

Michigan Department of Environmental Quality  
Surface Water Quality Division  
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Total Maximum Daily Load (TMDL) for Phosphorus in Strawberry Lake

**Location:** Strawberry Lake is a 257 acre (104 ha) inland lake of the Huron River located in Livingston County (Figure1). It is the upstream most lake in a chain of lakes including Strawberry, Gallagher, Whitewood, and Baseline Lakes. Strawberry Lake is downstream of four other lakes in which phosphorus TMDLs are being developed, including Brighton, Kent, Limekiln, and Ore Lakes.

**Pollutant:** Total Phosphorus.

**Phosphorus Data and Goal:**

Year	Total Phosphorus Concentration (mg/L)	Total Load to Lake (lbs/yr)	Actual Point Source Contribution (lbs/yr)	Nonpoint Source Contribution (lbs/yr)	
1978		<b>16,700</b>	<b>9,100</b>	<b>7,600</b>	
1997	<b>0.020</b>	13,760	<b>2,067</b>	11,696	
1998	<b>0.022</b>	15,130	<b>1,972</b>	13,158	
1999	<b>0.022</b>	<b>15,575</b>	<b>1,794</b>	<b>13,781</b>	
Average 1997-99	0.021	14,822	1,944	12,878	
	Total Phosphorus Concentration (mg/L)	Loading Capacity (lbs/yr)	Waste Load Allocation (lbs/yr)	Load Allocation (lbs/yr)	Margin of Safety (lbs/yr)
<b>TMDL Goal</b>	0.025	17,100	5,877	11,000	223

**Bold numbers indicate actual measured values.**

**Background:** In the 1970s, Strawberry Lake was classified as a eutrophic lake in which phosphorus was identified as the most appropriate nutrient for controlling algae growth (Tierney and Massey, 1979). In 1978, the total phosphorus load to Strawberry Lake was 16,700 pounds/year (lbs/yr) (Tierney and Massey, 1979). Of that 16,700 pounds of phosphorus, approximately 54 percent was from point source contributions and 46 percent was from nonpoint source contributions. In 1980, a point source phosphorus allocation was established by the Water Resources Commission to be protective of Strawberry Lake. This point source allocation included Brighton WWTP, Ford Motor Company-Wixom, Milford WWTP, Northfield Township WWTP, South Lyon WWTP, Vision Metals, and Wixom WWTP, with a total permitted phosphorus discharge upstream of Strawberry Lake of 7,353 lbs/yr. Based on retention in upstream lakes (Tierney and Massey, 1979) approximately 5,825 lbs/yr of the permitted phosphorus loading could potentially reach Strawberry Lake. In August 1991, the Ford Motor Company-Wixom diverted its effluent from the Huron River system to the Wixom WWTP, and its portion of the allocation was given to Wixom WWTP. Currently, the total permitted point source contribution upstream of Strawberry Lake is limited to 8,218 lbs/yr, including Brighton Township WWTP, a newly permitted facility, and General Motors Proving Grounds in Milford. Based on updated retention factors in upstream lakes (Alexander, 2000) approximately 5,877 lbs/yr of the permitted phosphorus loading could potentially reach Strawberry Lake.

Based on the data gathered through 1998, Strawberry Lake is currently meeting designated uses, but was listed as a threatened waterbody on Michigan's 1998 Section 303(d) list of waterbodies needing TMDLs due to the rapid growth in this area. The primary issue identified as threatening Strawberry Lake was nutrient enrichment (phosphorus). This TMDL was developed consistent with the Brighton Lake TMDL, the Kent Lake TMDL, and the Ore Lake TMDL.

In April 1998, a 12-month phosphorus loading analysis was begun to determine the most appropriate predictive phosphorus model for Strawberry Lake (Alexander, 2000). This phosphorus analysis showed a total phosphorus load to Strawberry Lake of 15,575 pounds from April 1998 to March 1999. The April 1999 average spring phosphorus concentration was 0.022 micrograms per liter (mg/L), and the predicted in-lake phosphorus concentration using the Reckhow General Model (Reckhow, 1978) was 0.023 mg/L. Based on comparison of the actual in-lake phosphorus concentration and the predicted phosphorus concentration, the Reckhow General Model was determined to be a good predictor for phosphorus, both for loading and in-lake concentration for Strawberry Lake (Alexander, 2000).

Of the total phosphorus loading to Strawberry Lake from April 1998 to March 1999, 12 percent (1,794 pounds) was attributed to the seven upstream point sources and the remaining 88 percent (13,791 pounds) was attributed to nonpoint source contributions. In 1997, the average spring phosphorus concentration was 0.020 mg/L (Alexander, 1998). Using the Reckhow General Model, total phosphorus loading in the preceding 12 months was estimated to be 13,760 lbs/yr. Of the total loading for 1997, 15 percent was estimated to be from point source contributions and 85 percent from nonpoint source contributions. In 1998, average spring phosphorus concentration was 0.022 mg/L (Alexander, 2000). Using the Reckhow General Model, total phosphorus loading in the preceding 12 months was estimated to be 15,130 lbs/yr with point source contributions making up 13 percent of the total and nonpoint source contributing the remaining 87 percent. Based on this data, the nonpoint source phosphorus contributions account for a much larger portion of the total phosphorus loading today when compared to the 1978 loading results.

A goal of 0.030 mg/L in-lake phosphorus concentration was originally recommended in the draft TMDL for phosphorus in Strawberry Lake, which was public noticed from January 18, 1999 to February 19, 1999. After reviewing the considerable public comments received and considering the existing condition of Strawberry Lake, an in-lake phosphorus concentration goal of 0.025 mg/L was established for Strawberry Lake. This goal will allow the lake to meet the requirements of Water Quality Standards R 323.1060(2) for plant nutrients. This rule states "nutrients shall be limited to the extent necessary to prevent stimulation of growths of aquatic rooted, attached, suspended, and floating plants, fungi, or bacteria which are or may become injurious to the designated uses of the waters of the state."

**Waste Load Allocation:** The waste load allocation was established at 5,877 lbs/yr total phosphorus load to Strawberry Lake, using current National Pollutant Discharge Elimination System permit limits, upstream lake retention factors, and TMDLs for Brighton, Kent, and Ore Lakes. The individual waste load allocations are given in Table 1. Phosphorus loading from the seven point source discharges averaged 1,944 lbs/yr during 1997, 1998, and 1999 (Table 2), significantly less than the 9,100 lbs/yr in 1978.

**Load Allocation:** The estimated total nonpoint source contribution during 1997, 1998, and 1999 averaged 12,878 lbs/yr with a range of 11,696 lbs/yr to 13,986 lbs/yr. This is more than the 7,600 lbs/yr in 1978 in prior studies. Based on this information, it can be assumed that there is some variability in nonpoint source contributions and that there has been an increase in nonpoint source loading since 1978. Therefore, a load allocation of 11,000 lbs/yr of phosphorus

was established for nonpoint source contributions to Strawberry Lake. This load allocation equates to a reduction of 15 percent (1,878 lbs/yr) from the average phosphorus nonpoint source contributions. The Michigan Department of Environmental Quality anticipates this reduction will be achieved through work to be conducted by the Huron River Watershed Council (HRWC) in the upper Huron River Watershed. It is anticipated that the HRWC will be given a Section 319 Grant to develop best management practices (BMPs) for reduction of the nonpoint source phosphorus contributions in the Kent Lake and Limekiln Lake Watersheds. These reductions should aid in reaching the needed reductions in Strawberry Lake. Additionally, the BMPs developed by the HRWC should be applicable throughout the upper Huron River Watershed and can be applied where appropriate to reach the load allocation goal of the Strawberry Lake TMDL. This will likely occur over the time period that point source loads are increasing. Therefore, it is anticipated that Strawberry Lake will continue to meet the goal of 0.025 mg/L during this period.

**Margin of Safety:** The remaining 223 lbs/yr of phosphorus loading is allocated to a margin of safety. This is appropriate due to the good predictions found with the model used in the TMDL development process.

**Summary:** The TMDL for Strawberry Lake allocates 11,000 pounds of phosphorus to nonpoint source loads, 5,877 pounds of phosphorus to point source loads, and 223 pounds for a margin of safety. These loads are necessary on an annual basis to meet the goal of 17,100 lbs/yr total loading and an in-lake total phosphorus concentration of 0.025 mg/L.

#### **References:**

- Alexander, M. A. 2000. Water quality and phosphorus loading analysis of Strawberry and Limekiln Lakes, Livingston and Oakland Counties, April 1998-September 1999. MDEQ, Surface Water Quality Division, Report #MI/DEQ/SWQ-00/020.
- Alexander, M. A. 1999. Water quality and phosphorus loading analysis of Brighton, Kent, and Ore Lakes, Livingston and Oakland Counties, April 1998-April 1999. MDEQ, Surface Water Quality Division, Report #MI/DEQ/SWQ-99/107.
- Alexander, M. A. 1998. A nutrient chemistry survey of Brighton, Kent, Ore, Portage, Sandy Bottom, and Strawberry Lakes, Livingston, Oakland, and Washtenaw Counties, April, June, and August 1997. MDEQ, Surface Water Quality Division, Report #MI/DEQ/SWQ-98/010.
- Reckhow, K. H. 1978. Quantitative techniques for the assessment of lake quality. Prepared for: Michigan Department of Natural Resources. p. 138.
- Tierney, D. and A. Massey. 1979. Water quality and phosphorus loading analysis of Strawberry Lake, Livingston County, 1977-1978. MDEQ, Surface Water Quality Division, Report #84590.

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Table 1. Current permit limits and waste load allocations for facilities discharging upstream of Strawberry Lake.

Facility	Current Limits (lbs/yr)	Percent Retention in Upstream Lake*	Waste Load Allocation to Strawberry Lake (lbs/yr)
Brighton WWTP	600	40	360
Brighton Twp WWTP	525	0	525
GM Proving Grounds Milford	340	0	340
Milford WWTP	900	22	702
Northfield Twp WWTP	1,826	0	1,826
South Lyon WWTP	1,387 (800)**	50	400
Vision Metals	840 (640)**	50	320
Wixom WWTP	1,800	22	1,404

\*Based on retention factors of 22 percent for Kent Lake, 50 percent for Nichwagh/Limekiln/Sandy Bottom Lakes (combined), and 40 percent for Ore Lake. These retention factors are based on the average retention of the Ore Lake and Kent Lake 1978 and 1999 data (Tierney and Massey, 1975 and Alexander, 1999). The 50 percent retention for Nichwagh Chain of Lakes was selected due to the uncertainty associated with the loading data collected during the two sampling periods.

\*\*These are the proposed new annual phosphorus permit limits of 800 pounds per year for South Lyon WWTP and 640 pounds per year for Vision Metals. The column for Waste Load Allocation to Strawberry Lake depicts potential loading to Strawberry Lake with the new permit limits for South Lyon and Vision Metals.

Table 2. Recent actual phosphorus data for facilities discharging upstream of Strawberry Lake.

Facility	Year	Design flow (MGD)	Avg. flow (MGD)	Total load (lbs/yr)	Percent retention in upstream lake*	Load to Strawberry Lake (lbs/yr)
Brighton WWTP	1997	1.52	1.01	100	40*	60
	1998		1.17	139	40*	83
	1999		1.17	109	35**	71
Milford WWTP	1997	1.04	0.44	178	22*	139
	1998		0.74	187	22*	146
	1999		0.59	261	13**	227
GM Proving Grounds Milford	1997	0.45	0.18	215	0	215
	1998		0.16	206	0	206
	1999		0.15	182	0	182
Northfield Twp WWTP	1997	3	0.84	521	0	521
	1998		0.86	378	0	378
	1999		0.67	200	0	200
South Lyon WWTP	1997	1.5	1.04	281	50*	141
	1998		0.99	289	50*	145
	1999		0.98	341	72**	95
Vision Metals	1997	1.0	0.35	145	50*	73
	1998		0.43	262	50*	131
	1999		0.38	187	72**	52
Wixom WWTP	1997	2.8	2.34	1177	22*	918
	1998		2.34	1132	22*	883
	1999		2.41	1112	13**	967

\* Based on retention factors of 22 percent for Kent Lake, 50 percent for Nichwagh/Limekiln/Sandy Bottom Lakes (combined), and 40 percent for Ore Lake. These retention factors are based on the average retention of the 1978 and 1999 data (Tierney and Massey, 1979 and Alexander, 1999).

\*\* Based on retention factors from the 1999 data only (Alexander, 1999).

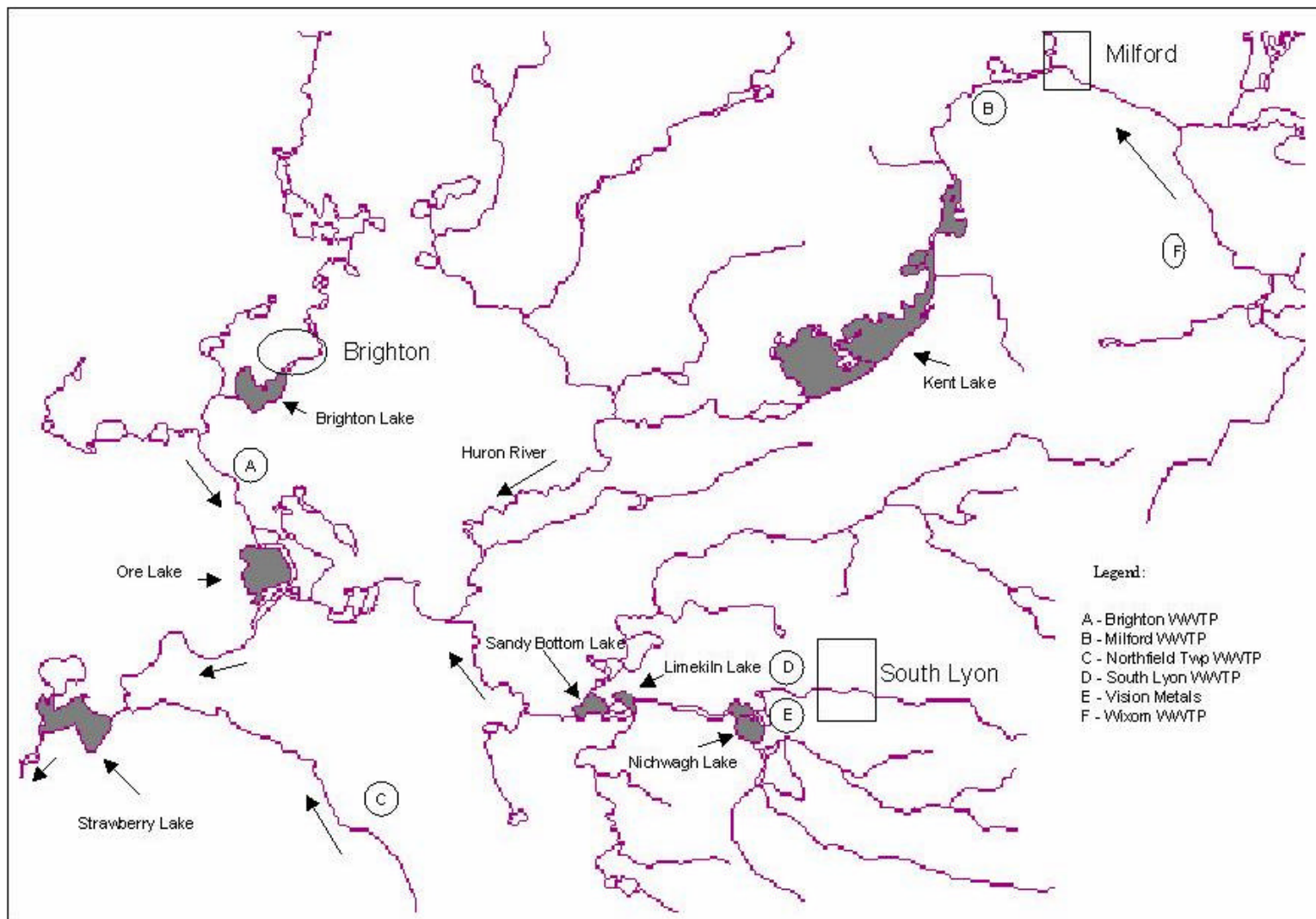


Figure 1. Upper Huron River watershed showing the five TMDL lakes Brighton, Kent, Limekiln, Ore, and Strawberry Lake and the current point source discharges.