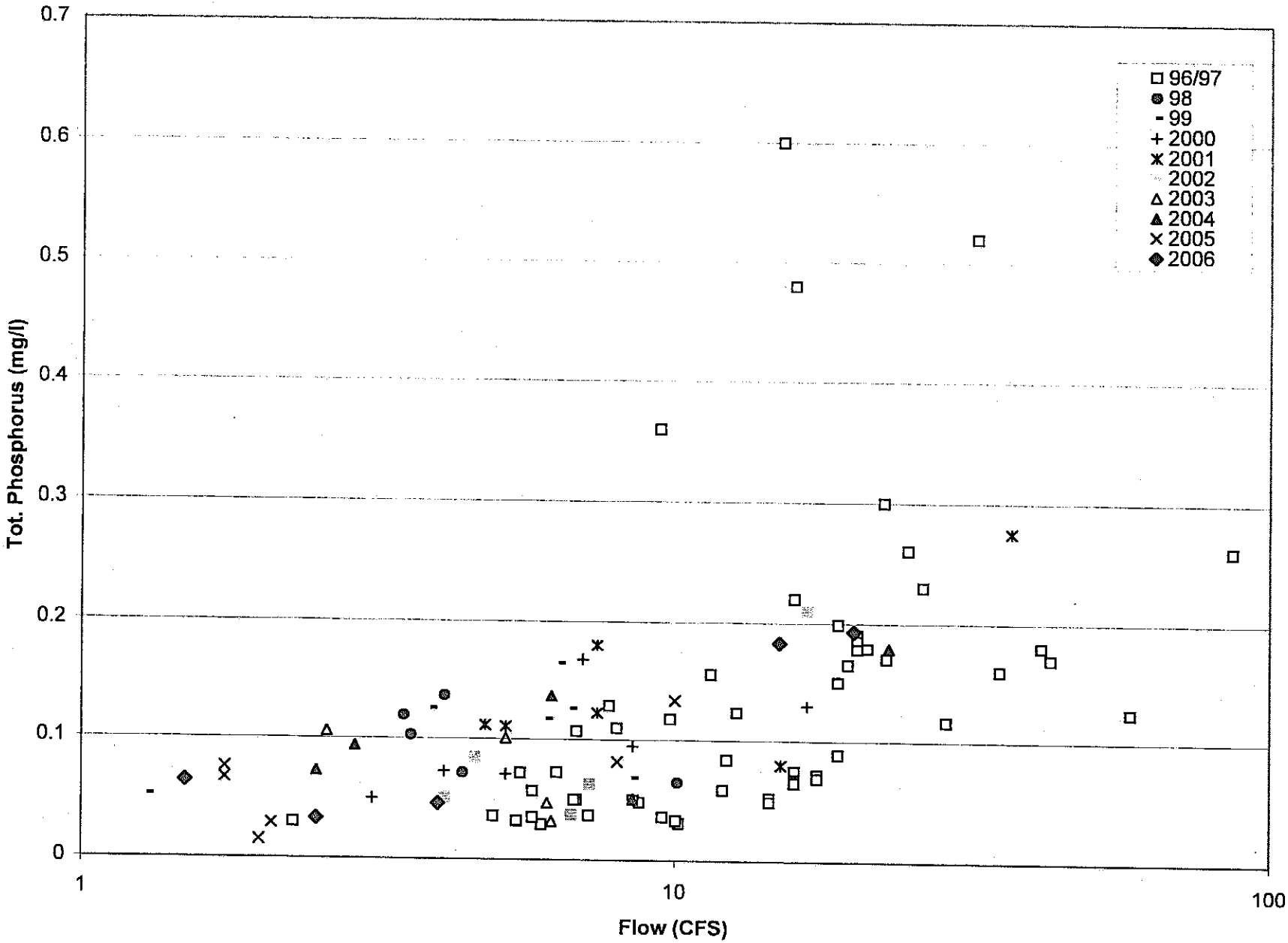


Figure 11. Phosphorus Sampling Results In Relation To Flow In Maplewood Drain

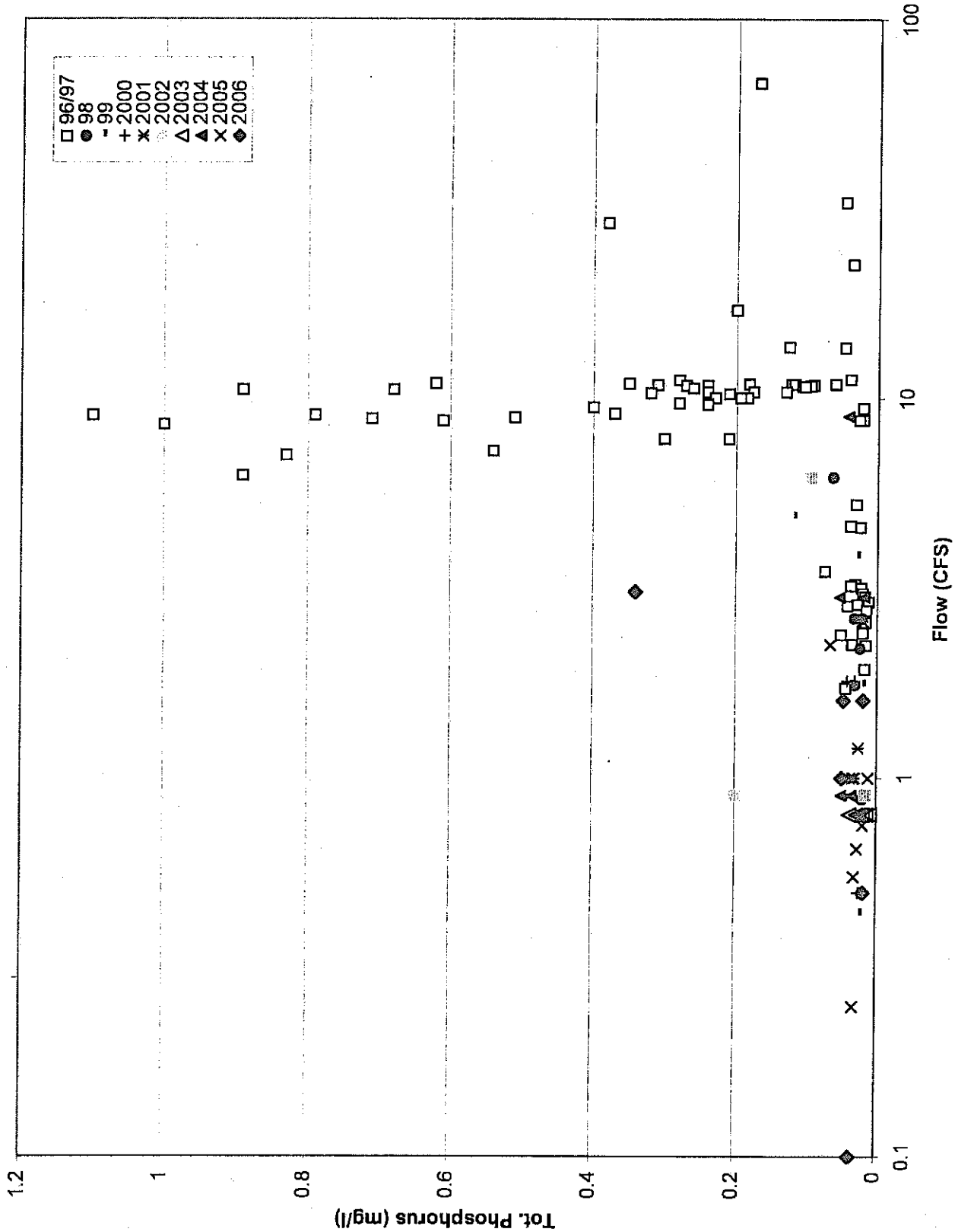


Figure 12. Phosphorus Sampling Results In Relation To Flow In Pine Creek

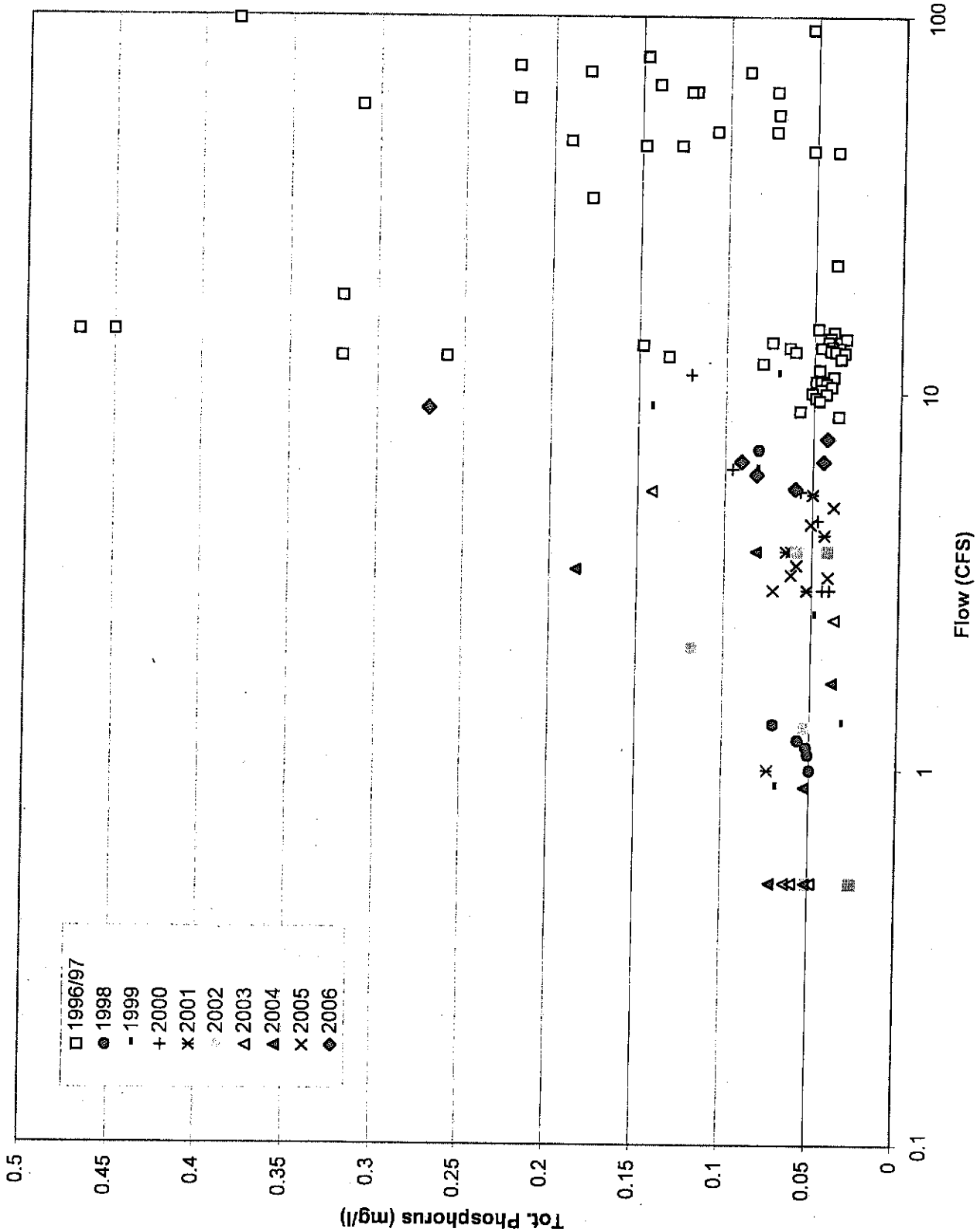


Figure 13. Phosphorus Sampling Results In Relation To Flow In Railroad Tributary

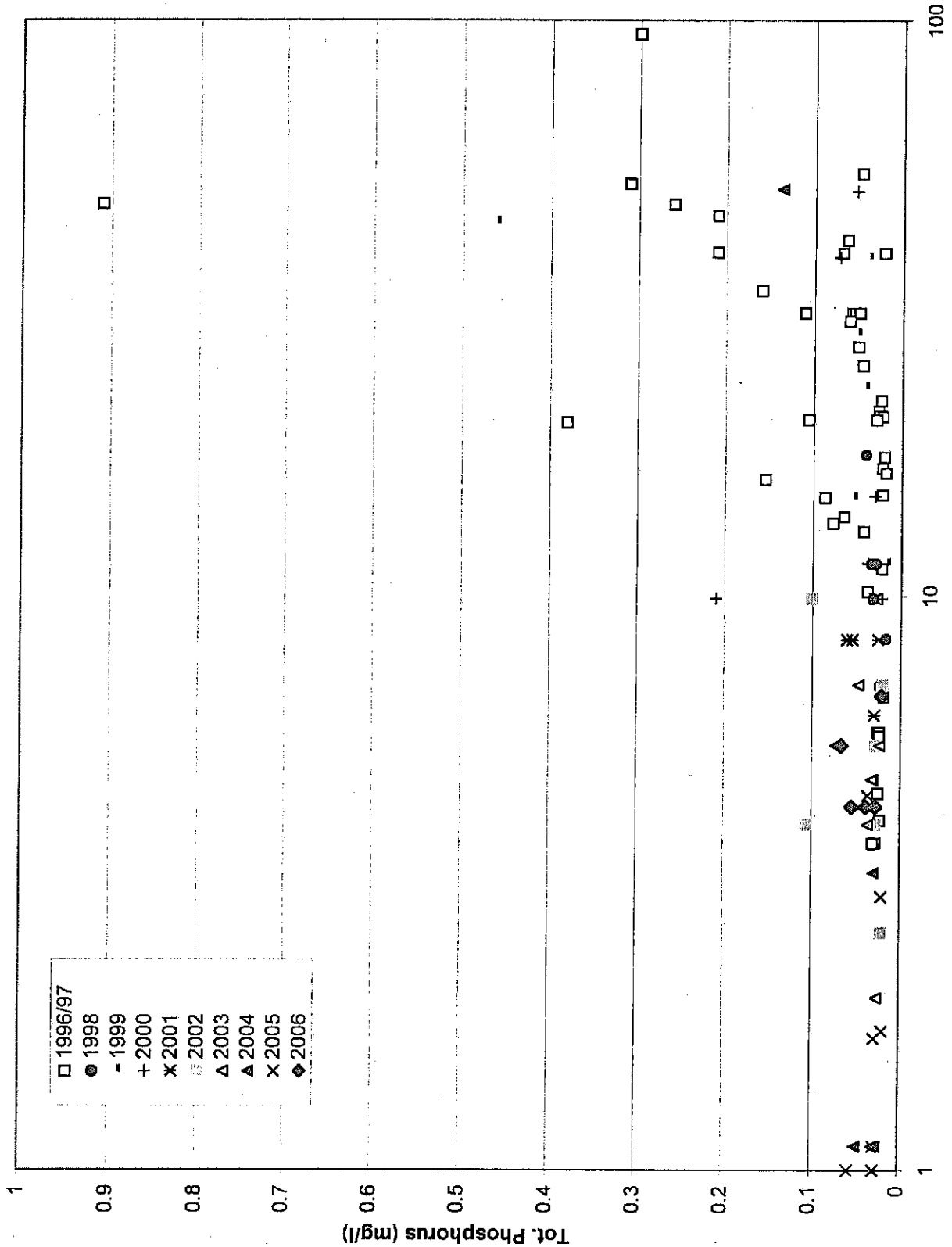
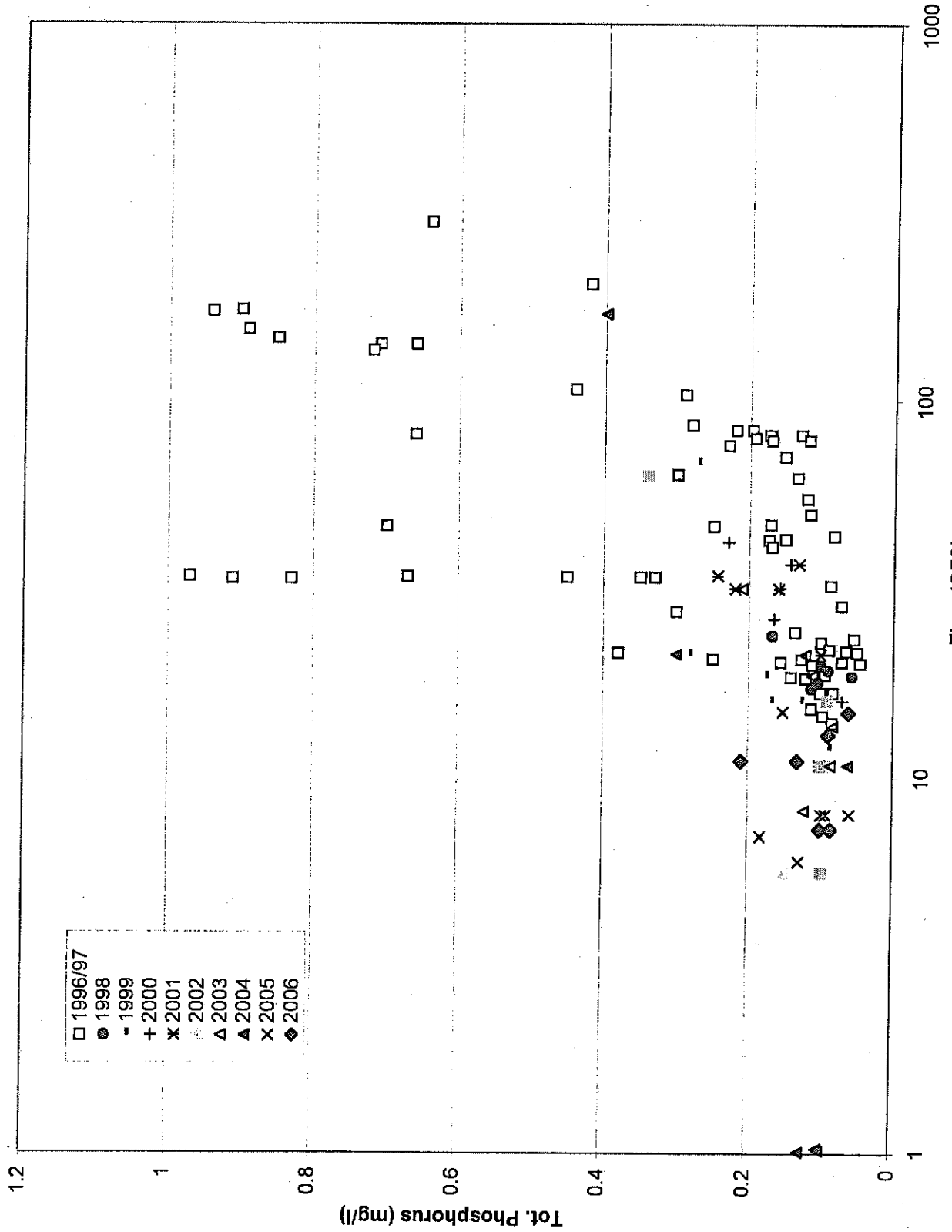


Figure 14. Phosphorus Sampling Results In Relation To Flow In Bosch & Hulst Drain



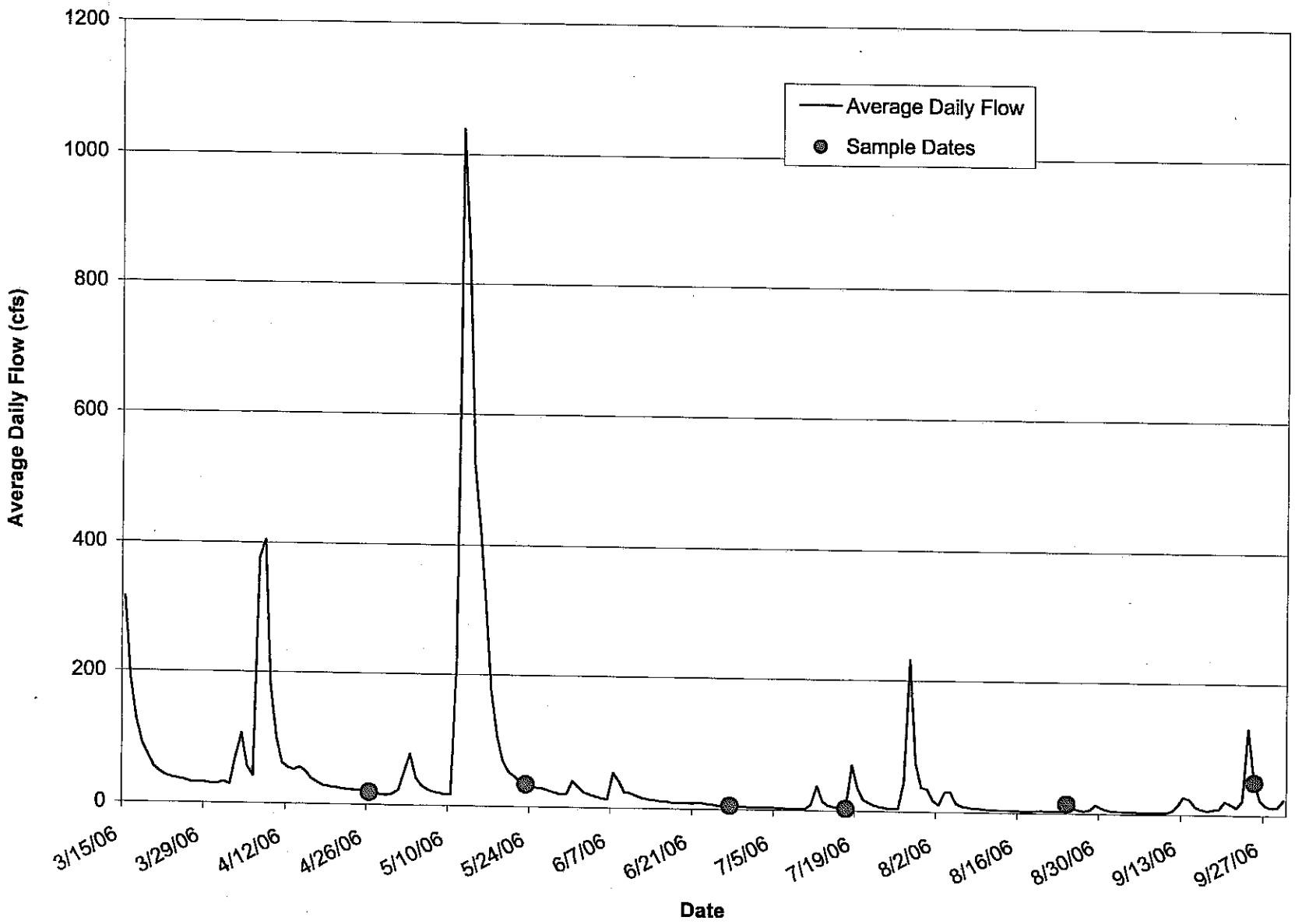


Figure 15. Average Daily flow at the USGS Gage on the Macatawa River, Ottawa County, Michigan, March 15 - September 30, 2006.

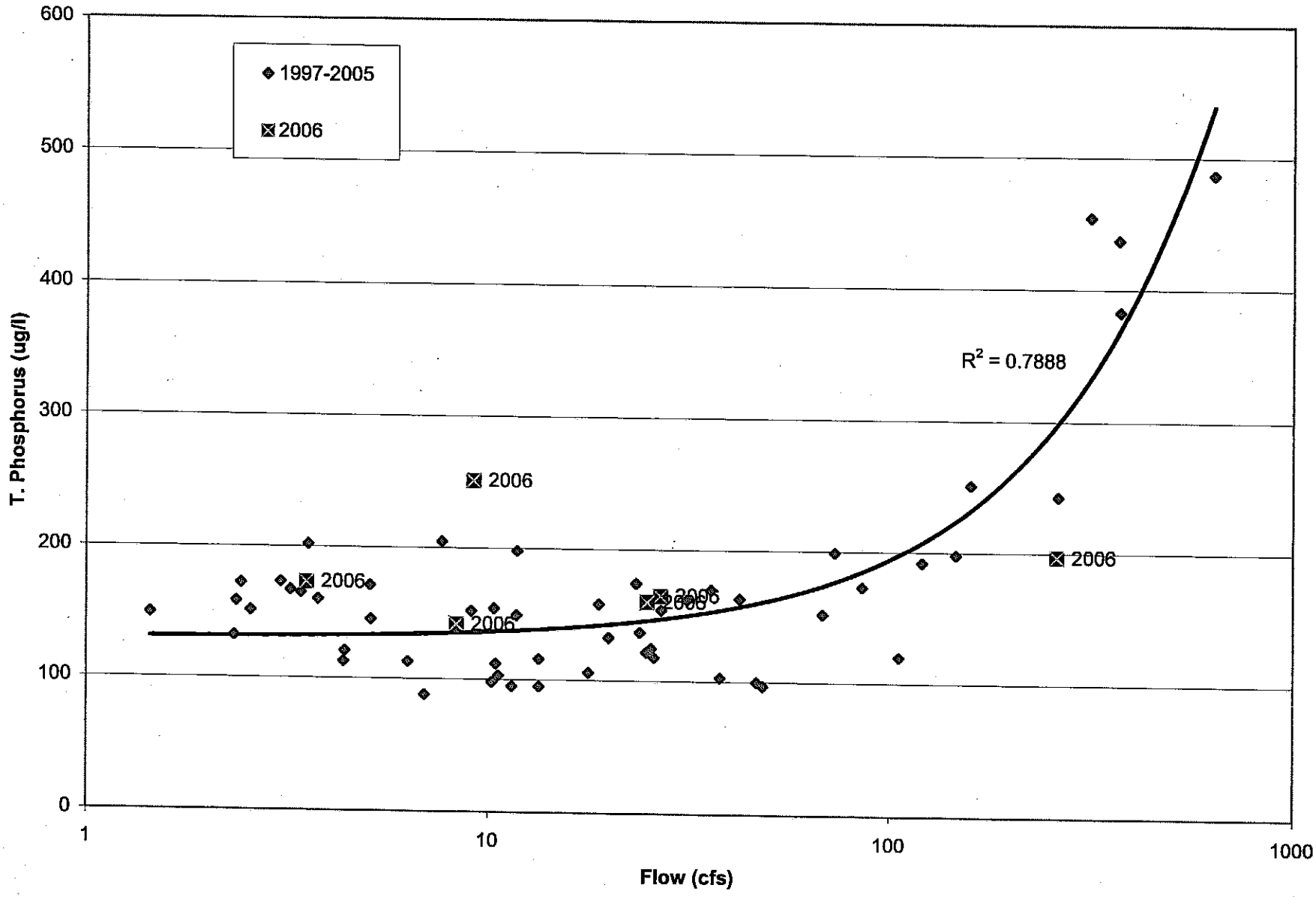


Figure 16. Average phosphorus concentrations in Lake Macatawa from April to September vs average flow of the Macatawa River during the 10 day period prior to sampling, 1997-2005.

Table 1. Water Quality Sampling Results, Lake Macatawa and Major Tributaries, Allegan and Ottawa Counties, April 26, 2006.

STATION	DEPTH (ft)	TEMP. (F)	D. O. (mg/l)	COND. (umho/cm)	pH	CHLORO A. (ug/l)	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Lake Macatawa-West Basin (1)													
Storet # 700237	Sur.	55.0	11.7	494	8.4	52	1.39	2.4	.05 D	.054	.005	22	.104
Station #4- 12:50 pm	5	55.0	11.6	494	8.4								
Depth (ft): 32	10	54.9	11.5	494	8.4								
Secchi Depth (ft): 2.25	15	54.9	11.4	495	8.4		1.40	2.4	.06 D	.054	.004	21	.105
Color: brownish	20	54.9	11.4	495	8.4								
	25	55.0	11.4	496	8.4								
	30	55.0	11.3	496	8.4		1.42	2.4	.06 D	.054	.004	34	.119
Lake Macatawa-West Basin (2)													
Storet # 700573	Sur.	55.2	12.4	487	8.6	52	1.38	2.3	ND @.05 D	.048	.004	25	.104
Station #5- 1:40 pm	5	55.2	12.1	486	8.6								
Depth (ft): 13	10	54.9	12.0	486	8.5								
Secchi Depth (ft): 2.0	13	54.2	8.1	492	8.0		1.41	2.3	ND @.05 D	.047	.005	29	.112
Color: brownish													
Lake Macatawa-Central Basin													
Storet # 700574	Sur.	57.9	12.4	605	8.1	85	2.2	3.2	.25 D	.110	.004	32	.157
Station #2- 11:55 am	5	57.7	12.6	602	8.4								
Depth (ft): 25.0	10	57.5	12.5	594	8.4		2.2	3.1	.20 D	.103	.015 PI	30	.158
Secchi Depth (ft): 2.5	15	57.3	12.4	597	8.4								
Color: brownish	20	57.4	12.2	607	8.3								
	25	57.0	11.9	618	8.2		2.4	3.2	.32 D	.115	.023	60	.20
Lake Macatawa-Pine Creek Bay													
Storet # 700384	Sur.	57.2	13.4	585	8.5	87	1.9	2.8	.08 D	.090	.011	27	.130
Station #3- 2:10 pm	5	57.0	13.3	583	8.5								
Depth (ft): 10.0	10	55.6	11.5	580	7.9		1.83	2.7	.08 D	.089	.010	29	.133
Secchi Depth (ft): 1.5													
Color: brownish													
Lake Macatawa-East Basin													
Storet # 700238	Sur.	60.3	11.6	726	7.5	98	4.3	3.3	1.2	.154	.016	33	.20
Station #1- 2:30 pm	5	60.3	11.8	724	7.5								
Depth (ft): 21.0	10	60.0	11..8	708	7.7		3.3	3.3	1.0	.152	.004	46	.21
Secchi Depth (ft): 1.25	15	59.7	12.0	715	7.7								
Color: brownish	20	59.7	11.8	700	7.7		3.1	3.3	1.0	.150	.004	57	.23
Lake Macatawa @ River St.							3.3	3.3	1.2	.161	.001 T	26	.165
	Time	**Stage**	**Flow(cfs)**	**Visual Observations**									
Pine Creek	3:20 pm	7.1	7.6	clear baseflow			.51	1.14	.049	.021	.018	10	.042
Railroad Tr. D/S of Confluence	3:40 pm	12.9	6.7	clear baseflow			.71	.61	.011	.012	.006	10	.022
Maplewood Drain	10:00 am	11.8	1.6	clear baseflow			.56	1.80	.013	.023	.001 T	ND @ 4	.019
Bosch and Hulst Drain	10:10 am	13.6	14.9	clear baseflow			.91	2.9	.08 D	.32	.021 PI	ND @ 4	.061
N. Br. Macatawa River	10:40 am	3.3	2.5	clear baseflow			.92	.34	.013	.009	.005	ND @ 4	.033
Macatawa River @ USGS Gage	10:30 am		19.0	clear baseflow			.97	7.1	.05 D	.118	.023	ND @ 4	.056

D - Analyte value quantified from a dilution(s); reporting limit (RL) raised, MDEQ-Environmental Laboratory.
ND - Non detectable, MDEQ-Environmental Laboratory.
PI - Possible Interference
T -Report value is less than the reporting limit (RL).

Table 2. Water Quality Sampling Results, Lake Macatawa and Major Tributaries, Allegan and Ottawa Counties, May 23, 2006.

STATION	DEPTH (ft)	TEMP. (F)	D. O. (mg/l)	COND. (umho/cm)	pH	CHLORO A. (ug/l)	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Lake Macatawa-West Basin (1)													
Storet # 700237	Sur.	58.0	13.9	480	8.5	120	1.88	3.5	ND @.05 D	.079	.011	21	.196
Station #4- 10:00 am	5	57.7	13.3	481	8.4								
Depth (ft): 33	10	57.5	12.9	483	8.4								
Secchi Depth (ft): 1.5	15	57.1	12.2	483	8.3		1.84	3.5	ND @.05 D	.078	.011	26	.197
Color: brownish	20	56.5	11.6	479	8.1								
	25	55.3	10.9	442	8.0								
	30	54.7	10.6	432	7.9		1.39	2.5	.08 D	.053	.014	30	.171
Lake Macatawa-West Basin (2)													
Storet # 700573	Sur.	57.9	14.5	479	8.6	120	1.86	3.4	ND @.05 D	.076	.007 PI	25	.188
Station #5- 10:20 am	5	57.2	13.7	483	8.4								
Depth (ft): 15	10	56.5	13.1	481	8.4		1.760	3.4	ND @.05 D	.077	.007	24	.181
Secchi Depth (ft): 1.5	14	56.1	11.6	482	8.3								
Color: brownish													
Lake Macatawa-Central Basin													
Storet # 700574	Sur.	59.0	11.5	501	7.9	80	2.1	5.0	.31 D	.102	.049	24	.22
Station #2- 10:45 am	5	58.7	11.3	501	7.9								
Depth (ft): 27.0	10	58.0	11.1	498	7.9		2.0	4.8	.25 D	.099	.043	31	.21
Secchi Depth (ft): 1.25	15	57.7	11.1	497	7.9								
Color: brownish	20	57.6	11.0	498	78.0								
	25	57.5	10.8	498	7.8		1.98	4.8	.27 D	.098	.044	41	.23
Lake Macatawa-Pine Creek Bay													
Storet # 700384	Sur.	59.5	12.4	501	8.0	65	1.87	4.8	.27 D	.096	.042	17	.188
Station #3- 11:15 am	5	57.6	11.5	495	7.8								
Depth (ft): 10.0	10	55.1	9.6	527	7.6		1.70	4.0	.29 D	.078	.042	18	.176
Secchi Depth (ft): 1.5													
Color: brownish													
Lake Macatawa-East Basin													
Storet # 700238	Sur.	61.4	9.8	614	7.5	53	2.6	5.9	.91	.148	.043	25	.188
Station #1- 11:45 am	5	61.3	9.3	617	7.4								
Depth (ft): 25.0	10	60.5	8.6	627	7.3		2.6	5.8	.98	.154	.047	25	.185
Secchi Depth (ft): 1.5	15	60.4	8.1	623	7.3								
Color: brownish	20	59.3	6.4	635	7.3		2.1	5.5	.67	.108	.041	28	.179
		58.2	6.2	737	7.3								
Lake Macatawa @ River St.							2.5	5.6	.98	.157	.034	20	.158
	Time	**Stage**	**Flow(cfs)**	**Visual Observations**									
Pine Creek	12:15 pm	6.8	9.1	clear baseflow			.60	.95	.084	.022	.023	4	.27
Railroad Tr. D/S of Confluence				No Access									
Maplewood Drain	9:30 am	12.0	0.5	clear baseflow			.50	1.83	.033	.023	.004 PI	ND @ 4	.018
Bosch and Hulst Drain	12:25 pm	13.7	13.0	baseflow slightly turbid			.95	4.2	.05 D	.034	.042	5	.089
N. Br. Macatawa River	12:50 pm	3.4	4.0	clear, up slightly			.85	1.57	.017	.017	.014	ND @ 4	.046
Macatawa River @ USGS Gage	12:30 pm		34.0	slightly turbid & up			1.38(1.33)	11.(11.)	.14 D (.16)	.109(.109)	.049(.050)	5(5)	.095(.093)

D - Analyte value quantified from a dilution(s); reporting limit (RL) raised, MDEQ-Environmental Laboratory.
ND - Non detectable, MDEQ-Environmental Laboratory.
PI - Possible Interference
( ) - duplicate sample result

Table 3. Water Quality Sampling Results, Lake Macatawa and Major Tributaries, Allegan and Ottawa Counties, June 27, 2006.

STATION	DEPTH (ft)	TEMP. (F)	D. O. (mg/l)	COND. (umho/cm)	pH	CHLORO A. (ug/l)	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Lake Macatawa-West Basin (1)													
Storet # 700237	Sur.	72.1	10.2	477	8.4	67	1.31	.86	.010	.054	.011	9	.091
Station #4- 10:00 am	5	72.1	10.1	477	8.4								
Depth (ft): 31	10	71.1	8.3	468	8.1								
Secchi Depth (ft): 2.5	15	70.2	7.6	464	7.9		1.20	.81	.109	.047	.011	10	.094
Color: greenish brown	20	64.7	7.7	361	7.9								
	25	64.4	7.0	365	7.7								
	30	62.9	6.0	356	7.6		.82	.40	.21	.020	.023	27	.106
Lake Macatawa-West Basin (2)													
Storet # 700573	Sur.	71.6	9.9	470	8.2	44	.97	.80	.011	.046	.012	7	.061
Station #5- 10:45 am	5	71.2	9.4	471	8.2								
Depth (ft): 14	10	71.0	8.9	471	8.1								
Secchi Depth (ft): 2.5	13	70.2	4.5	480	7.7		1.13	.77	.062	.047	.015	15	.086
Color: greenish brown													
Lake Macatawa-Central Basin													
Storet # 700574	Sur.	74.1	10.9	555	8.4	100	2.1	1.12	.146	.106	.021	18	.154
Station #2- 11:00 am	5	73.6	9.5	560	8.2								
Depth (ft): 25.0	10	73.1	6.3	564	8.0		1.84	1.01	.48	.108	.027	25	.139
Secchi Depth (ft): 2.0	15	70.8	5.0	504	7.7								
Color: greenish brown	20	68.1	2.8	427	7.6								
	25	67.4	0.6	433	7.3		1.45	.52	.53	.051	.043	36	.146
Lake Macatawa-Pine Creek Bay													
Storet # 700384	Sur.	73.9	9.8	574	8.3	78	1.74	1.06	.160	.099	.020	18	.126
Station #3- 11:15 am	5	72.4	9.8	581	7.8								
Depth (ft): 9.0	9	71.7	2.3	577	7.5		1.61	.97	.21	.083	.020	18	.126
Secchi Depth (ft): 2.0													
Color: greenish brown													
Lake Macatawa-East Basin													
Storet # 700238	Sur.	75.7	9.8	584	8.0	160	3.0(2.8)	1.14(1.14)	.56(.56)	.155(.156)	.031(.030)	29(27)	.23(.21)
Station #1- 11:45 am	5	74.7	8.8	585	7.8								
Depth (ft): 23.0	10	74.2	8.1	580	7.7		2.2	1.13	.56	.143	.011	20	.150
Secchi Depth (ft): 1.5	15	71.9	5.2	532	7.6								
Color: brown	20	69.7	1.8	467	7.4								
	23	68.6	1.2	453	7.4		1.62	.64	.60	.058	.035	29	.169
Lake Macatawa @ River St.							2.3	1.51	.47	.181	.016	19	.187
	Time	**Stage**	**Flow(cfs)**	**Visual Observations**									
Pine Creek	12:30 pm	7.3	6.6	baseflow clear			.69	1.34	.068	.029	.033	9	.091
Railroad Tr. D/S of Confluence	12:40 pm	13.1	4.3	baseflow clear			.82	.57	.083	.029	.016	ND @ 4	.039
Maplewood Drain	12:50 pm	13.95	1.0	baseflow clear			.67	1.37	.038	.042	.019	4	.049
Bosch and Hulst Drain	12:55 pm	14.02	7.3	low and clear			.67	4.1	ND @ .05 D	.023	.041	4	.085
N. Br. Macatawa River	1:30 pm	< staff	1.5	low and clear			.87	.025	.022	.004	.037	ND @ 4	.064
Macatawa River @ USGS Gage	1:15 pm		6.1	Low and clear			.81	7.1	ND @ .1 D	.052	.069	4	.099

D - Analyte value quantified from a dilution(s); reporting limit (RL) raised, MDEQ-Environmental Laboratory.
ND - Non detectable, MDEQ-Environmental Laboratory.
( )- duplicate sample result

Table 4. Water quality Sampling Results, Lake Macatawa and Major Tributaries, Allegan and Ottawa Counties, July 17, 2006.

STATION	DEPTH (ft)	TEMP. (F)	D. O. (mg/l)	COND. (umho/cm)	pH	CHLORO A. (ug/l)	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Lake Macatawa-West Basin (1)													
Storet # 700237	Sur.	78.0	8.1	459	8.0	72	1.58	.002 W	.009 T	.004	.005	22	.174
Station #4- 10:00 am	5	77.8	7.9	458	8.0								
Depth (ft): 31	10	77.5	7.9	448	8.0								
Secchi Depth (ft): 1.75	15	76.8	7.0	442	7.9		1.41	.015	.035	.007	.008	22	.171
Color: greenish brown	20	76.6	6.3	442	7.8								
	25	71.2	0.2	417	7.3								
	30	62.9	0.2	393	7.2		1.99	.002 W	1.2	.003	.22	17	.38
Lake Macatawa-West Basin (2)													
Storet # 700573	Sur.	78.6	9.2	436	8.3	58	1.35	.001 W	.006 T	.002	.007	20	.142
Station #5- 10:30 am	5	78.5	9.2	435	8.3								
Depth (ft): 14	10	78.4	9.0	435	8.3								
Secchi Depth (ft): 1.75	14	77.1	7.9	429	8.1		1.50	ND @ .01 W	.006 T	.002	.005	24	.162
Color: greenish brown													
Lake Macatawa-Central Basin													
Storet # 700574	Sur.	79.8	7.3	523	7.7	89	1.71	.155	.103	.116	.024	30	.197
Station #2- 11:00 am	5	79.8	7.1	524	7.7								
Depth (ft): 26.0	10	79.7	6.5	527	7.6		1.81	.164	.159	.120	.023	36	.21
Secchi Depth (ft): 1.5	15	79.5	5.5	526	7.5								
Color: greenish brown	20	79.3	5.2	521	7.5								
	25	78.9	3.6	528	7.4		1.97	.143	.23	.107	.029	52	.27
Lake Macatawa-Pine Creek Bay													
Storet # 700384	Sur.	80.3	9.1	530	8.1	130	2.0	.034	.015	.031 H	.017 H	30	.21
Station #3- 11:30 am	5	80.3	8.9	531	8.1								
Depth (ft): 9.0	9	80.1	8.6	533	8.0		1.89	.043	.020	.039	.020	32	.20
Secchi Depth (ft): 1.5													
Color: greenish brown													
Lake Macatawa-East Basin													
Storet # 700238	Sur.	82.9	8.7	592	7.5	220	3.2	.52	.42	.26	.073	34	.36
Station #1- 12:05 pm	5	82.6	8.0	588	7.5								
Depth (ft): 26.0	10	82.3	7.9	584	7.5		2.4	.47	.26	.22	.045	45	.28
Secchi Depth (ft): 1.5	15	81.9	8.0	578	7.6								
	20	81.7	8.0	578	7.6								
	25	81.4	7.9	579	7.6		2.3	.43	.190	.23	.039	59	.28
Lake Macatawa @ River St.							5.6	.73	.29	.20	.26	56	.81
	Time	**Stage**	**Flow(cfs)**	**Visual Observations**									
Pine Creek	12:45 pm	7.5	5.6	baseflow clear			.53	1.31	.044	.023	.026	6	.060
Railroad Tr. D/S of Confluence	12:55 pm	13.1	4.3	baseflow clear			.62	.41	.032	.017	.011	ND @ 4	.028
Maplewood Drain	9:15 am	12.1	0.1	baseflow clear			.49	1.69	.057	.019	.018	ND @ 4	.036
Bosch and Hulst Drain	1:10 pm	14.0	7.3	baseflow slightly turbid			.61	3.4	.05 D	.027	.066	5	.100
N. Br. Macatawa River	1:30 pm	< staff	0.5	low and clear			.90	.041	.017	.005	.065	ND @ 4	.107
Macatawa River @ USGS Gage	1:20 pm		3.9	Baseflow clear			.79	5.4	ND @ 0.1 D	.037	.093	5	.131

D - Analyte value quantified from a dilution(s); reporting limit (RL) raised, MDEQ-Environmental Laboratory.
ND - Non detectable, MDEQ-Environmental Laboratory.
T -Report value is less than the reporting limit (RL).
W - Reported value is less than the method detection limit (MDL)
H - Recommended laboratory holding time was exceeded

Table 5. Water Quality Sampling Results, Lake Macatawa and Major Tributaries, Allegan and Ottawa Counties, August 24, 2006.

STATION	DEPTH (ft)	TEMP. (F)	D. O. (mg/l)	COND. (umho/cm)	pH	CHLORO A. (ug/l)	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Lake Macatawa-West Basin (1)													
Storet # 700237	Sur.	73.5	15.4	408	8.5	67	1.17	.002 W	.005 T	.003	.004	14	.105
Station #4- 9:50 am	5	73.0	13.6	406	8.3								
Depth (ft): 31	10	71.2	11.7	387	8.1								
Secchi Depth (ft): 2.0	15	68.8	11.5	361	7.9		.82	.086	.016	.005	.003	13	.082
Color: greenish brown	20	65.2	5.2	357	7.3								
	25	61.2	4.2	342	7.2								
	30	59.5	1.0	340	7.0		1.23	.127	.51	.019	.019	30	.149
Lake Macatawa-West Basin (2)													
Storet # 700573	Sur.	73.8	15.8	391	8.5	72	No	S	A	M	P	L	E
Station #5- 10:10 am	5	73.5	14.7	393	8.5								
Depth (ft): 14	10	73.4	14.7	391	8.4								
Secchi Depth (ft): 1.75	14	68.3	2.1	380	7.2		1.20	.001 W	.005 T	.004	.004	19	.119
Color: greenish brown													
Lake Macatawa-Central Basin													
Storet # 700574	Sur.	75.1	16.5	462	8.5	110	1.50	ND @ .01 W	.005 T	.004	.008	18	.153
Station #2- 10:30 am	5	74.7	15.2	461	8.4								
Depth (ft): 26.0	10	73.5	12.0	453	8.1								
Secchi Depth (ft): 1.5	15	68.6	6.3	388	7.6		1.15	.034	.022	.007	.010	26	.146
Color: greenish brown	20	67.3	3.5	380	7.3								
	25	66.8	2.8	377	7.2		1.09	.069	.097	.009	.015	50	.188
Lake Macatawa-Pine Creek Bay													
Storet # 700384	Sur.	75.6	17.3	465	8.5	93	1.41	ND @ .01 W	.007 T	.004	.007	25	.158
Station #3- 10:40 am	5	75.2	14.3	469	8.3								
Depth (ft): 10.0	10	74.9	5.3	484	7.6		1.53	ND @ .01 W	.008 W	.005	.011	43	.21
Secchi Depth (ft): 1.5													
Color: greenish brown													
Lake Macatawa-East Basin													
Storet # 700238	Sur.	76.6	12.8	523	7.7	220	2.7	.28	.22	.131	.015	29	.30
Station #1- 9:15 am	5	76.4	11.4	519	7.6								
Depth (ft): 24.0	10	76.2	10.7	515	7.5		2.3	.21	.40	.102	.010	46	.26
Secchi Depth (ft): 1.25	15	74.0	5.6	484	7.2								
Color: brown	20	70.3	1.6	428	7.1								
	23	69.1	0.31	415	7.1		1.49	.046	.31	.026	.009	28	.178
Lake Macatawa @ River St.							3.3	.89	.28	.117	.041	30	.39
	Time	**Stage**	**Flow(cfs)**	**Visual Observations**									
Pine Creek	11:30 am	7.4	6.1	Clear, up slightly			.66	1.27	.093	.034	.023	7	.082
Railroad Tr. D/S of Confluence	11:45 am	13.1	4.3	Slightly turbid & up			.82	.43	.073	.030	.010	4	.055
Maplewood Drain	9:00 am	11.5	3.1	6" secchi, high flow			1.23	.66	.23	.037	.108	200	.34
Bosch and Hulst Drain	11:35 am	13.8	11.1	6" secchi, up slightly			.69	4.3	.08 D	.029	.057	18	.132
N. Br. Macatawa River	12:15 pm	6.3	14.0	6" secchi, high flow			.94	.54	.134	.023	.060	40	.183
Macatawa River @ USGS Gage	12:05 pm		15.0	12" secchi, up slightly			.85	5.6	.05 D	.022	.063	12	.121

D - Analyte value quantified from a dilution(s); reporting limit (RL) raised, MDEQ-Environmental Laboratory.
ND - Non detectable, MDEQ-Environmental Laboratory.
W - reported value is less than the method detection limit
T -Report value is less than the reporting limit (RL).

Table 6. Water Quality Sampling Results, Lake Macatawa and Major Tributaries, Allegan and Ottawa Counties, September 25, 2006.

STATION	DEPTH (ft)	TEMP. (F)	D. O. (mg/l)	COND. (umho/cm)	pH	CHLORO A. (ug/l)	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Lake Macatawa-West Basin (1)													
Storet # 700237	Sur.	61.5	8.8	384	8.7	50	1.11	.127	.176	.015	.010	20	.118
Station #4- 10:15 am	5	61.5	8.8	383	8.5								
Depth (ft): 31	10	61.4	8.7	384	8.4								
Secchi Depth (ft): 2.0	15	61.4	8.7	384	8.2		1.10	.132	.182	.016	.010	20	.119
Color: greenish brown	20	61.4	8.7	388	8.2								
Absorbance @ 400nm--.007 PCU	25	61.4	8.6	388	8.1								
	30	61.5	5.6	389	7.9		1.20	.141	.198	.017	.009	36	.139
Lake Macatawa-West Basin (2)													
Storet # 700573	Sur.	61.3	9.5	376	8.1	59	1.03	.095	.062	.012	.006	18	.111
Station #5- 10:35 am	5	61.2	9.5	377	8.1								
Depth (ft): 14	10	61.1	9.3	378	8.1								
Secchi Depth (ft): 2.0	14	61.1	2.0	380	8.1		1.05	.094	.063	.011	.005	18	.115
Color: greenish brown													
Absorbance @ 400 nm --.008 PCU													
Lake Macatawa-Central Basin													
Storet # 700574	Sur.	62.3	8.3	469	7.9	55	1.79	.41	.58	.064	.011	30	.153
Station #2- 11:00 am	5	62.3	8.2	469	7.9								
Depth (ft): 25	10	62.2	8.2	469	7.8		1.73	.42	.57	.064	.011	29	.148
Secchi Depth (ft): 1.5	15	62.2	8.2	469	7.8								
Color: greenish brown	20	62.1	8.2	468	7.8								
Absorbance @ 400 nm --.010 PCU	25	62.2	2.8	482	7.6		1.76	.42	.57	.064	.011	42	.166
Lake Macatawa-Pine Creek Bay													
Storet # 700384	Sur.	61.7	9.6	456	7.8	58	1.54	.40	.41	.054	.006	19	.122
Station #3- 11:15 am	5	61.7	9.4	457	7.9								
Depth (ft): 10.0	10	59.3	3.5	455	7.7		1.50	.40	.40	.054	.007	19	.122
Secchi Depth (ft): 2.0													
Color: greenish brown													
Absorbance @ 400 nm--.012 PCU													
Lake Macatawa-East Basin													
Storet # 700238	Sur.	63.5	7.5	525	7.7	33(33)	2.4(2.5)	1.3(1.3)	1.3(1.3)	.125(.125)	.033(.034)	24(23)	.156(.167)
Station #1- 11:55 am	5	63.6	7.2	525	7.7								
Depth (ft): 21	10	63.6	7.1	525	7.6		2.4	1.3	1.3	.126	.033	23	.162
Secchi Depth (ft): 1.25	15	63.5	7.1	526	7.6								
Color: brown	20	63.4	7.0	526	7.5								
Absorbance--.017(.018) PCU	21	61.1	6.3	515	7.5		2.2	1.9	1.0	.120	.090	39	.28
Lake Macatawa @ River St.							2.4	2.1	1.1	.185	.101	35	.27

	Time	Stage	Flow(cfs)	Visual Observations							
Pine Creek	12:20 pm	7.3	6.6	clear and up slightly	.47	1.14	.052	.020	.021	ND @ 4	.044
Railroad Tr. D/S of Confluence	12:35 pm	13.0	5.5	24' secchi and up slightly	.71	.42	.078	.019	.017	7	.067
Maplewood Drain	9:35 am	11.8	1.6	6" secchi , storm flow	.46	1.30	.053	.013	.023	5	.047
Bosch and Hulst Drain	12:45 pm	13.8	11.1	12' secchi at baseflow	1.00	3.6	.09 D	.034	.125	14	.21
N. Br. Macatawa River	1:05 pm	3.6	20.0	12" secchi at storm flow	1.09	.86	.036	.019	.093	12	.193
Macatawa River @ USGS Gage	12:55 pm		50.0	6" secchi and up a couple feet	2.1	10.	.23 D	.137	.44	43	.62

D - Analyte value quantified from a dilution(s); reporting limit (RL) raised, MDEQ-Environmental Laboratory.
ND - Non detectable, MDEQ-Environmental Laboratory.
( )- duplicate sample result
PCU - Platinum-Cobalt Units

MI/DEQ/WB-09/076

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER BUREAU
NOVEMBER 2009

STAFF REPORT

MONTHLY WATER QUALITY ASSESSMENT OF LAKE MACATAWA AND ITS TRIBUTARIES 2008

INTRODUCTION

Water quality monitoring of Lake Macatawa was planned on an annual basis, as resources allow, through 2009 to document the effectiveness of phosphorus reduction efforts. Monitoring was not conducted in 2007. Walterhouse (2007) presented water quality monitoring results from 2006 and contrasted them with recent lake and tributary water quality results. This report presents the results of sampling efforts in 2008, and compares the results with previous sampling results collected in conjunction with development of the phosphorus total maximum daily load (TMDL) in 1997, and annual sampling results collected subsequent to TMDL development.

Lake Macatawa is a 1,780-acre drowned river mouth lake located along the southeastern shoreline of Lake Michigan near the city of Holland, Michigan. The lake and its watershed encompass 179 square miles (114,560 acres) in Ottawa and Allegan Counties. Lake Macatawa is a relatively shallow lake with an average depth of 12 feet and a maximum depth of 40 feet in the western basin. The water level of Lake Macatawa changes along with the fluctuations in Lake Michigan water levels. Consequently, the water level of Lake Macatawa was approximately 3 feet lower in 2008 than 1997 when the TMDL was developed and Lake Michigan water levels were above the long-term average levels. A man-made shipping channel about 5 miles in length is maintained at a depth of 22 feet from Lake Michigan to the eastern basin of the lake. The width of the lake varies from less than 0.25 miles to slightly more than 1 mile.

Major tributaries to Lake Macatawa are the Macatawa River and Pine Creek. The Macatawa River enters the shallow eastern basin of Lake Macatawa after passing through a several hundred-acre wetland. Recent low water levels have decreased the wetted surface area of the wetland exposing vast mud flats that have developed lush stands of wetland vegetation. The shoreline of the eastern basin is dominated by industrial development. The remainder of the lake's shoreline consists of residential development, city and township parks, or commercial marinas. A small portion of the middle basin in Pine Creek Bay in 1997 was natural and undeveloped, but recent home construction has drastically reduced the extent of natural shoreline.

The Michigan Department of Environmental Quality (MDEQ) is required by Section 303(d) of the federal Clean Water Act to biennially develop and submit to the United States Environmental Protection Agency (USEPA) a list of water bodies that do not attain water quality standards (WQS). Lake Macatawa and all tributaries within the watershed were included on this list submitted to the USEPA because of nutrient enrichment. Lake Macatawa displays the classic symptoms of a hypereutrophic lake, including: extremely high nutrient and chlorophyll a levels, excessive turbidity, periodic nuisance algal blooms, low dissolved oxygen (D.O.) levels, and a

high rate of sediment deposition. Lake Macatawa was included in a 1971 publication entitled, "Problem Lakes in the United States" (Ketelle and Uttormark, 1971). Thirty-seven years later the lake is still considered to be one of the most nutrient enriched lakes in Michigan. Federal, state, and local agencies, as well as several universities, have documented Lake Macatawa's water quality, sediment chemistry, watershed resources, and various specifics of the dynamics that impact water quality. Historic published literature available for Lake Macatawa is compiled in the references section of a past report prepared by the MDEQ (Walterhouse, 1998).

The MDEQ received a Section 104(b)(3) grant from the USEPA in October 1996 to develop a phosphorus TMDL for Lake Macatawa and used some of the funding to quantify phosphorus loading throughout the Lake Macatawa Watershed and relate the loading to Lake Macatawa's in-lake phosphorus concentration. Walterhouse (1998) summarized the sampling efforts, sampling results, and outlined the methods used to develop a phosphorus TMDL that will result in Lake Macatawa meeting WQS. The TMDL document was public noticed on November 23, 1998, and submitted to the USEPA on January 27, 1999 (Walterhouse, 1999b). USEPA approval of the TMDL required the submission of additional documents on June 30, 1999; October 22, 1999; and February 24, 2000. Final approval from the USEPA was received on April 13, 2000. The MDEQ dedicated the remainder of the USEPA funds to the Macatawa Area Coordinating Council (MACC), a local organization that accepted the challenge of coordinating the development of a locally derived watershed management plan to achieve the goal of the TMDL. The MACC finalized a plan on September 16, 1999, entitled "Phosphorus Reduction Implementation Plan for the Macatawa Watershed, 1999-2009" (Higgins and Kosky, 1999). A voluntary agreement to reduce phosphorus loading to Lake Macatawa was signed on May 1, 2000, by representatives of all government units within the watershed, point sources that contribute phosphorus, and the MDEQ. As per the agreement, the MACC is responsible for preparing a report on an annual basis summarizing the progress made toward meeting the phosphorus goals identified in the TMDL. Efforts to reduce phosphorus loading to Lake Macatawa are outlined in the 2007 annual report that covered the time frame from October 1, 2006, to September 30, 2007 (MACC, 2007). The report provides a summary of the best management practices (BMPs) implemented and other efforts throughout the 114,000-acre watershed to reduce nonpoint source (NPS) phosphorus loading prior to sampling in 2008.

In addition to the BMPs, numerous efforts and actions have been taken to reduce NPS loading from urban and agricultural sources throughout the watershed. The point sources in the watershed have reduced phosphorus loading to Lake Macatawa from over 14,000 pounds in 2000, to less than 12,000 pounds in 2007, and are well below the phosphorus wasteload allocation of 20,000 pounds per year established in the TMDL (MACC, 2007).

METHODS

Sampling was conducted once per month from April through September 2008, at 5 stations in Lake Macatawa (Figure 1). Grab samples were collected at the surface, bottom, and middepth at each station. A depth integrated sample of the photic zone was also collected at each station for chlorophyll a analysis. Additional sampling at each station included a measurement of secchi transparency and a profile at 5-foot increments of temperature, D.O., conductivity, and pH from the surface to the lake bottom using a calibrated Yellow Springs Instruments 6 series environmental monitoring system.

Grab samples were also collected once per month, on the same day the lake sampling was conducted, at the 6 tributaries where annual loads were determined during development of the

TMDL (Figure 2). Flow at the time of sampling was obtained from the United States Geological Survey (USGS) Web site for the gage station located on the Macatawa River. Flows at the time of sampling for the other 5 tributaries were calculated using the stage height at the time of sampling and the stage discharge curves previously developed by the MDEQ's Land and Water Management Division.

All of the samples from the lake and tributaries were collected, preserved (if necessary), stored at 4° Celsius, and transported to the MDEQ's Environmental Laboratory for chemical analysis using standard protocols (Michigan Department of Natural Resources, 1994). The samples were analyzed for total and ortho-phosphorus, nitrate + nitrite, Kjeldahl nitrogen, nitrite, ammonia, suspended solids, and chlorophyll a. All samples collected in 2008 were analyzed by the MDEQ's Environmental Laboratory.

SAMPLING RESULTS

Monthly water quality sampling results for Lake Macatawa and the tributary sites are presented by month in Tables 1 through 6. The 2008 average monthly sampling results for total phosphorus are displayed in Figures 3 and 4 for Stations 1, 2, and 4, along with historic data that was collected at the same 3 locations (Creal and Walterhouse, 1997; and Walterhouse, 1998, 1999a, 2000, 2001, 2002, 2003, 2004, 2005, 2006, and 2007). The 1997 monthly sampling results used to develop the TMDL suggested that conditions might be improving in Lake Macatawa compared to the previous years. The 2000 data demonstrated that conditions were not improving. Average phosphorus concentrations in April, May, and September 2000 were the highest recorded since reliable and comparable data collection began in 1982. All of the monthly average phosphorus concentrations in 2008, except the September average, were within the historic range of values for each month. The average phosphorus concentration of 364 micrograms per liter (ug/l) in April was the highest value recorded for the month since 2000, but during May the concentration decreased to 136 ug/l, the lowest value recorded since 1998. The average phosphorus concentration increased to 172 ug/l in June, decreased to 124 ug/l in July, and increased again in August to 151 ug/l. The phosphorus concentration increased dramatically in September to 213 ug/l, the highest value on record, after a major storm event.

The spring (April and May) average phosphorus levels at the 3 locations where additional historic, comparable data were available (USEPA, 1975) are presented in Figure 5. The spring overturn phosphorus concentration of 250 ug/l in 2008 was higher than the concentrations recorded in 2005 and 2006, but is consistent with historic levels before and after implementation of the TMDL. The 2008 spring phosphorus concentration was more than 5 times greater than the TMDL interim goal of 50 ug/l. The total nitrogen (nitrate + nitrite and Kjeldahl nitrogen) to total phosphorus ratios in April, May, June, and July 2008 were once again greater than 15:1 indicating that phosphorus continues to be the limiting nutrient in Lake Macatawa. The primary conclusion of the data analysis to date continues to be that phosphorus levels are consistently unacceptable, and phosphorus concentrations are extremely variable on a monthly and annual basis.

The historic monthly average chlorophyll a concentrations are presented along with the results from monthly sampling at the 5 stations in 2008 in Figure 6. Chlorophyll a measurements provide an indication of the amount of algae present in the lake. Michigan lakes with chlorophyll a concentrations greater than 22 ug/l are generally considered to be hypereutrophic. Monitoring during 2008 demonstrated once again that chlorophyll a levels were greater than 22 ug/l during every month from May through September. The highest monthly average recorded during 2008 was 100 ug/l in May, while the lowest monthly average was 11 ug/l in April when water

temperatures were still cold and not conducive for algal growth. The 2008 monthly averages for May through September were within the range of values that have been documented with previous monitoring efforts. Like the phosphorus data collected to date, the chlorophyll a concentrations are consistently high, 3 to 4 times greater than desirable, and variable on a monthly and annual basis.

The monthly average Secchi depth readings for 2008, along with comparable historic data, are presented in Figure 7. Secchi depth readings provide a measurement of water clarity that is related to the chemical and physical properties of a lake. While water clarity is not a direct measurement of the chemical properties of lake water, it is an easy-to-understand indicator of a lake's water quality. Lakes in Michigan with secchi depth readings less than 3 feet are normally considered to be hypereutrophic. Secchi depth monitoring on an annual basis in Lake Macatawa has shown that water clarity is normally less than 2 feet (Figure 8). The June 2002 and 2003 average secchi depth readings exceeded 2.5 feet and were the highest values recorded since comparable data collection began in 1982. This relatively high level of water clarity, at least for Lake Macatawa, corresponded with the relatively low total phosphorus levels that were recorded in June 2002 and 2003. The July 2008 average secchi depth reading exceeded 2.5 feet and also corresponded with the lowest total phosphorus level for the year. The average secchi depths during all of the other months in 2008 were never greater than 2.0 feet. The lowest secchi depths in 2008 were recorded during April in all 3 basins when secchi depth was only 0.5 feet. The largest secchi depth value recorded in 2008 was 3.5 feet in the west basin during July. It is well documented that Michigan lakes normally exhibit a strong correlation between total phosphorus, chlorophyll a, and water clarity. Consequently, it is not surprising that the water clarity data for Lake Macatawa demonstrates monthly and annual variability consistent with phosphorus and chlorophyll a results that are consistently less than desirable.

Water quality parameters in the west basin were once again generally better than those measured in the east basin. Secchi depth readings in the east basin ranged from 0.5 to 2.0 feet compared to a range of 0.5 to 3.5 feet in the west basin during the 2008 monitoring. Chlorophyll a concentrations in 2008 were higher in the east basin, ranging from 6 to 140 ug/l, than the west basin, ranging from 16 to 100 ug/l, during all months, except April and September. Visible surface blooms of algae were not present during any of the periods of sample collection despite the high chlorophyll a concentrations all year. Surface total suspended solids ranged from 6 milligrams per liter (mg/l) to 34 mg/l in the west basin and 8 mg/l to 77 mg/l in the east basin. Similar differences in the water quality of the basins were also noted once again in 2008 for ortho phosphorus, nitrite, ammonia, nitrate + nitrite, and Kjeldahl nitrogen with higher concentrations in the east basin during all months.

D.O. was depressed in 2008 to less than 5.0 mg/l near the lake bottom during June, July, August, and September in all 3 basins of Lake Macatawa. All other D.O. readings were above 5.0 mg/l. Thermal stratification of the water column was not apparent anywhere in the lake until June when the west basin was thermally stratified. The thermal stratification of the west basin did not persist in July but was reestablished once again in August. Solid thermal stratification of the water column in the east and central basins did not develop during any month in 2008. Phosphorus concentrations were not elevated in the water samples collected near the bottom when D.O. was depressed and the water column was thermally stratified. Monitoring since 1995 has revealed that thermal stratification can and does occur in all 3 basins of Lake Macatawa on a periodic basis during the summer months. D.O. depletion near the lake bottom occurs sporadically, but the release of phosphorus from the sediments during anaerobic conditions does not appear to be a problem that occurs on a regular basis.

A significant observation of the 2008 sampling events was the continued presence of rooted aquatic vegetation, primarily milfoil, in the west basin in 3 to 4 feet of water. The vegetation, which became established during the summer of 2002, flourished during the summers of 2002 and 2003, and weed beds were present in a large portion of the shallow water throughout the west basin in both years. The growth of aquatic vegetation might be considered undesirable by boaters, but is typically an indication of improved lake quality due to increased water clarity. However, since water clarity has not improved in Lake Macatawa, the continued presence of aquatic vegetation is probably a product of lower lake levels. The lower lake levels have created large areas of water that are 3 to 5 feet deep allowing sunlight to reach the lake bottom and stimulate the growth of aquatic plants. These areas were previously 6 to 8 feet deep and beyond the extent of sunlight penetration. Water levels have remained relatively low since 2003 but the abundance of the aquatic vegetation has been lower during the summers of 2004 through 2008, as compared to 2003.

The results of the 2008 tributary sampling results for total phosphorus concentration and stream flow at the time of sampling, along with previous data collected during low flow conditions, is presented in Figures 9 through 14. Average daily flow at the USGS gage on the Macatawa River from spring through fall 2008 is presented in Figure 15. The extensive sample results from 1996/1997 showed a strong positive correlation between flow and total phosphorus concentrations. The 2008 samples were collected as scheduled and relatively low flow conditions were encountered during all of the sample events at all 6 sites. The April, June, and September samples were collected just after large storm events but stream flows were back to normal when the samples were collected. The lowest phosphorus concentrations of the year at 4 of the 6 stations were recorded in August after an extended period of low flow conditions. The highest phosphorus concentrations of the year at Pine Creek (101 ug/l), Maplewood Drain (32 ug/l), and the Railroad Tributary (39 ug/l) were recorded after the June storm event. The highest phosphorus concentration of the year at the Macatawa River (261 ug/l) was recorded following the April storm event. While the highest phosphorus concentrations at Bosch & Hulst Drain (110 ug/l) and North Branch Macatawa River (86 ug/l) were recorded in July during low flow conditions several weeks after a minor storm event. The phosphorus concentrations measured at all of the sites in 2008 were similar to concentrations that were measured during similar flow conditions in previous years. The results indicate that total phosphorus concentrations during various flow conditions throughout the watershed have not changed since sampling began in 1996/1997. The Macatawa River at the gage station and the sample site on Bosch & Holst Drain continue to have higher levels (normally greater than 100 ug/l) of total phosphorus during periods of low flow than the other sample sites in the watershed, while the site on Maplewood Drain typically has the lowest concentrations (less than 50 ug/l) during periods of low flow. The 2008 sampling results from throughout the watershed continue to demonstrate that when flows increase even minimally during storm events, total phosphorus concentrations increase substantially and phosphorus loading to Lake Macatawa increases dramatically.

In order to demonstrate the impact storm events have on the water quality of Lake Macatawa, an analysis of the water quality data collected at Lake Macatawa from 1997 to 2003 was regressed against peak and average daily stream flow of varying durations at the USGS gage on the Macatawa River (Walterhouse, 2005). The best statistically significant relationship was found between the average phosphorus concentration in Lake Macatawa and the average flow at the USGS gage, during the 10-day period prior to the sampling date. The 2004 through 2006 monitoring results were included in the analysis producing a similar correlation to what was obtained with the 1997-2003 monitoring data (Figure 16). The 2008 monitoring results are also

included in Figure 16 demonstrating that phosphorus concentrations in Lake Macatawa are lower after extended periods of low stream flow prior to sampling. The relationship between flow and phosphorus concentrations in Lake Macatawa demonstrates that the water quality of Lake Macatawa continues to be strongly influenced by NPS inputs during periods of higher flow (storm events). BMPs that are designed to reduce peak flows and improve water quality during storm events need to continue to be pursued aggressively throughout the watershed.

Fieldwork by: Sarah LeSage, Tamara Lipsey, Mike Walterhouse, Matt Wesner, and Seth Wright
Surface Water Assessment Section
Water Bureau

Mary Fales and Beth McDonald
Macatawa Area Coordinating Council

Report by: Mike Walterhouse, Aquatic Biologist
Surface Water Assessment Section
Water Bureau

REFERENCES

Creal, W. and M. Walterhouse. 1997. Biological and Chemical Assessment of Lake Macatawa and its Tributaries, Allegan and Ottawa Counties, Michigan, 1979-1983. MDEQ, Report No. MI/DEQ/SWQ-97/080.

Higgins, S. and K. Kosky. 1999. Phosphorus Reduction Implementation Plan for the Macatawa Watershed, 1999-2009. September 16, 1999. MACC, Holland, Michigan.

Ketelle, M. and P. Uttormark. 1971. Problem Lakes in the United States, University of Wisconsin for USEPA, Project No. 06010EHR.

MACC. 2007. Macatawa Watershed Voluntary Agreement, 2007 Annual Report, October 1, 2006 – September 30, 2007.

Michigan Department of Natural Resources. 1994. Quality Assurance for Water and Sediment Sampling. Environmental Protection Bureau, Lansing, Michigan, Publication No. 3730-0028.

USEPA, National Eutrophication Survey. 1975. Report on Lake Macatawa, Ottawa County, Michigan, USEPA Region V, Working Paper No. 200.

Walterhouse, M. 1998. Phosphorus Loading Assessment for Lake Macatawa, 1995 through 1997. MDEQ Report No. MI/DEQ/SWQ-98/015.

Walterhouse, M. 1999a. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 1998. MDEQ Report No. MI/DEQ/SWQ-99/084.

Walterhouse, M. 1999b. Total Maximum Daily Load for Phosphorus in Lake Macatawa, January 20, 1999. MDEQ Submittal to U.S. Environmental Protection Agency.

Walterhouse, M. 2000. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 1999. MDEQ Report No. MI/DEQ/SWQ-00/035.

Walterhouse, M. 2001. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2000. MDEQ Report No. MI/DEQ/SWQ-01/021.

Walterhouse, M. 2002. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2001. MDEQ Report No. MI/DEQ/SWQ-02/060.

Walterhouse, M. 2003. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2002. MDEQ Report No. MI/DEQ/WD-03/015.

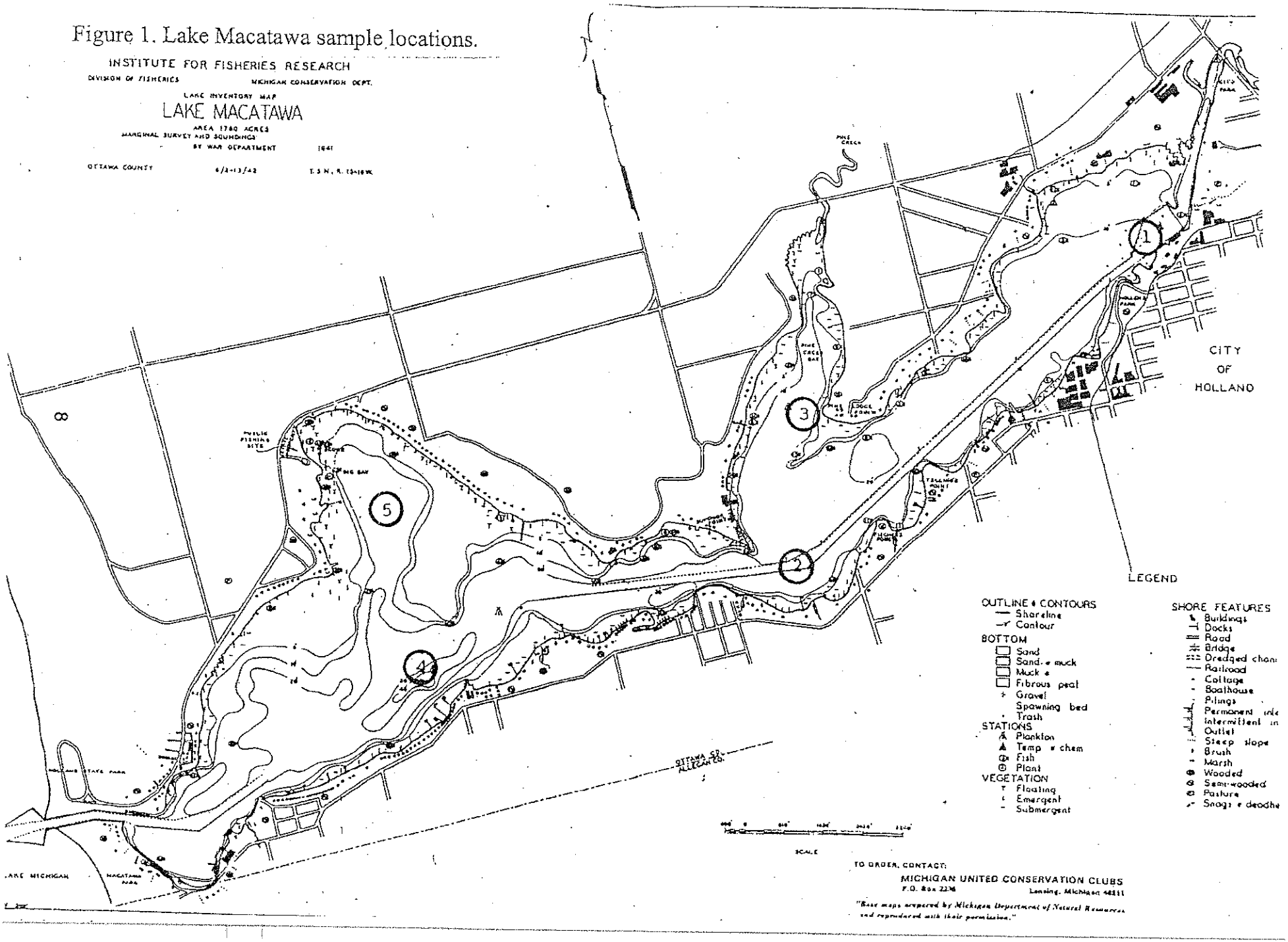
Walterhouse, M. 2004. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2003. MDEQ Report No. MI/DEQ/WD-04/022.

Walterhouse, M. 2005. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2004. MDEQ Report No. MI/DEQ/WB-05/039.

Walterhouse, M. 2006. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2005. MDEQ Report No. MI/DEQ/WB-060/070.

Walterhouse, M. 2007. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2006. MDEQ Report No. MI/DEQ/WB-07/066.

Figure 1. Lake Macatawa sample locations.



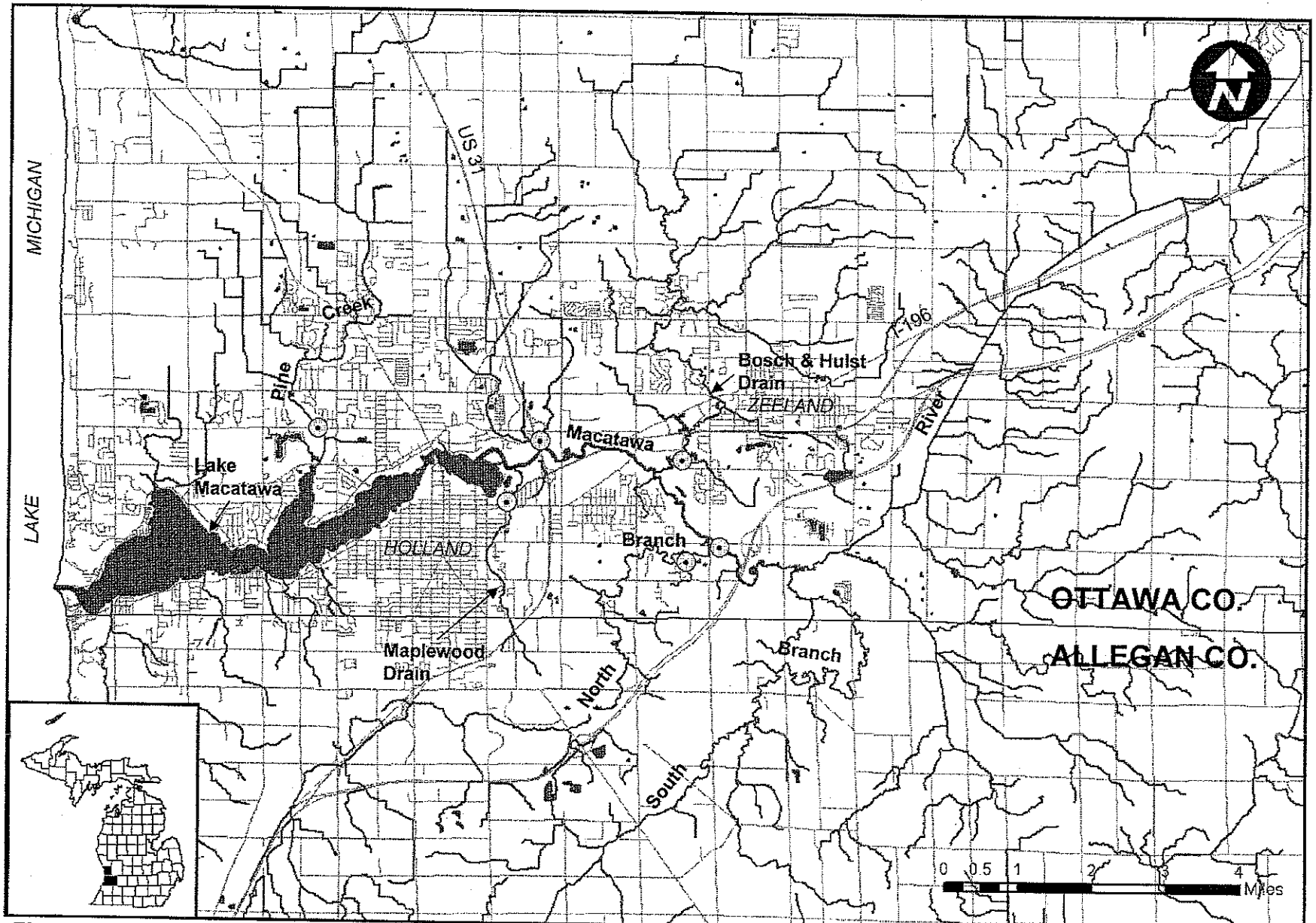


Figure 2: Tributary sampling locations in the Macatawa River Watershed, Allegan and Ottawa Counties, 2006.

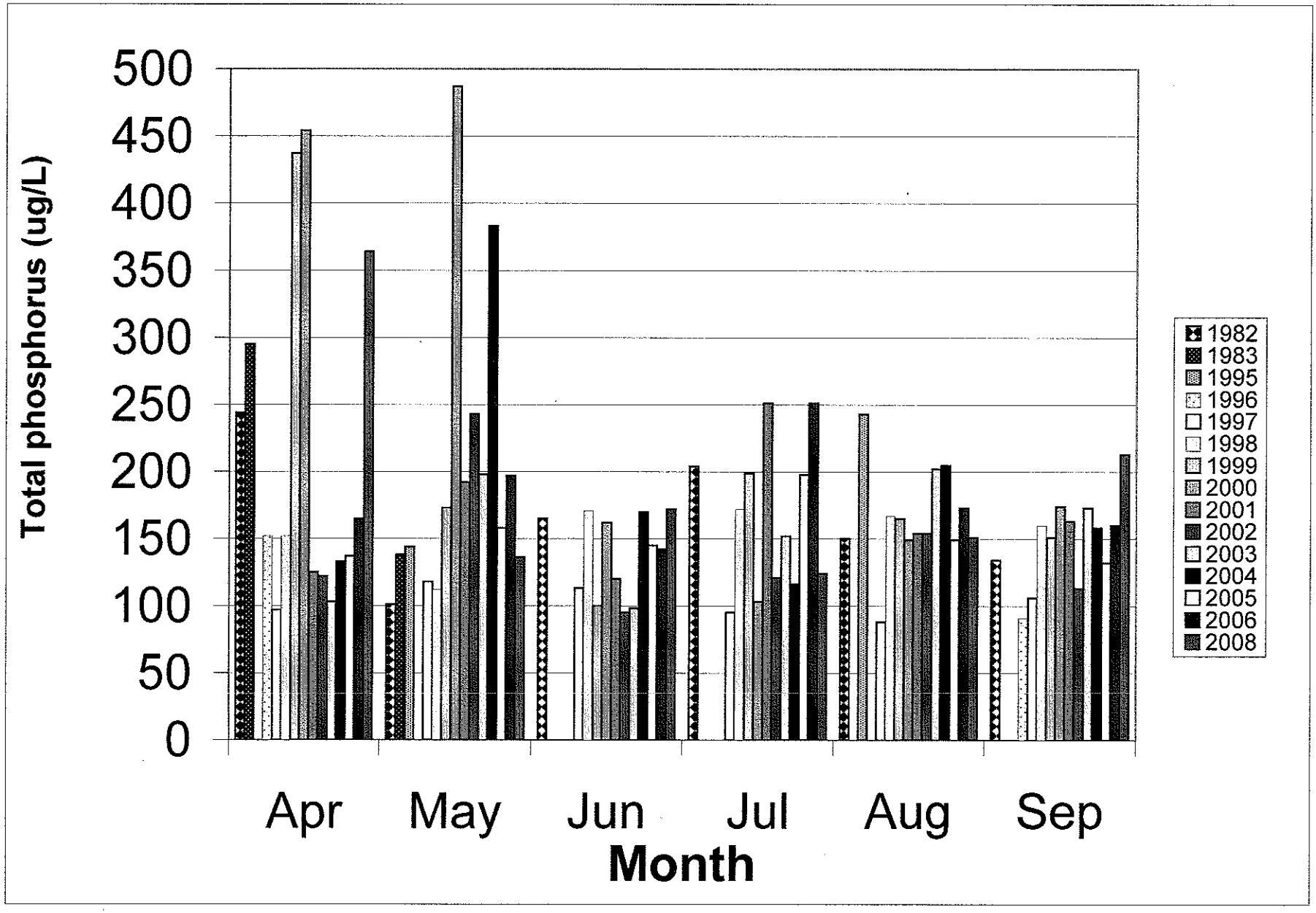


Figure 3. Historic monthly average phosphorus concentrations by month in Lake Macatawa at stations 1, 2, and 4, Ottawa County, Michigan,

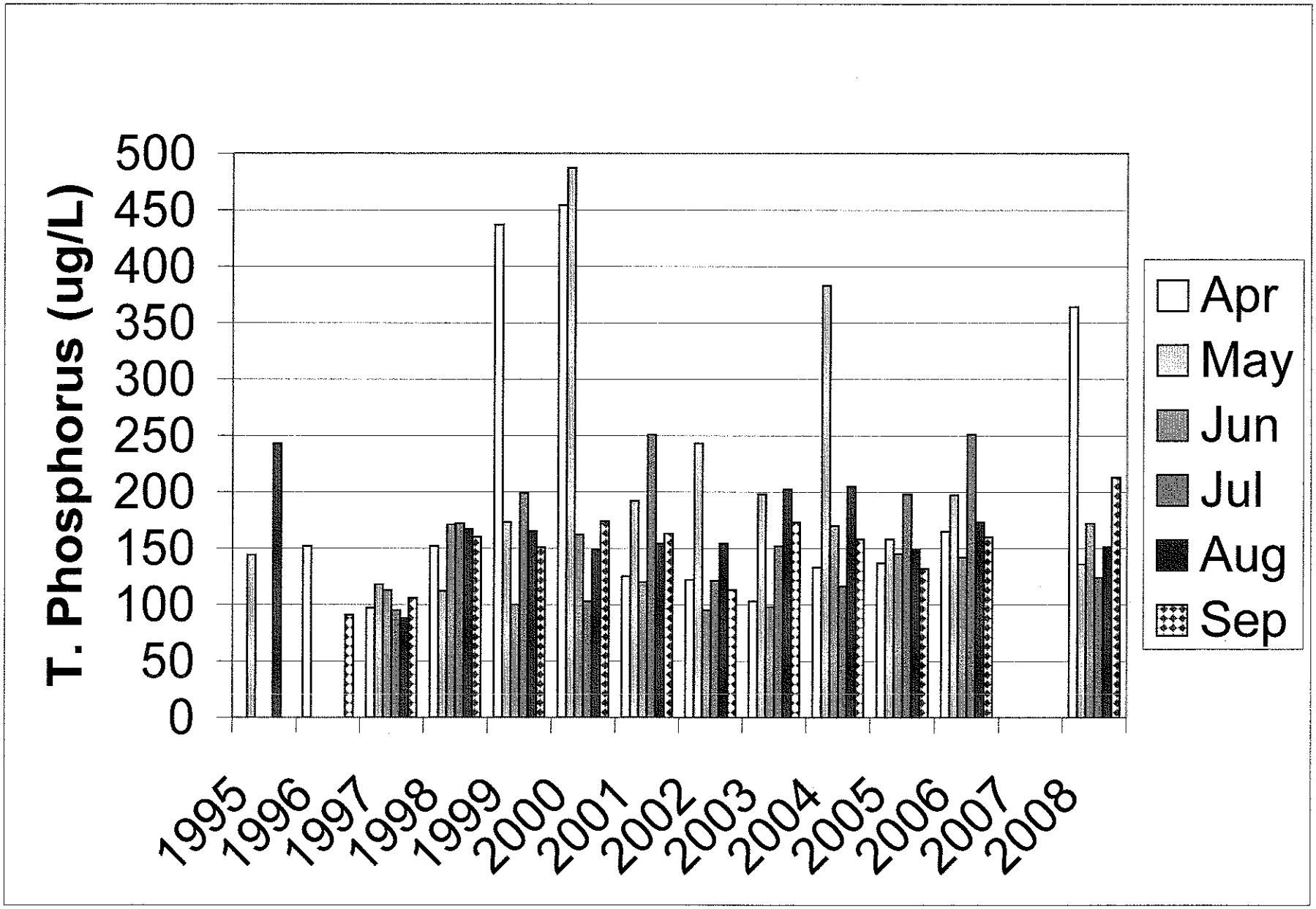


Figure 4. Monthly average total phosphorus concentrations by year in Lake Macatawa, stations 1, 2, and 4, Ottawa County, Michigan.

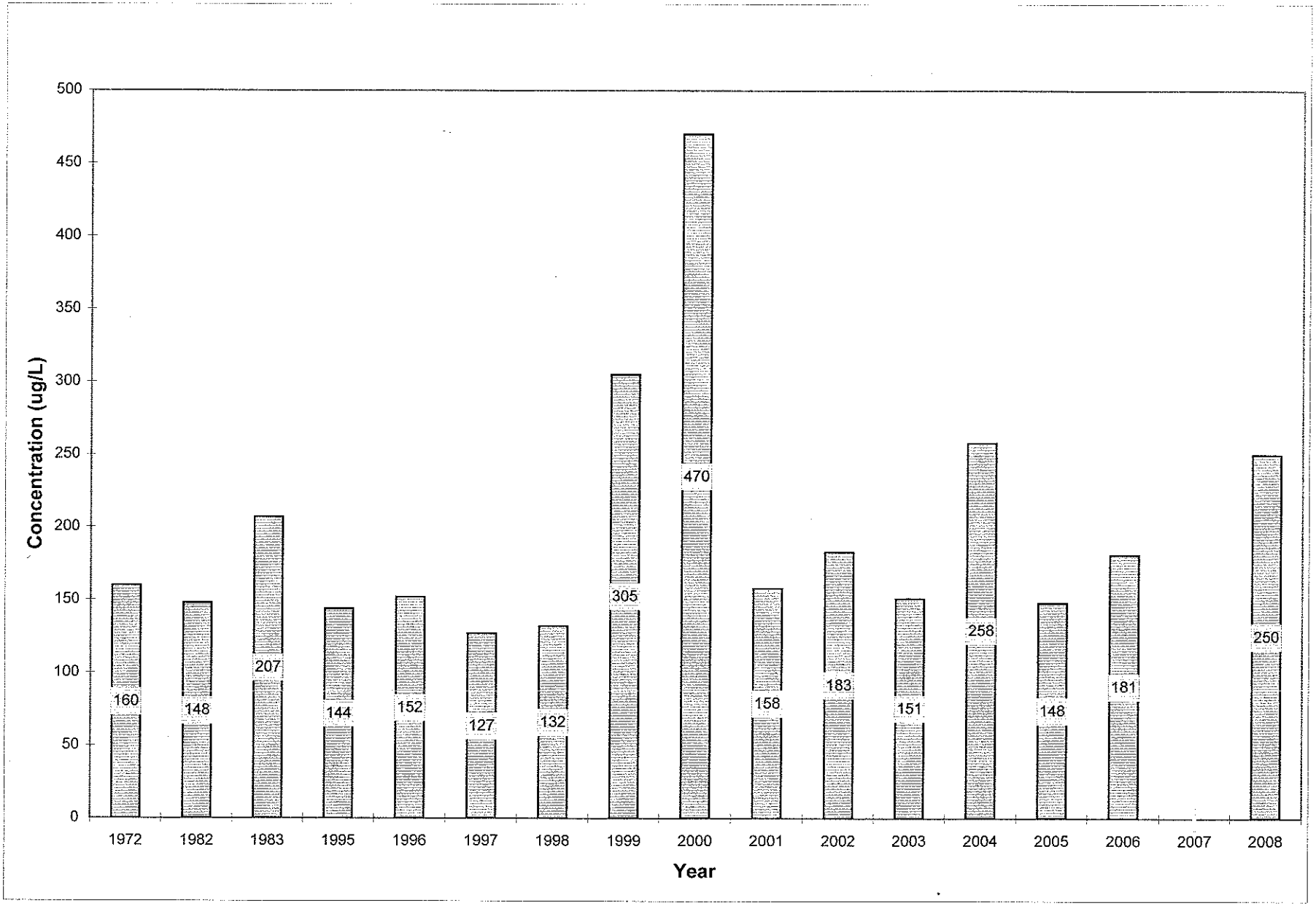


Figure 5. Average historic spring phosphorus concentrations at stations 1, 2, and 4 in Lake Macatawa, Ottawa County, Michigan.

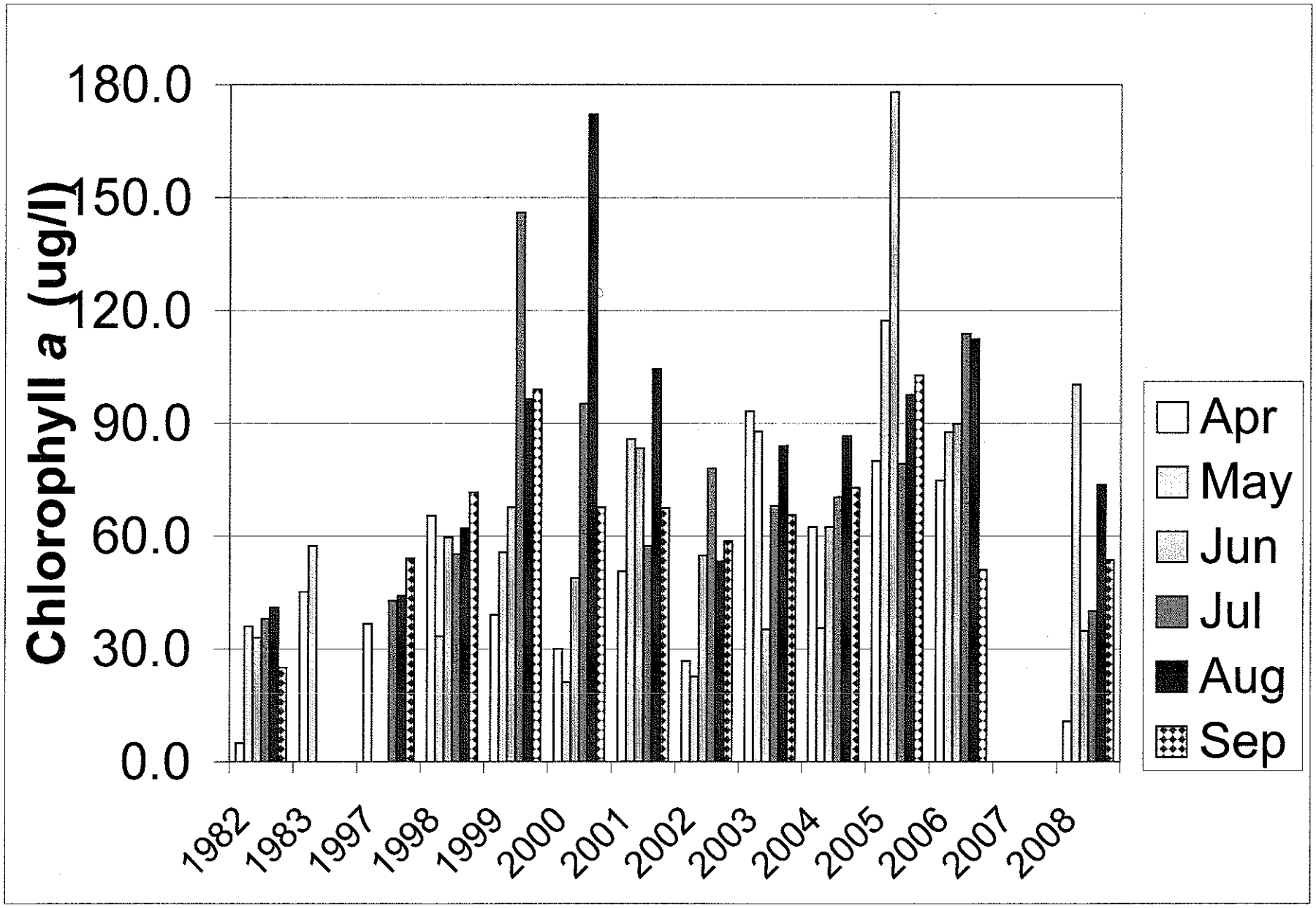


Figure 6. Historic monthly average chlorophyll *a* concentrations at stations 1-5 in Lake Macatawa, Ottawa County, Michigan.

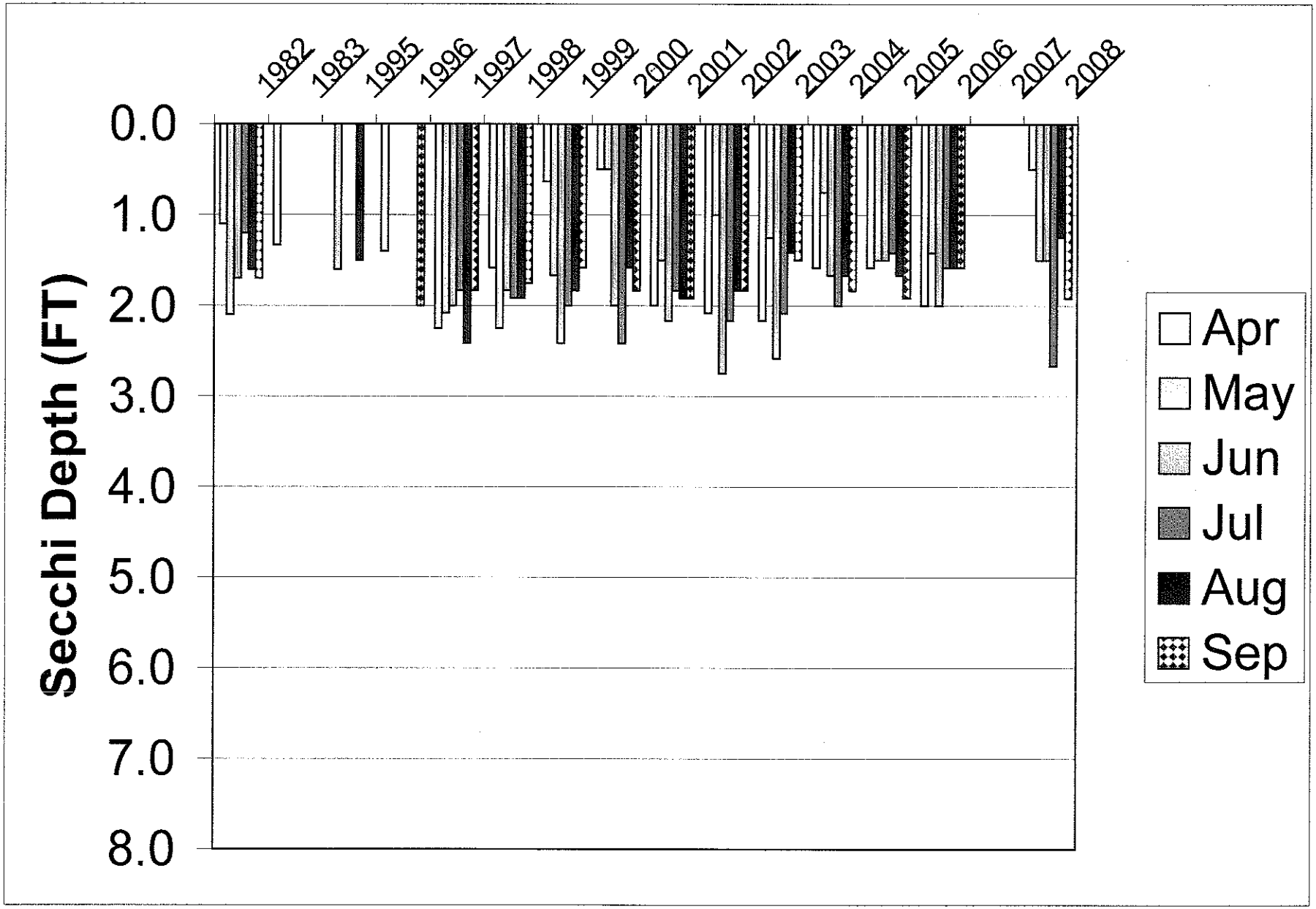


Figure 7. Monthly average secchi depths in Lake Macatawa at stations 1, 2, and 4, Ottawa County, Michigan.

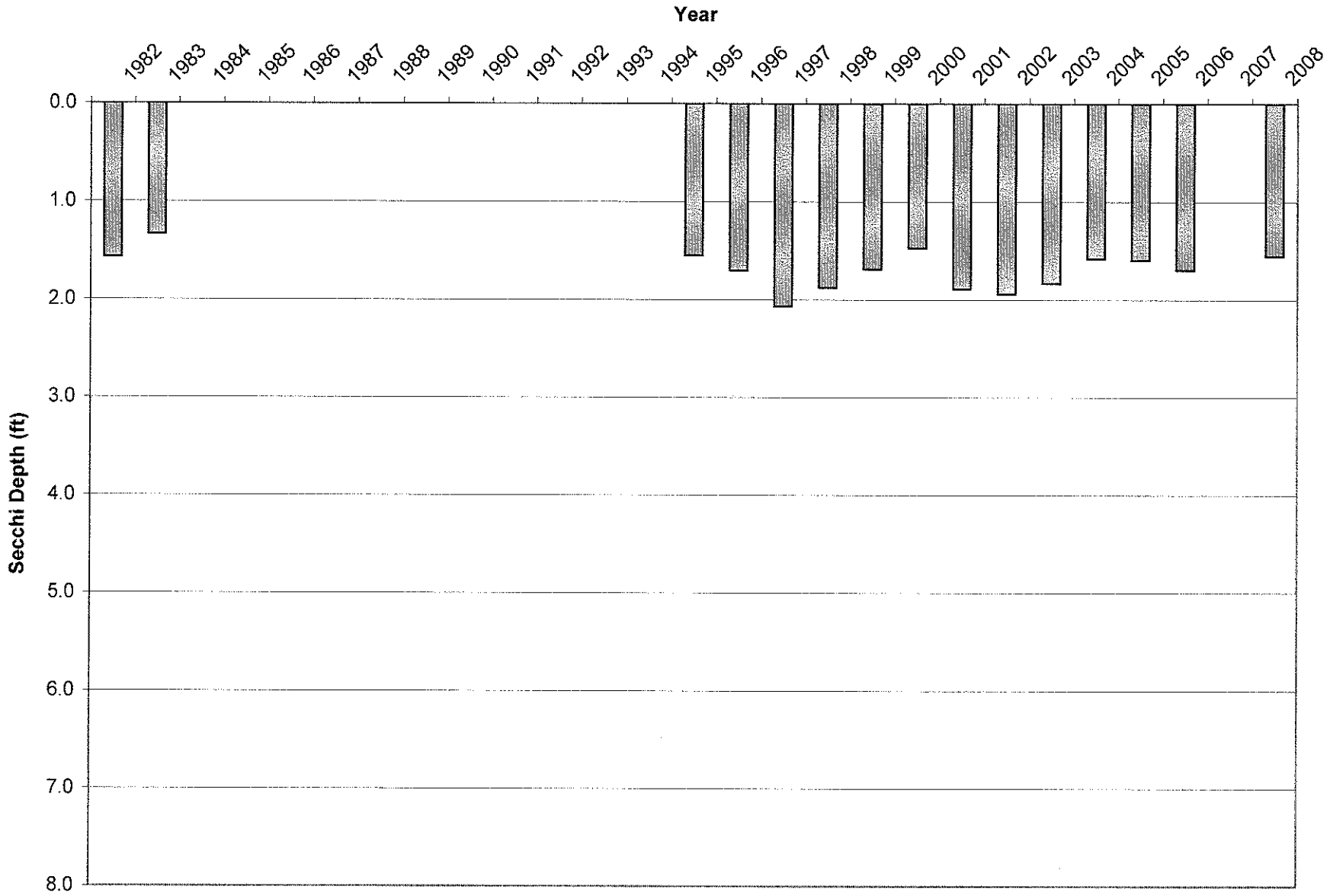


Figure 8. Annual Average secchi depth from April through September at stations 1, 2, and 4 in Lake Macatawa, Ottawa County, Michigan.

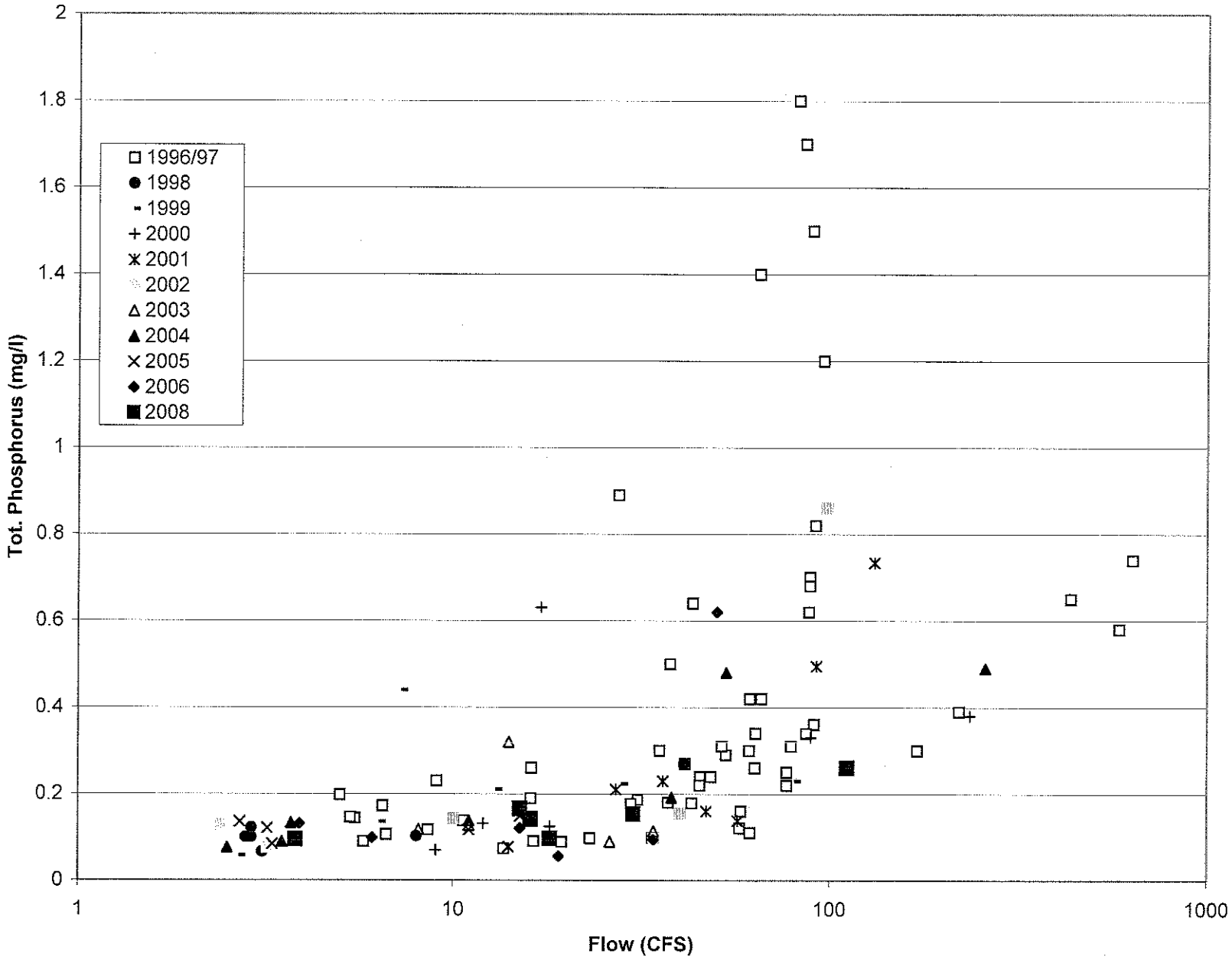


Figure 9. Phosphorus sampling results in relation to flow at the USGS Gage on the Macatawa River.

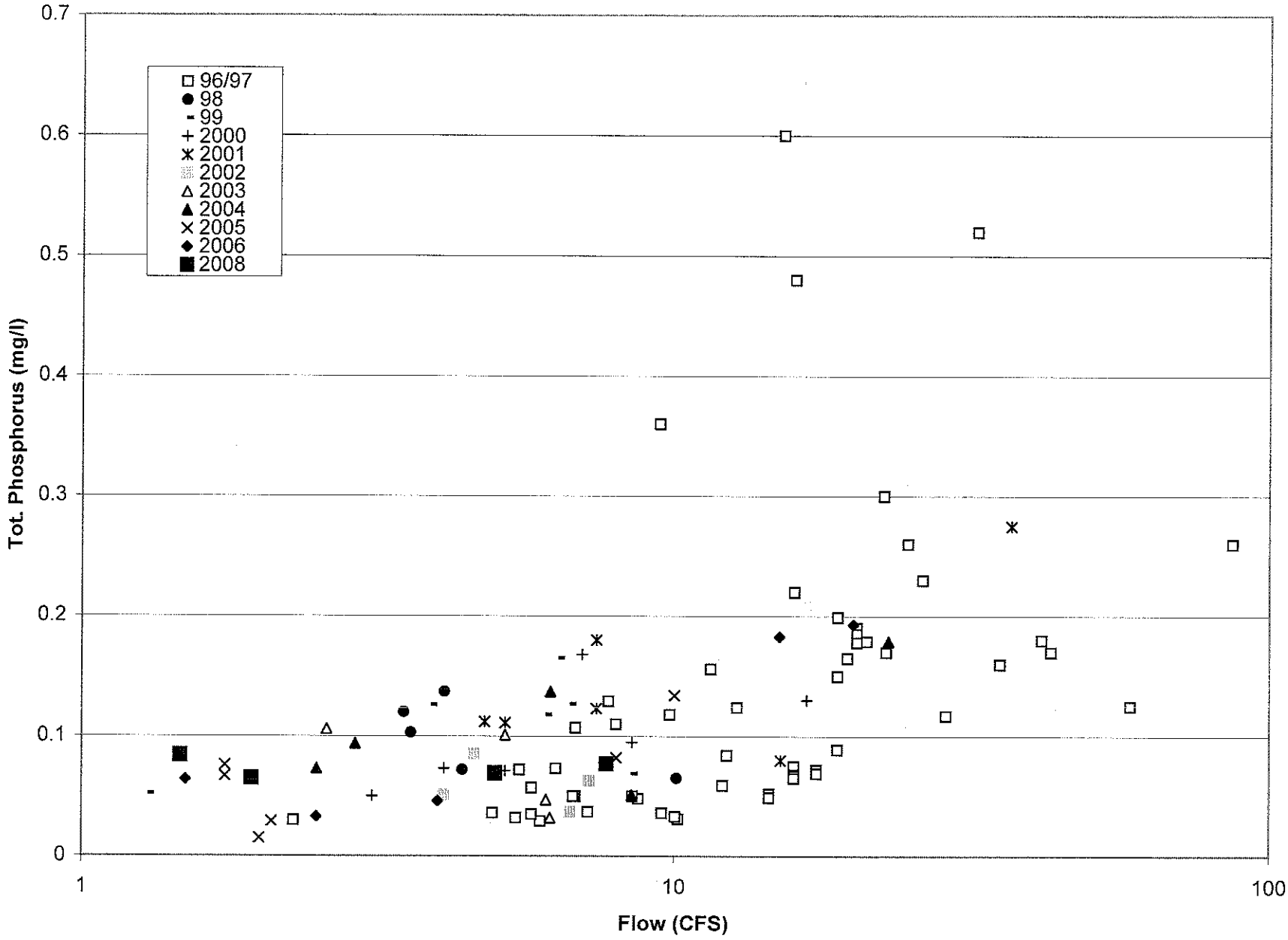


Figure 10. Phosphorus sampling results in relation to flow at the North Branch Macatawa River.

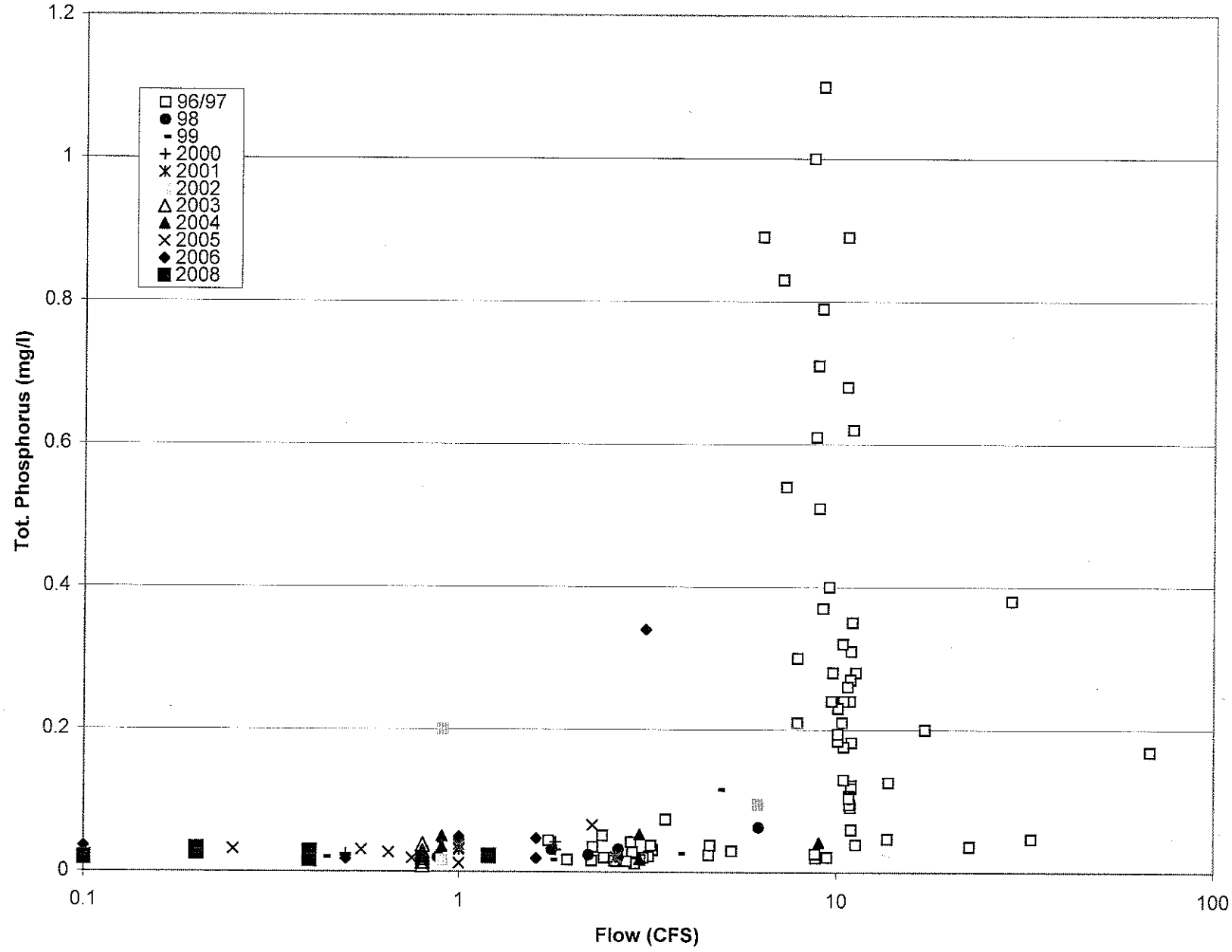


Figure 11. Phosphorus sampling results in relation to flow at Maplewood Drain.

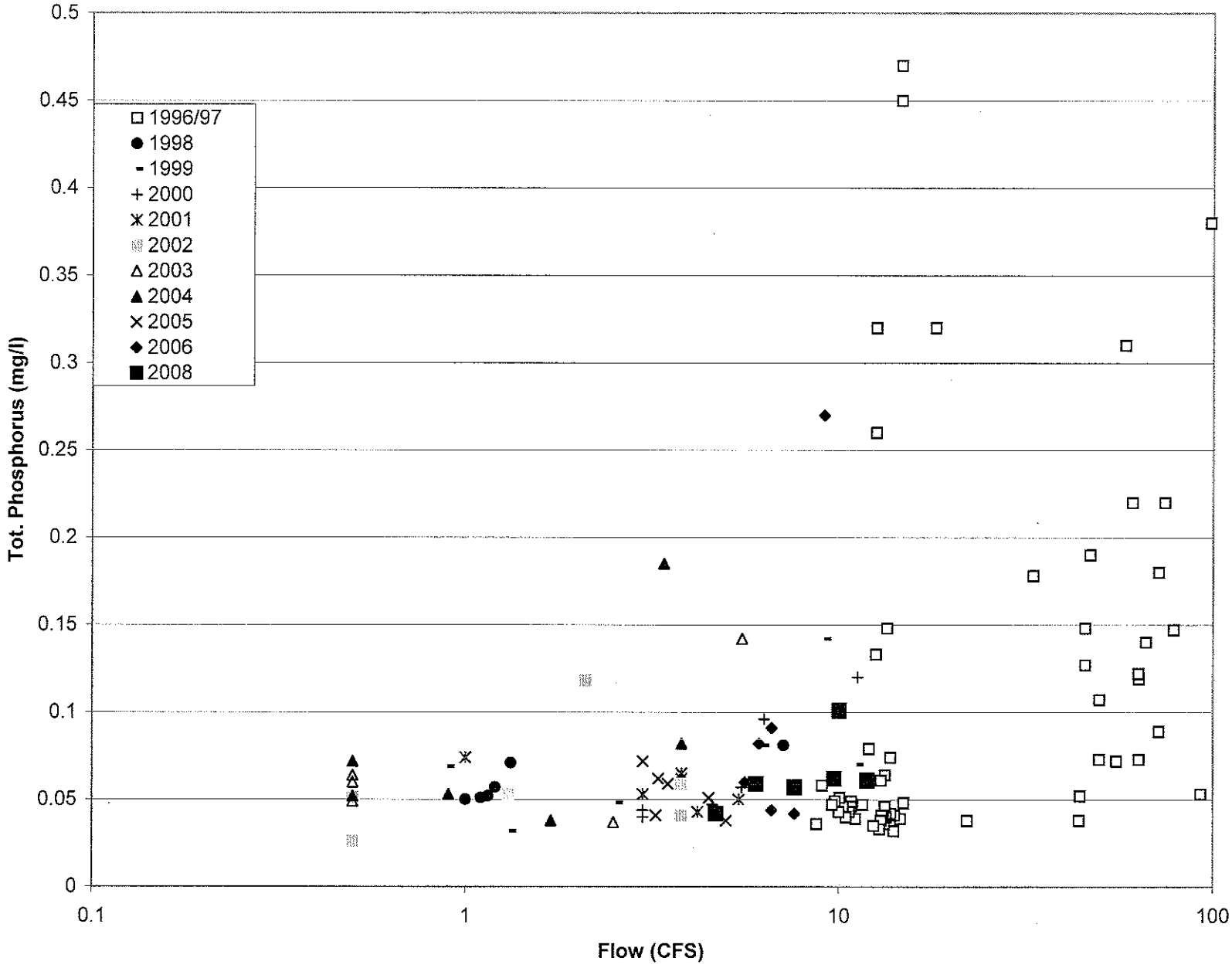


Figure 12. Phosphorus sampling results in relation to flow at Pine Creek.

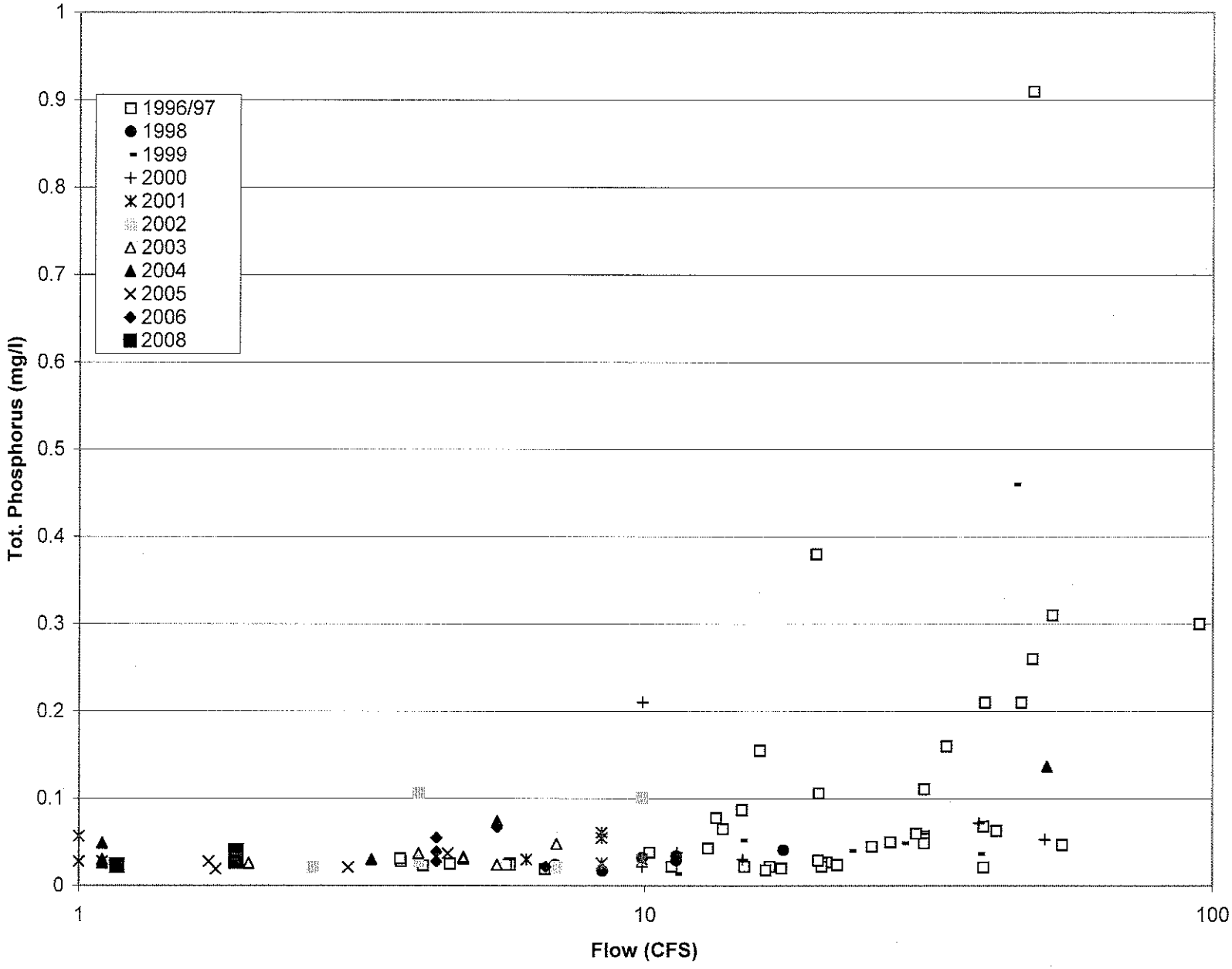


Figure 13. Phosphorus sampling results in relation to flow at the Railroad Tributary.

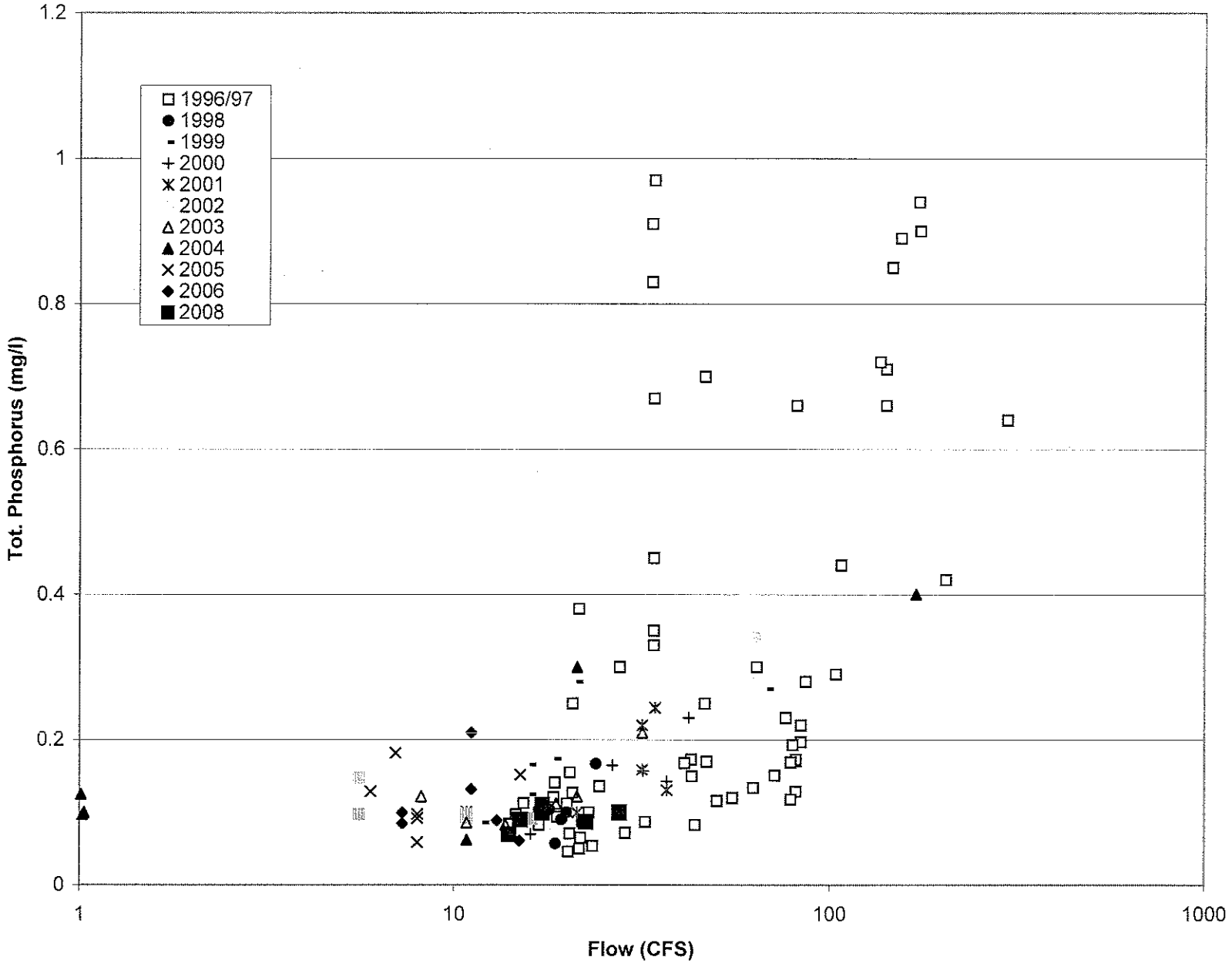


Figure 14. Phosphorus sampling results in relation to flow at Bosch Hulst Drain.

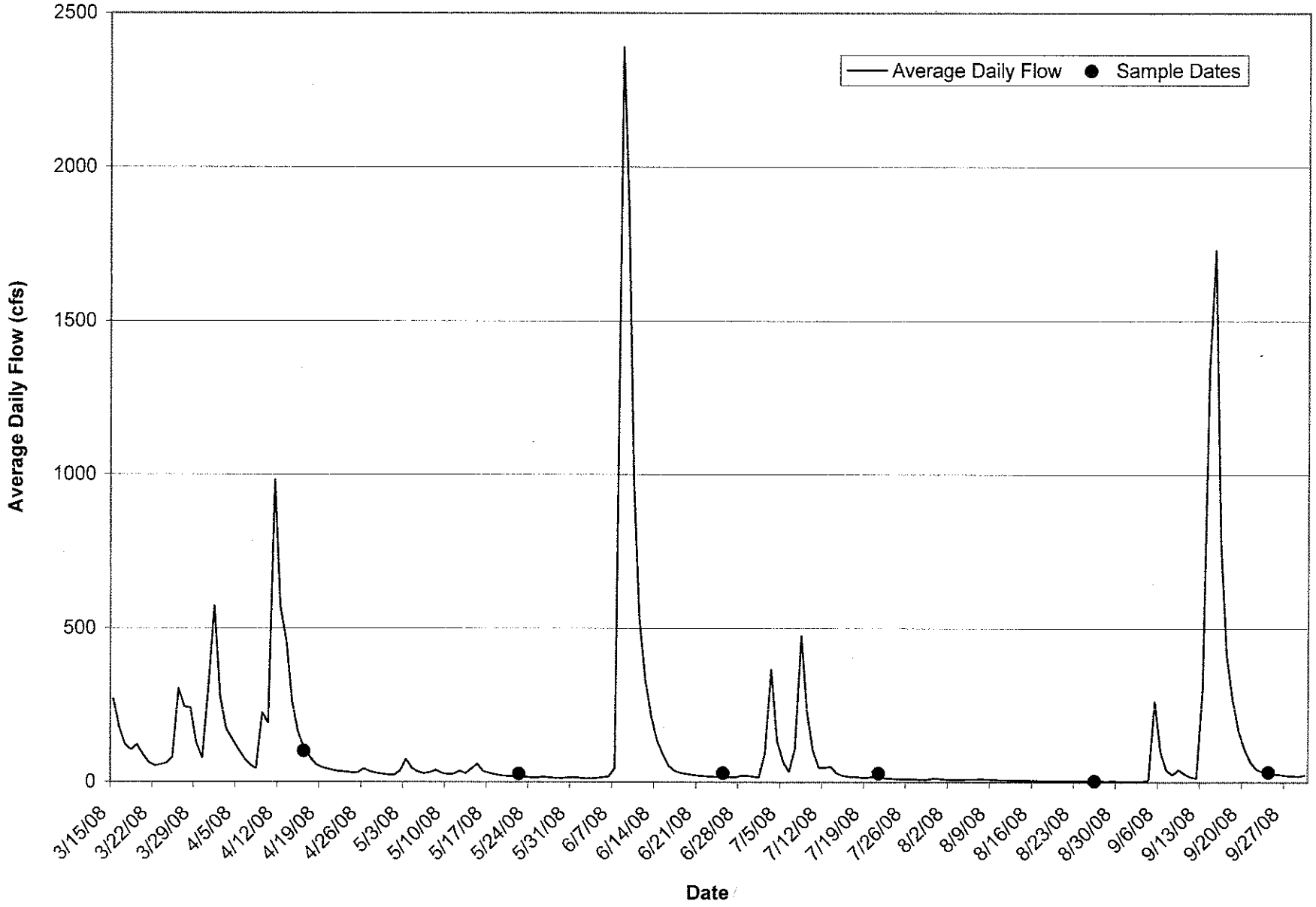


Figure 15. Average daily flow at the USGS gage station on the Macatawa River, Ottawa County, Michigan, March 15-September 30, 2008.

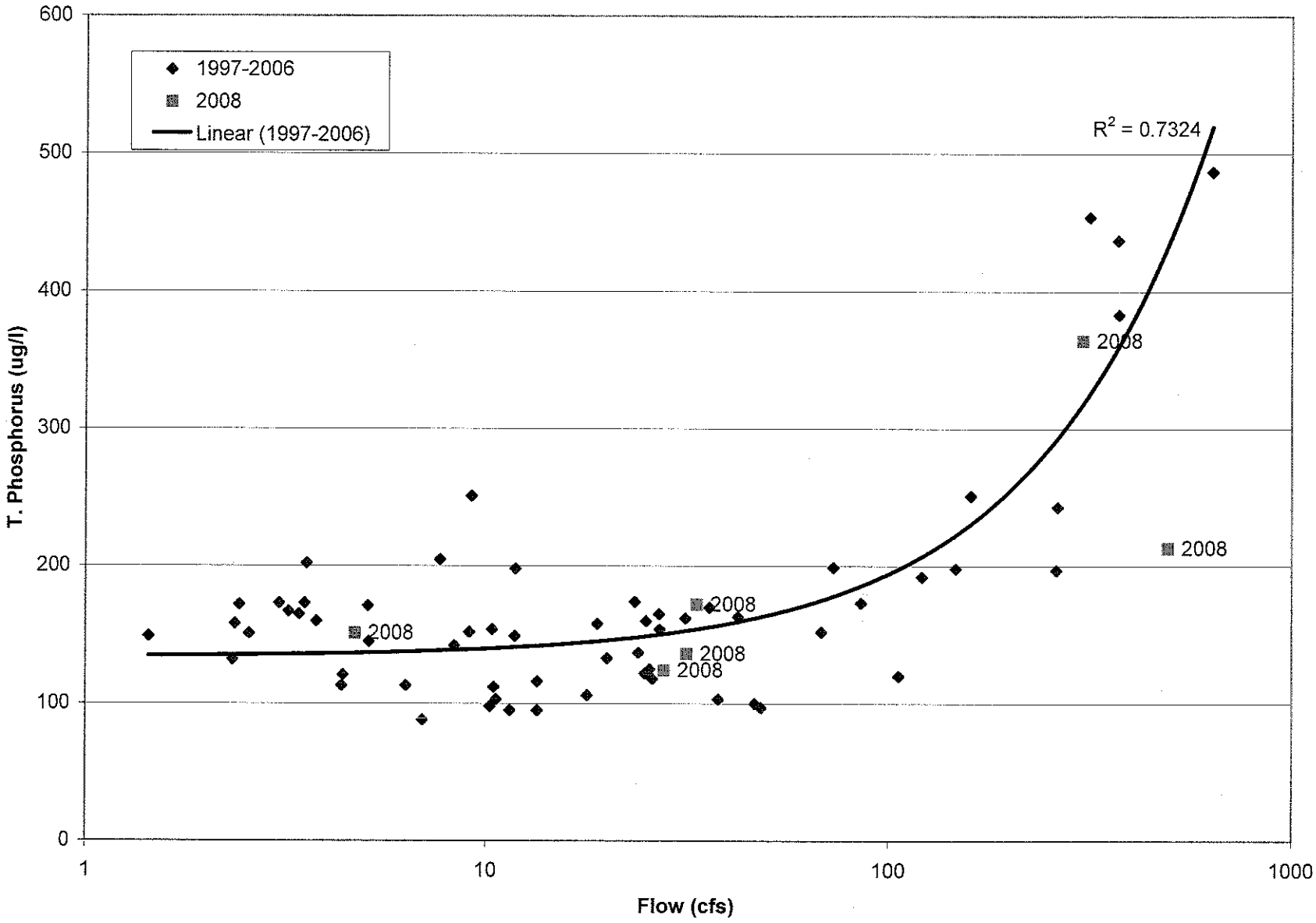


Figure 16. Average phosphorus concentrations in Lake Macatawa from April to September versus average flow of the Macatawa River during the 10 day period prior to sampling, 1997-2006.

Table 1. Water Quality Sampling Results, Lake Macatawa and Major Tributaries, Allegan and Ottawa Counties, April 16, 2008.

STATION	DEPTH (ft)	TEMP. (F)	D. O. (mg/l)	COND. (umho/cm)	pH	CHLORO A. (ug/l)	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Lake Macatawa-West Basin (1)													
Storet # 700237	Sur.	48.2	10.7	475	7.8	16	1.79	2.4	.58	.080	.080	34	.26
Station #4- 11:00 am	5	48.2	10.6	473	7.8								
Depth (ft): 32	10	48.1	10.6	473	7.8								
Secchi Depth (ft): 0.5	15	48.1	10.6	473	7.8		1.89	2.5	.60	.080	.081	32	.28
Color: brownish	20	48.1	10.6	472	7.8								
	25	48.1	10.6	473	7.8								
	30	47.8	9.2	508	7.8		1.94	2.5	.60	.080	.079	67	.30
Lake Macatawa-West Basin (2)													
Storet # 700573				NOT									
Station #5-				SAMPLED									
Depth (ft):													
Secchi Depth (ft):													
Color: brownish													
Lake Macatawa-Central Basin													
Storet # 700574	Sur.	48.4	9.5	437	7.4	5.4	1.86	2.8	.59	.083	.176	97	.41
Station #2- 10:30 am	5	48.3	9.5	436	7.4								
Depth (ft): 22.0	10	48.4	9.4	436	7.4		1.88	3.9	.60	.082	.175	100	.42
Secchi Depth (ft): 0.5	15	48.4	9.4	438	7.4								
Color: brownish	20	48.2	8.4	515	7.4		1.85	2.9	.62	.085	.182	89	.40
Lake Macatawa-Pine Creek Bay													
Storet # 700384				NOT									
Station #3-				SAMPLED									
Depth (ft):													
Secchi Depth (ft):													
Color: brownish													
Lake Macatawa-East Basin													
Storet # 700238	Sur.	49.4	10.2	478	7.6	5.6	2.1	2.9	.60	.101	.156	77	.39
Station #1- 11:30 am	5	49.4	10.0	480	7.5								
Depth (ft): 23.0	10	49.3	9.9	497	7.5		2.1	3.3	.62	.095	.148	84	.42
Secchi Depth (ft): 0.5	15	49.4	9.8	496	7.5								
Color: brownish	20	48.9	9.9	472	7.5		2.0	3.2	.60	.088	.157	83	.40

Stream	**Time**	**Stage**	**Flow(cfs)**	**Visual Observations**	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Pine Creek	12:50 pm	6.05	11.9	Clear-flood stage	.72	.90	.024	.014	.022	4	.061
Railroad Tr. D/S of Confluence	1:00 pm	13.20	1.9	Clear-up 6"	.74	.67	.080	.013	.012	6	.038
Maplewood Drain	9:35 am	11.90	1.2	Clear-up 6"	.61	1.82	.018	.011	.005	ND @ 4	.022
Bosch and Hulst Drain	1:10 pm	13.15	27.7	Slightly turbid-up 12"	1.03	3.7	.09 D	.029	.051	7	.100
N. Br. Macatawa River	1:25 pm	7.30	7.7	Turbid(1 ft secchi)-up 6"	.79	1.51	.027	.015	.038	7	.077
Macatawa River @ USGS Gage	1:15 pm		111	Turbid(0.5 ft secchi)-up 2-3 ft	1.64	5.8	.21 D	.052	.108	29	.261

D - Analyte value quantified from a dilution(s); reporting limit (RL) raised, MDEQ-Environmental Laboratory.
ND - Non detectable, MDEQ-Environmental Laboratory.

Table 2. Water Quality Sampling Results, Lake Macatawa and Major Tributaries, Allegan and Ottawa Counties, May 22, 2008.

STATION	DEPTH (ft)	TEMP. (F)	D. O. (mg/l)	COND. (umho/cm)	pH	CHLORO A. (ug/l)	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Lake Macatawa-West Basin (1)													
Storet # 700237	Sur.	58.9	13.1	486	9.0	100	1.42	.77	.016	.044	.003	14	.114
Station #4- 10:24 am	5	58.8	13.6	469	9.0								
Depth (ft): 32	10	58.8	13.6	471	9.0								
Secchi Depth (ft): 1.75	15	58.8	13.6	470	9.0		1.48	.80	.014	.045	.003	16	.125
Color: brownish	20	58.3	13.1	463	8.9								
	25	57.1	12.0	431	8.8								
	30	56.7	10.9	429	8.6		1.49	.79	.015	.046	.004	16	.124
Lake Macatawa-West Basin (2)													
Storet # 700573	Sur.	58.7	14.0	459	9.1	82	1.36	.75	.014	.043	.003	15	.105
Station #5- 10:50 am	5	58.6	14.2	458	9.0								
Depth (ft): 17	10	58.5	14.0	455	9.0								
Secchi Depth (ft): 1.75	15	58.5	14.0	455	9.0		1.32	.74	.014	.042	.003	16	.105
Color: brownish													
Lake Macatawa-Central Basin													
Storet # 700574	Sur.	61.5	15.2	577	8.9	90	1.78	1.29	.018	.096	.004	6	.137
Station #2- 11:05 am	5	60.7	14.8	570	8.9								
Depth (ft): 26.0	10	60.4	14.4	564	8.9								
Secchi Depth (ft): 1.5	15	60.4	14.4	565	8.9		1.53	1.24	.016	.087	.004	18	.118
Color: brownish	20	60.4	14.4	564	8.9								
	25	60.1	13.3	569	8.7		1.64	1.24	.016	.088	.003	18	.127
Lake Macatawa-Pine Creek Bay													
Storet # 700384	Sur.	61.3	15.8	564	8.9	90	1.50	1.10	.016	.083	.004	18	.108
Station #3- 11:25 am	5	60.4	16.0	566	8.9								
Depth (ft): 9.0	9						1.64	1.11	.017	.084	.004	20	.124
Secchi Depth (ft): 1.25													
Color: brownish													
Lake Macatawa-East Basin													
Storet # 700238	Sur.	64.7	15.2	678	8.5	140	2.3 P	2.1 P	.37 P	.22	.006	19	.132 P
Station #1- 11:45 am	5	64.4	14.7	678	8.5								
Depth (ft): 22.0	10	64.3	14.6	678	8.5		2.6	2.1	.26	.21	.005	22	.170
Secchi Depth (ft): 1.25	15	63.6	14.0	673	8.5								
Color: brownish	20	63.0	13.6	660	8.5		2.3	1.98	.189	.186	.004	33	.176

	Time	Stage	Flow(cfs)	Visual Observations	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Pine Creek	12:15 pm	7.15	6.0	Clear-baseflow	.55	1.04	.064	.023	.016	ND @ 4	.059
Railroad Tr. D/S of Confluence	12:30 pm	13.33	1.2	Clear-baseflow	.61	.35	.059	.019	.006	ND @ 4	.023
Maplewood Drain	12:45 pm	12.30	0.2	Clear-baseflow	.42	1.82	.019	.015	.006	ND @ 4	.027
Bosch and Hulst Drain	12:55 pm	13.60	15.0	Slightly turbid(2 ft secchi)-baseflow	.79	4.4	.08 D	.036	.045	ND @ 4	.090
N. Br. Macatawa River	1:15 pm	6.90	1.9	Clear-baseflow	.92	.66	.067	.046	.026	ND @ 4	.065
Macatawa River @ USGS Gage	1:10 pm		18	Slightly turbid(3 ft secchi)-baseflow	.94	6.4	.12 D	.124	.043	ND @ 4	.097

D - Analyte value quantified from a dilution(s); reporting limit (RL) raised, MDEQ-Environmental Laboratory.

ND - Non detectable, MDEQ-Environmental Laboratory.

P-Recommended sample collection/preservation technique not used; reported result is an estimate.

Table 3. Water Quality Sampling Results, Lake Macatawa and Major Tributaries, Allegan and Ottawa Counties, June 25, 2008.

STATION	DEPTH (ft)	TEMP. (F)	D. O. (mg/l)	COND. (umho/cm)	pH	CHLORO A. (ug/l)	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Lake Macatawa-West Basin (1)													
Storet # 700237	Sur.	71.6	7.3	355	7.8	32	1.60	1.74	.35	.114	.045	11	.150
Station #4- 10:00 am	5	71.5	6.9	356	7.8								
Depth (ft): 32	10	70.7	6.3	345	7.7								
Secchi Depth (ft): 2.0	15	68.7	5.6	338	7.7		1.38	1.69	.40	.105	.052	13	.137
Color: brown	20	64.7	6.7	323	7.7								
	25	61.8	7.4	314	7.8								
	30	60.0	5.6	313	7.6		.80	.67	.30	.034	.028	17	.099
	32	60.0	2.7	317	7.5								
Lake Macatawa-West Basin (2)													
Storet # 700573	Sur.	71.8	7.8	345	7.9	37	1.41	1.77	.26	.106	.043	13	.143
Station #5- 10:30 am	5	71.8	7.7	345	7.9								
Depth (ft): 14	10	71.8	7.6	345	7.9								
Secchi Depth (ft): 2.0	13	71.5	6.9	345	7.9		1.42	1.83	.26	.106	.042	12	.141
Color: brown													
Lake Macatawa-Central Basin													
Storet # 700574	Sur.	72.9	5.1	476	7.6	26	2.1	2.3	.69	.198	.048	12	.157
Station #2- 10:50 am	5	72.9	5.0	476	7.6								
Depth (ft): 25.0	10	72.3	4.6	445	7.6								
Secchi Depth (ft): 1.5	15	71.4	3.9	420	7.5		2.1	2.3	.64	.185	.048	13	.166
Color: brown	20	69.5	2.9	382	7.5								
	25	68.6	2.7	360	7.5		1.52	1.34	.64	.108	.049	25	.173
Lake Macatawa-Pine Creek Bay													
Storet # 700384	Sur.	73.7	6.1	494	7.6	40	2.1	2.3	.65	.196	.040	13	.143
Station #3- 11:20 am	5	73.6	5.9	491	7.6								
Depth (ft): 10.0	9	73.3	5.6	483	7.6		2.2	2.2	.63	.191	.040	12	.167
Secchi Depth (ft): 1.5													
Color: brown													
Lake Macatawa-East Basin													
Storet # 700238	Sur.	76.3	4.4	593	7.4	39	3.1	2.7	1.2	.27 D	.050	32	.25
Station #1- 11:40 am	5	76.3	4.1	592	7.4								
Depth (ft): 22.0	10	75.5	3.6	592	7.4		3.0	2.7	1.2	.27 D	.051	28	.21
Secchi Depth (ft): 1.0	15	74.3	2.8	616	7.4								
Color: brown	20	72.8	1.4	628	7.3								
	22	72.5	1.1	652	7.2		2.7	2.5	1.1	.23 D	.048	33	.21

	Time	Stage	Flow(cfs)	Visual Observations	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Pine Creek	12:20 pm	6.30	10.0	turbid(1 ft secchi)-up 1 ft	.91	1.09	.070	.038	.030	6	.101
Railroad Tr. D/S of Confluence	12:30 pm	13.20	1.9	clear-baseflow	.78	.41	.078	.033	.016	ND @ 4	.039
Maplewood Drain	9:40 am	12.30	0.2	slightly turbid(3 ft secchi)-above baseflo	.57	2.1	.04 D	.016	.012	ND @ 4	.032
Bosch and Hulst Drain	12:40 pm	15.50	17.2	turbid(2 ft secchi)-baseflow	.78	3.8	ND	.028	.055	4	.100
N. Br. Macatawa River	12:55 pm	4.00	0.6	clear-baseflow	.78	.72	.026	.008	.020	ND @ 4	.047
Macatawa River @ USGS Gage	12:50 pm		16.0	turbid(2 ft secchi)-above baseflow	1.43	7.4	.10 D	.21	.058	19	.142

D - Analyte value quantified from a dilution(s); reporting limit (RL) raised, MDEQ-Environmental Laboratory.

ND - Non detectable, MDEQ-Environmental Laboratory.

Table 4. Water quality Sampling Results, Lake Macatawa and Major Tributaries, Allegan and Ottawa Counties, July 21, 2008.

STATION	DEPTH (ft)	TEMP. (F)	D. O. (mg/l)	COND. (umho/cm)	pH	CHLORO A. (ug/l)	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Lake Macatawa-West Basin (1)													
Storet # 700237	Sur.	77.2	5.6	397	7.9	18	1.35	.92	.42	.102 P	.026 P	6	.081
Station #4- 11:30 am	5	76.7	4.8	397	7.7								
Depth (ft): 31	10	76.5	4.4	395	7.7								
Secchi Depth (ft): 3.5	15	76.1	4.1	386	7.7		1.38	.80	.47	.090 P	.034 P	5	.096
Color: brown	20	75.6	1.7	383	7.5								
	25	75.1	1.0	368	7.5								
	30	74.8	2.6	383	7.6		1.52	.48	.64	.061 P	.078 P	14	.171
Lake Macatawa-West Basin (2)													
Storet # 700573	Sur.	77.9	8.1	383	8.4	44	1.45	.82	.130	.078 P	.003 P	9	.075
Station #5- 11:20 am	5	76.9	6.8	389	8.0								
Depth (ft): 14	10	76.3	4.9	390	7.7								
Secchi Depth (ft): 3.0	14	76.1	0.8	391	7.5		1.36	.75	.35	.077 P	.019 P	11	.092
Color: brown													
Lake Macatawa-Central Basin													
Storet # 700574	Sur.	78.1	5.7	456	7.7	41	1.83	1.40	.68	.184 P	.020 P	10	.099
Station #2- 11:00 am	5	77.9	5.2	458	7.7								
Depth (ft): 25.0	10	77.6	4.7	457	7.6								
Secchi Depth (ft): 2.5	15	77.4	5.0	459	7.6		1.82	1.41	.69	.182 P	.024 P	11	.105
Color: brown	20	77.4	5.1	460	7.6								
	24	77.2	4.2	464	7.4		1.87	1.43	.65	.183	.024	27	.139
Lake Macatawa-Pine Creek Bay													
Storet # 700384	Sur.	79.1	9.5	476	8.2	52	2.0	1.69	.36	.20 P	.004 P	11	.101
Station #3- 10:40 am	5	78.0	6.4	470	7.7								
Depth (ft): 10.0	10	76.0	7.3	476	7.7		1.89	1.63	.63	.21 P	.014 P	7	.093
Secchi Depth (ft): 3.0													
Color: brown													
Lake Macatawa-East Basin													
Storet # 700238	Sur.	80.2	6.7	512	7.5	45	2.4	1.78	.98	.27 D, P	.018 P	9	.124
Station #1- 10:25 am	5	79.6	5.6	593	7.4								
Depth (ft): 21.0	10	79.1	2.0	600	7.3		2.4	1.84	.95	.27 D,P	.023 P	12	.116
Secchi Depth (ft): 2.0	15	78.5	2.1	602	7.3								
Color: brown	20	78.2	2.2	604	7.1		2.8	1.58	1.1	.23 D,P	.044 P	67	.23

	Time	Stage	Flow(cfs)	Visual Observations	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Pine Creek	12:35 pm	6.8	7.6	Turbid(1 ft secchi)- up 12"	.60	1.11	.052	.028 P	.020 P	4	.057
Railroad Tr. D/S of Confluence	12:50 pm	13.2	1.9	Turbid(1 ft secchi)- up 4"	.64	.37	.044	.023 P	.009 P	ND @ 4	.028
Maplewood Drain	9:30 am	12.2	0.4	Clear-up 6"	.62	1.77	.032	.016 P	.011 P	ND @ 4	.028
Bosch and Hulst Drain	1:00 pm	13.5	17.2	Turbid(2 ft secchi)-baseflow	.66	3.4	.05 D	.032 P	.066 P	5	.110
N. Br. Macatawa River	1:15 pm	6.2	0.8	Turbid(2 ft secchi)-baseflow	.85	.40	.020	.007 P	.045 P	ND @ 4	.086
Macatawa River @ USGS Gage	1:10 pm		15	Slightly turbid(3 ft secchi)	1.12	5.7	.06 D	.120 P	.077 P	17	.166

D - Analyte value quantified from a dilution(s); reporting limit (RL) raised, MDEQ-Environmental Laboratory.

ND - Non detectable, MDEQ-Environmental Laboratory.

P-Recommended sample collection/preservation technique not used; reported result is an estimate. Bottle left out at room temperature overnight.

Table 5. Water Quality Sampling Results, Lake Macatawa and Major Tributaries, Allegan and Ottawa Counties, August 26, 2008.

STATION	DEPTH (ft)	TEMP. (F)	D. O. (mg/l)	COND. (umho/cm)	pH	CHLORO A. (ug/l)	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Lake Macatawa-West Basin (1)													
Storet # 700237	Sur.	72.0	8.8	413	8.7	51	1.26	.002 W	.003 T	.002	.006	12	.120
Station #4- 10:50 am	5	72.0	8.8	414	8.7								
Depth (ft): 31	10	72.0	8.1	413	8.6								
Secchi Depth (ft): 1.5	15	72.0	7.4	417	8.4		1.18	.004 T	.005 T	.002	.007	21	.136
Color: greenish brown	20	65.0	8.1	359	8.2								
	25	62.0	4.3	328	7.9								
	30	57.0	4.7	366	7.4		.57	.20	.045	.003	.003	18	.080
Lake Macatawa-West Basin (2)													
Storet # 700573	Sur.	72.0	8.3	417	8.6	50	1.20	.001 W	.004 T	.001 T	.007	11	.125
Station #5- 11:05 am	5	72.0	8.2	417	8.6								
Depth (ft): 14	10	71.0	8.6	419	8.5								
Secchi Depth (ft): 1.5	14	71.0	8.6	416	8.6		1.20	.001 W	.005 T	.002	.005	17	.120
Color: greenish brown													
Lake Macatawa-Central Basin													
Storet # 700574	Sur.	74.0	8.8	478	8.4	100	1.74	.126	.064	.056	.004	21	.154
Station #2- 10:30 am	5	74.0	8.6	479	8.3								
Depth (ft): 26.0	10	73.0	5.8	476	8.3								
Secchi Depth (ft): 1.25	15	73.0	4.5	468	7.9		1.59	.102	.081	.046	.004	18	.141
Color: greenish brown	20	70.5	1.8	401	7.4								
	25	70.0	2.2	430	7.4		1.33	.045	.163	.006	.016	60	.25
Lake Macatawa-Pine Creek Bay													
Storet # 700384	Sur.	73.0	10.9	464	8.7	83	1.63	.004 T	.007 T	.002	.004	17	.141
Station #3- 11:40 am	5	73.0	10.7	463	8.7								
Depth (ft): 10.0	10	72.0	10.0	462	8.6		1.62	ND @ .01 W	.008 T	.002	.005	30	.164
Secchi Depth (ft): 1.5													
Color: greenish brown													
Lake Macatawa-East Basin													
Storet # 700238	Sur.	74.0	8.7	487	8.4	84	1.59	.175	.121	.074	.006	17	.137
Station #1- 11:50 am	5	74.0	8.2	489	8.2								
Depth (ft): 25.0	10	74.0	7.3	489	8.0		1.40	.176	.21	.077	.006	22	.124
Secchi Depth (ft): 1.0	15	74.0	4.8	489	8.0								
Color: brown	20	72.0	2.6	431	7.6								
	24	72.0	3.4	429	7.5		1.52	.024	.22	.013	.011	48	.22

	Time	Stage	Flow(cfs)	Visual Observations	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Pine Creek	12:30 pm	7.45	4.7	Clear-low	.49	1.49	.035	.018	.017	ND @ 4	.042
Railroad Tr. D/S of Confluence	12:45 pm	13.35	1.0	Clear-low	.58	.32	.025	.007	.008	ND @ 4	.021
Maplewood Drain	9:30 am	12.40	0.1	Clear-low	.42	1.65	.030	.012	.008	ND @ 4	.020
Bosch and Hulst Drain	1:00 pm	13.65	14.0	Clear-low	.60	5.2	ND @ .05 D	.020	.044	ND @ 4	.070
N. Br. Macatawa River	1:15 pm	6.60	1.5	Clear-low	1.23	.008 T	.010	.002	.023	ND @ 4	.084
Macatawa River @ USGS Gage	1:10 pm		3.8	Clear-low	.78	5.9	ND @ .05 D	.016	.064	ND @ 4	.095

D - Analyte value quantified from a dilution(s); reporting limit (RL) raised, MDEQ-Environmental Laboratory.
ND - Non detectable, MDEQ-Environmental Laboratory.
W - reported value is less than the method detection limit
T -Report value is less than the reporting limit (RL).

Table 6. Water Quality Sampling Results, Lake Macatawa and Major Tributaries, Allegan and Ottawa Counties, September 24, 2008.

STATION	DEPTH (ft)	TEMP. (F)	D. O. (mg/l)	COND. (umho/cm)	pH	CHLORO A. (ug/l)	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Lake Macatawa-West Basin (1)													
Storet # 700237	Sur.	68.2	9.3	343	8.1	54	1.49 (1.41)	1.14 (1.13)	.107 (.112)	.063 (.062)	.067 (.067)	7 (7)	.199 (.188)
Station #4- 11:00 am	5	68.1	8.9	344	8.0								
Depth (ft): 31	10	67.9	8.2	345	7.9								
Secchi Depth (ft): 2.0	15	67.2	6.0	347	7.8		1.39	1.15	.23	.064	.083	7	.192
Color: brownish red	20	66.6	3.8	348	7.6								
	25	66.3	2.4	352	7.4								
	30	64.8	0.6	393	7.3		2.0	1.13	.65	.075	.097	28	.25
Lake Macatawa-West Basin (2)													
Storet # 700573	Sur.	69.4	10.9	347	8.5	70	1.64	1.00	.046	.060	.044	11	.21
Station #5- 10:45 am	5	69.3	10.6	347	8.5								
Depth (ft): 14	10	68.6	9.6	352	8.2								
Secchi Depth (ft): 2.0	14	67.5	8.6	359	8.0		1.43	1.23	.123	.070	.072	8	.192
Color: brownish red													
Lake Macatawa-Central Basin													
Storet # 700574	Sur.	68.0	7.4	383	7.7	36	1.79	1.40	.34	.086	.099	5	.23
Station #2- 10:30 am	5	67.4	6.4	370	7.5								
Depth (ft): 26	10	66.7	3.8	365	7.4								
Secchi Depth (ft): 2.0	15	66.2	1.8	398	7.3		1.78	1.23	.60	.081	.088	12	.21
Color: brownish red	20	65.2	1.6	593	7.2								
	25	65.0	0.9	610	7.2		2.5	2.0	.90	.101	.071	24	.22
Lake Macatawa-Pine Creek Bay													
Storet # 700384	Sur.	69.4	10.1	387	8.0	59	1.80	1.39	.143	.080	.084	12	.24
Station #3- 10:00 am	5	69.1	9.4	390	7.9								
Depth (ft): 10.0	10	67.0	6.3	459	7.6		1.58	1.38	.24	.083	.099	4	.21
Secchi Depth (ft): 1.75													
Color: brownish red													
Lake Macatawa-East Basin													
Storet # 700238	Sur.	69.0	6.2	458	7.6	49	2.4	1.70	.71	.142	.093	8	.23
Station #1- 11:15 am	5	68.1	6.1	457	7.4								
Depth (ft): 24	10	67.5	4.8	447	7.3		2.1	1.70	.74	.138	.103	6	.22
Secchi Depth (ft): 1.75	15	67.1	4.0	481	7.3								
Color: brownish red	20	65.7	3.8	687	7.3								
	23	65.1	1.7	693	7.2		2.0	2.3	.62	.090	.067	24	.17

	Time	Stage	Flow(cfs)	Visual Observations	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Pine Creek	1:10 pm	6.4	9.7	turbid(1 ft secchi)-up 1 ft	.62	.98	.054	.033	.024	ND @ 4	.062
Railroad Tr. D/S of Confluence	1:25 pm	13.2	1.9	turbid(2 ft secchi)-up 4"	.73	.42	.083	.030	.013	ND @ 4	.035
Maplewood Drain	9:35 am	12.2	0.4	clear-up 6"	.45	1.92	.021	.011	.008	ND @ 4	.017
Bosch and Hulst Drain	1:35 pm	13.3	22.5	Slightly turbid(3 ft secchi)-baseflow	.75	3.5	ND @.05 D	.020	.043	ND @ 4	.087
N. Br. Macatawa River	1:55 pm	estimated flow	5.0	clear-baseflow	.87	1.48	.013	.008	.040	ND @ 4	.069
Macatawa River @ USGS Gage	1:40 pm		30.0	turbid(2 ft secchi)-	1.60	5.9	.16 D	0.123	.086	ND @ 4	.154

D - Analyte value quantified from a dilution(s); reporting limit (RL) raised, MDEQ-Environmental Laboratory.
ND - Non detectable, MDEQ-Environmental Laboratory.
( )- duplicate sample result

MICHIGAN DEPARTMENT OF ENVIRONMENTAL QUALITY
WATER RESOURCES DIVISION
SEPTEMBER 2011

STAFF REPORT

MONTHLY WATER QUALITY ASSESSMENT OF LAKE MACATAWA AND ITS TRIBUTARIES APRIL-SEPTEMBER 2010

INTRODUCTION

Water quality monitoring of Lake Macatawa and its tributaries is planned, as resources allow, through 2020 to document the effectiveness of phosphorus reduction efforts. Walterhouse (2009) presented water quality monitoring results from 2008 and contrasted them with recent lake and tributary water quality results. This report presents the results of sampling efforts in 2010, and compares the results with previous sampling results collected in conjunction with development of the phosphorus Total Maximum Daily Load (TMDL) in 1997, and annual sampling results collected subsequent to TMDL development. Monitoring was not conducted in 2007 and 2009 because of resource limitations

Lake Macatawa is a 1,780-acre drowned river mouth lake located along the southeastern shoreline of Lake Michigan near the city of Holland, Michigan. The lake and its watershed encompass 179 square miles (114,560 acres) in Ottawa and Allegan Counties. Lake Macatawa is a relatively shallow lake with an average depth of 12 feet and a maximum depth of 40 feet in the western basin. The water level of Lake Macatawa changes along with the fluctuations in Lake Michigan water levels. Consequently, the water level of Lake Macatawa was approximately 3 feet lower in 2010 than 1997 when the TMDL was developed, and Lake Michigan water levels were above the long-term average levels. A man-made shipping channel about 5 miles in length is maintained at a depth of 22 feet from Lake Michigan to the eastern basin of the lake. The width of the lake varies from less than 0.25 miles to slightly more than 1 mile.

Major tributaries to Lake Macatawa are the Macatawa River and Pine Creek. The Macatawa River enters the shallow eastern basin of Lake Macatawa after passing through a several hundred-acre wetland. Recent low water levels have decreased the wetted surface area of the wetland exposing vast mud flats that have developed lush stands of wetland vegetation. The shoreline of the eastern basin is dominated by industrial development. The remainder of the lake's shoreline consists of residential development, city and township parks, or commercial marinas.

The Michigan Department of Environmental Quality (MDEQ) is required by Section 303(d) of the federal Clean Water Act to biennially develop and submit to the United States Environmental Protection Agency (USEPA) a list of water bodies that do not attain water quality standards (WQS). Lake Macatawa and all tributaries within the watershed were included on this list submitted to the USEPA because of nutrient enrichment. Lake Macatawa displays the classic symptoms of a hypereutrophic lake, including: extremely high nutrient and chlorophyll *a* levels, excessive turbidity, periodic nuisance algal blooms, low dissolved oxygen (D.O.) levels, and a high rate of sediment deposition. Lake Macatawa was included in a 1971 publication entitled, "Problem Lakes in the United States" (Ketelle and Uttormark, 1971). Forty years later, the lake

is still considered to be one of the most nutrient enriched lakes in Michigan. Federal, state, and local agencies, as well as several universities, have documented Lake Macatawa's water quality, sediment chemistry, watershed resources, and various specifics of the dynamics that impact water quality. Historic published literature available for Lake Macatawa is compiled in the reference section of a past report prepared by the MDEQ (Walterhouse, 1998).

The MDEQ received a Section 104(b)(3) grant from the USEPA in October 1996 to develop a phosphorus TMDL for Lake Macatawa and used some of the funding to quantify phosphorus loading throughout the Lake Macatawa watershed and relate the loading to Lake Macatawa's in-lake phosphorus concentration. Walterhouse (1998) summarized the sampling efforts and sampling results, and outlined the methods used to develop a phosphorus TMDL that will result in Lake Macatawa meeting WQS. The TMDL document was public noticed on November 23, 1998, and submitted to the USEPA on January 27, 1999 (Walterhouse, 1999b). The USEPA approval of the TMDL required the submission of additional documents on June 30, 1999; October 22, 1999; and February 24, 2000. Final approval from the USEPA was received on April 13, 2000. The MDEQ dedicated the remainder of the USEPA funds to the Macatawa Area Coordinating Council (MACC), a local organization that accepted the challenge of coordinating the development of a locally derived watershed management plan to achieve the goal of the TMDL. The MACC finalized a plan on September 16, 1999, entitled, "Phosphorus Reduction Implementation Plan for the Macatawa Watershed, 1999-2009" (Higgins and Kosky, 1999). The plan is currently being updated to meet the USEPA's Nine Key Elements Criteria. A voluntary agreement to reduce phosphorus loading to Lake Macatawa was signed on May 1, 2000, by representatives of all government units within the watershed, point sources that contribute phosphorus, and the MDEQ. The agreement was revised and renewed in July 2010.

As per the agreement, the MACC is responsible for preparing a report on an annual basis summarizing the progress made toward meeting the phosphorus goals identified in the TMDL. Efforts to reduce phosphorus loading to Lake Macatawa are outlined in the 2009 annual report that covered the time frame from October 1, 2008, to September 30, 2009 (MACC, 2009). Previous annual reports provided a summary of the best management practices (BMPs) implemented and other efforts throughout the 114,000-acre watershed to reduce nonpoint source (NPS) phosphorus loading prior to sampling in 2010.

In addition to the BMPs, numerous efforts and actions have been taken to reduce NPS loading from urban and agricultural sources throughout the watershed. The point sources in the watershed have reduced phosphorus loading to Lake Macatawa from over 14,000 pounds in 2000, to less than 9,500 pounds in 2009, and are well below the phosphorus waste load allocation of 20,000 pounds per year established in the TMDL (MACC, 2009).

METHODS

Sampling was conducted once per month from April through September 2010, at 5 stations in Lake Macatawa (Figure 1). Grab samples were collected at the surface, bottom, and mid-depth at each station. A depth integrated sample of the photic zone was also collected at each station for chlorophyll *a* analysis. Additional sampling at each station included a measurement of secchi transparency and a profile at 5-foot increments of temperature, D.O., conductivity, and pH from the surface to the lake bottom using a calibrated Yellow Springs Instruments 6 series environmental monitoring system.

Grab samples were also collected once per month, on the same day the lake sampling was conducted, at the 6 tributaries where annual loads were determined during development of the

TMDL (Figure 2). Flow at the time of sampling was obtained from the United States Geological Survey (USGS) Web site for the gage station located on the Macatawa River. Flows for the site on the North Branch Macatawa River were estimated at the time of sample collection. Flows at the time of sampling for the other 4 tributaries were calculated using the stage height at the time of sampling and the stage discharge curves previously developed by the MDEQ's Land and Water Management Division.

All of the samples from the lake and tributaries were collected, preserved (if necessary), stored at 4° Celsius, and transported to the MDEQ's Environmental Laboratory for chemical analysis using standard protocols (MDEQ, 1994). The samples were analyzed for total and ortho phosphorus, nitrate + nitrite, Kjeldahl nitrogen, nitrite, ammonia, suspended solids, and chlorophyll *a*. All samples collected in 2010 were analyzed by the MDEQ's Environmental Laboratory.

SAMPLING RESULTS

Monthly water quality sampling results for Lake Macatawa and the tributary sites are presented by month in Tables 1 through 6. The 2010 average monthly sampling results for total phosphorus are displayed in Figures 3 and 4 for Stations 1, 2, and 4, along with historic data that was collected at the same 3 locations (Creal and Walterhouse, 1997; and Walterhouse, 1998, 1999a, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, and 2009). All of the monthly average phosphorus concentrations in 2010 were within the historic range of values for each month. The average phosphorus concentration of 237 micrograms per liter (ug/l) in April was lower than the value recorded in April 2008; but during May, the concentration of 217 ug/l was greater than the value recorded in May 2008. The average phosphorus concentration decreased to 138 ug/l in June, increased to 209 ug/l in July, decreased to 185 ug/l in August, and decreased again in September to 152 ug/l.

The spring (April and May) average phosphorus levels at the 3 locations where additional historic, comparable data were available (USEPA, 1975) are presented in Figure 5. The spring overturn phosphorus concentration of 227 ug/l in 2010 was lower than the concentration recorded in 2008, but still higher than the concentrations recorded in 2005 and 2006. The phosphorus concentration in 2010 is consistent with historic levels before and after implementation of the TMDL. The 2010 spring phosphorus concentration was more than 4 times greater than the TMDL interim goal of 50 ug/l. The total nitrogen (nitrate + nitrite and Kjeldahl nitrogen) to total phosphorus ratios in all of the basins in April, May, June, and July 2010 were once again greater than 15:1 indicating that phosphorus continues to be the limiting nutrient in Lake Macatawa. The primary conclusion of the data analysis to date continues to be that phosphorus levels are consistently unacceptable, and phosphorus concentrations are extremely variable on a monthly and annual basis.

The historic monthly average chlorophyll *a* concentrations are presented along with the results from monthly sampling at the 5 stations in 2010 in Figure 6. Chlorophyll *a* measurements provide an indication of the amount of algae present in the lake. Michigan lakes with chlorophyll *a* concentrations greater than 22 ug/l are generally considered to be hypereutrophic (Fuller and Minnerick, 2008). Monitoring during 2010 demonstrated once again that chlorophyll *a* levels were greater than 22 ug/l during every month except May. The highest monthly average recorded during 2010 was 236 ug/l in August, which was also the highest average value ever recorded in Lake Macatawa. The lowest monthly average was 10 ug/l in May after a storm when water temperatures were still relatively cool and not conducive for algal growth. The 2010 monthly averages for April, June, July, and September were within the range

of values that have been documented with previous monitoring efforts. Like the phosphorus data collected to date, the chlorophyll *a* concentrations are consistently high, normally 3 to 4 times greater than desirable, and variable on a monthly and annual basis.

The monthly average secchi depth readings for 2010, along with comparable historic data, are presented in Figure 7. Secchi depth readings provide a measurement of water clarity that is related to the chemical and physical properties of a lake. While water clarity is not a direct measurement of the chemical properties of lake water, it is an easy-to-understand indicator of a lake's water quality. Lakes in Michigan with secchi depth readings less than 3 feet are normally considered to be hypereutrophic (Fuller and Minnerick, 2008). Secchi depth monitoring on an annual basis in Lake Macatawa has shown that water clarity is normally less than 2 feet (Figure 8). The June 2002 and 2003 average secchi depth readings exceeded 2.5 feet and were the highest values recorded since comparable data collection began in 1982. This relatively high level of water clarity, at least for Lake Macatawa, corresponded with the relatively low total phosphorus levels that were recorded in June 2002 and 2003. The monthly 2010 average secchi depth readings ranged from 1.0 feet in April to 2.2 feet in June. The lowest secchi depth recorded in 2010 was during May in the east basin when secchi depth was only 0.5 feet. The largest secchi depth value recorded in 2010 was 3.0 feet in the west basin during June. It is well documented that Michigan lakes normally exhibit a strong correlation between total phosphorus, chlorophyll *a*, and water clarity. Consequently, it is not surprising that the water clarity data for Lake Macatawa demonstrates monthly and annual variability consistent with phosphorus and chlorophyll *a* results that are consistently less than desirable.

Water quality parameters in the west basin were once again generally better than those measured in the east basin. Secchi depth readings in the east basin ranged from 0.5 to 2.0 feet compared to a range of 0.75 to 3.0 feet in the west basin during the 2010 monitoring. Surface total suspended solids ranged from 10 milligrams per liter (mg/l) to 25 mg/l in the west basin and 21 mg/l to 77 mg/l in the east basin. Similar differences in the water quality of the basins were also noted once again in 2010 for ortho phosphorus, nitrite, ammonia, nitrate + nitrite, and Kjeldahl nitrogen with higher concentrations in the east basin during all months. However, chlorophyll *a* concentrations in 2010 were higher in the west basin, ranging from 14 to 330 ug/l, than the east basin, ranging from 5.6 to 210 ug/l, during all months except June and July. Visible surface blooms of algae were not present during any of the periods of sample collection despite the high chlorophyll *a* concentrations all year.

D.O. was depressed in 2010 to less than 5.0 mg/l near the lake bottom during June in the east basin, during July in all 3 basins, and during August in the west and central basins of Lake Macatawa. All other D.O. readings were above 5.0 mg/l. Thermal stratification of the water column was not apparent anywhere in the lake until July when the west basin was weakly thermally stratified. The thermal stratification of the west basin did not persist in August. Solid thermal stratification of the water column in the east and central basins did not develop during any month in 2010. The phosphorus concentration was elevated in the water sample collected near the bottom of the west basin when D.O. was depressed and the water column was weakly thermally stratified. Monitoring since 1995 has revealed that thermal stratification can and does occur in all 3 basins of Lake Macatawa on a periodic basis during the summer months. D.O. depletion near the lake bottom occurs sporadically, but the release of phosphorus from the sediments during anaerobic conditions does not appear to be a problem that occurs on a regular basis for an extended period of time.

A significant observation of the 2010 sampling events was the continued presence of rooted aquatic vegetation, primarily milfoil, in the west basin in 3 to 4 feet of water. The vegetation,

which became established during the summer of 2002, flourished during the summers of 2002 and 2003, and weed beds were present in a large portion of the shallow water throughout the west basin in both years. The growth of aquatic vegetation might be considered undesirable by boaters, but is typically an indication of improved lake quality due to increased water clarity. However, since water clarity has not improved in Lake Macatawa, the continued presence of aquatic vegetation is probably a product of lower lake levels. The lower lake levels have created large areas of water that are 3 to 5 feet deep allowing sunlight to reach the lake bottom and stimulate the growth of aquatic plants. These areas were previously 6 to 8 feet deep and beyond the extent of sunlight penetration. Water levels have remained relatively low since 2003 but the abundance of the aquatic vegetation has been lower during the summers of 2004 through 2010, as compared to 2003.

The results of the 2010 tributary sampling results for total phosphorus concentration and stream flow at the time of sampling, along with previous data collected during low flow conditions, is presented in Figures 9 through 14. Average daily flow at the USGS gage on the Macatawa River from spring through fall 2010 is presented in Figure 15. The extensive sample results from 1996/1997 showed a strong positive correlation between flow and total phosphorus concentrations. The 2010 samples were collected as scheduled and relatively low flow conditions were encountered during all of the sample events at all 6 sites. The April, May, and June samples were collected just after large storm events but stream flows were back to normal when the samples were collected. Rather surprisingly, the lowest phosphorus concentrations of the year at 4 of the 6 stations were recorded in April after a significant storm event. The lowest phosphorus concentrations of the year at Pine Creek and the Railroad Tributary were recorded in August after extended period of low flow conditions. The highest phosphorus concentrations of the year at the Railroad Tributary (51 ug/l), Maplewood Drain (84 ug/l), North Branch Macatawa River (121 ug/l), and the Macatawa River (360 ug/l) were recorded during a low flow period in July after a small storm event that occurred just prior to sample collection. The highest phosphorus concentrations at Bosch & Hulst Drain (95 ug/l) and Pine Creek (66 ug/l) were recorded in June following the largest storm event recorded during the sampling period. The phosphorus concentrations measured at all of the sites in 2010 were similar to concentrations that were measured during similar flow conditions in previous years. The results indicate that total phosphorus concentrations during various flow conditions throughout the watershed have not changed since sampling began in 1996/1997. The Macatawa River at the gage station and the sample site on Bosch & Holst Drain continue to have higher levels (normally greater than 100 ug/l) of total phosphorus during periods of low flow than the other sample sites in the watershed, while the site on Maplewood Drain typically has the lowest concentrations (less than 50 ug/l) during periods of low flow. The 2010 sampling results from throughout the watershed continue to demonstrate that when flows increase even minimally during storm events, total phosphorus concentrations increase substantially and phosphorus loading to Lake Macatawa increases dramatically.

In order to demonstrate the impact storm events have on the water quality of Lake Macatawa, an analysis of the water quality data collected at Lake Macatawa from 1997 to 2003 was regressed against peak and average daily stream flow of varying durations at the USGS gage on the Macatawa River (Walterhouse, 2005). The best statistically significant relationship was found between the average phosphorus concentration in Lake Macatawa and the average flow at the USGS gage, during the 10-day period prior to the sampling date. The analysis was updated with monitoring results from 1997 to 2006 and 2008 producing a similar correlation to what was obtained with the 1997-2003 monitoring data (Figure 16). The 2010 monitoring results are also included in Figure 16 demonstrating that phosphorus concentrations in Lake Macatawa are lower after extended periods of low stream flow prior to sampling. The

relationship between flow and phosphorus concentrations in Lake Macatawa demonstrates that the water quality of Lake Macatawa continues to be strongly influenced by NPS inputs during periods of higher flow (storm events). BMPs that are designed to reduce peak flows and improve water quality during storm events need to continue to be pursued aggressively throughout the watershed.

Fieldwork by: Sarah Holden, Dawn Roush, Jason Smith, and Mike Walterhouse
Surface Water Assessment Section
Water Resources Division

Steven Douglas, Intern
Macatawa Area Coordinating Council

Report by: Mike Walterhouse, Aquatic Biologist
Surface Water Assessment Section
Water Resources Division

REFERENCES

Creal, W. and M. Walterhouse. 1997. Biological and Chemical Assessment of Lake Macatawa and its Tributaries, Allegan and Ottawa Counties, Michigan, 1979-1983. MDEQ, Report No. MI/DEQ/SWQ-97/080.

Fuller, L.M., Minnerick, R.J., 2008. State and Regional Water-Quality Characteristics and Trophic Conditions of Michigan's Inland Lakes, 2001-2005: U.S. Geological Survey Scientific Investigations Report 2008-5188, 58p.

Higgins, S. and K. Kosky. 1999. Phosphorus Reduction Implementation Plan for the Macatawa Watershed, 1999-2009. September 16, 1999. MACC, Holland, Michigan.

Ketelle, M. and P. Uttormark. 1971. Problem Lakes in the United States, University of Wisconsin for USEPA, Project No. 06010EHR.

MACC. 2009. Macatawa Watershed Voluntary Agreement, 2009 Annual Report, October 1, 2008 – September 30, 2009.

MDEQ. 1994. Quality Assurance Manual for Water, Sediment, and Biological Sampling. Surface Water Quality Division. Report #MI/DEQ/SWQ-98/083.

USEPA, National Eutrophication Survey. 1975. Report on Lake Macatawa, Ottawa County, Michigan, USEPA Region V, Working Paper No. 200.

Walterhouse, M. 1998. Phosphorus Loading Assessment for Lake Macatawa, 1995 through 1997. MDEQ Report No. MI/DEQ/SWQ-98/015.

Walterhouse, M. 1999a. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 1998. MDEQ Report No. MI/DEQ/SWQ-99/084.

Walterhouse, M. 1999b. Total Maximum Daily Load for Phosphorus in Lake Macatawa, January 20, 1999. MDEQ Submittal to U.S. Environmental Protection Agency.

Walterhouse, M. 2000. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 1999. MDEQ Report No. MI/DEQ/SWQ-00/035.

Walterhouse, M. 2001. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2000. MDEQ Report No. MI/DEQ/SWQ-01/021.

Walterhouse, M. 2002. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2001. MDEQ Report No. MI/DEQ/SWQ-02/060.

Walterhouse, M. 2003. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2002. MDEQ Report No. MI/DEQ/WD-03/015.

Walterhouse, M. 2004. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2003. MDEQ Report No. MI/DEQ/WD-04/022.

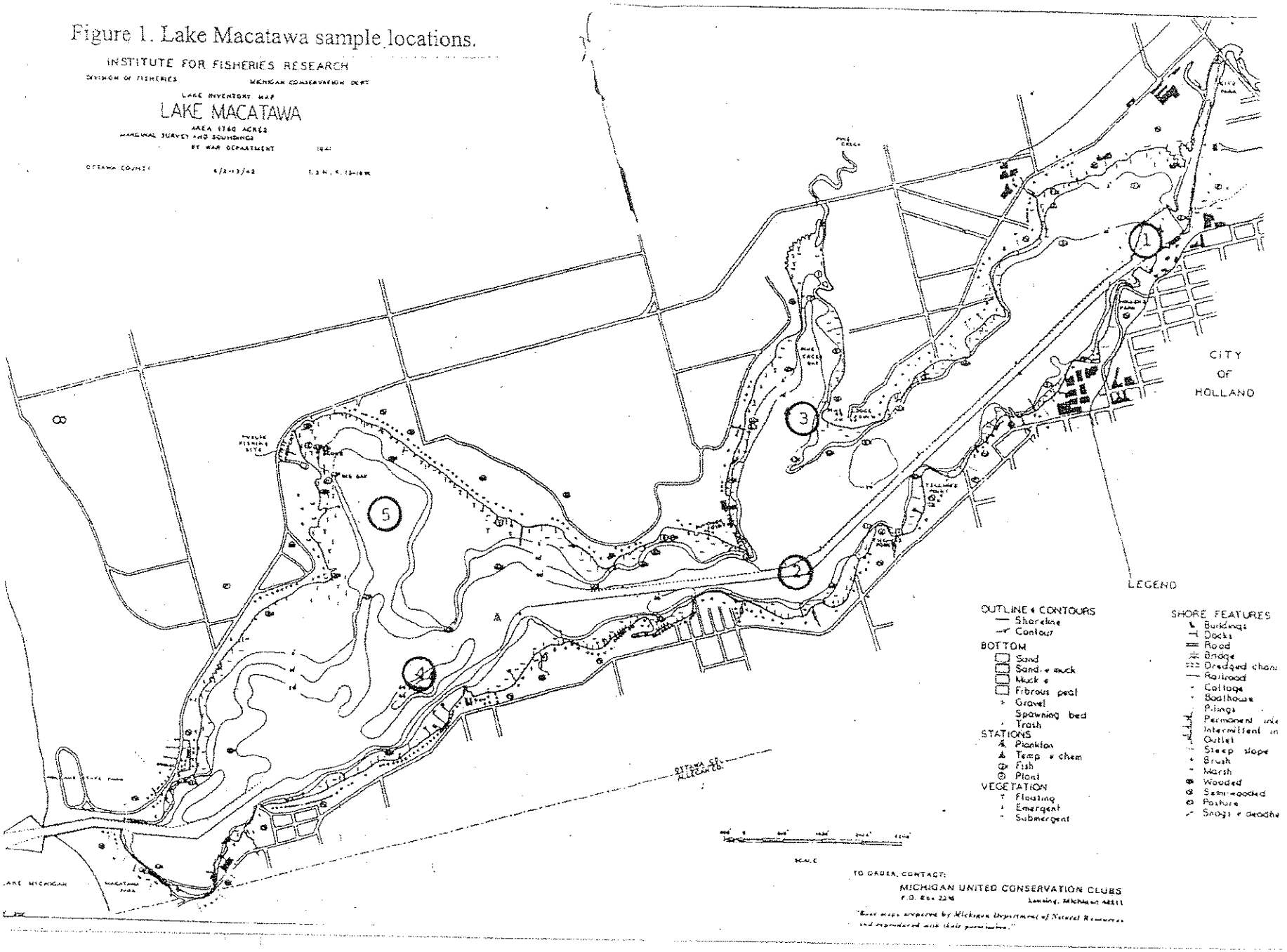
Walterhouse, M. 2005. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2004. MDEQ Report No. MI/DEQ/WB-05/039.

Walterhouse, M. 2006. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2005. MDEQ Report No. MI/DEQ/WB-060/070.

Walterhouse, M. 2007. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2006. MDEQ Report No. MI/DEQ/WB-07/066.

Walterhouse, M. 2009. Monthly Water Quality Assessment of Lake Macatawa and Its Tributaries, 2008. MDEQ Report No. MI/DEQ/WB-09/076.

Figure 1. Lake Macatawa sample locations.



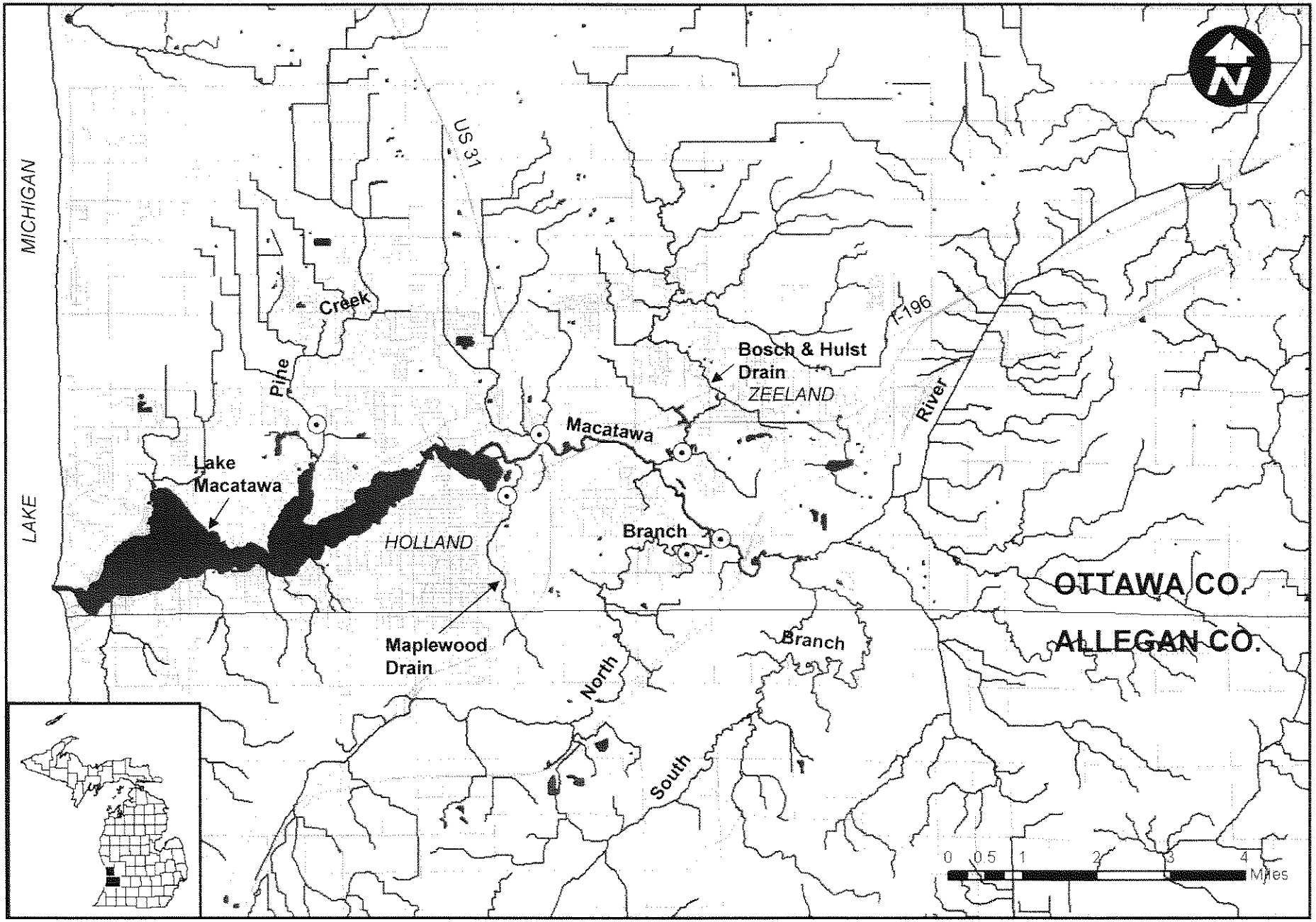


Figure 2: Tributary sampling locations in the Macatawa River Watershed, Allegan and Ottawa Counties, 2010.

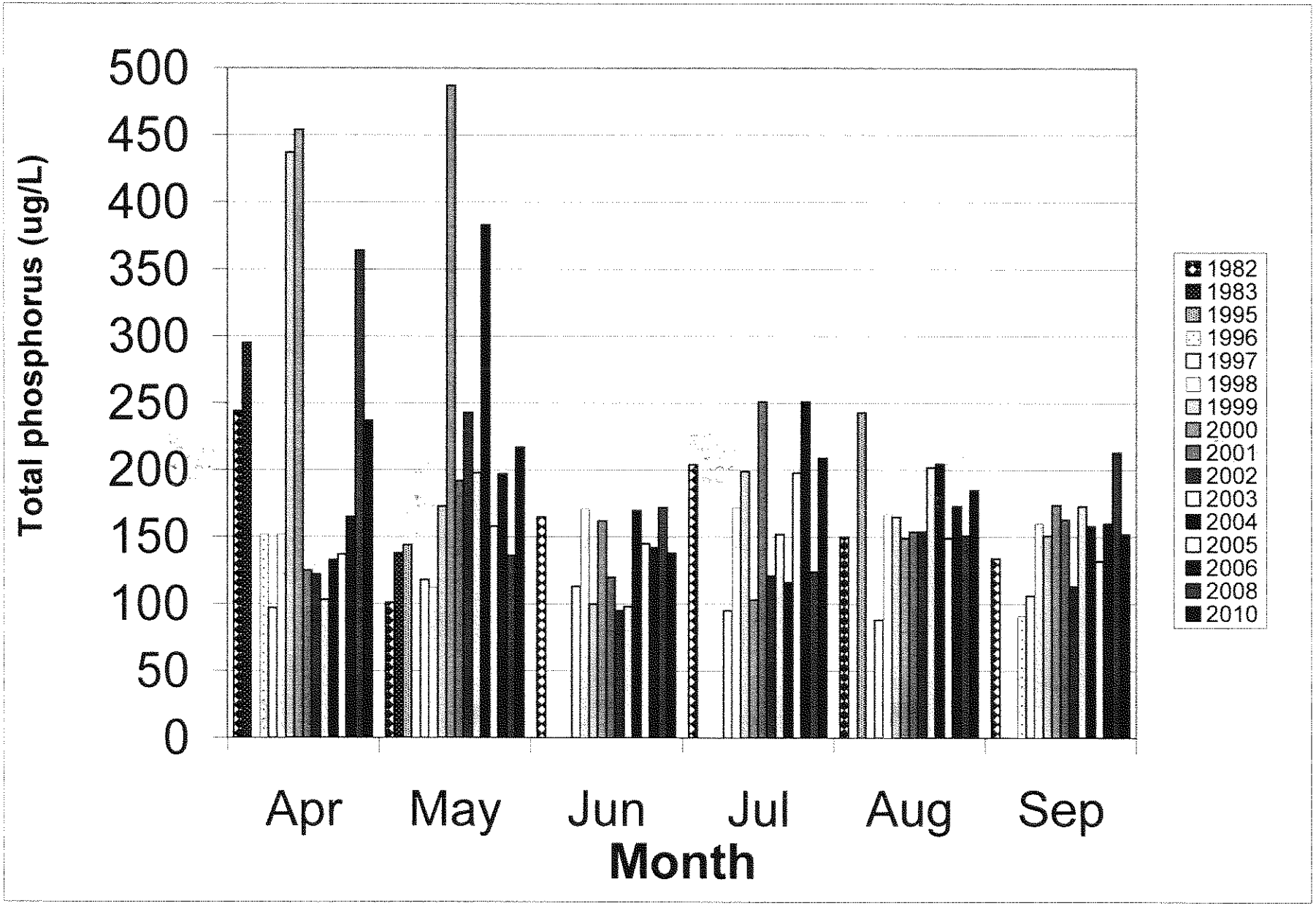


Figure 3. Historic monthly average phosphorus concentrations by month in Lake Macatawa at stations 1, 2, and 4, Ottawa County, Michigan,

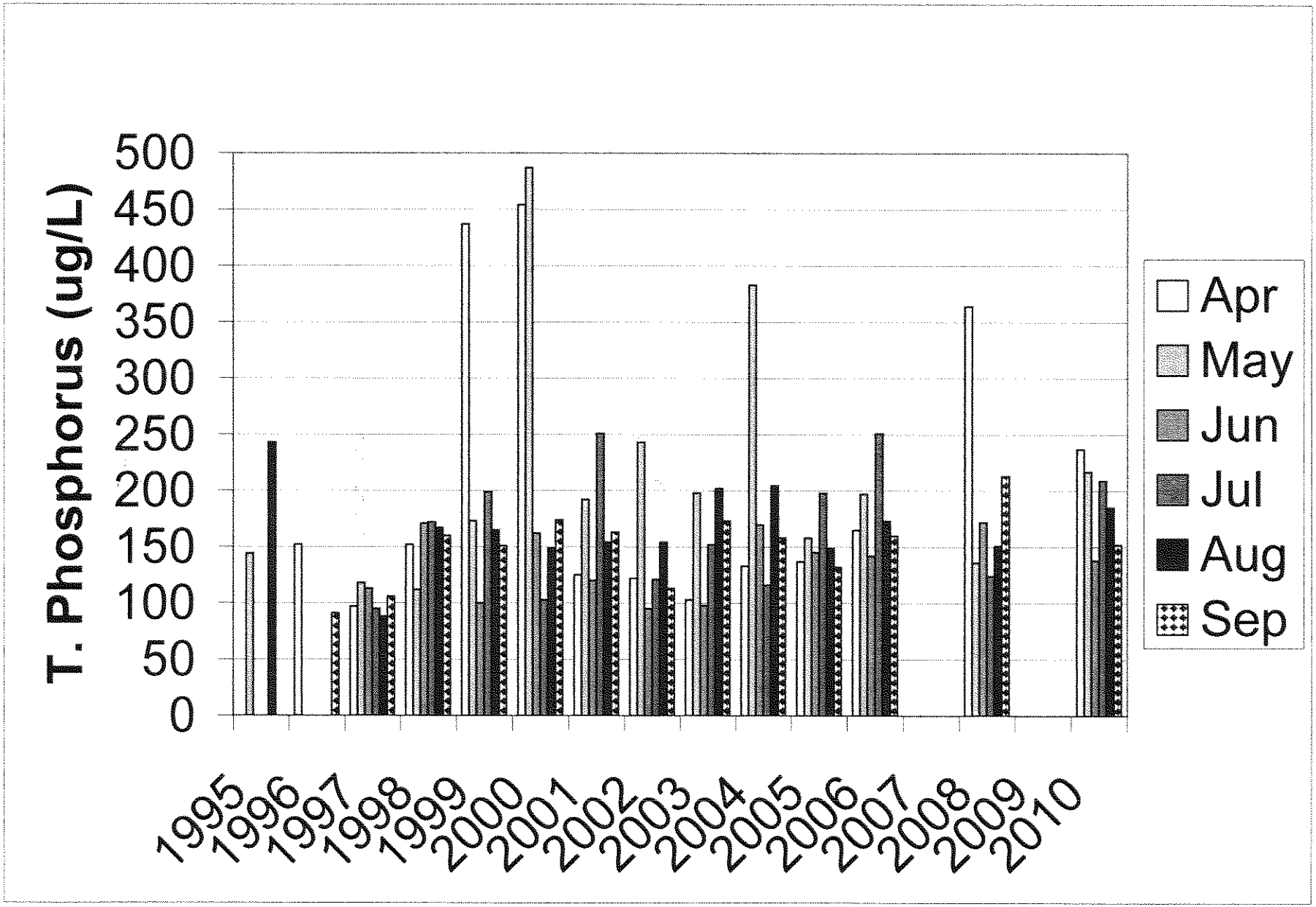


Figure 4. Monthly average total phosphorus concentrations by year in Lake Macatawa, stations 1, 2, and 4, Ottawa County, Michigan.

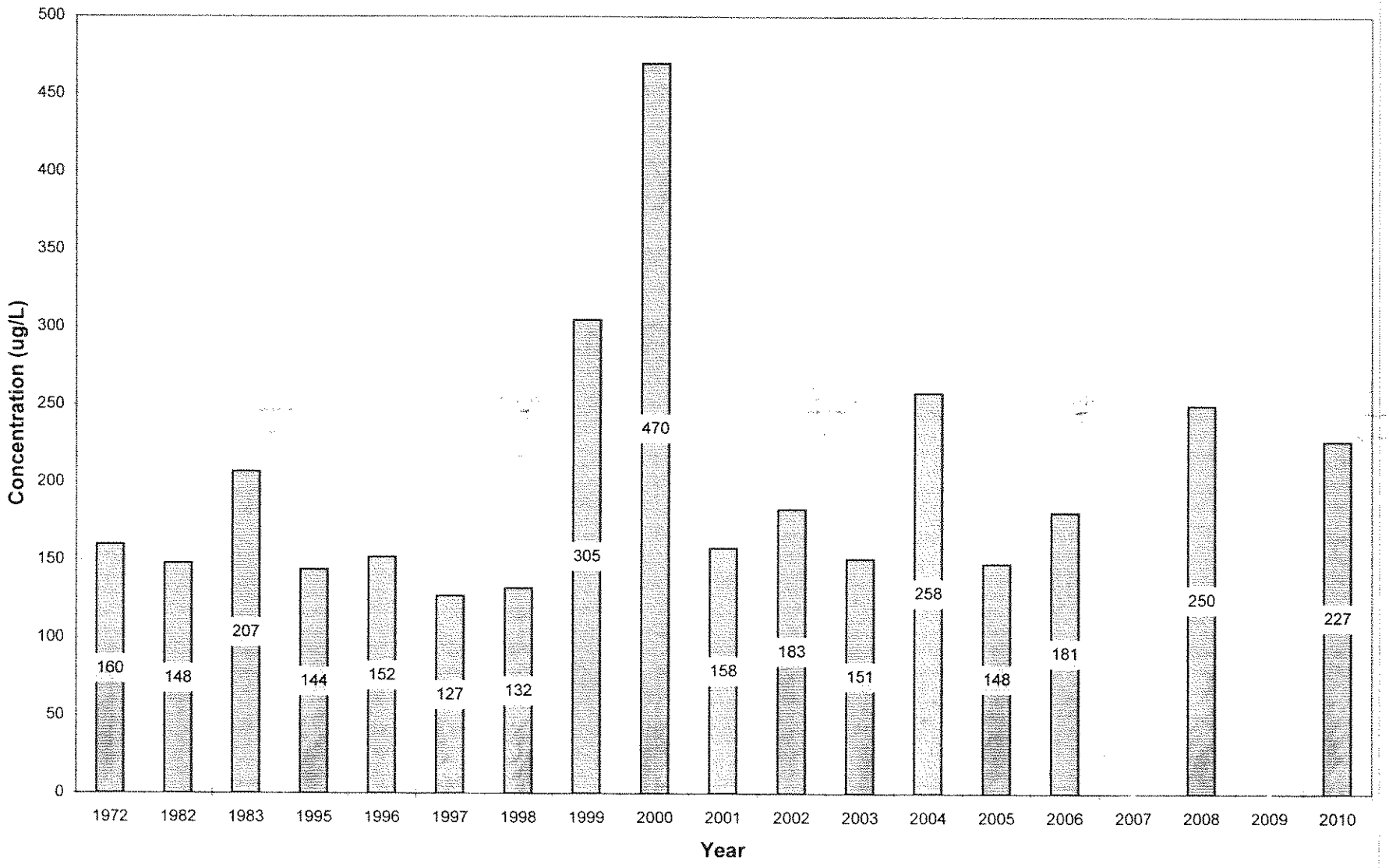


Figure 5. Average historic spring phosphorus concentrations at stations 1, 2, and 4 in Lake Macatawa, Ottawa County, Michigan.

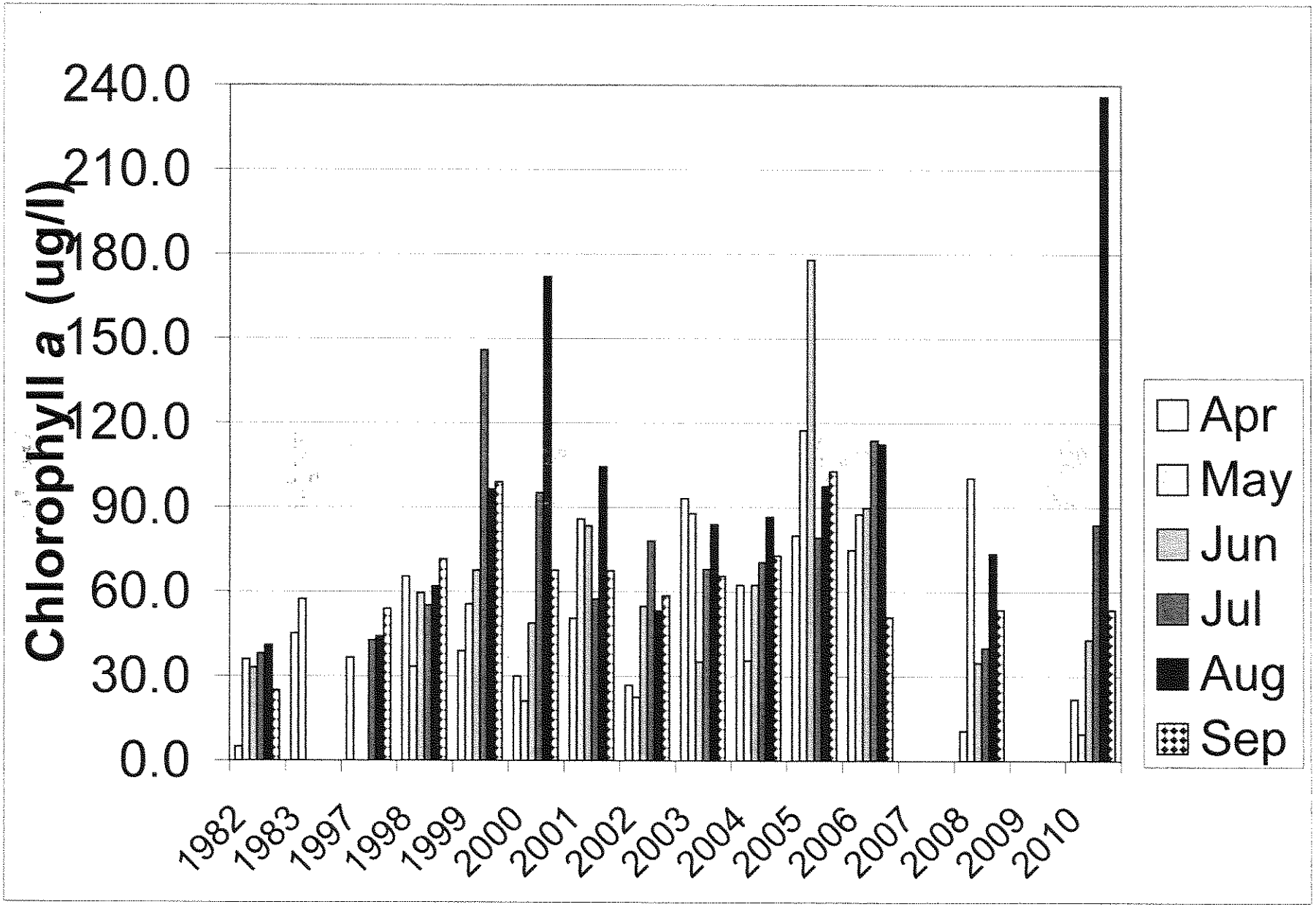


Figure 6. Historic monthly average chlorophyll *a* concentrations at stations 1-5 in Lake Macatawa, Ottawa County, Michigan.

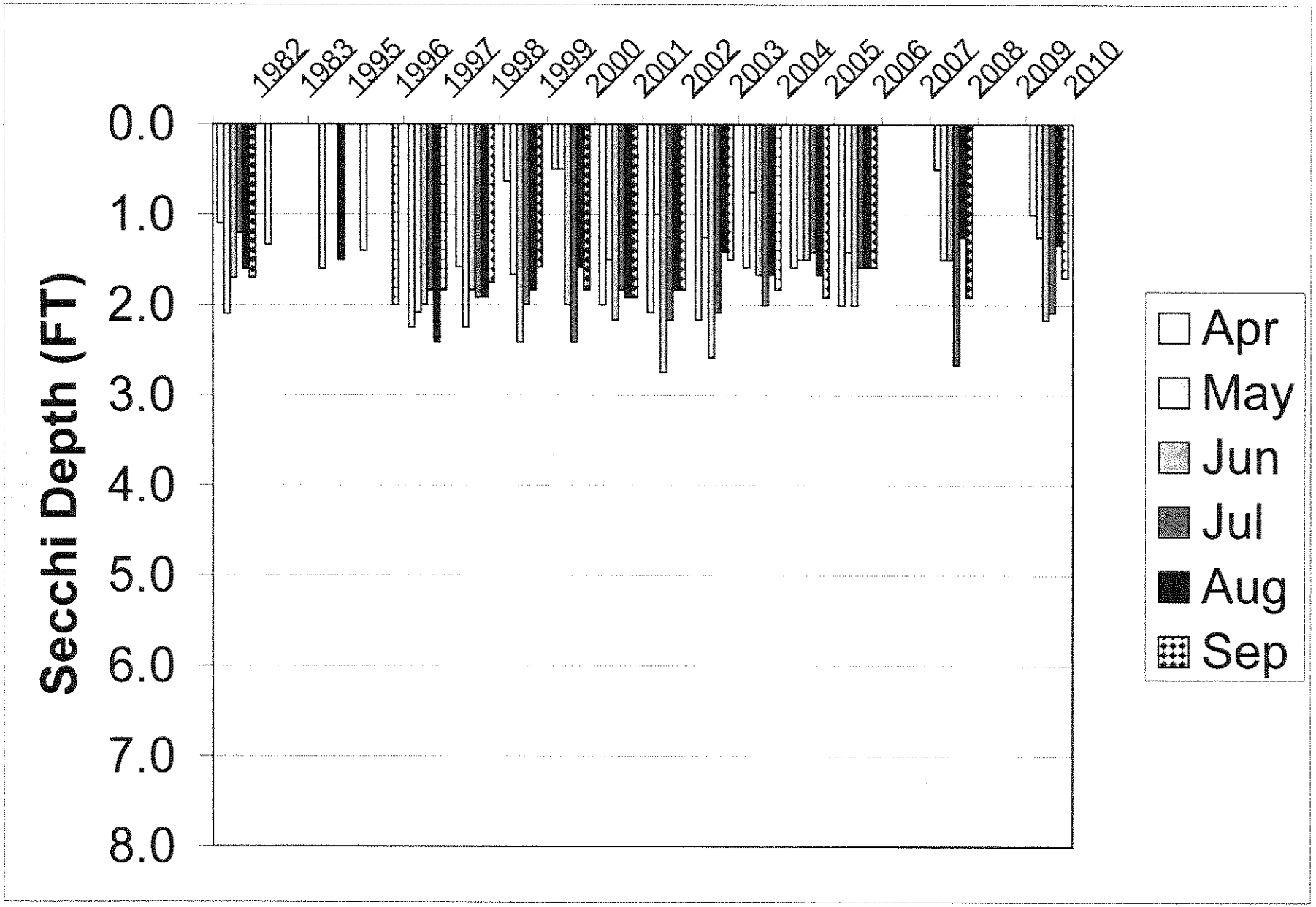


Figure 7. Monthly average secchi depths in Lake Macatawa at stations 1, 2, and 4, Ottawa County, Michigan.

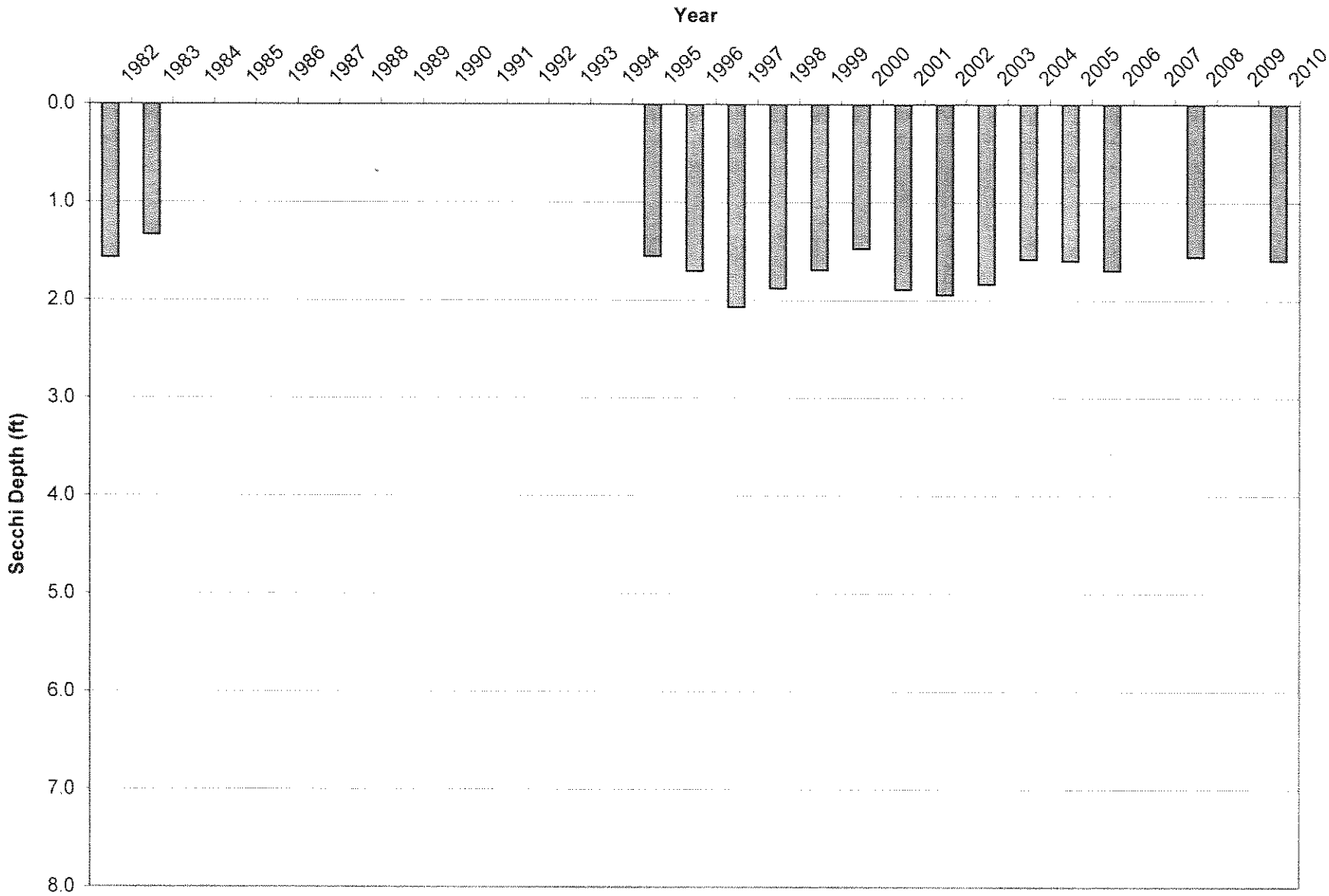


Figure 8. Annual Average secchi depth from April through September at stations 1, 2, and 4 in Lake Macatawa, Ottawa County, Michigan.

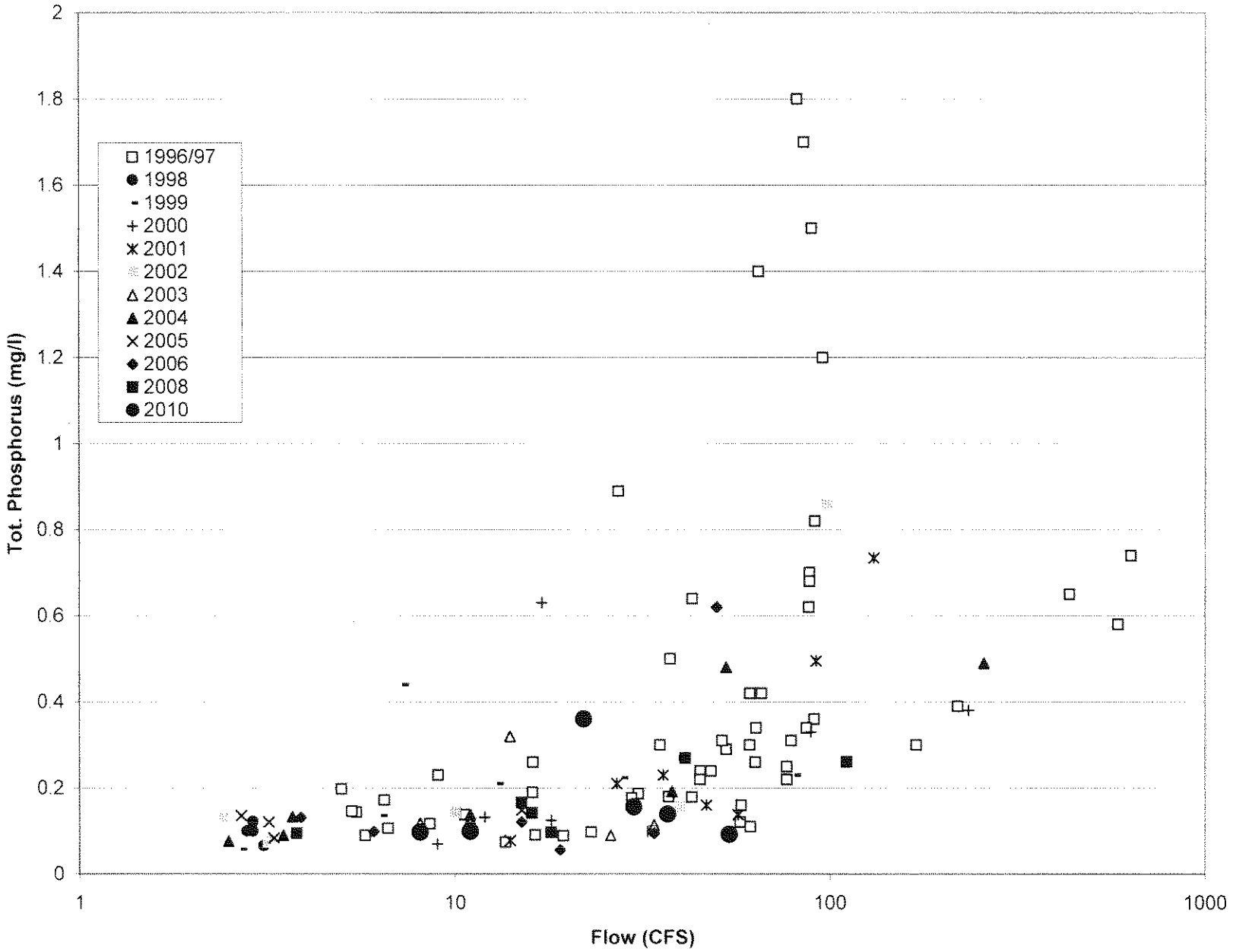


Figure 9. Phosphorus sampling results in relation to flow at the USGS Gage on the Macatawa River.

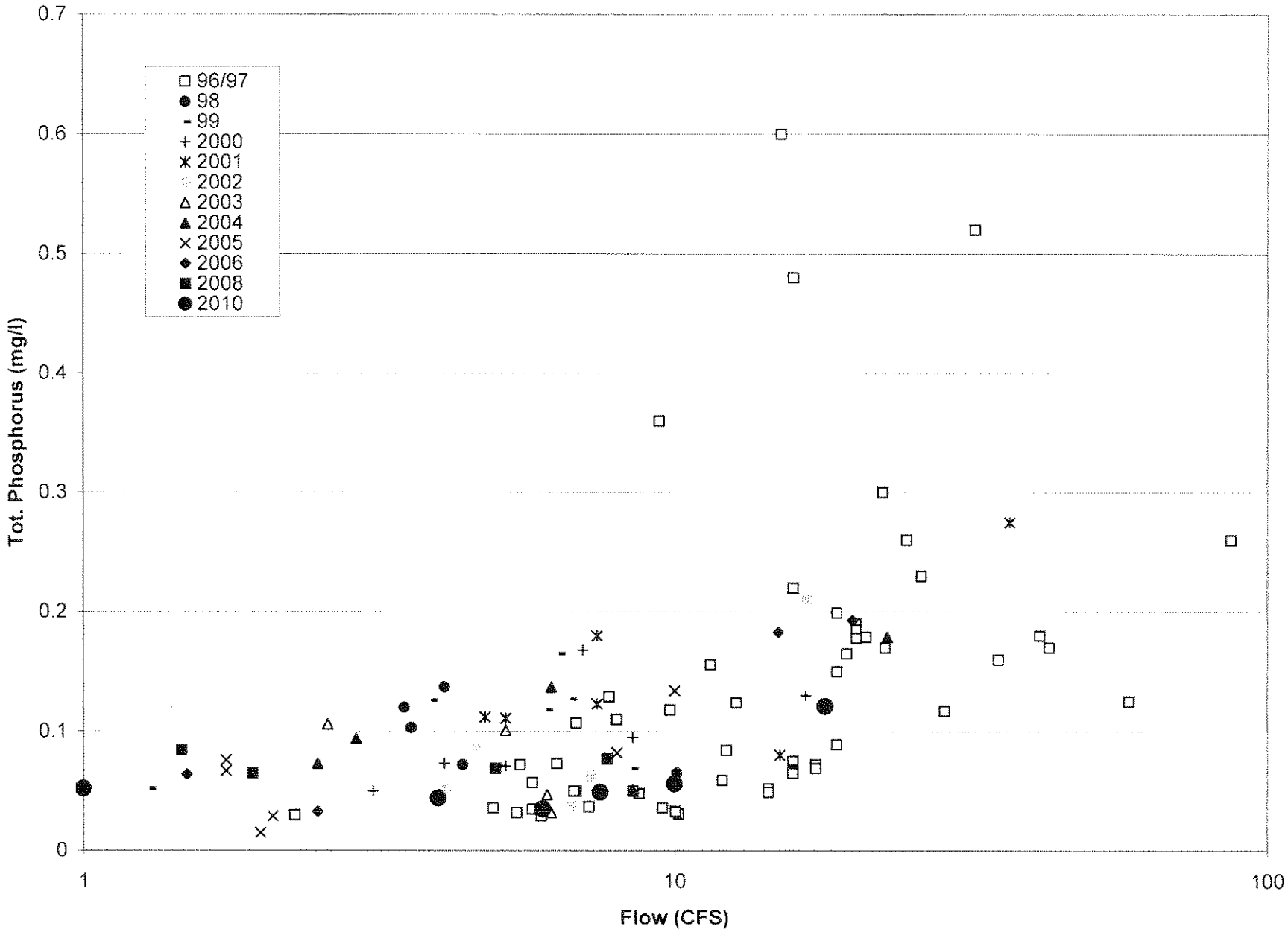


Figure 10. Phosphorus sampling results in relation to flow at the North Branch Macatawa River.

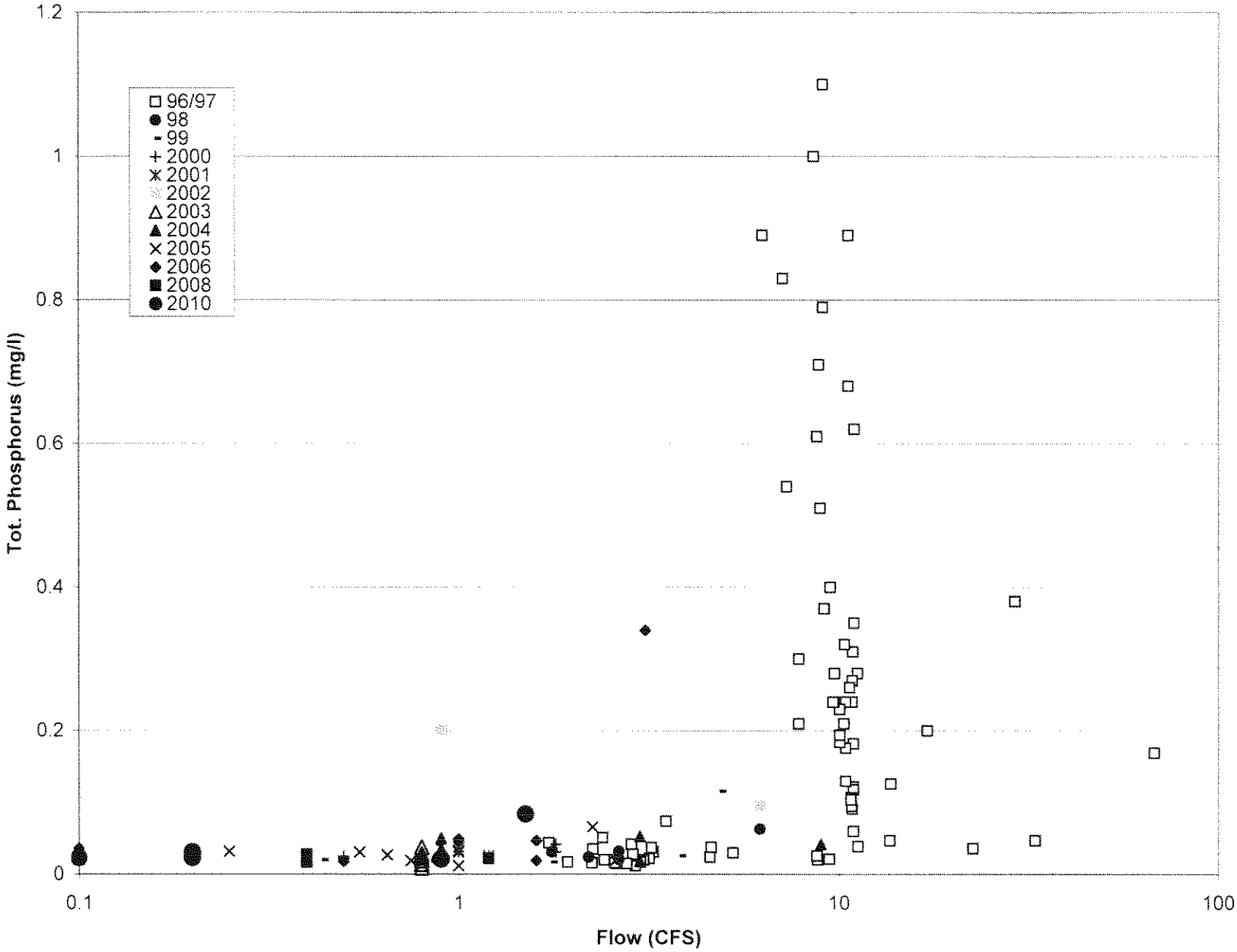


Figure 11. Phosphorus sampling results in relation to flow at Maplewood Drain.

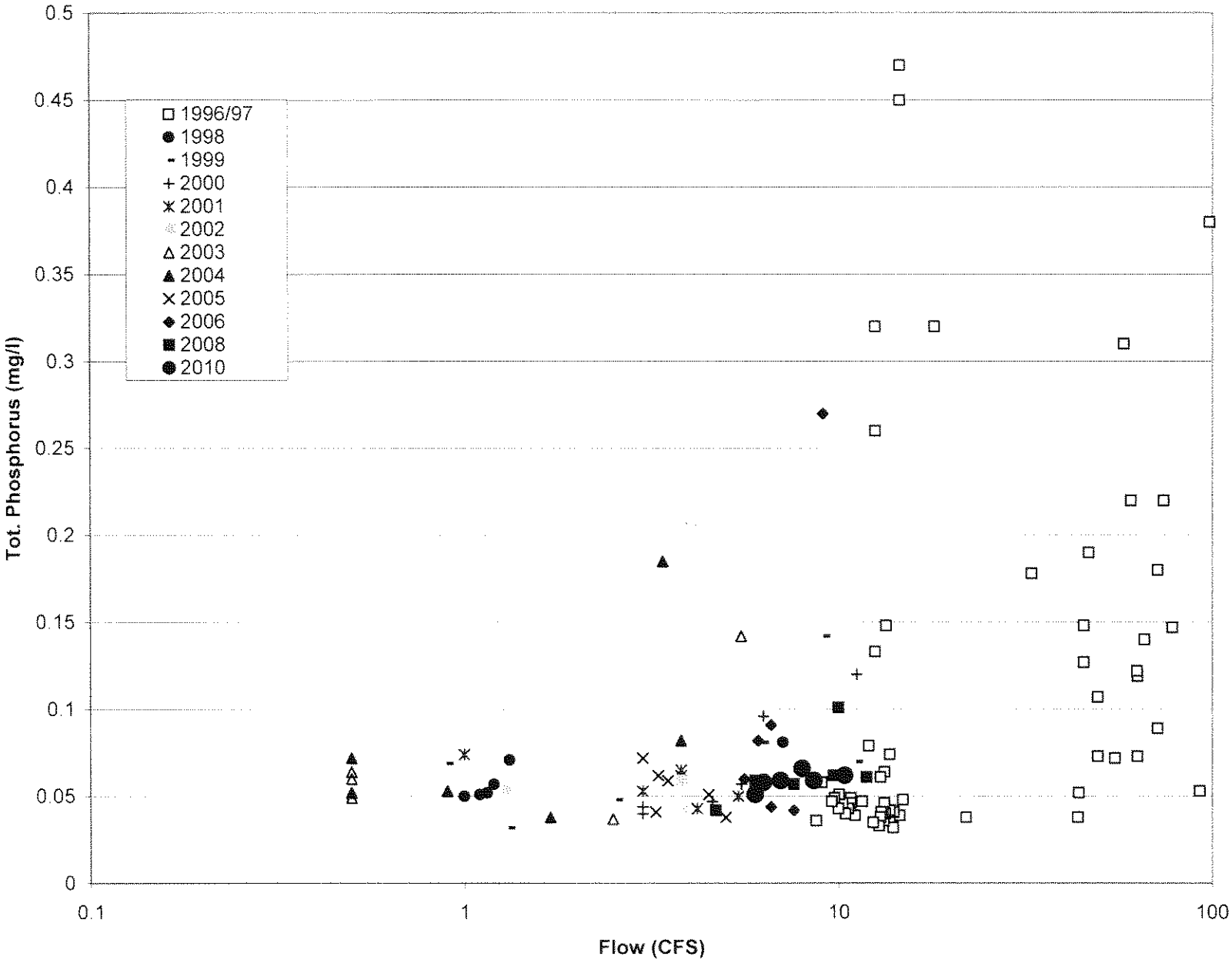


Figure 12. Phosphorus sampling results in relation to flow at Pine Creek.

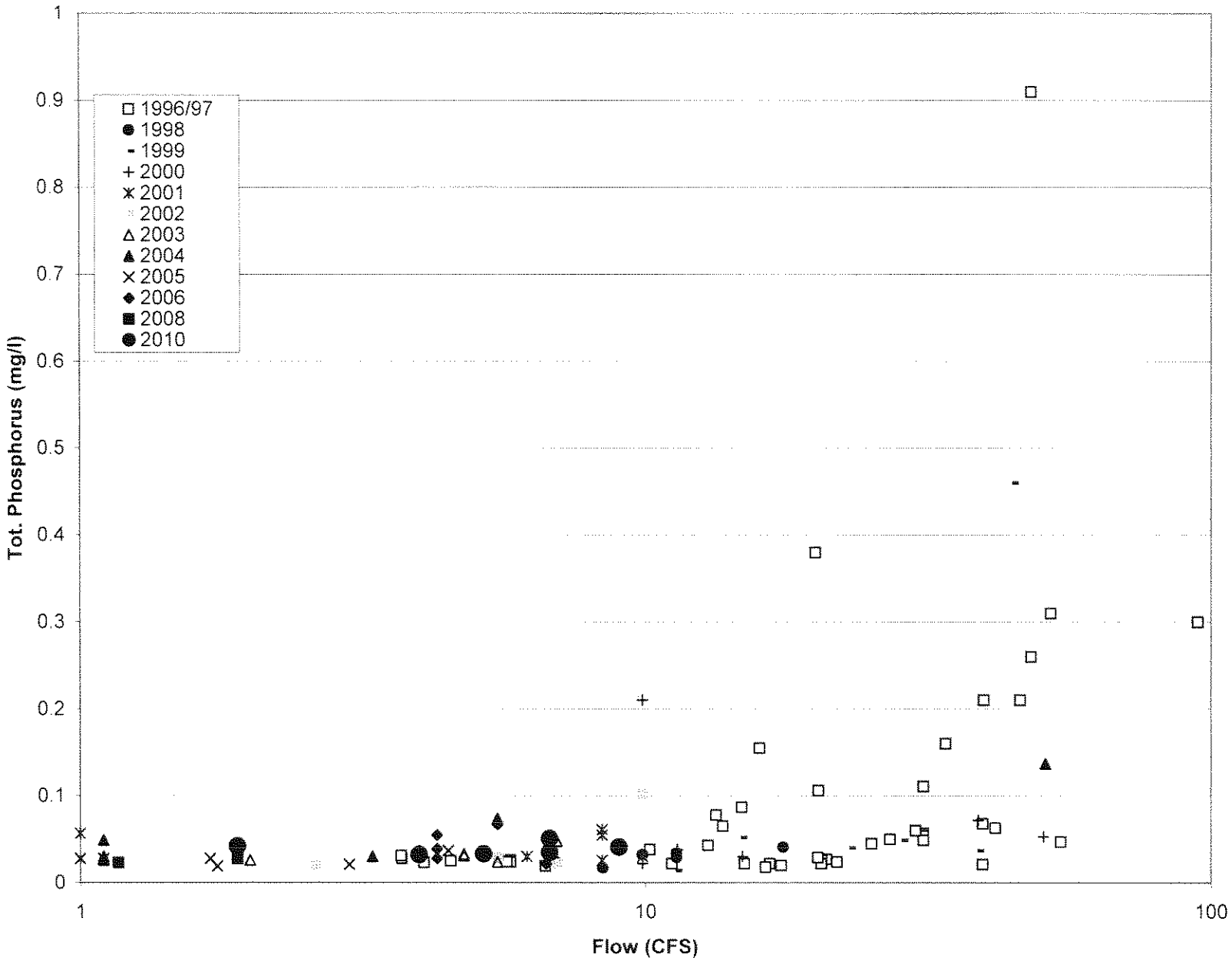


Figure 13. Phosphorus sampling results in relation to flow at the Railroad Tributary.

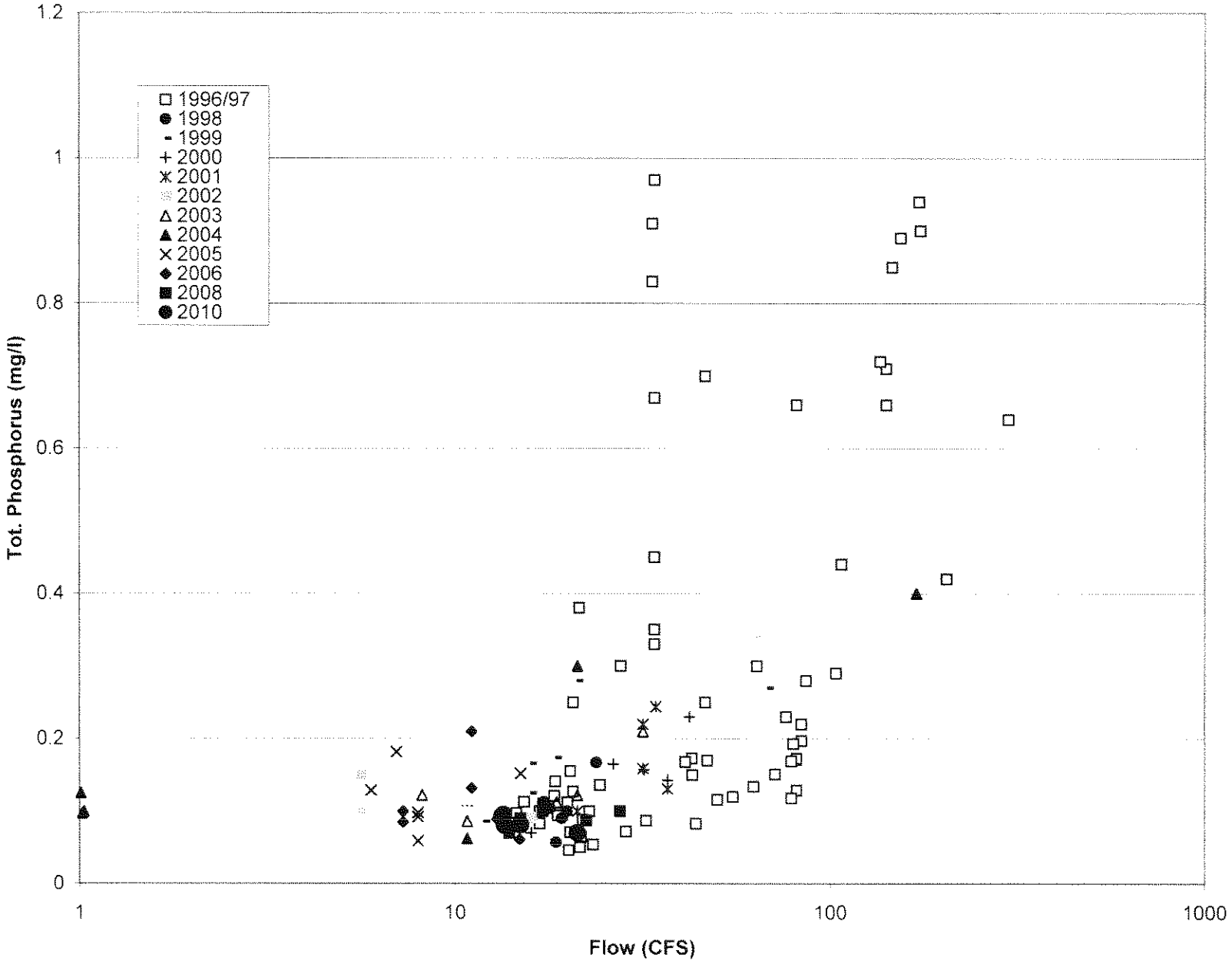


Figure 14. Phosphorus sampling results in relation to flow at Bosch Hulst Drain.

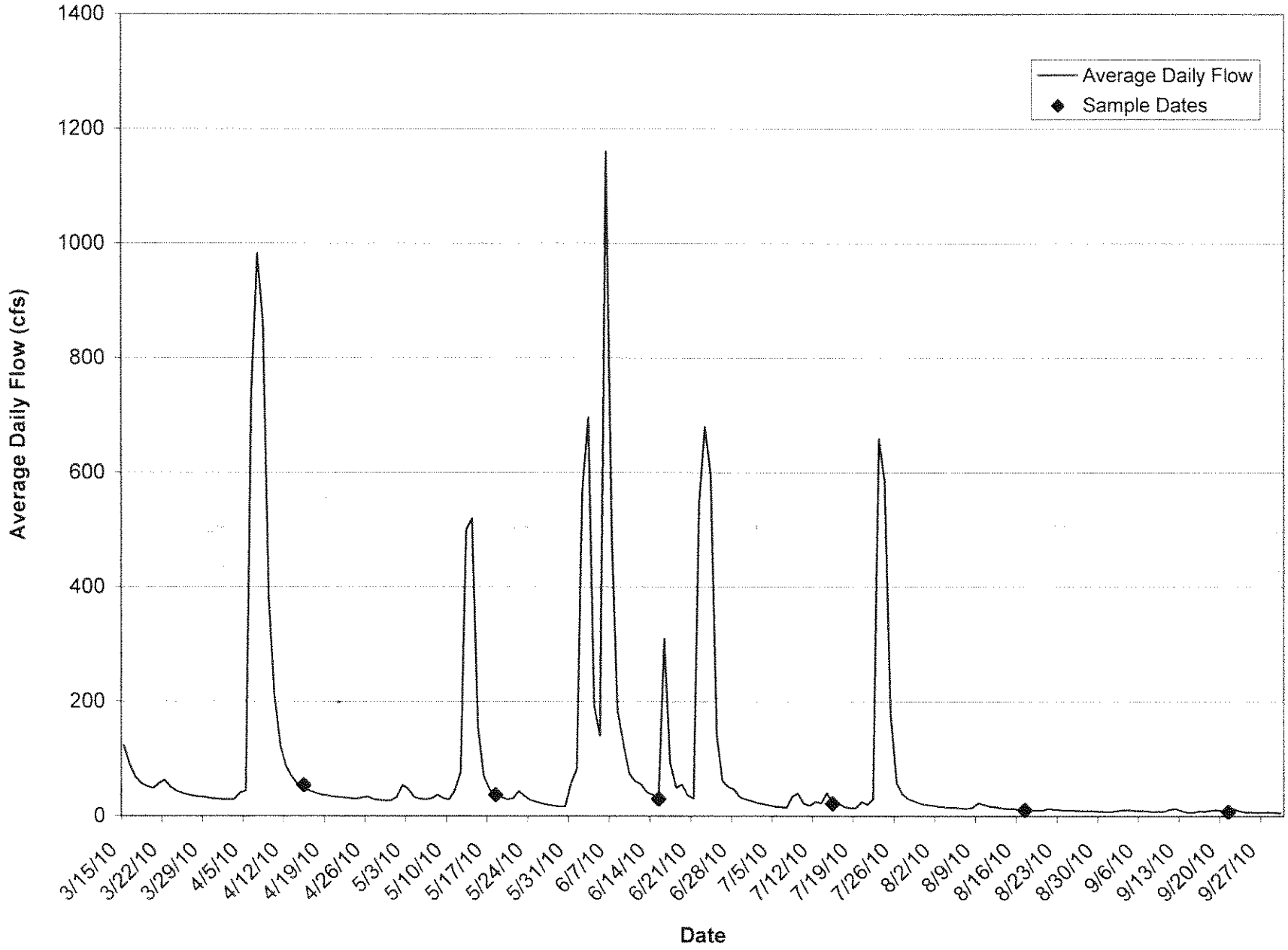


Figure 15. Average daily flow at the USGS Gage on the Macatawa River, Ottawa County, Michigan, March 15-September 30, 2010.

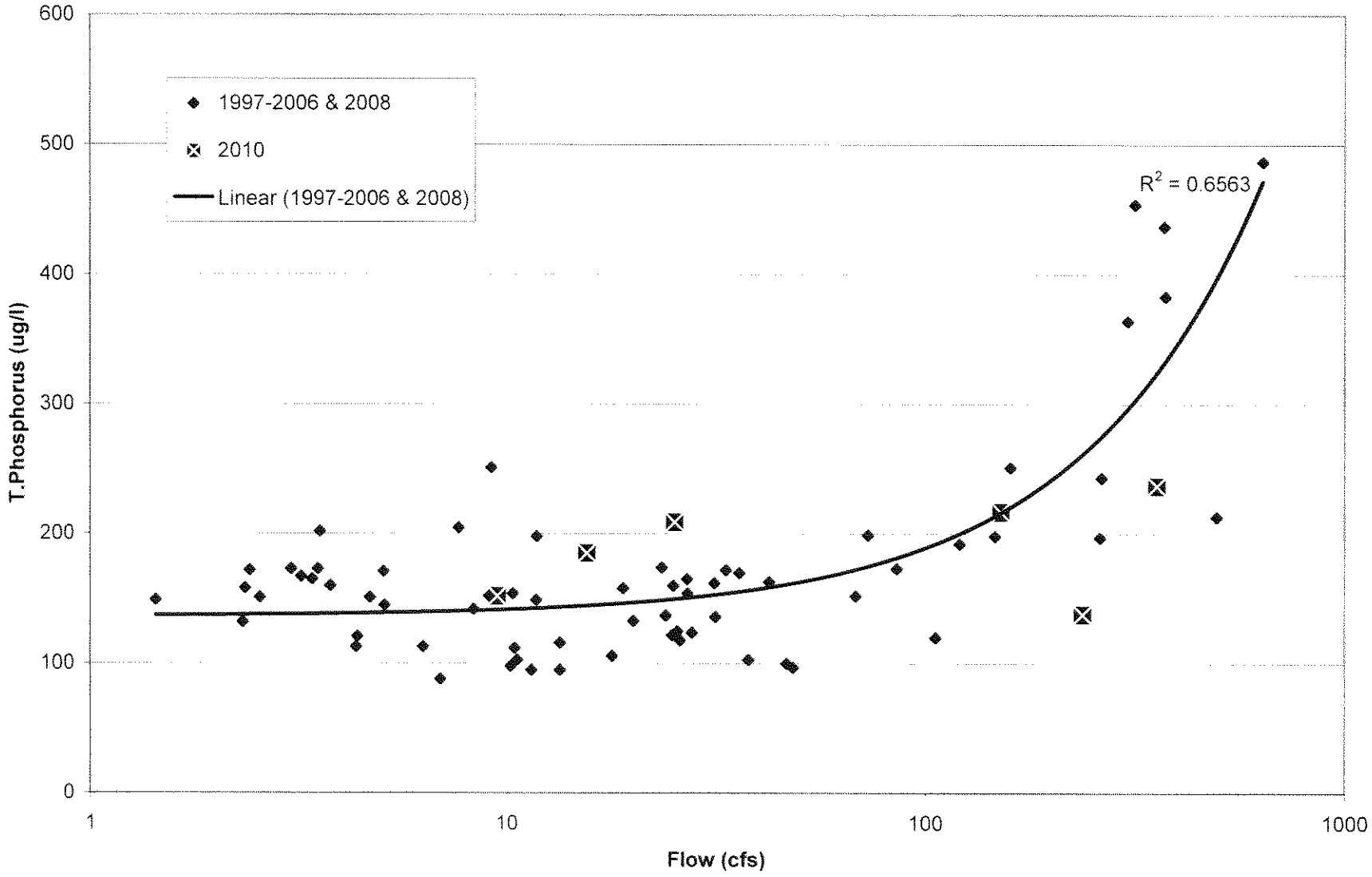


Figure 16. Regression of the average phosphorus concentrations in Lake Macatawa from April to September versus average flow of the Macatawa River during the 10 day period prior to sampling, 1997-2006 and 2008.

Table 1. Water Quality Sampling Results, Lake Macatawa and Major Tributaries, Allegan and Ottawa Counties, April 15, 2010.

STATION	DEPTH (ft)	TEMP. (F)	D. O. (mg/l)	COND. (umho/cm)	pH	CHLORO A. (ug/l)	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Lake Macatawa-West Basin (1)													
Storet # 700237	Sur.	53.8	10.7	408	8.1	48	1.75	1.37	0.58	0.058	0.044	18	0.167
Station #4- 10:30 am	5	53.7	10.6	407	8.0								
Depth (ft): 33	10	53.7	10.5	408	8.0								
Secchi Depth (ft): 1.5	15	53.7	10.4	407	8.0		1.76	1.34	0.60	0.058	0.044	17	0.168
Color: brown	20	53.7	10.4	408	8.0								
	25	53.7	10.3	408	8.0								
	30	52.6	9.6	410	7.9		1.73	1.32	0.67	0.056	0.048	25	0.173
Lake Macatawa-West Basin (2)													
Storet # 700573	Sur.	55.2	10.8	407	8.2	No Sample	1.85	1.38	0.55	0.058	0.038	25	0.177
Station #5- 10:40 am	5	55.3	10.8	407	8.2								
Depth (ft): 14	10	55.3	10.8	407	8.2								
Secchi Depth (ft): 0.75	13	55.2	10.8	406	8.1		1.76	1.38	0.55	0.058	0.038	28	0.177
Color: brown													
Lake Macatawa-Central Basin													
Storet # 700574	Sur.	53.8	8.0	393	7.6	8.6	2.00	1.73	0.85	0.084	0.111	27	0.259
Station #2- 10:20 am	5	53.8	8.0	392	7.6								
Depth (ft): 25.0	10	53.8	8.0	393	7.6		1.99	1.74	0.86	0.085	0.113	21	0.271
Secchi Depth (ft): 0.75	15	53.7	7.8	393	7.6								
Color: brown	20	53.4	7.5	395	7.6								
	22	53.2	7.0	426	7.5		2.02	1.72	0.86	0.084	0.109	22	0.260
Lake Macatawa-Pine Creek Bay													
Storet # 700384	Sur.	57.0	9.3	400	7.9	17	1.93	1.62	0.70	0.075	0.10	24.000	0.261
Station #3- 10:10 am	5	56.9	8.8	400	7.8								
Depth (ft): 10.0	10	56.3	7.8	401	7.7		1.93	1.60	0.69	0.074	0.10	26.000	0.257
Secchi Depth (ft): 0.75													
Color: brown													
Lake Macatawa-East Basin													
Storet # 700238	Sur.	57.4	8.2	432		14	2.29	1.98	1.0	0.122	0.105	34	0.272
Station #1- 10:55 am	5	57.3	8.1	432									
Depth (ft): 24.0	10	57.0	8.1	435									
Secchi Depth (ft): 0.75	15	56.7	8.0	440			2.30	1.93	1.0	0.116	0.103	35	0.282
Color: brown	20	53.4	8.0	460									
	23	53.0	7.2	531			1.90	2.100	0.74	0.076	0.09	45	0.285

Stream	**Time**	**Stage**	**Flow(cfs)**	**Visual Observations**	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Pine Creek	12:30 pm	6.25	10.4	Clear-baseflow	0.60	0.62	0.04	0.015	0.020	6	0.062
Railroad Tr. D/S of Confluence	1:15 pm	12.70	9.0	Clear-baseflow	0.66	0.32	0.023	0.010	0.010	7	0.041
Maplewood Drain	9:30 am	12.00	0.9	Clear-baseflow	0.45	1.24	0.02	0.010	0.005	5	0.021
Bosch and Hulst Drain	1:25 pm	13.35	21.3	Slightly turbid-baseflow	0.96	2.8	0.08 D	0.046	0.014	4	0.070
N. Br. Macatawa River	1:45 pm	estimated flow	6	Clear-baseflow	0.78	0.21	0.014	0.007	0.007	5	0.035
Macatawa River @ USGS Gage	1:30 pm		54	Slightly turbid(2 ft secchi)	1.12	4.9	0.13 D	0.052	0.040	12	0.092

D - Analyte value quantified from a dilution(s); reporting limit (RL) raised, MDEQ-Environmental Laboratory

Table 2. Water Quality Sampling Results, Lake Macatawa and Major Tributaries, Allegan and Ottawa Counties, May 18, 2010.

STATION	DEPTH (ft)	TEMP. (F)	D. O. (mg/l)	COND. (umho/cm)	pH	CHLORO A. (ug/l)	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Lake Macatawa-West Basin (1)													
Storet # 700237	Sur.	55.8	9.8	438	7.5	14	1.25	1.06	0.33	0.060	0.024	22	0.102
Station #4- 10:00 am	5	55.8	9.5	438	7.6								
Depth (ft): 31	10	55.8	9.4	438	7.6								
Secchi Depth (ft): 2.0	15	55.7	9.4	438	7.7		1.22	1.09	0.31	0.060	0.023	23	0.105
Color: brownish	20	55.8	9.4	438	7.7								
	25	55.7	9.4	438	7.3								
	30	55.7	9.4	438	7.3		1.39	0.99	0.34	0.059	0.024	23	0.087
Lake Macatawa-West Basin (2)													
Storet # 700573	Sur.	55.8	9.7	447	7.9	15	1.27	1.11	0.37	0.064	0.025	16	0.087
Station #5- 10:30 am	5	55.9	9.4	447	7.9								
Depth (ft): 18	10	55.9	9.3	447	7.9								
Secchi Depth (ft): 2.0	15	55.7	9.2	447	7.9								
Color: brownish	17	55.5	4.5	466	7.5		1.32	1.06	0.40	0.063	0.027	30	0.125
Lake Macatawa-Central Basin													
Storet # 700574	Sur.	56.8	8.9	472	7.7	6.7	2.0	2.6	0.75	0.098	0.079	38	0.21
Station #2- 11:00 am	5	56.9	8.0	471	7.6								
Depth (ft): 26.0	10	56.9	7.9	472	7.6								
Secchi Depth (ft): 1.25	15	56.9	7.9	471	7.6		1.88	2.5	0.77	0.099	0.078	33	0.21
Color: brownish	20	56.9	7.9	471	7.6								
	25	55.8	7.2	472	7.5		1.95	2.5	0.77	0.098	0.076	36	0.21
Lake Macatawa-Pine Creek Bay													
Storet # 700384	Sur.	57.1	8.0	471	7.7	6.5	1.96	2.8	0.76	0.097	0.086	32	0.22
Station #3- 11:30 am	5	57.1	7.6	471	7.6								
Depth (ft): 10.0	9	57.0	7.0	471	7.6		1.95	2.8	0.77	0.098	0.096	37	0.23
Secchi Depth (ft): 1.0													
Color: brownish													
Lake Macatawa-East Basin													
Storet # 700238	Sur.	57.5	9.1	469	7.7	5.6	2.6	4.0	1.1	0.124	0.113	77	0.33
Station #1- 11:55 am	5	57.7	7.6	467	7.5								
Depth (ft): 22.0	10	57.2	7.1	464	7.4		2.7	4.0	1.1	0.125	0.110	79	0.34
Secchi Depth (ft): 0.5	15	57.1	6.9	462	7.4								
Color: brownish	20	57.0	6.5	457	7.4		2.6	4.1	1.1	0.122	0.102	97	0.36

	Time	**Stage**	**Flow(cfs)**	**Visual Observations**	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Pine Creek	12:30 pm	6.6	8.6	Clear-baseflow	0.62	0.66	0.057	0.018	0.020	6	0.059
Railroad Tr. D/S of Confluence	1:05 pm	12.9	6.8	Clear-baseflow	0.69	0.34	0.079	0.020	0.010	6	0.035
Maplewood Drain	9:30 am	12.3	0.2	Clear-baseflow	0.47	1.2	0.034	0.013	0.005	4	0.023
Bosch and Hulst Drain	11:15 pm	13.6	15.0	Slightly turbid(2 ft secchi)-baseflow	0.82	3.7	0.07 D	0.041	0.037	11	0.080
N. Br. Macatawa River	1:30 pm	esimated flow	7.5	Slightly turbid-baseflow	0.75	1.12	0.028	0.022	0.016	ND @ 4	0.049
Macatawa River @ USGS Gage	1:20 pm		37	Slightly turbid(2 ft secchi)-baseflow	1.26	7	0.20 D	0.090	0.058	27	0.139

D - Analyte value quantified from a dilution(s); reporting limit (RL) raised, MDEQ-Environmental Laboratory

ND - Non detectable, MDEQ-Environmental Laboratory.

Table 3. Water Quality Sampling Results, Lake Macatawa and Major Tributaries, Allegan and Ottawa Counties, June 15, 2010.

STATION	DEPTH (ft)	TEMP. (F)	D. O. (mg/l)	COND. (umho/cm)	pH	CHLORO A. (ug/l)	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Lake Macatawa-West Basin (1)													
Storet # 700237	Sur.	68.9	9.8	399	8.0	36	1.16	2.3	0.060	0.075	0.007	15	0.089
Station #4- 11:05 am	5	68.9	10.0	400	8.0								
Depth (ft): 31	10	68.4	9.1	402	7.7								
Secchi Depth (ft): 3.0	15	67.7	8.2	397	7.6		1.27	2.2	0.149	0.076	0.011	15	0.101
Color: brownish	20	67.1	8.8	378	7.9								
	25	66.8	9.3	380	7.8								
	30	65.3	7.6	379	7.3		1.23	1.79	0.22	0.067	0.017	25	0.106
Lake Macatawa-West Basin (2)													
Storet # 700573	Sur.	69.4	9.2	413	8.1	39	1.34	2.2	0.147	0.082	0.009	19	0.095
Station #5- 11:45 am	5	69.3	8.8	414	8.0								
Depth (ft): 15	10	68.5	8.2	415	7.7								
Secchi Depth (ft): 2.5	14	67.4	6.3	414	7.4		1.53	1.77	0.41	0.081	0.018	21	0.118
Color: brownish													
Lake Macatawa-Central Basin													
Storet # 700574	Sur.	71.8	8.3	464	7.7	37	2.10	3.4	0.56	0.148	0.033	18	0.144
Station #2- 12:05 pm	5	71.7	7.6	466	7.6								
Depth (ft): 25.0	10	70.4	7.4	445	7.7		1.90	3.0	0.52	0.127	0.029	21	0.126
Secchi Depth (ft): 2.0	15	67.8	6.9	411	7.7								
Color: brownish	20	66.5	6.5	384	7.6								
	24	66.1	5.1	380	7.6		1.22	1.59	0.31	0.064	0.031	42	0.146
Lake Macatawa-Pine Creek Bay													
Storet # 700384	Sur.	72.1	9.2	443	8.3	62	1.64	3.0	0.11 D	0.117	0.012	17	0.111
Station #3- 12:20 pm	5	71.6	10.3	445	8.1								
Depth (ft): 10.0	9	68.1	9.1	478	7.7		1.53	2.7	0.21	0.107	0.015	23	0.109
Secchi Depth (ft): 2.25													
Color: brownish													
Lake Macatawa-East Basin													
Storet # 700238	Sur.	72.4	8.2	479	7.7	41	2.3	3.4	0.65	0.165	0.037	26	0.157
Station #1- 12:30 am	5	72.4	7.1	478	7.6								
Depth (ft): 22.0	10	71.2	6.1	461	7.6		2.1	3.2	0.72	0.151	0.051	31	0.154
Secchi Depth (ft): 1.5	15	70.6	4.9	465	7.5								
Color: brown	20	70.2	4.3	460	7.6		2.0	2.9	0.64	0.132	0.059	64	0.220

	Time	**Stage**	**Flow(cfs)**	**Visual Observations**	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Pine Creek	1:05 pm	6.70	8.0	Clear	0.62	0.64	0.068	0.028	0.034	4	0.066
Railroad Tr. D/S of Confluence	1:20 pm	13.20	1.9	Slightly turbid(3 ft secchi)	0.77	0.42	0.084	0.037	0.021	4	0.042
Maplewood Drain	1:25 pm	12.40	0.1	Clear-baseflow	0.52	1.22	0.035	0.015	0.012	ND @ 4	0.023
Bosch and Hulst Drain	10:05 am	13.50	17.2	turbid(1 ft secchi)-baseflow	0.88	2.8	0.09	0.043	0.060	14	0.095
N. Br. Macatawa River	9:45 am	estimated flow	10	clear-baseflow	0.79	1.70	0.028	0.021	0.031	4	0.056
Macatawa River @ USGS Gage	9:55 am		30.0	turbid(6 inch secchi)	1.27	8.0	0.13 D	0.14	0.091	30	0.156

D - Analyte value quantified from a dilution(s); reporting limit (RL) raised, MDEQ-Environmental Laboratory

ND - Non detectable, MDEQ-Environmental Laboratory.

Table 4. Water quality Sampling Results, Lake Macatawa and Major Tributaries, Allegan and Ottawa Counties, July 15, 2010.

STATION	DEPTH (ft)	TEMP. (F)	D. O. (mg/l)	COND. (umho/cm)	pH	CHLORO A. (ug/l)	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Lake Macatawa-West Basin (1)													
Storet # 700237	Sur.	81.2	9.0	411	8.9	53	1.36	0.58	0.042	0.062	0.006	10	0.088
Station #4- 10:35 am	5	80.6	8.3	413	8.7								
Depth (ft): 32	10	79.9	6.4	408	8.7								
Secchi Depth (ft): 2.5	15	79.1	5.8	396	8.6		1.13	0.56	0.226	0.050	0.016	8	0.084
Color: brownish green	20	76.2	2.1	391	8.4								
	25	75.5	1.4	392	8.4								
	30	70.9	1.0	398	8.5		2.4	0.136 D	1.46 D	0.003	0.48	19	0.67
Lake Macatawa-West Basin (2)													
Storet # 700573	Sur.	82.0	11.1	403	9.0	91	1.65	0.41	0.023	0.056	0.003	15	0.119
Station #5- 10:55 am	5	81.9	11.3	404	9.0								
Depth (ft): 14	10	81.7	11.1	406	9.0								
Secchi Depth (ft): 2.5	14	80.9	9.4	410	8.9		1.43	0.43	0.36	0.051	0.047	15	0.160
Color: brownish green													
Lake Macatawa-Central Basin													
Storet # 700574	Sur.	82.0	8.8	481	8.9	73	1.87	0.84	0.22	0.114	0.007	15	0.125
Station #2- 11:15 am	5	81.6	8.5	488	8.8								
Depth (ft): 26.0	10	80.9	6.9	482	8.6								
Secchi Depth (ft): 1.75	15	79.7	4.2	454	8.5		1.74	0.69	0.47	0.097	0.031	13	0.135
Color: brownish green	20	78.9	2.4	440	8.4								
	25	77.7	1.3	431	8.4		1.74	0.30	0.79	0.070	0.115	24	0.25
Lake Macatawa-Pine Creek Bay													
Storet # 700384	Sur.	82.7	10.3	482	8.9	98	2.0	0.73	0.038	0.106	0.006	21	0.142
Station #3- 10:35 am	5	82.7	10.6	482	8.9								
Depth (ft): 10.5	10	82.6	10.7	484	8.9		2.1	0.84	0.033	0.110	0.007	17	0.140
Secchi Depth (ft): 1.5													
Color: brown													
Lake Macatawa-East Basin													
Storet # 700238	Sur.	83.7	9.6	551	8.7	104	3.0	1.27	0.482	0.188	0.012	24	0.240
Station #1- 10:25 am	5	83.6	9.4	554	8.6								
Depth (ft): 24.0	10	82.6	6.4	556	8.4		2.3	1.28	0.883	0.166	0.010	16	0.132
Secchi Depth (ft): 2.0	15	79.4	3.4	550	8.3								
Color: brown	20	77.0	1.3	579	8.3								
	23	76.2	0.9	586	8.3		2.2	1.39	0.951	0.098	0.029	29	0.160

	Time	**Stage**	**Flow(cfs)**	**Visual Observations**	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Pine Creek	12:50 pm	6.9	7.0	Clear- over baseflow	0.53	0.81	0.057	0.023	0.024	ND @ 4	0.059
Railroad Tr. D/S of Confluence	1:40 pm	12.9	6.8	Clear- slightly over baseflow	0.71	0.29	0.049	0.020	0.013	ND @ 4	0.051
Maplewood Drain	9:50 am	11.8	1.5	Turbid(6 inch secchi)	0.70	0.48	0.085	0.021	0.012	28	0.084
Bosch and Hulst Drain	1:50 pm	13.4	20	Turbid(2 ft secchi)-baseflow	0.73	3.7 D	0.063	0.036	0.044	11	0.093
N. Br. Macatawa River	2:05 pm	estimated flow	18	Turbid(2 ft secchi)-above baseflow	0.90	0.56	0.033	0.020	0.051	22	0.121
Macatawa River @ USGS Gage	2:00 pm		22	Turbid(2 ft secchi)	1.37	5.0 D	0.122	0.14	0.24	32	0.36

D - Analyte value quantified from a dilution(s); reporting limit (RL) raised, MDEQ-Environmental Laboratory

ND - Non detectable, MDEQ-Environmental Laboratory.

Table 5. Water Quality Sampling Results, Lake Macatawa and Major Tributaries, Allegan and Ottawa Counties, August 17, 2010.

STATION	DEPTH (ft)	TEMP. (F)	D. O. (mg/l)	COND. (umho/cm)	pH	CHLORO A. (ug/l)	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Lake Macatawa-West Basin (1)													
Storet # 700237	Sur.	76.3	9.2	411	8.7	260	1.31	0.004 T	0.010	0.004	0.048	20	0.175
Station #4- 1:20 pm	5	76.3	8.9	411	8.7								
Depth (ft): 31	10	76.2	8.7	410	8.7								
Secchi Depth (ft): 1.3	15	76.2	8.5	410	8.6		1.24	0.006 T	0.011	0.006	0.048	19	0.165
Color: greenish brown	20	76.2	8.3	410	8.6								
	25	75.8	6.9	411	8.5								
	30	75.6	4.7	419	8.1		1.53	0.007 T	0.124	0.007	0.049	32	0.21
Lake Macatawa-West Basin (2)													
Storet # 700573	Sur.	76.0	9.9	405	8.8	330	1.31	0.005 T	0.012	0.004	0.049	21	0.174
Station #5- 2:00 pm	5	76.0	9.7	404	8.8								
Depth (ft): 18	10	75.9	8.6	406	8.7								
Secchi Depth (ft): 1.6	15	74.9	5.6	410	8.3								
Color: greenish brown	17	74.7	4.5	411	8.2		1.53	0.011	0.142	0.009	0.078	38	0.24
Lake Macatawa-Central Basin													
Storet # 700574	Sur.	77.3	9.6	499	8.5	200	1.71	0.25	0.024	0.199	0.037	26	0.198
Station #2- 2:30 pm	5	77.3	9.4	499	8.5								
Depth (ft): 23.0	10	77.3	9.3	498	8.5		1.66	0.25	0.024	0.199	0.035	25	0.186
Secchi Depth (ft): 1.3	15	77.0	7.6	497	8.3								
Color: greenish brown	20	76.5	5.3	496	8.0								
	22	76.4	4.2	500	7.9		1.70	0.21	0.22	0.175	0.051	45	0.230
Lake Macatawa-Pine Creek Bay													
Storet # 700384	Sur.	77.5	12.7	491	8.9	180	1.69	0.069	0.024	0.090	0.021	23	0.184
Station #3- 3:00 pm	5	77.3	10.4	496	8.7								
Depth (ft): 10.0	9	75.9	4.9	499	8.1		1.51	0.134	0.068	0.126	0.028	23	0.171
Secchi Depth (ft): 1.3													
Color: greenish brown													
Lake Macatawa-East Basin													
Storet # 700238	Sur.	80.1	11.2	639	8.0	210	3.0	1.05	0.90	0.58	0.019	21	0.20
Station #1- 3:30 pm	5	80.1	11.0	638	8.0								
Depth (ft): 23.0	10	78.0	6.7	603	7.8		1.95	0.89	0.50	0.53	0.017	18	0.135
Secchi Depth (ft): 1.4	15	77.7	5.9	589	7.8								
Color: brown	20	77.1	5.3	555	7.8								
	22	77.1	5.2	551	7.8		1.68	0.59	0.29	0.37	0.029	29	0.162

	Time	**Stage**	**Flow(cfs)**	**Visual Observations**	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Pine Creek	12:15 pm	7.15	6.0	Clear-low	0.48	0.92	0.047	0.019	0.031	ND @ 4	0.051
Railroad Tr. D/S of Confluence	11:30 am	13.10	4.0	Clear-low	0.65	0.27	0.041	0.011	0.016	ND @ 4	0.032
Maplewood Drain	11:15 am	12.30	0.2	Clear-low	0.54	1.16	0.035	0.014	0.016	ND @ 4	0.031
Bosch and Hulst Drain	10:50 am	13.60	15.0	Clear-low	0.54	2.8	.05 D	0.028	0.048	5	0.081
N. Br. Macatawa River	10:25 am	estimated flow	1	Clear-very low	0.79	0.22	0.036	0.008	0.022	4	0.052
Macatawa River @ USGS Gage	10:15 am		11.0	Turbid(2 ft secchi)-low	0.89	4.0	ND @ .05 D	0.029	0.067	5	0.099

D - Analyte value quantified from a dilution(s); reporting limit (RL) raised, MDEQ-Environmental Laboratory

ND - Non detectable, MDEQ-Environmental Laboratory.

T -Report value is less than the reporting limit (RL).

Table 6. Water Quality Sampling Results, Lake Macatawa and Major Tributaries, Allegan and Ottawa Counties, September 21, 2010.

STATION	DEPTH (ft)	TEMP. (F)	D. O. (mg/l)	COND. (umho/cm)	pH	CHLORO A. (ug/l)	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Lake Macatawa-West Basin (1)													
Storet # 700237	Sur.	63.1	9.3	420	8.4	44	0.99	0.040	0.024	0.006	0.010	15	0.106
Station #4- 11:15 am	5	63.1	9.2	422	8.4								
Depth (ft): 31	10	63.1	9.1	422	8.4								
Secchi Depth (ft): 2.0	15	63.0	8.9	425	8.5		1.05	0.039	0.033	0.006	0.008	16	0.122
Color: greenish brown	20	63.0	8.9	426	8.5								
	25	63.0	8.8	428	8.5								
	30	62.7	8.1	427	8.3		1.32	0.047	0.078	0.007	0.011	44	0.187
Lake Macatawa-West Basin (2)													
Storet # 700573	Sur.	63.4	9.4	452	8.5	58	1.15	0.098	0.034	0.011	0.006	21	0.131
Station #5- 11:45 am	5	63.4	9.3	451	8.5								
Depth (ft): 15	10	63.3	9.2	466	8.4								
Secchi Depth (ft): 2.25	14	63.3	9.1	466	8.4		1.28	0.141	0.029	0.014	0.005	27	0.142
Color: greenish brown													
Lake Macatawa-Central Basin													
Storet # 700574	Sur.	64.2	8.6	565	8.1	60	1.54	0.54	0.156	0.044	0.005	25	0.147
Station #2- 12:05 pm	5	64.2	8.4	565	8.1								
Depth (ft): 26	10	64.2	8.3	565	8.1								
Secchi Depth (ft): 2.0	15	64.2	8.4	565	8.1		1.54	0.54	0.161	0.044	0.006	23	0.149
Color: greenish brown	20	64.1	8.2	566	8.1								
	25	63.8	7.2	571	7.4		1.57	0.53	0.167	0.044	0.007	24	0.157
Lake Macatawa-Pine Creek Bay													
Storet # 700384	Sur.	64.4	10.0	582	8.1	66	1.78	0.60	0.193	0.054	0.003	28	0.160
Station #3- 12:30 pm	5	64.4	9.4	581	8.1								
Depth (ft): 10.0	9	64.0	0.7	593	7.4		1.69	0.62	0.21	0.058	0.005	29	0.153
Secchi Depth (ft): 1.5													
Color: greenish brown													
Lake Macatawa-East Basin													
Storet # 700238	Sur.	66.6	7.6	647	7.3	40	2.5	1.1	1.1	0.125	0.018	32	0.154
Station #1- 12:55 pm	5	66.4	7.3	646	7.3								
Depth (ft): 23	10	65.7	7.4	635	7.4		2.5	1.1	1.1	0.125	0.018	32	0.152
Secchi Depth (ft): 1.1	15	65.4	7.4	629	7.5								
Color: greenish brown	20	65.3	7.5	624	7.5								
	22	65.3	7.5	624	7.5		2.2	0.90	0.76	0.112	0.016	49	0.190

	Time	**Stage**	**Flow(cfs)**	**Visual Observations**	K. NITRO. (mg/l)	NITRATE + NITRITE (mg/l)	AMMONIA (mg/l)	NITRITE (mg/l)	ORTHO PHOS. (mg/l)	TSS (mg/l)	TOTAL PHOS. (mg/l)
Pine Creek	1:40 pm	7.0	6.3	Clear-baseflow	0.58	0.61	0.046	0.017	0.024	ND @ 4	0.058
Railroad Tr. D/S of Confluence	2:20 pm	13.0	5.2	Clear-baseflow	0.66	0.24	0.053	0.012	0.009	7	0.033
Maplewood Drain	10:20 am	12.3	0.2	Clear-up 6"	0.40	0.97	0.037	0.012	0.011	ND @ 4	0.028
Bosch and Hulst Drain	2:30 pm	13.6	15.0	Clear-basefow	0.71	4.6	0.06	0.024	0.043	7	0.080
N. Br. Macatawa River	2:45 pm	estimated flow	4	Clear-baseflow	0.65	0.063	0.015	0.005	0.013	4	0.044
Macatawa River @ USGS Gage	2:40 pm		8.1	Baseflow-turbid(2 ft secchi)	0.68	2.6	ND @.05 D	0.029	0.048	8	0.097

D - Analyte value quantified from a dilution(s); reporting limit (RL) raised, MDEQ-Environmental Laboratory

ND - Non detectable, MDEQ-Environmental Laboratory.