Total Maximum Daily Load for Total Phosphorus in Ford and Belleville Lakes

Washtenaw and Wayne Counties

Michigan Department of Environment, Great Lakes, and Energy
Water Resources Division
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1. INTRODUCTION

Section 303(d) of the federal Clean Water Act and the United States Environmental Protection Agency's (USEPA) Water Quality Planning and Management Regulations (Title 40 of the Code of Federal Regulations (CFR), Part 130) require states to develop Total Maximum Daily Loads (TMDL) for water bodies that are not meeting water quality standards (WQS) with current pollution control technologies due to one or more pollutants. The TMDL process establishes the allowable loadings of pollutants for a water body based on the relationship between pollution sources and in-stream water quality conditions. TMDLs provide a basis for determining the pollutant reductions necessary from both point and nonpoint sources to restore and maintain the quality of water resources. The purpose of this TMDL is to establish the allowable loadings of total phosphorus that will result in the attainment of the applicable WQS in Ford and Belleville Lakes. The Assessment Unit Identifiers (AUID) for these water bodies are 040900050403-02 (Ford Lake) and 040900050404-02 (Belleville Lake).

1.1 PROBLEM STATEMENT

Algal blooms have often been reported in Ford and Belleville Lakes for at least the past 30 years. In 1991, Ford Lake experienced a September algal bloom so severe that a hazardous material response team was summoned to investigate the "green paint spill." Water quality monitoring data collected in 1994 and 1995 showed extremely high levels of phosphorus in Ford and Belleville Lakes. These data indicated that both lakes were not attaining the Other Indigenous Aquatic Life and Wildlife (OIALW) designated use according to the Michigan Department of Environment, Great Lakes, and Energy (EGLE) methodology for listing lakes and streams as impaired in the Integrated Report (Goodwin et al., 2016). This led to the development of a TMDL for these lakes in 1996 (Kosek, 1996). An updated TMDL was produced in 2004 to reflect additional information collected up to that point (Michigan Department of Environmental Quality [MDEQ], 2004). EGLE's sampling results since 2012 (2012, 2014, 2016, and 2018) indicate that the total phosphorus concentrations continue to consistently exceed the 30 microgram per liter (ug/L) target established for Belleville Lake in the previous TMDLs (Figures 1 and 2) (Varricchione, 2015; Chambers, 2019). This updated TMDL addresses the ongoing impairments in Ford and Belleville Lakes due to total phosphorus by incorporating additional loading data, evaluating source information, and reconsidering the previous loading targets.

1.2 BACKGROUND

Ford and Belleville Lakes are impoundments on the Huron River, which has approximately 96 dams along its length, with 19 on the mainstem and 77 on tributaries (Hay-Chmielewski et al., 1995). These lakes have important recreational value because they are located in or near large population centers. The Huron River is a warmwater system that flows through Ingham, Livingston, Monroe, Oakland, Washtenaw, and Wayne Counties before emptying into Lake Erie. Its watershed covers an area of about 900 square miles. Ford and Belleville Lakes are at the lower end of the portion of the Huron River known as the Middle Huron River watershed, which encompasses 292 square miles. Ann Arbor is the primary city in this portion of the watershed, along with Ypsilanti, Dexter, Chelsea, and Pinckney. The land usage in the Middle Huron River watershed is 36 percent cultivated crops and pasture/hay; 30 percent developed/urban; 18 percent forest; 14 percent wetland/open water; and 2 percent grassland/barren (National Land Cover Database, 2011; Figure 3). The 2011 Middle Huron River Watershed Management Plan (WMP) (currently being updated) provides an excellent summary of the area's climate, topography, soils, geology, hydrology, land use, and other natural features (Huron River Watershed Council, 2011).

At a 1987 meeting of the Water Resources Commission, the State of Michigan established a goal of 30 ug/l phosphorus concentration for Belleville Lake to restore designated uses in the lake. This target concentration was adopted by EGLE in the 1996 and 2004 versions of this TMDL. EGLE also determined that a phosphorus concentration of 50 ug/l must be met going into Ford Lake during the period of April-September (the algae growing season) to achieve the 30 ug/l target for Belleville Lake. Since that time, numerous restoration activities have been implemented in the watershed upstream of Ford and Belleville Lakes to reduce phosphorus inputs into the system. Some of the activities are described in the 2011 WMP (Huron River Watershed Council, 2011) and the Phosphorus Reduction Implementation Plan for the Middle Huron River Watershed (Middle Huron Initiative, 2011).

The current TMDL only includes the middle portion of the Huron River watershed. This TMDL uses the same sub-watershed that begins at Bell Road (42.401636, -83.908601), between Portage Lake and Territorial Road in Washtenaw County. Most of the area upstream of this TMDL watershed is included in other total phosphorus TMDLs (Strawberry Lake, Ore Lake, Brighton Lake, and Kent Lake.) These nested lake watersheds are meeting their respective TMDL goals (Noffke, 2015). The area between the Strawberry Lake TMDL and the Ford and Belleville Lakes TMDL includes both Portage and Baseline Lakes, which are both meeting WQS.

1.3 NUMERIC TARGET

The OIALW is the impaired designated use addressed by this TMDL based on nuisance algal blooms and associated high concentrations of nutrients, especially phosphorus. EGLE's Integrated Report (Section 4.6.2.2) describes the assessment methodology for determining nuisance aquatic plant growth conditions in surface waters (Goodwin et al., 2016). Evaluations include site-specific visual observations and/or water column nutrient concentration measurements. A determination of not supporting is made if excessive/nuisance growths of algae or aquatic macrophytes are present.

Michigan does not have numeric criteria for total phosphorus, instead relying on the narrative WQS found under R 323.1060(2) (Rule 60), Plant Nutrients, of the Part 4 rules, WQS, promulgated under Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (NREPA). Rule 60 was developed to provide the authority to limit the addition of nutrients to surface waters of the state, which are or may become injurious to the designated uses of the surface waters of the state.

Specifically, this rule says:

> R 323.1060 Plant Nutrients.
> Rule 60. (1) Consistent with Great Lakes protection, phosphorus which is or may readily become available as a plant nutrient shall be controlled from point source discharges to achieve 1 milligram per liter of total phosphorus as a maximum monthly average effluent concentration unless other limits, either higher or lower, are deemed necessary and appropriate by the department.
>
> (2) In addition to the protection provided under subrule (1) of this rule, 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 surface waters of the state.

Excess phosphorus can stimulate nuisance growths of algae and aquatic plants that indirectly reduce oxygen concentrations to levels that cannot support a balanced fish or aquatic macroinvertebrate community (e.g., extreme day/night time fluctuations in oxygen) and can shade out beneficial phytoplankton (algal) and aquatic macrophyte (vascular plant) communities that are important food sources and habitat areas for fish and wildlife. The period of time when it is most critical to reduce phosphorus concentrations is in the summer during the growing season. Between July 1 and September 30, environmental conditions such as higher temperatures and increased light intensity are most likely to result in nuisance plant growth if nutrient concentrations are elevated.

The numeric concentration targets for phosphorus in Ford and Belleville Lakes were developed based on information from Michigan and other midwestern states indicating when nuisance algal conditions are likely to occur, and below which nuisance conditions are not typically observed. To address plant nutrient impairments in these lakes, the target concentration is 30 ug/L total phosphorus in both lakes. These target concentrations were used to calculate the acceptable load, which equates to 27,000 pounds of phosphorus entering Ford Lake per year (74 pounds/day) and 34,000 pound of phosphorus entering Belleville Lake per year using Walker (1977) and Reckhow (1979) lake models (Appendix 1). Reducing the summer (July to September) total phosphorus to an average of 30 ug/L in both Ford and Belleville Lakes is supported in the literature (Watson et al., 1992; Soranno et al., 2008; and Carvalho et al., 2013) to be protective of the OIALW designated use and ensure that nuisance algal blooms do not regularly occur in either lake.

EGLE has historically calculated average phosphorus concentrations in lakes as unweighted averages of all of the data collected over a given time period and has used this approach in other Michigan phosphorus TMDLs. In the future, we will consider using both unweighted and volume weighted averages to assess progress towards the TMDL, along with the frequency of large algal blooms.

2. DATA DISCUSSION

EGLE staff conducted a study in 1995 to determine annual and monthly phosphorus loads to Ford and Belleville Lakes from the cities of Ann Arbor and Ypsilanti as well as the Huron River watershed immediately upstream of Ann Arbor (Kosek, 1996). Twenty-nine stations were sampled, including 21 stream stations and 8 lake stations. Samples were analyzed for total and ortho phosphorus, Total Kjeldahl nitrogen, and total suspended solids. The results indicated that WQS were not being met in Ford and Belleville Lakes.

The annual phosphorus load to Ford Lake in 1995 was approximately 80,000 pounds per year, which was less than previous loading estimates of 100,000 or more pounds per year. The study found that phosphorus loads increased from Bell Road down to Michigan Avenue, and that the tributaries contributing the highest loads were Mill Creek, Allen Drain, and Mallets Creek. Fleming Creek, Honey Creek, and Boyden Creek had very low phosphorus concentrations.

Since the 1994-1995 study, EGLE conducted annual monitoring from 1996-2006 (except for 2000); sampled again in 2009; and has sampled every other year from 2012-2018. Four stations on both Ford and Belleville Lakes are sampled monthly from April through September, as well as 2 sites on the Huron River (at Bandemer Park just downstream from Barton Pond and at Michigan Avenue immediately upstream of Ford Lake; Varricchione, 2015; Chambers, 2019, Figure 4). The Bandemer Park location showed a statistically significant decline in phosphorus concentration from 1994-2018, while the location near the Ford Lake inlet was below the 2004

TMDL target of 50 ug/L entering Ford Lake in 10 of the 17 months of data collection (samples were not collected in April 2018). Despite the apparent decline in phosphorus levels from the Huron River stations over time, there is no statistical indication that phosphorus levels are declining in either lake compared to 1994. Phosphorus concentrations show extreme monthly and inter-annual variability from 2014-2018, with a minimum monthly concentration in Ford Lake of 30 ug/L and a maximum monthly concentration of 111 ug/L (Figures 5 and 6). During this time period, Belleville Lake exceeded the 30 ug/L 2004 TMDL phosphorus target in 15 out of 17 months, with a minimum monthly concentration of 29 ug/L and a maximum of 122 ug/L (Figures 1 and 2). Similarly, no improvements in Secchi depth measurements have been noted in either lake. Algal blooms also have been noted in both lakes since 2014. The average July to September phosphorus concentration in both lakes was approximately 60 ug/L. Both lakes also showed regular evidence of anoxic conditions at the bottom of the lake. These results indicate that Ford and Belleville Lakes are still highly eutrophic water bodies (Chambers, 2019).

In addition to the EGLE monitoring described here, several organizations and municipalities in the Huron River watershed coordinate effort and resources to monitor water chemistry and stream flow in the Upper, Middle, and Lower sections of the watershed. The intent of this project is to identify pollutant “hot spots” and to evaluate progress in reducing loadings from point and nonpoint sources in the watershed. The Middle Huron River monitoring locations are most relevant for this TMDL. Sampling under this program began in 2002 and has expanded over the years to include more sites. Eleven long-term stations on the Huron River and its tributaries are monitored. Sites are sampled for nutrients (including phosphorus), total suspended and dissolved solids, bacteria, and other parameters twice per month from April through September. Storm sampling also is conducted.

Results from this sampling program indicate the total phosphorus levels have declined by approximately 20% overall across stations in the Middle Huron River watershed, after accounting for flow and seasonality. Most of that decline has occurred since 2012. Similarly, baseflow concentrations of phosphorus appear to be declining, and levels at the Michigan Avenue station (just upstream of Ford Lake) in 2018 were generally below the 50 ug/l target established for this location in the 2004 TMDL. More details can be found at: https://www.hrwc.org/what-we-do/programs/chemistryandflow/washtenaw-results/

Faculty at the University of Michigan have also conducted extensive monitoring of nutrient loads and dynamics in the Ford and Belleville Lakes TMDL watershed. Lehman et al. (2009 and 2011) used intensive baseline monitoring from 2003-2005 to show that a local municipal ban limiting the use of lawn fertilizer containing phosphorus produced an 11-23% reduction in total phosphorus concentrations in June to September 2008-2010. Bosch and Allan (2008) and Lehman (2016) documented that there is nutrient retention in the small reservoirs in the Huron River upstream of Ford Lake. Annual variations in Huron River flow and weather have been found to affect the likelihood of the large algae blooms with conditions that lead to less stratification producing clearer water (Lehman, 2014). Many of these studies also documented that Ford Lake acts as a sink of phosphorus during most of the year, but during the summer higher concentrations of phosphorus are measured at the outlet versus the inlet (Lehman, 2011). Other research has focused on understanding the response of algae in Ford Lake to different nutrient conditions (Lehman et al., 2008 and 2013; McDonald and Lehman, 2013).

3. SOURCE ASSESSMENT

Sources of concern cover an array of nonpoint and point sources. Potential nonpoint sources include agricultural crop land (e.g., soil erosion, nutrient loss from fields, subsurface tile drainage, tile outlet problems), livestock (e.g., runoff from animal feeding areas, lack of manure storage, unregulated land-application of livestock waste), urban storm water runoff, illicit discharges, failing septic systems, groundwater discharge, and atmospheric deposition. Point sources are regulated through the National Pollutant Discharge Elimination System (NPDES) permitting program.

3.1 NPDES Discharges

Point sources are those originating from a single, identifiable source in the watershed. Point source discharges are regulated through NPDES permits. There are three types of NPDES permits: individual permits, general permits, and permit by rule. Staff of EGLE, Water Resources Division (WRD), determine the appropriate permit type for each surface water discharge.

- An individual NPDES permit is site-specific. The limitations and requirements in an individual permit are based on the permittee's discharge type, amount of discharge, facility operations (if applicable), and receiving stream characteristics.

- A general permit is designed to cover permittees with similar operations and/or type of discharge. Locations or situations where more stringent requirements are necessary require an individual permit. Facilities that are eligible to be covered under a general permit receive a Certificate of Coverage (COC).

- "Permit by rule" denotes that permit requirements are stated in a formally promulgated administrative rule. A facility requiring coverage under a permit by rule must abide by the provisions written in the rule. Instead of applying for an NPDES permit, the facility submits a form called a Notice of Coverage (NOC).

NPDES individual permits, COCs, and general permits are reissued every five years on a rotating schedule, and the requirements within the permits may also change at reissuance. Pursuant to R 323.1207(1)(b)(ii) of the Part 8 Rules, Water Quality-Based Effluent Limit Development for Toxic Substances, of the NREPA, and 40 CFR, Part 130.7, NPDES permits issued or reissued to facilities discharging to impaired waters after the approval of this TMDL are required to be consistent with the goals of this TMDL.

EGLE staff inspect or audit NPDES-permitted facilities approximately once every five years. At the time of these audits, EGLE staff review permits, permittee actions, submittals, and records to ensure that each permittee is fulfilling the requirements of their permit. Consistency of the permit with the TMDL, and any potential deficiencies of the facility, are reviewed and addressed as part of the audit and permit reissuance processes.

There are currently 12 individual permits in the TMDL watershed (Table 1). The Ann Arbor Wastewater Treatment Plant (WWTP) is by far the most significant contributor based on volume and phosphorus loading, permitted to discharge over 50,000 pounds per year, with average annual loads of 22,000 pounds from 2006-2018. Most of these facilities have NPDES permits with total phosphorus limits. The five WWTP facilities are also permitted to land apply biosolids on agricultural fields in the TMDL watershed through separate COCs. Biosolids are the residual solids that settle out during the sewage treatment process. Additional information on biosolids is available at: www.mi.gov/biosolids.

In addition to these individual permits, there are currently 72 COCs under the General Permit category. These consist of MS4 permits (16); noncontact cooling water (4); public swimming pool wastewater (17); industrial storm water (33); and wastewater discharge from potable water supplies (2). Most of the permittees are upstream of Ford Lake, but 3 permits discharge to water that goes directly to Belleville Lake and do not pass through Ford Lake (Table 1). Other permit categories in the watershed include Construction Storm Water NOC (33); and Industrial Storm Water No Exposure Certificate (16).

Municipalities with a regulated MS4 (e.g., separated storm sewer pipes, parking lots, public roads, and roadside ditches) located within an urbanized area with a discharge to surface waters are required to have the MS4 permit. These permits are generally issued to counties, cities, townships, universities, public school systems, airports with public areas, and state agencies. Urbanized areas are defined by the U.S. Census Bureau and updated after each major population census, every ten years. Cities, villages, and townships are required to have their own MS4 permit (Table 1).

Federal regulation (40 CFR, Part 122.26) requires that facilities apply for industrial storm water permit coverage if the storm water runoff discharges to surface waters of the state after being exposed to industrial materials or areas of industrial activity. This requirement also includes facilities that discharge storm water runoff indirectly to surface waters of the state via a private or municipal storm sewer system that conveys storm water. Industrial storm water permit coverage is issued to regulate storm water originating from regulated industrial sites, including factories, food processors, transportation facilities that conduct maintenance on their equipment, airports, and landfills. The decision on which facilities must be regulated is based on the primary industrial activity conducted at the facility and federal regulation. The 11 categories described in the regulations are identified by Standard Industrial Classification codes, or by narrative description of the industrial activity. As mentioned above, the TMDL watershed includes 33 industrial storm water COCs.

Sanitary Sewer Overflows (SSO) are the illegal discharge of partially or untreated sanitary wastewater that occur from sanitary sewer systems, which are separate from storm sewer systems. SSOs occur occasionally due to mechanical or electrical equipment failure. Chronic or recurring SSOs may occur due to extremely large precipitation events due to poorly maintained or aging collection systems that allow groundwater and storm water to infiltrate the sanitary sewer lines. The Ann Arbor WWTP reported three SSO events in 2017; two discharged to Allen Creek and one discharged to Malletts Creek (both are tributaries to the Huron River). A total of 0.0001 million gallons was discharged on May 7, 2017; 0.0135 million gallons on June 22, 2017; and 0.0001 million gallons on August 24, 2017. All three of the SSOs occurred due to pipe blockages, which were soon corrected (MDEQ, 2018). A small number of SSO discharges from the Ann Arbor WWTP also occurred in 2015 and 2016 (MDEQ, 2016 and 2017).

3.2 Nonpoint Sources

Nonpoint sources of phosphorus include any source that is not a discharge regulated by an NPDES permit, including some types of storm water, failing septic systems, regulated septage land application, groundwater discharges, non-Concentrated Animal Feeding Operations (CAFO) livestock operations, and manure land applications to agricultural fields not covered by a CAFO permit. Some types of nonpoint sources contaminate surface water under specific weather conditions. Wet weather nonpoint sources are caused when rain or snowmelt carry pollutants off the land or out of unregulated drains and storm sewers, and into surface water. Impervious surfaces such as concrete roads and parking lots play a major role in delivering precipitation-driven phosphorus to surface waters, because water cannot readily penetrate below the ground surface. As indicated previously, urban area land use represents 30% of the watershed.

Because approximately 36% of the land area in the TMDL watershed is used for agriculture, farming operations can be potential nonpoint sources of phosphorus. Runoff from pastures and livestock operations can be potential agricultural sources of phosphorus. Livestock are animals that are bred and raised for human use, and include cattle, swine (hogs), poultry, horses, and more uncommon types (such as llamas, sheep, and goats). Animals grazing in pastures deposit manure directly upon the land surface. The manure is often concentrated near feeding and watering areas in the field or at stream access points. These areas can become compacted and barren of plant cover, increasing the possibility of erosion and contaminated runoff during storm events. Polluted runoff from livestock production areas and discharges from artificial drainages such as tiles are also potential sources of phosphorus to surface waters.

Any size of livestock operation directly adjacent to water bodies is more likely to create contamination issues. Livestock farms near water bodies are more likely to contaminate surface waters from barnyard or pasture runoff, particularly if animal pasture areas slope towards the water bodies without buffer vegetation or embankments to contain runoff. Larger animal feeding operations can generate more waste that requires storage, disposal, or land application; however, smaller farms, such as hobby horse farms and small farms, can also contaminate surface water if the pastures slope into adjacent water bodies, animals have direct access, or if manure is stockpiled upslope of a water body.

Land used for crop production can be a significant source of phosphorus. Crop land can accumulate phosphorus from the application of fertilizers (chemical and manure), decomposition of plant residue, wildlife excrement (waterfowl and terrestrial), and atmospheric deposition including wind erosion. Most nutrient loads from crop land is attributed to fertilizer application that exceeds plant growth requirements. Surface erosion from bare fields, nutrients carried through tile drain flow, and streambank erosion associated with the loss of vegetation or with increased flow rates in response to tile drainage are all potential sources of phosphorus delivered to Ford and Belleville Lakes. Manure fertilizer improperly applied to crop land can also be a source of phosphorus during runoff conditions that carry pollutants through surface or tile flow. In addition, manure applied adjacent to or across streams or ditches can be a source of phosphorus. There are currently no approved septage land application areas in the Huron River watershed, but only Livingston County has prohibited septage application at the county level.

The extensive urban/residential land use in the Middle Huron River watershed is also a potential source of phosphorus. As the amount of developed land in a watershed increases, the amount of impervious surface also increases. Impervious surfaces, such as roads and rooftops, do not allow storm water to infiltrate the ground, and thus increases runoff. The risk of surface water contamination increases as the amount of runoff increases, because the capture of pollutants by infiltration is lessened or eliminated prior to the discharge of the runoff into a surface water.

Spatial areas of high human population density near surface waters may be especially prone to contaminating surface waters through on-site septic systems failures, illicit connections, trash, and pet waste. When septic systems are not functioning properly, or are poorly designed, they can deliver phosphorus to nearby streams. The on-site septic system failure rate in Michigan is estimated to range between 10-24% (Barry-Eaton District Health Department, 2017). The incidence of failure is variable depending on geology and age of the septic system. Another potential, but undocumented, source of phosphorus could be illicit discharges from residential units.

Direct addition of phosphorus to the lakes also occurs through both internal loading of phosphorus from lake sediments and from precipitation. The load from precipitation was estimated using the loading rate of 0.156 pounds/acre/year (USEPA, 1974) and lakes areas of 975 and 1,247 acres (Michigan Department of Natural Resources, Institute of Fisheries Research, National Hydrography Dataset lake layer), for Ford and Belleville Lakes, respectively.

The internal load of phosphorus was estimated by assuming a sediment release rate of 8.68 milligram per square meter per day for 29% of the lake surface area, which is the proportion of the lake greater than 6 meters deep (Lehman, 2011).

The Long-Term Hydrologic Impact Assessment (L-THIA) Web-based software created and maintained by Purdue University (2017) was used to estimate phosphorus loads from the various land use types based on annual average runoff and 12-digit hydrologic unit code (HUC) watershed boundaries (Table 2). The phosphorus loads from the detailed land use/cover categories in the upper portion of Table 2 were aggregated to broad categories of urban, agriculture, and other land use/cover classes as presented in the summarized loads at the bottom of the Table and incorporated in Tables 3 and 4 in the current loads going to Ford and Belleville Lakes. The L-THIA loads were rounded or truncated due of model variability.

4. LOADING CAPACITY (LC) DEVELOPMENT

Under the regulatory framework for development of TMDLs, calculation of the LC for impaired segments identified on the Section 303(d) list is an important step. The USEPA's regulation defines LC as, *"the greatest amount of loading that a water can receive without violating water quality standards"* (40 CFR, Part 130.2[f]). The LC is the basis of the TMDL and provides a measure against which attainment with WQS will be evaluated. The LC also guides pollutant reduction efforts needed to bring a water into compliance with WQS.

The LC comprises the sum of individual waste load allocations (WLA) for point sources and load allocations (LA) for nonpoint sources and natural background levels. Federal and state regulations determine whether sources are point or nonpoint (WLA or LA); therefore, sources listed may be shifted from LA to WLA, or from WLA to LA, in the future. The allocation for the discharge of unpermitted, untreated sanitary wastewater (including leaking sanitary sewer systems, SSOs, and illicit connections) is zero and is not included in the LC.

In addition, the TMDL must include a Margin of Safety (MOS), either implicitly or explicitly, that accounts for uncertainty in the relationship between pollutant loads and the quality of the receiving water body. Conceptually, this definition is denoted by the equation:

Loading Capacity = ΣWLAs + ΣLAs + MOS

River systems with impoundments such as the Huron River experience greater phosphorus removal because of settling and burial of phosphorus and the longer water residence times. Bosch and Allan (2008) and Lehman (2016) have demonstrated nutrient retention occurs in the Huron River. There is also a withdrawal of water by the Ann Arbor WFP from Barton Pond, which can remove approximately 3,000 pounds of phosphorus a year. The amount of retention, combined with the water withdrawal, is estimated to be 26% of the load of phosphorus entering the TMDL watershed. This TMDL assumes that all sources of phosphorus are equally likely to be retained.

The phosphorus LC required to meet the concentration goal in Ford Lake is 27,000 pounds and is expected to be met if the phosphorus loading to the watershed from all sources is held to 36,500 pounds a year. This is equivalent to an average daily load of 100 pounds of phosphorus per day. The LC required to meet the concentration goal in Belleville Lake is 34,000 pounds of phosphorus per year or an average of 93 pounds of phosphorus per day. Tables 3 and 4 present the LCs for Ford and Belleville Lakes.

4.1. WLAs

All current and future NPDES permitted facilities discharging to the TMDL area are subject to the WLA. Table 1 lists the facilities that discharge phosphorus to Ford Lake or Belleville Lake. A WLA for the Ann Arbor WWTP, based on its current permit limit, exceeds the LC at the inlet of Ford Lake. Other significant WWTP, industrial, and MS4 dischargers are listed in Table 1. The WLA for Ford and Belleville Lakes is presented in Tables 3 and 4.

The focus of this TMDL is to achieve a July to September average total phosphorus concentration of 30 µg/L in Ford and Belleville Lakes. For this reason, the WLA requires large reductions in phosphorus loading to Ford Lake (Table 3). The WLA incorporates the permanent retention of 26% of the annual load for all facilities upstream of Ford Lake and sets individual WWTP WLAs to the lowest load that can be met consistently with current available treatment technology. Individual WLAs for each WWTP were set at the current design flow discharging 0.1 mg/L of total phosphorus. The MS4 permits have a WLA that requires a large reduction of phosphorus loads (Tables 3 and 4). This is a realistic expectation because of the local ordinance preventing the use of phosphorus containing lawn fertilizer in most instances and the work that the MS4 facilities have already carried out to reduce phosphorus loading.

4.2 LAs

LAs (Tables 3 and 4) have been identified for the Ford and Belleville Lakes TMDL to account for runoff from non-permitted sources of phosphorus in the watershed. These allocations are based on meeting the LC that will attain the 30 ug/L target in both lakes. It is assumed that 26% of the LA is retained in the channel and upstream impoundments, as previously described.

The current land-based phosphorus loads are modeled using L-THIA (Purdue University, 2017), which is not calibrated specifically for this watershed and may overestimate current loading. Using best practices, it is expected that the agricultural and urban land uses both in the TMDL watershed and upstream of the TMDL watershed can have significant phosphorus loading reductions. Internal load is expected to go down gradually in both lakes as the external load decreases. The long-term solution to reduce internal loading is the control of phosphorus entering the lake, and that premise serves as the basis for this TMDL. All of the phosphorus in the surface sediments in both lakes originated as external load. If local stakeholders successfully manage the lakes to maintain adequate oxygen levels at the bottom of Ford Lake, that will contribute to a more immediate reduction in algal blooms that are caused by anoxic hypolimnetic phosphorus releases. The other land cover category includes a variety of types of forests and wetlands. Along with precipitation, these areas are not expected to have reductions in phosphorus loading.

4.3 MOS

Section 303(d) of the Clean Water Act and USEPA's regulations at 40 CFR, Part 130.7, require that *"TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numeric water quality standards with seasonal variations and a margin of safety (MOS) which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality."* The MOS can either be implicitly incorporated into conservative assumptions used to develop the TMDL or added as a separate explicit component of the TMDL (USEPA, 1991). The MOS is used, in part, to account for variability in source inputs to the system, or lack of knowledge concerning the relationship between pollutant loading and water quality.

For Ford Lake this TMDL uses an implicit MOS to develop the target loads. In total phosphorus TMDLs the MOS often is implicit because the quality of the algal and plant communities represents an integration of the effects of spatial and temporal variability in nutrient loads to the aquatic environment. This TMDL moves from using growing season load to meet WQS to an annual load even though some portion of the phosphorus likely moves through the lakes and does not have the opportunity to impact algal productivity. We did not explicitly account for this loss of phosphorus and are using it as an implicit MOS. For Belleville Lake this TMDL uses an explicit MOS because the major reduction in phosphorus needed from Ford Lake may take a decade or more to achieve. For Belleville Lake an explicit MOS will ensure that Belleville Lake is closer to meeting WQS even if the load from Ford Lake is reduced slowly.

The phosphorus load reduction to Ford Lake from the previous TMDL is significant and conservative. Assigning a 30 ug/L phosphorus concentration goal to Ford Lake, versus a 50 ug/L goal for water entering Ford Lake, led to an annual load goal that is similar to the 6-month goal in the 2004 TMDL. This large reduction is conservative and justifies the use of the implicit MOS for Ford Lake. The majority of the phosphorus load to Belleville Lake comes from Ford Lake. In the 2004 TMDL, Belleville Lake had a phosphorus concentration goal, but did not have an LC developed. We have less information to track changes in loading into Belleville Lake over time and because this is a new LC for the lake, we incorporated an explicate MOS to be conservative.

4.4 Seasonal Variation

TMDLs must consider critical conditions and seasonal variation for streamflow, loading, and water quality parameters. The critical condition is the set of environmental conditions for which controls designed to protect water quality will ensure attainment of WQS for all other conditions. The intent of this requirement is to ensure protection of water quality in water bodies during periods when they are most vulnerable.

The previous versions of this TMDL established phosphorus loading targets during the growing season (April-September) under the rationale that excessive phosphorus levels are expressed via algal blooms. This revised TMDL establishes annual loading targets rather than seasonal targets for two reasons. First, in recent years it is not unusual for EGLE-WRD to receive reports of heavy algal blooms in southern Michigan lakes in October and even November. Under current climate projections, one can reasonably expect that the algal growing season will increase into the future. Second, the small impoundments upstream of Ford Lake in the TMDL watershed cause longer water residence times, phosphorus removal, and increased seasonal variability in the timing of nutrient export (Bosch et. al, 2009). We are not confident that all of the phosphorus discharged upstream of Ford and Belleville Lakes in the winter months passes through the lakes prior to the growing season. Some of that phosphorus settles into bottom sediments for some period of time, and cycles through the aquatic ecosystem over several months. In fact, our LAs take into account that phosphorus will settle out or be taken up as it moves downstream. Bosch et. al (2009) specifically notes the need to consider the entire annual phosphorus cycle when estimating nutrient dynamics or management plans in the Huron River watershed. Some nutrients discharged in the winter likely enter Ford and Belleville Lakes during the growing season. Therefore, we have chosen to establish an annual phosphorus load in this TMDL rather than seasonal loads.

5. REASONABLE ASSURANCE ACTIVITIES

The Ford and Belleville Lakes watershed includes both point and nonpoint sources. Point source discharges are regulated through NPDES permits, and necessary pollutant reduction from point sources can be achieved through the NPDES permit process. The USEPA's 1991

TMDL guidance states that the TMDL should provide reasonable assurances that the implementation of nonpoint source control measures will achieve expected load reductions. To that end, EGLE coordinates with organizations and programs that have an important role or can provide assistance for meeting the goals and recommendations of this TMDL. Efforts specific to the Middle Huron River watershed are described below.

5.1 NPDES

The facilities identified in Table 1 are required to meet their NPDES permit limits. As described in the Source Assessment section above, NPDES permits are reissued every five years on a rotating schedule, and the requirements within the permits may also change at reissuance. Pursuant to R 323.1207(1)(b)(ii) and 40 CFR, Part 130.7, NPDES permits issued or reissued to facilities discharging to impaired waters after the approval of this TMDL are required to be consistent with the goals of this TMDL as provided in the WLA in Section 4.1. The WLA calls for reductions in phosphorus loadings from several of the facilities holding individual permits, which will be addressed when each permit is scheduled for reissuance.

The MS4 permits require permittees to identify and prioritize actions to be consistent with the requirements and assumptions of the TMDL. Through prioritizing TMDL actions, the permittees are able to focus their efforts, which will help to make progress towards reducing phosphorus loads. For example, MS4s in the Middle Huron River watershed are working toward improved controls on sediment runoff and soil erosion from construction sites, which will have an ancillary benefit of reducing phosphorus inputs in surface waters. The MS4s also have prioritized the elimination of illicit discharges. MS4s implement and benefit from many of the same items described below for nonpoint source reductions, including the reduction of phosphorus loading from the legislative ban of the use of fertilizer containing phosphorus. For both MS4 permittees and nonpoint source reduction tracking, monitoring data collected at different locations throughout the watershed can be used to identify sources of phosphorus that can be targeted for reductions, and used as site-specific data to track progress on nutrient reduction.

The COCs for the general industrial storm water permit (MIS310000) listed in Table 1, specify that facilities need to obtain a certified operator who will supervise the control structures at the facility, eliminate any unauthorized non-storm water discharges, and develop and implement the Storm Water Pollution Prevention Plan (SWPPP) for the facility. The permittee shall determine whether its facility discharges storm water to a water body for which EGLE has established a TMDL. If so, the permittee shall assess whether the TMDL requirements for the facility's discharge are being met through the existing SWPPP controls or whether additional control measures are necessary. The permittee's assessment of whether the TMDL requirements are being met shall focus on the effectiveness, adequacy, and implementation of the permittee's SWPPP controls. The applicable TMDLs will be identified in the COC issued under this permit.

SSOs are illegal events, and EGLE will continue to take appropriate actions when they are reported. The Ann Arbor WWTP has had some SSO occurrences in recent years, primarily due to pipe blockages, which were reported and corrected to EGLE's satisfaction.

5.2 Nonpoint Sources

Nonpoint source reductions are typically voluntary, and funding is available to help implement these reductions. To facilitate this, EGLE has a Nonpoint Source Program that focuses on the voluntary aspects of pollution reduction. The basis of the program is watershed management planning and working with local stakeholders to solve problems. The purpose of a WMP is to identify stakeholders' concerns, find problems, assign responsibility for and prioritize actions to achieve water quality goals. The USEPA requires that WMPs meet nine major elements and be approved by EGLE for work described in the plan to be funded by Clean Water Act Section 319 funding. Assigning responsibility for priority actions identified in the WMP (i.e., who does what) is key to the success of the plan. A WMP for the Middle Huron River area was completed in 2011, which identified priority areas and sources and served as the basis for many implementation activities. The Huron River Watershed Council received a Nonpoint Source grant from EGLE in 2017 to revise the existing WMP, which will be completed in the near future. We expect the updated WMP will continue to drive water quality improvement by the Middle Huron Partners through enhanced nonpoint implementation projects.

Since 2009, the Huron River Watershed Council and other local entities in the Huron River watershed have received 13 grants for a variety of planning, monitoring, and nonpoint source pollution reduction activities. Projects have included detection/correction of failing septic systems; bacteria/pathogen reduction; green infrastructure; rain gardens; sediment reduction; and TMDL planning. We expect the updated WMP to result in additional implementation projects that will lead to reductions in phosphorus loads to Ford and Belleville Lakes.

The Phosphorus Reduction Implementation Plan for the Middle Huron River watershed (Middle Huron Initiative, 2011) identified a number of priority activities for the 2012-2016 time frame to reduce phosphorus loadings. Projects included:

- Priority agricultural Best Management Practices from the Mill Creek Subwatershed Management Plan.
- Malletts Creek Restoration Plan activities.
- Items from the Millers Creek Watershed Improvement Plan.
- Local and state ordinances to reduce phosphorus in fertilizer.
- Point source improvements.
- Construction site runoff control.
- Public education.
- Septic inspection and repair.
- Illicit discharge elimination.
- Street sweeping.

Partnering with other agencies as part of the Mill Creek Subwatershed Management Plan, the Huron River Watershed Council has worked with local farmers to adopt conservation practices on more than 2,600 acres in the Middle Huron watershed. There is an ongoing payment plan (Whole Farms for Clean Water) to pay farmers who implement long-term conservation approaches to reduce phosphorus runoff. Mill Creek, Honey Creek, Boyden Creek, and Fleming Creek in the TMDL watershed area are eligible for this funding. Farms in the Portage Creek watershed just upstream of the TMDL watershed are also eligible.

Many projects designed to manage storm water and reduce nutrient loading have been implemented in the Middle Huron. Mill Creek has also had stream bank stabilization projects implemented on two sections of eroding banks. In Millers Creek, an urbanized subwatershed, a project was developed to educate locals on storm water runoff, which led to reductions in peak flows during storm events. In another urbanized watershed, Malletts Creek, a 5-acre in-stream detention facility was converted to an 11-acre wetland adjacent to the stream to reduce phosphorus loading.

More detailed descriptions of these activities are provided in the Implementation Plan or at www.mi.gov/nps. Some of these projects have been implemented through the Clean Water Act

Section 319 nonpoint source grants mentioned above, as well as through other funding sources. We expect that the partners to the Middle Huron Initiative will continue to make progress on the remaining activities.

Funding for nonpoint source activities is available on a competitive basis through Clean Michigan Initiative and federal Clean Water Act Section 319 grants for TMDL implementation and watershed planning and management activities (www.michigan.gov/nps). Grants or loans for sewage treatment and storm water planning and infrastructure may be available to eligible organizations through the Storm Water, Asset Management, and Wastewater Program (for more information, go to www.michigan.gov/egle and search for "SAW").

Vegetated riparian buffer strips wide enough to trap sediment have been shown to reduce the phosphorus in runoff (Coyne et al., 1998 and Lim et al., 1998). EGLE staff will continue to promote the maintenance and installation of vegetated riparian buffers in this watershed through grants issued using federal Clean Water Act Section 319 grants.

Animal feeding operations with direct animal access to TMDL water bodies, or with obvious runoff potential, are reported to the Michigan Department of Agriculture and Rural Development (MDARD), pursuant to Michigan's Right to Farm Act (Section 286.474, Michigan Compiled Laws, Public Act 93 of 1981). A Memorandum of Understanding between EGLE and MDARD specifies that MDARD staff will investigate these complaints.

State legislation was passed in 2012 that bans the use and application in Michigan of fertilizer containing phosphorus in most circumstances. This legislation eliminated a significant source of phosphorus and will continue to contribute to reduction in phosphorus runoff to surface waters.

Unpermitted discharges of pollutants to waters of the state (illicit connections), whether direct or indirect, are illegal in the state of Michigan. Section 3109(1) of Part 31 states that a person shall not directly or indirectly discharge into the waters of the state a substance that is or may become injurious to public health, safety, or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other uses that may be made of such waters. Section 3109(2) further specifically prohibits the discharge of raw sewage of human origin, directly or indirectly, into any of the waters of the state. The municipality in which that discharge originates is responsible for the violation, unless the discharge is regulated by an NPDES permit issued to another party. The elimination of illicit discharges of raw human sewage to the TMDL water body will significantly improve water quality by removing a public health threat and a source of phosphorus.

The Michigan Agriculture Environmental Assurance Program is a voluntary program established by Michigan law (Section 324.3109[d] of Part 31) to minimize the environmental risk of farms, and to promote the adherence to Right to Farm Generally Accepted Agricultural Management Practices, also known as GAAMPs. For a farm to earn Michigan Agriculture Environmental Assurance Program verification, the operator must demonstrate that they are meeting the requirements geared toward reducing contamination of ground and surface water, as well as the air. Livestock*a*Syst is the portion of the Michigan Agriculture Environmental Assurance Program verification process that holds the most promise for protecting waters of the state from contamination by phosphorus, which includes steps to promote the separation of contaminated storm water from clean storm water at the farm site; the completion of a nutrient management plan similar to that required by NPDES permitted CAFOs; runoff control at feedlots and the identification of environmentally sensitive areas; the prevention of manure reaching tile lines; and controlling contamination of runoff through incorporation on land application fields.

EGLE endorses the use of its Landscape Level Wetland Functional Assessment (LLWFA) tool as a means to prioritize areas for wetland restoration and protection. Michigan's LLWFA methodology identifies historically lost wetlands, determines the functions they once provided, and helps to prioritize wetlands for restoration to obtain the most significant water quality improvements. Wetland restoration has the potential to decrease phosphorus concentrations in contaminated runoff by increasing the filtration provided by sediment and vegetation (Knox et al., 2008). Riparian wetlands (located between uplands and lakes/streams) with high amounts of emergent vegetation (such as wet meadows and emergent marsh) have the most potential to decrease phosphorus in runoff.

Failing or poorly designed septic systems are likely a source of nutrients, including phosphorus, to unsewered areas. Michigan has no unified statewide sanitary code and no centralized regulatory authority over septic systems (Sacks and Falardeau, 2004). Instead, Michigan regulatory code (Section 2435 of the Public Health Code, 1978 PA 368, as amended) gives local district health departments the authority to "adopt regulations to properly safeguard the public health and to prevent the spread of diseases and sources of contamination." The state of Michigan does issue design criteria for septic systems that are utilized by more than two homes and discharge 1,000-10,000 gallons per day (Michigan Department of Public Health, 1994). For systems that discharge less than 1,000 gallons per day, the system must be approved by the local health department in accordance with local sanitary code (R 323.2210 of the Part 22 Rules). Local health departments must be accredited by the state in a process that involves evaluation of the local departments every three years. Additionally, adopted sanitary codes must meet minimum measures proscribed by the state of Michigan.

Washtenaw and Wayne Counties operate Time-of-Sale septic system inspection programs, which require that septic systems are functioning properly each time property is sold. Homeowners who are selling their house hire an inspector certified by Washtenaw or Wayne County to carry out the inspection. More details can be found at https://www.washtenaw.org/1727/Time-of-Sale-Program-TOS or https://www.waynecounty.com/departments/hvcw/wellness/septic-onsite-sewage.aspx. The adoption of a statewide sanitary code that requires time-of-sale inspection of on-site septic systems would add additional protection of water quality to areas without local ordinances.

5.3 Potential Stakeholders

Potential stakeholders in the TMDL process have been identified and could potentially serve as partners in implementation efforts. These include:

- Conservation Districts, Drain and Road Commissions, and Environmental Health Departments for Washtenaw and Livingston Counties.
- The cities in the watershed, including Ann Arbor, Belleville, Chelsea, Dexter, and Ypsilanti.
- The Townships of Ann Arbor, Northfield, Pittsfield, Superior, and Ypsilanti.
- The University of Michigan.
- EGLE and MDARD.
- Farm Bureau.
- Huron River Watershed Council.
- NPDES permittees.

6. FUTURE MONITORING

EGLE will continue to monitor Ford and Belleville Lakes, as well as two stations on the Huron River, every other year (even years) from April through September. Additional sampling in the Middle Huron River watershed may be conducted as part of the five-year rotating basin monitoring, as resources allow, to better identify potential sources and track improvements over time. Future data collected by EGLE will be accessible to the public through the EGLE Monitoring Web page at www.michigan.gov/waterquality.

In addition, we expect that Huron River and tributary monitoring conducted by the organizations and municipalities in the Middle Huron River watershed (described in the Data Discussion) also will continue in the future. Therefore, data will continue to be collected on a regular basis in, and upstream of, Ford and Belleville Lakes, to track progress on meeting the goals of this TMDL.

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Table 1. Individual NPDES permitted facilities discharging to the source watershed of the TMDL.

Category	Sub-category	Permit Name	Permit Number	Notes
NPDES Individual Permit	NPDES Individual Permit (13)	Ann Arbor WWTP	MI0022217	Major
		Chelsea WWTP	MI0020737	Major
		Chrysler-Chelsea Proving Grds	MI0046540	Major
		Dexter WWTP	MI0022829	Major
		Loch Alpine SA-Scio-Web WWTP	MI0024066	Major
		Sweepster-Harley Attachments	MI0045934	
		Thetford/Norcold-Dexter	MI0036951	
		Thornton Farms WWTP	MI0056405	
		Ann Arbor MS4	MI0053856	
		RACER-Powertrain-Willow Run	MI0043702	Belleville Lake
		Wayne Disposal Inc LF	MI0056413	Belleville Lake
		YCUA Regional WWTP (Emergency Outfall 003)	MI0042676	Belleville Lake
NPDES COC under General Permit	MS4	Ann Arbor PS MS4-Washtenaw	MIS040016	
		Barton Hills MS4-Washtenaw	MIS040025	
		Belleville MS4-Wayne	MIG610375	
		Dexter MS4-Washtenaw	MIS040022	
		Pittsfield Twp MS4-Washtenaw	MIS040021	
		UM MS4	MI0053902	
		VA Hosp MS4-Washtenaw	MIS040071	
		Van Buren PS MS4-Wayne	MIS040011	
		Van Buren Twp MS4-Wayne	MIG610021	
		Washtenaw Co MS4-Washtenaw	MIG610039	
		Washtenaw Comm College MS4	ACO-SW11-008	
		Washtenaw CRC MS4	MIG610314	
		Ypsilanti MS4-Washtenaw	MIS040015	
		Ypsilanti PS MS4-Washtenaw	ACO-SW11-011	
		Ypsilanti Twp MS4-Washtenaw	MIG610037	
		MDOT-MS4	MI0057364	
NPDES COC under General Permit	Noncontact Cooling Water (4)	Bell Tower Hotel	MIG250498	**

Category	Sub-category	Permit Name	Permit Number	Notes
		CECO-Freedom Compressor Sta	MIG250511	**
		Federal Mogul Corp-Sealing Sys	MIG250421	**
		UM Power Plant	MIG250333	Source water is from Ann Arbor WFP.
	Petroleum Contaminated Wastewater	Sunoco-Ypsilanti #0016-5688	MIG081222	**
	Public Swimming Pool Wastewater (17)	Annex Apartments Pool - Ann Arbor	MIG760039	**
		Foundry Lofts	MIG760030	**
		Hampton Inn & Suites	MIG760032	**
		Hilton Garden Inn	MIG760020	**
		Hyatt Place	MIG760035	**
		LA Fitness Maple Village Ann Arbor	MIG760041	**
		Marriott TownePlace Suites	MIG760021	**
		Mill Creek One-Mill Creek Apt	MIG760027	**
		Orchard Hills AC-Dolphin Pool	MIG760034	**
		Orchard Hills AC-Yorktown Pool	MIG760033	**
		PSAA-Packard Sq Pool - Ann Arbor	MIG760042	**
		Residence Inn-Ann Arbor	MIG760026	**
		Staybridge Suites Pool - Ann Arbor	MIG760038	**
		Traverwood-Oakcliff Apt Pool	MIG760028	**
		UMRC Wellness Center Pool-Chelsea	MIG760036	**
		Webers Inn	MIG760018	**
		615 S. Main - Ann Arbor	MIG760043	**
	SW-Industrial CY4 (33)	A-1 Auto Salvage & Scrap	MIS410624	**
		Abrasive Finishing Inc	MIS410605	**
		Alco Manufacturing Corporation	MIS410058	**
		Alpha Packaging MI Inc	MIS410051	**
		Ann Arbor MRF	MIS410029	**
		Ann Arbor Trans Authority	MIS410056	**
		AVL Powertrain Engineering	MIS410604	**
		Barrett Paving Mtls-Ann Arbor	MIS410054	**
		Bell Induction Heat-Belleville	MIS410210	**
		Bottcher America Inc	MIS410018	**

Category	Sub-category	Permit Name	Permit Number	Notes
		Cadillac Asphalt-Belleville	MIS410138	**
		Chelsea Milling Company	MIS410517	**
		Dexter Fastener Technologies	MIS410776	**
		Durham School Services - Ann Arbor	MIS410771	**
		Durham School Services - Ypsilanti	MIS410774	**
		Fendt Builders-Ann Arbor	MIS410059	**
		Ford-Rawsonville Plt	MIS410057	**
		Frame Hardwoods Inc	MIS410593	**
		Frito-Lay-Ann Arbor Bin	MIS410769	**
		Gestamp-Chelsea	MIS410801	**
		Hardwood Solutions Inc	MIS410623	**
		Hatch Stamping Co-Chelsea	MIS410024	**
		Marsh Plating Corp-Ypsilanti	MIS410025	**
		R & L Carriers-Ypsilanti	MIS410590	**
		Razorback Metals LLC	MIS410674	**
		Recycle Ann Arbor	MIS410752	**
		Sheridan Books-Chelsea	MIS410391	**
		Stoneco of Michigan-Manchester	MIS410306	**
		Superior Materials Plt 38	MIS410484	**
		Thetford Corp-Ann Arbor	MIS410357	**
		Thomson Shore Inc	MIS410622	**
		WA Thomas-Chelsea	MIS410278	**
		WTPS Willis Terminal	MIS410711	**
	Wastewater Discharge from Potable Water Supply (2)	Ann Arbor WFP	MIG640207	
		Dexter WFP	MIG640205	**
NPDES Construction Storm Water Notice of Coverage (NOC)		81-16195 Old US 12-Chelsea		**
		Arbor Research Collab for Health-Washtenaw Co		**

Category	Sub-category	Permit Name	Permit Number	Notes
		Ann Arbor-Apex-Phoenix 120-kV Underground Trans Proj		**
		Arbor Research Collab for Health-Washtenaw Co		**
		Belleville Dev-Wayne Co		**
		Beztak Land-All Seasons of Ann Arbor		**
		Beztak-Uptown of Ann Arbor		**
		BRE-The Annex Apt Comm		**
		CECO-Freedom Compressor Sta		**
		Concordia Lutheran Junior College		**
		Dexter Comm Sch-New Elementary		**
		Dexter HS Turf Fields-Washtenaw Co		**
		Dexter-Creekside Inter Quad Flds		**
		Dominos Farms O&R Annex		**
		DTE-Chelsea Gas Pipeline Ext		**
		HC-Honey Creek Subd		**
		HunterPasteur Homes Arbor Ch		**
		Kaiser Optical Systems-Washtenaw		**
		Kensington Woods-Washtenaw Co		**
		Menards-Van Buren-Wayne Co		**
		MMB-Grandview Commons		**
		Morningside-1200 Broadway St		**
		Pulte-North Sky		**
		Rover Pipeline Project-SE Mich		**
		SE Mich Land-Northbrooke South		**
		Suburban Chrysler Dodge Jeep Ram Site Plan		**
		Toll Bros-Nixon North		**
		Toll Bros-Nixon South		**
NPDES Construction Storm Water Notice of Coverage (NOC)		Trailwoods Ph 2V-Washtenaw Co		**
		U of M-Athletic S Competition		**

Category	Sub-category	Permit Name	Permit Number	Notes
		U-M-NC-53 Parking Lot Recon-Washtenaw Co		**
		UM-Parking Lot NC92 Recon		**
		Washtenaw CRC-Harris Rd		**
		Webster Prop-Arlington Woods		**
		Webster Prop-Arlington Woods		**
Groundwater				
	Rule 2210(y) Authorization	Humane Society of Huron Valley	GW1110343	##
	Rule 2211 Authorization	Industrial Services Inc	GW1110710	##
		MDOT-Chelsea Rest Area	GW1110169	##
		Northbrooke	GW1110680	##
		Reserve at Northbrooke	GW1110757	##
		Sisters of Mary Motherhouse	GW1110435	##
		Univ of Michigan Power Washer	GW1110289	##
	Rule 2215 Authorization	Dexter Community Schools-Tra	GW1520020	##
		Stoneco of Michigan-Manchester	GW1540047	##
		Stoneco-Zeeb Rd West	GW1540054	##
	Rule 2216 Authorization	Oak Ridge Estates-Arbor Height	GW1610018	##

** Not a source of phosphorus.
Groundwater discharges do not discharge to surface waters of the state.

Table 2. L-THIA Annual Phosphorus Loads by Land-Use/Cover Type

Land use/cover	Ford Lake TMDL Watershed	Belleville 12 Digit HUC Watershed
Barren Land	78	0.0
Commercial/Industrial/Transportation	2338	31
Cropland generalized agriculture	19523	468
Deciduous Forest	29	787
Emergent Wetlands (marsh)	0.0	536
Evergreen Forest	0.3	0.7
Grassland; Herbaceous	18	0.6
High-density Residential (townhomes to 1/4 ac lots)	5537	0.0
Low-Density Residential (general 1/3 - 2 ac lots)	4369	0.0
Mixed Forest	0.3	0.0
Open Space/Park	333	0.6
Open Water	0.0	0.8
Pasture/Hay	439	63
Shrub; Scrub	0.3	0.0
Woody Wetlands (swamp)	0.0	0.0
Total	32665	1887
Summarized Loads		
Urban (Total)	12244	1791
Urban-LA*	3061	0
Urban-WLA*	9183	179
Agriculture	19962	64
Other (non-urban;non-agriculture)	459	33

*Partitioning urban phosphorus load between LA and WLA (MS4): In the Ford Lake TMDL watershed 75% of urban land use is currently in an MS4 permit (unpublished GIS analysis). In the 12-digit HUC watershed draining to Belleville Lake all of the urban land use is in an MS4 permit.

Table 3. Ford Lake Loading Capacity.

	Permit Number	Current Load lbs/yr	TMDL Goal lbs/yr	TMDL Goal lbs/day
LA				
Huron River upstream of Bell Road/TMDL watershed		19000	15000	41.1
Urban		3000	800	2.2
Agriculture		19000	7000	19.2
Other		500	500	1.4
Internal Load		2000	480	1.3
Precipitation/Deposition		130	130	0.4
LA Total		43630	23910	65.5
TMDL WLA				
WWTP				
Ann Arbor WWTP	MI0022217	22000	8980	24.6
Chelsea WWTP	MI0020737	600	560	1.5
Dexter WWTP	MI0022829	270	180	0.5
Loch Alpine SA-Scio-WEB WWTP	MI0024066	510	95	0.3
Thornton Farms WWTP	MI0056405	200	45	0.1
Other				
Chrysler-Chelsea Proving Grds	MI0046540	40	40	0.1
Sweepster Harley Attachments	MI0045934	100	100	0.3
Thetford/Norcold-Dexter	MI0036951	40	40	0.1
UM Power Plant	MIG250333	20	20	0.1
Ann Arbor WFP	MIG640207	30	30	0.1
Aggregate MS4	(See Table 1)	9180	2500	7
WLA Total		32990	12590	34
Margin of Safety			Implicit (0)	
Total Load		76620	36500	100

Table 4. Belleville Lake Loading Capacity.

	Permit Number	Current Load lbs/yr	TMDL Goal lbs/yr	TMDL Goal lbs/day
LA				
Ford Lake Load		50000	27000	74.0
Agriculture		100	100	0.3
Other		100	100	0.3
Internal Load		1600	400	1.1
Precipitation		200	200	0.5
Total		52000	27800	76.2
WLA				
MS4		1800	600	1.7
RACER-Powertrain-Willow Run	MI0043702	100	100	0.3
Wayne Disposal Inc LF	MI0056413	200	200	0.6
YCUA Regional WWTP (Emergency Outfall 003)*	MI0042676	0	0	0
Total		2100	900	2.6
MOS			5300	14.2
Total Load		54100	34000	93

* YUCA Regional WWTP Outfall 003 discharges to Belleville Lake, but is only authorized for emergency use and is not allocated a load in this phosphorus TMDL.

Figure 1. Total phosphorous (µg/L) concentrations in Belleville Lake, 1994-1999, 2001-2006, 2009, 2012, 2014, 2016, and 2018. Horizontal red line indicates the 30 µg/L total phosphorous goal established for this site in the 1996 phosphorous TMDL for Ford and Belleville Lakes.

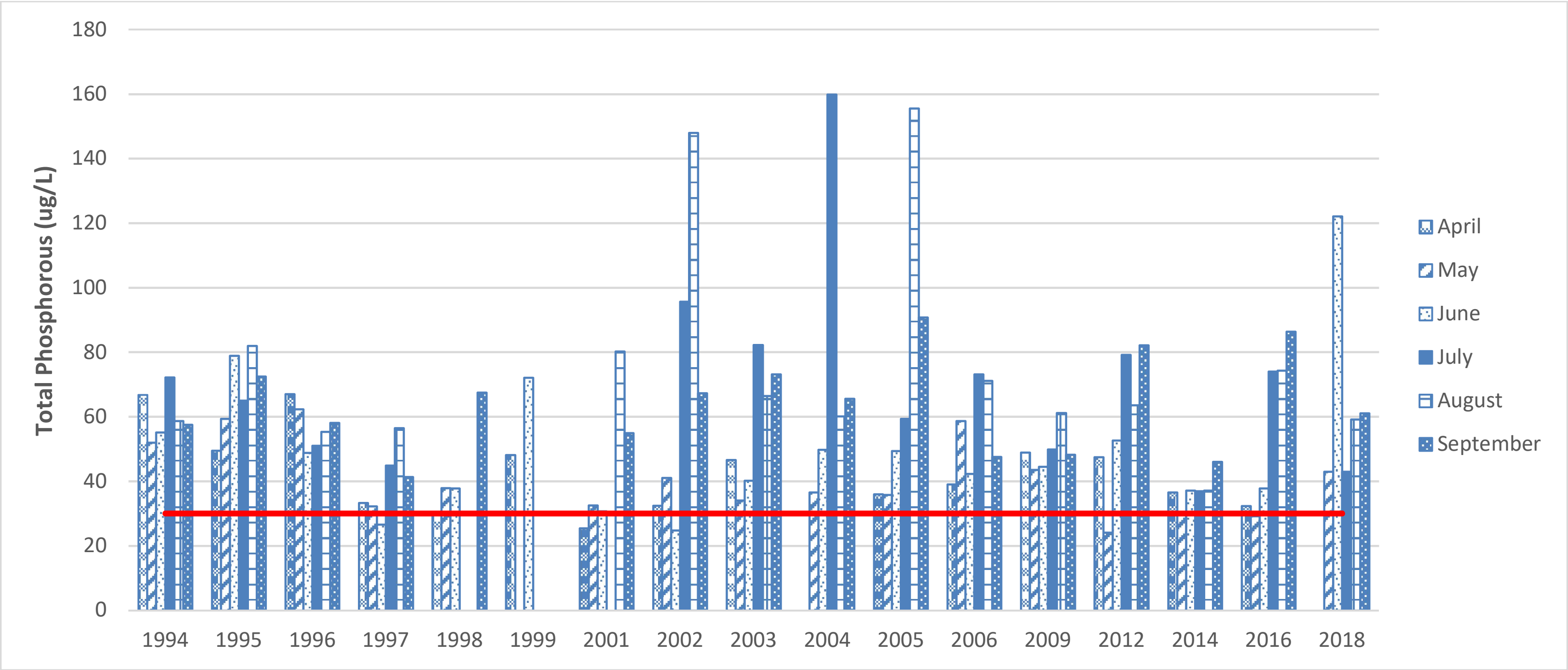


Figure 2. Mean total phosphorous (µg/L) concentrations in Belleville Lake, 1994-1999, 2001-2006, 2009, 2012, 2014, 2016, and 2018. Horizontal red line indicates the 30 µg/L total phosphorous goal established for this site in the 1996 phosphorous TMDL for Ford and Belleville Lakes. Error bars represent standard error of the mean.

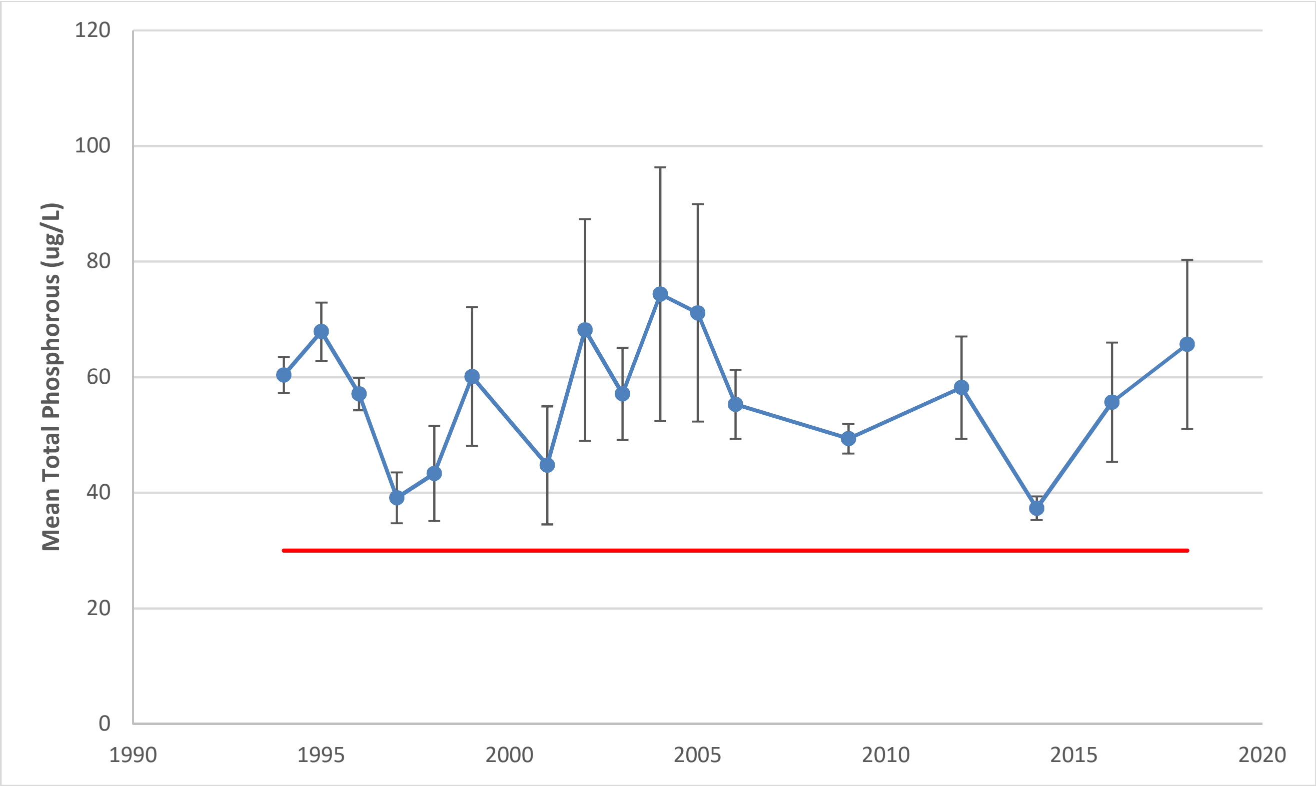


Figure 3. Land use in the Middle Huron River watershed.

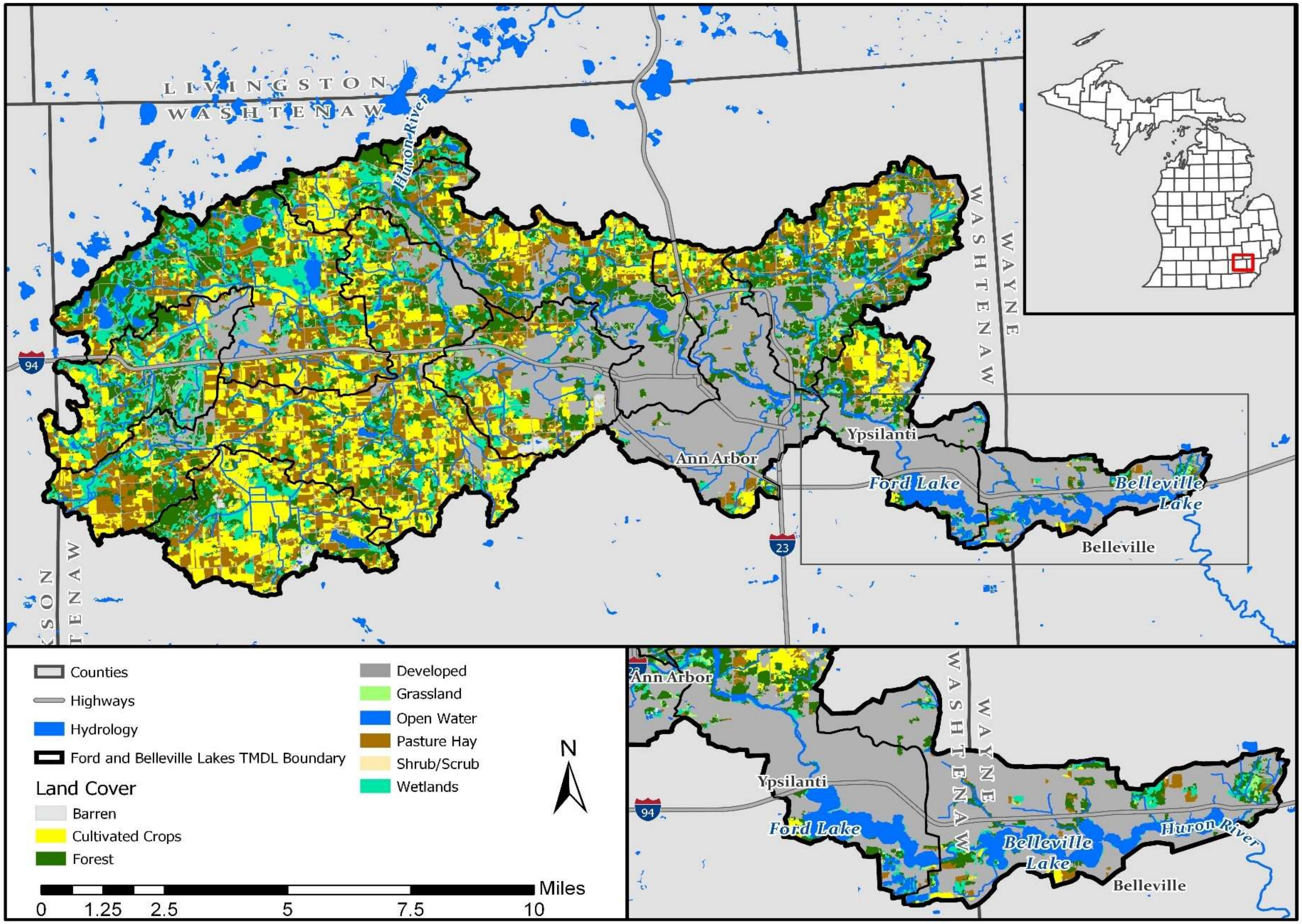


Figure 4. Sampling locations in the Huron River and in Ford and Belleville Lakes, Washtenaw and Wayne Counties, Michigan.

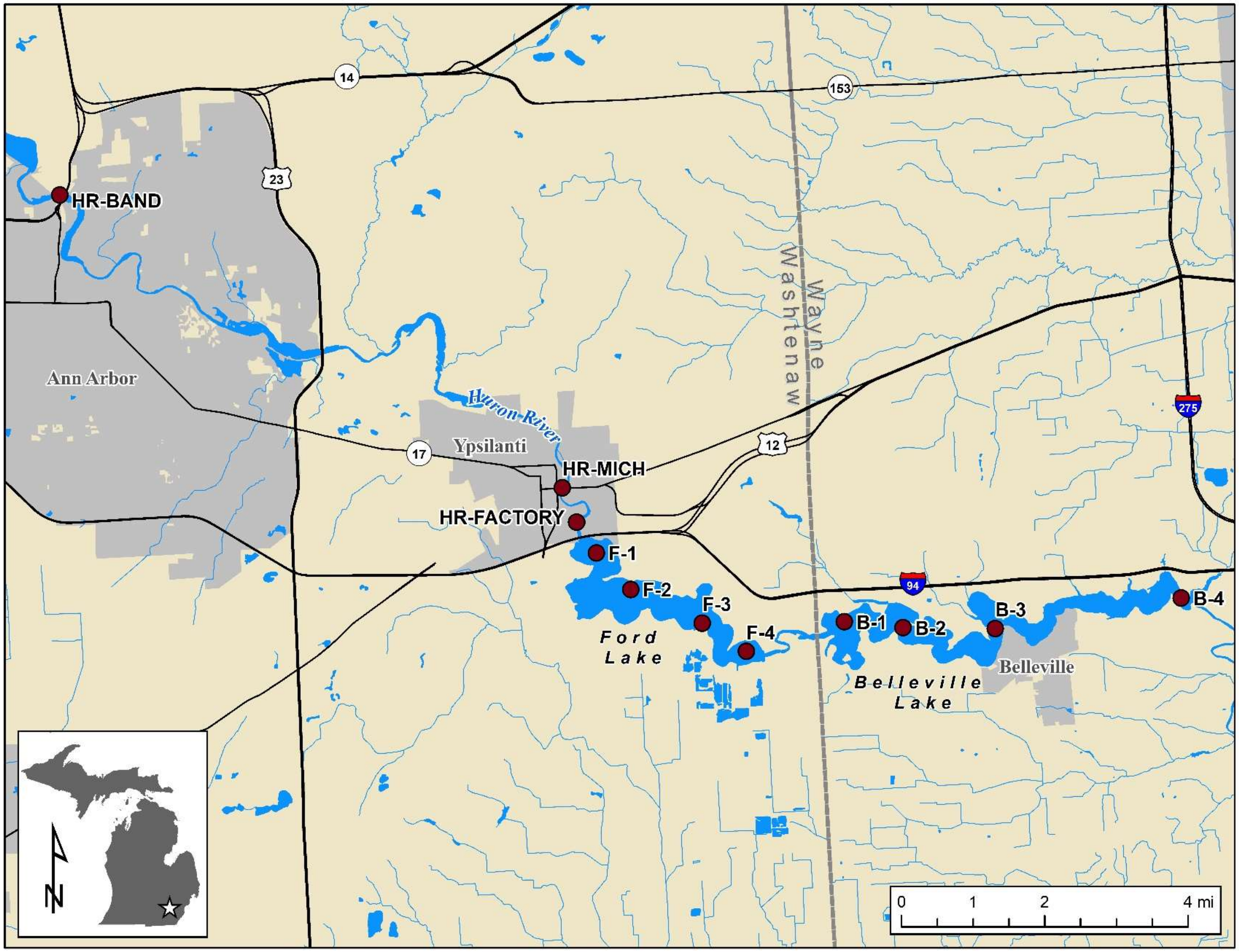


Figure 5. Total phosphorous (µg/L) concentrations in Ford, 1994-1999, 2001-2006, 2009, 2012, 2014, 2016, and 2018.

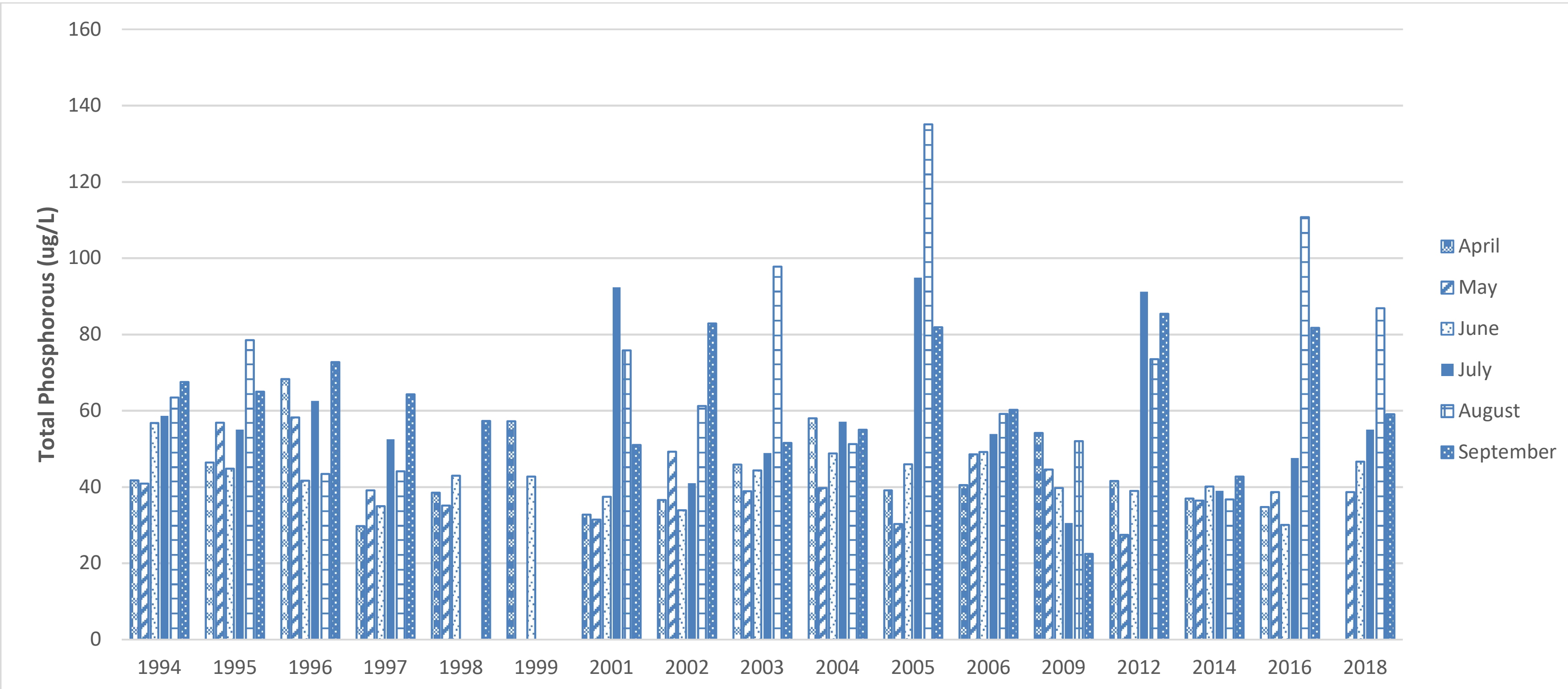
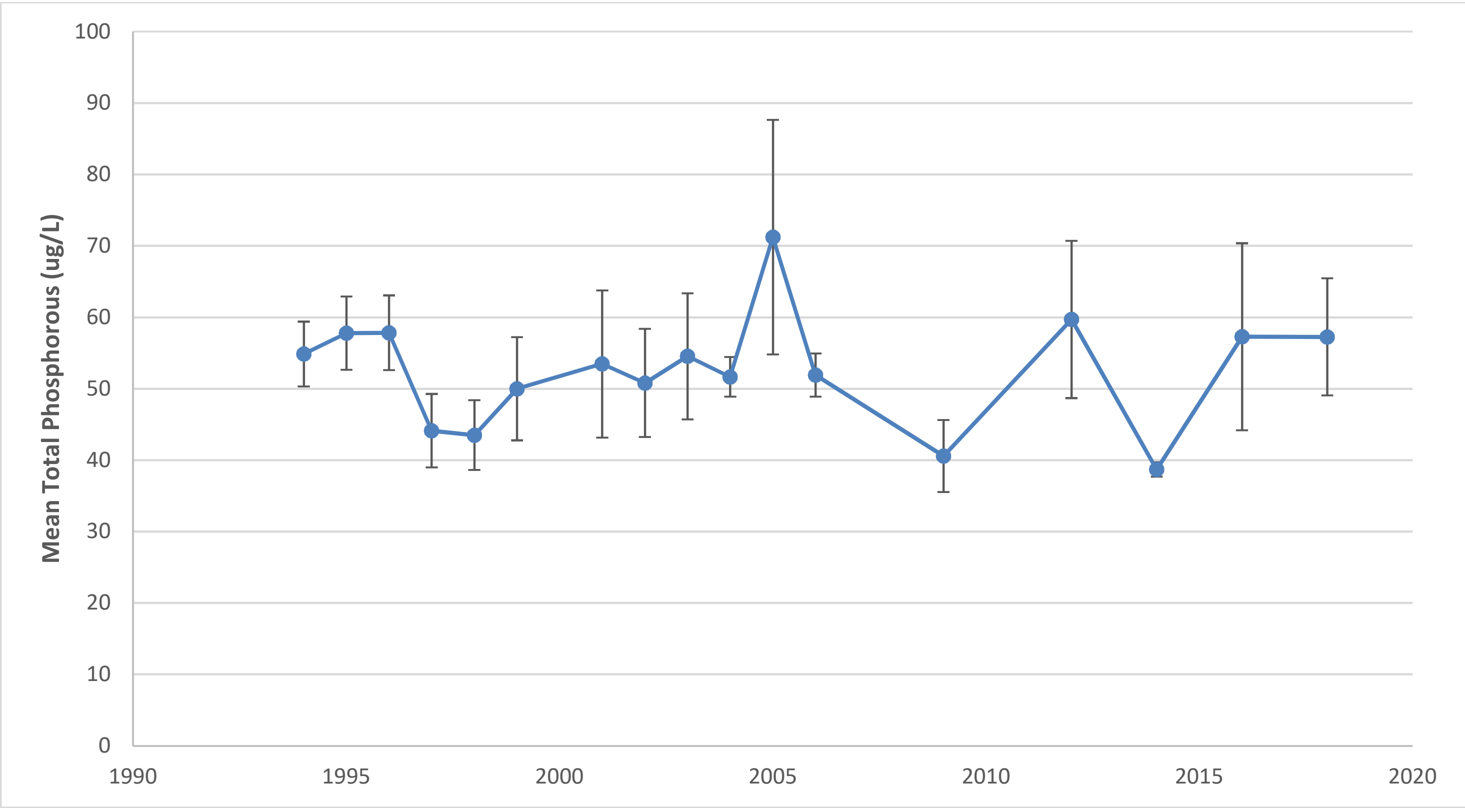


Figure 6. Mean total phosphorous (µg/L) concentrations in Ford Lake, 1994-1999, 2001-2006, 2009, 2012, 2014, 2016, and 2018. Error bars represent standard error of the mean.



Appendix 1.

Lake Models and Model Parameters

The following lake models were used to predict lake phosphorus concentrations based on external phosphorus loads. EGLE has used these models in other lake or reservoir phosphorus TMDLs.

Walker (1977)
P = (L*T/z)*(1/(1+0.824*T^0.454))

Reckhow (1979)
Anoxic Lake Model
P = L/((0.17*z)+1.13*(z/T))

P = in-lake phosphorus concentration
L = annual phosphorus loading (g/m^2/yr)
T = hydraulic retention time (years)
Z = mean lake depth (meters)

Lake specific data used in TMDL calculations:

	Ford Lake	Belleville Lake
Z (m)	4.7	3.8
area (m2)	3941640	5046430
volume (m3)	18525708	19176434
50% flow (cfs)	370	370
Flow (m3/yr)	330409716	330409716
T (retention time (yr))	0.056	0.058
Retention (days)	20.5	21.2

Annual Phosphorus Loading into Ford Lake (for lake model)

Measured Loads to Ford Lake

- Middle Huron Initiative (2011): 55,272 lb/yr (based on the 151.43 lbs/day as a mean daily load estimate from 2003-2010.) Ongoing Huron River Watershed Council monitoring data show variable annual loads within this range.
- Lehman et al. (2009): 54,971 lbs/year
- Lehman et al. (2011): Saw a reduction in TP concentration in the Huron River of 11-23% in June through September. For this TMDL we estimated this might result in a 5% annual load reduction to Ford Lake.

L (annual phosphorus loading used for lake model) = ranges from 6 to 6.35 (g/m2/yr) based on the above loads.

Lake Phosphorus Model Results

The tables below provide the working data that were used to develop the LC for Ford and Belleville Lakes. The three columns labeled “Current” are different estimated loads going into each lake. The top row presents the annual load and the second row presents the annual load in grams per m2 surface area of the lake per year. This value is called “L” and used in the Walker (1977) and Reckhow (1979) models presented above. Using the input variables L (load in g/m2/yr), hydraulic retention time (years), and mean depth (meters), the predicted lake concentration for each model is presented in the third and fourth rows. These results are similar to the summer concentrations measured by EGLE in recent years (Chambers, 2019).

The models were then used to come up with the load of phosphorus that would ensure the lakes meet WQS and the TMDL phosphorus goal of 30 µg/L. The two models gave similar results and indicate that an annual load of phosphorus of 27000 lbs/yr and 34000 lbs/yr for Ford and Belleville Lakes, respectively, would reach the lake concentration goals.

Lake Model Results – Ford Lake Phosphorus Predicted

	Current (Middle Huron Initiative, 2011)	Current (Lehman et al., 2009)	Current (Estimate from Lehman et al. 2011)	**TMDL Goal**
Phosphorus load (lbs/yr)	55272	54971	51843	**27000**
L (TP load g/m2/yr)	6.35	6.28	5.966	**3.1**
Ford Lake Predicted Phosphorus Concentration Walker (1977) (mg/L)	0.062	0.061	0.058	**0.030**
Ford Lake Predicted Phosphorus Concentration Reckhow (1979) (mg/L)	0.066	0.065	0.06	**0.032**

Lake Model Results – Belleville Lake Phosphorus Predicted

	Current (Middle Huron Initiative, 2011) Modified f Belleville Lake.	Current (Lehman et al., 2009)- Modified for Belleville Lake.	Current (Estimate from Lehman et al. 2011) Modified for Belleville Lake.	**TMDL Goal**
Phosphorus load (lbs/yr)	54108	54180	50954	**34000**
L (TP load g/m2/yr)	4.87	4.82	4.58	**2.38**
Ford Lake Predicted Phosphorus Concentration Walker (1977) (mg/L)	0.060	0.060	0.057	**0.030**
Ford Lake Predicted Phosphorus Concentration Reckhow (1979) (mg/L)	0.065	0.065	0.061	**0.032**