Total Maximum Daily Load and Watershed Management Plan for Total Phosphorus and Total Suspended Solids in the Lower Fox River Basin and Lower Green Bay

Brown, Calumet, Outagamie, and Winnebago Counties, Wisconsin

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Prepared for:

Wisconsin Department of Natural Resources

Oneida Tribe of Indians of Wisconsin

U.S. Environmental Protection Agency

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1.0 INTRODUCTION

1.1. Background

In April of 1991, the United States Environmental Protection Agency (EPA) Office of Water's Assessment and Protection Division published "Guidance for Water Quality-based Decisions: The Total Maximum Daily Load (TMDL) Process." In July 1992, EPA published the final "Water Quality Planning and Management Regulation" (40 CFR Part 130). Together, these documents describe the roles and responsibilities of EPA and the states in meeting the requirements of Section 303(d) of the Federal Clean Water Act (CWA) as amended by the Water Quality Act of 1987, Public Law 100-4. Section 303(d) of the CWA requires each state to identify those waters within its boundaries not meeting EPA-approved water quality standards for any given pollutant applicable to the water's designated uses.

Further, Section 303(d) requires EPA and states to develop TMDLs for all pollutants violating or causing violation of applicable water quality standards for each impaired water body. A TMDL determines the maximum amount of pollutant that a water body is capable of assimilating while continuing to meet the existing water quality standards. Such loads are established for all the point and nonpoint sources of pollution that cause the impairment at levels necessary to meet the applicable standards with consideration given to seasonal variations and a margin of safety. TMDLs provide the framework that allows states to establish and implement pollution control and management plans with the ultimate goal indicated in Section 101(a)(2) of the CWA: "water quality which provides for the protection and propagation of fish, shellfish, and wildlife, and recreation in and on the water, wherever attainable" (USEPA, 1991a).

1.2. Problem Statement

The Lower Fox River (LFR) Basin is located in northeast Wisconsin (Figure 1). The LFR Basin and Lower Green Bay (also referred to as the Green Bay Area of Concern or AOC) are impaired by excessive phosphorus and sediment loading, which leads to nuisance algae growth, oxygen depletion, reduced submerged aquatic vegetation, water clarity problems, and degraded habitat. The TMDL for the LFR Basin and Lower Green Bay focuses on waters impaired by excessive sediment and/or high phosphorus concentrations. Phosphorus and sediment cause numerous impairments to waterways, including low dissolved oxygen concentrations, degraded habitat, and excessive turbidity. These impairments adversely impact fish and aquatic life, water quality, recreation, and potentially navigation.

Although phosphorus is an essential nutrient for plant growth, excess phosphorus is a concern for most aquatic ecosystems. Where human activities do not dominate the landscape, phosphorus is generally in short supply. The absence of phosphorus limits the growth of algae and aquatic plants. When a large amount of phosphorus enters a water body, it essentially fertilizes the aquatic system, allowing more plants and algae to grow; this leads to excessive aquatic plant growth, often referred to as an algae bloom. This condition of nutrient enrichment and high plant productivity is referred to as eutrophication. Eutrophication can damage the ecology of the water, degrade its aesthetics and swimming conditions, and affect the economic well-being of the surrounding community. Overabundant aquatic plant growth in a water body can lead to a number of undesirable consequences. Excessive surface vegetation blocks sunlight from penetrating the

Figure 1. Location of the Lower Fox River Basin

water, choking out beneficial submerged aquatic vegetation. Large areas of excessive surface vegetation growth can inhibit or prevent access to a waterway, which restricts use of the water for fishing, boating, and swimming. A bloom of aquatic plants may include toxic blue-green algae or cyanobacteria, which are harmful to fish and pose health risks to humans. Algal blooms, and particularly surface scums that form, are unsightly and can have unpleasant odors. This makes recreational use of the water body unpleasant and poses a problem for people who live close to the affected water body. When the large masses of both submerged and surface aquatic plants die, the decomposition of the organic matter depletes the supply of dissolved oxygen in the water, suffocating fish and other aquatic life; depending on the severity of the low dissolved oxygen event, large fish kills can occur. Nearly all of these effects have economic impacts on the local community, as well as the state.

The Lower Fox River, its tributaries, and Lower Green Bay are also impacted by excess sediment loading (Figure 2). Excess sediments in the river and bay scatter and absorb sunlight, reducing the amount of light that reaches submerged aquatic vegetation, which restricts its ability to grow via photosynthesis. Bottom-rooted aquatic plants produce life-giving oxygen, provide food and habitat for fish and other aquatic life, stabilize bottom sediments, protect shorelines from erosion, and utilize nutrients that would otherwise be available for nuisance algae growth. As photosynthetic rates decrease, less oxygen is released into the water by the plants. If light is completely blocked from bottom dwelling plants, the plants stop producing oxygen and die. While decomposing the plants, bacteria use up even more oxygen from the water. Historically, fish kills have been reported in Green Bay and the Lower Fox River in association with low oxygen events (WDNR, 1988; WDNR, 1993a). Submerged aquatic vegetation also serves as vital habitat and is a food source for fish, waterfowl, frogs, turtles, insects, and other aquatic life. Reduced water clarity also interferes with the ability of fish and waterfowl to see and catch food. Suspended sediments can also clog fish and invertebrate gills and cause respiratory stress. When sediments settle to the bottom of the river and bay, they can smother the eggs of fish and aquatic insects, as well as suffocate newly hatched insect larvae. Settling sediments can also fill in spaces between rocks, reducing the amount of sheltered habitat available to aquatic organisms. The aforementioned ability of sediment particles to absorb heat from sunlight can also cause an increase in surface water temperature. This can cause dissolved oxygen levels to drop even lower (warmer waters hold less dissolved oxygen that colder waters), and further harm aquatic life.

Figure 2. Sediment blooms in Lower Green Bay following 3 inches of rain in April 2011 (Photo credit: Steve Seilo)

Over the last 15 years, the Wisconsin Department of Natural Resources (WDNR) has placed numerous waters in the LFR Basin, including Lower Green Bay, on the state's 303(d) Impaired Waters List, and has ranked the waters as high priority for the development of TMDLs to address the impairments caused by excess phosphorus and sediment loading. The complete list of impaired waters and impairments being addressed by the TMDL are listed in Table 1 and shown in Figure 3. Note that the term "designated use" in Table 1 refers to those waters that are codified in Wisconsin Administrative Code NR 104.

Trout Creek and portions of Duck and Dutchman Creeks are not included on Wisconsin's 303(d) Impaired Waters List because they are within the Oneida Tribe of Wisconsin's Reservation, and, therefore, the State of Wisconsin does not have authority to develop TMDLs for these waters. In addition, the Oneida Tribe of Wisconsin does not currently have Water Quality Standards Program authorization from EPA. TMDLs can only be developed for waters that are not meeting EPA-approved water quality standards. However, Trout Creek and portions of Duck and Dutchman Creeks exhibit similar low dissolved oxygen and degraded habitat impairments due to excess phosphorus and sediment loading. Although the TMDLs established for the LFR Basin and Lower Green Bay are not applicable to the water bodies located within the boundary of the Oneida Reservation, in order to meet the TMDLs for the LFR Basin and Lower Green Bay, voluntary reductions are needed from sources located within the Oneida Tribe of Wisconsin's Reservation. Therefore, load reduction goals for pollutants in the waters that flow through the Oneida Tribe of Wisconsin's Reservation have been identified in this report in the form of a Watershed Management Plan.

As shown in Table 1, there are 27 segments listed as impaired on the state's 303(d) Impaired Waters List due to excess phosphorus and/or sediment loading, resulting in a need for 45 individual TMDLs. The TMDLs for the LFR Basin and Lower Green Bay were developed using a watershed framework to address each of the 45 TMDLs needed. Under a watershed framework, TMDLs and the associated tasks[1] are simultaneously completed for multiple impaired water bodies in a watershed. This report identifies the TMDLs, load allocations, and recommended management actions that will help restore water quality in the Lower Fox River, the tributaries in the basin, and Lower Green Bay.

1.3. Restoration Goals

The following list summarizes the primary restoration goals for the LFR Basin (including tributary streams) and Lower Green Bay that will be addressed through implementation of this TMDL.

- ***Reduce excess algal growth.*** Aesthetic reasons aside, reducing blue-green algae will reduce the risks associated with algal toxins to recreational users of the river and bay. In addition, a decrease in algal cover will also increase light penetration into deeper waters of the bay.
- ***Increase water clarity in Lower Green Bay.*** Achieving an average Secchi[2] depth measurement of at least 1.14 meters will allow photosynthesis to occur at deeper levels in the bay, as well as improve conditions for recreational activities such as swimming.
- ***Increase growth of beneficial submerged aquatic vegetation in Lower Green Bay.*** This will help reduce the re-suspension of sediment particles from the bottom of the bay up into the water column, which will increase water clarity.
- ***Increase dissolved oxygen levels.*** This will better support aquatic life in the tributary streams and main stem of the Lower Fox River.
- ***Restore degraded habitat.*** This will better support aquatic life.

[1] Characterizing the impaired water body and its watershed, identifying sources, setting targets, calculating the loading capacity, identifying source allocations, preparing TMDL reports, and coordinating with stakeholders.

[2] A Secchi disk is a black-and-white disk that is lowered into the water until it is no longer visible. The point where it disappears from sight is the Secchi depth. Higher Secchi depths indicate clearer water and lower Secchi depths indicate more turbid water.

Table 1. Impaired segments on Wisconsin's 2008 303(d) list addressed by the Lower Fox River Basin and Lower Green Bay TMDL

Water body Name	County	WATERS ID	Start Mile	End Mile	Impairments	Pollutants	Designated Use
Green Bay	Brown	357876	21 mi^2		DH, Low DO	TSS, TP	Default - FAL
Fox River	Brown	10678	0	7.39	DH, Low DO	TSS, TP	Default - FAL
Fox River	Brown, Outagamie	357301	7.39	32.18	Low DO	TP	Default - FAL
Fox River	Outagamie, Winnebago	357364	32.18	40.09	Low DO	TP	Default - FAL
East River	Brown	10679	0	14.15	DH, Low DO	TSS, TP	Default - FAL
East River	Brown, Calumet	10680	14.15	42.25	DH, Low DO	TSS, TP	Default - FAL
Baird Creek	Brown	10681	0	3.5	DH, Low DO	TSS, TP	Default - FAL
Baird Creek	Brown	10682	3.5	13.1	DH, Low DO	TSS, TP	Default - FAL
Bower Creek	Brown	10683	0	3	DH	TSS, TP	Default - FAL
Bower Creek	Brown	10684	3	13	DH	TSS, TP	Default - FAL
Dutchman Creek	Brown	10832	0	4.04	Low DO	TP	Default - FAL
Ashwaubenon Creek	Brown	10834	0	15	DH, Low DO	TSS, TP	Default - FAL
Apple Creek	Brown, Outagamie	10839	3.99	23.88	DH, Low DO	TSS, TP	Default - FAL
Apple Creek	Brown	313933	0	3.99	DH, Low DO	TSS, TP	Default - FAL
Plum Creek	Brown	10841	0	13.86	DH	TSS, TP	Default - FAL
Plum Creek	Brown, Calumet	357670	13.87	16.42	DH	TSS	Default - FAL
Plum Creek	Calumet	357719	16.42	19.5	DH	TSS	Default - FAL
Kankapot Creek	Outagamie	10844	0	2.66	DH	TSS, TP	Default - FAL
Kankapot Creek	Calumet, Outagamie	357763	2.66	9.57	DH	TSS, TP	Default - FAL
Garners Creek	Outagamie	10845	0	5	DH	TSS, TP	Default - FAL
Mud Creek	Outagamie, Winnebago	10846	0	3.71	DH	TSS, TP	Default - FAL
Mud Creek	Outagamie	10847	3.71	6.87	DH	TSS	Default - FAL
Neenah Slough	Winnebago	10848	0	2.77	Low DO	TP	Default - FAL
Neenah Slough	Winnebago	357915	2.77	3.54	Low DO	TP	Default - FAL
Neenah Slough	Winnebago	357955	3.55	6.12	Low DO	TP	Default - FAL
Duck Creek	Brown	10850	0	4.96	DH, Low DO	TSS, TP	Default - FAL
Duck Creek	Outagamie	10851	25.69	39.46	DH, Low DO	TSS, TP	Default - FAL

DH = Degraded habitat
DO = Dissolved oxygen

TSS = Total suspended solids
TP = Total phosphorus

Default FAL = No use classification survey completed for Fish and Aquatic Life Use

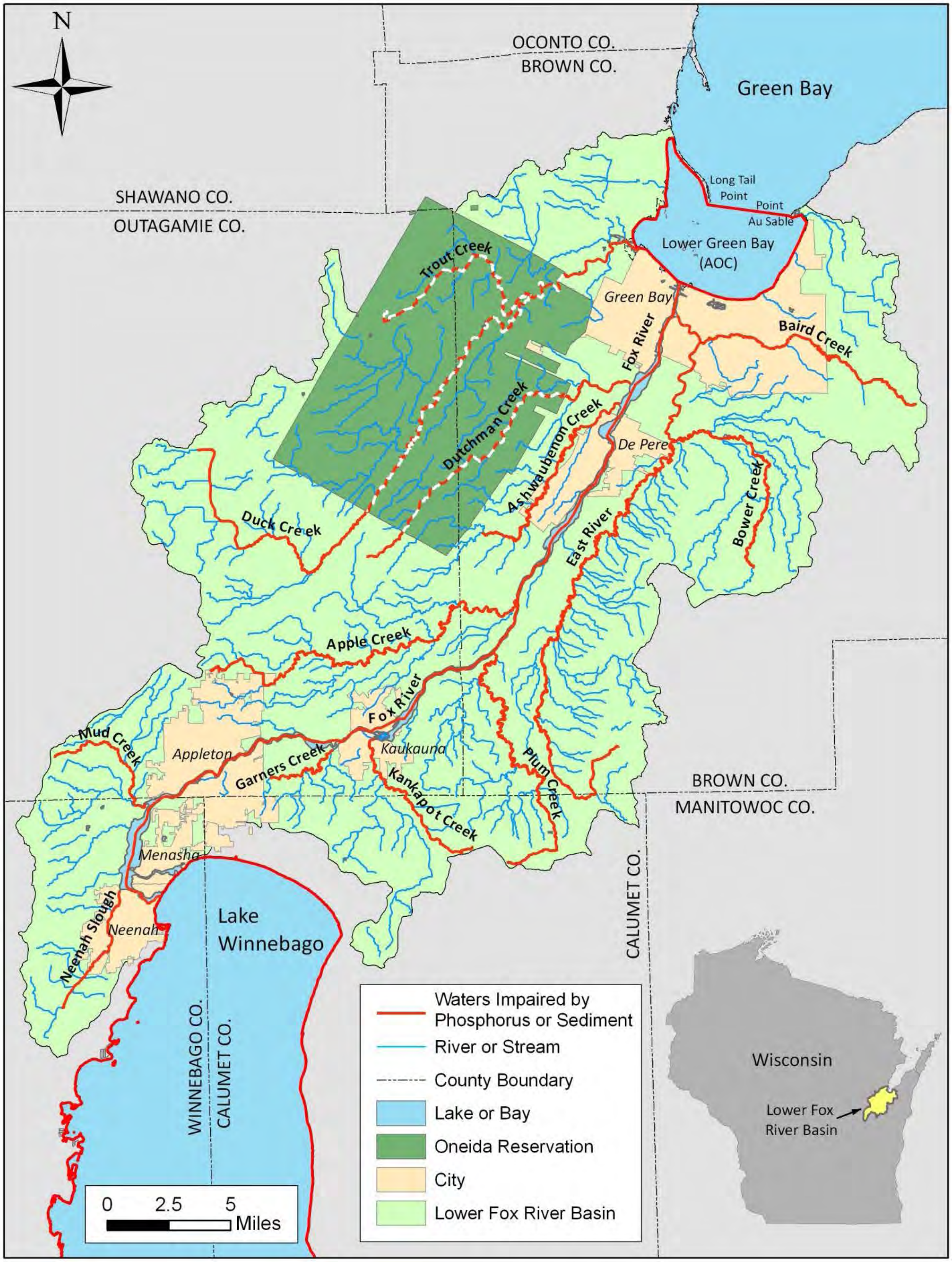


Figure 3. Direct drainage basin for the Lower Fox River Basin and Lower Green Bay

2.0 WATERSHED CHARACTERIZATION

2.1. History of the Basin

Green Bay is the largest freshwater estuary in the world. The bay itself is an inflow to Lake Michigan. The Lower Fox River and Green Bay are important environmental and economic resources for the state, as well as the local community. The wetlands along Green Bay's west shore, as well as the wetlands lining the banks of the Lower Fox River, provide critical fish spawning habitat for perch, northern walleye, and the elusive spotted musky. The natural resources of the Lower Fox River and Green Bay support popular recreational activities such as boating and fishing. People have long used the river and bay for transportation, commerce, energy, food, and recreation. Historically, Native Americans occupied the banks of the Fox River for centuries and used the water as a source of food and water, as well as for recreation, transportation, and crop irrigation. Beginning in the 1600s, European pioneers used the river for fur trading and as an exploration route. Settlements were established in the early 1800s, including Fort Howard, which is now the City of Green Bay.

Paper mills began to flourish in the mid 1800s, after the flour mill industry peaked (WDNR, 1991). The early 1900s saw a booming timber industry followed by rapid urbanization (WDNR, 1988). As logging, agriculture, and industry spread into Wisconsin, the Lower Fox River developed into an urbanized, industrialized area. The forests were harvested and land was cleared for agriculture, causing severe soil erosion, increased sediment and nutrient loadings, and higher water temperatures in the river and the bay. Over the past century hundreds of acres of wetlands that provided important habitat for fish and wildlife were filled and/or destroyed along the river and in the bay (WDNR, 1988).

Numerous occurrences of low dissolved oxygen and fish kills were reported from the 1920s through the 1970s. During this time, the river and bay also saw an increasing predominance of only those organisms able to tolerate highly polluted conditions. From the 1930s to 1970s, dissolved oxygen conditions grew worse due to increased industrial discharges and population growth. Between 1972 and 1985, the area saw dramatic improvements in dissolved oxygen levels and the fishery due to passage of the CWA. As a result of the CWA's stricter pollution control requirements, industries and municipalities invested more than $300 million to reduce pollutant discharges to the river (WDNR, 1988). As a result, dissolved oxygen levels improved in the river and, to a lesser extent, in the bay. This helped to revive the diversity of aquatic life in the river and the bay. This improvement encouraged WDNR to establish a walleye fish stocking program below the De Pere Dam from 1977 through 1984 (WDNR, 1988). This helped revive the diversity of aquatic life in the river and bay. More than 35 species of native fish have been documented in the Lower Fox River since 1980. The program was also successful in attracting many people to fish in the area. Walleye were stocked from 1977 to 1984 and today provide a nationally-famous fishery (Kapuscinski, 2010). A WDNR Lake Michigan Creel Survey estimated that 47,000 walleyes were harvested from the Lower Fox River and the Brown County waters of Green Bay in 2009. Muskellunge restoration began in 1989 to return this extirpated native species to Green Bay. Stocking has re-established a population, and in 2008, natural reproduction was documented for the first time (Rowe and Lange, 2009). In addition to restoring a native species, this program has created a very popular fishery, and in 2009, more than 31,000 hours of fishing were targeted at muskellunge on Green Bay. Restoring water quality in the entire LFR Basin through this TMDL will help to protect this important fishery and continue to improve upstream habitat for fish and aquatic life.

Industries, municipalities, small businesses, farms, and thousands of residents occupy the LFR Basin today. A significant amount of phosphorous is still discharged to the Lower Fox River from municipal and industrial dischargers, as well as from runoff from croplands, barnyards, construction sites, parking lots, residential yards, streets, and other sources. Many of these sources also contribute significant amounts of sediment to the river and bay as well.

2.2. Watershed Characteristics

The 641 mi^2 (1,661 km^2) LFR Basin is located in northeast Wisconsin and encompasses the following counties: Brown, Calumet, Outagamie, and Winnebago, and most of the Oneida Tribe of Wisconsin's Reservation (Figure 3). The Lower Fox River originates at the outlet of Lake Winnebago and flows northeast for 39 miles where it empties into Lower Green Bay. Although the Lower Fox River is impounded by 12 dams and is navigable through 17 locks, the river has the appearance and characteristics of a large flowing stream rather than a series of impoundments (WDNR, 1988).

Green Bay is an elongated arm of Lake Michigan partially separated from the lake by the Door County peninsula. The bay runs northeast from the Fox River's mouth, is 119 miles long, and has a maximum width of 23 miles. Green Bay is relatively shallow, ranging from an average of 10 to 15 feet at the southwestern end to 120 feet at its deepest point (WDNR, 1988). Lower Green Bay includes a little over 21 mi^2 of southern Green Bay out to Point au Sable and Long Tail Point (Figure 3).

The LFR Basin, often referred to as the Fox River Valley, is the second largest urbanized area in the State of Wisconsin (WDNR, 2001a). According to the 2000 U.S. Census, about 404,000 people reside in the LFR Basin (USCB, 2000). Most of the LFR Basin's urban areas are near the main stem of the Lower Fox River, and localized urban and industrial runoff has contributed to water quality problems.

Existing land use and land cover in the LFR Basin was determined in a geographic information system (GIS) using digital aerial photography and spatial datasets (see Appendix B for more detail). Table 2 and Figure 4 summarize land use data for the LFR Basin, and Figure 5 shows the final basin land use layer used for the TMDL analysis. Approximately 50% of the basin consists of agricultural land (including barnyards), 35% consists of urban land (including regulated and non-regulated areas, as well as land under construction), and just under 15% consists of natural areas, including forests and wetlands, which are considered background sources of phosphorus and sediment in the basin.

Those interested in additional details on other characteristics about the basin are encouraged to review the *State of the Green Bay Report* (Qualls et al. 2010), *Lower Fox River Basin Integrated Management Plan* (WDNR, 1991) and *Lower Green Bay Remedial Action Plan* (WNDR, 1988), which provide additional details on other characteristics of the basin, including geography, geology, soils, meteorology, groundwater, ecological resources, and cultural resources.

Table 2. Summary of land use in Lower Fox River Basin

Land Use Category	Acres	% of Drainage Basin
Agriculture (includes barnyards)	202,580	50.2%
Urban (non-regulated)	34,955	8.7%
Urban (regulated MS4)	104,598	25.9%
Construction Sites	2,275	0.6%
Natural Areas (forests & wetlands)	59,249	14.7%
TOTAL	**403,657**	**100%**

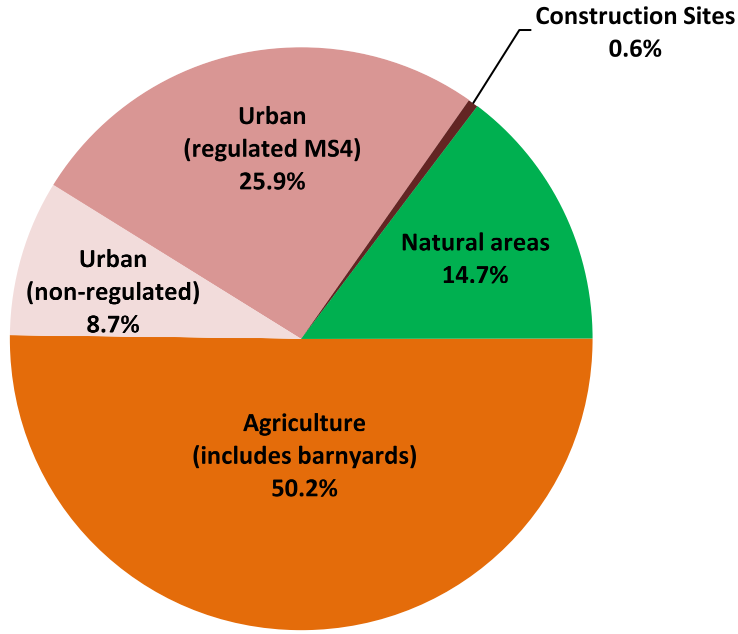


Figure 4. Summary of land use in Lower Fox River Basin

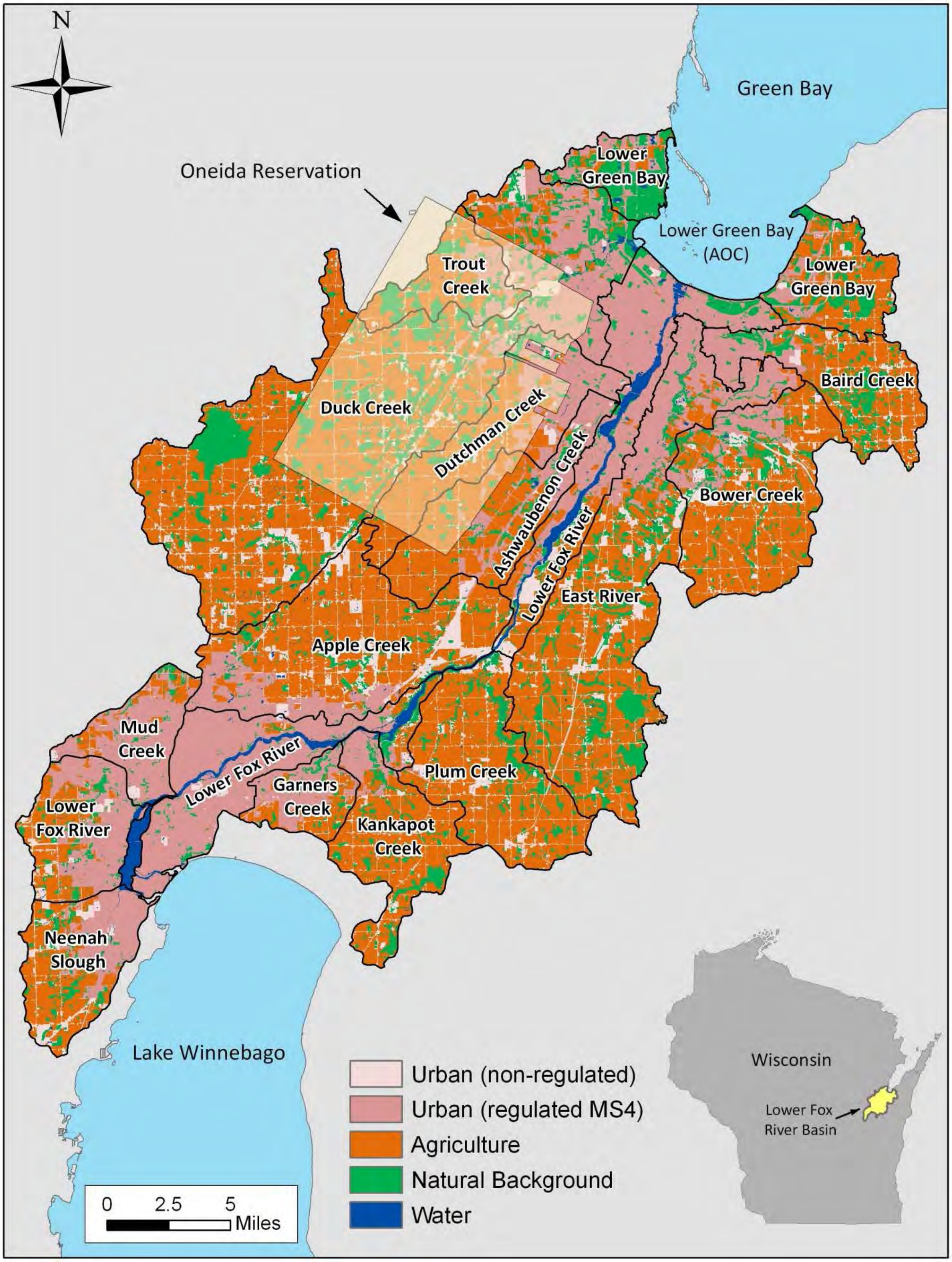


Figure 5. Land use/land cover in the Lower Fox River Basin

2.3. Water Quality

The following sections provide a summary of baseline water quality conditions (based on phosphorus and sediment concentrations) in the LFR Basin, including the outlet of the main stem of the Lower Fox River to Lower Green Bay. All of the impaired tributary streams in the LFR Basin have been assessed at one or more sites over the last two decades, with the majority of the data collected during or after the 2000 field season. The majority of warmwater Index of Biotic Integrity (IBI[3]) scores for the tributary streams range from very poor to poor. Macroinvertebrate sampling results (Hilsenhoff Biotic Index value, or HBI) range from very poor to good depending on the sampling locale. Habitat surveys conducted on several streams characterize habitat as very poor to fair (WDNR, 1993b; WDNR, 1997).

2.3.1. Total Phosphorus

A 30-year record of total phosphorus (TP) concentrations is available for Green Bay from the Green Bay Metropolitan Sewerage District[4] (GBMSD) ambient water quality monitoring program, as well as research efforts at University of Wisconsin Green Bay (UWGB) (Qualls et al., 2010). GBMSD is a Wisconsin state-certified lab that maintains up-to-date quality assurance and quality control procedures for the collection and analysis of water samples. UWGB's methods for collecting data are overseen and set forth by the United States Geological Survey (USGS). USGS' monitoring procedures and data quality statements are available online.[5]

Figure 6 and Figure 7 show the monitoring stations for which the 30-year record of data exists. Figure 8 provides a summary of annual summer (May through October) median TP concentrations from 1993 to 2008 (post zebra mussel invasion[6]) for the outlet of the Lower Fox River to Lower Green Bay (River Station 16 in Figure 6). Between 1993 and 2008, summer median concentrations ranged from 0.12 to 0.28 mg/L. Figure 9 provides a summary of annual summer (May through October) median TP concentrations from 1993 to 2008 (post zebra mussel invasion) for Lower Green Bay (Zone 1 in Figure 6). Between 1993 and 2008, summer median TP concentrations ranged from 0.09 to 0.22 mg/L.

A 3-year record of TP concentrations is also available from the Lower Fox River Watershed Monitoring Program[7] (LFRWMP) for Apple Creek, Ashwaubenon Creek, Baird Creek, Duck Creek, and East River. Figure 10 provides a summary of annual summer (May through October) median TP concentrations from 2004 to 2006 for these tributary streams. Between 2004 and 2006, summer median concentrations ranged from 0.2 to 0.31 mg/L in Apple Creek; 0.275 to 0.4 mg/L in Ashwaubenon Creek; 0.12 to 0.19 mg/L in Baird Creek; 0.16 to 0.195 mg/L in Duck Creek; and 0.18 to 0.355 mg/L in East River (P. Baumgart, personal communication, May 8, 2009).

[3] An IBI is a scientific tool used to identify and classify water pollution problems. An IBI associates anthropogenic influences on a water body with biological activity in the water body, and is formulated using data developed from biosurveys.

[4] Web site for the GBMSD Ambient Water Quality Monitoring Program: http://gbmsd.org/gbsewer/water+quality+research/ambient+water+quality+monitoring+program/default.asp

[5] http://wdr.water.usgs.gov/current/documentation.html

[6] Zebra mussels are a notorious exotic species that entered Green Bay around 1991. Zebra mussels are filter feeders that may improve water clarity, affecting the entire lake ecosystem. Although zebra mussels are present in Green Bay, they are not as abundant in zone 1 (the area including the AOC), and there is no significant difference in Secchi depth (water clarity) before or after the zebra mussel invasion of the Great Lakes (Qualls et al., 2010).

[7] Web site for the LFRWMP Monitoring Program: http://www.uwgb.edu/watershed/data/index.htm

2.3.2. Total Suspended Solids

The amount of sediment in a water body is usually measured as turbidity, total suspended solids (TSS), and water clarity. For the Lower Fox River TMDL, sediment concentration is estimated and measured as TSS. TSS can include a wide variety of material, such as soil, biological solids, decaying organic matter, and particles discharged in wastewater. Figure 11 provides a summary of annual summer (May through October) median TSS concentrations from 1993 to 2008 (post zebra mussel invasion) for the outlet of the Lower Fox River to Lower Green Bay (River Station 16 in Figure 6). Between 1993 and 2008, summer median TSS concentrations ranged from 26 to 62 mg/L. Figure 12 provides a summary of annual summer (May through October) median TSS concentrations from 1993 to 2008 (post zebra mussel invasion) for Lower Green Bay (Zone 1 in Figure 6). Between 1993 and 2008, summer median TSS concentrations ranged from 20.0 to 38.8 mg/L.

A 3-year record of TSS concentrations is also available from the Lower Fox River Watershed Monitoring Program for Apple Creek, Ashwaubenon Creek, Baird Creek, Duck Creek, and East River. Figure 13 provides a summary of annual summer (May through October) median TSS concentrations from 2004 to 2006 for these tributary streams. Between 2004 and 2006, summer median concentrations ranged from 13 to 22 mg/L in Apple Creek; 22 to 34 mg/L in Ashwaubenon Creek; 5.4 to 20 mg/L in Baird Creek; 4.8 to 7.6 mg/L in Duck Creek; and 40 to 74.5 mg/L in East River (unpublished data provided by P. Baumgart, personal communication, May 8, 2009).

The majority of sediment annually deposited in the tributaries on the east side of the Lower Fox River is from agricultural upland erosion, gully erosion, and stream bank erosion. Soils in this part of the basin are relatively fine in texture with slow permeability. In addition, the landscape consists of moderate to steep slopes and is subject to increased urbanization and significant agricultural land use. All of these conditions play a part in the increased erosion potential and delivery of sediment to the streams, especially for areas in close proximity to the streams.

On the west side of the Lower Fox River, soils tend toward clay loam glacial till or sandy soils, which range from poorly-drained to well-drained. Upland erosion in this area of the basin contributes to high sediment loading to the tributary streams. Improperly managed livestock operations that allow cattle access to streams are a key cause for eroding stream banks, loss of bank cover and vegetation, and degradation to the stream-bed and habitat. Eroding stream banks contribute to flashy stream conditions, which results in smaller tributaries experiencing little to no flow in summers, limiting fish and aquatic life uses. In addition, organic pollutants from livestock waste can cause in-stream temperatures to rise and dissolved oxygen levels to fall.

Increased urbanization in the basin also impacts stream hydrology, as runoff volume increases in magnitude and peak stream flows intensify. Flashy stream flows can heighten the impact of stream bank erosion, changing the overall morphology of streams. The natural system is destroyed in many cases, increasing the transport rate of pollutants downstream to the Lower Fox River and Lower Green Bay. In addition, increased areas of impervious surface (e.g., parking lots, roads, rooftops, etc.) result in decreased groundwater recharge; this can reduce base flow to regional streams that are vital to sustaining fish and aquatic life during periods of low rainfall.

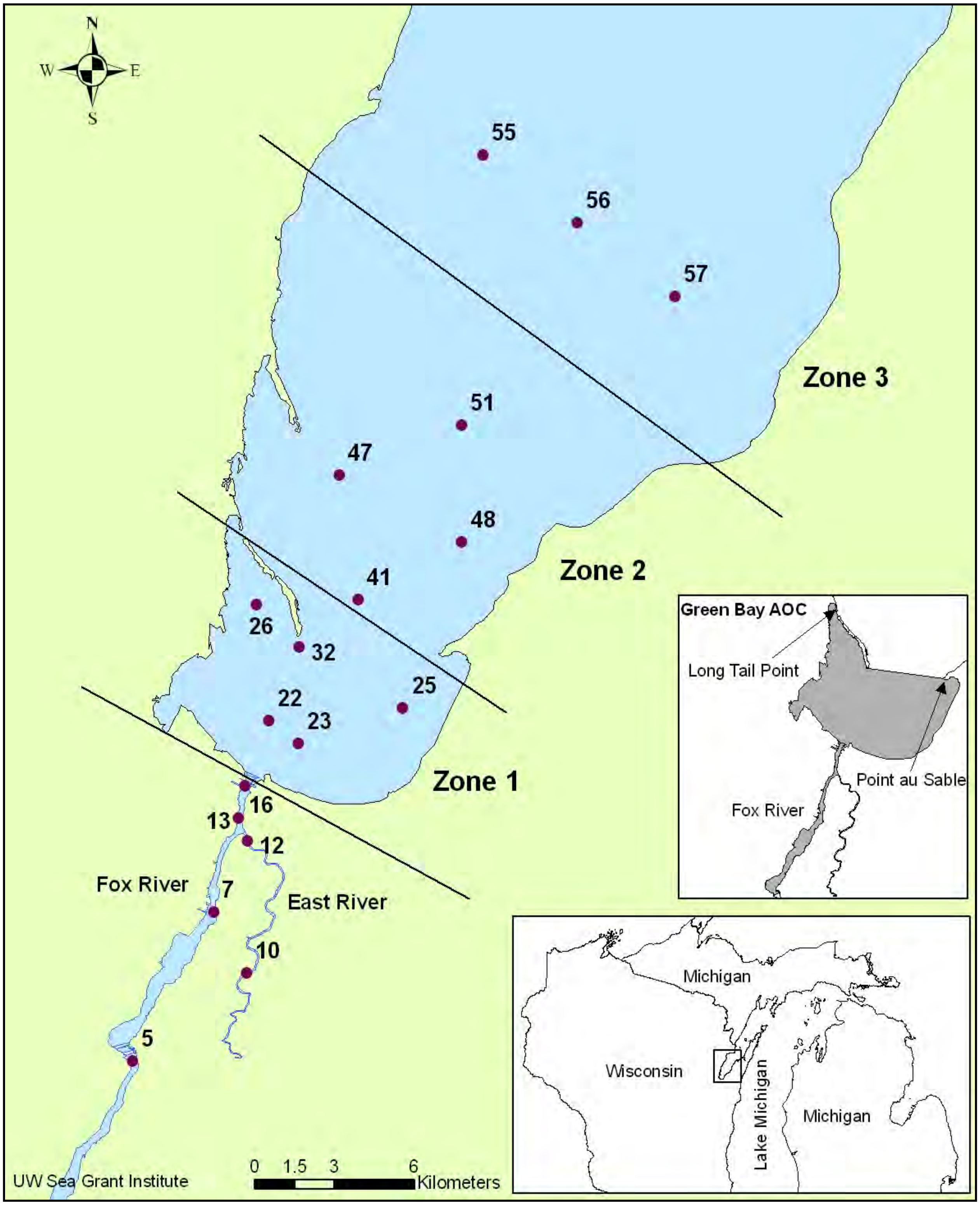


Figure 6. Lower Green Bay sampling stations (Qualls et al., 2010)

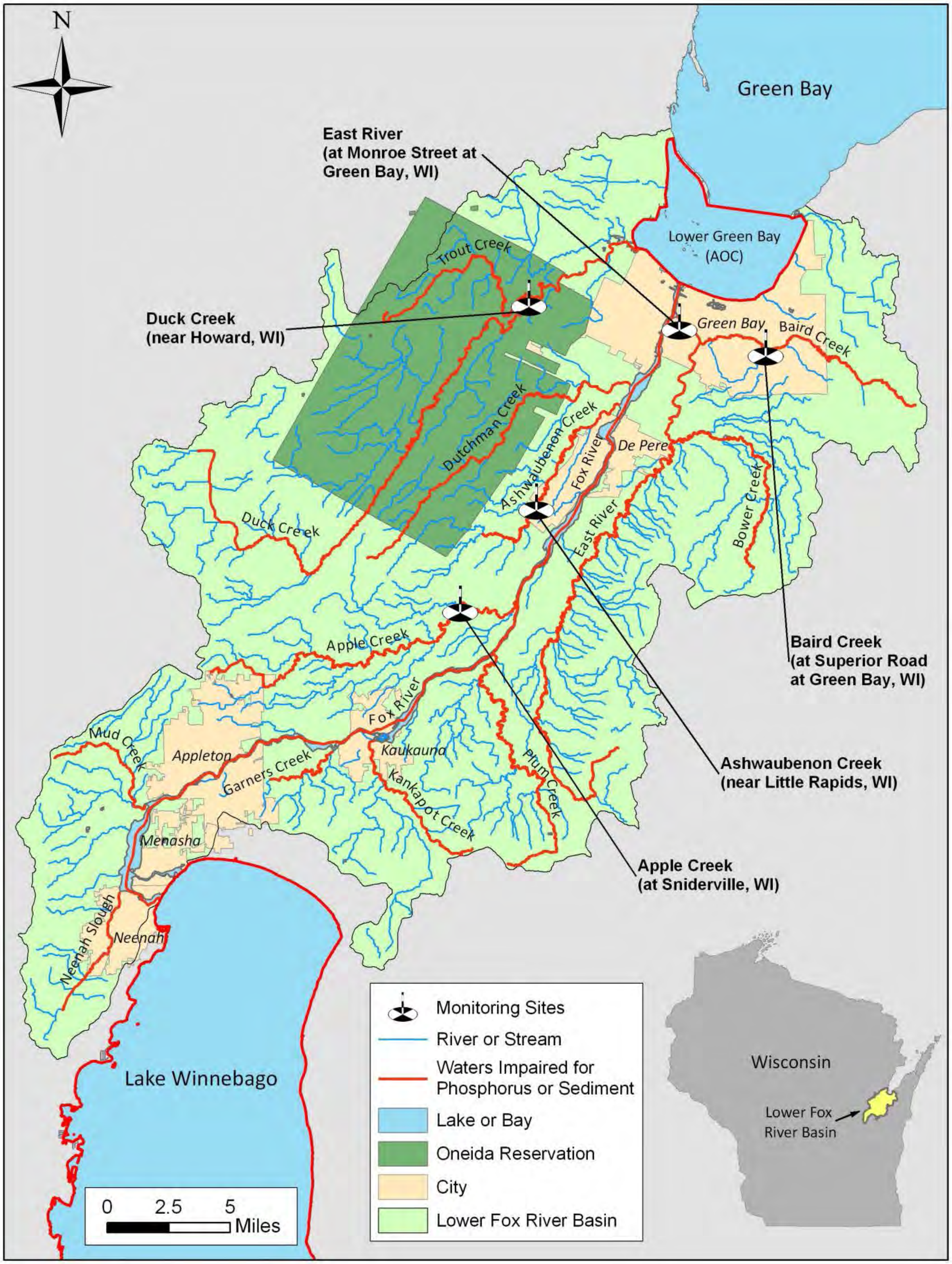


Figure 7. Lower Fox River Watershed Monitoring Program stations (P. Baumgart, personal communication, May 8, 2009)

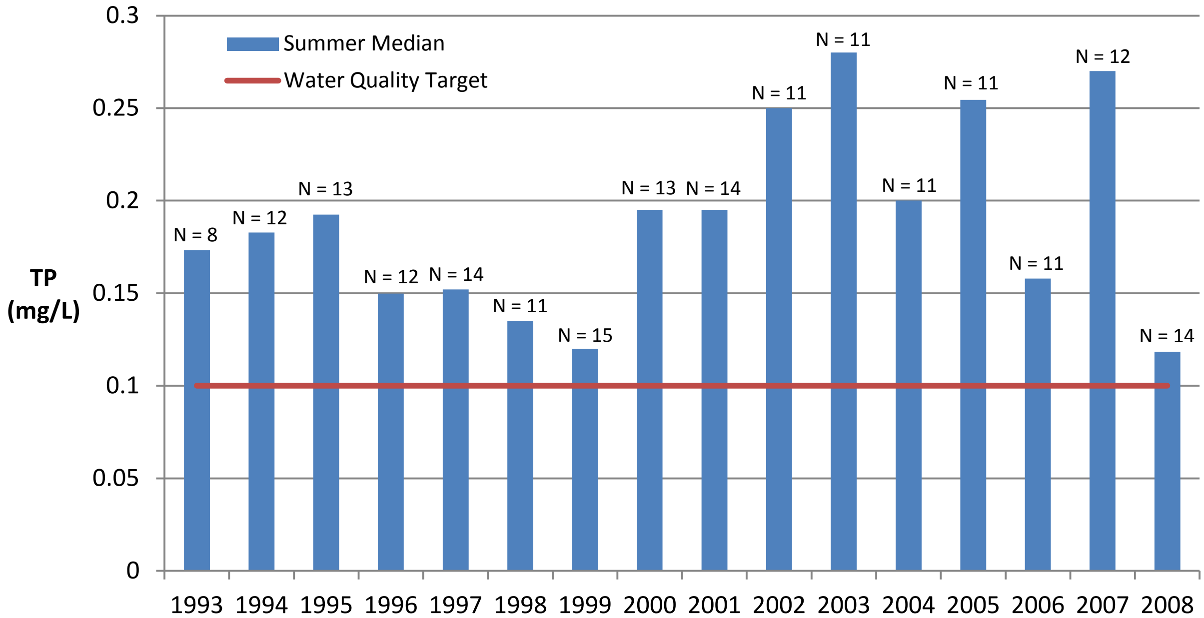


Figure 8. Annual summer (May through October) median TP concentrations from 1993-2008 for Lower Fox River Station 16 (see Figure 6 for station location; Qualls et al., 2010)

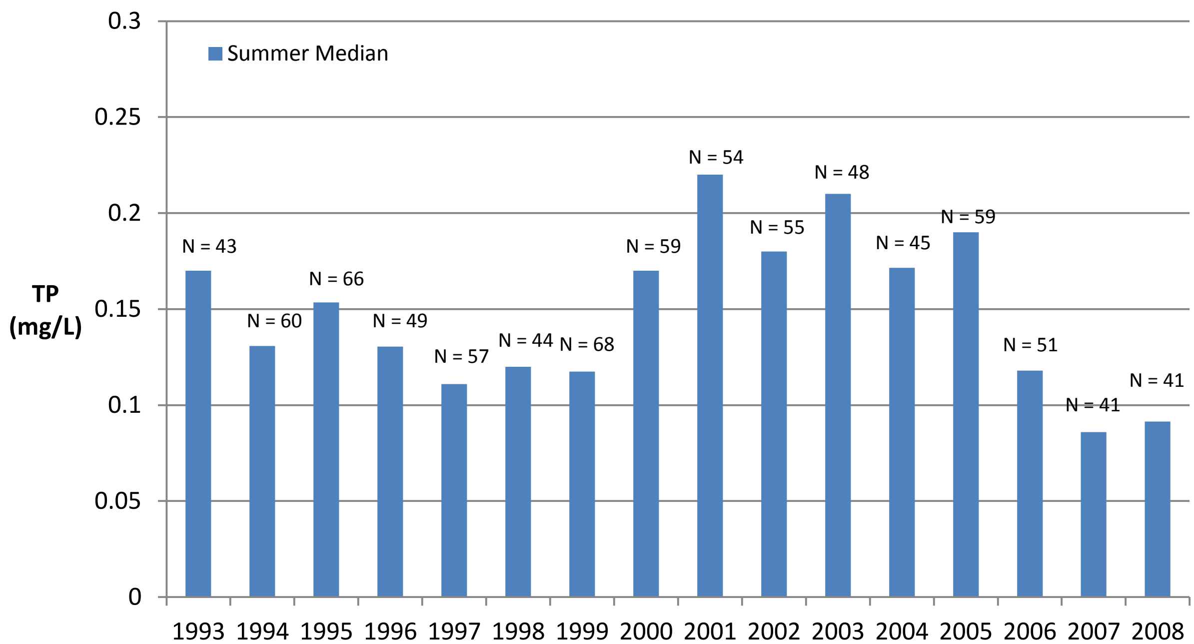


Figure 9. Annual summer (May through October) median TP concentrations from 1993-2008 for Lower Green Bay Zone 1[8] (see Figure 6 for station location; Qualls et al., 2010)

[8] A numeric water quality target is not shown on the chart, as Lower Green Bay only has a narrative target.

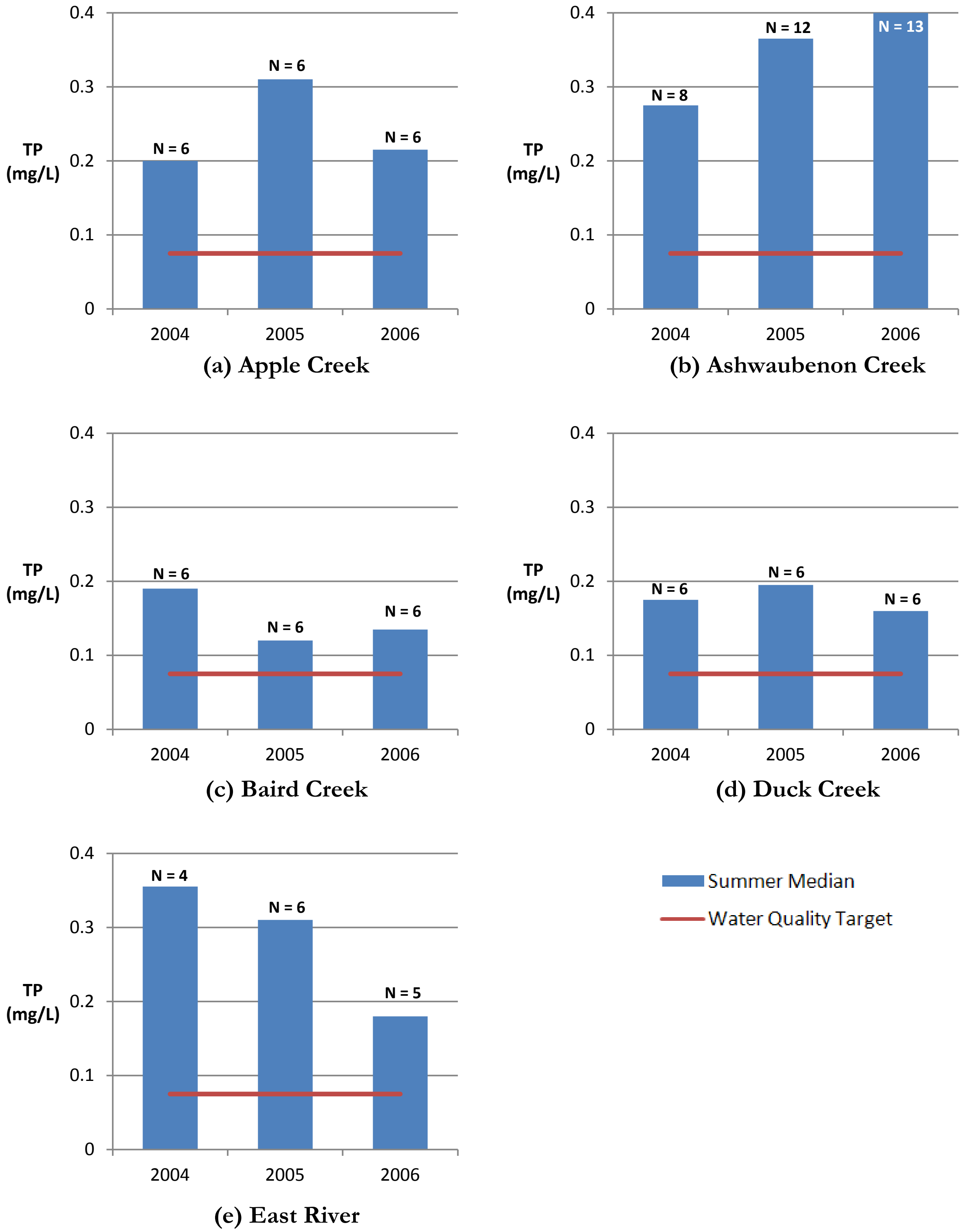


Figure 10. Annual summer (May through October) median TP concentrations from 2004-2006 for Apple Creek (a), Ashwaubenon Creek (b), Baird Creek (c), Duck Creek (d), and East River (e) (see Figure 7 for station locations; unpublished data provided by P. Baumgart, personal communication, May 8, 2009)

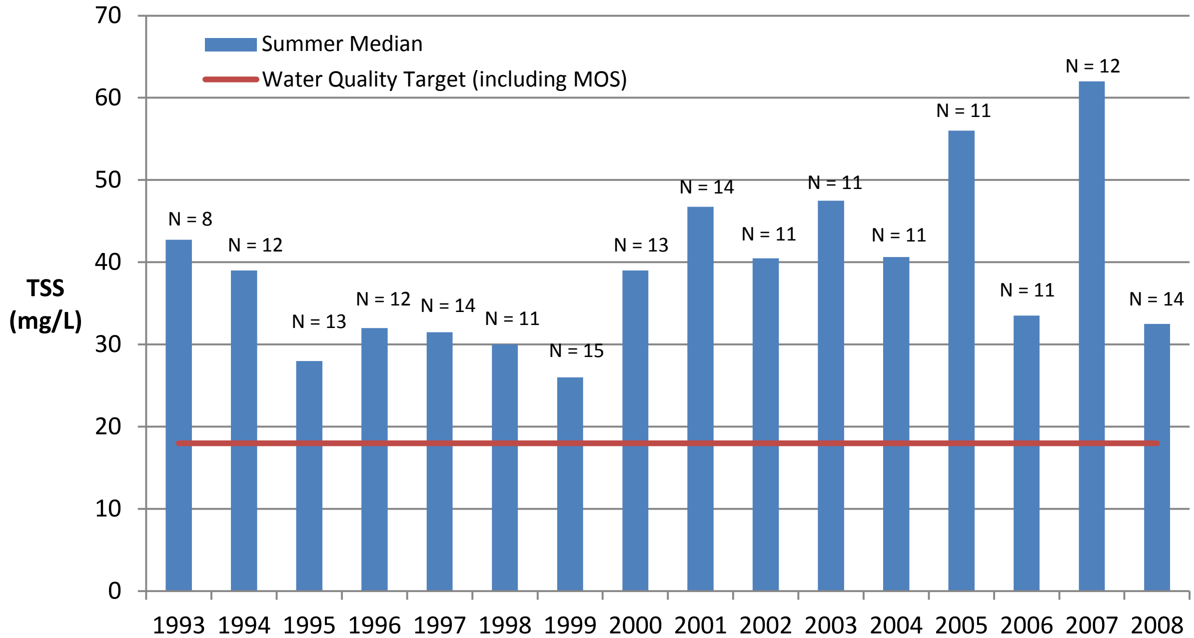


Figure 11. Annual summer (May through October) median TSS concentrations from 1993-2008 for Lower Fox River Station 16 (see Figure 6 for station location; Qualls et al., 2010)

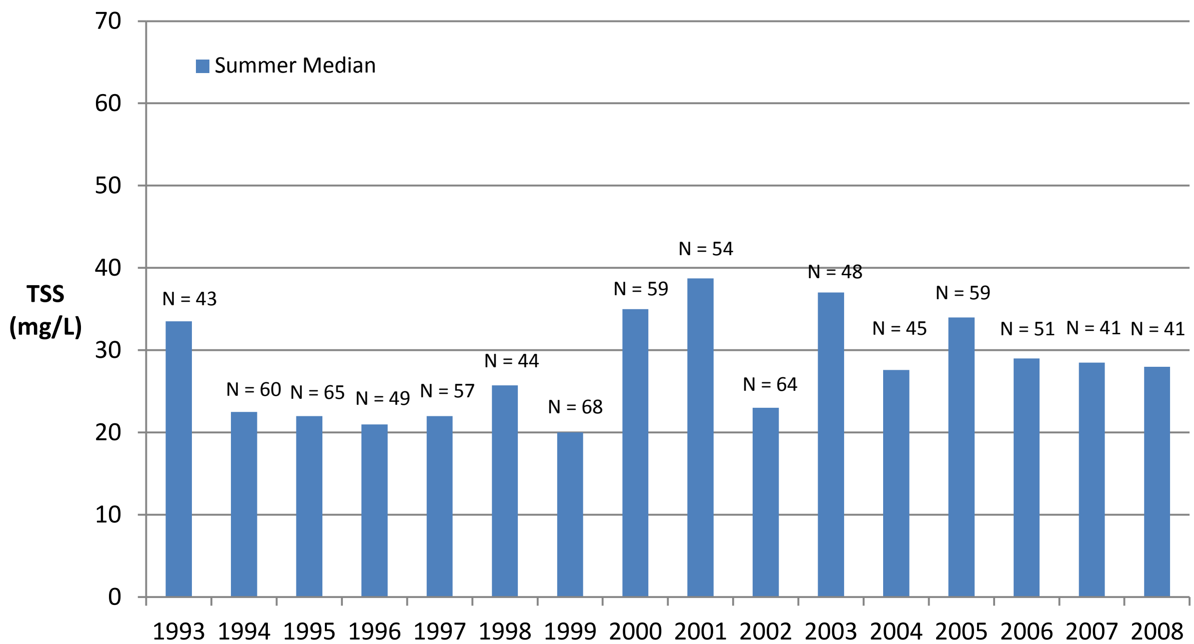


Figure 12. Annual summer (May through October) median TSS concentrations from 1993-2008 for Lower Green Bay Zone 1[9] (see Figure 6 for station location; Qualls et al., 2010)

[9] A numeric target is not shown on the chart, as Lower Green Bay only has a narrative target.

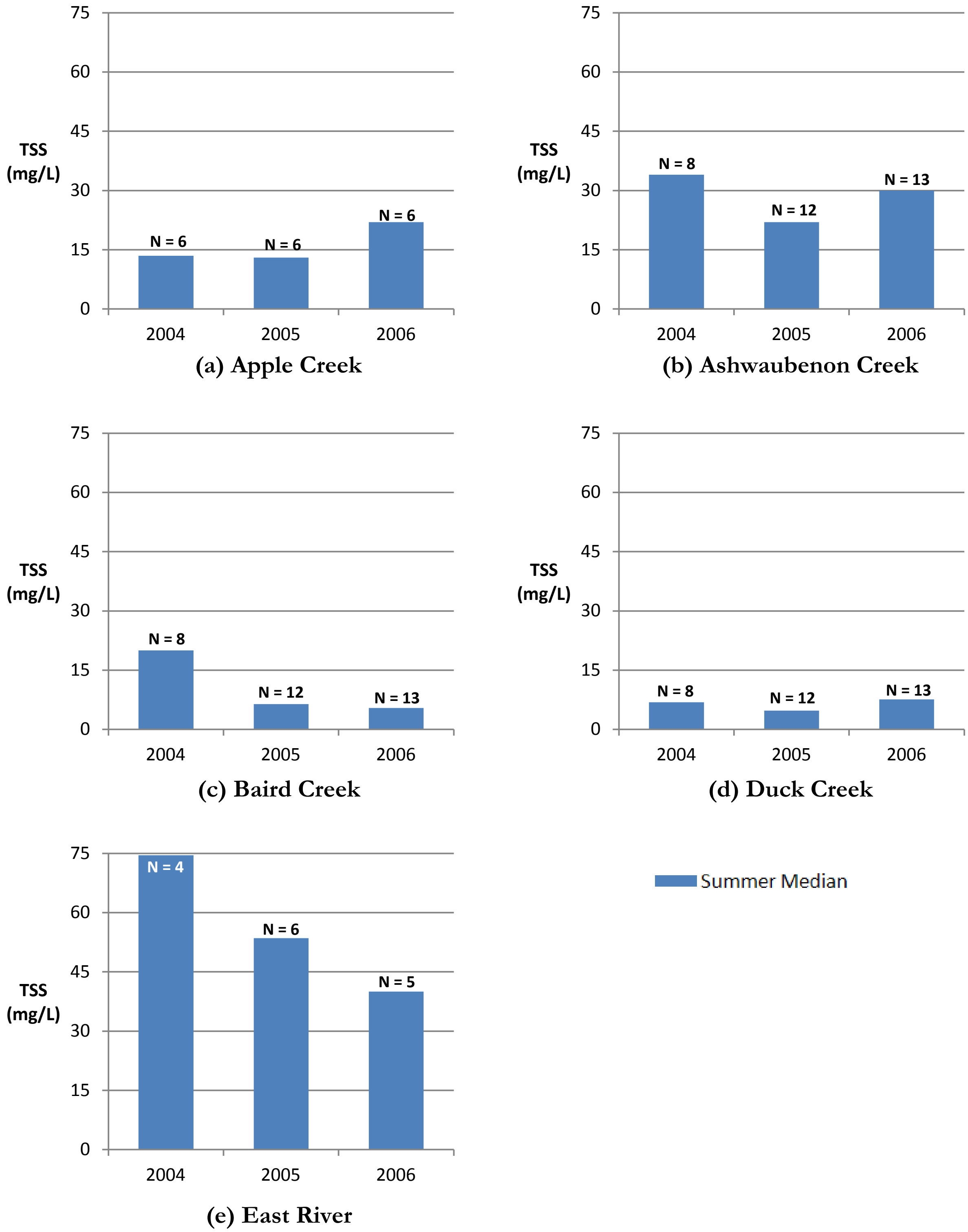


Figure 13. Annual summer (May through October) median TSS concentrations from 2004-2006 for Apple Creek (a), Ashwaubenon Creek (b), Baird Creek (c), Duck Creek (d), and East River (e) (see Figure 7 for station locations; unpublished data provided by P. Baumgart, personal communication, May 8, 2009)

3.0 APPLICABLE WATER QUALITY STANDARDS

3.1. Parameters of Concern and Applicable Water Quality Criteria

There are currently 27 impaired water body segments in the LFR Basin, including Lower Green Bay (Table 1). Section 303(d) of the CWA requires that a TMDL be developed for each pollutant for each listed water body. The watershed TMDL for the LFR Basin and Lower Green Bay includes the development of 45 individual TMDLs for phosphorus and sediment. As described in Section 1.2, excess phosphorus and sediment can cause numerous impairments to waterways including low dissolved oxygen concentrations, degraded habitat, degraded biological community, and excessive turbidity. These impairments impact fish and aquatic life, water quality, recreation, and potentially navigation.

Due to excessive phosphorus and sediment loading, the segments listed in Table 1 are not currently meeting the applicable narrative water quality criterion as defined in Wisconsin Administrative Code NR 102.04(1), and must meet the following water quality standards regardless of their designated uses, as follows:

> "NR 102.04(1). GENERAL. To preserve and enhance the quality of waters, standards are established to govern water management decisions. Practices attributable to municipal, industrial, commercial, domestic, agricultural, land development or other activities shall be controlled so that all waters including the mixing zone and the effluent channel meet the following conditions at all times and under all flow conditions: (a) Substances that will cause objectionable deposits on the shore or in the bed of a body of water, shall not be present in such amounts as to interfere with public rights in waters of the state, (b) Floating or submerged debris, oil, scum or other material shall not be present in such amounts as to interfere with public rights in waters of the states, (c) Materials producing color, odor, taste or unsightliness shall not be present in such amounts as to interfere with public rights in waters of the state."

Excessive sediments are considered objectionable deposits.

In addition, the applicable numeric water quality standard for phosphorus as described in Wisconsin Administrative Code NR 102.06(1) and 102.06(3) must be met in the LFR Basin:

> "(1). GENERAL. This section identifies the water quality criteria for total phosphorus that shall be met in surface waters.
>
> (3) STREAMS AND RIVERS. To protect the fish and aquatic life uses established in s. NR 102.04(3) on rivers and streams that generally exhibit unidirectional flow, total phosphorus criteria are established as follows:
>
>> (a) A total phosphorus criterion of 100 ug/L is established for the following rivers…
>>
>>> 14. Fox River from outlet of Lake Puckaway near Princeton to Green Bay, excluding Lake Butte des Mortes and Lake Winnebago.
>>
>> (b) Except as provided in subs (6) and (7) all other surface waters generally exhibiting unidirectional flow that are not listed in par. (a) are considered streams and shall meet a total phosphorus criterion of 75 ug/L."

Therefore, the numeric water quality criterion that applies to the main stem of the LFR from Lake Winnebago to Green Bay is a summer median concentration of 0.10 mg/L (100 μg/L); and the numeric water quality criterion that applies to all tributary streams in the LFR Basin is a summer median concentration of 0.075 mg/L (75 μg/L). In addition, the narrative standard also is applicable in this TMDL. Excessive phosphorus loading causes algal blooms in the LFR Basin, which may be characterized as floating scum, producing a green color, strong odor, and unsightliness. Sometimes these algal blooms contain toxins that limit recreational uses of the water bodies. Because of the low dissolved oxygen and degraded habitat caused by TP and TSS, the codified designated uses as warm water sport and forage fish communities and limited forage fish communities are not supported (parts b, c, and d below). Algal blooms associated with excess phosphorus loading are also considered "objectionable deposits," and are characterized as "floating debris, scum and material," which produce "color, odor, taste, or unsightliness" that interferes with both the fish and aquatic life and recreational uses of the water body.

The designated uses of the segments listed in Table 1[10] are described in Wisconsin Administrative Code NR 102.04(3) introduction and (b), (c), and (d), as follows:

> "(3) FISH AND OTHER AQUATIC LIFE USES. The department shall classify all surface waters into one of the fish and other aquatic life subcategories described in this subsection. Only those use subcategories identified in pars. (a) to (c) shall be considered suitable for the protection and propagation of a balanced fish and other aquatic life community as provided in federal water pollution control act amendments of 1972, PL 92-500; 33 USC 1251 et.seq.
>
> > (a) Cold water communities. This subcategory includes surface waters capable of supporting a community of cold water fish and other aquatic life, or serving as a spawning area for cold water fish species. This subcategory includes, but is not restricted to, surface waters identified as trout waters by the department of natural resources (Wisconsin Trout Streams, publication 6-3600(80)).
> >
> > (b) Warm water sport fish communities. This subcategory includes surface waters capable of supporting a community of warm water sport fish or serving as a spawning area for warm water sport fish.
> >
> > (c) Warm water forage fish communities. This subcategory includes surface waters capable of supporting an abundant diverse community of forage fish and other aquatic life.
> >
> > (d) Limited forage fish communities. (Intermediate surface waters). This subcategory includes surface waters of limited capacity and naturally poor water quality or habitat. These surface waters are capable of supporting only a limited community of forage fish and other aquatic life."

Lastly, the following narrative criteria are applicable for the Lower Green Bay segment:

> "NR 102.06(5). GREAT LAKES. To protect fish and aquatic life uses established in s. NR 102.04(3) and recreational uses established in NR 102.04(5) on the Great Lakes, total phosphorus criteria are established as follows:

[10] Note that the term "designated use" in Table 1 refers to those waters that are codified in NR 104, and "current use" refers to the existing use or existing condition of the water body.

(c) For the portion of Green Bay from the mouth of the Fox River to a line from Long Tail Point to Point au Sable, the water clarity and other phosphorus-related conditions that are suitable for support of a diverse biological community, including a robust and sustainable area of submersed aquatic vegetation in shallow water areas."

3.2. Numeric Water Quality Targets

The TMDL target is a numeric endpoint specified to represent the level of acceptable water quality that is to be achieved by implementing the TMDL. For phosphorus, these targets are equal to the numeric water quality standard in Wisconsin Administrative Code NR 102.06. Numeric standards do not exist for total suspended solids in Wisconsin, but numeric water quality targets for this TMDL may be determined under Wisconsin Administrative Code NR 102.04(1) to control activities that may result in harm to humans and fish and other aquatic life.

Using its authority under Wisconsin Administrative Code NR 102.04(1), WDNR has established site-specific numeric water quality targets for the tributary streams and main stem of the Lower Fox River for this TMDL. The targets were developed with the input of an *Ad-Hoc Science Team*[11] and using the best available monitoring and scientific data. The targets are linked to biological indicators and other conditions that are protective of the designated uses and applicable water quality standards for the impaired segments in the LFR Basin. In addition, the targets reflect what is needed to meet narrative water quality goals for Lower Green Bay

Numeric targets for TP and TSS were set for the tributary streams and main stem of the Lower Fox River by evaluating predicted improvements in water quality and littoral zone habitats in Zones 1 and 2 in Green Bay (see Figure 6) from simulated reductions in LFR levels of TP and TSS. Using data collected by GBMSD from 1993-2005 (for the period June through September), a multiple regression model was established, relating Epar in Zones 1 and 2 to corresponding levels of TP and TSS in the LFR. Epar scores are inversely proportional indicators of the ability of light to penetrate the water column. Low Epar scores suggest clearer water with deep light penetration, while high scores suggest turbid water with minimal light penetration. An additional, simple regression model was calculated to relate Epar to Secchi depth measurements. Appendix A provides a summary table of the results of the model calculations for Epar for the various TP and TSS reduction scenarios, and the relationship of those values to Secchi depth.

The targets for TP (consistent with existing numeric water quality criteria in Wisconsin Administrative Code NR 102.06) are a summer median concentration of 0.10 mg/L (100 μg/L) for the main stem of the river (from the outlet of Lake Winnebago to the mouth of Green Bay) and a summer median concentration of 0.075 mg/L (75 μg/L) for all of the tributary streams in the basin. The initial target for TSS for the outlet of the Lower Fox River is a summer median concentration of 20 mg/L. When an implicit margin of safety (MOS) of 10% is taken into account, the target for TSS for the outlet of the Lower Fox River is a summer median concentration not to exceed 18 mg/L. These targets are expected to result in a mean Epar of 1.5 m in zones 1 and 2, which translates to an estimated Secchi depth of 1.14 m. Achieving this Secchi depth is expected to result in a 63% increase in water clarity from the 1993-2005 (median) baseline Secchi depth of 0.70 m.

[11] An *Ad-hoc Science Team* for this TMDL was formed in June 2007. The purpose of this team was to contribute local data and scientific expertise to set numeric targets for the TMDL in the LFR Basin because numeric water quality standards for TP were not yet promulgated in Wisconsin when this TMDL was initiated. The *Ad-Hoc Science Team* includes staff from WDNR, UWGB, UW-Milwaukee Water Institute, GBMSD, UW-Sea Grant, Oneida Reservation, and EPA.

The projected levels of TP and TSS for Zones 1 and 2 can be used to predict two additional responses to the TMDL target for the LFR. The response of Secchi transparency has been estimated to reach 1.14 m for Zones 1 and 2 based on the LFR TMDL data (see Appendix A). Using the GBMSD data on Secchi depth, TP, and TSS in Zones 1 and 2, a multiple regression model was created. This model yields a Secchi depth transparency of 1.17 m for a TP (0.06 mg/l) and TSS (15 mg/l) that agree closely with the 1.14 m value produced by the LFR- based model.

A specific numeric water quality target for TSS was not established for tributary streams or the main stem of the Lower Fox River, as it is believed that the estimated percent reductions in TSS loads from the tributaries and main stem needed to meet the target for the outlet of the Lower Fox River will achieve the *water quality goals* and meet the narrative water quality criteria, and improve stream habitat conditions for the tributary streams and main stem. Further, TP and TSS concentrations are reasonably well-correlated and proportionally responsive to the same watershed build-up and wash-off processes. Therefore, attainment of the TP water quality standards for the main stem of the river and for all of the tributary streams in the LFR Basin is believed to result in sufficient reductions in TSS to achieve the *water quality goals* and meet the narrative water quality criteria.

Water quality improvements and attainment with the TMDL target for TP will be evaluated based on the comparison of annual summer median water column TP concentrations during critical conditions (i.e., May through October) to the targets. Water quality improvements and attainment with the TMDL target for TSS will be evaluated based on the comparison of the target to annual summer median water column TSS concentrations taken at the outlet of the Lower Fox River during critical conditions (i.e., May through October). In order to delist the water bodies, both the water quality standards and the fish and aquatic life and recreational use designations need to be met.

As the numeric targets for this TMDL are met, improved water clarity in Lower Green Bay is expected, as well as other conditions suitable to support a diverse biological community, including a robust and sustainable area of submersed aquatic vegetation (e.g., *Vallisneria americana*) in shallow water areas. Meeting the numeric targets for this TMDL will achieve the aquatic life uses in the water bodies in the basin.

Sedimentation is the suspected cause of habitat degradation in the tributary streams of the LFR Basin. Achieving the TSS load reductions identified in this TMDL (based on the numeric target) will result in reduced sedimentation and embeddedness of the substrate, which will help foster native aquatic life and result in an increase in biotic integrity scores for fish and macroinvertebrate communities. In addition, achieving the phosphorus load reductions identified in this TMDL will significantly reduce the frequency and extent of algae blooms in the LFR main stem and in Lower Green Bay; as a result, this will achieve the narrative criteria of no nuisance deposits or algal blooms.

Additional benefits from achieving the numeric TMDL targets (attributable to increased water clarity and reduced phosphorus and sediment loading) include:

- Increased area (~35-45%) of littoral zone habitat for invertebrates, fish, and waterfowl resulting from increased water clarity (Sager, 1993).
- Reduced density and frequency of nuisance algal blooms resulting in lowered health risks to humans and animals – especially pets (reduced TP).
- Increased dissolved oxygen concentrations that will support a more diverse and robust community of fish and other aquatic life (increased water clarity and reduced TP).

- Reduced resuspension of sediment due to the stabilizing effect of increased submerged aquatic vegetation (increased water clarity).
- Increased numbers and safety of swimmers, boaters, wind-surfers, and other water craft users (increased water clarity).

4.0 SOURCE ASSESSMENT

There are two general types of water pollution: point source and nonpoint source. Point source pollution come from identifiable, localized sources that discharge directly into a water body, usually through a pipe or outfall. Industries and wastewater treatment facilities are two common point sources. Stormwater runoff from certain urban areas is also considered a point source (see Section 4.1.3 for more about this). Nonpoint source pollution does not come from a single source like point source pollution; it comes from land use activities such as agriculture and other diffuse sources. Most nonpoint source pollution occurs as a result of runoff. When rain or melted snow moves over and through the ground, the water carries any pollutants it comes into contact with to nearby water bodies. Sources of phosphorus and sediment loading in the LFR Basin include: discharges from regulated wastewater treatment facilities and runoff from agricultural land, urban land (both regulated and non-regulated areas), and natural areas (i.e., forests and wetlands).

In particular, nonpoint sources of pollution from agricultural and urban runoff contribute an excess of sediment and phosphorus loading to smaller streams, such as the tributaries in the LFR Basin. As discussed earlier, this excessive loading leads to degraded stream habitat, unbalanced fish populations, and eutrophic conditions. Sediment deposition leads to loss of spawning habitat for fish, burial of fish eggs and embryos, reduction of forage fish populations, reduced macroinvertebrate populations, and altered channel morphology. Suspended solids in the water column and excessive algal growth also reduce water clarity, decrease light availability for beneficial aquatic plants, increase water temperatures, and can cause fish kills due to clogging of gills.

Specific overland sources of TP and TSS loading in the LFR Basin include: runoff from agricultural fields, urban areas (regulated and non-regulated areas as previously discussed), construction sites, and natural areas (i.e., forests and wetlands, which are considered background sources); and discharges from wastewater treatment facilities.

Runoff from agricultural land is one of the largest contributors of TP and TSS in the basin. TP and TSS loading from agricultural land in the basin originate primarily from soil erosion and the application fertilizers and manure (i.e., animal waste applied to agricultural fields as fertilizer) to cropland. Pasture land and animal feeding operations in the basin are also sources of agricultural TP and TSS loading. Runoff from animal feedlots can transport animal waste high in phosphorus to surface waters. Permitting livestock direct access to streams not only allows direct input of phosphorus, but also erodes the stream bank, causing excess sediments to enter the water body, and contributes to habitat and channel degradation. Even if livestock are not allowed direct access to a water body, allowing livestock to graze to the edge of a water body eliminates essential riparian vegetation (through consumption and/or trampling), which results in destabilized stream banks and increased transport of eroded material to the water body.

TP and TSS loading from urban areas originates primarily from human activities, such as applying fertilizer to lawns. The development of stormwater sewer systems has increased the speed and efficiency of transporting urban runoff to local water bodies. This runoff carries materials like grass clippings, fertilizers, leaves, car wash wastewater, soil, and animal waste; all of which contain phosphorus.

Construction activities and new development can have a large TP and TSS loading impact on nearby water bodies, especially if the activity is near the shorelines of water bodies.

Internal production represents the growth of biotic solids (e.g., plankton) in the water column of the Lower Fox River main stem in response to temperature, light, and nutrients. Internal biotic solids are an important component of the overall solids balance of the Lower Fox River and are accounted for in the TMDL analysis for TSS. Internal biotic solids are estimated to contribute an additional 34,833,037 lbs/yr (1989-95 average based on data summarized by WDNR) to TSS loads in the Lower Fox River between the Lake Winnebago outlet and LFR outlet (WDNR 2001b, LTI, 1999).

Atmospheric deposition, residential on-site septic systems, wildlife, waterfowl, and domestic pets may also be potential sources of TP and/or TSS loading in the basin, and have been incorporated into the land use loadings as identified in the TMDL analysis (and therefore accounted for).

Section 4.1 briefly summarizes the methods used to calculate loads from each of these sources in the LFR Basin; additional details are provided in Appendix B. Section 4.2 provides a quantitative summary of the phosphorus and sediment loads originating from each source within the LFR Basin.

4.1. Analysis of Phosphorus and Sediment Loading

4.1.1. Nonpoint Source Runoff

The Soil & Water Assessment Tool (SWAT) was used to calculate nonpoint sources of phosphorus and sediment loading under baseline conditions in the LFR Basin. Nonpoint sources of phosphorus and sediment loading simulated by SWAT include runoff from agricultural and urban land, as well as from natural areas (i.e., forests and wetlands, herein referred to as natural background). Nonpoint source loads were calculated by SWAT using a 23-year (1977-2000) long-term hydrologic simulation period, as well as land use data that reflect the 2004-2005 timeframe (see Appendix B). Use of a 23-year averaging period for hydrologic simulations minimizes the potential influence of climate dependant factors and provides a more representative estimate of average conditions. Output from the model was on a daily time step, but was summarized on an average annual basis for the TMDL analysis.

SWAT is a distributed parameter, daily time-step model that was developed by the U.S. Department of Agriculture - Agricultural Research Service (USDA-ARS) to assess nonpoint source pollution from watersheds and large complex river basins (Neitsch et al., 2002). SWAT simulates hydrologic and related processes to predict the impact of land use management on water, sediment, nutrient, and pesticide export. With SWAT, a large heterogeneous river basin can be divided into hundreds of subwatersheds; thereby, permitting more detailed representations of the specific soil, topography, hydrology, climate and management features of a particular area. Crop and management components within the model permit representation of the cropping, tillage, and nutrient management practices typically used in Wisconsin. Major processes simulated within the SWAT model include: surface and groundwater hydrology, weather, soil water percolation, crop growth, evapotranspiration, agricultural management, urban and rural management, sedimentation, nutrient cycling and fate, pesticide fate, and water and constituent routing. The QUAL2E sub-model within SWAT was used to simulate nutrient transport within each of the tributary reaches, but not the LFR main stem. A detailed description of the SWAT model can be found on the SWAT model's Web site.[12]

[12] http://www.brc.tamus.edu/swat/

The SWAT model was previously calibrated and validated for use in estimating TP and TSS loading in the LFR Basin (Baumgart, 2005; Cadmus, 2007). The previously calibrated and validated SWAT model was refined for this TMDL analysis in order to make use of new data sets of continuous flow and daily loads of TP and TSS from the five LFRWMP monitoring stations (Figure 7). The new model calibration and validation strengthened the ability of SWAT to simulate flow, TP, and TSS with a reasonable level of accuracy. Appendix B provides a detailed summary of the calibration and validation of SWAT, including the results of the model calibration and validation.

4.1.2. Regulated Wastewater Treatment Facilities

Phosphorus and sediment loads for regulated municipal and industrial wastewater treatment facilities (WWTFs) were calculated using an average of actual loads reported to WDNR in Discharge Monitoring Reports (DMRs) between 2003 and 2009 (averaging period for each facility calculated using one or more years of data in this timeframe). At the time of the TMDL analysis, there were 20 industrial and 14 municipal permitted WWTFs operating in the LFR Basin (Table 3 and Figure 14). GW Partners LLC (permit no. 0001121) is not listed in this table, as it is no longer operating. However, the estimated baseline load from GW Partners LLC (6,362 lbs/year for TP and 52,979 lbs/year for TSS) is being set aside to support potential new or expanded permits on the main stem of the Lower Fox River (see Section 6.5.1 for additional discussion about this). Through the use of coordinates, GIS software, and aerial photos, it was determined to which subwatershed each of the municipal and industrial WWTFs discharges. Each facility's load was added to the SWAT simulated load for the corresponding subwatershed.

4.1.3. Regulated Stormwater Runoff

Stormwater runoff from municipal areas contains a mixture of pollutants from parking lots, streets, rooftops, lawns, and other areas. Although these areas are efficient at diverting water to avoid flooding in developed areas, they also transport polluted runoff (including sediments and phosphorus) into nearby lakes, rivers, and streams without the benefit of wastewater treatment or filtration by soil or vegetation. Even though stormwater is precipitation driven and better fits the model of nonpoint pollution, stormwater runoff from regulated municipalities is considered a point source and, therefore, accounted for in the wasteload allocation of a TMDL.

To meet the requirements of the federal CWA, WDNR developed the Wisconsin Pollutant Discharge Elimination System (WPDES) Storm Water Discharge Permit Program, which is administered under Wisconsin Administrative Code NR 216. The WPDES Storm Water Program regulates discharge of storm water in Wisconsin from municipalities, industrial facilities, and construction sites. The goal of WDNR's municipal storm water management program is to decrease the pollutants carried to waters of the state through these Municipal Separate Storm Sewer Systems (MS4s). Communities that meet the requirements stipulated under EPA's Phase 1 or Phase 2 stormwater regulations are required to obtain a permit to discharge stormwater. Under Phase 1, communities with a population greater than 100,000 were required to obtain a permit. Under Phase 2, communities that meet the definition of an urbanized area (a total population of 10,000 or more as determined by U.S. Census data) were required to obtain a permit. In limited cases, Wisconsin regulations allow for smaller communities to be issued a permit if they are part of an urbanized area.

Currently there are five different WPDES industrial storm water general permits. WDNR coverage for general industrial storm water discharges is based on the type of industrial activity and how likely a facility is to contaminate storm water. The requirements of each general permit differ in chemical monitoring requirements, inspection frequency, plan development requirements and the annual permit fee. A list of general permits can be found on WDNR's storm water website.[13] The industrial storm water general permits in the LFR Basin include: Storm Water Auto Parts Recycling; Tier 1 and Tier 2 Industrial Storm Water; Storm Water Scrap Recycling; and Nonmetallic Mining Operations. There are approximately 256 industrial storm water general permits within the MS4 boundaries, and approximately 142 industrial storm water general permits outside of the MS4 boundaries in the LFR Basin.

The SWAT model was used to calculate phosphorus and sediment loading from urban sources regulated by WPDES stormwater permits. These regulated sources include stormwater runoff from MS4s, industrial facilities, and construction sites. Details about the use of the SWAT model to simulate loading from regulated urban areas, including a summary of the studies upon which the sediment and phosphorus yield estimates are based, are provided in Appendix B.

There are 29 regulated MS4s in the LFR Basin (Table 4 and Figure 15). Loads were simulated for MS4 and industrial urban areas using the build-up and wash-off routine in SWAT, along with a sediment yield of 275 lbs/acre and phosphorus yield of 0.7 lbs/acre. Using an area-weighted approach, loads were apportioned to each MS4 using the MS4 boundaries developed for this TMDL analysis (see Appendix B). Loads from facilities covered under a general permit and located within an MS4 are included in the simulation of loads from the MS4s. Similarly, stormwater runoff from the Wisconsin Department of Transportation system is also accounted for in simulated loads for the MS4s. Loads from facilities covered under a general permit outside of the MS4 boundaries were estimated to be 10% of the pollutant runoff from SWAT simulated loads from non-regulated urban land (WDNR, personal communication, November 9, 2009).

The area of land under construction (also called urbanizing land) represents a transitional change from rural to urban land use. The rate and amount of urbanization is variable making it difficult to simulate in a model. For the TMDL, loads from construction sites were simulated by adding a separately calculated urban load to the SWAT-simulated loads. Loads were computed for each subwatershed by assuming that the annualized change in urban area from 2001 to 2004 remained constant. The area of land under construction was estimated as the change in urban areas between a land use layer representative of 2001 developed by Baumgart (2005) in a previous modeling effort, and the 2004-2005 land use layer developed for this analysis. To derive the load associated with urbanizing areas (i.e., construction sites), the annual average increase in urban area within each subwatershed was multiplied by a sediment yield of 4,047 lbs/acre (5.0 t/ha) and a phosphorus yield of 4.5 lbs/acre (as routed to the watershed outlets). These yields are based on two separate Wisconsin studies conducted by Owens et al. (2000) and Madison et al. (1979), as well as SWAT simulations under fallow conditions. Appendix B provides detail about these studies.

4.1.4. Regulated Concentrated Animal Feeding Operations

Every farm, regardless of size, is responsible for proper manure management to protect water quality from discharges. Over the past ten years, Wisconsin has become home to an increasing number of Concentrated Animal Feeding Operations (CAFOs), those operations with 1,000 or more animal units. Due to the increased number and concentration of animals, it is particularly important for these facilities to properly manage manure in order to protect water quality in Wisconsin.

A specific regulatory program for the handling, storage, and utilization of manure was developed by WDNR in 1984 in Wisconsin Administrative Code Chapter NR 243. The rule creates criteria and standards to be used in issuing permits to CAFOs as well as establishing procedures for investigating

[13] WDNR's storm water web site: http://dnr.wi.gov/runoff/stormwater.htm

water quality problems caused by smaller animal feeding operations. Because of the potential water quality impacts from CAFOs, animal feeding operations with 1,000 animal units or more are required to have a WPDES CAFO permit. These permits are designed to ensure that operations choosing to expand to 1,000 animal units or more use proper planning, construction, and manure management to protect water quality from adverse impacts.

There are 15 regulated CAFOs in the LFR Basin, including United Meadows Dairy in Brown County, which has a medium[14] size CAFO permit, but does not have more than 1,000 animal units (Table 5 and Figure 16). WPDES permits for CAFOs require that the facilities be designed, constructed and operated to have no discharge of pollutants to navigable waters, unless caused by a catastrophic storm (24-hour duration exceeding the 25-year recurrence interval). CAFOs must comply with their no-discharge permit requirements; therefore, loading from CAFOs is assumed to be zero (0) from the production area. Land application of manure from CAFOs, however, is not included in the assumption of zero discharge. Loading of phosphorus and sediments from land spreading is accounted for in the nonpoint source loads.

[14] WDNR's definition for a medium sized CAFO is described in NR 243.03 (39): "Medium CAFO" means an animal feeding operation with 300 to 999 animal units that has a category I discharge to navigable waters under s. NR 243.24, or that is designated by the department as a CAFO under s. NR 243.26 (2).

Table 3. WWTFs in the LFR Basin.

Industrial Facilities	Permit	Map
Appleton Coated LLC	0000990	1
Arla Foods Production LLC – Holland	0027197	2
Belgioso Cheese - Sherwood	0027201	3
Cellu Tissue – Neenah	0000680	4
Fox Energy LLC	0061891	5
Galloway Company	0027553	6
Georgia Pacific Consumer Products LP	0001261	7
Georgia Pacific Consumer Products LP	0001848	8
Green Bay Packaging - Green Bay	0000973	9
Neenah Paper, Inc.	0037842	10
Menasha Electric & Water Utility	0027707	11
NewPage Wisconsin Systems – Kimberly	0000698	12
Pechiney Plastic Packaging - Menasha 001	0026999	13
Procter & Gamble	0001031	14
Provimi Foods – Seymour	0044628	15
SCA Tissue North America 001 & 002	0037389	16
Schroeder's Greenhouse	0046248	17
Thilmany LLC – DePere	0001473	18
Thilmany LLC – Kaukauna	0000825	19
Wisconsin Public Service Corp., Pulliam	0000965	20

Municipal Facilities	Permit	Map
Appleton	0023221	21
GBMSD - De Pere	0023787	22
Forest Junction	0032123	23
Freedom San. Dist. #1	0020842	24
Grand Chute - Menasha West	0024686	25
Green Bay MSD	0020991	26
Heart of the Valley	0031232	27
Neenah – Menasha	0026085	28
Oneida WWTF *	WI0071323	29
Sherwood	0031127	30
Town of Holland SD #1 001 & 003	0028207	31
Wrightstown	0022497	32
Wrightstown SD#1	0022438	33
Wrightstown SD#2	0022357	34

* Regulated via EPA NPDES permit

Table 4. MS4s in the LFR Basin.

MS4s	FIN
Brown County	33656
Calumet County	33653
City of Appleton	31098
City of De Pere	31088
City of Green Bay	33657
City of Kaukauna	31102
City of Menasha	31110
City of Neenah	31112
Outagamie County	33644
Town of Buchanan	31099
Town of Grand Chute	31102
Town of Greenville	31103
Town of Harrison	31104
Town of Lawrence	31092
Town of Ledgeview	31093
Town of Menasha	31111
Town of Neenah	31113
Town of Scott	31095
University of Wisconsin Green Bay	37165
Village of Allouez	31085
Village of Ashwaubenon	31086
Village of Bellevue	31087
Village of Combined Locks	31100
Village of Hobart	Oneida
Village of Howard	31091
Village of Kimberly	31107
Village of Little Chute	31108
Village of Suamico	31096
Winnebago County	33642

Table 5. CAFOs in the LFR Basin.

CAFOs	Permit
Country Aire Farms	0059200
Brickstead Dairy	0064378
Meadowlark Dairy L.L.C.	0061905
Neighborhood Dairy, L.L.C.	0062618
New Horizons Dairy LLC	0063428
Ranovael Dairy	0062821
Rueden Beef LLC	0063312
Schuh View Dairy L.L.C.	0059129
Stencil Farms	0056731
Thompsons Gold Dust Dairy	0058386
Tidy View Farm, Inc.	0056839
Tinedale Farms L.L.C.	0058947
United Meadows Dairy	0064106
Verhasselt Farm	0049034
Weise Brothers Farms	0059056

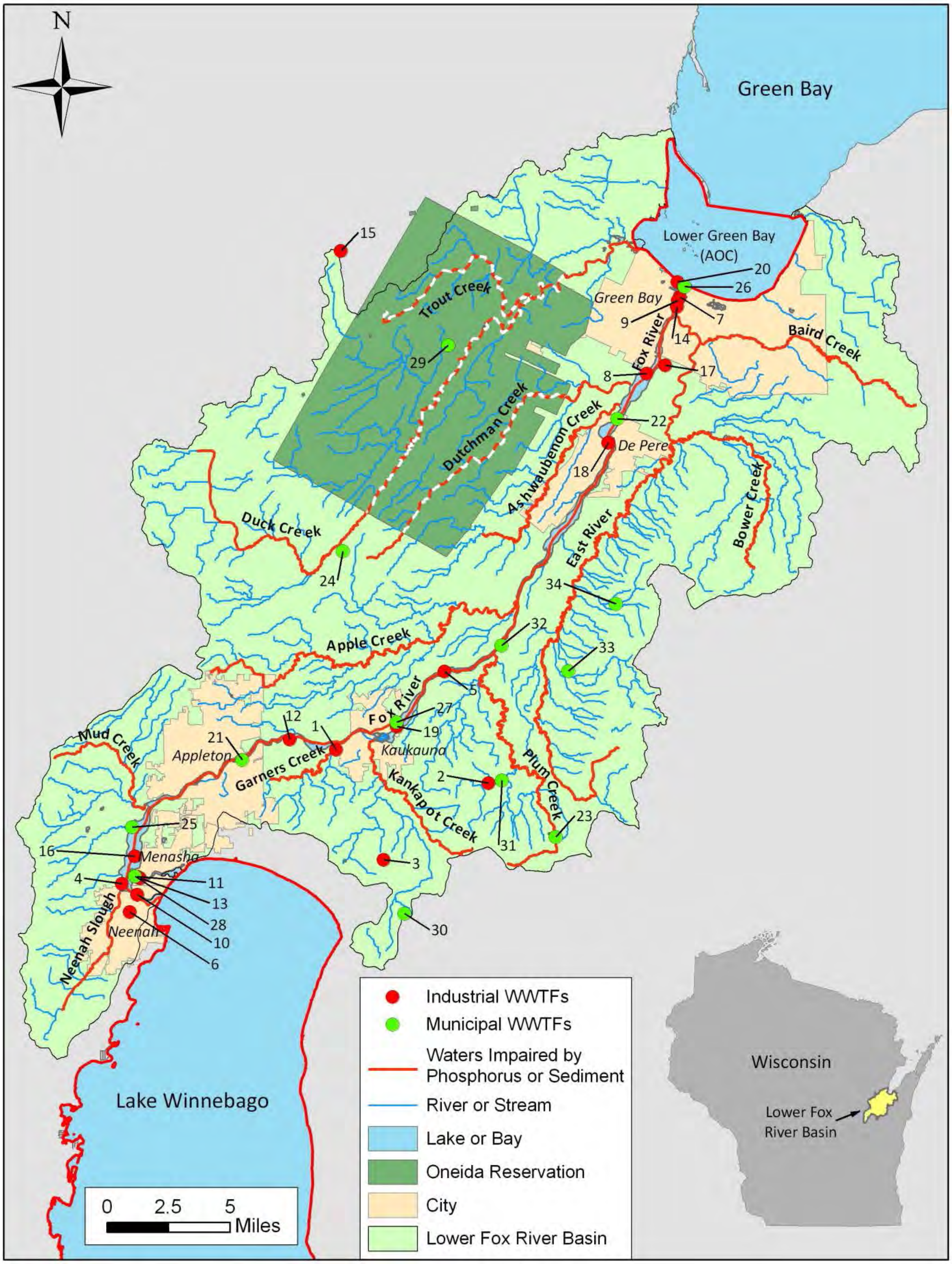


Figure 14. Location of municipal and industrial WWTFs in the LFR Basin (see Table 3 for facilities names corresponding to numbers on map)

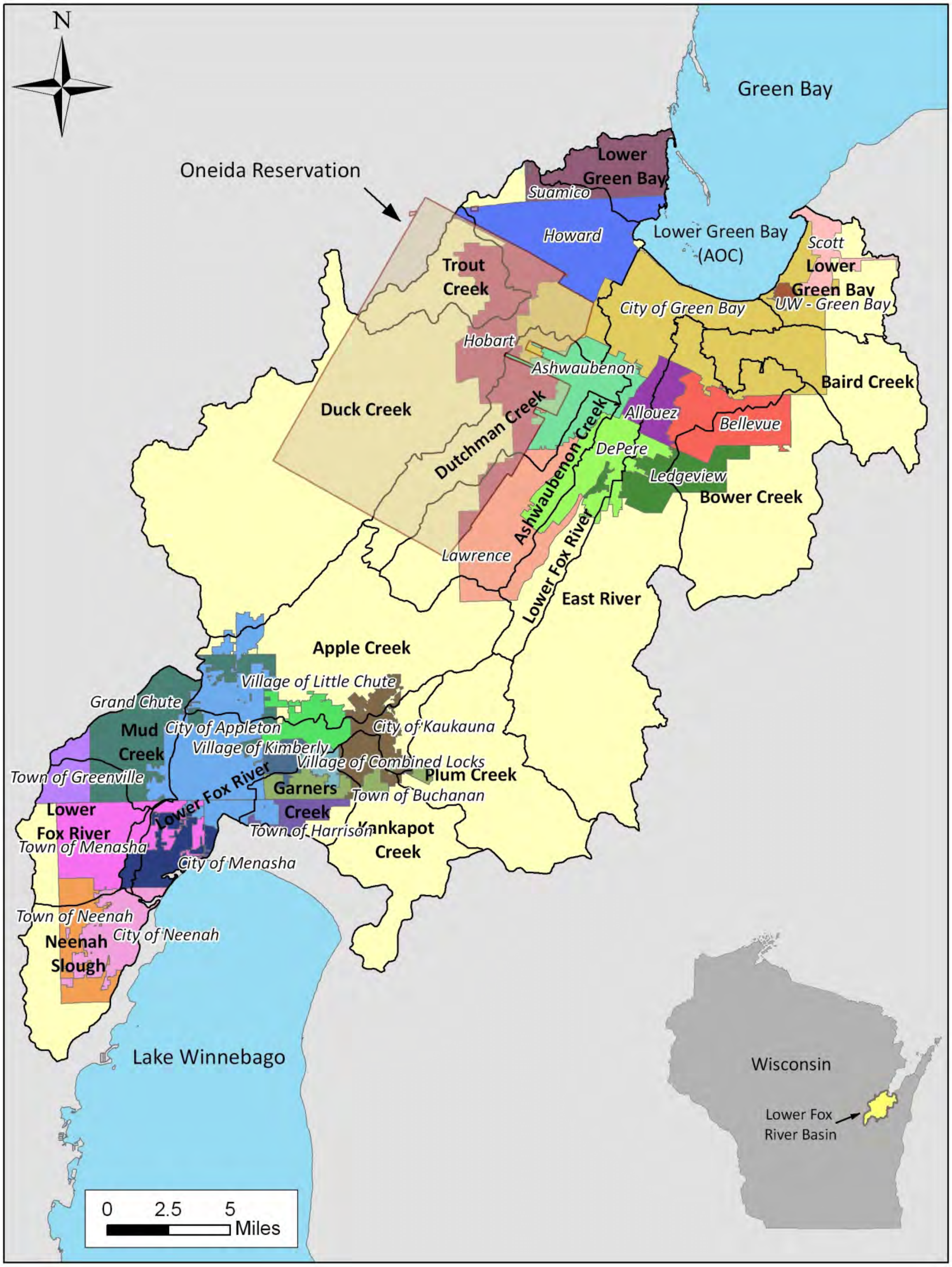


Figure 15. Location of MS4s in the LFR Basin

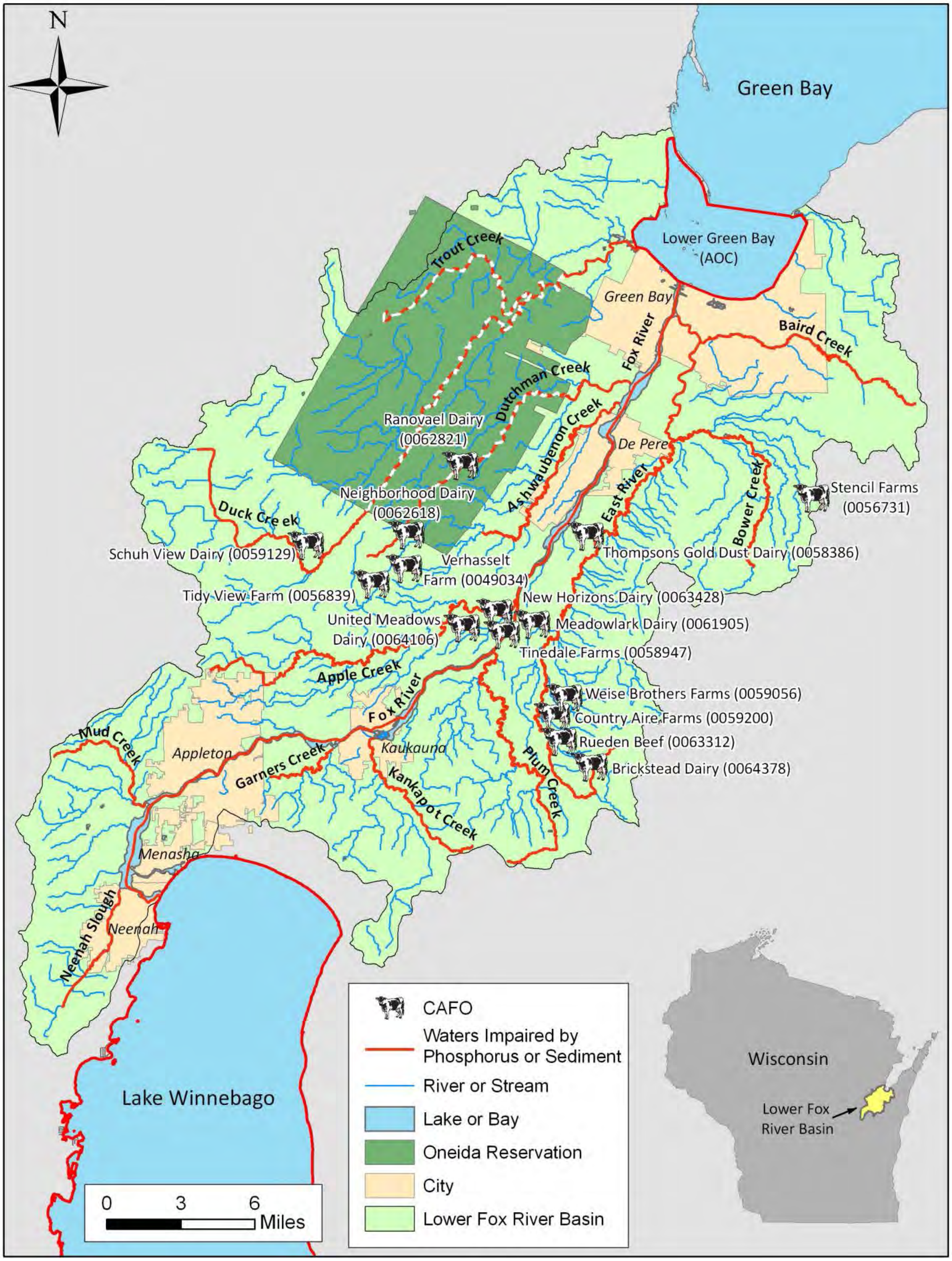


Figure 16. Location of CAFOs in the LFR Basin

4.1.5. Out-of-Basin Sources

The drainage basin for Lower Green Bay actually includes more than just the LFR Basin. As shown in Figure 17, three major river basins (the Upper Fox River, the Lower Fox River, and the Wolf River), referred to collectively as the Fox-Wolf Basin, represent the drainage basin for Lower Green Bay. Figure 18 shows the percent of total land area in the Fox-Wolf Basin for each of the Upper Fox River, the Lower Fox River, and the Wolf River Basins. This includes Lake Winnebago, which is an inlet to the LFR Basin. The focus of this TMDL is the LFR Basin and Lower Green Bay; however, contributions from Lake Winnebago and the Upper Fox and Wolf Basins must also be reduced if the goals established by this TMDL are to be met. This will be addressed in a forthcoming TMDL report slated to be final in the next few years, as federal and state resources allow.

Baseline loads entering the LFR Basin at the outlet of Lake Winnebago were derived from a regression equation developed by Dale Robertson of the USGS (unpublished data produced for the Lower Fox River TMDL project by Dale Robertson of the USGS in 2008; methods provided in Robertson and Saad, 1996, and Robertson, 1996). Robertson's constituent transport regression model was applied to estimate TP and TSS loads entering the Lower Fox River from the outlet of Lake Winnebago from 1989 to 2006, and an average was used to represent baseline conditions. Appendix C provides a summary of these data.

Figure 17. Drainage basins for the Upper Fox River, Lower Fox River, and Wolf River

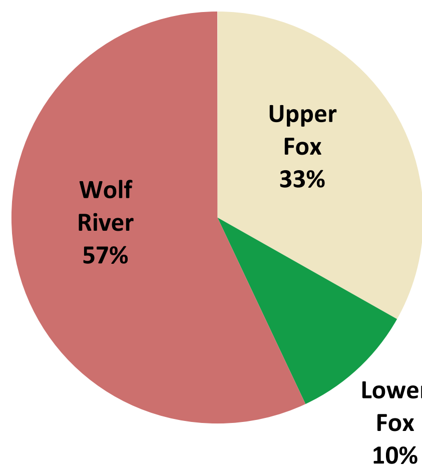


Figure 18. Percent of total land area of the Fox-Wolf Basin

4.2. Summary of Baseline Sources of Phosphorus and Sediment Loading

Baseline TP and TSS loading conditions in the LFR Basin were estimated using the methods summarized in Section 4.1. This section provides a data summary of baseline loads and sources of baseline loads for the basin.

Mean annual TP loading in the LFR Basin is an estimated 549,703 lbs/yr (Table 6 and Figure 19). Lake Winnebago is estimated to contribute an additional 716,954 lbs/yr at its outlet, resulting in a combined total mean annual TP loading of 1,266,657 lbs/yr.

Table 6. Sources of baseline TP loading in the LFR Basin

Source	Total Phosphorus (lbs/yr)
Natural Background	5,609
Agriculture	251,382
Urban (non-regulated)	15,960
Urban (regulated MS4)	65,829
Construction Sites	7,296
General Permits	2,041
Industrial WWTFs	114,426
Municipal WWTFs	87,160
TOTAL (in-basin)	**549,703**
Lake Winnebago	716,954
TOTAL (in-basin + Lake Winnebago)	**1,266,657**

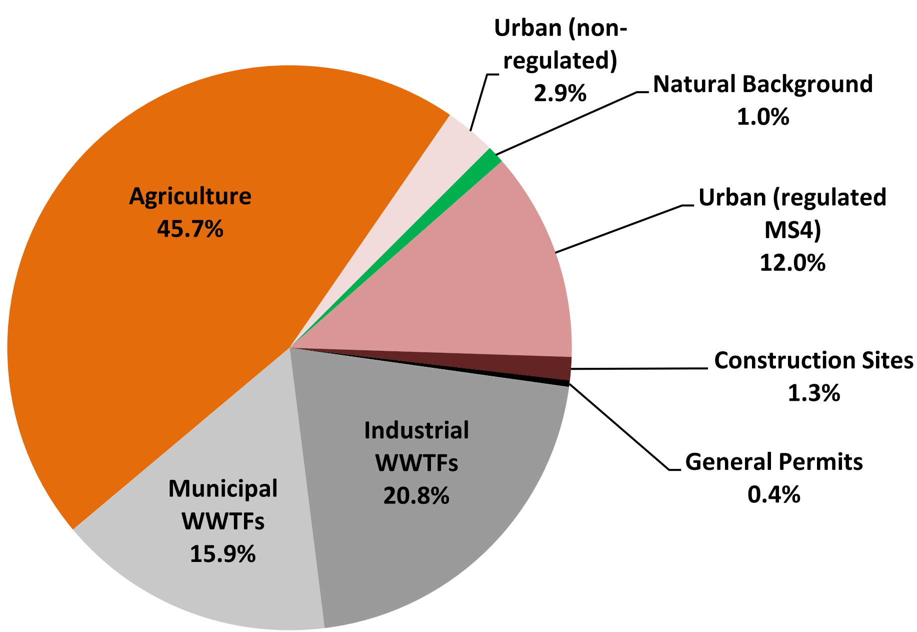


Figure 19. Sources of baseline TP loading in the LFR Basin

Mean annual TSS loading in the LFR Basin is an estimated 176,434,787 lbs/yr (Table 7 and Figure 20). Lake Winnebago is estimated to contribute an additional 127,397,076 lbs/yr at its outlet, resulting in a combined total mean annual TSS loading of 303,831,863 lbs/yr.

Table 7. Sources of baseline TSS loading in the LFR Basin

Source	Total Suspended Solids (lbs/yr)	Total Suspended Solids (mt/yr)
Natural Background	1,264,433	574
Agriculture	93,101,945	42,230
Urban (non-regulated)	4,491,399	2,037
Urban (regulated MS4)	31,505,733	14,291
Construction Sites	7,015,420	3,182
General Permits	616,532	280
Industrial WWTFs	2,435,778	1,105
Municipal WWTFs	1,170,510	531
Biotic Solids	34,833,037	15,800
TOTAL (in-basin)	**176,434,787**	**80,030**
Lake Winnebago	127,397,076	57,786
TOTAL (in-basin + Lake Winnebago)	**303,831,863**	**137,816**

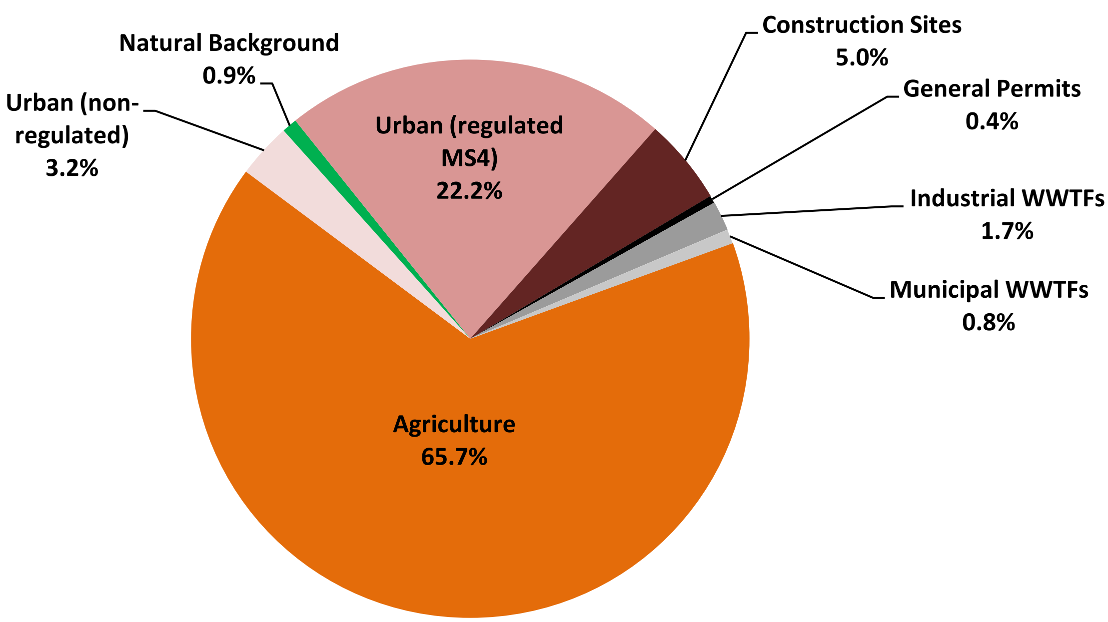


Figure 20. Sources of baseline TSS loading in the LFR Basin (excluding biotic solids)

In order to support planning for implementation of the TMDL within the LFR Basin, the results of the analysis are summarized by the 15 major sub-basins that make up the LFR Basin (Figure 21). Table 8 provides a summary of mean annual baseline TP and TSS loads originating from within each of the 15 sub-basins.

Table 8. Summary of baseline TP and TSS loads originating from within each sub-basin

Sub-Basin	Total Phosphorus (lbs/yr)	Total Suspended Solids	
		lbs/yr	mt/yr
East River	48,748	19,796,496	8,980
Baird Creek	12,748	3,791,217	1,720
Bower Creek	27,777	10,318,235	4,680
Apple Creek	35,088	12,736,271	5,777
Ashwaubenon Creek	15,681	4,871,171	2,210
Dutchman Creek	15,280	5,033,703	2,283
Plum Creek	31,569	12,038,905	5,461
Kankapot Creek	20,050	7,253,520	3,290
Garners Creek	6,575	2,863,318	1,299
Mud Creek	6,594	2,924,841	1,327
Duck Creek	63,172	25,394,165	11,519
Trout Creek	4,518	1,451,838	659
Neenah Slough	11,912	4,846,168	2,198
Lower Fox River (main stem)	237,339	23,980,196	10,877
Lower Green Bay	12,652	4,301,706	1,951
TOTAL (in-basin)*	**549,703**	**141,601,750**	**64,231**

* Not including loads from biotic solids

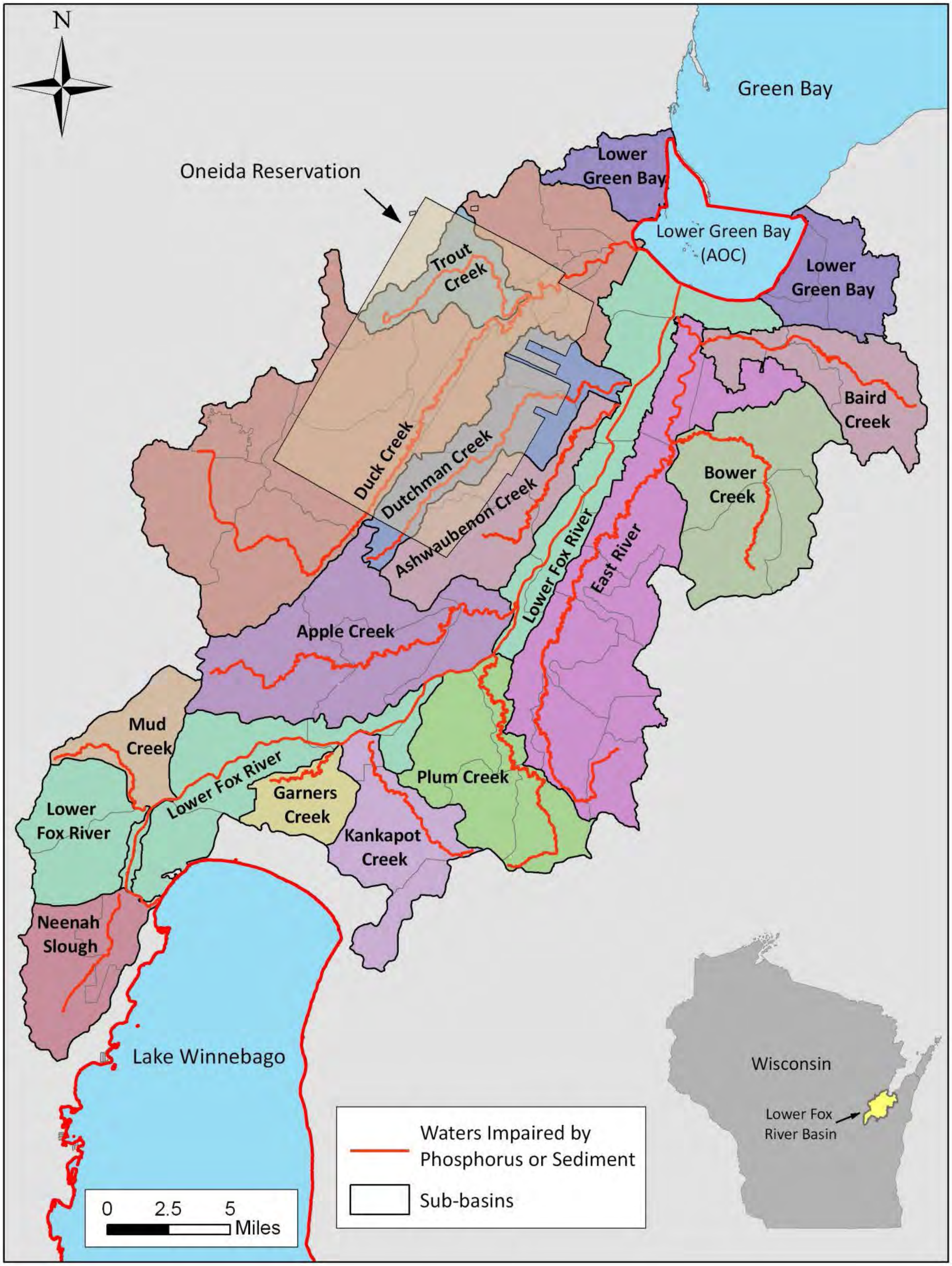


Figure 21. Sub-basins in the Lower Fox River Basin

5.0 DETERMINATION OF LOAD CAPACITY

5.1. Linking Phosphorus and Sediment Loading to the Numeric Water Quality Targets

The targets for TP are a summer (May through October[15]) median concentration of 0.10 mg/L (100 μg/L) for the main stem of the Lower Fox River and a summer (May through October) median concentration of 0.075 mg/L (75 μg/L) for tributary streams in the basin, including Duck Creek, which discharges directly to Lower Green Bay. The target for TSS for the outlet of the LFR Basin to Lower Green Bay is a summer (May through October) median concentration of 18 mg/L. TSS targets for the tributary streams and main stem of the river are calculated as the percent load reductions needed to meet the target for the outlet of the LFR Basin to Lower Green Bay. The SWAT model is only capable of simulating phosphorus and sediment concentrations and loads rather than response variables in the water body (such as biological conditions). However, this TMDL is based on in-stream phosphorus and sediment targets that are linked to biological indicators and other conditions that are protective of the designated uses and applicable water quality standards for the impaired segments in the LFR Basin.

Water quality monitoring data will need to be collected to determine whether numeric water quality targets and load allocations are being met for this TMDL. This evaluation of compliance with water quality standards will be made based on minimum data requirements and thresholds as outlined in Wisconsin's Consolidated Assessment and Listing Methodology (WisCALM) document.

5.2. Critical Conditions

TMDLs must take into account critical environmental conditions to ensure that water quality is protected during times when it is most vulnerable. Critical conditions for phosphorous impairments are generally during summer months when temperature, flow, and sunlight conditions are conducive to excessive plant growth. However, loadings throughout the entire year contribute to high phosphorus concentrations during this critical period. Critical loadings for TSS impairments occur during wet weather events, which result in upland and stream bank erosion. Wet weather events can occur at various times during the year, but are especially prevalent in spring and summer.

A TMDL is typically expressed as a load over time; however, it is the in-stream phosphorus and sediment concentrations under critical conditions that must be reduced to remove the impairments in the LFR Basin and Lower Green Bay. Therefore, water quality improvements will be evaluated through comparison of water column concentrations during the critical period (i.e., summer). The SWAT model uses daily time steps for weather data and water balance calculations. Annual calculations are made for phosphorus and sediment loads based on the daily water balance accumulated to annual values. Therefore, all possible flow conditions are taken into account for loading calculations. Because there is generally a significant lag time between the introduction of phosphorus and sediment to a water body and the resulting impact on beneficial uses, establishing this TMDL using average annual conditions is protective of the impaired segments in the LFR Basin. Further, the TMDLs are presented as both a daily load and an average annual load. An annual loading target is more appropriate than a daily loading target for guiding implementation efforts, as annual loads are more easily aligned with the design of best management practices (BMPs) used to implement nonpoint source and stormwater controls for nutrient and sediment impairments. The daily TMDLs and allocations were calculated by dividing the annual load by the number of days in the year.

[15] During the algae growing season.

5.3. Loading Capacity

The objective of a TMDL is to allocate loads among pollutant sources so that appropriate control measures can be implemented and water quality standards achieved. Wasteload allocations (WLAs) are assigned to point source discharges regulated by WPDES permits and unregulated nonpoint source loads are assigned load allocations (LAs). A TMDL is expressed as the sum of all individual WLAs for point source loads, LAs for nonpoint source loads, and an appropriate margin of safety (MOS), which takes into account uncertainty (Equation 1).

Equation 1. Calculation of the TMDL

$$TMDL = \sum WLA + \sum LA + MOS$$

As previously mentioned, this TMDL was developed using a watershed framework. Under a watershed framework, TMDLs and the associated tasks[16] are simultaneously completed for multiple impaired water bodies in a watershed. Appendix C summarizes the methodology used to calculate the TMDLs and load reductions needed to attain the numeric targets.

A portion of the LFR Basin is located within the Oneida Tribe of Wisconsin's Reservation. This TMDL is not applicable to the water bodies located within the boundary of the Oneida Reservation. However, to meet the TMDLs for the LFR Basin and Lower Green Bay, voluntary reductions are needed from sources located within the Oneida Reservation. Therefore, load reduction goals for pollutant loads originating from within the Oneida Reservation have been identified in this report.

5.3.1. Total Phosphorus

The maximum average annual phosphorus load that will achieve the 0.075 mg/L target for the tributary streams in the basin and the 0.1 mg/L target for the LFR main stem and outlet to the bay is an average annual TP load of 224,301 lbs/yr from in-basin loads. The daily equivalent TMDL of this load is 614 lbs/day. Achieving the average annual TMDL will require a 59.2% total reduction from in-basin loads. Table 9 provides a summary of baseline loads, allocated loads, and load reduction goals for TP loads originating from within each sub-basin. Voluntary reduction goals for phosphorus loads originating from within the Oneida Reservation have also been identified in Table 9.

As previously discussed, phosphorus loads from Lake Winnebago (and the Upper Fox and Wolf Basins) must also be reduced if the goals established by this TMDL are to be met. As discussed in Appendix C, a 40% reduction goal (286,782 lbs/yr) has been established for phosphorus loads entering the basin at the outlet of Lake Winnebago. This reduction goal for loads entering the LFR Basin from the outlet of Lake Winnebago represents reasonable expectations for load reductions that may be achievable in the Upper Fox and Wolf Basins given that Lake Winnebago is a eutrophic/hypereutrophic lake. Reducing the amount of phosphorus released from the lake by greater than 40% may not be feasible given that part of the phosphorus input to Lake Winnebago may come from internal sources (D. Robertson, personal communication, June 2010). Further studies by USGS and WDNR are being conducted to determine what measures would be needed to reduce phosphorus loading from Lake Winnebago by 40%. The reduction goal for Lake Winnebago may need to be adjusted following the TMDL analysis for the Upper Fox and Wolf Basins.

[16] Characterizing the impaired water body and its watershed, identifying sources, setting targets, calculating the loading capacity, identifying source allocations, preparing TMDL reports, and coordinating with stakeholders.

Table 9. Summary of baseline loads, allocated loads, and load reduction goals for TP loads originating from within each sub-basin

Sub-Basin	Baseline TP (lbs/yr)	Allocated TP (lbs/yr)			TP Reduction (lbs/yr)	% Reduction*
		State	Oneida	Total		
East River	48,748	14,592	0	14,592	34,156	70.1%
Baird Creek	12,748	4,801	0	4,801	7,947	62.3%
Bower Creek	27,777	7,964	0	7,964	19,813	71.3%
Apple Creek	35,088	12,557	0	12,557	22,531	64.2%
Ashwaubenon Creek	15,681	4,636	1,151	5,787	9,894	63.1%
Dutchman Creek	15,280	2,626	3,638	6,263	9,017	59.0%
Plum Creek	31,569	7,193	0	7,193	24,376	77.2%
Kankapot Creek	20,050	5,548	0	5,548	14,502	72.3%
Garners Creek	6,575	2,949	0	2,949	3,626	55.1%
Mud Creek	6,594	4,254	0	4,254	2,340	35.5%
Duck Creek	63,172	14,113	9,139	23,252	39,920	63.2%
Trout Creek	4,518	0	2,495	2,495	2,023	44.8%
Neenah Slough	11,912	5,758	0	5,758	6,154	51.7%
Lower Fox River (main stem)	237,339	114,263	0	114,263	123,076	51.9%
Lower Green Bay	12,652	6,625	0	6,625	6,027	47.6%
TOTAL (in-basin)	**549,703**	**207,878**	**16,423**	**224,301**	**325,402**	**59.2%**

*Provided for informational purposes only and calculated as follows: Baseline TP / TP Reduction

5.3.2. Total Suspended Solids

The maximum average annual sediment load that will achieve compliance with the 18 mg/L target for the outlet to Lower Green Bay is an average annual TSS load of 79,512,059 lbs/yr from in-basin loads. The daily equivalent TMDL of this load is 217,692 lbs/day. Achieving the average annual TMDL will require a 54.9% total reduction in loads from in-basin loads. Table 10 provides a summary of baseline loads, allocated loads, and load reductions goals for TSS loads originating from within each sub-basin, as well as from biotic solids from the Lower Fox River main stem. Voluntary reduction goals for TSS loads originating from within the Oneida Reservation have also been identified in Table 10.

TSS loads from Lake Winnebago (and the Upper Fox and Wolf Basins) must also be reduced if the goals established by this TMDL are to be met. As discussed in Appendix C, an estimated 48.3% reduction goal (61,472,726 lbs/yr) is expected for TSS loads entering the basin at the outlet of Lake Winnebago. This reduction goal for loads entering the LFR Basin from the outlet of Lake Winnebago represents reasonable expectations for load reductions that may be achievable in the Upper Fox and Wolf Basins. This reduction goal may need to be adjusted following the TMDL analysis for the Upper Fox and Wolf Basins.

Table 10. Summary of baseline loads, allocated loads, and load reduction goals for TSS loads originating from within each sub-basin, from biotic solids

Sub-Basin	Baseline TSS (lbs/yr)	Allocated TSS (lbs/yr)			TSS Reduction (lbs/yr)	% Reduction*
		State	Oneida	Total		
East River	19,796,496	7,231,130	0	7,231,130	12,565,366	63.5%
Baird Creek	3,791,217	2,374,777	0	2,374,777	1,416,440	37.4%
Bower Creek	10,318,235	3,939,913	0	3,939,913	6,378,322	61.8%
Apple Creek	12,736,271	6,211,712	0	6,211,712	6,524,559	51.2%
Ashwaubenon Creek	4,871,171	2,198,993	664,069	2,863,062	2,008,109	41.2%
Dutchman Creek	5,033,703	1,075,794	2,022,278	3,098,072	1,935,631	38.5%
Plum Creek	12,038,905	3,558,318	0	3,558,318	8,480,587	70.4%
Kankapot Creek	7,253,520	2,744,726	0	2,744,726	4,508,794	62.2%
Garners Creek	2,863,318	1,459,045	0	1,459,045	1,404,273	49.0%
Mud Creek	2,924,841	2,104,168	0	2,104,168	820,673	28.1%
Duck Creek	25,394,165	7,095,397	4,321,078	11,416,475	13,977,690	55.0%
Trout Creek	1,451,838	0	1,234,199	1,234,199	217,639	15.0%
Neenah Slough	4,846,168	2,848,353	0	2,848,353	1,997,815	41.2%
Lower Fox River (main stem)	23,980,196	11,115,433	0	11,115,433	12,864,763	53.6%
Lower Green Bay	4,301,706	2,265,758	0	2,265,758	2,035,948	47.3%
Biotic Solids	34,833,037	15,046,918	0	15,046,918	19,786,119	56.8%
TOTAL (in-basin)	**176,434,787**	**71,270,435**	**8,241,624**	**79,512,059**	**96,922,728**	**54.9%**

*Provided for informational purposes only and calculated as follows: Baseline TSS / TSS Reduction

6.0 POLLUTANT LOAD ALLOCATIONS

6.1. In-Basin Sources

Each sub-basin's TMDL, load allocations, wasteload allocations, and needed reductions for both TP and TSS are summarized in tables on pages 43–87. Individual sub-basin maps are provided with the allocation tables. Appendix C provides a summary of the methodology used to calculate the TMDLs and the load and wasteload allocations.

6.1.1. Load Allocation

The load allocations for nonpoint sources of TP and TSS are summarized on pages 43–87. Appendix C provides a summary of the methodology used to calculate the load allocations.

6.1.2. Wasteload Allocation

The wasteload allocations for point sources of TP and TSS are summarized on pages 43–87. Appendix C provides a summary of the methodology used to calculate the wasteload allocations.

Water quality-based effluent limits (WQBELs) that implement WLAs in approved TMDLs must be "consistent with the assumptions and requirements of any available WLA for the discharge" (Title 40 of the *Code of Federal Regulations* [CFR] 122.44(d)(1)(vii)(B)). Note that these provisions do not require that effluent limits in WPDES permits be expressed in a form that is identical to the form in which the WLA for the discharge is expressed in a TMDL. Permit limits need only be "consistent with the assumptions and requirements" of a TMDL's WLA (USEPA, 2007). Accordingly, WDNR may use the guidance in EPA's *Technical Support Document for Water Quality-based Toxics Control* (1991b) to derive WQBELs from the WLA established by this TMDL. The approach in this guidance takes into consideration inherent variability of wastewater treatment effectiveness and effluent monitoring. For example, applying EPA's guidance to a hypothetical point source with a WLA of 365 pounds per year and 1 pound per day, an effluent monitoring frequency of weekly, and an effluent coefficient of variation of 0.6 would produce a daily maximum effluent limit of 2.7 lbs/day and a monthly average effluent limit of 1.4 lbs/day. To meet the daily maximum and monthly average effluent limits consistently, the discharger's effluent would have to average 1 pound per day over the entire year, which totals 365 pounds per year. Conversely, to consistently meet a daily maximum effluent limit of 1 pound per day, the effluent would have to average 0.37 pounds per day over the entire year, which equals a total of only 135 pounds per year.

In addition to showing each MS4's WLA on pages 43–87, Appendix D includes additional tables that summarize each MS4's WLA by subwatershed and in total (for both TP and TSS). Each MS4 has been assigned a WLA as specified in Appendix C. In some cases, the WLA for TSS assigned to MS4s in certain sub-basins (e.g., Mud Creek) results in a lower percent reduction (from baseline conditions) than that required by Wisconsin Administrative Code NR 151. The developed urban area of each unique MS4 is still required to meet, at a minimum, the Wisconsin Administrative Code NR 151 mandated 40% TSS reduction specified in MS4 permits.

6.2. Oneida Reservation

Trout Creek and portions of Duck and Dutchman Creeks are located within the boundary of the Oneida Reservation. The TMDLs established for the LFR Basin and Lower Green Bay are not applicable to the water bodies located within the boundary of the Oneida Reservation. However, to meet the TMDLs for the LFR Basin and Lower Green Bay, voluntary reductions are needed from sources within the Oneida

Reservation. Therefore, load reduction goals for pollutant loads originating from within the Oneida Reservation are also identified on pages 43–87.

6.3. Out-of-Basin Sources

Even though the LFR Basin accounts for only 10% of the land area of the Fox-Wolf Basin (see Figure 17 and Figure 18), it contributes about 43% of the TP load and 56% of the TSS load delivered to Lower Green Bay (at the outlet of the Lower Fox River main stem). Also, as illustrated in the maps in Figure 29 and Figure 30 in Appendix E, the sources of TP and TSS loads originating from within the Upper Fox River and Wolf River are more diffuse than those originating from within the LFR Basin. Therefore, TP and TSS loads from Lake Winnebago (and the Upper Fox and Wolf Basins) must be reduced if the goals established by this TMDL are to be met. A 40% reduction goal (286,782 lbs/yr) has been established for TP loads entering the basin at the outlet of Lake Winnebago; and a 48.3% reduction goal (61,472,726 lbs/yr) is expected for TSS loads entering the basin at the outlet of Lake Winnebago. These reduction goals for loads entering the LFR Basin from the outlet of Lake Winnebago represent reasonable expectations for load reductions that may be achievable in the Upper Fox and Wolf Basins. These reduction goals may need to be adjusted if the TMDL analysis for the Upper Fox and Wolf Basins reveals that these reduction goals are not feasible. The TMDL for the Upper Fox and Wolf Basins is slated to be final in the next few years, as federal and state resources allow.

6.4. Margin of Safety

The margin of safety (MOS) can be implicit (incorporated into the TMDL analysis through conservative assumptions) or explicit (expressed in the TMDL as a portion of the loadings) or a combination of both. A margin of safety has been incorporated implicitly into the TMDLs for phosphorus and TSS as follows:

- Although the calibration and validation of SWAT indicate that it can be applied to reliably simulate phosphorus and TSS loads in the LFR Basin, the model shows a slight tendency to over predict flows and loads at some of the calibration sites when comparing model output to observed data (see Appendix B for more discussion). This occasional over-prediction of loads provides for an implicit MOS in the TMDL analysis.
- An additional 10% MOS is implicitly incorporated in the TMDL analysis for TSS to account for uncertainty in meeting the load reduction goal for biotic solids. This was done through use of an 18 mg/L summer (May through October) median TMDL target for the outlet to the bay (see Appendix C for more information).

The MOS can be reviewed in the future as new data become available.

6.5. Reserve Capacity

Reserve capacity is an optional means of reserving a portion of the loading capacity to allow for future growth. Reserve capacity is typically considered in an area where new or expanded WPDES permits are likely. The following summarizes how reserve capacity is included in the TMDL.

6.5.1. Wastewater Treatment Facilities

Although GW Partners LLC (permit no. 0001121) still has an active permit, the facility is no longer operating. Therefore, the estimated baseline load from GW Partners LLC (6,362 lbs/year for TP and 52,979 lbs/year for TSS,) is being set aside to support potential new or expanded WPDES permits on the main stem of the Lower Fox River. This WWTF Reserve Capacity load is shown in the Lower Fox River main stem subwatershed allocation tables (in the following pages).

6.5.2. Regulated MS4 Communities

Two main factors limit the need for a reserve capacity being set aside for MS4 communities:

1. ***Expansion of municipalities generally involves the conversion of agricultural land into urban land.*** The growth of MS4 communities generally involves conversion of agricultural land into urban land uses. Under this model, TP and TSS loads may remain the same or decrease as soils are either placed under perennial vegetation (lawns) or impervious surfaces. Therefore urban growth possibly will entail a transfer of the load allocation for phosphorus and sediment from agriculture land be assigned to the waste load allocation for the MS4. If this transfer requires more load allocation than available, than the urban area must either find additional reductions within its service area or pollutant trade to offset the difference in loads. This process differs from wastewater treatment plants that may increase discharge with no change in land area served.

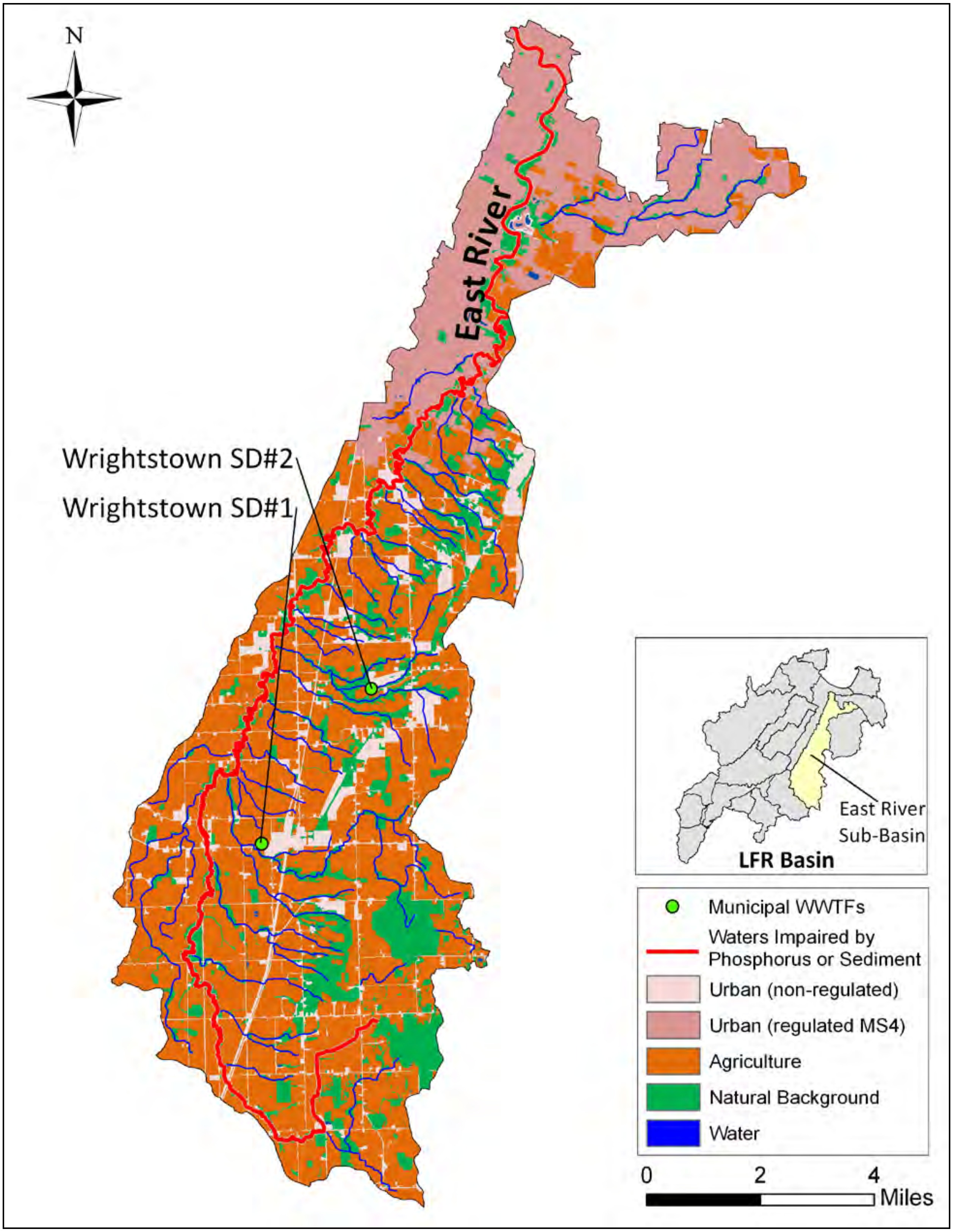
2. ***MS4s need to comply with the requirements contained in Wisconsin Administrative Code NR 151 and NR 216, which limit pollutant loads from urban areas.*** Under WDNR's storm water regulations and performance standards, new urban development is required to reduce TSS loads and meet infiltration requirements; also, urban re-development is required to reduce TSS loads. These performance standards were promulgated to meet water quality standards. If more stringent standards are needed, targeted performance standards may be promulgated through Wisconsin Administrative Code NR 151.004 such that urban development will meet allocations stipulated in the TMDL

6.6. Seasonal Variation

TMDLs must take into account seasonal variation in environmental conditions. As previously discussed, critical conditions for phosphorus impairments generally occur during summer months when temperature, flow, and sunlight conditions are conducive to excessive plant growth. However, loadings throughout the entire year contribute to high phosphorus concentrations during this critical period. Critical loadings for TSS impairments occur during wet weather events, which result in upland and stream bank erosion. Wet weather events are especially prevalent in spring and summer.

Seasonal variations in the phosphorus and TSS loads are captured in the model used for the TMDL analysis. First, SWAT uses daily time steps for weather data and water balance calculations. Loads were calculated by SWAT using a 23-year (1977-2000) long-term hydrologic simulation period, which minimizes the potential influence of climate dependant factors and provides a more representative estimate of average conditions. Second, output from SWAT is on a daily time step, but is summarized on an average annual basis for the TMDL analysis. Therefore, all possible flow conditions are taken into account for load calculations.

EAST RIVER SUB-BASIN



EAST RIVER
TOTAL PHOSPHORUS

Sub-basin Loading Summary (lbs/yr)	
Baseline	48,748
TMDL	14,592
Reduction	34,156
% Reduction Needed	70.1%
Daily TMDL (lbs/day)	39.95

Land Use	Acres	% of Total
Agriculture	26,520	54.3%
Urban (non-regulated)	4,423	9.1%
Urban (MS4)	9,091	18.6%
Construction	256	0.5%
Natural Background	8,571	17.5%
TOTAL	**48,861**	**100.0%**

Sources	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	38,020	6,123	31,897	83.9%	16.76
Urban (non-regulated)	2,195	2,195	-	-	6.01
Natural Background	853	853	-	-	2.34
LOAD ALLOCATION	**41,068**	**9,171**	**31,897**	**77.7%**	**25.11**
Urban (MS4)	5,797	4,058	1,739	30.0%	11.11
Construction	836	836	-	-	2.29
General Permits	322	322	-	-	0.88
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	725	205	520	71.7%	0.56
WASTELOAD ALLOCATION	**7,680**	**5,421**	**2,259**	**29.4%**	**14.84**
TOTAL (WLA + LA)	**48,748**	**14,592**	**34,156**	**70.1%**	**39.95**

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Allouez	1,101	771	330	30.0%	2.11
Bellevue	1,076	753	323	30.0%	2.06
DePere	737	516	221	30.0%	1.41
Green Bay	2,122	1,485	637	30.0%	4.07
Ledgeview	761	533	228	30.0%	1.46

WWTF-Municipal	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Wrightstown SD#1	690	170	520	75.4%	0.47
Wrightstown SD#2	35	35	-	-	0.10

EAST RIVER

TOTAL SUSPENDED SOLIDS

Sub-basin Loading Summary (lbs/yr)	
Baseline	19,796,496
TMDL	7,231,130
Reduction	12,565,366
% Reduction Needed	63.5%

Daily TMDL (lbs/day)	19,798

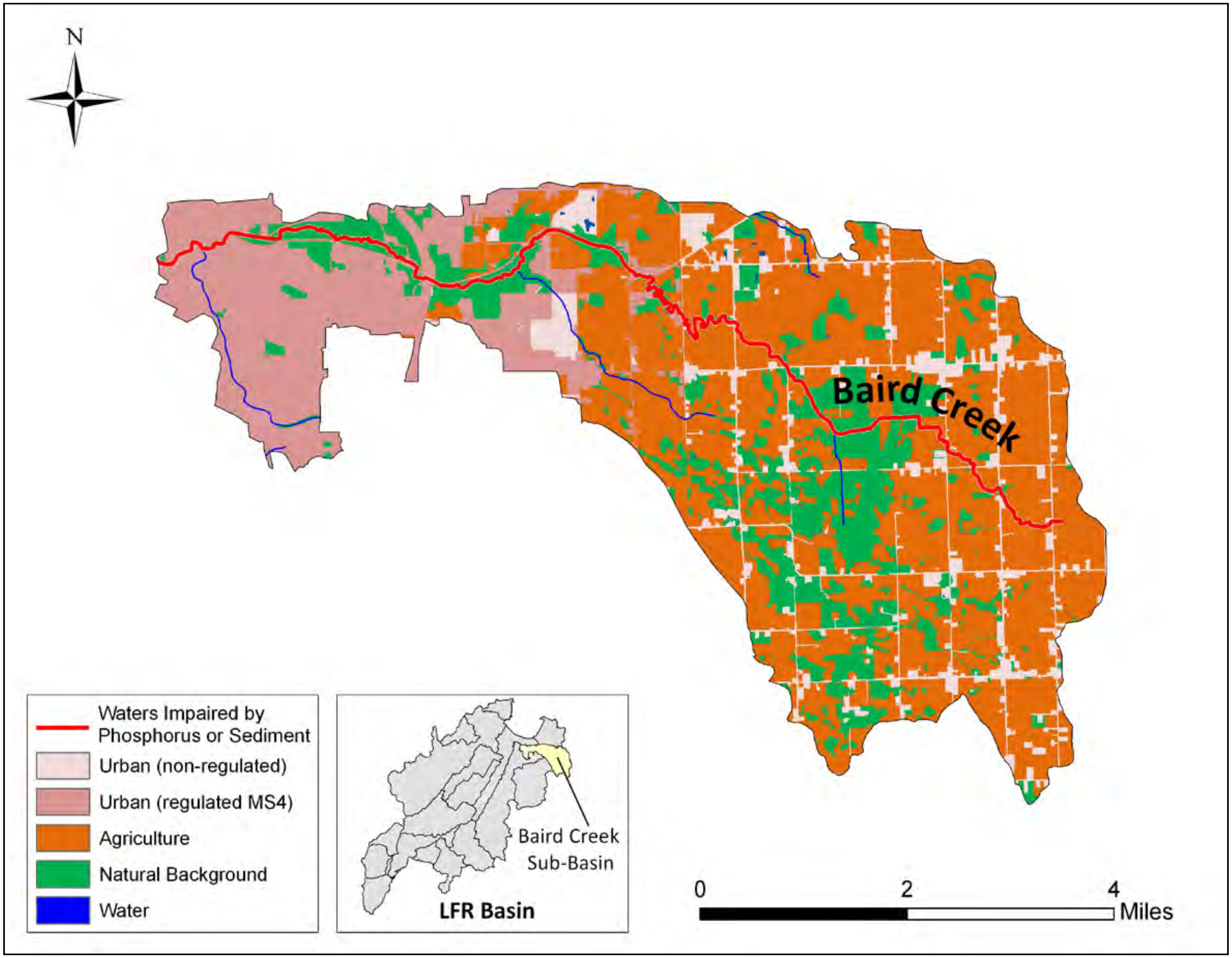
Land Use	Acres	% of Total
Agriculture	26,520	54.3%
Urban	4,423	9.1%
Urban-MS4	9,091	18.6%
Construction	256	0.5%
Natural Background	8,571	17.5%
TOTAL	**48,861**	**100.0%**

Sources	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	15,364,278	4,511,822	10,852,456	70.6%	12,353
Urban (non-regulated)	581,660	581,660	-	-	1,592
Natural Background	279,417	279,417	-	-	765
LOAD ALLOCATION	**16,225,355**	**5,372,899**	**10,852,456**	**66.9%**	**14,710**
Urban (MS4)	2,622,118	1,573,271	1,048,847	40.0%	4,307
Construction	830,079	166,016	664,063	80.0%	455
General Permits	118,364	118,364	-	-	324
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	580	580	-	-	2
WASTELOAD ALLOCATION	**3,571,141**	**1,858,231**	**1,712,910**	**48.0%**	**5,088**
TOTAL (WLA + LA)	**19,796,496**	**7,231,130**	**12,565,366**	**63.5%**	**19,798**

Urban (MS4)	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Allouez	444,964	266,978	177,986	40%	731
Bellevue	511,765	307,059	204,706	40%	841
DePere	273,714	164,228	109,486	40%	450
Green Bay	1,119,137	671,482	447,655	40%	1,838
Ledgeview	272,538	163,523	109,015	40%	448

WWTF-Municipal	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Wrightstown SD#1	472	472	-	-	1
Wrightstown SD#2	108	108	-	-	-

BAIRD CREEK SUB-BASIN



BAIRD CREEK
TOTAL PHOSPHORUS

Sub-basin Loading Summary (lbs/yr)	
Baseline	12,748
TMDL	4,801
Reduction	7,947
% Reduction Needed	62.3%

Daily TMDL (lbs/day)	13.14

Land Use	Acres	% of Total
Agriculture	8,633	52.7%
Urban (non-regulated)	1,437	8.8%
Urban (MS4)	3,004	18.3%
Construction	149	0.9%
Natural Background	3,149	19.2%
TOTAL	**16,372**	**100.0%**

Sources	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	9,018	1,772	7,246	80.4%	4.85
Urban (non-regulated)	588	588	-	-	1.61
Natural Background	263	263	-	-	0.72
LOAD ALLOCATION	**9,869**	**2,623**	**7,246**	**73.4%**	**7.18**
Urban (MS4)	2,338	1,637	701	30.0%	4.48
Construction	476	476	-	-	1.30
General Permits	65	65	-	-	0.18
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
WASTELOAD ALLOCATION	**2,879**	**2,178**	**701**	**24.3%**	**5.96**
TOTAL (WLA + LA)	**12,748**	**4,801**	**7,947**	**62.3%**	**13.14**

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Bellevue	4	2.8	1.2	30.0%	0.01
Green Bay	2,334	1,634.2	699.8	30.0%	4.47

BAIRD CREEK
TOTAL SUSPENDED SOLIDS

Sub-basin Loading Summary (lbs/yr)	
Baseline	3,791,217
TMDL	2,374,777
Reduction	1,416,440
% Reduction Needed	37.4%

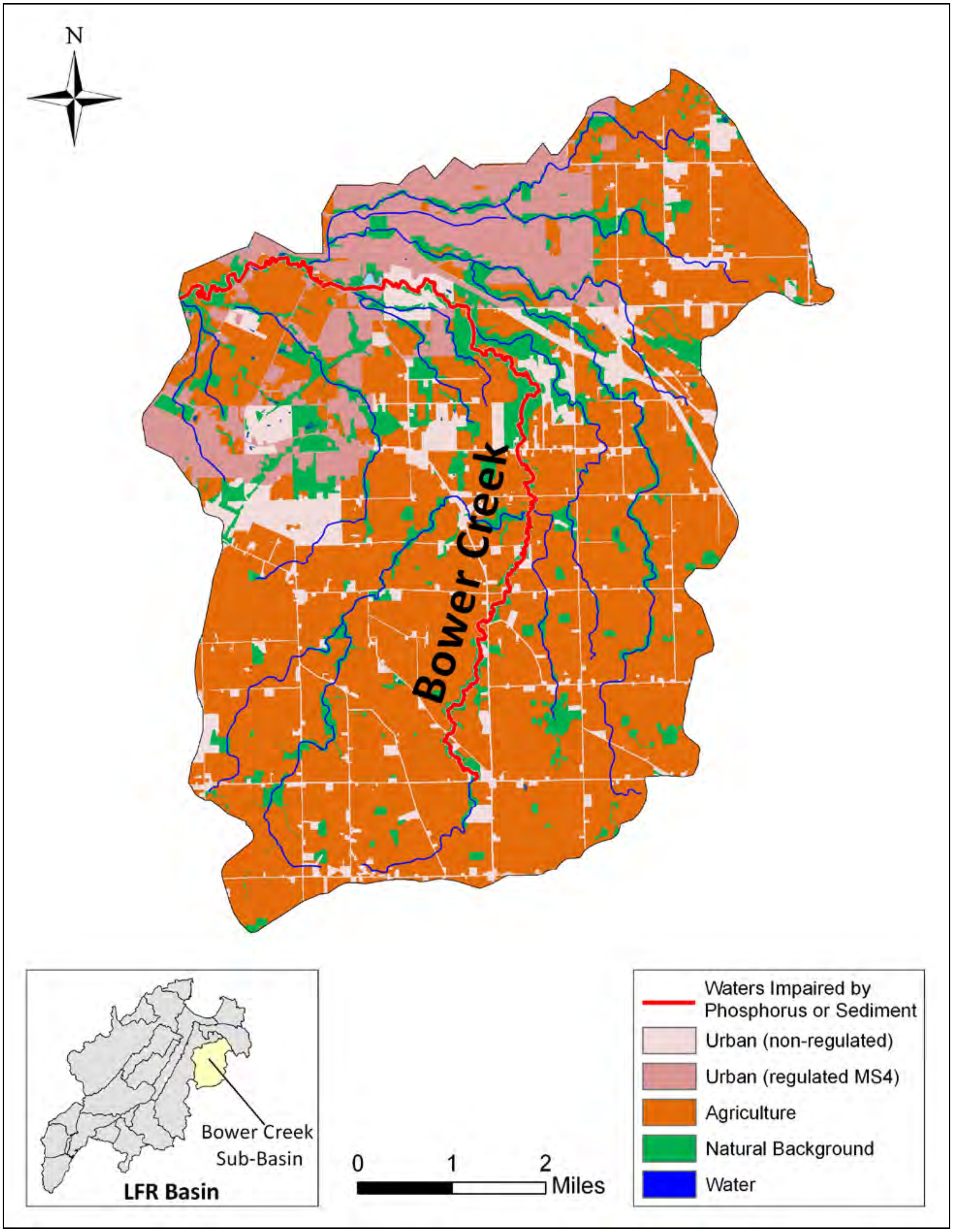
Daily TMDL (lbs/day)	6,503

Land Use	Acres	% of Total
Agriculture	8,633	52.7%
Urban	1,437	8.8%
Urban-MS4	3,004	18.3%
Construction	149	0.9%
Natural Background	3,149	19.2%
TOTAL	**16,372**	**100.0%**

Sources	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	2,146,760	1,495,195	651,565	30.4%	4,094
Urban (non-regulated)	108,357	108,357	-	-	297
Natural Background	40,639	40,639	-	-	111
LOAD ALLOCATION	**2,295,756**	**1,644,191**	**651,565**	**28.4%**	**4,502**
Urban (MS4)	1,054,983	632,990	421,993	40.0%	1,733
Construction	428,603	85,721	342,882	80.0%	235
General Permits	11,875	11,875	-	-	33
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
WASTELOAD ALLOCATION	**1,495,461**	**730,586**	**764,875**	**51.1%**	**2,001**
TOTAL (WLA + LA)	**3,791,217**	**2,374,777**	**1,416,440**	**37.4%**	**6,503**

Urban (MS4)	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Bellevue	2,631	1,579	1,052	40.0%	4
Green Bay	1,052,352	631,411	420,941	40.0%	1,729

BOWER CREEK SUB-BASIN



BOWER CREEK
TOTAL PHOSPHORUS

Sub-basin Loading Summary (lbs/yr)	
Baseline	27,777
TMDL	7,964
Reduction	19,813
% Reduction Needed	71.3%
Daily TMDL (lbs/day)	21.80

Land Use	Acres	% of Total
Agriculture	17,142	63.6%
Urban (non-regulated)	2,983	11.1%
Urban (MS4)	3,203	11.9%
Construction	142	0.5%
Natural Background	3,468	12.9%
TOTAL	**26,938**	**100.0%**

Sources	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	22,946	3,860	19,086	83.2%	10.57
Urban (non-regulated)	1,435	1,435	-	-	3.93
Natural Background	283	283	-	-	0.77
LOAD ALLOCATION	**24,664**	**5,578**	**19,086**	**77.4%**	**15.27**
Urban (MS4)	2,422	1,695	727	30.0%	4.64
Construction	445	445	-	-	1.22
General Permits	246	246	-	-	0.67
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
WASTELOAD ALLOCATION	**3,113**	**2,386**	**727**	**23.4%**	**6.53**
TOTAL (WLA + LA)	**27,777**	**7,964**	**19,813**	**71.3%**	**21.80**

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Bellevue	1,545	1,081.2	463.8	30.0%	2.96
Green Bay	29	20.3	8.7	30.0%	0.06
Ledgeview	848	593.5	254.5	30.0%	1.62

BOWER CREEK
TOTAL SUSPENDED SOLIDS

Sub-basin Loading Summary (lbs/yr)	
Baseline	10,318,235
TMDL	3,939,913
Reduction	6,378,322
% Reduction Needed	61.8%

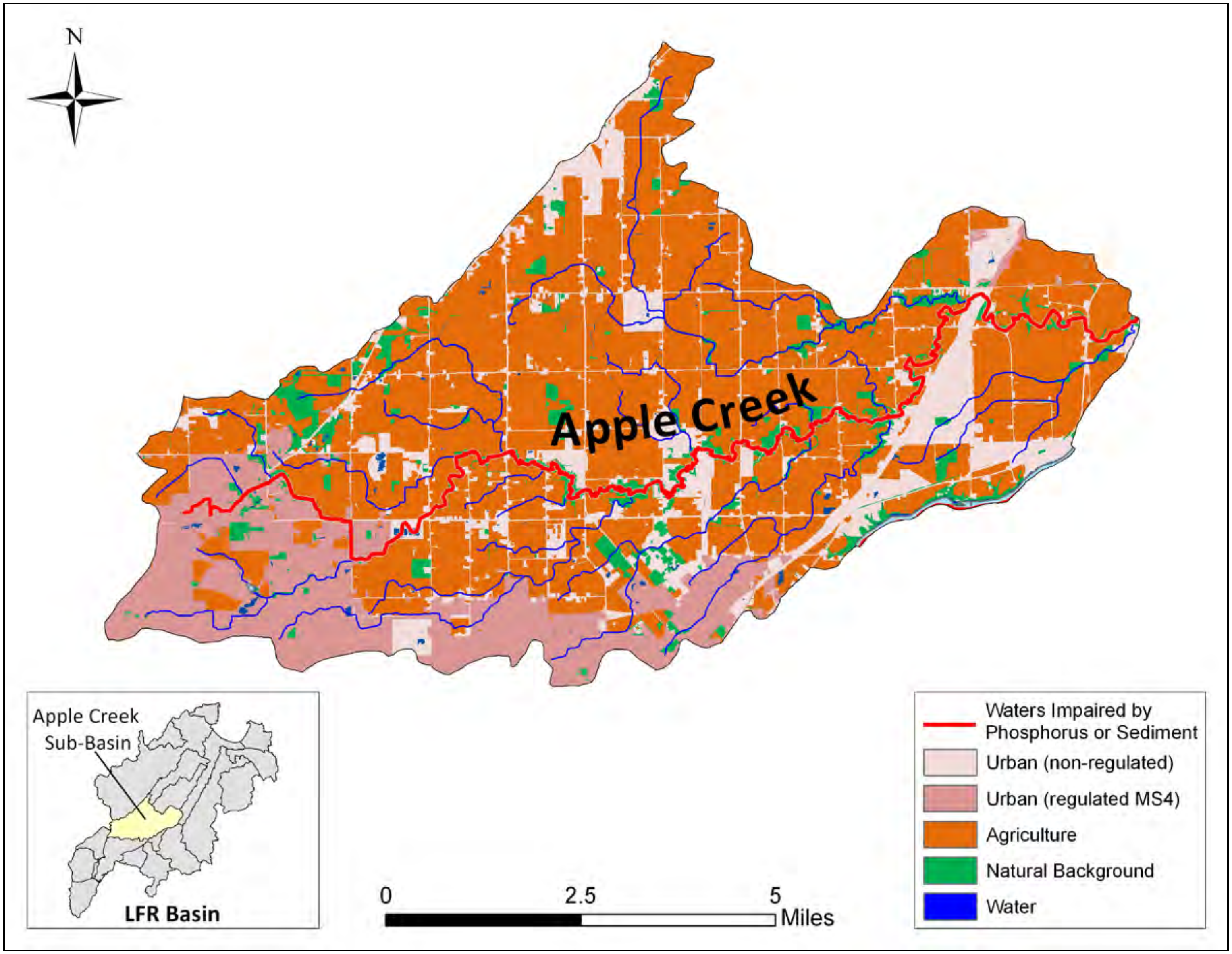
Daily TMDL (lbs/day)	10,787

Land Use	Acres	% of Total
Agriculture	17,142	63.6%
Urban	2,983	11.1%
Urban-MS4	3,203	11.9%
Construction	142	0.5%
Natural Background	3,468	12.9%
TOTAL	**26,938**	**100.0%**

Sources	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	8,490,347	2,776,357	5,713,990	67.3%	7,601
Urban (non-regulated)	387,277	387,277	-	-	1,060
Natural Background	118,283	118,283	-	-	324
LOAD ALLOCATION	**8,995,907**	**3,281,917**	**5,713,990**	**63.5%**	**8,985**
Urban (MS4)	828,393	497,036	331,357	40.0%	1,361
Construction	416,219	83,244	332,975	80.0%	228
General Permits	77,716	77,716	-	-	213
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
WASTELOAD ALLOCATION	**1,322,328**	**657,996**	**664,332**	**50.2%**	**1,802**
TOTAL (WLA + LA)	**10,318,235**	**3,939,913**	**6,378,322**	**61.8%**	**10,787**

Urban (MS4)	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Bellevue	536,593	321,956	214,637	40.0%	881
Green Bay	9,715	5,829	3,886	40.0%	16
Ledgeview	282,085	169,251	112,834	40.0%	463

APPLE CREEK SUB-BASIN



APPLE CREEK
TOTAL PHOSPHORUS

Sub-basin Loading Summary (lbs/yr)	
Baseline	35,088
TMDL	12,557
Reduction	22,531
% Reduction Needed	64.2%

Daily TMDL (lbs/day)	34.39

Land Use	Acres	% of Total
Agriculture	20,613	60.2%
Urban (non-regulated)	5,378	15.7%
Urban (MS4)	5,653	16.5%
Construction	245	0.7%
Natural Background	2,343	6.8%
TOTAL	**34,232**	**100.0%**

Sources	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	27,297	5,828	21,469	78.6%	15.96
Urban (non-regulated)	2,837	2,837	-	-	7.77
Natural Background	255	255	-	-	0.70
LOAD ALLOCATION	**30,389**	**8,920**	**21,469**	**70.6%**	**24.43**
Urban (MS4)	3,541	2,479	1,062	30.0%	6.79
Construction	890	890	-	-	2.44
General Permits	268	268	-	-	0.73
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
WASTELOAD ALLOCATION	**4,699**	**3,637**	**1,062**	**22.6%**	**9.96**
TOTAL (WLA + LA)	**35,088**	**12,557**	**22,531**	**64.2%**	**34.39**

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Appleton	1,617	1,132	485	30.0%	3.10
GrandChute	571	399.7	171.3	30.0%	1.09
Kaukauna	563	394.1	168.9	30.0%	1.08
Lawrence	58	40.6	17.4	30.0%	0.11
LittleChute	732	512.5	219.5	30.0%	1.40

APPLE CREEK
TOTAL SUSPENDED SOLIDS

Sub-basin Loading Summary (lbs/yr)	
Baseline	12,736,271
TMDL	6,211,712
Reduction	6,524,559
% Reduction Needed	51.2%

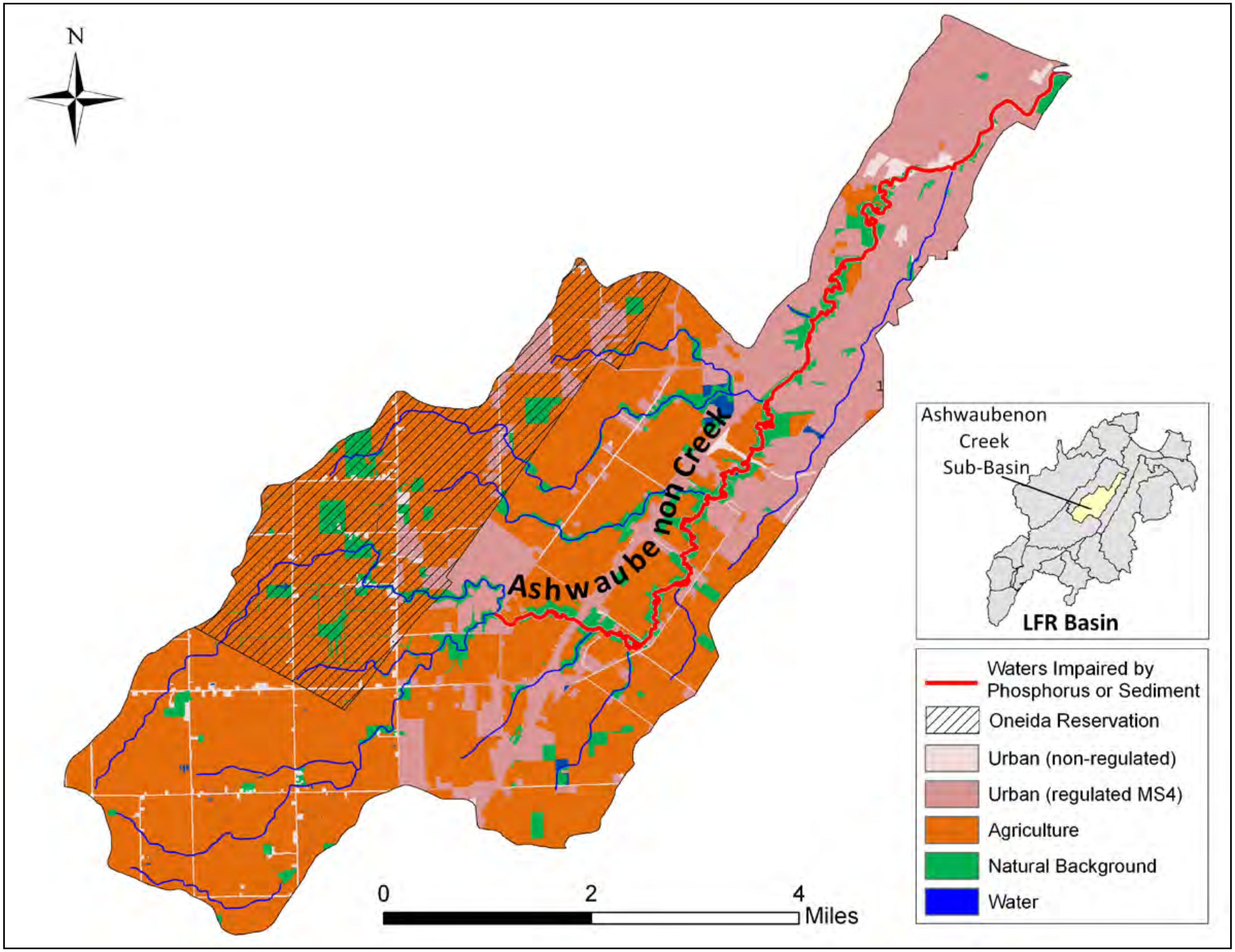
Daily TMDL (lbs/day)	17,007

Land Use	Acres	% of Total
Agriculture	20,613	60.2%
Urban	5,378	15.7%
Urban-MS4	5,653	16.5%
Construction	245	0.7%
Natural Background	2,343	6.8%
TOTAL	**34,232**	**100.0%**

Sources	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	9,450,834	4,149,661	5,301,173	56.1%	11,361
Urban (non-regulated)	886,462	886,462	-	-	2,427
Natural Background	68,486	68,486	-	-	188
LOAD ALLOCATION	**10,405,782**	**5,104,609**	**5,301,173**	**50.9%**	**13,976**
Urban (MS4)	1,411,610	846,966	564,644	40.0%	2,319
Construction	823,428	164,686	658,742	80.0%	451
General Permits	95,451	95,451	-	-	261
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
WASTELOAD ALLOCATION	**2,330,489**	**1,107,103**	**1,223,386**	**52.5%**	**3,031**
TOTAL (WLA + LA)	**12,736,271**	**6,211,712**	**6,524,559**	**51.2%**	**17,007**

Urban (MS4)	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Appleton	635,802	381,481	254,321	40.0%	1,044
GrandChute	200,022	120,013	80,009	40.0%	329
Kaukauna	237,775	142,665	95,110	40.0%	391
Lawrence	21,308	12,785	8,523	40.0%	35
LittleChute	316,703	190,022	126,681	40.0%	520

ASHWAUBENON CREEK SUB-BASIN



ASHWAUBENON CREEK
TOTAL PHOSPHORUS

Sub-basin Loading Summary (lbs/yr)	
Baseline	15,681
TMDL	5,787
Reduction	9,894
% Reduction Needed	63.1%

Daily TMDL (lbs/day)	15.83

Land Use	Acres			% of Total
	State	Oneida	Total	
Agriculture	8,220	3,244	11,464	61.9%
Urban (non-regulated)	454	112	566	3.1%
Urban (MS4)	4,352	354	4,706	25.4%
Construction	106	31	137	0.7%
Natural Background	1,276	379	1,655	8.9%
TOTAL	**14,408**	**4,120**	**18,528**	**100.0%**

Sources from State Land	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	8,797	2,288	6,509	74.0%	6.26
Urban (non-regulated)	154	154	-	-	0.42
Natural Background	113	136	(23)	-	0.37
LOAD ALLOCATION	**9,064**	**2,578**	**6,486**	**71.6%**	**7.05**
Urban (MS4)	2,549	1,784	765	30.0%	4.88
Construction	268	268	-	-	0.73
General Permits	6	6	-	-	0.02
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
WASTELOAD ALLOCATION	**2,823**	**2,058**	**765**	**27.1%**	**5.63**
TOTAL (WLA + LA)	**11,887**	**4,636**	**7,251**	**61.0%**	**12.68**

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Ashwaubenon	554	387.7	166.3	30.0%	1.06
DePere	927	648.8	278.2	30.0%	1.78
Hobart	-	-	-	-	-
Lawrence	1,068	747.5	320.5	30.0%	2.05

Sources from Oneida Reservation	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	3,472	903	2,569	74.0%	2.47
Urban (non-regulated)	38	38	-	-	0.10
Natural Background	34	11	23	67.6%	0.03
NONPOINT SOURCES	**3,544**	**952**	**2,592**	**73.1%**	**2.60**
Urban (MS4)	170	119	51	30.0%	0.33
Construction	78	78	-	-	0.21
General Permits	2	2	-	-	0.01
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
POINT SOURCES	**250**	**199**	**51**	**20.4%**	**0.55**
TOTAL (NPS + PS)	**3,794**	**1,151**	**2,643**	**69.7%**	**3.15**

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Ashwaubenon	-	-	-	-	-
DePere	-	-	-	-	-
Hobart	170	119.0	51.0	30.0%	0.33
Lawrence	-	-	-	-	-

ASHWAUBENON CREEK
TOTAL SUSPENDED SOLIDS

Sub-basin Loading Summary (lbs/yr)	
Baseline	4,871,171
TMDL	2,863,062
Reduction	2,008,109
% Reduction Needed	41.2%
Daily TMDL (lbs/day)	7,840

Land Use	Acres			% of
	State	Oneida	Total	Total
Agriculture	8,220	3,244	11,464	61.9%
Urban	454	112	566	3.1%
Urban-MS4	4,352	354	4,706	25.4%
Construction	106	31	137	0.7%
Natural Background	1,276	379	1,655	8.9%
TOTAL	**14,408**	**4,120**	**18,528**	**100.0%**

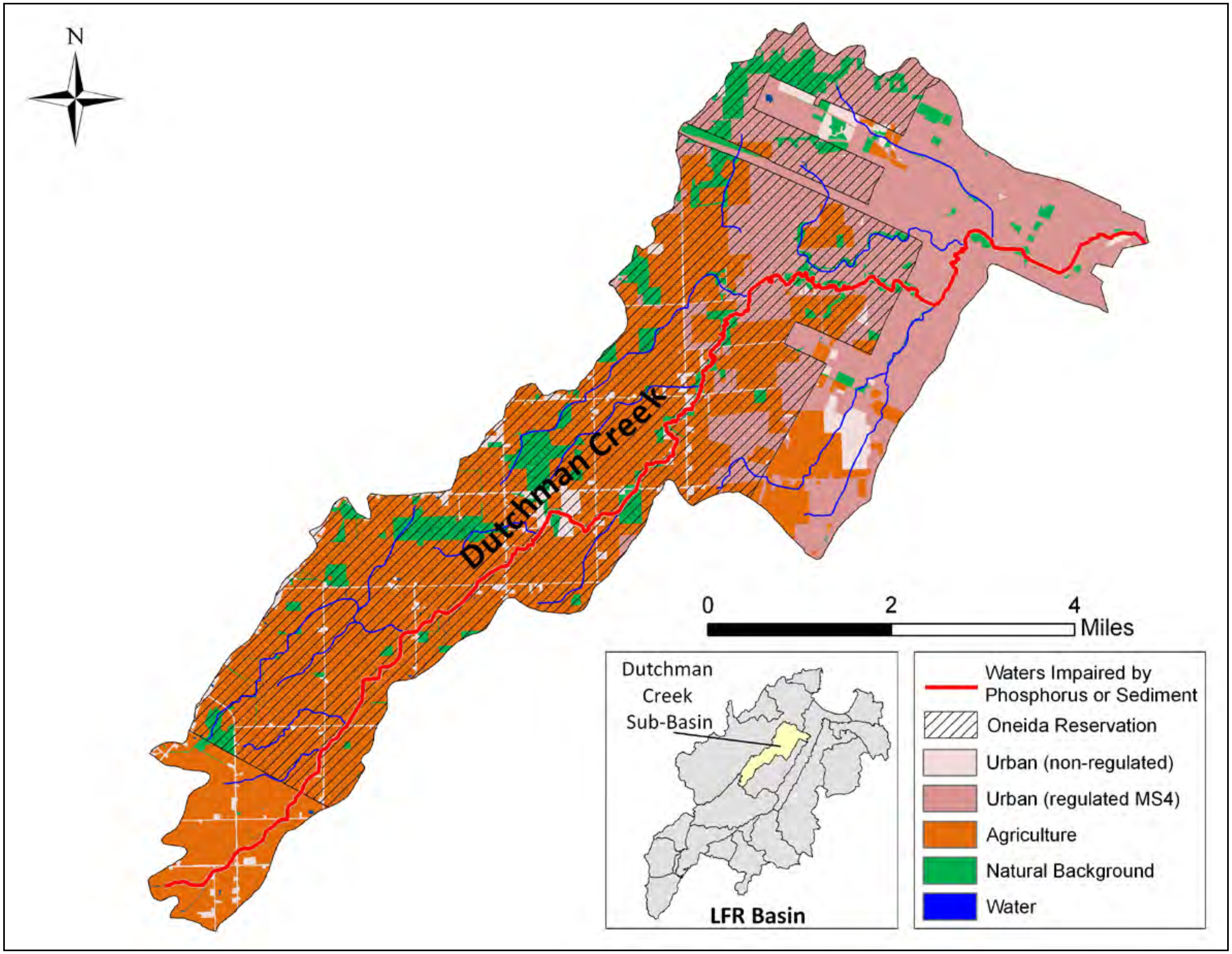
Sources from State Land	Total Suspended Solids Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Agriculture	2,555,692	1,539,868	1,015,824	39.7%	4,216
Urban (non-regulated)	55,179	55,179	-	-	151
Natural Background	24,136	24,136	-	-	66
LOAD ALLOCATION	**2,635,007**	**1,619,183**	**1,015,824**	**38.6%**	**4,433**
Urban (MS4)	894,105	536,463	357,642	40.0%	1,469
Construction	211,272	42,255	169,017	80.0%	116
General Permits	1,092	1,092	-	-	3
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
WASTELOAD ALLOCATION	**1,106,469**	**579,810**	**526,659**	**47.6%**	**1,588**
TOTAL (WLA + LA)	**3,741,476**	**2,198,993**	**1,542,483**	**41.2%**	**6,021**

Urban (MS4)	Total Suspended Solids Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Ashwaubenon	249,169	149,501	99,668	40.0%	409
DePere	329,712	197,827	131,885	40.0%	542
Hobart	-	-	-	-	-
Lawrence	315,224	189,134	126,090	40.0%	518

Sources from Oneida Reservation	Total Suspended Solids Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Agriculture	1,008,597	607,705	400,892	39.7%	1,664
Urban (non-regulated)	13,613	13,613	-	-	37
Natural Background	7,169	7,169	-	-	20
NONPOINT SOURCES	**1,029,379**	**628,487**	**400,892**	**38.9%**	**1,721**
Urban (MS4)	38,259	22,955	15,304	40.0%	63
Construction	61,787	12,357	49,430	80.0%	34
General Permits	270	270	-	-	1
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
POINT SOURCES	**100,316**	**35,582**	**64,734**	**64.5%**	**98**
TOTAL (NPS + PS)	**1,129,695**	**664,069**	**465,626**	**41.2%**	**1,819**

Urban (MS4)	Total Suspended Solids Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Ashwaubenon	-	-	-	-	-
DePere	-	-	-	-	-
Hobart	38,259	22,955	15,304	40.0%	63
Lawrence	-	-	-	-	-

DUTCHMAN CREEK SUB-BASIN



DUTCHMAN CREEK
TOTAL PHOSPHORUS

Sub-basin Loading Summary (lbs/yr)	
Baseline	15,280
TMDL	6,263
Reduction	9,017
% Reduction Needed	59.0%

Daily TMDL (lbs/day)	17.16

Land Use	Acres			% of Total
	State	Oneida	Total	
Agriculture	1,809	7,888	9,697	50.5%
Urban (non-regulated)	398	634	1,032	5.4%
Urban (MS4)	3,714	2,800	6,514	34.0%
Construction	74	31	105	0.5%
Natural Background	1,459	379	1,838	9.6%
TOTAL	**7,454**	**11,732**	**19,186**	**100.0%**

Sources from State Land	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	1,890	446	1,444	76.4%	1.22
Urban (non-regulated)	156	156	-	-	0.43
Natural Background	122	122	-	-	0.33
LOAD ALLOCATION	**2,168**	**724**	**1,444**	**66.6%**	**1.98**
Urban (MS4)	2,404	1,683	721	30.0%	4.61
Construction	204	204	-	-	0.56
General Permits	15	15	-	-	0.04
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
WASTELOAD ALLOCATION	**2,623**	**1,902**	**721.00**	**27.5%**	**5.21**
TOTAL (WLA + LA)	**4,791**	**2,626**	**2,165**	**45.2%**	**7.19**

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Ashwaubenon	2,113	1,478.9	634.1	30.0%	4.05
Green Bay	98	68.6	29.4	30.0%	0.19
Hobart	-	-	-	-	-
Lawrence	193	135.1	57.9	30.0%	0.37

Sources from Oneida Reservation	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	8,240	1,946	6,294	76.4%	5.33
Urban (non-regulated)	248	248	-	-	0.68
Natural Background	32	32	-	-	0.09
NONPOINT SOURCES	**8,520**	**2,226**	**6,294**	**73.9%**	**6.10**
Urban (MS4)	1,858	1,301	557	30.0%	3.56
Construction	86	86	-	-	0.24
General Permits	25	25	-	-	0.07
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
POINT SOURCES	**1,969**	**1,412**	**557**	**28.3%**	**3.87**
TOTAL (PS + NPS)	**10,489**	**3,638**	**6,851**	**65.3%**	**9.97**

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Ashwaubenon	500	350.0	150.0	30.0%	0.96
Green Bay	426	298.2	127.8	30.0%	0.82
Hobart	932	652.3	279.7	30.0%	1.79
Lawrence	-	-	-	-	-

DUTCHMAN CREEK
TOTAL SUSPENDED SOLIDS

Sub-basin Loading Summary (lbs/yr)	
Baseline	5,033,703
TMDL	3,098,072
Reduction	1,935,631
% Reduction Needed	38.5%
Daily TMDL (lbs/day)	8,483

Land Use	Acres			% of Total
	State	Oneida	Total	
Agriculture	1,809	7,888	9,697	50.5%
Urban	398	634	1,032	5.4%
Urban-MS4	3,714	2,800	6,514	34.0%
Construction	74	31	105	0.5%
Natural Background	1,459	379	1,838	9.6%
TOTAL			**19,186**	**100.0%**

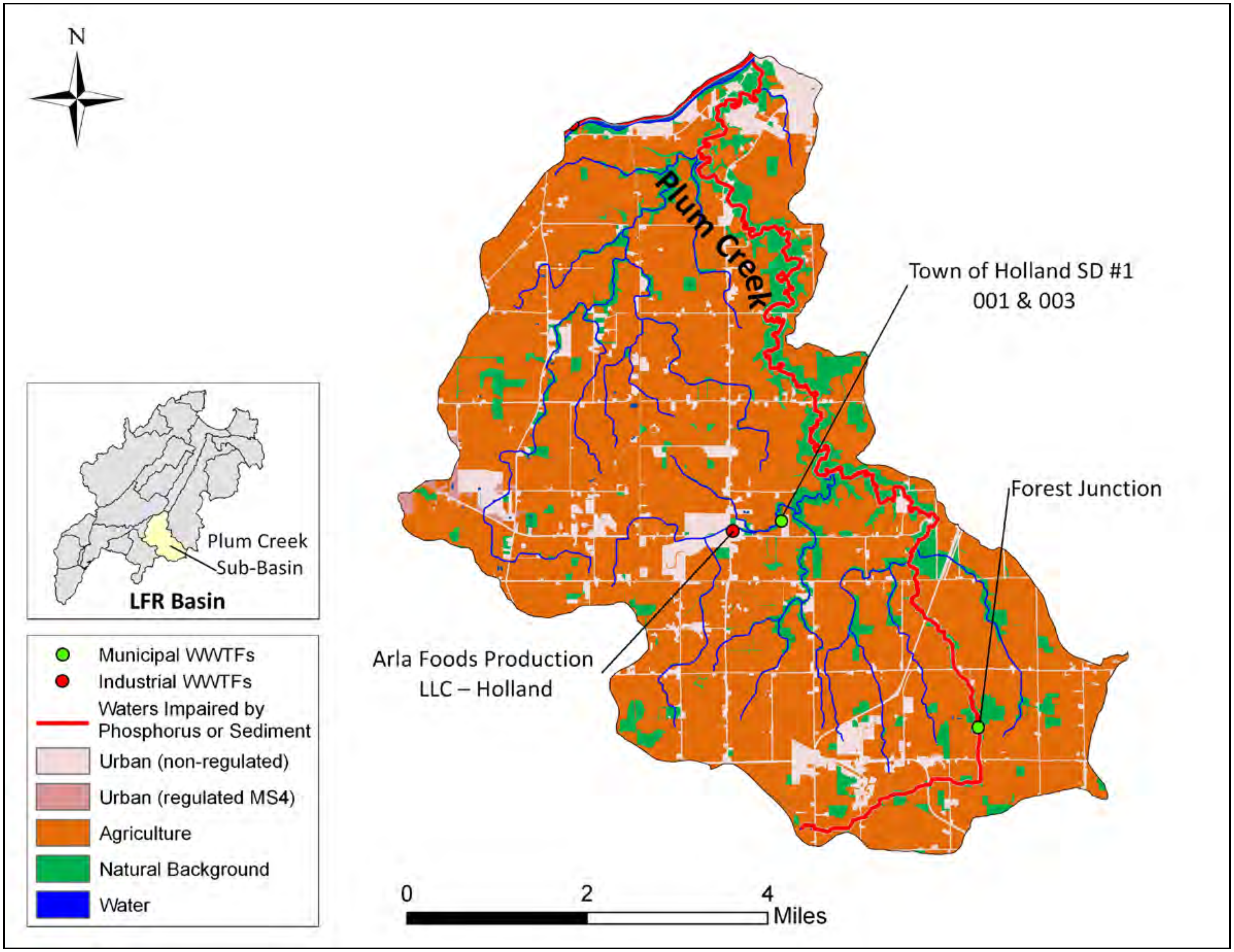
Sources from State Land	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	535,463	343,756	191,707	35.8%	941
Urban (non-regulated)	34,083	34,083	-	-	93
Natural Background	19,266	19,266	-	-	53
LOAD ALLOCATION	**588,812**	**397,105**	**191,707**	**32.6%**	**1,087**
Urban (MS4)	1,070,534	642,321	428,213	40.0%	1,759
Construction	161,830	32,366	129,464	80.0%	89
General Permits	4,002	4,002	-	-	11
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
WASTELOAD ALLOCATION	**1,236,366**	**678,689**	**557,677**	**45.1%**	**1,859**
TOTAL (WLA + LA)	**1,825,178**	**1,075,794**	**749,384**	**41.1%**	**2,946**

Urban (MS4)	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Ashwaubenon	961,049	576,630	384,419	40.0%	1,579
Green Bay	37,282	22,369	14,913	40.0%	61
Hobart	-	-	-	-	-
Lawrence	72,203	43,322	28,881	40.0%	119

Sources from Oneida Reservation	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	2,334,844	1,498,918	835,926	35.8%	4,104
Urban (non-regulated)	54,292	54,292	-	-	149
Natural Background	5,005	5,005	-	-	14
NONPOINT SOURCES	**2,394,141**	**1,558,215**	**835,926**	**34.9%**	**4,267**
Urban (MS4)	740,214	444,128	296,086	40.0%	1,216
Construction	67,794	13,559	54,235	80.0%	37
General Permits	6,376	6,376	-	-	17
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
POINT SOURCES	**814,384**	**464,063**	**350,321**	**43.0%**	**1,270**
TOTAL (PS + NPS)	**3,208,525**	**2,022,278**	**1,186,247**	**37.0%**	**5,537**

Urban (MS4)	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Ashwaubenon	227,524	136,514	91,010	40.0%	374
Green Bay	162,975	97,785	65,190	40.0%	268
Hobart	349,715	209,829	139,886	40.0%	574
Lawrence	-	-	-	-	-

PLUM CREEK SUB-BASIN



PLUM CREEK
TOTAL PHOSPHORUS

Sub-basin Loading Summary (lbs/yr)	
Baseline	31,569
TMDL	7,193
Reduction	24,376
% Reduction Needed	77.2%
Daily TMDL (lbs/day)	19.69

Land Use	Acres	% of Total
Agriculture	17,382	76.2%
Urban (non-regulated)	2,465	10.8%
Urban (MS4)	79	0.3%
Construction	45	0.2%
Natural Background	2,833	12.4%
TOTAL	**22,804**	**100.0%**

Sources	Total Phosphorus Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Agriculture	27,660	3,861	23,799	86.0%	10.57
Urban (non-regulated)	1,316	1,316	-	-	3.60
Natural Background	359	359	-	-	0.98
LOAD ALLOCATION	**29,335**	**5,536**	**23,799**	**81.1%**	**15.15**
Urban (MS4)	76	53	23	30.0%	0.15
Construction	164	164	-	-	0.45
General Permits	168	168	-	-	0.46
WWTF-Industrial	546	341	205	37.5%	0.93
WWTF-Municipal	1,280	931	349	27.3%	2.55
WASTELOAD ALLOCATION	**2,234**	**1,657**	**577**	**25.8%**	**4.54**
TOTAL (WLA + LA)	**31,569**	**7,193**	**24,376**	**77.2%**	**19.69**

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Buchanan	30	21	9	30.0%	0.06
Kaukauna	46	32	14	30.0%	0.09

WWTF-Industrial	Total Phosphorus Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Arla Foods Production LLC - Holland	546	341	205	37.5%	0.93

WWTF-Municipal	Total Phosphorus Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Forest Junction	471	122	349	74.1%	0.33
Town of Holland SD #1	809	809	-	-	2.21

PLUM CREEK
TOTAL SUSPENDED SOLIDS

Sub-basin Loading Summary (lbs/yr)	
Baseline	12,038,905
TMDL	3,558,318
Reduction	8,480,587
% Reduction Needed	70.4%
Daily TMDL (lbs/day)	9,742

Land Use	Acres	% of Total
Agriculture	17,382	76.2%
Urban	2,465	10.8%
Urban-MS4	79	0.3%
Construction	45	0.2%
Natural Background	2,833	12.4%
TOTAL	**22,804**	**100.0%**

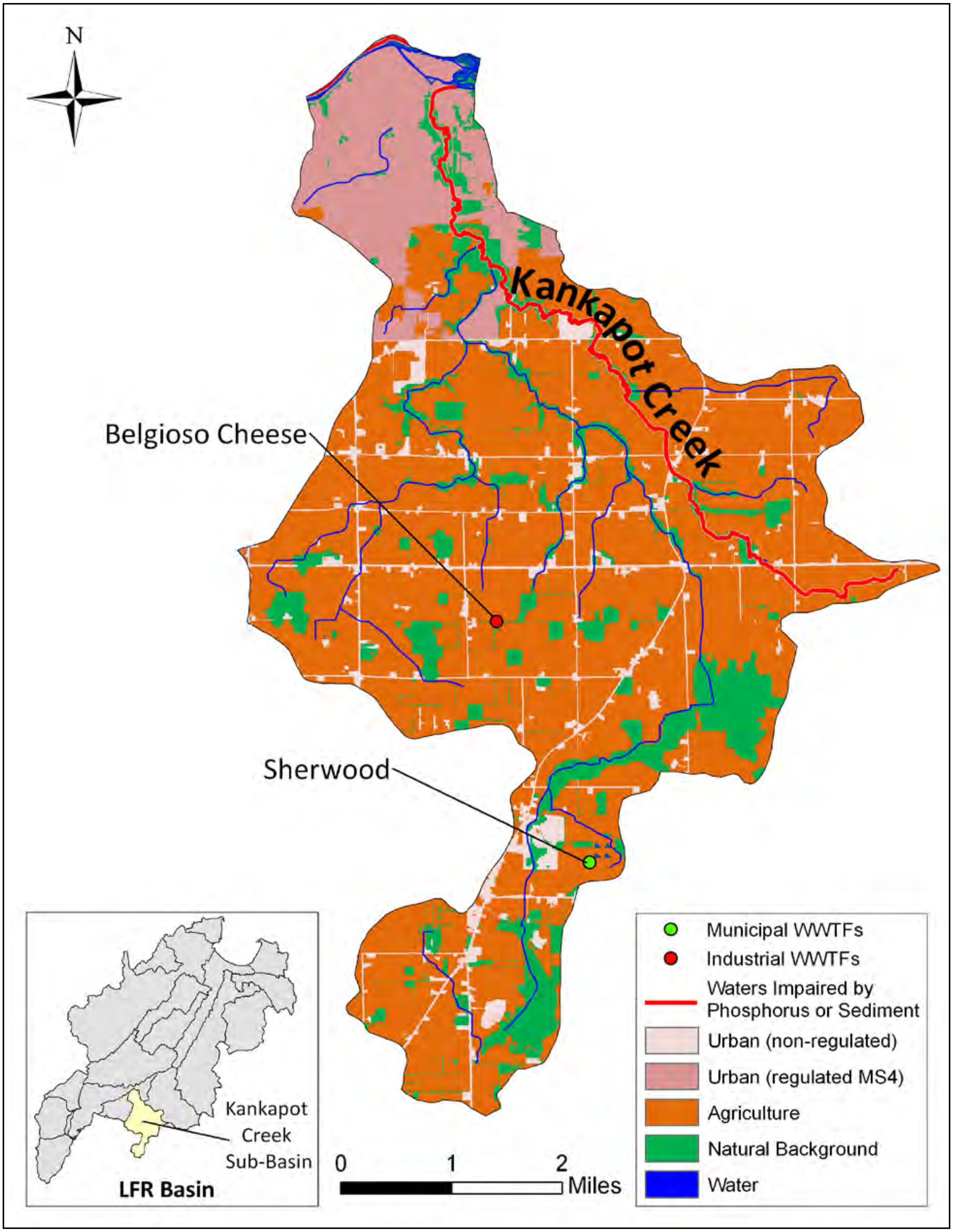
Sources	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	11,171,743	2,835,478	8,336,265	74.6%	7,763
Urban (non-regulated)	447,810	447,810	-	-	1,226
Natural Background	148,577	148,577	-	-	407
LOAD ALLOCATION	**11,768,130**	**3,431,865**	**8,336,265**	**70.8%**	**9,396**
Urban (MS4)	24,329	14,597	9,732	40.0%	40
Construction	168,238	33,648	134,590	80.0%	92
General Permits	47,269	47,269	-	-	129
WWTF-Industrial	682	682	-	-	2
WWTF-Municipal	30,257	30,257	-	-	83
WASTELOAD ALLOCATION	**270,775**	**126,453**	**144,322**	**53.3%**	**346**
TOTAL (WLA + LA)	**12,038,905**	**3,558,318**	**8,480,587**	**70.4%**	**9,742**

Urban (MS4)	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Buchanan	9,209.00	5,525	3,684	40.0%	15
Kaukauna	15,120.00	9,072	6,048	40.0%	25

WWTF-Industrial	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Arla Foods Production LLC - Holland	682	682	-	-	2

WWTF-Municipal	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Forest Junction	2,471	2,471	-	-	7
Town of Holland SD #1	27,786	27,786	-	-	76

KANKAPOT CREEK SUB-BASIN



KANKAPOT CREEK
TOTAL PHOSPHORUS

Sub-basin Loading Summary (lbs/yr)	
Baseline	20,050
TMDL	5,548
Reduction	14,502
% Reduction Needed	72.3%
Daily TMDL (lbs/day)	15.19

Land Use	Acres	% of Total
Agriculture	11,367	69.3%
Urban (non-regulated)	1,120	6.8%
Urban (MS4)	1,711	10.4%
Construction	31	0.2%
Natural Background	2,172	13.2%
TOTAL	**16,401**	**100.0%**

Sources	Total Phosphorus Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Agriculture	17,195	3,135	14,060	81.8%	8.58
Urban (non-regulated)	493	493	-	-	1.35
Natural Background	269	269	-	-	0.74
LOAD ALLOCATION	**17,957**	**3,897**	**14,060**	**78.3%**	**10.67**
Urban (MS4)	1,473	1,031	442	30.0%	2.82
Construction	99	99	-	-	0.27
General Permits	83	83	-	-	0.23
WWTF-Industrial	143	143	-	-	0.39
WWTF-Municipal	295	295	-	-	0.81
WASTELOAD ALLOCATION	**2,093**	**1,651**	**442**	**21.1%**	**4.52**
TOTAL (WLA + LA)	**20,050**	**5,548**	**14,502**	**72.3%**	**15.19**

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Buchanan	156	109.2	46.8	30.0%	0.30
CombLocks	5	3.5	1.5	30.0%	0.01
Kaukauna	1,312	918.3	393.7	30.0%	2.51

WWTF-Industrial	Total Phosphorus Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Belgioso Cheese - Sherwood	143	143	-	-	0.39

WWTF-Municipal	Total Phosphorus Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Sherwood	295	295	-	-	0.81

KANKAPOT CREEK
TOTAL SUSPENDED SOLIDS

Sub-basin Loading Summary (lbs/yr)	
Baseline	7,253,520
TMDL	2,744,726
Reduction	4,508,794
% Reduction Needed	62.2%
Daily TMDL (lbs/day)	7,515

Land Use	Acres	% of Total
Agriculture	11,367	69.3%
Urban	1,120	6.8%
Urban-MS4	1,711	10.4%
Construction	31	0.2%
Natural Background	2,172	13.2%
TOTAL	**16,401**	**100.0%**

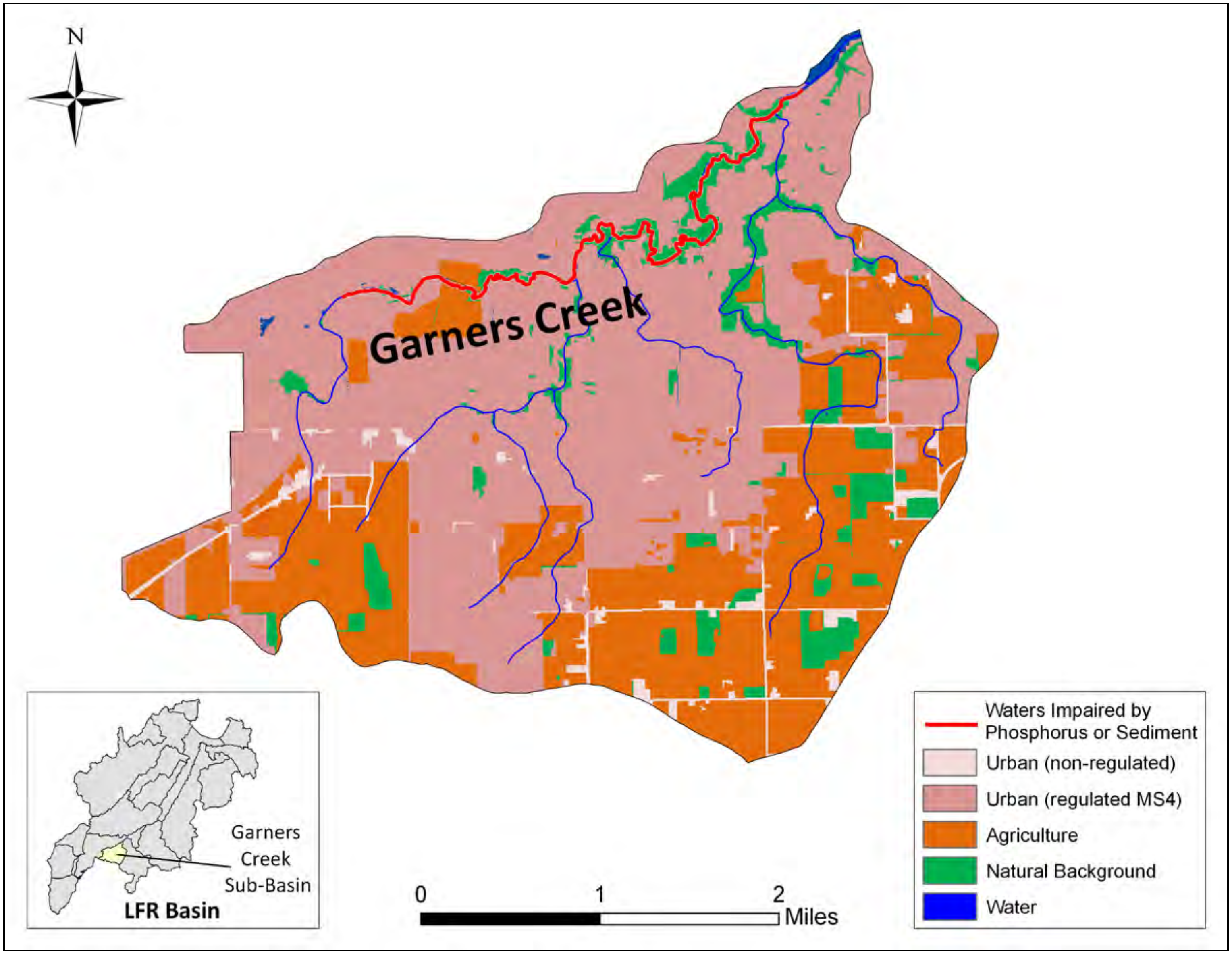
Sources	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	6,144,676	2,002,512	4,142,164	67.4%	5,483
Urban (non-regulated)	192,526	192,526	-	-	527
Natural Background	62,915	62,915	-	-	172
LOAD ALLOCATION	**6,400,117**	**2,257,953**	**4,142,164**	**64.7%**	**6,182**
Urban (MS4)	736,480	441,888	294,592	40.0%	1,210
Construction	90,047	18,009	72,038	80.0%	49
General Permits	22,731	22,731	-	-	62
WWTF-Industrial	2,432	2,432	-	-	7
WWTF-Municipal	1,713	1,713	-	-	5
WASTELOAD ALLOCATION	**853,403**	**486,773**	**366,630**	**43.0%**	**1,333**
TOTAL (WLA + LA)	**7,253,520**	**2,744,726**	**4,508,794**	**62.2%**	**7,515**

Urban (MS4)	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Buchanan	68,126	40,876	27,250	40.0%	112
CombLocks	2,354	1,412	942	40.0%	4
Kaukauna	666,000	399,600	266,400	40.0%	1,094

WWTF-Industrial	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Belgioso Cheese - Sherwood	2,432	2,432	-	-	7

WWTF-Municipal	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Sherwood	1,713	1,713	-	-	5

GARNERS CREEK SUB-BASIN



GARNERS CREEK
TOTAL PHOSPHORUS

Sub-basin Loading Summary (lbs/yr)	
Baseline	6,575
TMDL	2,949
Reduction	3,626
% Reduction Needed	55.1%
Daily TMDL (lbs/day)	8.07

Land Use	Acres	% of Total
Agriculture	2,256	32.1%
Urban	201	2.9%
Urban-MS4	3,814	54.2%
Construction	208	3.0%
Natural Background	558	7.9%
TOTAL	**7,037**	**100.0%**

Sources	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	2,908	1,072	1,836	63.1%	2.93
Urban (non-regulated)	46	46	-	-	0.13
Natural Background	67	67	-	-	0.18
LOAD ALLOCATION	**3,021**	**1,185**	**1,836**	**60.8%**	**3.24**
Urban (MS4)	2,835	1,045	1,790	63.1%	2.86
Construction	697	697	-	-	1.91
General Permits	22	22	-	-	0.06
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
WASTELOAD ALLOCATION	**3,554**	**1,764**	**1,790**	**50.4%**	**4.83**
TOTAL (WLA + LA)	**6,575**	**2,949**	**3,626**	**55.1%**	**8.07**

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Appleton	313	115.4	197.6	63.1%	0.32
Buchanan	1,096	404.0	692.0	63.1%	1.11
CombLocks	372	137.1	234.9	63.1%	0.38
Harrison	872	321.4	550.6	63.1%	0.88
Kaukauna	126	46.4	79.6	63.1%	0.13
Kimberly	56	20.6	35.4	63.1%	0.06

GARNERS CREEK
TOTAL SUSPENDED SOLIDS

Sub-basin Loading Summary (lbs/yr)	
Baseline	2,863,318
TMDL	1,459,045
Reduction	1,404,273
% Reduction Needed	49.0%

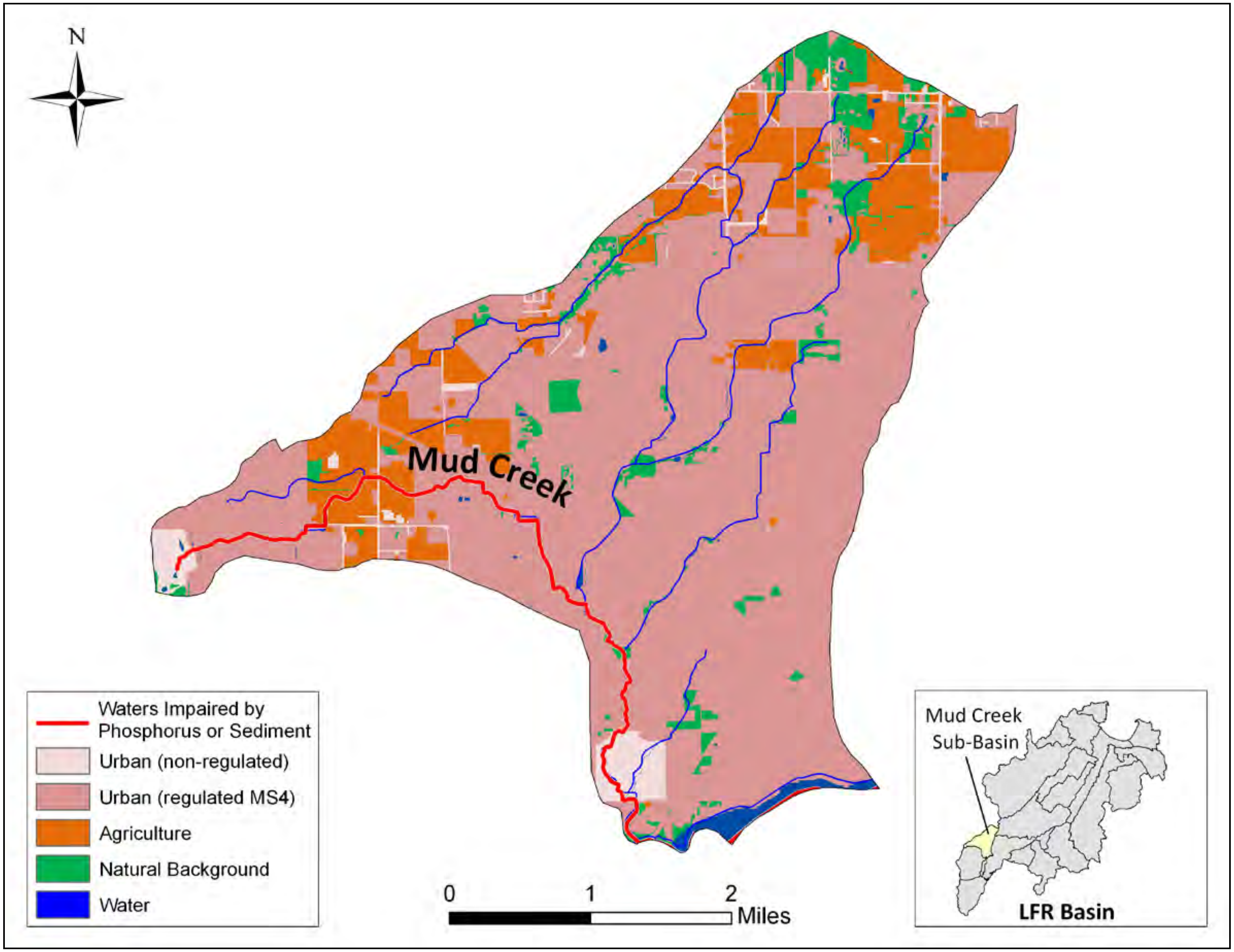
Daily TMDL (lbs/day)	3,994

Land Use	Acres	% of Total
Agriculture	2,256	32.1%
Urban	201	2.9%
Urban-MS4	3,814	54.2%
Construction	208	3.0%
Natural Background	558	7.9%
TOTAL	**7,037**	**100.0%**

Sources	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	990,663	669,193	321,470	32.4%	1,832
Urban (non-regulated)	26,395	26,395	-	-	72
Natural Background	17,920	17,920	-	-	49
LOAD ALLOCATION	**1,034,978**	**713,508**	**321,470**	**31.1%**	**1,953**
Urban (MS4)	1,249,940	626,306	623,634	49.9%	1,715
Construction	573,961	114,792	459,169	80.0%	314
General Permits	4,439	4,439	-	-	12
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
WASTELOAD ALLOCATION	**1,828,340**	**745,537**	**1,082,803**	**59.2%**	**2,041**
TOTAL (WLA + LA)	**2,863,318**	**1,459,045**	**1,404,273**	**49.0%**	**3,994**

Urban (MS4)	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Appleton	147,082	73,698	73,384	49.9%	202
Buchanan	484,488	242,762	241,726	49.9%	665
CombLocks	167,155	83,756	83,399	49.9%	229
Harrison	371,650	186,222	185,428	49.9%	510
Kaukauna	54,218	27,167	27,051	49.9%	74
Kimberly	25,347	12,701	12,646	49.9%	35

MUD CREEK SUB-BASIN



MUD CREEK
TOTAL PHOSPHORUS

Sub-basin Loading Summary (lbs/yr)	
Baseline	6,594
TMDL	4,254
Reduction	2,340
% Reduction Needed	35.5%

Daily TMDL (lbs/day)	11.64

Land Use	Acres	% of Total
Agriculture	1,474	15.4%
Urban (non-regulated)	335	3.5%
Urban (MS4)	7,165	74.8%
Construction	79	0.8%
Natural Background	532	5.6%
TOTAL	**9,585**	**100.0%**

Sources	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	1,884	1,150	734	39.0%	3.15
Urban (non-regulated)	245	245	-	-	0.67
Natural Background	49	49	-	-	0.13
LOAD ALLOCATION	**2,178**	**1,444**	**734**	**33.7%**	**3.95**
Urban (MS4)	4,119	2,513	1,606	39.0%	6.88
Construction	290	290	-	-	0.79
General Permits	7	7	-	-	0.02
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
WASTELOAD ALLOCATION	**4,416**	**2,810**	**1,606**	**36.4%**	**7.69**
TOTAL (WLA + LA)	**6,594**	**4,254**	**2,340**	**35.5%**	**11.64**

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Appleton	725	442.32	282.68	39.0%	1.21
GrandChute	3,053	1,862.63	1,190.37	39.0%	5.10
Greenville	288	175.71	112.29	39.0%	0.48
T_Menasha	53	32.34	20.66	39.0%	0.09

MUD CREEK
TOTAL SUSPENDED SOLIDS

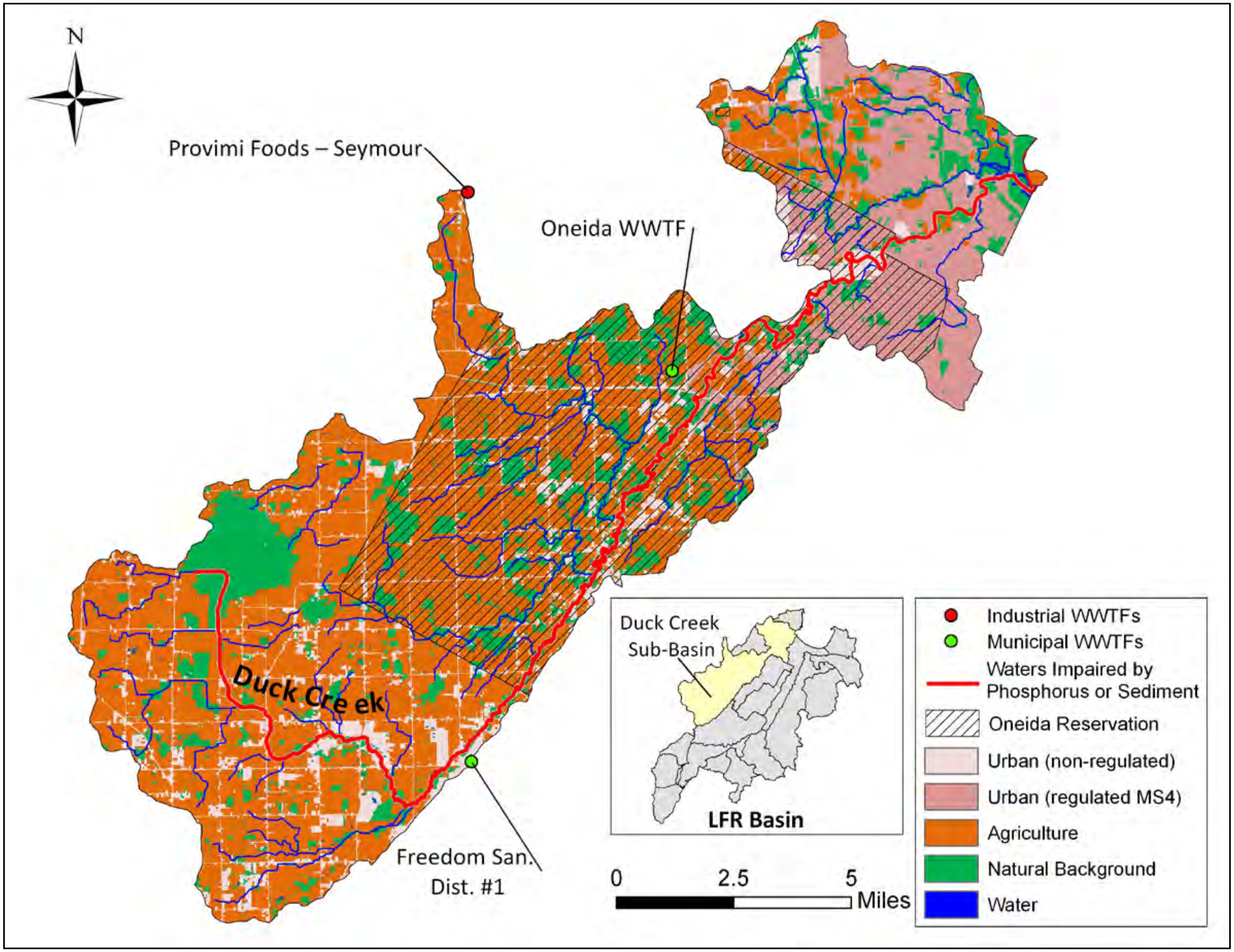
Sub-basin Loading Summary (lbs/yr)	
Baseline	2,924,841
TMDL	2,104,168
Reduction	820,673
% Reduction Needed	28.1%
Daily TMDL (lbs/day)	5,761

Land Use	Acres	% of Total
Agriculture	1,474	15.4%
Urban	335	3.5%
Urban-MS4	7,165	74.8%
Construction	79	0.8%
Natural Background	532	5.6%
TOTAL	**9,585**	**100.0%**

Sources	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	679,097	619,002	60,095	8.8%	1,695
Urban (non-regulated)	35,252	35,252	-	-	97
Natural Background	7,405	7,405	-	-	20
LOAD ALLOCATION	**721,754**	**661,659**	**60,095**	**8.3%**	**1,812**
Urban (MS4)	1,942,546	1,389,118	553,428	28.5%	3,803
Construction	258,937	51,787	207,150	80.0%	142
General Permits	1,604	1,604	-	-	4
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
WASTELOAD ALLOCATION	**2,203,087**	**1,442,509**	**760,578**	**34.5%**	**3,949**
TOTAL (WLA + LA)	**2,924,841**	**2,104,168**	**820,673**	**28.1%**	**5,761**

Urban (MS4)	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Appleton	374,837	268,047	106,790	28.5%	734
GrandChute	1,414,456	1,011,480	402,976	28.5%	2,769
Greenville	127,695	91,315	36,380	28.5%	250
T_Menasha	25,558	18,277	7,281	28.5%	50

DUCK CREEK SUB-BASIN



DUCK CREEK
TOTAL PHOSPHORUS

Sub-basin Loading Summary (lbs/yr)	
Baseline	63,172
TMDL	23,252
Reduction	39,920
% Reduction Needed	63.2%
Daily TMDL (lbs/day)	63.66

Land Use	Acres			% of
	State	Oneida	Total	Total
Agriculture	30,098	18760	48,858	56.0%
Urban (non-regulated)	5,407	3585	8,992	10.3%
Urban (MS4)	7,512	4570	12,082	13.8%
Construction	214	131	345	0.4%
Natural Background	8,972	8020	16,992	19.5%
TOTAL	**52,203**	**35,066**	**87,269**	**100.0%**

Sources from State Land	Total Phosphorus Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Agriculture	30,382	7,028	23,354	76.9%	19.24
Urban (non-regulated)	2,070	2,070	-	-	5.67
Natural Background	790	790	-	-	2.16
LOAD ALLOCATION	**33,242**	**9,888**	**23,354**	**70.3%**	**27.07**
Urban (MS4)	4,076	2,853	1,223	30.0%	7.81
Construction	532	532	-	-	1.46
General Permits	224	224	-	-	0.61
WWTF-Industrial	74	74	-	-	0.20
WWTF-Municipal	542	542	-	-	1.48
WASTELOAD ALLOCATION	**5,448**	**4,225**	**1,223**	**22.4%**	**11.56**
TOTAL (WLA + LA)	**38,690**	**14,113**	**24,577**	**63.5%**	**38.63**

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Appleton	2	1.40	0.60	30.0%	-
Ashwaubenon	302	211.39	90.61	30.0%	0.58
Green Bay	474	331.79	142.21	30.0%	0.91
Hobart	-	-	-	-	-
Howard	2,790	1,952.92	837.08	30.0%	5.35
Suamico	508	355.58	152.42	30.0%	0.97

WWTP-Industrial	Total Phosphorus Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Provimi Foods - Seymour	74	74	-	-	0.20

WWTF-Municipal	Total Phosphorus Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Freedom San. Dist. #1	542	542	-	-	1.48

Sources from Oneida Reservation	Total Phosphorus Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Agriculture	18,937	4,380	14,557	76.9%	11.99
Urban (non-regulated)	1,372	1,372	-	-	3.76
Natural Background	707	707	-	-	1.94
NONPOINT SOURCES	**21,016**	**6,459**	**14,557**	**69.3%**	**17.69**
Urban (MS4)	2,620	1,834	786	30.0%	5.02
Construction	326	326	-	-	0.89
General Permits	137	137	-	-	0.38
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	383	383	-	-	1.05
POINT SOURCES	**3,466**	**2,680**	**786**	**22.7%**	**7.34**
TOTAL (PS + NPS)	**24,482**	**9,139**	**15,343**	**62.7%**	**25.03**

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Appleton	-	-	-	-	-
Ashwaubenon	-	-	-	-	-
Green Bay	1,290	903.0	387.0	30.0%	2.47
Hobart	1,316	921.2	394.8	30.0%	2.52
Howard	14	9.8	4.2	30.0%	0.03
Suamico	-	-	-	-	-

WWTF-Municipal	Total Phosphorus Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Oneida (regulated via EPA NPDES)	383	383	-	-	1.05

DUCK CREEK

TOTAL SUSPENDED SOLIDS

Sub-basin Loading Summary (lbs/yr)	
Baseline	25,394,165
TMDL	11,416,475
Reduction	13,977,690
% Reduction Needed	55.0%
Daily TMDL (lbs/day)	31,257

Land Use	Acres			% of
	State	Oneida	Total	Total
Agriculture	30,098	18760	48,858	56.0%
Urban	5,407	3585	8,992	10.3%
Urban-MS4	7,512	4570	12,082	13.8%
Construction	214	131	345	0.4%
Natural Background	8,972	8020	16,992	19.5%
TOTAL	**52,203**	**35,066**	**87,269**	**100.0%**

Sources from State Land	Total Suspended Solids Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Agriculture	12,724,387	5,273,111	7,451,276	58.6%	14,437
Urban (non-regulated)	478,796	478,796	-	-	1,311
Natural Background	114,410	114,410	-	-	313
LOAD ALLOCATION	**13,317,593**	**5,866,317**	**7,451,276**	**56.0%**	**16,061.00**
Urban (MS4)	1,655,931	993,559	662,372	40.0%	2,720
Construction	671,326	134,265	537,061	80.0%	368
General Permits	97,759	97,759	-	-	268
WWTF-Industrial	544	544	-	-	1
WWTF-Municipal	2,953	2,953	-	-	8
WASTELOAD ALLOCATION	**2,428,513**	**1,229,080**	**1,199,433**	**49.4%**	**3,365**
TOTAL (WLA + LA)	**15,746,106**	**7,095,397**	**8,650,709**	**54.9%**	**19,426**

Urban (MS4)	Total Suspended Solids Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Appleton	456	274	182	40.0%	1
Ashwaubenon	123,637	74,182	49,455	40.0%	203
Green Bay	189,004	113,402	75,602	40.0%	310
Hobart	-	-	-	-	-
Howard	1,164,267	698,560	465,707	40.0%	1,913
Suamico	178,567	107,140	71,427	40.0%	293

WWTP-Industrial	Total Suspended Solids Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Provimi Foods - Seymour	544	544	-	-	1

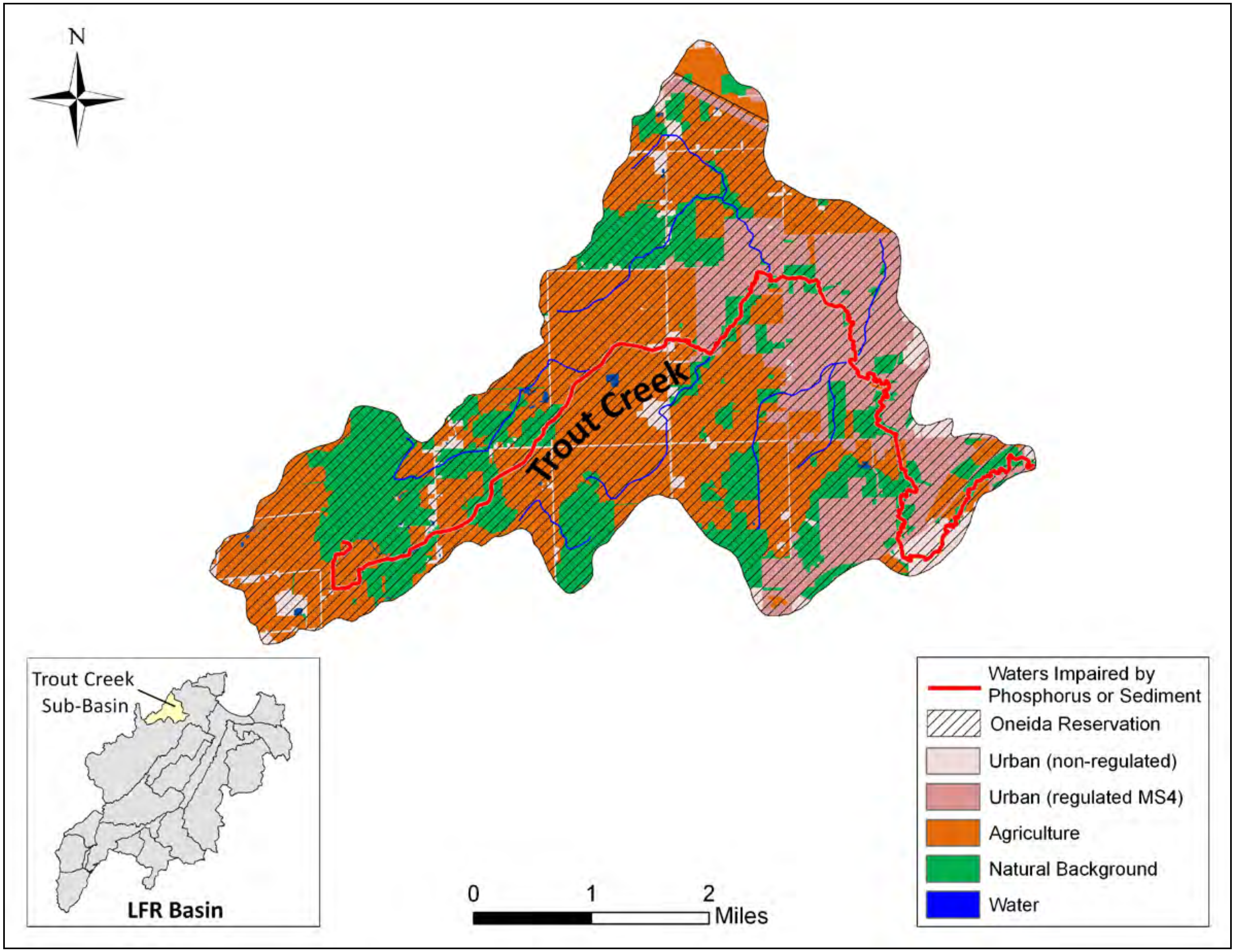
WWTF-Municipal	Total Suspended Solids Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Freedom San. Dist. #1	2,953	2,953	-	-	8

Sources from Oneida Reservation	Total Suspended Solids Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Agriculture	7,931,075	3,286,715	4,644,360	58.6%	8,999
Urban (non-regulated)	317,456	317,456	-	-	869
Natural Background	102,270	102,270	-	-	280
NONPOINT SOURCES	**8,350,801**	**3,706,441**	**4,644,360**	**55.6%**	**10,148**
Urban (MS4)	884,650	530,790	353,860	40.0%	1,453
Construction	410,952	82,191	328,761	80.0%	225
General Permits	-	-	-	-	-
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	1,656	1,656	-	-	5
POINT SOURCES	**1,297,258**	**614,637**	**682,621**	**52.6%**	**1,683**
TOTAL (PS + NPS)	**9,648,059**	**4,321,078**	**5,326,981**	**55.2%**	**11,831**

Urban (MS4)	Total Suspended Solids Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Appleton	-	-	-	-	-
Ashwaubenon	-	-	-	-	-
Green Bay	514,879	308,928	205,952	40.0%	846
Hobart	363,933	218,360	145,573	40.0%	598
Howard	5,838	3,503	2,335	40.0%	10
Suamico	-	-	-	-	-

WWTF-Municipal	Total Suspended Solids Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Oneida (regulated via EPA NPDES)	1,656	1,656	-	-	5

TROUT CREEK SUB-BASIN



TROUT CREEK
TOTAL PHOSPHORUS

Sub-basin Loading Summary (lbs/yr)	
Baseline	4,518
Loading Goal	2,495
Reduction	2,023
% Reduction Needed	44.8%

Land Use	Acres	% of Total
Agriculture	4,580	47.6%
Urban (non-regulated)	584	6.1%
Urban (MS4)	1,941	20.2%
Construction	8	0.1%
Natural Background	2,517	26.1%
TOTAL	**9,630**	**100.0%**

Sources from Oneida Reservation	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline
	Baseline	Allocated	Reduction	
Agriculture	3,272	1,477	1,795	54.9%
Urban (non-regulated)	253	253	-	-
Natural Background	211	211	-	-
NONPOINT SOURCES	**3,736**	**1,941**	**1,795**	**48.0%**
Urban (MS4)	759	531	228	30.0%
Construction	6	6	-	-
General Permits	17	17	-	-
WWTF-Industrial	-	-	-	-
WWTF-Municipal	-	-	-	-
POINT SOURCES	**782**	**554**	**228**	**29.2%**
TOTAL (PS + NPS)	**4,518**	**2,495**	**2,023**	**44.8%**

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline
	Baseline	Allocated	Reduction	
Hobart	748	523.3	224.7	30.0%
Howard	11	7.7	3.3	30.0%

TROUT CREEK
TOTAL SUSPENDED SOLIDS

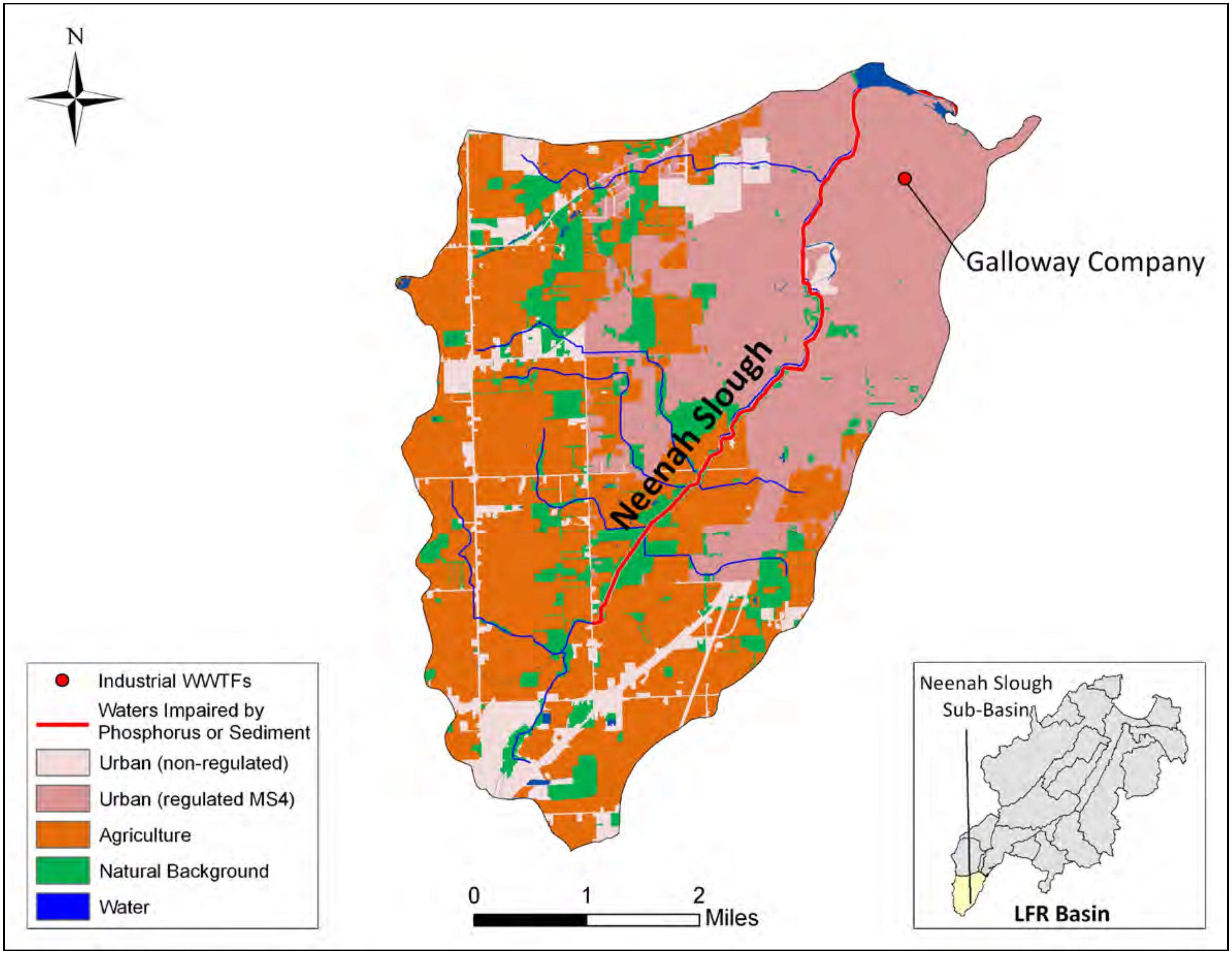
Sub-basin Loading Summary (lbs/yr)	
Baseline	1,451,838
Loading Goal	1,234,199
Reduction	217,639
% Reduction Needed	15.0%

Land Use	Acres	% of Total
Agriculture	4,580	47.6%
Urban	584	6.1%
Urban-MS4	1,941	20.2%
Construction	8	0.1%
Natural Background	2,517	26.1%
TOTAL	**9,630**	**100.0%**

Sources from Oneida Reservation	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline
	Baseline	Allocated	Reduction	
Agriculture	1,221,136	1,070,556	150,580	12.3%
Urban (non-regulated)	40,313	40,313	-	-
Natural Background	27,743	27,743	-	-
NONPOINT SOURCES	**1,289,192**	**1,138,612**	**150,580**	**11.7%**
Urban (MS4)	148,430	89,058	59,372	40.0%
Construction	9,609	1,922	7,687	80.0%
General Permits	4,607	4,607	-	-
WWTF-Industrial	-	-	-	-
WWTF-Municipal	-	-	-	-
POINT SOURCES	**162,646**	**95,587**	**67,059**	**41.2%**
TOTAL (PS + NPS)	**1,451,838**	**1,234,199**	**217,639**	**15.0%**

Urban (MS4)	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline
	Baseline	Allocated	Reduction	
Hobart	145,976	87,586	58,390	40.0%
Howard	2,454	1,472	982	40.0%

NEENAH SLOUGH SUB-BASIN



NEENAH SLOUGH
TOTAL PHOSPHORUS

Sub-basin Loading Summary (lbs/yr)	
Baseline	11,912
TMDL	5,758
Reduction	6,154
% Reduction Needed	51.7%
Daily TMDL (lbs/day)	15.77

Land Use	Acres	% of Total
Agriculture	6,302	43.6%
Urban (non-regulated)	1,447	10.0%
Urban (MS4)	5,007	34.6%
Construction	89	0.6%
Natural Background	1,616	11.2%
TOTAL	**14,461**	**100.0%**

Sources	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	8,015	2,665	5,350	66.7%	7.30
Urban (non-regulated)	572	572	-	-	1.57
Natural Background	173	173	-	-	0.47
LOAD ALLOCATION	**8,760**	**3,410**	**5,350**	**61.1%**	**9.34**
Urban (MS4)	2,681	1,877	804	30.0%	5.14
Construction	287	287	-	-	0.79
General Permits	128	128	-	-	0.35
WWTF-Industrial	56	56	-	-	0.15
WWTF-Municipal	-	-	-	-	-
WASTELOAD ALLOCATION	**3,152**	**2,348**	**804**	**25.5%**	**6.43**
TOTAL (WLA + LA)	**11,912**	**5,758**	**6,154**	**51.7%**	**15.77**

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Neenah	2,121	1,485	636	30.0%	4.07
T_Neenah	560	392	168	30.0%	1.07

WWTF-Industrial	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Galloway Company	56	56	-	-	0.15

NEENAH SLOUGH
TOTAL SUSPENDED SOLIDS

Sub-basin Loading Summary (lbs/yr)	
Baseline	4,846,168
TMDL	2,848,353
Reduction	1,997,815
% Reduction Needed	41.2%
Daily TMDL (lbs/day)	7,799

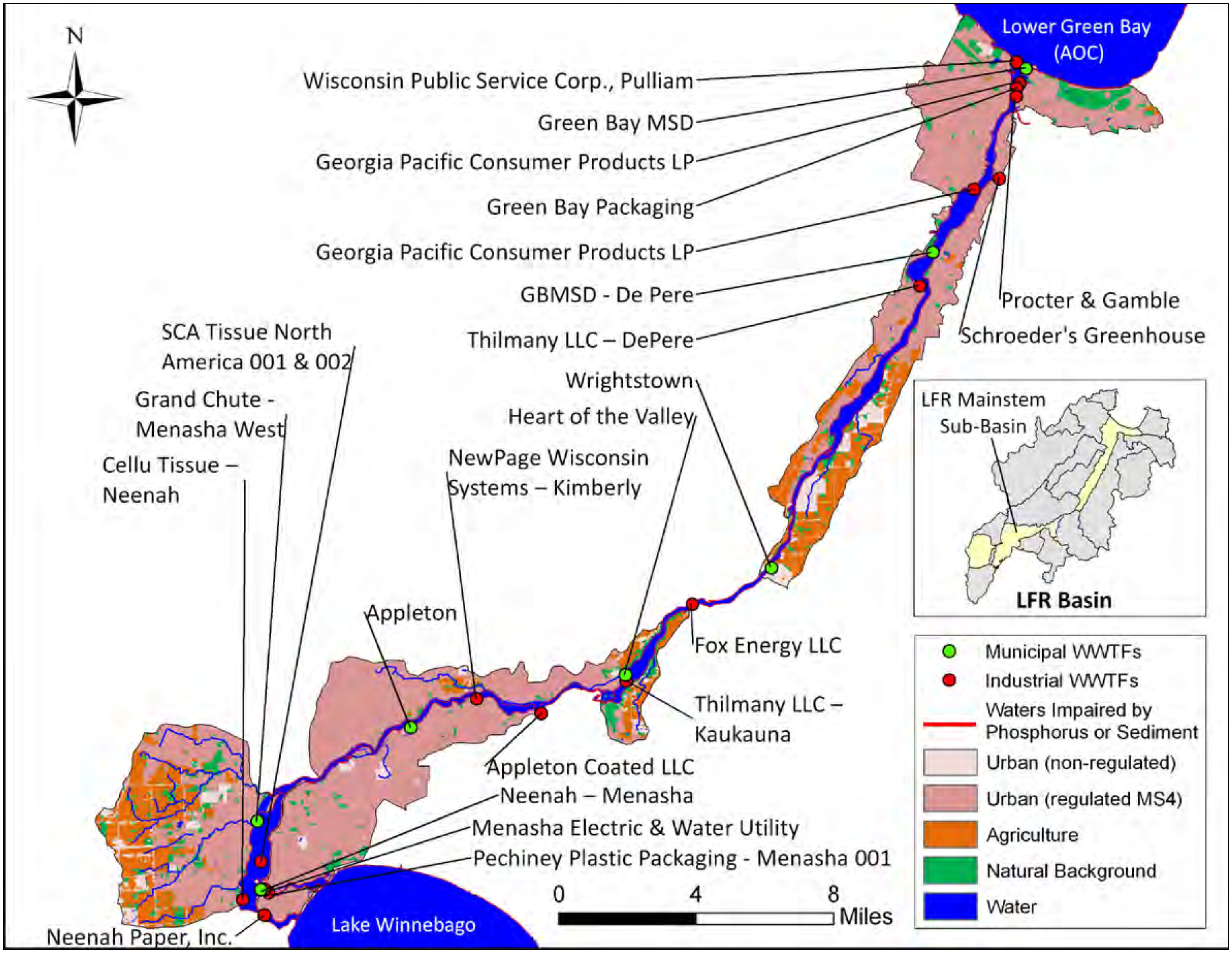
Land Use	Acres	% of Total
Agriculture	6,302	43.6%
Urban	1,447	10.0%
Urban-MS4	5,007	34.6%
Construction	89	0.6%
Natural Background	1,616	11.2%
TOTAL	**14,461**	**100.0%**

Sources	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	2,719,043	1,544,583	1,174,460	43.2%	4,229
Urban (non-regulated)	247,820	247,820	-	-	678
Natural Background	23,302	23,302	-	-	64
LOAD ALLOCATION	**2,990,165**	**1,815,705**	**1,174,460**	**39.3%**	**4,971**
Urban (MS4)	1,575,942	945,565	630,377	40.0%	2,589
Construction	241,223	48,245	192,978	80.0%	132
General Permits	38,217	38,217	-	-	105
WWTF-Industrial	621	621	-	-	2
WWTF-Municipal	-	-	-	-	-
WASTELOAD ALLOCATION	**1,856,003**	**1,032,648**	**823,355**	**44.4%**	**2,828**
TOTAL (WLA + LA)	**4,846,168**	**2,848,353**	**1,997,815**	**41.2%**	**7,799**

Urban (MS4)	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Neenah	1,303,458	782,075	521,383	40.0%	2,141
T_Neenah	272,484	163,490	108,994	40.0%	448

WWTF-Industrial	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Galloway Company	621	621	-	-	2

LOWER FOX RIVER MAIN STEM SUB-BASIN



LOWER FOX RIVER MAINSTEM
TOTAL PHOSPHORUS

Sub-basin Loading Summary (lbs/yr)	
Baseline	237,339
TMDL	114,263
Reduction	123,076
% Reduction Needed	51.9%
Daily TMDL (lbs/day)	312.83

Land Use	Acres	% of Total
Agriculture	9,157	17.0%
Urban (non-regulated)	3,183	5.9%
Urban (MS4)	36,779	68.4%
Construction	297	0.6%
Natural Background	4,328	8.1%
TOTAL	**53,744**	**100.0%**

Sources	Total Phosphorus Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Agriculture	12,779	3,291	9,488	74.2%	9.01
Urban (non-regulated)	1,618	1,618	-	-	4.43
Natural Background	454	454	-	-	1.24
LOAD ALLOCATION	**14,851**	**5,363**	**9,488**	**63.9%**	**14.68**
Urban (MS4)	23,557	16,490	7,067	30.0%	45.15
Construction	1,114	1,114	-	-	3.05
General Permits	275	275	-	-	0.75
WWTF-Industrial	107,245	41,713	65,532	61.1%	114.20
WWTF-Municipal	83,935	42,946	40,989	48.8%	117.58
WWTF Reserve Capacity	6,362	6,362	-	-	17.42
WASTELOAD ALLOCATION	**222,488**	**108,900**	**113,588**	**51.1%**	**298.15**
TOTAL (WLA + LA)	**237,339**	**114,263**	**123,076**	**51.9%**	**312.83**

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Allouez	579	405.3	173.7	30.0%	1.11
Appleton	5,239	3,667.3	1,571.7	30.0%	10.04
Ashwaubenon	437	305.9	131.1	30.0%	0.84
Buchanan	49	34.3	14.7	30.0%	0.09
CombLocks	217	151.9	65.1	30.0%	0.42
DePere	2,079	1,455.3	623.7	30.0%	3.98
GrandChute	1,085	759.5	325.5	30.0%	2.08
Green Bay	4,637	3,245.9	1,391.1	30.0%	8.89
Greenville	738	516.6	221.4	30.0%	1.41
Harrison	10	7.0	3.0	30.0%	0.02
Howard	3	2.1	0.9	30.0%	0.01
Kaukauna	739	517.3	221.7	30.0%	1.42
Kimberly	830	581.0	249.0	30.0%	1.59
Lawrence	543	380.1	162.9	30.0%	1.04
Ledgeview	151	105.7	45.3	30.0%	0.29
LittleChute	974	681.8	292.2	30.0%	1.87
Menasha	1,638	1,146.6	491.4	30.0%	3.14
Neenah	252	176.4	75.6	30.0%	0.48
T_Menasha	3,163	2,214.1	948.9	30.0%	6.06
T_Neenah	194	135.8	58.2	30.0%	0.37

WWTF-Industrial	Total Phosphorus Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Appleton Coated LLC	9,645	4,174	5,471	56.7%	11.43
Cellu Tissue - Neenah	749	749	-	-	2.05
Fox Energy LLC	570	570	-	-	1.56
Georgia Pacific Consumer Products LP {ex FJGBE}	3,826	3,826	-	-	10.48
Georgia Pacific Consumer Products LP {ex FJGBW}	21,200	6,558	14,642	69.1%	17.95
Green Bay Packaging - Green Bay	629	629	-	-	1.72
Neenah Paper, Inc.	2,499	927	1,572	62.9%	2.54
Menasha Electric & Water Utility	72	72	-	-	0.20
NewPage Wisconsin Systems - Kimberly	20,268	5,648	14,620	72.1%	15.46
Pechiney Plastic Packaging - Menasha 001	1,166	1,166	-	-	3.19
Procter & Gamble	238	238	-	-	0.65
SCA Tissue North America	6,971	3,623	3,348	48.0%	9.92
Schroeder's Greenhouse	36	36	-	-	0.10
Thilmany LLC - DePere	313	313	-	-	0.86
Thilmany LLC - Kaukauna	37,855	11,976	25,879	68.4%	32.79
Wisconsin Public Service Corp., Pulliam	1,208	1,208	-	-	3.31

WWTF-Municipal	Total Phosphorus Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Appleton	13,414	7,556	5,858	43.7%	20.69
GBMSD - De Pere	5,565	4,943	622	11.2%	13.53
Grand Chute - Menasha West	7,730	3,110	4,620	59.8%	8.51
Green Bay MSD	26,059	17,349	8,710	33.4%	47.50
Heart of the Valley	11,509	3,467	8,042	69.9%	9.49
Neenah - Menasha	19,412	6,275	13,137	67.7%	17.18
Wrightstown	246	246	-	-	0.67

LOWER FOX RIVER MAINSTEM
TOTAL SUSPENDED SOLIDS

Sub-basin Loading Summary (lbs/yr)	
Baseline	23,980,196
TMDL	11,115,433
Reduction	12,864,763
% Reduction Needed	53.6%
Daily TMDL (lbs/day)	30,432

Land Use	Acres	% of Total
Agriculture	9,157	17.0%
Urban	3,183	5.9%
Urban-MS4	36,779	68.4%
Construction	297	0.6%
Natural Background	4,328	8.1%
TOTAL	**53,744**	**100.0%**

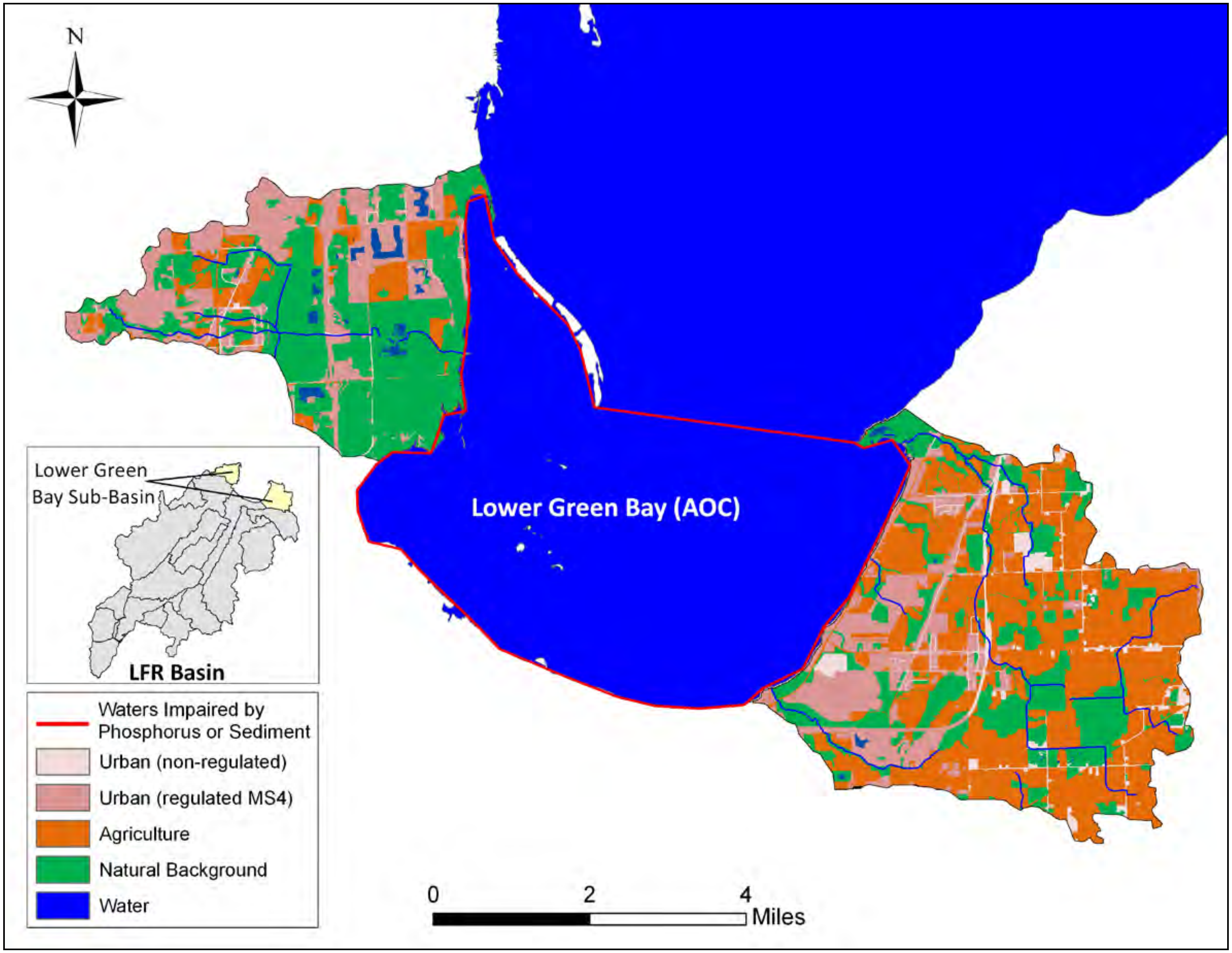
Sources	Total Suspended Solids Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Agriculture	4,942,324	1,881,910	3,060,414	61.9%	5,152
Urban (non-regulated)	475,960	475,960	-	-	1,303
Natural Background	128,777	128,777	-	-	353
LOAD ALLOCATION	**5,547,061**	**2,486,647**	**3,060,414**	**55.2%**	**6,808**
Urban (MS4)	13,693,558	4,765,188	8,928,370	65.2%	13,046
Construction	1,094,974	218,995	875,979	80.0%	600
General Permits	79,753	79,753	-	-	218
WWTF-Industrial	2,378,520	2,378,520	-	-	6,512
WWTF-Municipal	1,133,351	1,133,351	-	-	3,103
WWTF Reserve Capacity	52,979	52,979	-		145
WASTELOAD ALLOCATION	**18,433,135**	**8,628,786**	**9,804,349**	**53.2%**	**23,624**
TOTAL (WLA + LA)	**23,980,196**	**11,115,433**	**12,864,763**	**53.6%**	**30,432**

Urban (MS4)	Total Suspended Solids Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Allouez	285,657	99,405	186,252	65.2%	272
Appleton	3,030,547	1,054,593	1,975,954	65.2%	2,887
Ashwaubenon	299,242	104,132	195,110	65.2%	285
Buchanan	28,603	9,953	18,650	65.2%	27
CombLocks	123,837	43,094	80,743	65.2%	118
DePere	1,102,905	383,797	719,108	65.2%	1,051
GrandChute	524,839	182,637	342,202	65.2%	500
Green Bay	3,084,098	1,073,228	2,010,870	65.2%	2,938
Greenville	373,661	130,029	243,632	65.2%	356
Harrison	7,086	2,466	4,620	65.2%	7
Howard	2,220	773	1,447	65.2%	2
Kaukauna	410,816	142,959	267,857	65.2%	391
Kimberly	535,583	186,376	349,207	65.2%	510
Lawrence	198,889	69,211	129,678	65.2%	189
Ledgeview	66,978	23,308	43,670	65.2%	64
LittleChute	539,026	187,574	351,452	65.2%	514
Menasha	1,060,370	368,996	691,374	65.2%	1,010
Neenah	159,612	55,543	104,069	65.2%	152
T_Menasha	1,743,480	606,709	1,136,771	65.2%	1,661
T_Neenah	116,109	40,404	75,705	65.2%	111

WWTF-Industrial	Total Suspended Solids Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Appleton Coated LLC	249,129	249,129	-	-	682
Cellu Tissue - Neenah	53,937	53,937	-	-	148
Fox Energy LLC	5,042	5,042	-	-	14
Georgia Pacific Consumer Products LP {ex FJGBE}	105,698	105,698	-	-	289
Georgia Pacific Consumer Products LP {ex FJGBW}	175,717	175,717	-	-	481
Green Bay Packaging - Green Bay	108,259	108,259	-	-	296
Neenah Paper, Inc.	81,301	81,301	-	-	223
Menasha Electric & Water Utility	239	239	-	-	1
NewPage Wisconsin Systems - Kimberly	111,969	111,969	-	-	307
Pechiney Plastic Packaging - Menasha 001	3,373	3,373	-	-	9
Procter & Gamble	155,432	155,432	-	-	426
SCA Tissue North America	136,023	136,023	-	-	372
Schroeder's Greenhouse	341	341	-	-	1
Thilmany LLC - DePere	29,003	29,003	-	-	79
Thilmany LLC - Kaukauna	1,122,241	1,122,241	-	-	3,073
Wisconsin Public Service Corp., Pulliam	40,816	40,816	-	-	112

WWTF-Municipal	Total Suspended Solids Load (lbs/yr)			% Reduction	Allocated
	Baseline	Allocated	Reduction	from Baseline	(lbs/day)
Appleton	169,857	169,857	-	-	465
GBMSD - De Pere	50,297	50,297	-	-	138
Grand Chute - Menasha West	225,925	225,925	-	-	619
Green Bay MSD	354,861	354,861	-	-	972
Heart of the Valley	147,003	147,003	-	-	402
Neenah - Menasha	180,258	180,258	-	-	494
Wrightstown	5,150	5,150	-	-	14

LOWER GREEN BAY SUB-BASIN



LOWER GREEN BAY
TOTAL PHOSPHORUS

Sub-basin Loading Summary (lbs/yr)	
Baseline	12,652
TMDL	6,625
Reduction	6,027
% Reduction Needed	47.6%
Daily TMDL (lbs/day)	18.13

Land Use	Acres	% of Total
Agriculture	7,135	38.3%
Urban (non-regulated)	809	4.3%
Urban (MS4)	3,849	20.7%
Construction	139	0.7%
Natural Background	6,677	35.9%
TOTAL	**18,609**	**100.0%**

Sources	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	8,670	3,409	5,261	60.7%	9.33
Urban (non-regulated)	324	324	-	-	0.89
Natural Background	575	575	-	-	1.57
LOAD ALLOCATION	**9,569**	**4,308**	**5,261**	**55.0%**	**11.79**
Urban (MS4)	2,554	1,788	766	30.0%	4.90
Construction	498	498	-	-	1.36
General Permits	31	31	-	-	0.08
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
WASTELOAD ALLOCATION	**3,083**	**2,317**	**766**	**24.8%**	**6.34**
TOTAL (WLA + LA)	**12,652**	**6,625**	**6,027**	**47.6%**	**18.13**

Urban (MS4)	Total Phosphorus Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Green Bay	898	628.7	269.3	30.0%	1.72
Howard	41	28.7	12.3	30.0%	0.08
Scott	422	295.4	126.6	30.0%	0.81
Suamico	915	640.6	274.4	30.0%	1.75
UWGB	278	194.6	83.4	30.0%	0.53

LOWER GREEN BAY
TOTAL SUSPENDED SOLIDS

Sub-basin Loading Summary (lbs/yr)	
Baseline	4,301,706
TMDL	2,265,758
Reduction	2,035,948
% Reduction Needed	47.3%

Daily TMDL (lbs/day)	6,203

Land Use	Acres	% of Total
Agriculture	7,135	38.3%
Urban	809	4.3%
Urban-MS4	3,849	20.7%
Construction	139	0.7%
Natural Background	6,677	35.9%
TOTAL	**18,609**	**100.0%**

Sources	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Agriculture	2,690,986	1,424,635	1,266,351	47.1%	3,900
Urban (non-regulated)	108,148	108,148	-	-	296
Natural Background	68,713	68,713	-	-	188
LOAD ALLOCATION	**2,867,847**	**1,601,496**	**1,266,351**	**44.2%**	**4,384**
Urban (MS4)	933,711	560,227	373,484	40.0%	1,534
Construction	495,141	99,028	396,113	80.0%	271
General Permits	5,007	5,007	-	-	14
WWTF-Industrial	-	-	-	-	-
WWTF-Municipal	-	-	-	-	-
WASTELOAD ALLOCATION	**1,433,859**	**664,262**	**769,597**	**53.7%**	**1,819**
TOTAL (WLA + LA)	**4,301,706**	**2,265,758**	**2,035,948**	**47.3%**	**6,203**

Urban (MS4)	Total Suspended Solids Load (lbs/yr)			% Reduction from Baseline	Allocated (lbs/day)
	Baseline	Allocated	Reduction		
Green Bay	330,584	198,351	132,233	40.0%	543
Howard	16,804	10,082	6,722	40.0%	28
Scott	142,874	85,724	57,150	40.0%	235
Suamico	318,128	190,877	127,251	40.0%	523
UWGB	125,321	75,193	50,128	40.0%	206

7.0 IMPLEMENTATION

7.1. Reasonable Assurance for Implementation

Required by the Clean Water Act, reasonable assurances provide a level of confidence that the wasteload allocations and load allocations in TMDLs will be implemented. This TMDL will be implemented through enforcement of existing regulations, financial incentives, and various local, state, tribal, and federal water pollution control programs. The following are some of the activities, programs, requirements, and institutional arrangements that will provide reasonable assurance that this TMDL will be implemented and that the water quality goals will be achieved. Following approval by WDNR and EPA, the TMDL will be amended to the Areawide Water Quality Management Plan for the LFR Basin pursuant to chapter Wisconsin Administrative Code NR 121.

7.1.1. Point Sources

Sources of point source discharge in the LFR Basin include municipal and industrial wastewater treatment facilities, stormwater, and CAFOs. WDNR regulates point sources discharging wastewater to surface water or groundwater through the WPDES Permit Program. WPDES permits are divided into two categories - specific and general permits. Specific permits are issued to more complex facilities and activities such as municipal and industrial wastewater discharges. General permits are issued to classes of industries or activities that are similar in nature, such as nonmetallic mining, non-contact cooling water, and stormwater discharges.

Individual WPDES permits issued to municipal and industrial wastewater discharges to surface water will include limits that are consistent with the approved TMDL wasteload allocations, and may include options such as adaptive management as outlined in Wisconsin Administrative Code NR 217.06, while providing the necessary reasonable assurance that the WLAs in the TMDL will be achieved. Once a TMDL has been state and federally-approved, the permit for a point source that has been allocated a WLA by the TMDL may not be reissued without a limit that is consistent with the WLA. WDNR may modify an existing permit to include WLA-derived limits or wait until the permit is reissued to include WLA-derived limits. Facilities operating under general permits will be screened to determine whether additional requirements may be needed to ensure that the permitted activity is consistent with TMDL goals; this may include issuing individual permits or other measures.

7.1.2. Nonpoint Sources

To ensure the reduction goals of this TMDL are attained, management measures must be implemented and maintained to control phosphorus and sediment loadings from nonpoint sources of pollution.

Wisconsin's Nonpoint Source Pollution Abatement Program (NPS Program), described in the state's Section 319 Program Management Plan outlines a variety of financial, technical, and educational programs, which support implementation of management measures to address nonpoint source pollution.

WDNR is a leader in the development of regulatory authority to prevent and control nonpoint source pollution. Wisconsin Administrative Code NR 151 establishes polluted runoff performance standards and prohibitions for agricultural and non-agricultural facilities and practices. These standards are intended to be minimum standards of performance necessary to achieve water quality standards. Implementing the performance standards and prohibitions on a statewide basis is a high priority for the NPS Program.

In particular, the implementation and enforcement of agricultural performance standards and manure management prohibitions, listed below, will be critical to achieving the necessary nonpoint source load reductions throughout the basin:

- Sheet, rill and wind erosion: All cropped fields shall meet the tolerable (T) soil erosion rate established for that soil.
- Manure storage facilities: All new, substantially altered, or abandoned manure storage facilities shall be constructed, maintained or abandoned in accordance with accepted standards. Failing and leaking existing facilities posing an imminent threat to public health or fish and aquatic life or violating groundwater standards shall be upgraded or replaced.
- Clean water diversions: Runoff from agricultural buildings and fields shall be diverted away from contacting feedlots, manure storage areas, and barnyards located within water quality management areas (300 feet from a stream or 1,000 feet from a lake or areas susceptible to groundwater contamination).
- Nutrient management: Agricultural operations applying nutrients to agricultural fields shall do so according to a nutrient management plan.
- Manure management prohibitions:
    - No overflow of manure storage facilities;
    - No unconfined manure piles in a water quality management area;
    - No direct runoff from feedlots or stored manure into state waters; and
    - No unlimited livestock access to waters of the state in locations where high concentrations of animals prevent the maintenance of adequate or self-sustaining sod cover.

In addition to the performance standards and prohibitions, the NPS Program supports NPS pollution abatement by administering and providing cost-sharing grants to fund BMPs through various WDNR grant programs, including the Targeted Runoff Management (TRM) Grant Program; the Notice of Discharge (NOD) Grant Program; the Urban Nonpoint Source & Storm Water Management Grant Program; and the River Planning & Protection Grant Program.

It is important to partner with the Department of Agriculture, Trade, and Consumer Protection (DATCP), which oversees and supports county conservation programs that implement the state performance standards and prohibitions and conservation practices. DATCP's Soil and Water Resource Management Program requires counties to develop Land and Water Resource Management (LWRM) Plans to identify conservation needs. Counties must receive DATCP's approval of their plans to receive state cost-sharing grants for BMP installation. DATCP is also responsible for providing local assistance grant (LAG) funding for county conservation staff implementing NPS control programs included in the LWRM plans. County LWRM plans advance land and water conservation and prevent NPS pollution by:

- Inventorying water quality and soil erosion conditions in the county.
- Identifying relevant state and local regulations, and any inconsistencies between them.
- Setting water quality goals in consultation with WDNR.
- Identifying key water quality and soil erosion problems, and practices to address those problems.

- Identifying priority farm areas using a range of criteria (e.g., impaired waters, manure management, high nutrient applications).
- Identifying strategies to promote voluntary compliance with statewide performance standards and prohibitions, including information, cost-sharing, and technical assistance.
- Identifying enforcement procedures, including notice and appeal procedures.
- Including a multi-year work plan to achieve soil and water conservation objectives.

WDNR, DATCP, and the county (Brown, Calumet, Outagamie, and Winnebago) Land Conservation Departments (LCD) will work with landowners to implement agricultural and non-agricultural performance standards and manure management prohibitions to address sediment and nutrient loadings in the LFR Basin. Many landowners voluntarily install BMPs to help improve water quality and comply with the performance standards. Cost sharing may be available for many of these BMPs. In most cases, farmers will not be required to comply with the agricultural performance standards and prohibitions unless they are offered at least 70% cost sharing funds. If cost-share money is offered, those in violation of the standards are obligated to comply with the rule.

The four counties and other local units of government in the basin may apply for TRM grants through WDNR. TRM grants are competitive financial awards to support small-scale, short-term projects (24 months) completed locally to reduce runoff pollution. Both urban and agricultural projects can be funded through TRM grants, which require a local contribution to the project. Projects that correct violations of the performance standards and prohibitions and reduce runoff pollution to impaired waters are a high priority for this grant program.

Numerous federal programs are also being implemented in the basin and are expected to be an important source of funds for future projects designed to control phosphorus and sediment loadings in the LFR Basin. A few of the federal programs include:

- Environmental Quality Incentive Program (EQIP). EQIP is a federal cost-share program administered by the Natural Resources Conservation Service (NRCS) that provides farmers with technical and financial assistance. Farmers receive flat rate payments for installing and implementing runoff management practices. Projects include terraces, waterways, diversions, and contour strips to manage agricultural waste, promote stream buffers, and control erosion on agricultural lands.
- Conservation Reserve Program (CRP). CRP is a voluntary program available to agricultural producers to help them safeguard environmentally sensitive land. Producers enrolled in CRP plant long-term, resource conserving covers to improve the quality of water, control soil erosion, and enhance wildlife habitat. In return, the Farm Service Agency (FSA) provides participants with rental payments and cost-share assistance.
- Conservation Reserve Enhancement Program (CREP). CREP provides annual rental payments up to 15 years for taking cropland adjacent to surface water and sinkholes out of production. A strip of land adjacent to the stream must be planted and maintained in vegetative cover consisting of certain mixtures of tree, shrub, forbs, and/or grass species. Cost sharing incentives and technical assistance are provided for planting and maintenance of the vegetative strips. Landowners also receive an upfront, lump sum payment for enrolling in the program, with the amount of payment dependent on whether they enroll in the program for 15 years or permanently.

7.1.3. Implementation Plan Development

The next step following approval of the TMDL is to develop an implementation plan (or multiple implementation plans – one for each sub-basin) that specifically describes how the TMDL goals will be achieved. The implementation planning process may develop strategies to most effectively utilize existing federal, state, and county-based programs to achieve wasteload and load allocations outlined in the TMDL. Details of the implementation plan may include project goals, actions, costs, timelines, reporting requirements, and evaluation criteria.

Over the last three decades, there has been a tremendous amount of collaboration and partnering throughout the LFR Basin to try to restore beneficial uses and reduce loadings of nutrients and sediment to Green Bay. Since the 1980s, WDNR has worked with local stakeholders to implement the *Remedial Action Plan* for the Lower Fox River/Green Bay Area of Concern, as well as the Duck/Apple/Ashwaubenon Creeks and East River Priority Watershed Projects, bringing together people, policies, priorities, and resources through a watershed approach. Development of a TMDL implementation plan will require a continued collaborative effort that utilizes the funding and technical expertise of various agencies and private organizations.

An additional resource recently developed to support implementation planning efforts is an analysis of potentially restorable wetlands (PRWs) in the LFR Basin, which quantifies the estimated phosphorus and sediment that could potentially be reduced if all original wetlands in the basin are restored (Appendix F).

7.2. Watershed Management Plan for Waters within the Oneida Reservation

7.2.1. Point Sources within Oneida Reservation

For approximately ten years, the Oneida Reservation has required onsite treatment of stormwater for all new buildings. This includes a treatment train system at the Health Center, an innovative no discharge swale system at the Elder Complex, as well as wetland treatment designed to recharge the Oneida Creek watershed at the WWTF, which itself is a state of the art treatment system. Currently, any land disturbing activity of one acre or more on the Oneida Reservation is required to be covered under the EPA issued Construction Site General Permit. Coverage under this permit is to ensure that proper erosion control practices be implemented to prevent sediment and possibly other pollutants from leaving construction sites and negatively impacting surface or groundwater systems. Oneida Reservation staff work with EPA's Region 5 stormwater coordinator to ensure compliance and proper use of erosion control BMPs within the Reservation. With regards to industrial stormwater, the EPA Multi-Sector General Permit (MSGP) was issued in 2008, but has not been implemented as of yet. However, with the MS4 permit, the Oneida Reservation and three other entities covering the same urbanized area will all be implementing post-construction maintenance and monitoring of stormwater systems.

7.2.2. Nonpoint Sources within Oneida Reservation

The tribe has a nonpoint source program which works with the tribal farm and non-tribal farmers and focuses on agricultural BMPs. They have installed hundreds of acres of grassed waterways, buffers, and Water and Sediment Control Basins (WASCOBS) in the last 15 years. All agricultural leases made by the tribe include mandatory compliance with a nutrient management plan, as well as minimum buffers for any waterways or wetlands. The tribe also has partnered with other agencies such as Glacierland R, C, and D, Brown and Outagamie Counties, and WDNR to implement watershed-scale nonpoint source management.

7.3. Follow-up Monitoring

A post-TMDL monitoring effort will determine the effectiveness of the implementation activities associated with the TMDL. WDNR will monitor the tributaries of the LFR Basin based on the rate of management practices installed through the implementation of the TMDL, including sites where TRM grants are aimed at mitigating TSS and TP loading. Monitoring will occur as staff and fiscal resources allow until it is deemed that stream quality has responded to the point where it is meeting its codified designated uses and applicable water quality standards. In addition, the streams of the LFR Basin may be monitored on a 5-year rotational basis as part of WDNR's statewide water quality monitoring strategy to assess current conditions and trends in overall stream quality. That monitoring consists of collecting data to support a myriad of metrics contained in WDNR's baseline protocol for wadeable streams, such as the IBI, the HBI, a habitat assessment tool, and several water quality parameters determined on a site by site basis.

WDNR will work in partnership with local interest groups including the LFRWMP and GBMSD, to support monitoring efforts which often provide a wealth of data to supplement WDNR data. All other quality-assured available data in the basin will be considered when looking at the effectiveness of the implementation activities associated with the TMDL. In addition, WDNR will consider providing support for a more detailed monitoring strategy that may eventually be a component of a TMDL implementation plan developed for the LFR Basin and Lower Green Bay.

Additionally, the Oneida Reservation plans to continue to implement its own Water Quality Monitoring Program, which includes the collection of water samples for analysis of TP and TSS, as well as biological data (i.e., fish and aquatic invertebrate samples). The primary objective of the Oneida Reservation's Water Quality Monitoring Program is to gather data to evaluate baseline water quality for the water bodies of the Reservation, as well as trends in water quality (e.g., increases or decreases in parameters over time). Baseline physical, chemical, and biological information will be collected regularly at designated stations throughout the Reservation. This level of monitoring helps to determine water quality and biological status and trends in each subwatershed using ecologically-based indicators and identifies potential problem areas. Current baseline sites are located within the Reservation boundary; however, select sites outside of the Reservation boundary may also be monitored. These will be chosen based on proximity to the Reservation, as well as land use and/or wastewater discharge practices that may affect waters of the Reservation. Various approaches will be employed for sample collection (e.g. fixed station/site, surveys, and periodic sampling). When baseline monitoring data indicate a potential problem within a subwatershed, targeted site-specific monitoring is conducted. In addition, targeted site-specific monitoring is conducted for episodic events, such as reported fish kills, and monitoring (including collection of biological data) to measure water quality improvements associated with management actions.

8.0 PUBLIC PARTICIPATION

8.1. Public Notice

This draft TMDL was released and public notice was issued on June 24, 2010. A public hearing was held on July 12, 2010, in Grand Chute, WI. A 30-day public review period was established for soliciting written comments from stakeholders prior to the finalization and submission of the TMDL for EPA approval. Responses to comments received during the public review period are provided in Appendix H.

8.2. Stakeholder Engagement, Public Outreach, and Public Participation

WDNR supported the formation of three advisory teams to assist with the development of the TMDL: The Outreach Team, the *Ad Hoc Science Team*, and the Technical Team. While WDNR convened and led the latter two groups, the Outreach Team was convened and led by a partner agency, the UW Sea Grant Institute.

Outreach Team

In the fall of 2006, Victoria Harris, Water Quality Specialist with UW Sea Grant Institute, convened an Outreach Team to support WDNR in its efforts to inform stakeholders about the TMDL and engage them in TMDL development while also looking ahead to TMDL implementation. The Outreach Team members are listed in Table 11. The Team met 23 times between September 2006 and May 2010. In 2006, the team established the following theme and vision to guide outreach and education activities:

Restoring Our Water Heritage:

Together we can create a better future for the Lower Fox River and Green Bay

Our Vision: The Lower Fox River and Green Bay will be:

- Clean, healthy water bodies that are a destination for residents and visitors because of their abundant fish and wildlife resources and diverse recreational opportunities.
- Water bodies whose protection is widely acknowledged as critical to the economic health of the region.
- Recognized by area residents as valued resources that are important to their quality of life.
- Examples of a balanced, fair approach to solving water quality challenges.
- Identified by communities as an important stewardship responsibility and protected for future generations.

Table 11. TMDL Outreach Team Members

Name	Organization
Victoria Harris (Chair)	UW-Sea Grant Institute
Theresa Qualls	UW-Sea Grant Institute
Pat Robinson	UW-Extension
Kendra Axness	UW-Extension
Ken Genskow	UW-Extension
Denise Scheberle	UW-Green Bay
Trisha Cooper	UW-Green Bay
Jill Fermanich	UW-Green Bay
Bud Harris	UW-Green Bay
Paul Abrahams	Baird Creek Preservation Foundation
Michael Finney	Oneida Tribe of Indians
Bill Hafs	Brown Co. Land and Water Conservation Dept
Rama Zenz	Brown Co. Land and Water Conservation Dept
Lisa Evenson	Green Bay Metropolitan Sewerage District
Rob McLennan	WDNR
Nicole Clayton	WDNR
Erin Hanson	WDNR
Alie Muneer	USEPA
Dean Maraldo	USEPA
John Perrecone	USEPA-GLNPO
Angela Pierce	Bay Lake RPC

The Outreach Team recognized the need to better understand the perspectives, needs, and concerns of audiences that would be affected by the TMDL. With support from EPA and UW-Green Bay faculty, facilitated stakeholder meetings were held in late 2007 and early 2008 to better understand the concerns of agricultural and municipal stormwater stakeholders. Supplementing this information were two stakeholder surveys, conducted as part of an EPA Region 5 initiative to develop "social indicators" for nonpoint source pollution management. The first survey was mailed to dairy farmers in the Lower Fox Basin, and the second survey was mailed to urban residents within the East River Sub-basin. The surveys provided information about current awareness of water quality issues and attitudes toward water resources, status of best management practice implementation, and willingness to try new practices.

While the stakeholder meetings and surveys were underway, the Outreach Team developed and implemented communication strategies to inform watershed residents about the TMDL. Team members developed a variety of written materials, including fact sheets, newsletters, and web pages. In fall 2008, a two-page fact sheet and cover letter were mailed to approximately 1,600 farmers within the basin using county Farm Preservation and other mailing lists. The fact sheet was also mailed to local officials and environmental groups along with a cover letter inviting these recipients to contact either a WDNR staff person or Outreach Team member with any questions.

In late 2008, several Outreach Team members met with the Green Bay Press-Gazette editorial board. The meeting resulted in publication of an article titled, "Groups push to reduce pollution entering Fox River." The article appeared approximately two weeks before a January 23, 2009 public informational meeting that was attended by 63 individuals. Additional informational meetings were held for stakeholders throughout the TMDL development process. Outreach Team members also gave presentations to various groups and provided posters and exhibits for local events. Details regarding the Outreach Team's efforts during TMDL development are presented in Appendix G.

8.3. Technical Team

WDNR convened the Technical Team in October 2008 to ensure that stakeholder interests were represented throughout the TMDL development process. The role of the Technical Team was to ensure that watershed models for various restoration scenarios were grounded in feasible, socially acceptable best management practices. The team was also charged with exploring and assessing costs and barriers to implementation for a variety of best management practices (and/or potential modifications to wastewater treatment facilities). WDNR also asked the team to be creative in exploring allocation and restoration scenarios and implementation approaches. The Technical Team members are listed in Table 12. The team met five times between October 2008 and May 2010 (dates listed in Appendix G).

Table 12. TMDL Technical Team Members

Name	Title	Organization
Jim Bachhuber	National Stormwater Practice Leader	Earth Tech AECOM
Nick Vande Hey	Senior Project Engineer	McMahon and Associates
Ed Wilusz	VP, Government Relations	Wisconsin Paper Council
Steve Jossart	Optimizer Effluent Treatment/#10 Boiler	Georgia Pacific
Bill Hafs	County Conservationist	Brown Co. Land & Water Conservation Dept
Greg Baneck	County Conservationist	Outagamie Co. Land & Water Conservation Dept.
Eugene McLeod	County Conservationist	Calumet Co. Land & Water Conservation Dept.
John Kennedy	Environmental Programs Manager	Green Bay Metropolitan Sewerage District
Matt Heckenlaible	Assistant City Engineer	City of Green Bay
Kevin Erb	Conservation Professional Development & Training Coordinator	UW-Extension
Dennis Frame	Director	UW-Discovery Farms
Bud Harris	Professor Emeritus	UW-Green Bay
Kevin Fermanich	Associate Professor	UW-Green Bay
Paul Baumgart	Watershed Analyst	UW-Green Bay
Kelly Mattfield	Senior Water Resources Engineer	Earth Tech AECOM (alternate)

8.4. Ad-Hoc Science Team

The role of the Ad-Hoc Science Team was to contribute local data and scientific expertise in setting the numeric targets and restoration goals for the TMDL. The Ad Hoc Science Team members are listed in Table 13.

Table 13. TMDL Ad-Hoc Science Team Members

Name	Title	Organization
Bud Harris	Professor Emeritus	UW-Green Bay
Kevin Fermanich	Associate Professor	UW-Green Bay
Paul Baumgart	Watershed Analyst	UW-Green Bay
Paul Sager	Professor Emeritus	UW-Green Bay
John Kennedy	Environmental Programs Manager	Green Bay Metropolitan Sewerage District
Val Klump	Director, School of Freshwater Science	UW-Milwaukee
Tim Ehlinger	Associate Professor	UW-Milwaukee
Victoria Harris	Water Quality Specialist	UW-Sea Grant Institute
Theresa Qualls	Research Analyst	UW-Sea Grant Institute
Nicole Clayton	State TMDL Coordinator	WDNR
Rob McLennan	Regional Impaired Waters Coordinator	WDNR

9.0 REFERENCES

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APPENDIX A. ANALYSIS RESULTS FOR THE NUMERIC WATER QUALITY TARGETS

As discussed in the main body of the report, numeric targets for TP and TSS were needed for this TMDL, in lieu of no statewide numeric water quality criterion for these two parameters. Local monitoring data were used to determine the water quality targets for the TMDL. Predicted improvements in water quality and littoral zone habitat in Zones 1 and 2 were evaluated by simulating reductions in LFR Basin levels of TP and TSS. Using a data set produced by GBMSD sampling from June through September for the period, 1993-2005, a multiple regression model was determined relating Epar in Zones 1 and 2 to corresponding levels of TP and TSS in the LFR.

Understanding Light Extinction (Epar) and Secchi Depth Relationships

Light extinction or attenuation is the reduction of light with depth of the water by light scattering and absorption. Light scattering is a deflection of light predominantly by particles suspended in water and to a lesser extent by water. Absorption of light occurs by the water itself and by dissolved and suspended particles in it. Visible light is composed of many wavelengths and they are not all equally scattered or absorbed in lake water. Most light sensors used in lake studies operate in the photosynthetically available radiation (PAR) portion of the visible spectrum (400-700 nm), which ranges from blues to red-violets. Even in this range there are differences in specific wavelengths. For example, the blues (shorter wavelengths) penetrate deeper than the reds (longer wavelengths). The sensors used today integrate the different wavelengths and then measure PAR in mEinsteins/m^2/minute. Light measurements are taken at 1-meter intervals from the surface to a depth where light intensity is greatly reduced. Epar is calculated as the slope of a linear regression (a statistical analysis) of the natural log of light intensity versus depth, and is a measure of light attenuation through the water column. Low values of Epar indicate low light attenuation with depth and high values indicate high light attenuation and subsequently a shallow zone of light sufficient for photosynthesis by algae and plants. Lower Green Bay has high Epar values and the Upper Bay has low values and thus, a deeper photic zone, which refers to the photosynthetically active zone of the water column for algae and aquatic plants (zone where rate of photosynthesis is higher than respiration rate). When the factors influencing Epar in the AOC are better understood, goals can be set to reach lower values, in turn improving and restoring biotic diversity and production in the shallow zone of Lower Green Bay, the ultimate goal.

Epar scores are inversely proportional indicators of the ability of light to penetrate water. Low Epar scores suggest clearer water with deep light penetration while high scores suggest turbid water with minimal light penetration. Baseline data in LFR were then altered in six reduction scenarios and inserted into the regression model.

An additional, simple regression model was calculated to relate Epar to the more public-friendly, Secchi depth expression. Table 14 presents the models and the results of the calculations showing the increase in Secchi depth in response to the simulated decreases in TP levels and TSS levels in the LFR.

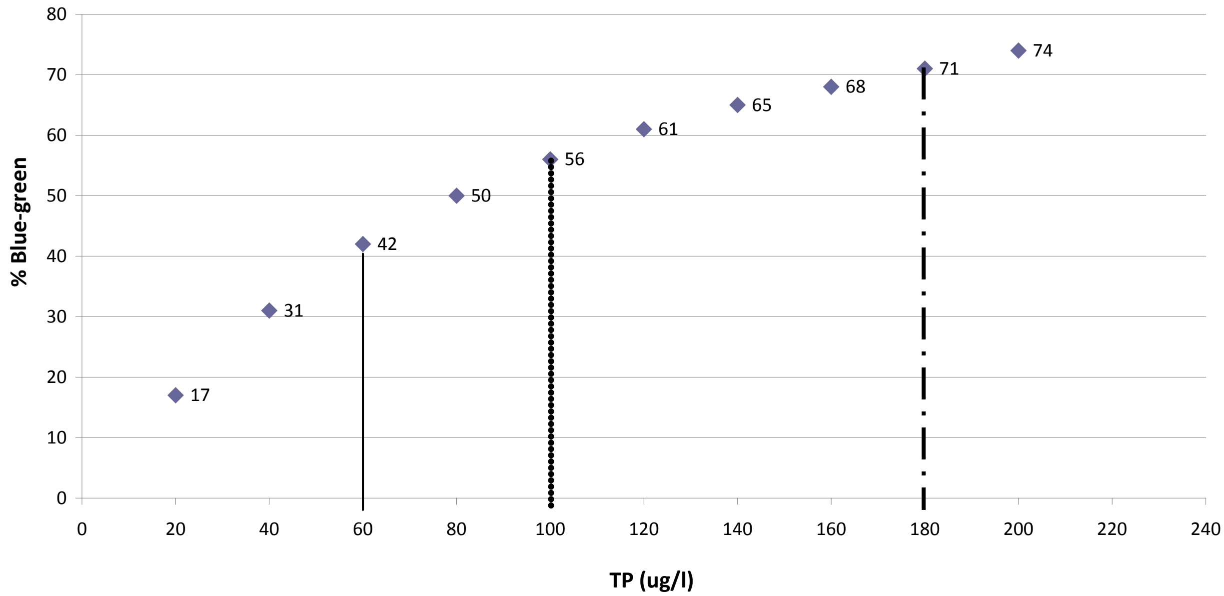
Table 14. Model results for Secchi depth response to simulated decreases in TP and TSS.

A) Baseline conditions summary (Summer median values, 1993-2005)								
Variable	**Median**	**N**	**Std Dev**	**Std Error**	**Minimum**	**Maximum**		
Epar Zones 1 & 2	1.89	1116	1.36	0.04	0.42	11.06		
Secchi Zones 1 & 2 (m)	0.7	1235	0.69	0.02	0.1	5		
TSS River (mg/l)	36.25	468	17.6	0.81	15.5	175.5		
TP River (mg/l)	0.1805	468	0.09	0	0.06	0.74		
B) TP and TSS levels determined by percent reduction from baseline means								
Variable	**Baseline Median (93-05)**	**25% Reduction**	**40% Reduction**	**45% Reduction**	**50% Reduction**	**60% Reduction**	**75% Reduction**	
TP river (mg/l)	0.181	0.135	0.108	0.099	0.09	0.072	0.045	
TSS river (mg/l)	36.25	27.188	21.75	19.983	18.125	14.5	9.063	
C) Epar values calculated for reduction scenarios for TP and TSS Epar = 0.78 + 2.80TP + 0.02TSS (r^2=0.35)								
Variable	**Baseline**	**25%↓**	**40%↓**	**45%↓**	**TP 40%↓ TSS 60%↓**	**50%↓**	**60%↓**	**75%↓**
Epar	2.1	1.77	1.57	1.5	1.41	1.44	1.3	1.11
D) Secchi depth predictions based on relationships to light extinction coefficients Secchi = 1.65 – 0.34 Epar (r^2=0.58)								
Variable	**Baseline**	**25%↓**	**40%↓**	**45%↓**	**TP 40%↓ TSS 60%↓**	**50%↓**	**60%↓**	**75%↓**
Secchi (meters)	0.94	1.05	1.12	1.14	1.17	1.16	1.21	1.27

<u>Evaluating TP concentrations and Blue-green Algae Relationships</u>

In addition to the relationship between TSS, TP loading and corresponding light extinction coefficients and Secchi depth, a relationship between the relative biomass of blue-green algae (%BG) in phytoplankton of lakes in relation to TP concentrations was also explored (Figure 22). Nuisance blue-green algae blooms are common in Lower Green Bay, presenting both an aesthetic problem as well as a health risk problem for pets and recreational users. Currently blue-green algae make up over 70% of the phytoplankton in Lower Green Bay. The vertical lines in Figure 22 identify baseline TP in the LFR (180 μg/l), the TMDL target for the LFR (100 μg/l) and a predicted numeric level (60 μg/l-for Zones 1 and 2) when the TMDL target is achieved (Table 15). The reduction in percent blue-green algae corresponding to the TP change is apparent and is likely one of the major benefits of the TMDL initiative.

Figure 22. Predicting the relative biomass of blue-green algae in phytoplankton from total phosphorus levels in lakes, where %BG = 100/e + 5-2.62 logTP 1 (Trimbee and Prepas, 1987).



Note:

a) The 180 µg/l line is the median TP level for the LFR in the period 1993-2005

b) The 100 µg/l line is the TMDL numerical target for the LFR

c) The 60 µg/l line is the mean TP level for Zones 1 and 2, predicted from the LFR target by the regression: TP = 0.02 + 0.60 (LFR TP) r^2 = 0.469 (see text above)

Table 15. Predicted Lower Bay (zones 1 and 2 combined) responses to achieving the LFR main stem targets of 0.1 mg/L TP and 20 mg/L TSS

TP = 60 µg/l (mean) by the regression: TP = 0.02 + 0.60LFR TP (r^2 =0.469)	
TSS = 15 mg/l(mean) by the regression: TSS = 6.7 + 0.41LFR TSS (r^2= 0.350)	
Secchi Depth = 1.7 m (mean) by the regression: Secchi = 1.62 – 0.85TP – 0.027 TSS (r^2= 0.439)	
% blue-green algae in the phytoplankton in relation to TP levels (Figure 2)	
TP	**%BG**
0.180 mg/l(LFR baseline)	71
0.100 mg/l(LFR TMDL Target)	56
0.060 mg/l(Zones 1 and 2)	42

APPENDIX B. SWAT WATERSHED MODELING ANALYSIS

Prepared by Paul Baumgart, University of Wisconsin – Green Bay, 10/19/09

The following provides a description of the SWAT model, describes the methods used to supply new inputs to the model, discusses model refinement and assessment, and contains summaries of some of the major outputs from the model.

Model Overview

SWAT is a distributed parameter, daily time step model that was developed by the USDA-ARS to primarily assess nonpoint source pollution from watersheds and large complex river basins (Neitsch et al. 2002). SWAT simulates hydrologic and related processes to predict the impact of land use management on water, sediment, nutrient and pesticide export. With SWAT, a large heterogeneous river basin can be divided into hundreds of subwatersheds; thereby, permitting more realistic representations of the specific soil, topography, hydrology, climate and management features of a particular area. Crop and management components within the model permit representation of the actual cropping, tillage and nutrient management practices typically used in Wisconsin. Modeled output data from SWAT can be easily input to a spreadsheet or database program, thereby enabling efficient modeling of large complex watersheds with multiple management scenarios. Major processes simulated within the SWAT model include: surface and groundwater hydrology, climate, soil water percolation, crop growth, evapotranspiration, agricultural management, urban and rural management, sedimentation, nutrient cycling and fate, pesticide fate, and water and constituent routing. SWAT also utilizes the QUAL2E sub-model to simulate nutrient transport. A detailed description of SWAT can be found on the SWAT web site (http://www.brc.tamus.edu/swat/).

The SWAT model framework that Baumgart (2005) applied to the LFR sub-basin for the allocation of total phosphorus (TP) and total suspended solids (TSS) loads was refined as part of a recent demonstration project (Cadmus, 2007) to estimate the load reduction associated with changes in agricultural management. For the LFR and Green Bay TMDL, this model was refined, extended, recalibrated, and validated. The LFR sub-basin model was expanded to include watersheds that drain directly to Lower Green Bay. The urban stormwater component of the model was refined to allow for the evaluation of TP and TSS loading from MS4 urban areas covered under WPDES stormwater permits. The model was refined to make use of new data sets of continuous flow and daily loads of TP and TSS from five Lower Fox River Watershed Monitoring Program (LFRWMP) monitoring stations. This extensive data set of continuous flow and daily loads of TP and TSS from these monitoring stations made it possible to further test the ability of the model to simulate flow, TP and TSS with a reasonable level of accuracy. After calibration and validation, the model was applied for a 1977 to 2000 period to simulate flow and loads from major nonpoint source categories under 2004 conditions. Loads from each source category were generated at the subwatershed outlet, watershed outlet, and to Green Bay.

Model Inputs and Methods

Model input data were acquired from a variety of qualified sources including, federal, state, and tribal agencies, as well as universities. Model inputs and sources are summarized in Table 16. The Geographical Information System (GIS) software product ArcGIS, created by the Environmental Systems Research Institute, Inc. (ESRI), was utilized to generate model inputs, conduct analyses and produce maps. Many of these inputs had already been assembled by Baumgart (2005; Cadmus, 2007), but were modified with more recent data.

Table 16. Major model input types and sources

GIS/Data Type	Source Agency	Source Location/Metadata Link
Meteorological: Daily rainfall, temperature and monthly statistics	NOAA Daily Climatic Data from NWS and co-op stations	Data available on request. Data obtained from UW-Extension Geological and Natural History Survey State Climatology Office in Madison, Wisconsin
	USGS: 4 tipping bucket/loggers at USGS and LFRWMP gages, plus Bower Creek station	http://waterdata.usgs.gov/wi/nwis/sw Bower-04085119; Baird-040851325; Ashwaubenon-04085068; Apple-04085046; Duck-04072150
	LFRWMP: 12 tipping bucket gauges with loggers	Rainfall data on request. http://www.uwgb.edu/watershed/data/climate.htm
Stream Flow & Water Quality (TSS and TP loads)	USGS	http://waterdata.usgs.gov/wi/nwis/sw Bower-04085119; Baird-040851325; East-040851378; Fox-040851385; Ashwaubenon-04085068; Apple-04085046; Duck-04072150
	LFRWMP	Baird Creek 2008 discharge and load data on request - http://www.uwgb.edu/watershed/data/index.htm; TP and TSS concentrations from USGS Baird station 040851325
Hydrography based on GIS data merged from many sources	WI Department of Natural Resources - surface waters	Utilized earlier version (available on request): most recent version at: ftp://gomapout.dnr.state.wi.us/geodata/hydro_24k/
	WI Department of Natural Resources - watershed boundaries	Utilized earlier version (available on request): most recent version at ftp://gomapout.dnr.state.wi.us/geodata/watersheds/
	Bay-Lake Regional Planning Commission - watershed boundaries	Lower portion of East River only. Available on request from source. GIS web site: http://www.baylakerpc.org/
	USGS - Wisconsin, watershed boundaries	Upper portion of East River only. Data available on request from source.
	USEPA - watershed boundaries	12-digit HUC obtained from EPA, available on request. Utilized for comparison purposes.
	LFRWMP - Final watershed boundaries	Available on request. Compiled and modified from above layers http://www.uwgb.edu/watershed/data/index.htm
Hydrography - 303(d) Impaired surface waters	WI Department of Natural Resources	Available on request from source. Contact: Matt.Rehwald@dnr.state.wi.us
Soil Types (SSURGO)	USDA-NRCS	Wisconsin: Brown, Calumet, Outagamie, Winnebago Counties http://soildatamart.nrcs.usda.gov http://soildatamart.nrcs.usda.gov/SSURGOMetadata.aspx
Elevation (DEM)	WI Dept. of Natural Resources	ftp://gomapout.dnr.state.wi.us/geodata/elevation/ Metadata for most WDNR layers available at ftp://gomapout.dnr.state.wi.us/geodata/metadata/ and/or included at data site in ZIP file
Land use, Land cover and ortho-photos	WI Department of Water Resources	WISCLAND land cover, primarily for wetlands: ftp://gomapout.dnr.state.wi.us/landcover/ ftp://gomapout.dnr.state.wi.us/metadata/
	Brown County Planning Dept.	2001 to 2004 land use. 2004 ortho-photo. Available on request to data source. GIS web site: http://www.co.brown.wi.us/Land_Information_Office/IMS.htm
	East Central Wisconsin Regional Planning Commission	2002 to 2003 land use. Available on request to data source. GIS web site: http://www.eastcentralrpc.org/
	US Dept. of Agriculture (USDA) - FSA	NASS 2007 cropland: www.nass.usda.gov/research/Cropland/SARS1a.htm

GIS/Data Type	Source Agency	Source Location/Metadata Link
	USDA-FSA, from Wisconsin View	NAIP 2004, 2005 and 2008 color ortho-photos http://www.wisconsinview.org/documents/2005_NAIP_FAQs.pdf data: http://www.wisconsinview.org/
Elevation and contours	Brown County Planning Dept.	Data utilized only as needed in this phase. http://www.co.brown.wi.us/planning_and_land_services/land_information_office/IMS.htm
Elevation and contours	Outagamie County Planning Dept	Data utilized only as needed in this phase. http://www.co.outagamie.wi.us/applications/arcims/public/html/
WDNR-Enhanced USGS 1:24K DRG topographic maps	WI Dept. of Natural Resources	http://dnrmaps.wisconsin.gov/webview/themes/drg.html http://dnr.wi.gov/maps/gis/documents/digital_raster_graphics_24k.pdf
Crop residue levels	WDATCP, USDA-NRCS and county land conservation departments	Data available on request. WI Dept. of Ag, Trade and Consumer Protection (WDATCP), NRCS county offices and Brown, Calumet, Outagamie, Winnebago Land and Water Conservation Departments
Political/municipal boundaries	Brown, Calumet, Outagamie and Winnebago county Planning Departments	Minor civil divisions (MCD) from counties. GIS layer available on request from source. County boundary from ftp://gomapout.dnr.state.wi.us/geodata/county_bnds/
MS4 Boundaries	WI Dept. of Natural Resources	WDNR provided data, mostly from consulting firms contracted by MS4's, including EarthTech, Inc. and McMahon and Associates. GIS layer available on request from source.
Vegetated Buffer Strips	Brown County Land Conservation Department	GIS layer available on request from source.
Wetlands	WI Dept. of Natural Resources	WDNR WISCLAND land cover layer: ftp://gomapout.dnr.state.wi.us/geodata/watersheds/
Point Source Loads	WI Dept. of Natural Resources	Loads and GIS layer available on request from source.

Watershed Delineations and Sub-basin Configuration

The LFR subwatershed delineation that was created by Baumgart (2005) and altered slightly to coincide with the location of the LFRWMP monitoring stations (Cadmus, 2007) was extended to include watersheds that contributed to Lower Green Bay. ArcGIS was used to create the revised subwatershed delineations. Subwatershed boundaries for the latest revision were based on merging data from the sources listed in Table 16. USGS digital raster graphic 1:24,000 topographic images and two-foot contours provided by Outagamie and Brown County Planning Departments were occasionally utilized where there were areas in question. As illustrated in Figure 23, the Lower Fox River sub-basin was divided into nine major hydrologic units (watersheds) for the calibration: (1) LF01 - East River; (2) LF02 - Dutchman, Ashwaubenon, and Apple Creeks; (3) LF03 - Plum, Kankapot and Garners Creeks; (4) LF04 - Appleton Watershed, which includes Mud Creek; (5) LF05 - Duck Creek; (6) LF06 - Little Lake Buttes des Morts Watershed, which includes the Neenah Slough Creek; (7) LFM - Lower Fox River Main Channel; (8) LFS7 - East Shore Watershed near; and (9) LFS8 - West Shore Watershed. These watersheds were further delineated into a total of 69 subwatersheds according to surface hydrology, land use and the placement of monitoring stations.

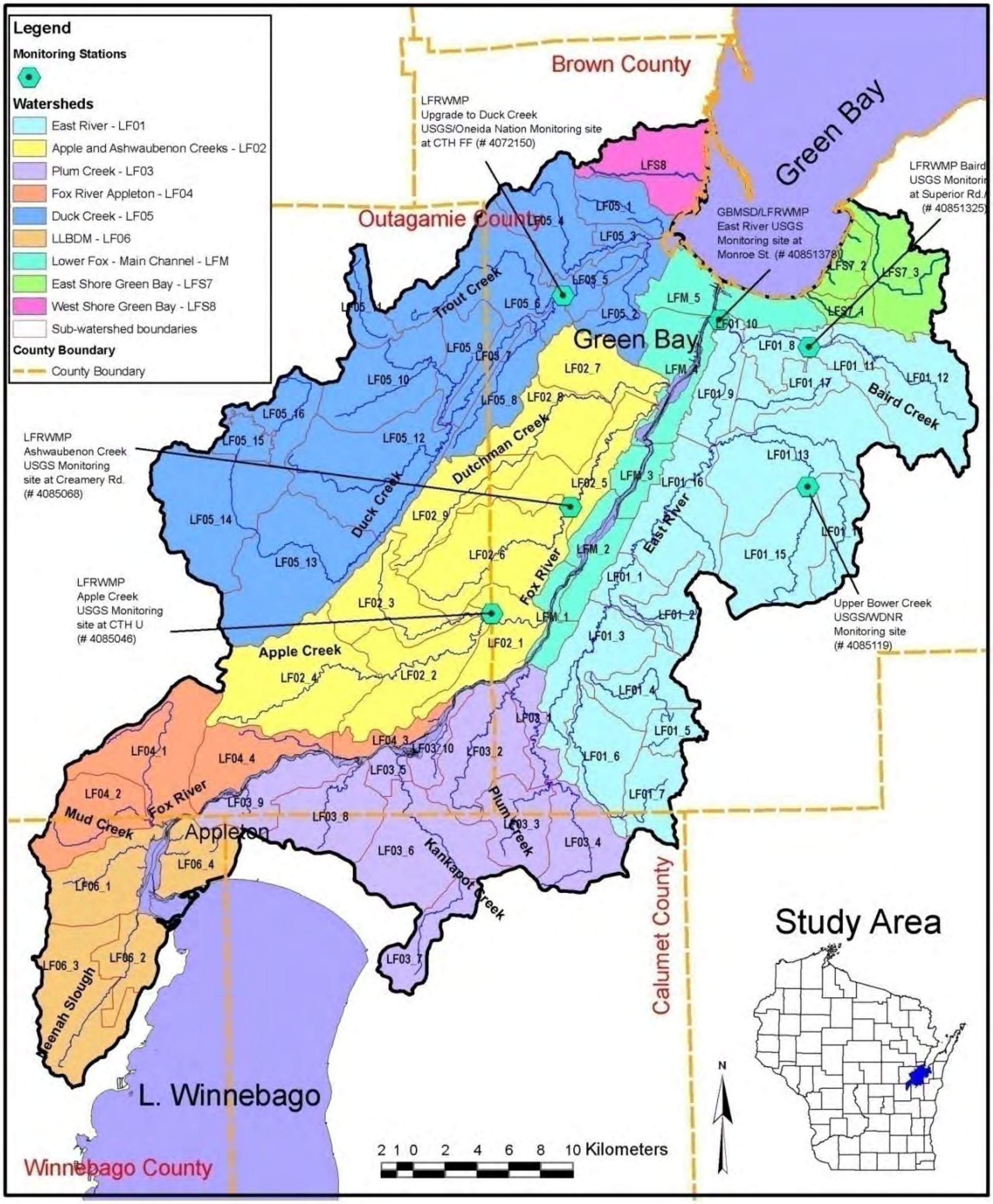


Figure 23. Lower Fox River Basin and Sub-basin boundaries
(USGS monitoring stations used for calibrating and validating the SWAT model are also shown)

Land Use GIS Baseline Layer

To create a year 2004 land use gridded raster and the associated model inputs, a GIS land use shapefile developed by the Brown County Planning Department[17] (BCPD) was merged with an East Central Wisconsin Regional Planning Commission (ECWRPC) land use shapefile,[18] and clipped to the LFR sub-basin boundary. The resulting shapefile was converted to a 5 m gridded raster, which was supplemented with additional wetland data from the WDNR 1993 WISCLAND land cover image. High-resolution color aerial photographs (2004 and 2005) were obtained from the U.S. Department of Agriculture (USDA) Wisconsin Farm Service Agency (WI-FSA) National Agriculture Imagery Program (NAIP) and used to manually update and refine land use categories for portions of the drainage basin to better reflect baseline land use conditions in the drainage basin. This was accomplished by adding urban areas where agriculture or other land use had been indicated.

Urban areas were identified as either regulated Municipal Separate Storm Sewer Systems (MS4s) or non-regulated urban areas. These areas were distinguished using a combination of the MS4 boundary areas provided by stormwater planning consultants, and the minor civil division (MCD) boundaries obtained from Brown, Calumet, Outagamie and Winnebago Counties.

Agricultural land cover is the most prevalent land cover in the sub-basin. Wetlands, grasslands and forested areas are relatively small components of the sub-basin compared to urban and agricultural areas. With the exception of LF01-5 and LF05-15, which have a high proportion of wetlands, most of the sub-watersheds are predominantly agricultural or urban.

Seven major land use categories were modeled with methods that are described in greater detail later in this section: agriculture, urban, golf course, forest, grassland, wetland and quarries. These land uses were further divided into 23 major groups of hydrologic response units (HRU's) which were directly modeled in the following fashion:

	Agriculture – Dairy 6 year rotation (corn, soybean, corn, alfalfa, alfalfa, alfalfa)	
1		Conventional tillage practice (CT)
2		Mulch-till (MT30)
3		Ridge-till or no-till (NT)
	Agriculture - Cash Crop 2 year rotation (corn, soybean)	
4		Conventional tillage practice (CT)
5		Mulch-till (MT30)
6		Ridge-till or no-till (NT)
7	Grassland	
8	Forest	
9	Wetland	
10	Quarries	
	Urban (8 urban sub-classes plus rural residential large lot):	
11-13		MS4 areas: high density (HD), medium density (MD), low density (LD)
14-16		Non-MS4 areas within MS4 municipal MCD boundaries: HD, MD, LD

17 The BCPD land use data approximately represent 2004 conditions.

18 The ECWRPC land use data represent 2002 to 2003 conditions, depending on which county it was obtained from.

17-18 Other urban outside of the MS4 areas and MCD boundaries: HD, MD
19 Rural Residential (simulated as large lot low density urban)
20 Farm building lot
21 Barnyard
22 Golf course
23 Rural Roads
Surface waters not included in simulation

HRUs represent areas within a subwatershed that are similar in a hydrology or management, but are not necessarily contiguous. For this TMDL, HRUs are the total area in the subwatershed with a particular land use and/or management. A GIS operation involving the land use image and sub-watershed boundary shapefile was used to derive the proportional area of the major HRUs within each of the 69 modeled subwatersheds.

The proportion of crops within each sub-watershed, and the typical crop rotations used to represent the LFR sub-basin were determined using the USDA NASS 2007 cropland image. Row crops, other than corn, were modeled as soybean to simplify the possible combinations of rotations that would otherwise need to be modeled. No single specific farming practice could be used to model the entire watershed; therefore, various proportions of the six possible agricultural practices that are listed above (six major HRUs) were used to simulate what occurred in each sub-watershed. Corn-silage and corn-grain were assumed to constitute tow thirds and one third, respectively, of the corn grown in a typical dairy rotation. In order to simulate all phases of a crop rotation in a single model run, the dairy (corn-silage, corn-grain, alfalfa, soybean) and cash crop (corn, soybean) rotations were modeled by adding HRUs to represent each phase of a crop rotation. Alternatively, separate model runs would be required to simulate each phase of a crop rotation. Since there were six years in a dairy rotation, two years in a cash crop rotation, and 69 sub-watersheds, the total number of modeled HRUs was 2,829 [69 subwatersheds * (6 years * 3 tillage practices + 2 years * 3 tillage practices + 17 other land uses)]. Many of these HRUs were later grouped for load allocation purposes.

Tillage Practices and Crop Residue

The conservation tillage levels utilized by Baumgart (2005) were updated to coincide with more recent LFRWMP water monitoring record from 2004 to 2008. Conservation Technology Information Center (CTIC) Conservation Tillage Reports (Transect Surveys) from the four counties were analyzed to determine the primary tillage practice inputs to SWAT. These Transect Survey reports were based on statistical sampling procedures of farm fields to estimate residue levels present shortly after spring planting, as well as other information. Data were supplied by the Wisconsin Department of Agriculture, Trade and Consumer Protection and analyzed with the Transect 2.16 software program produced by Purdue Research Foundation, Purdue University.

The most recent sub-basin wide crop residue and tillage practice reports were from 2002, and they indicated that there was a sharp decrease in the amount of residue left on the field since data had been collected in 1999 and 2000, especially for watersheds that had higher residue cover in the previous years. There was much variation in residue cover between watersheds, and some uncertainty in the applicability of the residue data because water monitoring data was from late 2003 to 2008 instead of 2002. Because of this uncertainty, the watershed-specific crop residue levels from 1999, 2000 and 2002 were averaged and applied uniformly as conservation tillage inputs to all of the watersheds in the LFR sub-basin. The average tillage inputs that were assumed for the baseline conditions were: 83.1% conventional tillage, 15.2% mulch-till, and 1.7% no-till, zone-till or high residue for the dairy crop rotation; and 75.9% conventional tillage, 20.2% mulch-till, and 3.9% no-till for the cash crop rotation. The NRCS field office conducted a joint NRCS and LFRWMP-funded survey over Brown County in the spring of 2008. The results were essentially the same as those assumed for Baseline Conditions, except for the Duck Creek watershed. Therefore the 2008 data were utilized for the Duck Creek watershed and the following tillage inputs were assumed for baseline conditions: 69.4% conventional tillage, 27.4% mulch-till, and 3.2% no-till, zone-till or high residue for the dairy crop rotation; and 56.3% conventional tillage, 36.5% mulch-till, and 7.2% no-till for the cash crop rotation.

Non-agricultural Rural Land Areas

HRUs designated as grassland, forest, wetlands and golf courses were assigned values from SWAT's default crop data sets for pasture, forest, wetland and lawn data sets, respectively. Those areas that were classified as barren were primarily quarries, and simulated accordingly. Rural roads were simulated as a combination of impervious road surface and grass ditch.

Urban MS4 Areas

Initially, the area of the LFR sub-basin that was considered to be regulated as municipal stormwater areas was delineated by combining GIS datasets that were provided by the consultants who developed stormwater management plans for many of the regulated communities. These GIS datasets, along with many of the associated stormwater permit plans was provided by the WDNR. Stormwater plans were not sufficiently developed for several communities, so the boundaries of these MS4 areas were estimated by Baumgart and added to the other areas through "heads-up-digitizing." Much editing was required to repair and label many open polygons, and to improve consistency between all of the labeled land use categories and the MS4 areas. The result was a shapefile that delineated the MS4 areas in the LFR sub-basin.

However, there was still significant inconsistency between the municipalities with regards to what areas were or were not classified as MS4s in the original GIS layers provided by the consultants. In addition, not all communities were able to supply MS4 boundaries, because their stormwater plans were not complete. Also, many areas were not classified as MS4s, in part because GIS data was not obtained from all MS4s, so there were concerns about how these areas would be affected under a TMDL. Therefore, it was decided by the WDNR that the MS4-classified area should include all urban areas within MS4-designated communities. To accommodate this change, minor civil division (MCD) boundaries obtained from Brown, Calumet, Outagamie and Winnebago counties were merged into a single GIS MCD shapefile that contained municipal boundaries. A field was added to separate MS4 and non-MS4 municipalities. Furthermore, six MS4 municipalities had relatively large areas that were mostly rural, so the rural portions of the following municipalities were not included in the MS4 boundary: Village of Bellevue, Village of Ledgeview, Village of Hobart, Town of Scott, Town of Buchanan and Town of Harrison. The original MS4 boundary shapefile was kept intact and intersected with the MCD shapefile. This process resulted in three major urban categories that were modeled in SWAT: 1) directly delineated MS4 areas (as provided by stormwater planning consultants or added where none were available); 2) indirectly delineated MS4 areas that were within MS4-designated municipal boundaries but not originally labeled as such; and 3) all other non-MS4 urban areas. For purposes related to TMDL allocations, loads and flow from the two MS4 categories were later combined into a single MS4 category.

Finally, the urban shapefile was overlaid with the USDA-NASS 2007 classified land cover raster image to create separate urban sub-classes for high and medium/low density urban areas that were directly simulated as HRUs in SWAT. Another shapefile was created to discriminate between rural areas and urban metropolitan areas so that relatively large low density rural residential lots could be distinguished from smaller low density lots within this quasi-metropolitan boundary. This boundary was primarily based on the U.S. Census Bureau 2000 urban boundary shapefile. These two shapefiles were combined with the three-category MS4 shapefile to create a final urban shapefile that contained a total of nine combinations of urban land use classes (including a low density rural residential class), which were modeled as the nine previously listed urban HRUs.

Urban Areas

The buildup and washoff option was selected as the method to simulate urban loads from impervious surfaces in SWAT. The buildup and washoff method incorporated in SWAT is similar to that used in the Storm Water Management Model (SWMM, Huber and Dickinson, 1988). Measured loads from different urban sources were not available within the project area, so all metropolitan urban areas were lumped into two primary classes: medium density residential areas and high intensity commercial/industrial areas. Some high density residential or mixed residential areas were included in the latter class. The fraction of impervious area was assumed to be: (1) 0.335 for medium residential, compared to the SWAT default of 0.38; and (2) 0.70 for commercial/industrial areas, which was based on averaging the SWAT defaults of 0.60 for high density urban, 0.67 for commercial, and 0.84 for industrial areas. For the pervious portion of the urban HRU, phosphorus and sediment loadings were simulated by assuming that these areas were in lawn grass, and a SWAT management routine was developed to simulate the runoff and loadings from these areas. Areas that were classified as urban lots that were located outside of metropolitan areas were assumed to be low density residential lots with a relatively low proportion of impervious area (0.09) because these lots can vary in size from a minimum of 0.75 acre to over 8 acres. The default SWAT value for the fraction of impervious area for low density residential is 0.12.

The urban component of the SWAT model was initially calibrated for TSS and TP by adjusting the urban management file and associated files to obtain a representative TSS concentration of about 90 mg/L and a TP concentration of 0.18 mg/L during a 1977-2000 climatic period (representative concentration = total simulated long-term load/total long-term water volume). These calibration concentrations and corresponding yields were based on a review of the following urban runoff data which is summarized in Table 17: (1) four urban Milwaukee, Wisconsin streams with a median and mean of 107 mg/L and 152 mg/L TSS, respectively, and median and mean of 0.18 mg/L and 0.21 mg/L TP, respectively (Bannerman et al., 1996); (2) eight Wisconsin and two Upper Michigan storm sewer sites with a median and mean of 120 mg/L and 237 mg/L TSS, respectively ,and median and mean of 0.29 mg/L and 0.45 mg/L TP, respectively (Bannerman et al. 1996); (3) eight Lake Superior Basin cities storm sewer sites with a median and mean of 284 mg/L and 433 mg/L TSS, respectively, and median and mean of 0.44 mg/L and 0.47 mg/L TP, respectively (Steuer et al., 1996); (4) Marquette, Michigan storm sewer site with a geometric means of 159 mg/L TSS and 0.29 mg/L TP (Steuer et al., 1997); (5) seven stormwater sites in Madison, Wisconsin with a median and mean of 93 mg/L and 106 mg/L TSS, respectively, and a median and mean of 0.32 and 0.38 mg/L TP, respectively (Waschbusch, 1995); (6) stormwater from 25 runoff events within residential basins in Madison, Wisconsin had a median and mean of 136 mg/L and 171 mg/L TSS, respectively, and a median and mean of 0.45 and 0.59 mg/L TP, respectively (Waschbusch et al., 1999); (7) stormwater from 15 runoff events that entered a treatment chamber installed below the pavement surface at a municipal maintenance garage and parking facility in Milwaukee, Wisconsin contained median event mean concentrations of 232 mg/L TSS, and 0.26 mg/L TP (Corsi et al., 1999); (8) 43 samples of stormwater that entered an urban stormwater treatment unit which collected runoff from a 4.3 acre municipal maintenance yard in Madison, Wisconsin contained median and mean concentrations of 251 mg/L and 345 mg/L TSS, respectively (Waschbusch et al., 1999); and (9) during 64 runoff events, stormwater entering a wet detention pond in Madison, Wisconsin from a 0.96 km^2 residential area had median and average event mean concentrations of 144 mg/L and

239 mg/L TSS, respectively, and median and average event mean concentrations of 0.45 mg/L and 0.57 mg/L TP, respectively (House et al., 1993).

Suspended solids in storm sewers are expected to have a higher proportion of large particles than in urban streams because as larger particles are more likely to settle out in streams, or before reaching the stream, than in storm sewers. Larger particles are not associated with reduced water clarity in Green Bay, nor are they expected to be a major component of runoff from rural areas. Therefore, greater emphasis was given to water quality data collected from streams than data from storm sewers when selecting the calibration concentrations. In addition, urban areas contribute more than just overland runoff to the stream, so urban runoff concentrations should be diluted by recharge or lateral flow that also comes from urban areas.

Table 17. Summary of phosphorus and suspended sediment/TSS concentrations measured in urban streams and storm sewers within Wisconsin and neighboring states

Reference	Sediment/TSS (mg/L)				Total Phosphorus (mg/L)			
	storm sewer		urban stream		storm sewer		urban stream	
	median	mean	median	mean	median	mean	median	mean
Bannerman, et al. 1996	120	237	107	152	0.29	0.45	0.18	0.21
Steuer et al. 1996	284	433			0.44	0.47		
Waschbusch, R.J. 1995	93	106			0.32	0.38		
Waschbusch, R.J. 1999	251	345						
House et al. 1993	144	239			0.45	0.57		
Steuer et al. 1999	159				0.29			
Corsi et al. 1999	232				0.26			
Waschbusch et al. 1999	136	171			0.45	0.59		
Median	152	238	107	152	0.32	0.47	0.18	0.21
Mean	177	255	107	152	0.36	0.49	0.18	0.21

The primary change that was made to calibrate the urban component of the SWAT model was to decrease the urban wash-off coefficient from 0.18 to 0.055 for residential areas and 0.039 for high density areas. This change was made to reduce the overall sediment concentration and loads (and associated phosphorus), and to have sediment yields from the two urban classes reflect the same relative proportions as in SLAMM modeling for the City of Green Bay (EarthTech, 2007).

After calibration, the 1977-2000 average annual SWAT-simulated TSS yield was 275 lbs/acre, based on 24 typical urban sub-watersheds. This area-weighted average TSS yield is similar to the observed median unit-area annualized yield of 372 lbs/acre TSS from 15 urban watersheds in Southeastern, Wisconsin till plains ecoregion (Corsi et al., 1997; ranging from 49 to 1,279 lbs/acre). The 1992-2008 mean annual suspended sediment yield was 275 lbs/acre at the USGS urban monitoring station located at Spring Harbor near Madison, Wisconsin (USGS #05427965), while the mean yield between 1999 and 2008 was243 lbs/acre. SWAT simulated TSS yields were also similar to the range of baseline and existing urban yields that were generated with the SLAMM model by Earth Tech (2007, 2008a, 2008b) for the stormwater management plans of the City of Green Bay (235 and 210 lbs/acre), Appleton (251 and 194 lbs/acre), and DePere (251 and 170 lbs/acre). The mean annual baseline urban yield from 14 LFR sub-basin municipal stormwater plans was 243 lbs/acre (reports produced by Earth Tech, McMahon Associates, Omni Associates and others). These values include contributions from open spaces. Without including open spaces, the SLAMM modeled TSS yield was 227 lbs/acre for Green Bay under existing conditions; whereas, the average sediment yield was 210 lbs/acre with open space areas. The former value is more comparable to the SWAT simulated yields because many of the open spaces are modeled as such in the SWAT framework.

After the initial calibration, the 1977-2000 average annual SWAT-simulated phosphorus yield was 0.52 lbs/acre, based on 24 typical urban sub-watersheds. However, the model was adjusted to increase the phosphorus yield to coincide more closely to the simulated yields from local stormwater plans. After final calibration, the 1977-2000 average annual SWAT-simulated urban phosphorus yield was 0.70 lbs/acre, based on the urban portions of nine sub-watersheds located in the East River watershed. The SWAT simulated phosphorus yields were similar to the baseline and existing condition urban yields that were generated with the SLAMM model by Earth Tech (2007, 2008a, 2008b) for the stormwater management plans of the City of Green Bay (0.77 and 0.70 lbs/acre), Appleton (0.85 and 0.70 lbs/acre), and DePere (0.84 and 0.71 lbs/acre). The mean simulated phosphorus yield under baseline condition from 14 LFR sub-basin municipal stormwater plans was 0.72 lbs/acre (reports produced by Earth Tech, McMahon Associates, Omni Associates and others). However, the SWAT-simulated phosphorus yield is somewhat higher than the observed median unit-area load of 0.50 lbs/acre phosphorus from four urban watersheds in Southeastern, Wisconsin till plains ecoregion (Corsi et al., 1997; ranged from 0.21 to 1.89 lbs/acre kg/ha).

Construction Sites - Urbanizing Areas

Urbanization is a transitional change from rural to urban land use. Urbanization and associated land use changes for the simulation period are by nature continuous. Therefore, the problem of constructing a model framework for simulating the spatial and time dependant nature of this change throughout the simulation period did not render a simple or obvious solution. Perhaps understandably, the current version of SWAT does not directly model continuous changes in land use over time in a single model simulation; that is, the area of each HRU remains unchanged over time.

Therefore, the rural to urban transition was simulated by adding a separate HRU within the model to represent construction sites, but the area of the HRU was kept constant and represented the average area transitioning to urban over a limited period of time. Loads were simulated with SWAT by assuming that the annualized change in urban area from 2001 to 2004 remained constant for each sub-watershed. The land use GIS raster image that was developed by Baumgart (2005) in a previous modeling exercise served as the 2001 land use, which was then compared to the baseline 2004 land use image that was created for this project to estimate the change in urban area. The average annual increase in urban area within each sub-watershed then served as the area of the construction site HRU. The total urban area within each sub-watershed was reduced to offset the area from HRU construction sites that was added to the model.

The simulated load and yields for the construction site HRU were based on several factors, including data from two separate Wisconsin construction site studies that are described below. In a study conducted from spring 1977 to summer 1978, Madison et al. (1979) found that the mean and median TSS concentrations from rapidly urbanizing watersheds in Germantown, Wisconsin were approximately 6,900 and 5,100 mg/L, respectively during monitored runoff events. The mean and median TP concentrations were about 4.5 and 2.9 mg/L, respectively. The mean sediment yield was roughly 13,193 lbs/acre and the mean phosphorus yield was approximately 9.55 lbs/acre over the two partial year sampling periods. The yields would be lower if calculated on an annualized basis. While some erosion controls were implemented in the non-control watershed, they were judged to be ineffective due to drought conditions. Owens et al. (2000) studied soil erosion from two small construction sites in Dane County, Wisconsin. Both sites were less than five acres. During the active construction phase the flow-weighted average concentration of suspended sediment from a commercial site was 12,700 mg/L (n=8), and 2,600 mg/L (n=3) from a residential site. However, they noted that few of the storms produced runoff at the residential site because most of the construction took place in winter; whereas, construction at the commercial site primarily took place during the summer months. Furthermore, they suggested that there was evidence which indicated that the suspended sediment concentrations could have been as high at the residential site as they were at the commercial site if construction had instead taken place during the summer months. An annualized sediment yield of 6,750 lbs/acre was estimated for the summer construction season at the commercial construction site, whereas 1,650 lbs/acre was estimated for the winter construction season at the residential construction site (Owens et al., 2000; loads estimated for un-sampled events).

Erosion controls are currently required at most constructions sites in the LFR sub-basin; whereas, controls were minimal or ineffective at the construction sites in the Dane County and Germantown studies. In addition, both total precipitation and rainfall intensity are lower in Northeastern Wisconsin. Therefore, baseline yields from construction sites in the LFR sub-basin would be expected to be lower than the aforementioned study sites where minimal controls were implemented. An HRU was created to roughly simulate fallow or limited vegetation conditions similar to what might occur at a construction site under "existing" 2004 condition. Based on the Wisconsin construction site runoff data and associated caveats about current erosion controls, the SWAT model construction site HRU was calibrated to produce average annual sediment yields of 4,047 lbs/acre (5.0 t/ha) and phosphorus yields of 4.5 lbs/acre from construction sites within the East River watershed over a 1977 to 2000 period (<u>as routed to the sub-watershed outlet</u>). These sediment and phosphorus yields were on average, 7.5 times and 3.1 times higher, respectively, than yields generated during the same 1977 to 2000 simulation period for comparable agricultural areas under a typical dairy rotation with conventional high intensity tillage.

Compared to standard urban development that occurs within the metropolitan areas, areas transitioning from agricultural land use to low density, large, rural residential lots should produce lower TP and TSS yields, because only a relatively small portion of the large lot is usually developed. To accommodate this difference, TSS yields and associated TP yields were reduced by decreasing the yields in proportion to the amount of very low density land use within each sub-watershed, and assuming that the yield from these areas was one third that of more dense developing areas.

<u>Climatological Inputs</u>

Daily precipitation and temperature data from the following weather stations served as input to the climate sub-model in SWAT: NOAA National Weather Service (NWS) Station at the Green Bay airport (long-term); three USGS stations located in the Upper Bower Creek watershed (1990-97); and official NWS cooperative stations in Appleton and Brillion (long-term). These data were combined to create a 1976 to 2000 climate data set that was used for all Baseline and optimal scenario simulations. Climatic data were assigned to each sub-watershed according to the nearest weather station.

In addition, up to four rain gauge-logger units were operated by the USGS (4 in 2003-06; 2 in 2007-2008), and 12 tipping bucket rain gauges and loggers were installed throughout the basin by the UW-Green Bay through the LFRWMP (2004-2008). Daily precipitation data from four independent stations that were part of a weather network whose real-time data was posted on the internet were also added to the climate database (http:/www.wbaytv.com). This dataset was checked for accuracy by comparison with nearby stations, and questionable data were removed from the database. Data from these stations were used to supplement the other data and provide more accurate precipitation data to the model for the 2004-2008 calibration and validation periods. During the calibration and validation periods, precipitation inputs to the model were generated for each sub-watershed based on an inverse-distance weighted formula and the distance between the centroid of each sub-watershed and the surrounding precipitation stations.

Routing TSS and Phosphorus to Green Bay

Subwatershed loads were routed from sub-watershed outlets to the watershed outlet within the SWAT model. However, in SWAT the loads and flow from all sources (i.e., simulated HRUs) are combined at the sub-watershed outlet and subsequent downstream points of interest. For the TMDL, the sources responsible for the loads need to be identified. Therefore, loads and flow from sources were tracked by routing these sources outside of the SWAT model and assuming that losses via settling were the same for all source loads as they were routed downstream. Phosphorus was routed as combined dissolved and organic/sediment phosphorus (TP) by using the net phosphorus that entered and exited a SWAT routing reach to derive the TP routing ratio. TSS and TP loads were then routed from the watershed outlets to Green Bay, along the main stem of the Fox River channel. Sediment routing/trapping coefficients for the main stem of the Fox River were based on a relationship between trapping efficiency and the reservoir capacity/average annual inflow ratio that was developed by Brune (1953) and by Dendy (1974). It was assumed that all of the dissolved P from the watersheds reached the outlet to Green Bay (no settling), while sediment-attached phosphorus had the same trapping efficiency as sediment; this was done by apportioning the now combined TP loads back into a dissolved phosphorus and sediment-attached phosphorus based on the respective proportions from SWAT output files that were generated for the major watershed outlets. In this way, both the sub-watershed routed loads and the loads from the SWAT watershed outlet files were consistent.

Stream Bank Erosion

The stream bank erosion sub-model within SWAT was not updated as planned for in the QAPP, because most of the data from an ongoing sediment source tracing investigation of LFR tributaries was not available in time to calibrate the SWAT model. Therefore, as in previous LFR modeling projects (Baumgart, 2005; Cadmus, 2007), the stream bank erosion component of the modeling framework was "turned off" which effectively lumped these contributions with upland sources because 1) county land conservation departments assessed the stream bank contributions of TSS and TP during watershed planning and estimated that they were not a major source compared to upland sources; and 2) actual watershed-wide precise measurements of stream bank contributions were not available to calibrate the model.

Model Calibration and Assessment

Stream Flow and Water Quality Data

Calibration and initial validation of the SWAT model was conducted with continuous stream discharge and daily TP and TSS loads from the USGS-WDNR monitoring station located on Bower Creek at CTH MM (1990-1997; 36 km^2). In addition, five continuous discharge monitoring stations within the LFR sub-basin were upgraded or installed through the LFRWMP and were operated cooperatively with the USGS, the Oneida Tribe, and the GBMSD. Three to five years of stream flow and water quality data from October 2003 through September 30, 2008 were available from the following stations:

1) Duck Creek at CTH FF (276 km^2; 2004 to 2008), upgraded with sampler (co-sponsored by Oneida Tribe).
2) Baird Creek at Superior Road (54 km^2; 2004 to 2008).

3) Apple Creek at CTH U / Campground (117 km^2; 2004 to 2006).

4) Ashwaubenon Creek at Creamery Road (48 km^2; 2004 to 2006).

5) East River at Monroe Street (374 km^2; 2004 to 2007), (co-sponsored by the GBMSD).

The USGS computed daily TP and TSS loads for each stream based on continuous discharge and discrete low-flow and automated event sampling. The UW-Green Bay applied regression analysis to estimate dissolved phosphorus loads. Data from the five LFRWMP USGS monitoring stations were utilized for model assessment as published by the USGS with two types of exceptions. First, the USGS did not officially track stream flow or calculate daily loads at the Baird Creek station after USGS water year 2007. However, the USGS continued the operation of all monitoring equipment at the Baird Creek station through 2008 and provided the unofficial discharge data to the LFRWMP; in return, the LFRWMP agreed to assist in the collection and processing of water samples from the USGS station at Bower Creek. The Baird Creek discharge measurements during 2008 remain unofficial because the USGS did not continue field measurements to verify that the stage-discharge relationship did not change, nor did the USGS maintain the monitoring equipment and verify that it was functioning correctly. The LFRWMP continued the same monitoring protocol that was utilized from 2004 to 2007 to collect and analyze samples. The LFRWMP then adjusted the 2008 raw stream flow data where necessary (e.g., ice-affected periods to ensure water balance was reasonable, or small log jam), and applied the USGS software program GCLAS to calculate daily loads of TSS and phosphorus using the unofficial discharge measurements from Baird. GCLAS was also used by the USGS to calculate the official loads from this site, as well as the other LFRWMP stations. The TSS and phosphorus concentrations from 2008 and 2009 are available for download from the USGS web site.

Second, as stated in the QAPP, there were times when the stage-discharge relationship in a stream was affected by ice conditions, thereby affecting stream flow and associated loads. During these times, the USGS estimated the flow. However, there were times when it appeared that the estimated stream flow was too high relative to the overall water balance and expected water inputs. That is, the water balance during and preceding the ice-affected flow events did not seem correct in the sense that the flow volume came close to, or even exceeded total precipitation during or preceding the event. Stream flow and associated loads estimated by the USGS during ice-affected periods were therefore adjusted approximately one year prior to model assessment by Paul Baumgart, UW-Green Bay watershed analyst with the LFRWMP. The TP and TSS loads were adjusted in proportion to the change in flow. Ice-affected estimated flow and loads were adjusted well before any modeling efforts were made; thereby limiting bias when the adjusted values were utilized for model assessment. Although the adjustments often favored an improved correspondence between simulated and observed flows, there were also times when they decreased the fit. The adjusted and un-adjusted daily flow and load data set from the LFRWMP are included with the electronic data submitted with this project.

Calibration

Model calibration involved adjusting model inputs within acceptable and published ranges to obtain the best fit between observed and simulated values. The Nash-Sutcliffe coefficient of efficiency (NSE; Nash and Sutcliffe, 1970), regression analysis, and visual inspection served as the criteria to compare observed and simulated flow and loads on an event, monthly, and annual basis. The Upper Bower Creek watershed (LF01-15, 36 km^2) was utilized as the primary calibration site for stream flow, TSS loads, and phosphorus loads. Recalibration of the previous SWAT model (Baumgart, 2005; Cadmus, 2007) was performed because the input structure of the model was altered to accommodate an increased number of HRUs, including an HRU for construction sites. These changes did not affect crop yields and crop biomass production, so no changes were made to related input parameters.

The Bower Creek monitoring site (USGS Station #04085119) is located in the East River Watershed (jointly funded by the USGS and WDNR), and has a continuous record of flow data and daily loads, which are vital to the model calibration. The Upper Bower Creek watershed has silty clay to clay loam soils with slow infiltration rates (NRCS hydrologic group C soils), shallow overland slopes, and land use comprised of 83% agriculture (mostly dairy) and 9% forest and wetland in 2004. These characteristics are typical of most areas within the LFR sub-basin.

The 1991 to 1994 (Oct. 1990 to March 31, 1995) Bower Creek monitoring data (daily flow and loads) were used for calibrating the model (50 to 52 events), while the monitoring data from 1996 to 1997 (17 events), along with data from other sites, were used in the model assessment phase. For model calibration and assessment purposes, the SWAT model was applied to the Bower Creek LF01-15 sub-watershed for a 1989 to 1997 climatic period. Only a single slight adjustment was made to calibrate the LFR sub-basin model that was previously used by Baumgart (2005; Cadmus, 2007): the evapotranspiration coefficient was increased by 0.5% (0.806 versus 0.810) to decrease the volume of runoff. Calibration results are summarized in Table 18. After calibration, the total simulated stream flow during the 1990 to 1994 calibration period was 909 mm compared to 902 mm for the observed stream flow. Annual simulated and observed stream flows were: 1991 (201 vs. 180 mm), 1992 (210 vs. 230 mm), 1993 (344 vs. 370 mm), and 1994 (132 vs. 102 mm), respectively. The maximum relative difference was 30% in 1994, when the lowest flow occurred; thereby, suggesting that the model may have greater difficulty simulating water yields during dry periods.

The NSE for 52 total event stream flow volumes was 0.79 and the coefficient of determination (r-squared) was 0.80. A NSE of one indicates a perfect fit. The NSE and r-squared were both 0.86 for monthly flows during the calibration period. The NSE and r-squared were 0.89 and 0.91, respectively for monthly TSS loads. The NSE and r-squared were 0.77 and 0.79, respectively for monthly TP loads. Two very large events that were utilized for flow evaluation were not used for evaluating TSS and TP event loads because no samples were collected during these events so the loads were only estimated by the USGS. The NSE for 50 total events was 0.90 for TSS and 0.80 for TP. NSE and r-squared statistics were above the minimum criteria of 0.6 that was stated in the QAPP. Relative differences were below the maximum level of 30% that was stated in the QAPP. Therefore, the statistical measures indicate that there was an acceptable level of correspondence between simulated and observed events, and that model assessment could proceed.

Table 18. Calibration and validation summary for Bower Creek monitoring station

	Observed	SWAT	R^2	NSE	Relative difference	R^2 or NSE basis
Calibration Period (1991 to 1994)						
Flow (mm)	902	909	0.86	0.86	0.8%	monthly
TSS (tons)	6,610	6,890	0.91	0.89	4.2%	Monthly
Phosphorus (kg)	22,380	21,250	0.79	0.77	-5.1%	Monthly
Flow (mm)	673	583	0.80	0.79	-13.4%	52 events
TSS (tons)	6,120	5,720	0.93	0.90	-6.6%	50 events
Phosphorus (kg)	18,460	15,879	0.82	0.80	-14.0%	50 events
Validation Period (April 1, 1996 to June 30, 1997)						
Flow (mm)	330	322	0.77	0.77	-2.4%	monthly
TSS (tons)	2,290	2,810	0.86	0.85	22.2%	monthly
Phosphorus (kg)	7,470	8,500	0.90	0.90	13.8%	monthly
Flow (mm)	178	164	0.80	0.79	-7.7%	17 events
TSS (tons)	1,920	2,010	0.83	0.81	4.9%	17 events
Phosphorus (kg)	5,420	5,320	0.85	0.84	-1.9%	17 events

Validation/Assessment

Model validation involved testing the ability of the calibrated model to predict flow and loads at times or locations other than those in the calibration phase, without adjusting model parameters. Model assessment and potential refinement were particularly important because the previous LFR modeling effort relied heavily on daily loads from the Bower Creek USGS station (Baumgart, 2005). With data made available through the LFRWMP, it was possible to thoroughly assess the ability of the model to provide reasonably accurate predictions in five LFR watersheds. Model assessment involved comparing the simulated output to continuous flow and daily loads of TSS and TP from the 1996 to 1997 Bower Creek data set, as well as the 2004 to 2008 data sets from the five USGS stations operated and funded cooperatively through the LFRWMP, the Oneida Nation, and the GBMSD. The SWAT model was applied to the LFRWMP watersheds for a 2002 to 2008 climatic period during the model assessment phase. R-squared and NSE values of 0.6 or greater, and percent bias of 30% or less served as goals for successful validation of the model for stream flow, TSS loads, and TP loads on an annual and monthly basis. As stated in the QAPP, any excursions from this target should be limited in scope, and a rationale provided to explain why the model would still be deemed valid.

As shown in Table 18, the relative differences between observed and simulated Bower Creek values were -2.4% for stream flow, 22% for TSS and 14% for phosphorus over the entire 1996 to 1997 validation period. The monthly NSE's were 0.77 for flow, 0.85 for TSS and 0.90 for phosphorus. Similar results were obtained for the 17 events that were selected for analysis, although relative differences between observed and simulated TSS and TP loads were smaller. NSE and r-squared statistics were above the minimum criterion of 0.6 that was stated in the QAPP. Relative differences were below the maximum level of 30% that was stated in the QAPP. These statistics indicate that there was an acceptable level of correspondence between simulated and observed events for the Bower Creek station.

As previously stated, the model was also applied to the five LFRWMP watersheds for the model assessment phase. Only data from USGS water years 2004 and 2005 were utilized in the initial assessment phase for these watersheds. This approach was used because Baumgart (Cadmus, 2007) found in a previous assessment that SWAT inputs for two of the watersheds needed to be adjusted to provide a more acceptable fit between observed and simulated loads. In general, the un-adjusted LFR sub-basin model was able to estimate flow, TSS loads and TP loads at the LFRWMP monitored sites with a reasonable degree of accuracy on a monthly and annual basis during the 2004 and 2005 USGS water year monitoring period. As summarized in Table 19, R-squared and NSE monthly flow statistics ranged from 0.84 to 0.94. R-squared and NSE statistics ranged from 0.67 to 0.88 for monthly TSS loads, and from 0.66 to 0.84 for monthly TP loads. All of these statistics are better than the minimum criterion of 0.60, which is stated in the QAPP.

Relative differences between observed and simulated flows over the 2004 to 2005 period ranged from -11.1% at Duck Creek to +22.2% at Ashwaubenon Creek. Relative differences for the total TSS load over the 2004 to 2005 period ranged from -26.8% at Apple Creek to +21.7% at East River. Relative differences for the TP load over the 2004 to 2005 period ranged from –12.9% at Ashwaubenon Creek to +13.2% at Duck Creek. Therefore, the relative differences between observed and simulated loads during the 2004 to 2005 initial assessment period were better than the 30% maximum criterion stated in the QAPP. In general, the un-adjusted LFR sub-basin model was able to estimate flow, TSS loads and TP loads at the LFRWMP monitored sites with a reasonable degree of accuracy on a monthly and total basis during the 2004 and 2005 USGS water year monitoring period. The model was therefore judged to be valid, and could be applied to reliably predict flow and loads of TSS and phosphorus from the LFR watersheds without further adjustments.

Table 19. Simulated and observed monthly flow, TSS, and TP statistics for WY 2004-2005 Simulated results based on un-adjusted LFR calibration parameters. Relative differences are for the entire period

Stream	Flow			TSS			Phosphorus		
	R^2	NSE	% diff	R^2	NSE	% diff	R^2	NSE	% diff
Apple	0.86	0.86	6.6%	0.88	0.74	-26.8%	0.82	0.82	-5.6%
Ashwaubenon	0.89	0.84	22.2%	0.69	0.67	-12.8%	0.82	0.81	-12.9%
Baird	0.87	0.86	12.3%	0.73	0.69	-12.4%	0.74	0.68	-7.4%
Duck	0.89	0.87	-11.1%	0.76	0.75	1.7%	0.67	0.66	13.2%
East River	0.94	0.94	-5.0%	0.72	0.70	21.7%	0.84	0.83	2.6%

Model Adjustments

Adjustments were made to the model because of the tendency for the model to overstate TSS loads from the East River, and to a lesser degree, TP loads from Duck Creek, particularly during the previous model assessment conducted by Baumgart (Cadmus, 2007). In the 2007 project, the monthly NSE was 0.59 for TSS in the East River watershed for the un-adjusted model, which was just short of the minimum QAPP criterion of 0.60. Importantly, the total simulated TSS loads at the East River site exceeded the observed loads by 45.6%.[19] This discrepancy compares to the 21.7% excess in simulated TSS loads for the current project. The improvement is likely due to: 1) areas identified as barren land use, now being simulated as quarries in the TMDL rather than barren lots; and 2) the addition of other urban land use HRUs instead of just one, so low density rural residential lots now have lower TSS loads than when there was just a single urban HRU.

To reduce TSS and improve model performance the stream power concentration parameter (SPCON) was decreased from 0.0008 (800 mg/L) to 0.0005 (500 mg/L) for the East River watershed, which was also done by Baumgart in the 2007 LFR model. Prior to calibration and the initial assessment phase, SPCON had been set at 0.0003 in the Duck Creek watershed and 0.0008 for all other major watershed modeling units. This change reduced the TSS load, but did not affect phosphorus, because the latter is only affected by the QUAL2E water quality sub-model and not the sediment transport sub-model. Lowering the SPCON effectively decreases the amount of sediment that can be re-entrained for a given flow and transported downstream.

Although the simulated phosphorus loads for the Duck Creek monitoring station were acceptable with the un-adjusted model (+25.5% in 2007, and +13.2% in current project), a slight modification was made to improve the fit of the model. As previously done by Baumgart in the 2007 LFR model, the phosphorus sorption coefficient (PSP) was changed from 0.39 to 0.44, and the phosphorus soil partitioning coefficient (PHOSKD) was changed from 185 to 235 for the Duck Creek watershed dataset. This change effectively decreased the simulated TP load from all of the sub-watersheds in the Duck Creek watershed, while maintaining a similar proportion of dissolved phosphorus. The soils within the Duck Creek watershed generally have lower clay content than those in the rest of the LFR sub-basin, and are more likely to be classified as hydrologic group B soils compared to group C soils that overly most of the rest of the LFR sub-basin. Therefore, it is not unreasonable to assume that some changes might be needed to account for this difference. These values were not changed for the other watersheds.

No effort was made to alter the Apple Creek inputs, because much of the difference between the observed and simulated TSS load was due to a single event in late November of 2004. Removing the daily TSS loads from this event changed the relative difference from -27% to -11%. This event was unusual in a number of ways. The scale of this event may have been influenced by sediment that likely accumulated just upstream of the monitoring site during very large events that occurred in late summer of 2004 (prior to the monitored period). During the 2004 to 2006 monitored record, this stretch of

[19] The precise reason for the discrepancy between observed and simulated 2004 to 2005 TSS loads at the East River site was not entirely clear in the 2007 modeling project. However, it may be due to the difficulty in simulating the load at the mouth of the East River, which is essentially part of the lowest portion of the Fox River, which is greatly affected by water levels and currents from Lower Green Bay, including the seiche induced flow reversals. Major flow reversals are common at the river outlet. The model may not be adequately simulating the effects of riparian wetlands, the Niagara escarpment, or other aspects of this watershed on TSS, particularly during a relatively dry year such as 2005. There may also be difficulties in obtaining representative samples at this station with just the single sampler inlet. There have only been a limited number of simultaneous pump samples and Equal-Width-Increment (EWI) samples collected at this monitoring station during major runoff events, which may not be enough to ensure that the pump samples are truly representative, or can be accurately adjusted with a correction factor.

stream area was observed by the LFRWMP to be prone to ice and log jams, and associated large sediment deposits. Eventually, the next large runoff event would flush much of the debris and sediment out where it was picked up by the sampling equipment.

Model Validation Results After Adjustments to East River and Duck Creek Parameters

In general, the LFR sub-basin model was able to estimate flow, TSS loads and TP loads at the LFRWMP monitored sites with a reasonable degree of accuracy on a monthly and total basis during the 2004 to 2008 monitoring record. The QAPP noted that it may not be possible to obtain percent bias values less than 40% or r-squared and NSE statistics much greater than 0.45 at one or two streams for some parameters, but the model may still be deemed valid as long as such excursions from our targets are limited in scope. The aforementioned slight excursion occurred only for TSS at Duck Creek. This excursion from the QAPP goal of 30% or less was slight, and possible explanations for lower than expected observed TSS and TP concentrations in 2008 at Duck Creek are discussed further in Cibulka (2009). The model is therefore judged to be valid, and can be applied to reliably predict flow and loads of TSS and phosphorus from the LFR watersheds without further adjustments.

The relative differences between simulated and observed event loads improved with the revised model. For the 2004 to 2005 model assessment period, the total relative difference between observed and simulated TSS loads improved from +21.7% to -4.0% at the East River site, while the monthly NSE statistic increased slightly from 0.70 to 0.71. The total relative difference between observed and simulated TSS loads improved from +13.2% to -4.0% at the Duck Creek site, while the monthly NSE statistic remained unchanged.

Final model assessment results for the entire 2004 to 2008 monitoring period are summarized in Table 20 and Table 21. R-squared and NSE monthly flow statistics ranged from 0.80 to 0.91. R-squared and NSE statistics ranged from 0.65 to 0.81 for monthly TSS loads, and from 0.68 to 0.82 for monthly TP loads. All of these statistics are better than the minimum criterion of 0.60, as stated in the QAPP. Relative differences between observed and simulated flows over the 2004 to 2008 period ranged from -7.9% at Duck Creek to +26.7% at Ashwaubenon Creek. Relative differences for the TSS load over the 2004 to 2008 period ranged from -16.2% at Apple Creek to +30.3% at Duck Creek. Relative differences for the TP load over the 2004 to 2008 period ranged from –5.6% at Ashwaubenon Creek to +17.4% at Duck Creek. With the exception of the Duck Creek TSS loads, the relative differences between observed and simulated loads during the 2004 to 2008 final assessment period were better than the 30% maximum criterion stated in the QAPP.

The difference between the observed and simulated TSS loads from Duck Creek was 1.0% over the 2004 to 2005 period, 13.4% over the 2004 to 2006 period, 17.3% over the 2004 to 2007 period, and 30.3% over the 2004 to 2008 period. Therefore, the model seems to be overstating TSS loads from Duck Creek primarily during the more recent years, particularly in 2008. Perhaps not coincidently, Cibulka (2009) found that a regression model that was used to predict TP loads as a function of flow, seasonality and time, had distinctly different coefficients and probabilities when data from 2008 were added. The 2008 spring snowmelt was rather unusual from two perspectives: 1) It was the third highest snow fall on record with associated high snow pack; and 2) Essentially no rain fall occurred during the main snow melt runoff event in the spring. Therefore, there was a large amount of runoff generated from the snow melt, but relatively low sediment because there was no rain drop impact energy adding to upland sediment erosion, or accelerating the runoff to create large rills or gullies. Another possible explanation for the model overstating TSS loads is that BMPs that have been implemented in recent years may be reducing the TSS load, and the model is not fully accounting for this effect. However, the regression model developed by Cibulka (2009) shows such a large drop off in both TP and TSS in 2008 that it seems unlikely that BMPs could have such a sudden impact on the water quality of a stream with a relatively large catchment area of 276 km². The discrepancy between the observed and simulated TSS loads deserves further attention.

The adjusted validated model was then applied to simulate flow, TSS and TP from the entire LFR sub-basin under baseline conditions and alternative scenarios.

Table 20. Simulated and observed monthly flow, TSS, and TP statistics for WY 2004-2008 Simulated results based on adjusted LFR calibration parameters for Duck Creek and East River*. Relative differences are for the entire period

Stream	Flow			TSS			Phosphorus		
	R^2	NSE	% diff	R^2	NSE	% diff	R^2	NSE	% diff
Apple	0.85	0.83	14.1%	0.81	0.72	-16.2%	0.78	0.78	4.2%
Ashwaubenon	0.89	0.83	26.7%	0.66	0.66	2.1%	0.82	0.82	-5.6%
Baird	0.81	0.80	19.0%	0.66	0.66	9.0%	0.71	0.69	8.5%
Duck*	0.89	0.87	-7.9%	0.73	0.72	30.3%	0.69	0.68	17.4%
East River*	0.91	0.91	-6.5%	0.66	0.65	4.8%	0.79	0.78	13.5%

Table 21. Annual observed and simulated stream flow, TSS, and TP yields (2004-2008)

Stream	2004		2005		2006		2007		2008	
	Obs.	SWAT	Obs.	SWAT	Obs.	SWAT	Obs.	SWAT	Obs.	SWAT
	Flow (mm)									
Apple	322	349	144	148	121	173				
Ashwaubenon	276	349	114	127	102	147				
Baird	364	399	114	137	173	220	119	149	259	317
Duck	344	333	140	97	116	119	75	68	241	226
East River	339	335	173	151	209	200	156	133		
	Total Suspended Solids (metric tons/ha)									
Apple	0.93	0.59	0.12	0.18	0.16	0.25				
Ashwaubenon	0.70	0.59	0.20	0.20	0.07	0.20				
Baird	0.73	0.59	0.10	0.13	0.18	0.27	0.12	0.18	0.23	0.31
Duck	0.36	0.36	0.11	0.11	0.03	0.09	0.04	0.06	0.11	0.21
East River	0.49	0.40	0.06	0.14	0.13	0.20	0.14	0.13		
	Total Phosphorus (kg/ha)									
Apple	1.89	1.74	0.59	0.60	0.51	0.77				
Ashwaubenon	2.02	1.79	0.82	0.68	0.53	0.71				
Baird	2.34	2.03	0.53	0.63	0.73	1.01	0.51	0.72	1.16	1.32
Duck	1.29	1.32	0.57	0.47	0.35	0.46	0.19	0.30	0.54	0.90
East River	1.63	1.58	0.46	0.67	0.68	0.89	0.53	0.62		

APPENDIX C. TMDL DEVELOPMENT AND LOAD ALLOCATION METHODOLOGY

Calculating TMDLs for Total Phosphorus

Sixty-nine subwatersheds were delineated for the purpose of tracking and routing loads in the LFR Basin. Using an Excel-based TMDL tracking tool, each of the 69 subwatersheds was identified as either a tributary or a main stem segment; a few segments discharge directly to the bay and were identified as such. Loads entering the basin from Lake Winnebago were also tracked as an input to the LFR Basin.

The goal of the TMDL analysis for TP is to reduce total average annual TP loads, such that both of the following are achieved:

- Summer median TP concentration of 0.075 mg/L (75 μg/L) for tributary streams in the basin.
- Summer median TP concentration of 0.10 mg/L (100 μg/L) for the main stem of the river.

Figure 24 provides a flow chart that illustrates the steps involved in calculating the TMDLs for TP. As a first step, the baseline TP concentration for each subwatershed was calculated using each subwatershed's estimated loading and flow. Next, the estimated baseline TP concentration was compared against the appropriate numeric target (i.e., 0.075 mg/L for tributary segments and 0.10 mg/L for the main stem segments). The numeric targets are defined as summer (May through October) medians. However, estimated baseline TP concentrations for each subwatershed are defined as average annual volume weighted concentration (VWC), which is calculated as follows:

$$average\ annual\ VWC = \frac{average\ annual\ load}{average\ annual\ volume\ of\ water}$$

Due to the difference in timeframes of the estimated baseline concentrations (i.e., annual VWC) and the target concentration (i.e., summer median), the annual VWC was converted into a summer median concentration, which could then be directly compared to the summer median targets. This conversion was accomplished by multiplying each subwatershed's estimated baseline annual VWC by an adjustment factor of 0.56. This adjustment factor was calculated using observed data from the LFRWMP sampling stations for Apple Creek, Ashwaubenon Creek, Baird Creek, Duck River, and East River (see Section 2.3). The adjustment factor was calculated as follows (see Table 22 for the data and calculation results):

1. Adjustment factors were calculated for each of the five monitoring stations by dividing the estimated baseline annual VWC by the observed summer median concentrations for each station (this was done for both monthly and weekly calculations[20]). For example:

   Apple Creek's monthly adjustment factor: 0.22 / 0.37 = 1.73

   Apple Creek's weekly adjustment factor: 0.24 / 0.37 = 1.57

2. An average was calculated for all of the monthly and weekly values:

   (1.73+1.29+2.88+2.18+1.33+1.57+0.99+1.92+2.18+1.66) / 10 = 1.78

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[20] Ideally, there should be little difference between the observed medians, regardless of whether the observed datasets were sub-sampled on a monthly or weekly basis. The LFRWMP was focused primarily on calculating loads as accurately as possible. Therefore, storm events were favored when sampling. It is difficult to remove all sampling bias by simply sub-sampling the dataset on a monthly, biweekly, weekly, or other basis. Since there is no way to determine which sub-sampling period is best to use, averaging the weekly and monthly summer medians is a compromise.

3. The final adjustment factor was then calculated by taking the inverse of this average value:

   1 / 1.78 = 0.56

Table 22. Data used to calculate the TP adjustment factor

	Observed Summer Median (mg/L)		Baseline Annual VWC (mg/L)	Adjustment Factors	
	Monthly	***Weekly***		***Monthly***	***Weekly***
Apple	0.22	0.24	0.37	1.73	1.57
Ashwaubenon	0.33	0.43	0.43	1.29	0.99
Baird	0.14	0.20	0.39	2.88	1.95
Duck	0.16	0.16	0.35	2.18	2.18
East River	0.30	0.24	0.40	1.33	1.66
Adjustment factor for tributary and main stem subwatersheds:				**0.56**	

Each subwatershed's estimated baseline annual VWC was converted to a summer median concentration by multiplying the estimated baseline annual VWC by the 0.56 adjustment factor. This estimated baseline summer median concentration was then compared against the appropriate numeric target (i.e., 0.075 mg/L for tributary segments and 0.10 mg/L for the main stem segments). If a subwatershed's baseline summer median concentration exceeded the target, that subwatershed's average annual load was reduced by the amount necessary to meet the target concentration. Once this was completed for all of the subwatersheds, the allocated loads were then aggregated for each of the sub-basins. As an extra check, the annual VWC associated with the total allocated load for each sub-basin was converted to a summer median concentration and compared against the appropriate target to confirm that the target was being met at the sub-basin scale, as well as the subwatershed scale.

Final allocated loads for each of the tributaries were routed to the outlet of the sub-basin. An additional loss of load at the confluence of the sub-basins with the main stem occurs during this step. In other words, the TMDLs for the tributaries result in a summer median TP concentration of 0.072 mg/L at the point of confluence with the main stem (note that the main stem's target is 0.1 mg/L).

Estimated baseline average annual loads (for the years 1989-2006) entering the LFR Basin at the outlet of Lake Winnebago were derived from a regression equation developed by Dale Robertson of the U.S. Geological Survey (unpublished data produced for the Lower Fox River TMDL project by Dale Robertson of the USGS in 2008; methods provided in Robertson and Saad, 1996 and Robertson, 1996). Figure 25 provides a summary of these average annual loads; the average of all years was used in the TMDL analysis. It should also be noted that the summer median TP concentration of inflow from Lake Winnebago is 0.093 mg/L. The estimated baseline average annual load from Lake Winnebago was also routed to the main stem and Lower Green Bay.

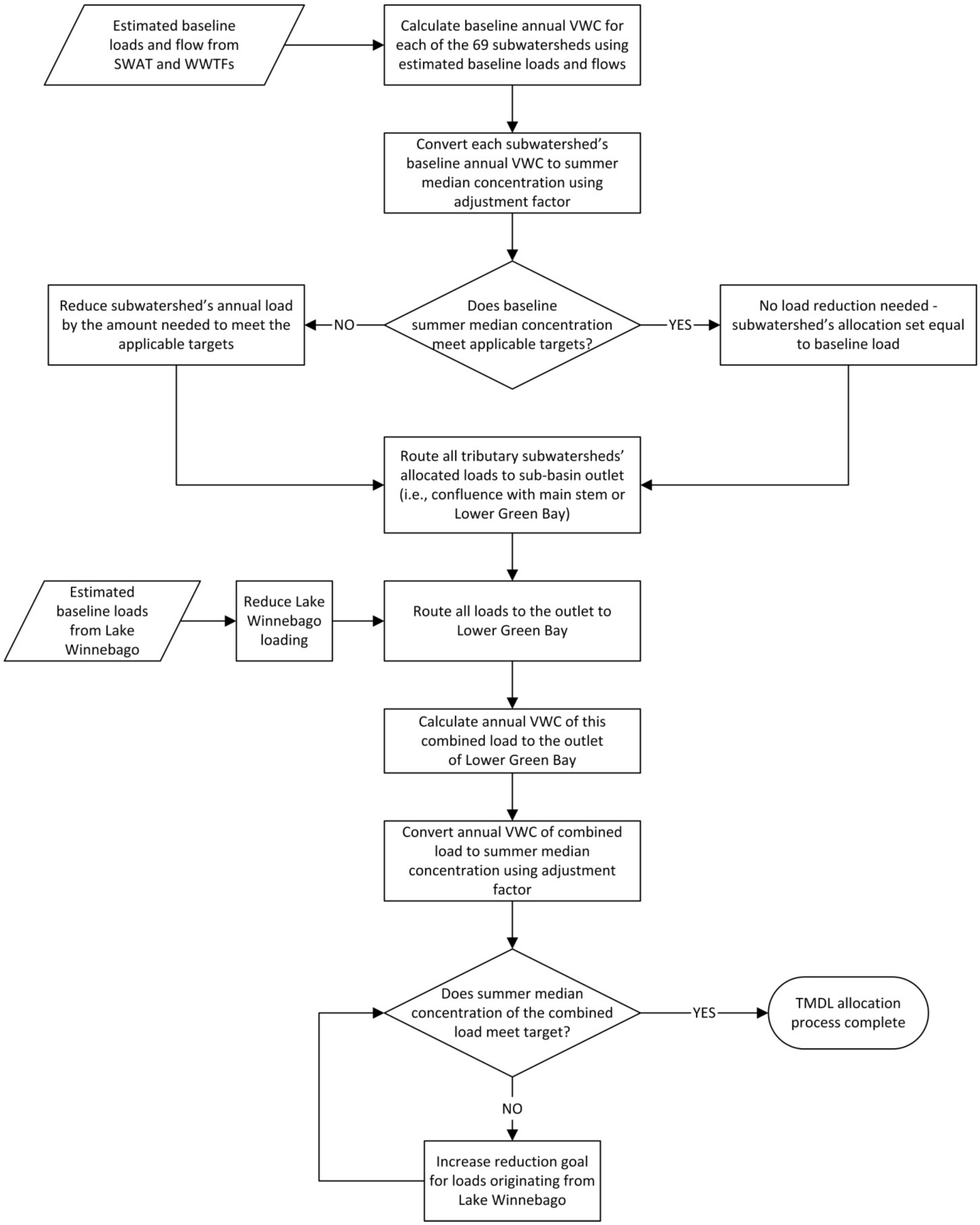

Figure 24. Flow chart illustrating the steps involved in calculating the TMDLs for TP

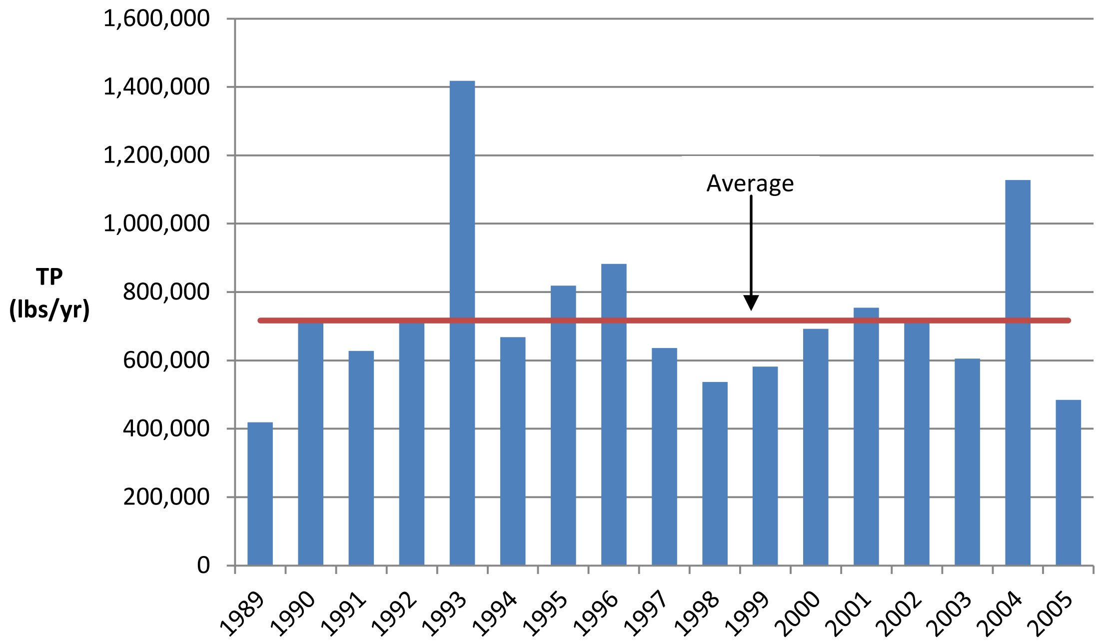

Figure 25. Average annual phosphorus loads entering the Lower Fox River Basin at the outlet of Lake Winnebago.
(unpublished data produced for the Lower Fox River TMDL project by Dale Robertson of the USGS in 2008; methods provided in Robertson and Saad, 1996 and Robertson, 1996)

The estimated baseline average annual load from Lake Winnebago and each tributary sub-basins' allocated load were added to the allocated loads for the main stem subwatersheds, and routed through the main stem and to the bay. The concentration of this "combined" load in the main stem and as routed to the bay was evaluated for compliance against the target for the main stem and outlet to the bay (0.1 mg/L). However, due to the difference in timeframes of this concentration (i.e., annual VWC) and the target concentration (i.e., summer median), the annual VWC for the "combined" load in the main stem and as routed to the bay was converted into a summer median concentration, which could then be directly compared to the summer median target. This conversion was accomplished by multiplying the estimated annual VWC for the main stem and as routed to the bay by an adjustment factor of 1.48. This adjustment factor was calculated by dividing the estimated baseline annual VWC for the outlet of the Lower Fox River (0.122 mg/L) with the observed summer median baseline concentration at GBMSD Fox River monitoring stations 7, 13 and 16 (0.1805 mg/L), and taking the inverse.

Upon evaluating the combined load against the target for the main stem and outlet to the bay, it was determined that the load allocations for the tributaries and main stem alone were not sufficient to meet the 0.1 mg/L target for the main stem and outlet to the bay. The additional needed reductions were taken from loads originating from Lake Winnebago. A 40% reduction goal has been established for phosphorus loads originating from Lake Winnebago. This reduction goal for loads entering the LFR Basin from the outlet of Lake Winnebago represents reasonable expectations for load reductions that may be achievable in the Upper Fox and Wolf Basins. This reduction goal may need to be adjusted if the TMDL analysis for the Upper Fox and Wolf Basins reveals that it is not feasible.

Load Allocation Process for Total Phosphorus

1. Loads from natural/background sources cannot be controlled, therefore, the LA for these sources is set equal to its baseline load for each sub-basin.

2. The LA for non-regulated urban areas is set equal to its baseline loads for each sub-basin.

3. The WLA for general permit holders is set equal to baseline loads. General permit holders are considered in compliance with the WLA if they are in compliance with their permit requirements.

4. The WLA for construction sites is set equal to baseline loads. Construction sites are considered in compliance with the WLA if they are in compliance with their stormwater permit requirements.

5. Loads from municipal and industrial wastewater treatment facilities discharging to tributary streams:
   - If a facility's baseline average annual effluent concentration is less than 1.0 mg/L, the facility's WLA is set equal to its average annual baseline load.
   - If a facility's baseline average annual effluent concentration is greater than 1.0 mg/L, and
     - The facility's baseline average annual load accounts for less than 1% of the total baseline load for the sub-basin, the facility's WLA is set equal to its average annual baseline load.
     - The facility's baseline average annual load accounts for greater than 1% of the total baseline load for the sub-basin, the facility's WLA is set to meet a 1 mg/L average annual effluent concentration.

6. Loads from municipal and industrial wastewater treatment facilities discharging to the main stem:
   - If a facility's baseline average annual effluent concentration is less than 0.2 mg/L, the facility's WLA is set equal to its average annual baseline load.
   - If a facility's baseline average annual effluent concentration is greater than 0.2 mg/L, and
     - The facility's baseline average annual load accounts for less than 1% of the total baseline load for the sub-basin, the facility's WLA is set equal to its average annual baseline load.
     - The facility's baseline average annual load accounts for greater than 1% of the total baseline load for the sub-basin, the facility's WLA is set to meet a 0.2 mg/L average annual effluent concentration.

7. Loads from regulated urban MS4s:
   - If the load from regulated urban MS4s accounts for less than 30% of the total baseline load for the sub-basin, the WLA for MS4s is set equal to 70% of their baseline load. This results in a reduction goal of 30% from the MS4s' baseline load.[21]
   - If the load from regulated urban MS4s accounts for greater than 30% of the total baseline load for the sub-basin, the WLA for MS4s is set equal to the load that results in a percent reduction equal to the MS4s' percent contribution to the controllable baseline load for the sub-basin.

[21] 30% is the average approximate reduction in TP that is expected if MS4s achieve a 40% TSS reduction.

- Agricultural areas are assigned a LA equal to the load that results in achievement of the remaining reductions needed to meet the TMDL after loads have been allocated to all other sources.

Calculating TMDLs for Total Suspended Solids

Sixty-nine subwatersheds were delineated for the purpose of tracking and routing loads in the LFR Basin. Using an Excel-based TMDL tracking tool, each of the 69 subwatersheds was identified as either a tributary or a main stem segment; a few segments discharge directly to the bay and were identified as such. Loads entering the basin from Lake Winnebago were also tracked as an input to the LFR Basin. Internal production represents the growth of biotic solids (e.g., plankton) in the water column of the LFR main stem in response to temperature, light, and nutrients. Internal biotic solids are an important component of the overall solids balance of the Lower Fox River. Therefore, internal biotic solids were also calculated using data from past studies (WDNR, 2001b; LTI, 1999) and tracked as a component of the loads generated within the LFR main stem segment.

The goal of the TMDL analysis for TSS is to reduce total average annual TSS loads by the amount necessary to meet a summer median TSS concentration of 20 mg/L at the outlet to Lower Green Bay, plus a margin of safety of 10%. The 10% margin of safety (to account for uncertainty in meeting the load reduction goal for biotic solids) is implicitly incorporated in the analysis through use of an 18 mg/L summer median TMDL target for the outlet to the bay, which is calculated as follows:

$$20\, mg/L \times 10\% = 2\, mg/L$$

$$20\, mg/L - 2\, mg/L = 18\, mg/L$$

Figure 26 provides a flow chart that illustrates the steps involved in calculating the TMDLs for TSS. Similar to TP (see above), estimated baseline TSS concentrations are average annual VWCs. Due to the difference in timeframes of the estimated baseline concentrations (i.e., annual VWC) and the target concentration (i.e., summer median), the annual VWC was converted into a summer median concentration, which could then be directly compared to the summer median target. This conversion was accomplished by multiplying the estimated baseline annual VWC for the outlet to the bay by an adjustment factor of 1.38. This adjustment factor was calculated by dividing the simulated baseline annual VWC for the outlet of the Lower Fox River (26.24 mg/L) with the observed summer median baseline concentration at GBMSD Fox River monitoring stations 7, 13 and 16 (36.25 mg/L), and taking the inverse.

Estimated baseline average annual loads (for the years 1989-2006) entering the LFR Basin at the outlet of Lake Winnebago were derived from a regression equation developed by Dale Robertson of the U.S. Geological Survey (unpublished data produced for the Lower Fox River TMDL project by Dale Robertson of the USGS in 2008; methods provided in Robertson and Saad, 1996 and Robertson, 1996). Figure 27 provides a summary of these average annual loads; the average of all years was used in the TMDL analysis. The reduction goal for TSS loads leaving Lake Winnebago was set at 48.3%.[22] This is the estimated TSS load reduction expected at the outlet of Lake Winnebago if the TP load reduction goal for the outlet of Lake Winnebago is met. This TSS load reduction goal is calculated based on the linear relationship between annual TP and annual TSS loads from Winnebago, as shown in Figure 28. This reduction goal for loads entering the LFR Basin from the outlet of Lake Winnebago represents

[22] This does not represent the load reduction goal for the Upper Fox-Wolf River Basin. The load reduction goal needed from the upper basin (and into Lake Winnebago) will be determined as part of a separate TMDL analysis.

reasonable expectations for load reductions that may be achievable in the Upper Fox and Wolf Basins. This reduction goal may need to be adjusted if the TMDL analysis for the Upper Fox and Wolf Basins reveals that it is not feasible.

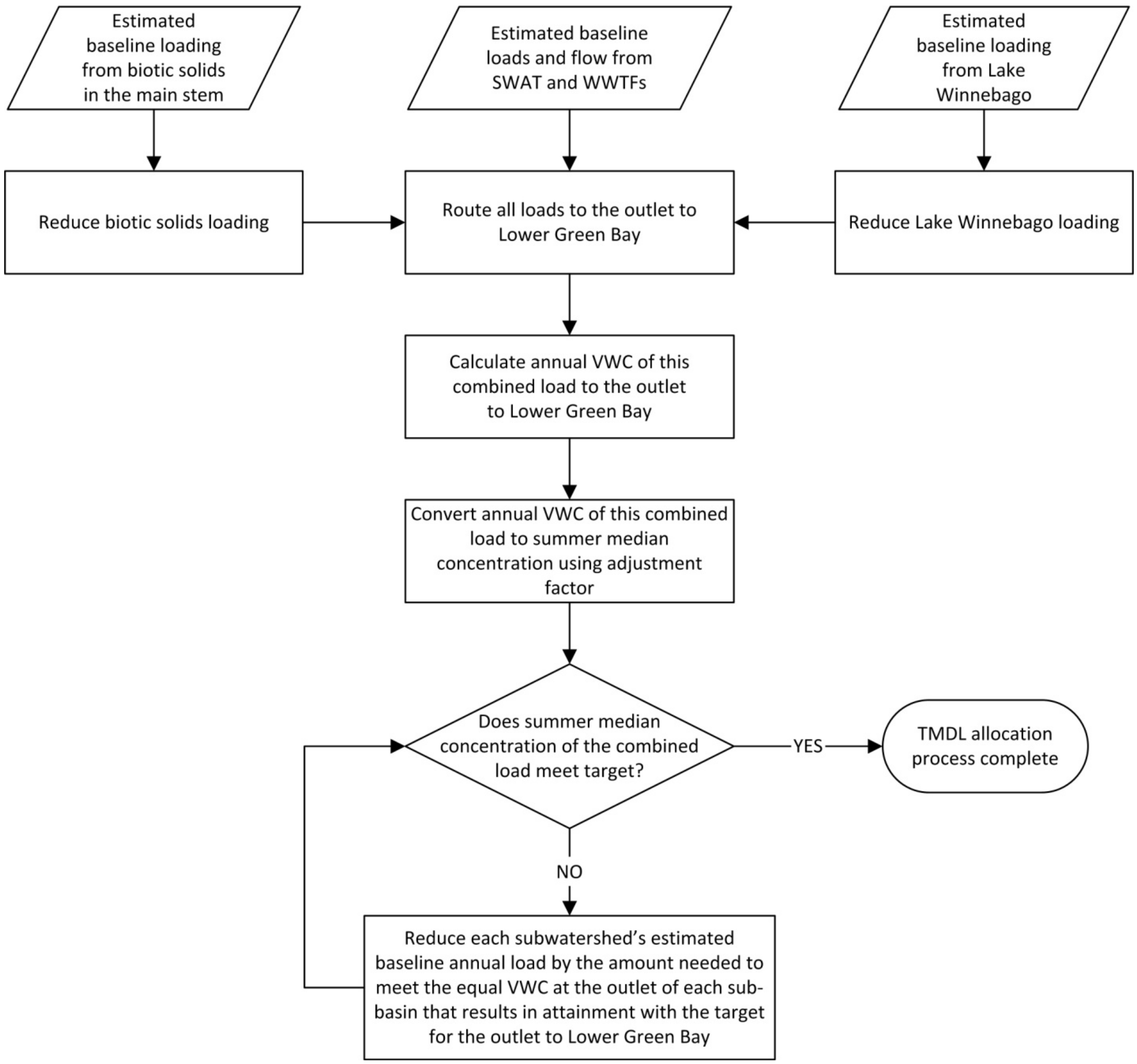

Figure 26. Flow chart illustrating the steps involved in calculating the TMDLs for TSS

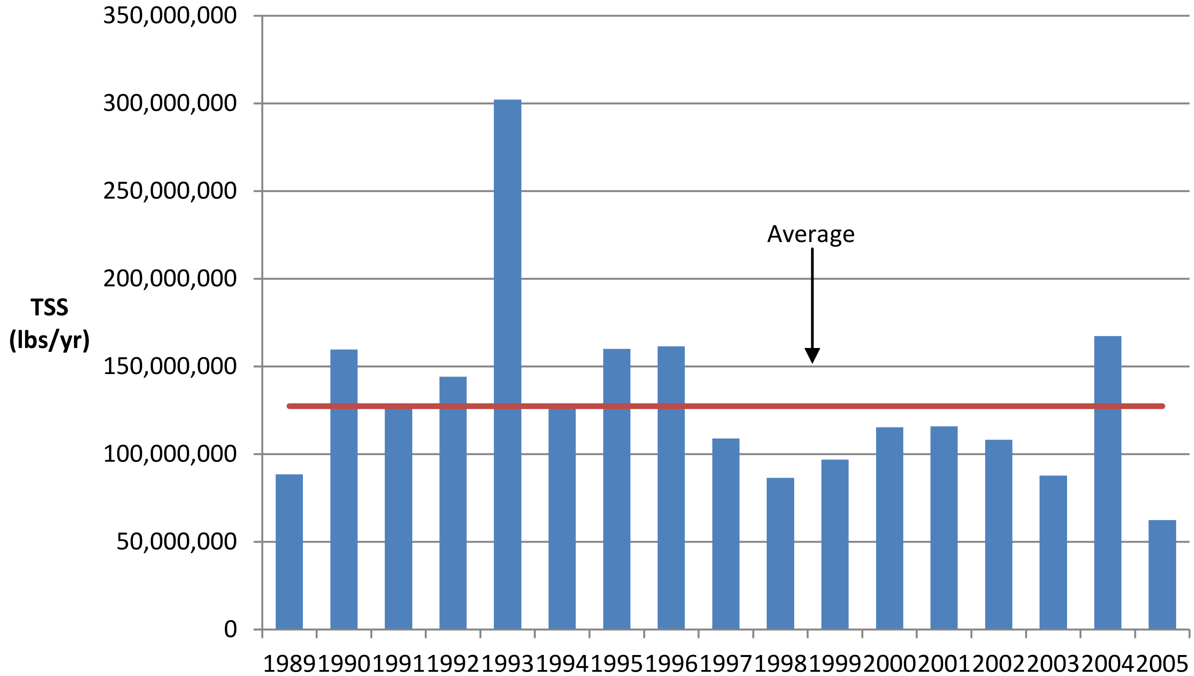

Figure 27. Average annual TSS loads entering the Lower Fox River Basin at the outlet of Lake Winnebago.
(unpublished data produced for the Lower Fox River TMDL project by Dale Robertson of the USGS in 2008; methods provided in Robertson and Saad, 1996and Robertson, 1996)

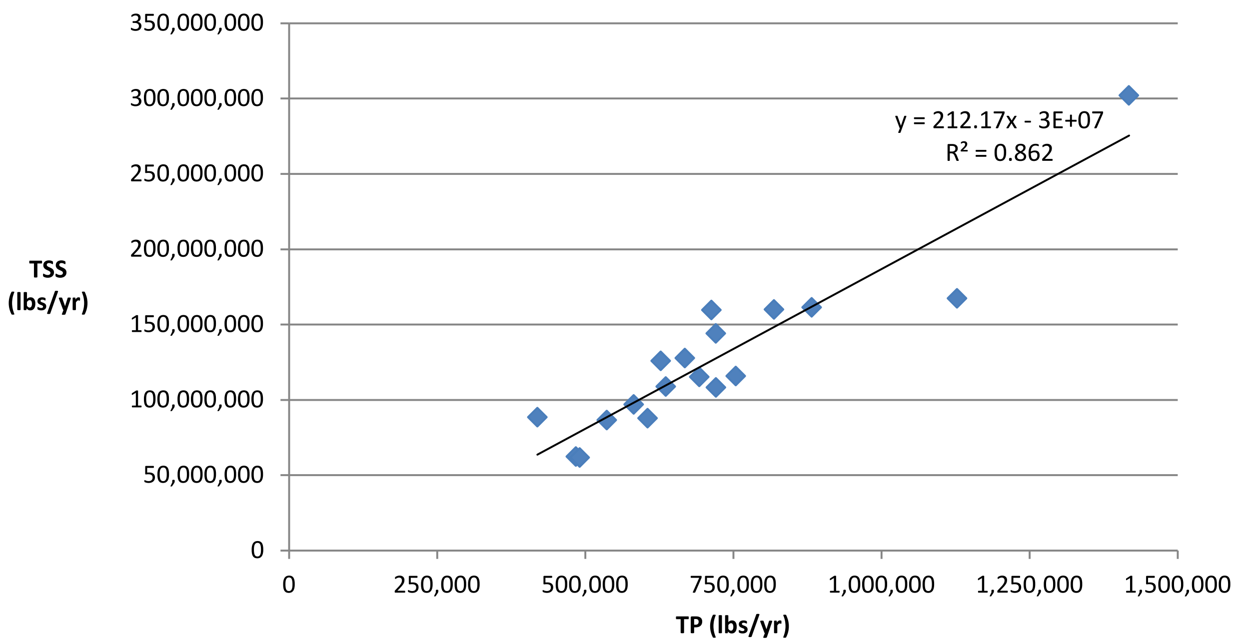

Figure 28. TSS vs. TP Loads from Lake Winnebago

The 56.8% reduction goal for biotic solids represents the estimated load reduction expected as a result of meeting the 0.1 mg/L TP target at the outlet to Green Bay, and was calculated using data summarized in Reynolds (1986) and Nalewajko (1966).

After accounting for the load reduction goal for Lake Winnebago and the estimated biotic solids load reduction expected as a result of meeting the 0.1 mg/L TP target at the outlet to Lower Green Bay, the TMDL for in-basin loads was calculated based on the additional reduction needed to meet the target at the outlet to the bay (i.e., 18 mg/L). This was accomplished by reducing sub-basin loads until the target was met at the outlet to the bay. Two methods were examined for setting the load reduction goals for the sub-basins: 1) Equal percent load reduction; and 2) Equal VWC (the final method used for determining the allocations for TSS).

The equal percent load reduction method assigns all of the sub-basins with the same percent reduction from their baseline load. The percent reduction is set based on the load reduction needed to meet the target at the outlet to the bay. Each sub-basin's percentage of the total reduced load is equal to its percent contribution to the total baseline load. As a result, sub-basins discharging greater loads to the bay will require greater reductions. This approach was not used for the final analysis because it penalizes sub-basins that discharge lower TSS concentrations (e.g., Duck Creek).

The equal VWC method was the final method selected for the TMDL analysis. The equal VWC method assigns each of the sub-basins a load reduction goal based on what is needed to meet an equal VWC at the outlet of each sub-basin. An annual VWC of 65.9 mg/L was used in the analysis; this represents the annual VWC for the outlet of each subwatershed that will result in attainment of the target for the outlet to the bay (i.e., 18 mg/L). The equal VWC method results in a different load reduction goal for each sub-basin; therefore, it does not penalize those sub-basins that are already discharging lower TSS concentrations (e.g., Duck Creek).

Load Allocation Process for Total Suspended Solids

1. Loads from natural/background sources cannot be controlled, therefore, the LA for these sources is set equal to its baseline load for each sub-basin.

2. The LA for non-regulated urban areas is set equal to its baseline load for each sub-basin.

3. The WLA for general permit holders is set equal to baseline loads. General permit holders are considered in compliance with the WLA if they are in compliance with permit requirements.

4. Loads from construction sites are assigned a WLA set equal to 20% of their baseline load. This results in a reduction goal of 80% from their baseline loads, which is consistent with stormwater permit requirements.

5. Municipal and industrial wastewater treatment facilities are assigned WLAs set equal to their average annual baseline load.

6. Loads from regulated urban MS4s:

    - If the load from regulated urban MS4s accounts for less than 40% of the total baseline load for the sub-basin, the WLA for MS4s is set equal to 60% of their baseline load. This results in a reduction goal of 40% from the MS4s' baseline load.[23]

    - If the load from regulated urban MS4s accounts for greater than 40% of the total baseline load for the sub-basin, the WLA for MS4s is set equal to the load that results in a percent reduction equal to the MS4s' percent contribution to the controllable baseline load for the tributary basin.

7. Agricultural areas are assigned a LA equal to the load that results in achievement of the remaining reductions needed to meet the TMDL after loads have been allocated to all other sources.

[23] 40% is the TSS reduction required by NR 151 stormwater regulations.

APPENDIX D. SUMMARY OF MS4 WASTELOAD ALLOCATIONS

Total Phosphorus

MS4	East	Baird	Bower	Apple	Ashwaubenon	Dutchman	Plum	Kankapot	Garners	Mud	Duck	Trout	Neenah	LFR (main stem)	LGB	TOTAL
Allouez	771													405		**1,176**
Appleton				1,132					115	442	1			3,667		**5,358**
State				*1,132*					*115*	*442*	*1*			*3,667*		***5,358***
Oneida Reservation				*0*					*0*	*0*	*0*			*0*		***0***
Ashwaubenon					388	1,829					211			306		**2,734**
State					*388*	*1,479*					*211*			*306*		***2,384***
Oneida Reservation					*0*	*350*					*0*			*0*		***350***
Bellevue	753	3	1,081													**1,837**
Buchanan							21	109	404					34		**569**
CombLocks								4	137					152		**293**
DePere	516				649									1,455		**2,620**
State	*516*				*649*									*1,455*		***2,620***
Oneida Reservation	*0*				*0*									*0*		***0***
GrandChute				400						1,863				760		**3,022**
Green Bay	1,485	1,634	20			367					1,235			3,246	629	**8,616**
State	*1,485*	*1,634*	*20*			*69*					*332*			*3,246*	*629*	***7,414***
Oneida Reservation	*0*	*0*	*0*			*298*					*903*			*0*	*0*	***1,201***
Greenville										176				517		**692**
Harrison									321					7		**328**
Hobart					119	652					921	523				**2,216**
State					*0*	*0*					*0*	*0*				***0***
Oneida Reservation					*119*	*652*					*921*	*523*				***2,216***
Howard											1,963	8		2	29	**2,001**
State											*1,953*	*8*		*2*	*29*	***1,991***
Oneida Reservation											*10*	*0*		*0*	*0*	***10***
Kaukauna				394			32	918	46					517		**1,908**
Kimberly									21					581		**602**
Lawrence				41	748	135								380		**1,303**
State				*41*	*748*	*135*								*380*		***1,303***
Oneida Reservation				*0*	*0*	*0*								*0*		***0***
Ledgeview	533		594											106		**1,232**
LittleChute				513										682		**1,194**
Menasha														1,147		**1,147**
Neenah													1,485	176		**1,661**
Scott															295	**295**
Suamico											356				641	**996**
State											*356*				*641*	***996***
Oneida Reservation											*0*				*0*	***0***
T_Menasha										32				2,214		**2,246**
T_Neenah													392	136		**528**
UWGB															195	**195**
TOTAL	**4,058**	**1,637**	**1,695**	**2,479**	**1,903**	**2,983**	**53**	**1,031**	**1,045**	**2,513**	**4,687**	**531**	**1,877**	**16,490**	**1,788**	**44,770**

Total Suspended Solids

MS4	East	Baird	Bower	Apple	Ashwaubenon	Dutchman	Plum	Kankapot	Garners	Mud	Duck	Trout	Neenah	LFR (main stem)	LGB	TOTAL
Allouez	266,978													99,405		**366,383**
Appleton				381,481					73,698	268,047	274			1,054,593		**1,778,092**
State				*381,481*					*73,698*	*268,047*	*274*			*1,054,593*		***1,778,092***
Oneida Reservation				*0*					*0*	*0*	*0*			*0*		***0***
Ashwaubenon					149,501	713,144					74,182			104,132		**1,040,960**
State					*149,501*	*576,630*					*74,182*			*104,132*		***904,446***
Oneida Reservation					*0*	*136,514*					*0*			*0*		***136,514***
Bellevue	307,059	1,579	321,956													**630,594**
Buchanan							5,525	40,876	242,762					9,953		**299,116**
CombLocks								1,412	83,756					43,094		**128,262**
DePere	164,228				197,827									383,797		**745,853**
State	*164,228*				*197,827*									*383,797*		***745,853***
Oneida Reservation	*0*				*0*									*0*		***0***
GrandChute				120,013						1,011,480				182,637		**1,314,130**
Green Bay	671,482	631,411	5,829			120,154					422,330			1,073,228	198,351	**3,122,785**
State	*671,482*	*631,411*	*5,829*			*22,369*					*113,402*			*1,073,228*	*198,351*	***2,716,073***
Oneida Reservation	*0*	*0*	*0*			*97,785*					*308,928*			*0*	*0*	***406,713***
Greenville										91,315				130,029		**221,344**
Harrison									186,222					2,466		**188,688**
Hobart					22,955	209,829					218,360	87,586				**538,730**
State					*0*	*0*					*0*	*0*				***0***
Oneida Reservation					*22,955*	*209,829*					*218,360*	*87,586*				***538,730***
Howard											702,063	1,472		773	10,082	**714,390**
State											*698,560*	*1,472*		*773*	*10,082*	***710,887***
Oneida Reservation											*3,503*	*0*		*0*	*0*	***3,503***
Kaukauna				142,665			9,072	399,600	27,167					142,959		**721,463**
Kimberly									12,701					186,376		**199,077**
Lawrence				12,785	189,134	43,322								69,211		**314,452**
State				*12,785*	*189,134*	*43,322*								*69,211*		***314,452***
Oneida Reservation				*0*	*0*	*0*								*0*		***0***
Ledgeview	163,523		169,251											23,308		**356,082**
LittleChute				190,022										187,574		**377,596**
Menasha														368,996		**368,996**
Neenah													782,075	55,543		**837,618**
Scott															85,724	**85,724**
Suamico											107,140				190,877	**298,017**
State											*107,140*				*190,877*	***298,017***
Oneida Reservation											*0*				*0*	***0***
T_Menasha										18,277				606,709		**624,986**
T_Neenah													163,490	40,404		**203,894**
UWGB															75,193	**75,193**
TOTAL	**1,573,271**	**632,990**	**497,036**	**846,966**	**559,418**	**1,086,449**	**14,597**	**441,888**	**626,306**	**1,389,118**	**1,524,349**	**89,058**	**945,565**	**4,765,187**	**560,227**	**15,552,425**

APPENDIX E. MAPS OF TP AND TSS YIELD FOR THE FOX-WOLF BASINS

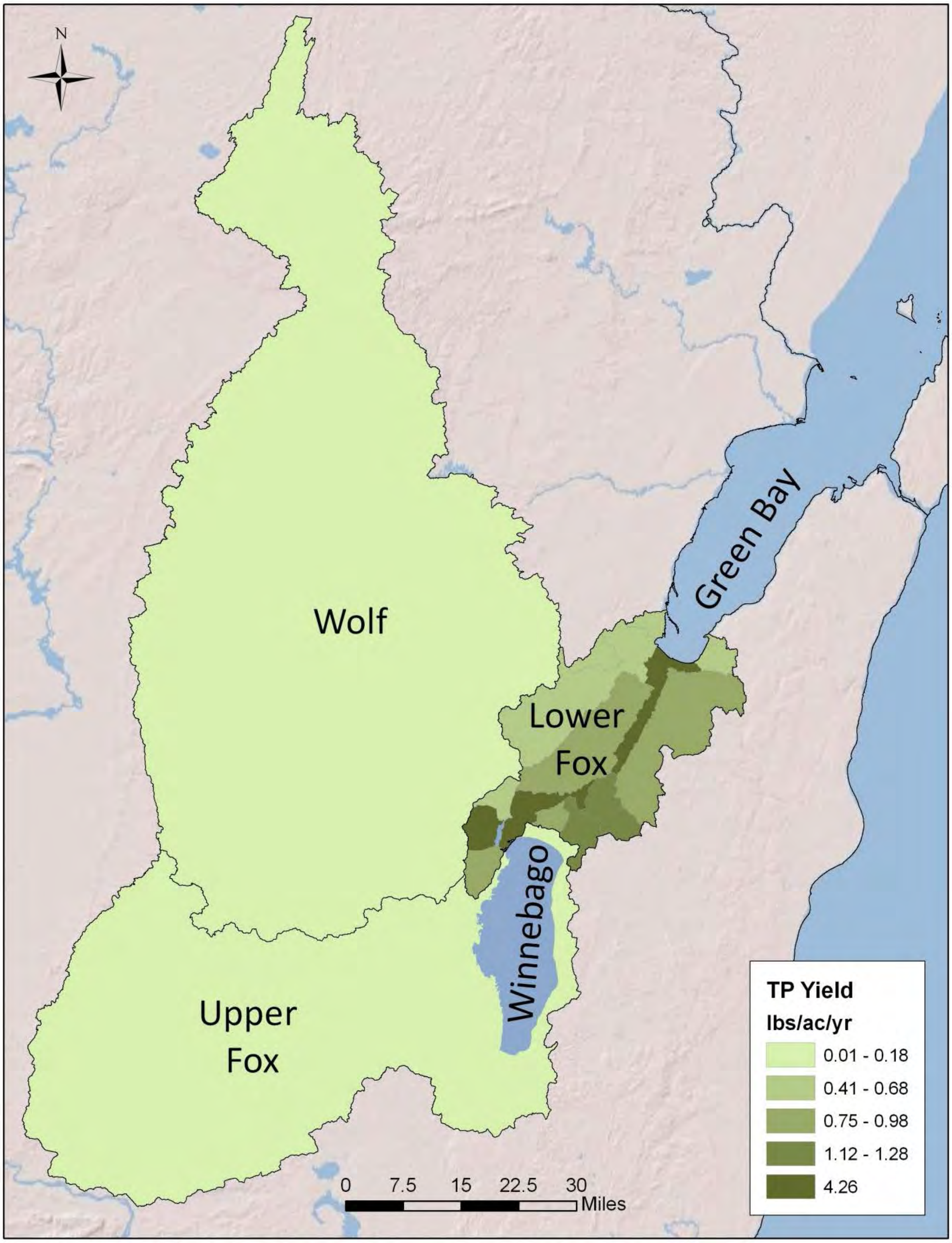

Figure 29. Summary of TP yields of total loads as routed to Lower Green Bay from the Fox-Wolf Basin

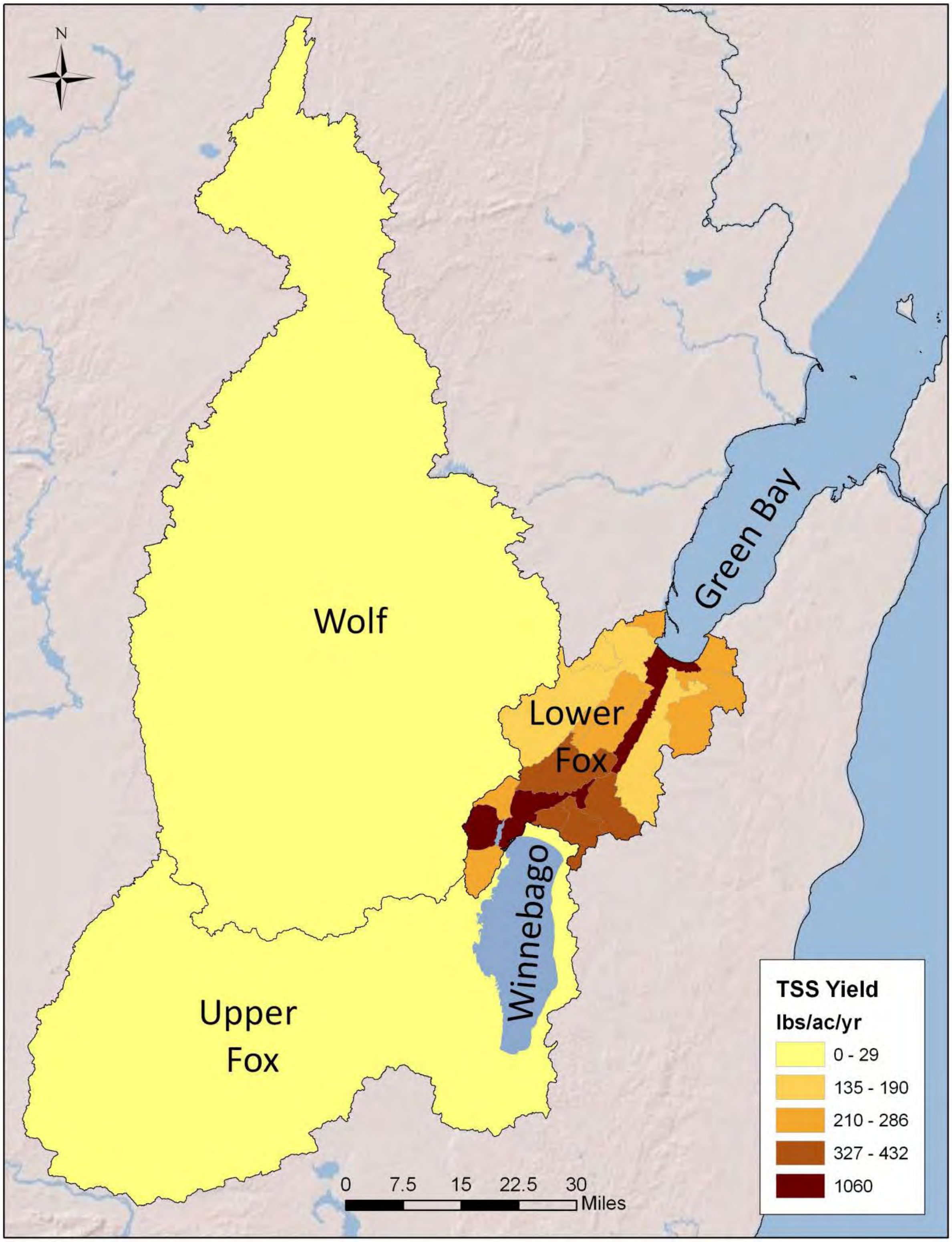

Figure 30. Summary of TSS yields of total loads (including biotic solids) as routed to Lower Green Bay from the Fox-Wolf Basin

APPENDIX F. POTENTIALLY RESTORABLE WETLANDS ANALYSIS

Wetlands provide a number of ecosystem services including water quality improvement, wildlife habitat, and flood control. As water flows over and through the landscape, it carries soluble and particulate materials with it. When this water enters a wetland, the reduction in velocity allows sediment and other pollutants to "settle out." Wetland vegetation can also remove a significant amount of pollutants from the water column, especially nutrients such as phosphorus. As a result of their water quality improvement functions, wetlands are now seen as an important component of healthy watersheds. They were not always viewed in this way, however. Between 1780 and 1980, an estimated 53% of the wetlands in the conterminous United States were lost (Mitsch & Gosselink, 2007). Much of this loss was the result of extensive agricultural development. Agricultural development is frequently associated with nonpoint source (NPS) pollution, specifically nitrogen, phosphorus, and sediment. Thus restoration of previously lost wetlands can be an attractive option for improving water quality in many NPS-impaired watersheds. The Wetlands Reserve Program (WRP) and Conservation Reserve Program (CRP) are two federal initiatives that provide landowner incentives for wetland restoration on agricultural lands.

The Lower Fox River (LFR) Basin typifies the kind of wetland loss that has occurred throughout the nation. The original extent of wetlands in the LFR Basin was an estimated 50,900 acres (13% of the Basin). Due to extensive agricultural and urban development, an estimated 42% (21,244 acres) of these wetlands have been lost (Table 23). With 549,695 lbs/yr of phosphorus and 141,589,688 lbs/yr of sediment being discharged from the Basin, restoration of these wetlands is an attractive option for improving water quality, while also restoring the landscape to a condition more reminiscent of its natural state. To facilitate watershed-scale planning of wetland restoration for the purposes of implementing the LFR TMDL, a potentially restorable wetlands (PRW) analysis was conducted for the LFR Basin. The methodology developed and applied by the Wisconsin Department of Natural Resources (WDNR) in the Milwaukee, Mead Lake, and Rock River Basins served as the foundation for this analysis (Kline, Bernthal, & Burzynski, 2006; Voss, 2007; Hatch & Bernthal, 2008).

A PRW can be defined as a lost wetland (based on the presence of hydric soils where wetlands no longer exist) that has a current land use compatible with restoration (i.e., non-urban land uses). This definition is predicated on the assumption that hydric soils indicate a site that is or was once under saturated conditions (a wetland or water body) and that wetland restoration is not feasible in urban areas. The analysis is conducted using standard GIS techniques to overlay available spatial data layers including land use, the Wisconsin Wetlands Inventory (WWI), and hydric soils (Figure 31). The land use layer was the same as that used in the development of the TMDL. Any wetland restorations that have already been documented through the WRP or the Wisconsin Wetlands Restoration Tracking Database (WRTD) were removed from the PRW analysis. Additionally, lost wetland sites under 0.5 acres were considered economically infeasible for restoration and thus not considered PRWs.

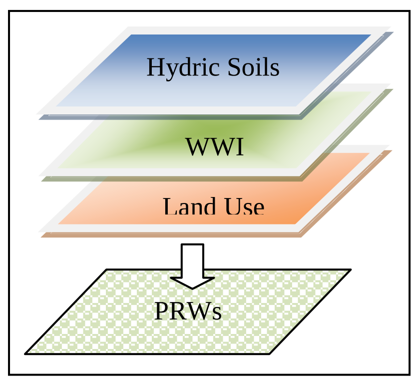

Figure 31. Illustration of GIS overlay analysis

The analysis identified 14,365 acres of PRWs in the LFR Basin (68% of the lost wetlands). Figure 32 displays all of the PRWs in the LFR Basin. While individual PRW sites cannot be easily discerned in a map of this scale, the figure gives an overall impression of the distribution of PRWs throughout the Basin. Table 23 details the acreage of original, lost, remaining, and potentially restorable wetlands for each sub-basin.

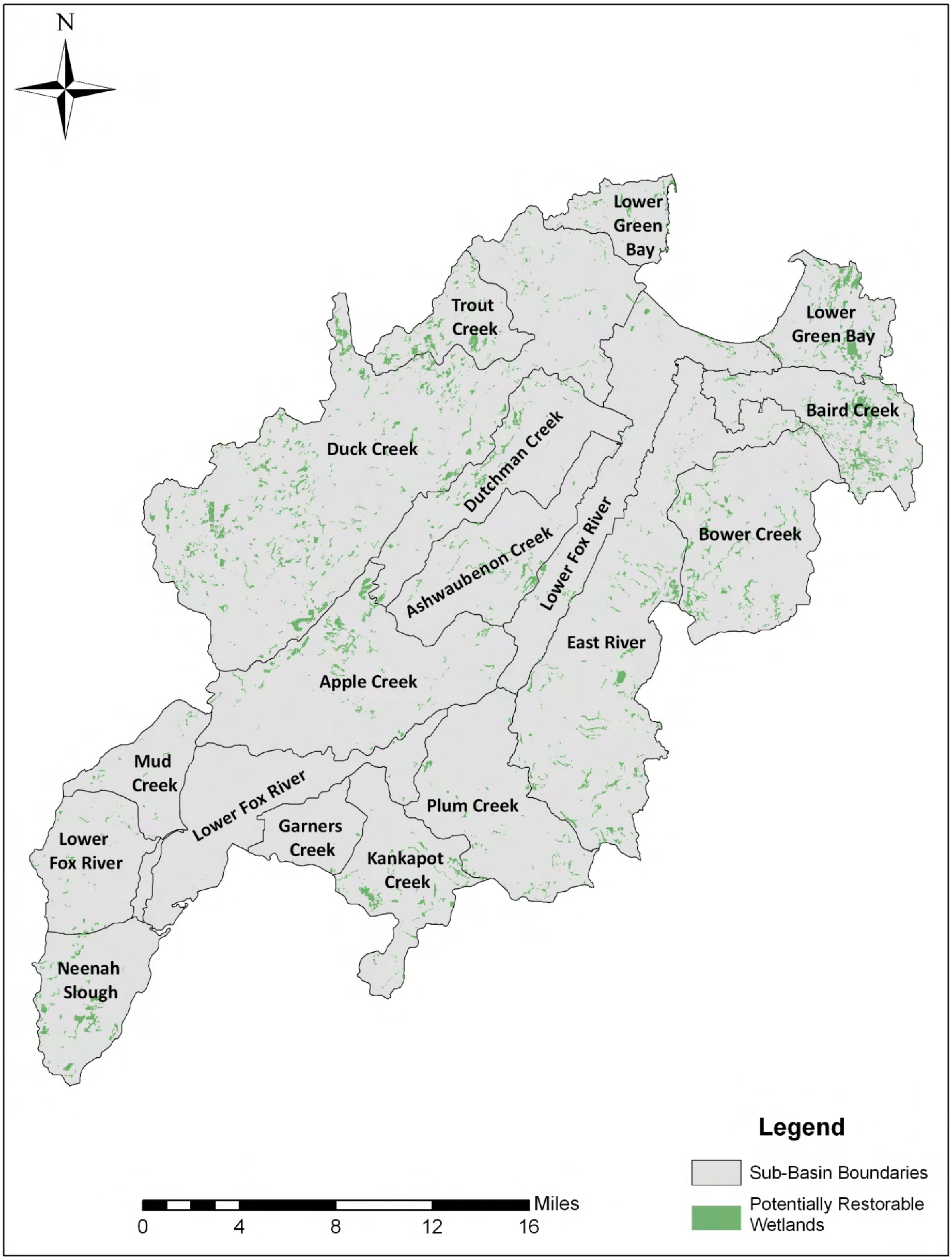

Figure 32. Distribution of potentially restorable wetlands in the Lower Fox River Basin

Table 23. Summary of original, lost, remaining, and potentially restorable wetlands (acres) for each sub-basin in the Lower Fox River Basin

Sub-Basins	Original	Lost	Remaining	PRWs
East River	4,479	2,052	2,427	1,558
Baird Creek	3,584	1,831	1,753	1,498
Bower Creek	2,221	1,541	680	1,193
Apple Creek	2,270	1,458	811	1,002
Ashwaubenon Creek	1,075	625	450	439
Dutchman Creek	2,168	949	1,219	561
Plum Creek	667	389	277	352
Kankapot Creek	1,993	704	1,289	619
Garners Creek	254	91	163	34
Mud Creek	753	394	359	103
Duck Creek	16,403	5,166	11,238	3,715
Trout Creek	2,753	838	1,915	662
Neenah Slough	1,734	998	735	696
Lower Fox (main stem)	3,974	2,163	1,811	494
Lower Green Bay	6,572	2,045	4,527	1,438
Total	**50,900**	**21,244**	**29,654**	**14,364**
Percent	**13% of Basin**	**42% of Original**	**58% of Original**	**68% of Lost**

An assessment of the relative water quality benefits that could be expected through restoration of PRWs in the LFR Basin was performed to help target wetland restoration efforts in those subwatersheds where they would have the greatest effect on phosphorus and sediment reductions. This assessment utilized regression equations from the P8 model, which were developed for use in the Milwaukee River Basin (Kline, Bernthal, & Burzynski, 2006). These equations estimate sediment and particulate phosphorus reductions in wetlands via settling based on the ratio of subwatershed area to PRW area and the average curve number for the subwatershed. In the P8 model, the ratio of subwatershed area to PRW area is used along with an assumed mean wetland depth of 1.5 meters and daily water balance calculations to estimate the hydraulic residence time for different Natural Resource Conservation Service (NRCS) curve numbers. The hydraulic residence time is strongly associated with the amount of pollutant removal in wetlands. The longer the residence time of the water in a wetland, the more sediment and particulate phosphorus that will be expected to settle out. Due to the complexity of simulating nutrient uptake of wetland vegetation and the fact that different PRWs likely have different types of wetland vegetation present, reductions in soluble phosphorus were not simulated (about 39% of the phosphorus yield in the LFR Basin is in soluble form). Thus the P8 model was used to estimate only the removal of sediment and particulate phosphorus. The ratio of subwatershed to PRW area was the independent variable in the regression equations that were developed for each curve number. These regression equations were applied to the PRWs and subwatersheds in the LFR Basin. In addition to the reduction in pollutant loads through wetland retention, restoration of a PRW in agricultural areas will also remove a *source* of pollutants. Therefore, a direct conversion reduction of sediment and particulate phosphorus was also calculated for agricultural PRWs. Sub-basins with relatively large reductions from direct conversion and high particulate phosphorus to sediment ratios will result in somewhat larger reductions of particulate phosphorus than sediment (on a percentage basis). The relative yield reductions expected from full restoration of all PRWs are documented for each sub-basin in Table 24. These results are graphically depicted for each sub-basin (Figure 33 and Figure 34) and each subwatershed (Figure 35 and Figure 36).

Table 24. Summary of relative yield reductions for particulate phosphorus (sed-P) and sediment (as TSS) for each sub-basin in the Lower Fox River Basin

Sub-Basins	Baseline Sed-P Yield (lbs/ac/yr)	Relative Sed-P Yield Reduction (lbs/ac/yr)	Sed-P Reduction (%)	Baseline TSS Yield (lbs/ac/yr)	Relative TSS Yield Reduction (lbs/ac/yr)	TSS Reduction (%)
East River	0.66	0.28	42%	405.1	168.1	42%
Baird Creek	0.45	0.28	62%	231.6	131.7	57%
Bower Creek	0.68	0.34	51%	383.0	194.0	51%
Apple Creek	0.63	0.23	37%	372.1	133.4	36%
Ashwaubenon Creek	0.49	0.17	35%	262.9	87.7	33%
Dutchman Creek	0.45	0.18	41%	262.4	107.8	41%
Plum Creek	0.90	0.24	27%	526.6	138.0	26%
Kankapot Creek	0.79	0.38	49%	442.0	212.8	48%
Garners Creek	0.58	0.05	9%	406.9	37.7	9%
Mud Creek	0.38	0.08	20%	305.1	62.2	20%
Duck Creek	0.43	0.21	49%	290.9	141.7	49%
Trout Creek	0.23	0.15	64%	150.8	97.0	64%
Neenah Slough	0.47	0.24	51%	335.1	147.7	44%
Lower Fox (main stem)	0.43	0.08	18%	379.9	64.4	17%
Lower Green Bay	0.41	0.24	59%	231.2	127.8	55%

Due to inherent uncertainties and assumptions in the modeling approach, the yield reduction estimates in Table 24 should only be considered relative to one another for the purpose of prioritizing wetland restoration in certain sub-basins. For example, the Kankapot Creek sub-basin has the highest predicted yield reductions for both particulate phosphorus and sediment. This means that restoration of wetlands in the Kankapot Creek sub-basin will likely have the greatest effect on reducing both particulate phosphorus and sediment loads. However, restoration of any particular individual PRW within this sub-basin will not necessarily reduce particulate phosphorus or sediment by the exact amounts listed in the table. These values represent expected average results only.

According to the analysis, assuming 100% restoration of all PRWs in the LFR Basin, an estimated 87,015 lbs/yr of particulate phosphorus and 52,634,010 lbs/yr of sediment could be reduced through wetland retention. This analysis, however, does not estimate reductions in soluble phosphorus, which makes up 39% of the total phosphorus yield in the LFR Basin. Therefore, reductions in total phosphorus would actually be higher than that predicted for particulate phosphorus. Again, these estimates should only be considered in relative terms for planning purposes. The actual load reductions that would occur through wetland restoration depend on a variety of physical, chemical, biological, and cultural factors that would be unique to each PRW restoration site.

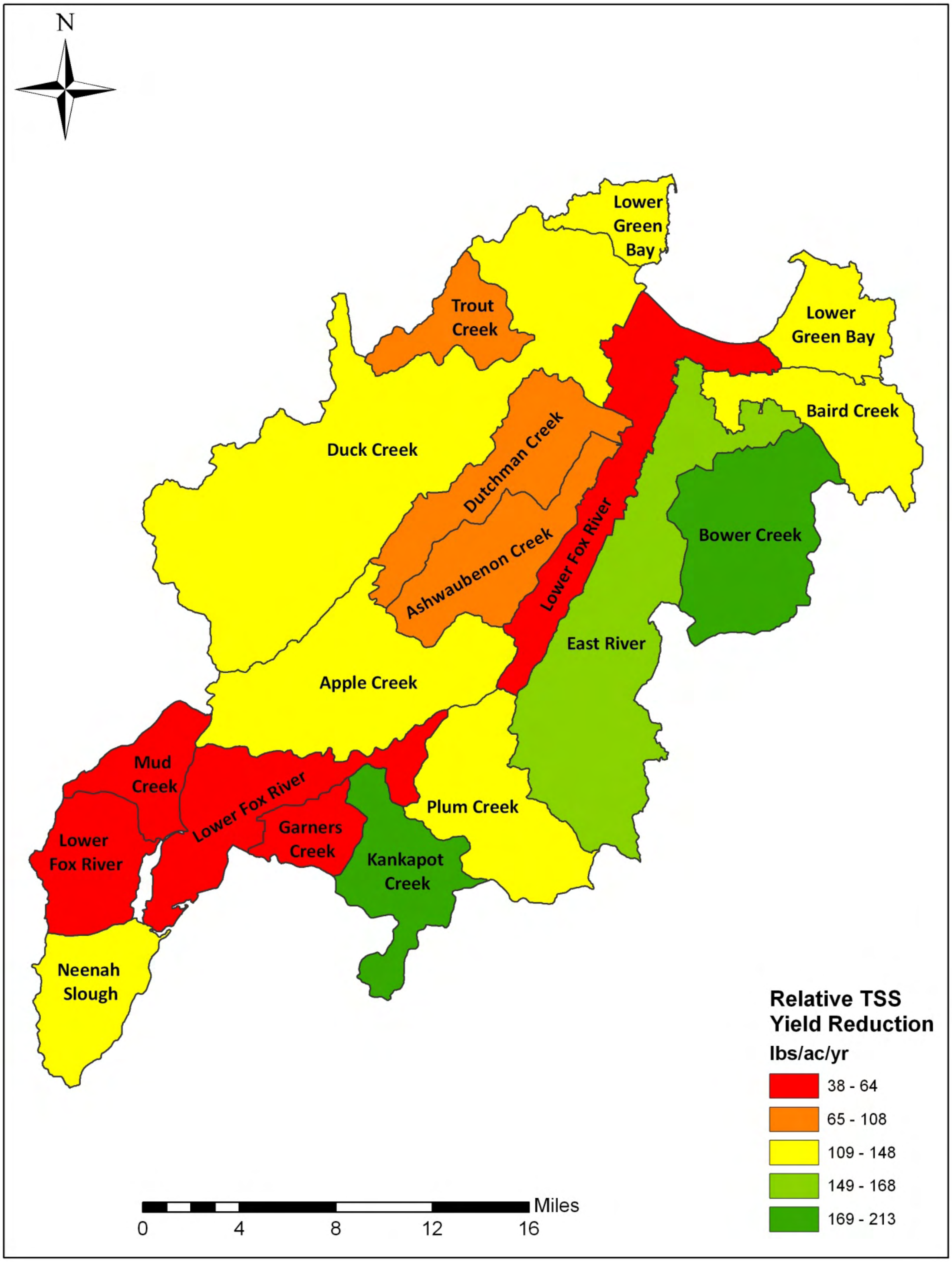

Figure 33. Summary of relative predicted TSS yield reduction for each sub-basin in the Lower Fox River Basin from the PRW analysis

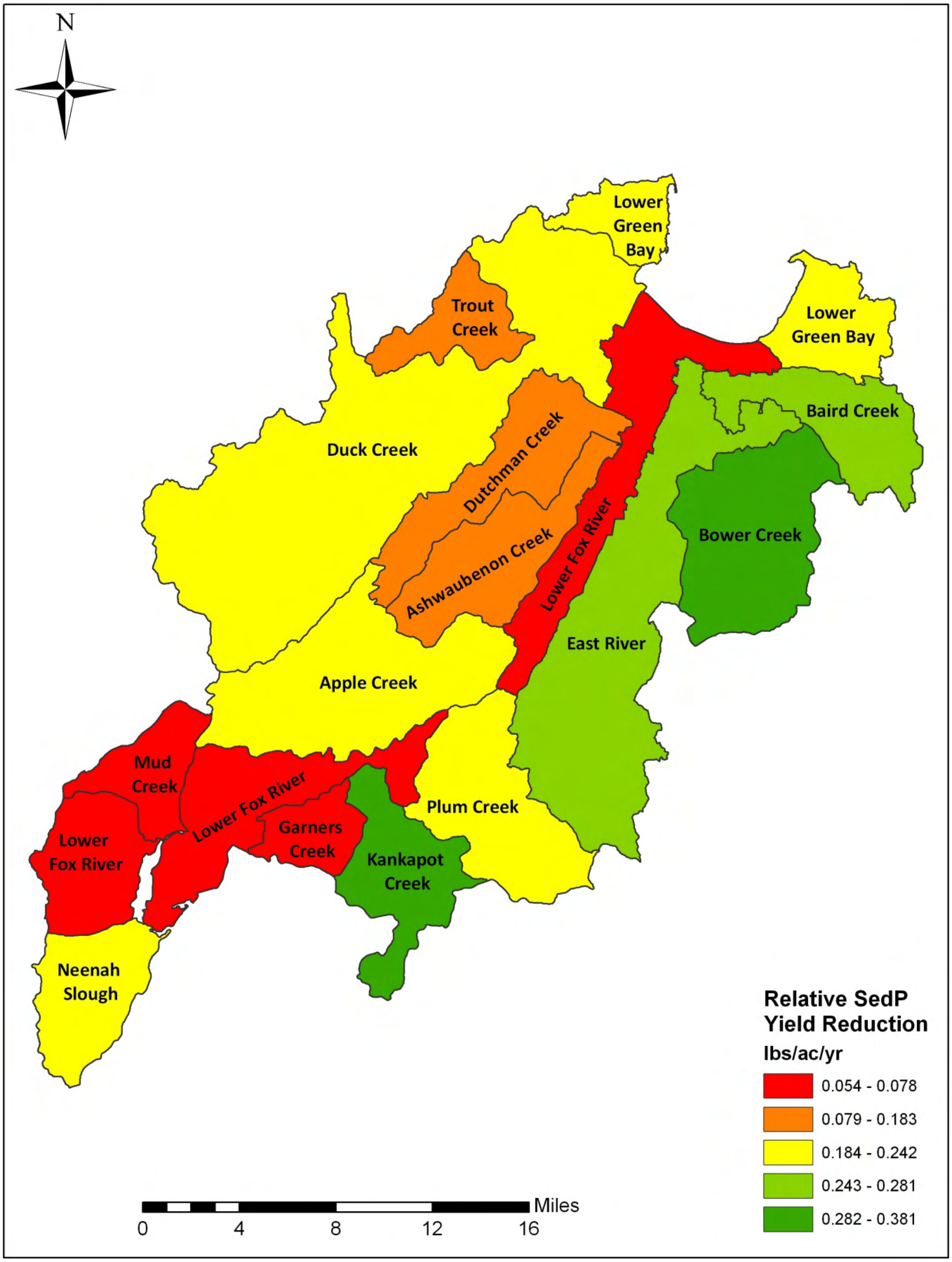

Figure 34. Summary of relative predicted particulate phosphorus (sed-P) yield reduction for each sub-basin in the Lower Fox River Basin from the PRW Analysis

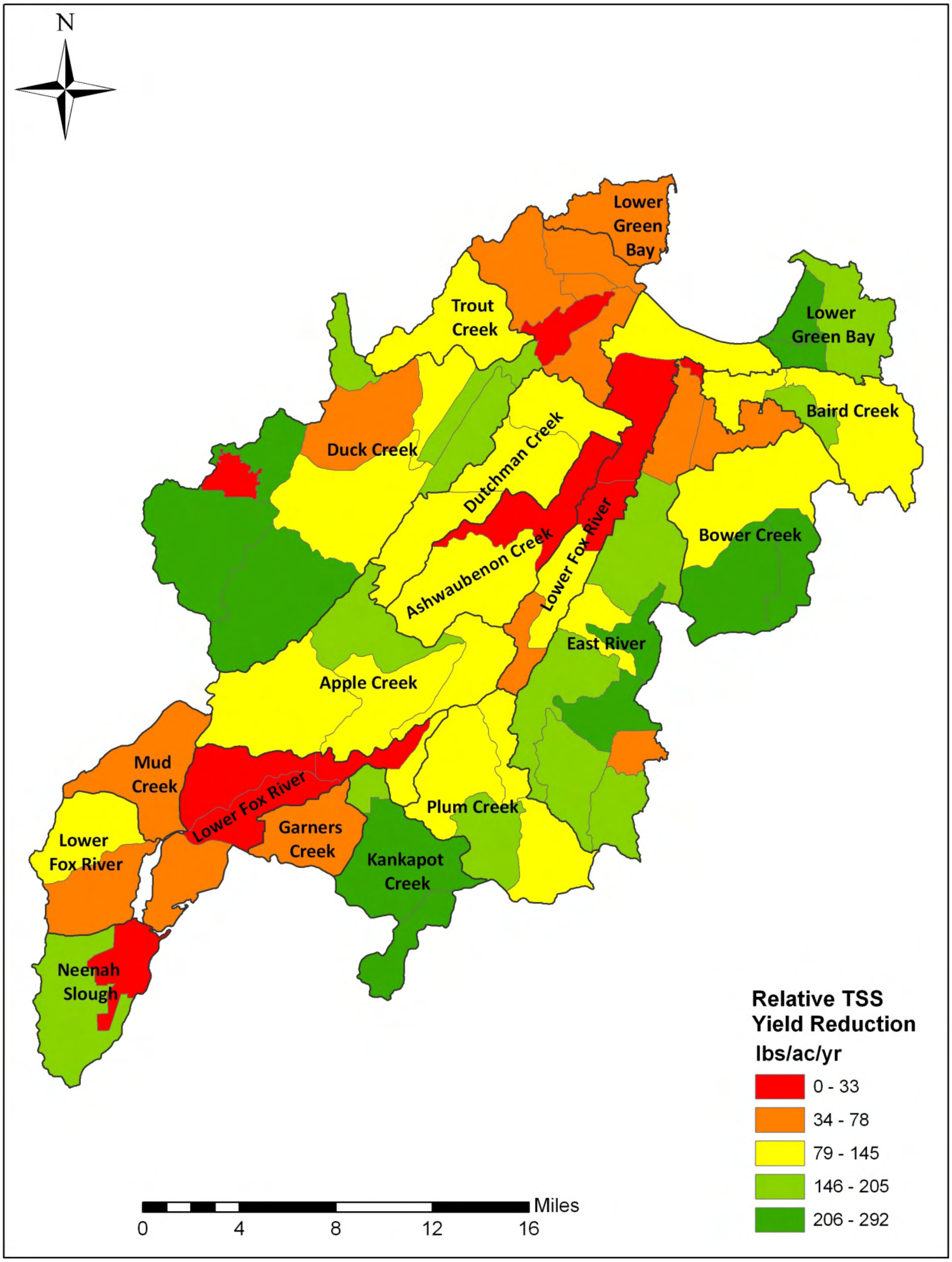

Figure 35. Summary of relative predicted TSS yield reduction for each subwatershed the Lower Fox River Basin from the PRW analysis

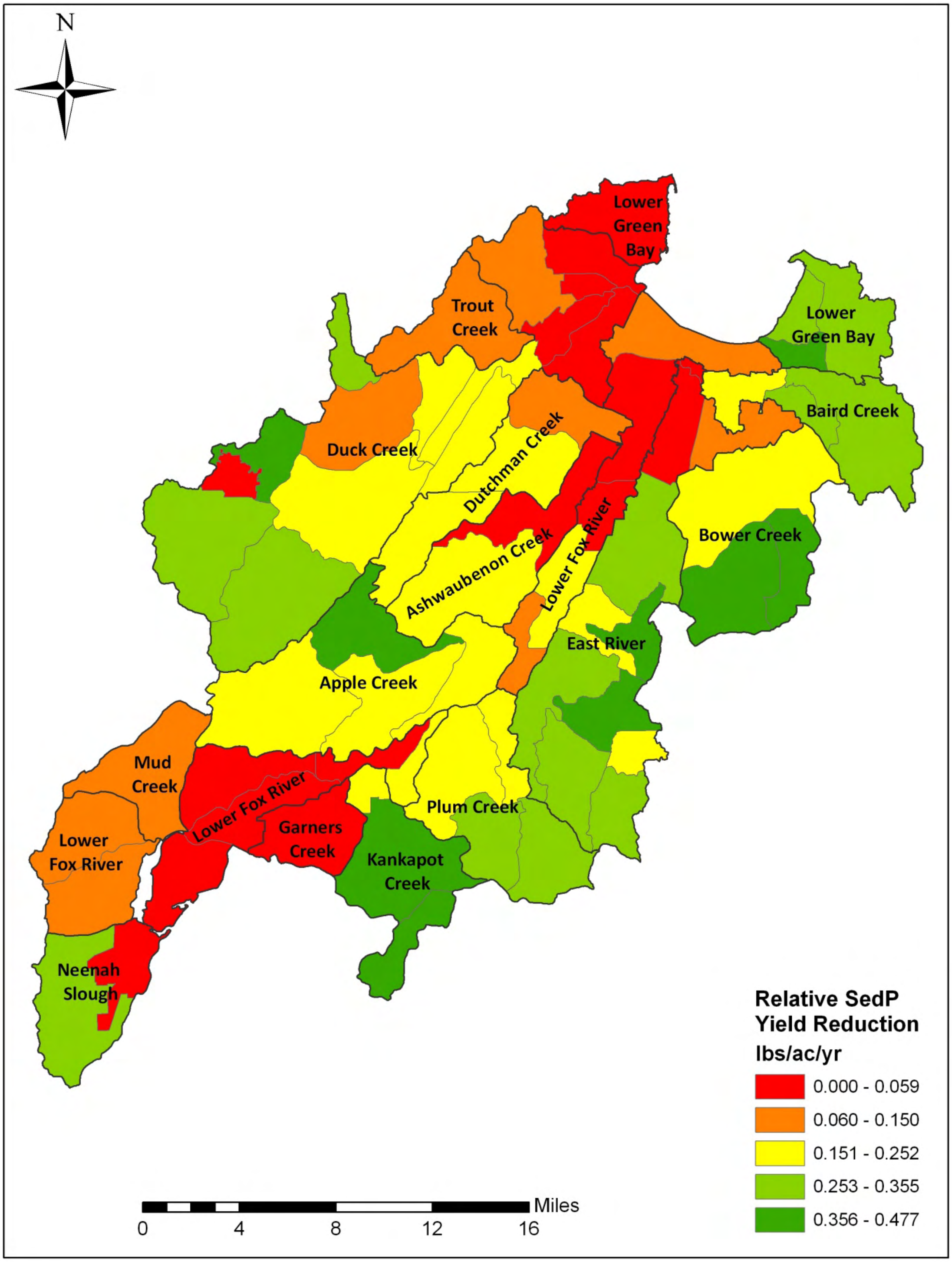

Figure 36. Summary of relative predicted particulate phosphorus (sed-P) yield reduction for each subwatershed in the Lower Fox River Basin from the PRW analysis

APPENDIX G. STAKEHOLDER ENGAGEMENT AND OUTREACH ACTIVITIES

<u>Meetings</u>

Outreach Team (23 meetings over 45 months, September 2006 through May 2010)

- 9-15-06
- 11-8-06
- 12-19-06
- 5-7-07
- 6-28-07
- 10-19-07
- 12-1-07
- 12-19-07
- 1-23-08
- 2-14-08
- 3-31-08
- 8-6-08
- 10-30-08
- 12-5-08
- 1-15-09
- 2-16-09
- 4-7-09
- 10-8-09
- 11-4-09
- 12-8-09
- 12-18-09
- 3-16-10
- 5-5-10

Communications Strategy Subcommittee of the Outreach Team (4 meetings, September 2008 through January 2009)

- 9-22-08
- 10-14-08
- 11-4-08
- 1-8-09

Technical Team (7 meetings, October 2008 through May 2010)

- 10-02-08
- 10-24-08
- 11-12-08
- 01-14-09
- 06-03-09
- 12-02-09
- 05-05-10

Ad Hoc Science Team (10 meetings, March 2007 through January 2009)

- 03-19-07
- 06-19-07
- 07-27-07
- 09-10-07
- 03-17-08
- 03-31-08
- 05-21-08
- 08-21-08
- 12-04-08
- 01-29-09

TMDL Development "Kick-off" meeting with Outreach, Technical, and Ad-Hoc Science Teams

- 10-2-08

Stakeholder & Public Informational Meetings
- 1-23-09 (63 attendees; two sessions, one in the afternoon and one in the evening)
- 12-2-09 (approximately 85 attendees)

Environmental Groups Meeting
- 2-24-09 (18 attendees representing 9 environmental/conservation groups & 5 agencies)

Outreach Planning and Audience Assessment

- Facilitated Stakeholder Meetings – agricultural groups, October 2007
- Facilitated Stakeholder Meetings – municipal stormwater stakeholders, May 2008
- Survey of Agricultural Producers, final report dated October 2008
- Survey of East River Residents, draft report March 2010 (draft)

Printed Materials

Newsletter Distribution
- September 2008 (171 recipients)
- October 2008 (223 recipients)
- March 2009 (231 recipients)
- March 2010 (250 recipients)

Fact Sheets
- General 4-page version – October 2007
- General 2-page version – November 2008
- Restoration Goals: Lower Fox River Watershed and Green Bay – June 2010
- Understanding and Improving Water Quality Through Watershed Models – June 2010

Direct-Mail Informational Letters
- Mailed 47 letters and two-page fact sheets to state and federal legislators – October 2008
- Mailed 700 two-page fact sheets along with Brown County's Farm Preservation mailing – December 2008
- Mailed 950 two-page fact sheets and cover letters to agricultural producers in the Lower Fox Basin within Winnebago, Calumet, and Outagamie counties – December 2008
- Mailed 47 letters and two-page fact sheets to representatives of environmental groups – January 2009

Media and Web

Media Coverage
- Green Bay Press-Gazette Perspectives Page, "Groups push to reduce pollution entering Fox River" by Terry Anderson – January 6, 2008
- Green Bay Press-Gazette article, "Sediments, nutrients harm quality: 14 area bodies of water have problems with excess toxins" by Mike Hoeft – April 19, 2010

Web Sites

- WDNR – "The Lower Fox River and Green Bay TMDL"
  http://dnr.wi.gov/org/water/wm/wqs/303d/FoxRiverTMDL/
- UWEX – "Lower Fox River Basin TMDL Outreach" (on-line December 2007)
  http://basineducation.uwex.edu/lowerfox/tmdl_outreach.html

Presentations at Conferences and Workshops

Exhibits/Posters/Displays

- Wisconsin Lakes Convention – March 2009
- State of Lake Michigan conference – October 2009
- Friends of the Fox meeting - April 2010

Oral Presentations

- LFR Point Source Dischargers meeting – August 2007 and February 2008
- FWWA Stormwater Conference – 2007, 2008, 2009, and 2010
- Regular updates at Lower Fox River Partners Meetings – 2007 - 2010
- Brown County Conservation Alliance Meeting – February 2008
- Lower Fox River Students Research Symposium – March 2008
- WEF Seminar on TMDL Development and Implementation – September 2008
- Lecture at UWGB Environmental Science (Nicole Clayton) – October 2008
- Clean Lakes and Green Jobs: The Promise of New Federal Funding for Great Lakes Restoration – August 2009
- WEF TMDL Conference (6-speaker session) Minneapolis MN – August 2009
- Appleton Paper Museum (Erin Hanson) – Winter 2010
- Lecture at Lawrence University (Nicole Clayton) – April 2010

APPENDIX H. RESPONSE TO COMMENTS

A public comment period for the Lower Fox River TMDL began on June 25, 2010 and ended on Monday July 26, 2010. The Public Notice was distributed via email to more than 200 stakeholders and was posted on WDNR's web site (http://dnr.wi.gov/org/water/wm/wqs/303d/Draft_TMDLs.html). The following items were made available on this website during the public comment period:

- A copy of the draft TMDL report.
- The official Public Notice for the draft TMDL report.
- Information on the Public Hearing, which was held in Grand Chute on July 12, 2010.
- Instructions for submitting comments on the draft TMDL to WDNR by July 26, 210.
- Source for additional information on the development of the TMDL (http://dnr.wi.gov/org/water/wm/wqs/303d/FoxRiverTMDL/).

An informational Public Hearing was held in Grand Chute on July 12, 2010. An open house prefaced the meeting and a short informational presentation was given prior to the formal comment period. No oral comments were received on record at the hearing.

The following pages contain a summary of written comments received during the formal comment period. Comments received were paraphrased and summarized to be more concise followed by the entity or entities making the comment in parentheses. Similar comments were grouped together. Table 25 lists all persons, agencies, and municipalities that provided comments on the draft TMDL report.

Table 25. Persons, Agencies, and Municipalities that Provided Comments on the Draft TMDL

Citizen, Organization, Agency Name or Local Governments	Name or Title
Borsuk, David J	Sadoff and Rudov Industries: Manager of Industrial Marketing and Quality Control
Brick, Dan	Owner & Manager of Brickstead Dairy LLC
Brown County Planning Commission	Peter Schleinz: Senior Planner
Burkholder, Dr. JoAnn	NC State: Aquatic Ecology Professor
Cellu Tissue	Mr. Kevin French - Operations Manager
City of Appleton	Paula Vandehey : Director of Public Works
City of Appleton	Chris Shaw: Director of Utilities
City of De Pere	Eric Rakers: City Engineer
Dairy Business Association (DBA)	Laurie Fischer
Dolan, Dave	University of Wisconsin - Green Bay; Associate Professor
GBMSD	Tom Sigmund: Executive Director
Harke, Bill	Milk Source (CAFO)
Kaukauna	John Neumeier: Engineer & GIS Specialist
League of Wisconsin Municipalities	Paul Kent on behalf of League of WI Municipalities: Attorney Stafford Rosenbaum
Midwest Environmental Advocates (MEA) and Clean Wisconsin	Amanda Ley, Betsy Lawton, Jamie Konopacky, Allison Donenberg, Melissa Mallott
Municipal Environmental Group (MEG)	Paul Kent on behalf of MEG: Attorney Stafford Rosenbaum
Ostrom, Jim	Milk Source (CAFO)
Thundercloud, Kelly	Citizen
Vande Hey, Nick	McMahon Group
Vanden Elzen, Ray and Shirley	Farmers
Village of Allouez	Craig L. Berndt: Director, Public Works
Village of Ashwaubenon	Michael W. Aubinger: Village President
Village of Bellevue	William Balke: Public Works
Village of Wrightstown	Stephen M. Johnson
Wisconsin Paper Council	Ed Wilusz: VP Government Relations
Wisconsin Section Central States WEA Government Affairs Committee (SCWEA)	Keith Hass (Current Chair); Jane Carlson
WPSC-Pulliam	Mark Metcalf on behalf of WPSC-Pulliam

Use Designations

1. **Comment:** The "designated use" and "existing use" terminology in the TMDL report is confusing. It appears most of the surface waters in the TMDL have not been officially classified into the various fish and aquatic life subcategories in Wisconsin Administrative Code Chapter NR 102. Chapter NR 102 requires the WDNR to classify all waters by their designated use, and designated uses are integral part of water quality standards. In our opinion, use classification should occur before an impairment assessment (303d listing) is made, let alone a TMDL conducted. This might be a matter of semantics in the draft TMDL report and we suggest it be clarified for the final TMDL report. (CSWEA)

   Response: In the context of this report, the "designated use" is that which is specified as the legal use in accordance with Wisconsin Administrative Code NR 102. Conversely, "existing use" is used in this report to describe what field biologists know about the current biological, chemical, and physical condition of the water body and the fish and aquatic life community it is currently capable of supporting. As noted, many of the surface waters affected by this TMDL are not specifically identified in Wisconsin Administrative Code NR 102 or NR 104. This is a reflection of the inability of WDNR to conduct classification studies on every water body in the state. Regardless, the construct of Wisconsin's use designation system is to specify the designations only for those waters that are *Coldwater Communities* by legal reference (see s. NR 102.04(3)(a)) or are *Limited Forage Fish Communities* or *Limited Aquatic Life Communities* in accordance with the provisions of Wisconsin Administrative Code NR 104. All other waters are assumed by law to support a fish and aquatic life use with the applicable water quality criteria being assigned to protect one of three sub-categories of the Fish and Aquatic Life Use found in pars. NR 102.04(3)(a)-(c).

Targets and Data

2. **Comment:** Please include raw data (from unpublished data and information used) in appendices of the report to be more transparent. We strongly encourage WDNR to utilize recent, high-quality data in the development of future high-impact TMDLs, as required by US EPA guidance and state listing and assessment methodologies. (CSWEA)

   Response: Over the past 30 years, water quality monitoring have been collected in the Lower Fox River Basin and Lower Green Bay by GBMSD, WDNR, the Lower Fox River Monitoring Project, UW-GB, UW-Sea Grant, UW-Milwaukee Water Institute and Oneida Nation. These data were thoroughly evaluated and used in developing this TMDL. Unpublished data and cited works in the TMDL are available upon request if not already included in the appendices. Raw data may be provided by the entities referenced in the document.

3. **Comment:** The 20 mg/L TSS target does not seem well developed. (CSWEA)

   Response: Wisconsin currently does not have numeric water quality standards for TSS. Therefore, the Ad Hoc Science Team formally met 10 times over 2 years to determine the best TSS target for the TMDL. Additional modeling was completed through contracts with UWGB during this time period to choose the best targets based on local data. Please see above response for data used, as well as Table 14 in Appendix A of the TMDL to better understand the correlation between TP, TSS, EPAR values and corresponding Secchi depth.

4. **Comment:** Using TSS as the target may differ from Impaired Waters Listing Methodology for the particular water body, too, creating a potential disconnect between the original reason for listing and the TMDL. (CSWEA)

   Response: Many waters are included on Wisconsin's 303(d) list where "degraded habitat" is the listed impairment and sediment is the listed pollutant. Historically, these listings were made using the professional judgment of field biologists who felt that excessive sediment runoff – as often indicated by elevated TSS – was the cause. The reliance on professional judgment was necessary due to the fact that Wisconsin does not have promulgated numeric criteria for TSS. This does not diminish the power of using TSS to develop the TMDL, however, as TSS provides a quantitative measurement that allows effective and equitable "load reductions" to be calculated that will achieve the narrative criteria in Wisconsin Administrative Code NR 102. Specifically, using TSS targets to meet appropriate instream goals – for both tributaries as well as downstream waters – allows load and wasteload allocations to be derived that will help achieve the goal of "no objectionable deposits" on the bed of the affected water bodies (see par. NR 102.04(1)(a)).

5. **Comment:** We support the effort to produce cleaner water including the TSS target of 20 mg/L. (Cellu Tissue)

   Response: Comment noted.

6. **Comment:** WDNR must relate TMDL targets for TP to production of toxic cyanobacteria and determine a TP target at a level that will not contribute to cyanobacterial blooms throughout the summer season. (Burkholder, MEA and Clean Wisconsin)

   Response: The listed impairment for Lower Green Bay is not related to the issue of "*toxic*" cyanobacteria (aka blue-green algae). The impairment is currently related to low levels of dissolved oxygen associated with excessive phosphorus, which may manifest itself in impacts to the **fish and aquatic life** community of the lower bay. This phenomenon of low dissolved oxygen is often associated with massive algal blooms and their impacts on oxygen consumption associated with photosynthesis, as well as decomposition of organic matter. Accordingly, it is expected that reductions of both the frequency and density of cyanobacteria will have a positive impact on the dissolved oxygen levels of the lower bay.

   Further, while the current listing is not directly related to impacts to the **recreational uses** of the bay, it is likely that the reductions of phosphorus may also have two additional benefits: 1) a positive impact on the concentration of algal toxins that may be released naturally when bloom conditions exist; and 2) increased visibility of the water due to improved Secchi depth – an indicator of light penetration. Both of these improvements should have a positive affect on the safety of people that want to recreate on or in the lower bay.

   Section 3.2 describes the process used to establish the targets in Lower Green Bay. Those target values were very clearly associated with clearer water and better light penetration. As noted above, using those "indicators" to establish target values will have a very direct correlation with water quality improvements – more so than setting targets solely on the prevention of the production of algal toxins.

7. **Comment:** TMDL targets are needed for TSS in the LFR and tributaries and for TP and TSS in Lower Green Bay. (Burkholder, MEA and Clean Wisconsin)

   Response: Please see response to Comment #3. One benefit of doing a watershed TMDL is that loads can be allocated equitably throughout the watershed/basin to assure that the most critical downstream goals are achieved. In the absence of numeric criteria for TSS, WDNR has used the narrative criterion of s. NR 102.04(1) to attempt to protect the water quality of the tributaries, the main stem of the Lower Fox River, and Lower Green Bay. Since the lower bay is a dynamic system, unlike most other Great Lakes' near-shore environments, development of a single and definitive numeric target for both TSS and TP would be a huge challenge outside the scope of the TMDL. Instead, using a narrative approach related to light penetration, as described in Section 3.2 of the TMDL, significant improvements to the fish and aquatic life community, as well as protected recreational and wildlife uses, are expected. WDNR fully expects that achievement of the numeric water quality targets for TP and TSS in the tributaries and main stem of the river will have a direct correlation with the water quality of the lower bay and will yield significant improvements in water quality related to fish and aquatic life, recreational uses, and other wildlife uses.

8. **Comment:** The draft TMDL does not adequately account for seasonal variation and critical periods. (Burkholder)

   Response: As discussed in the TMDL report, critical conditions for phosphorus impairments are generally during summer months when temperature, flow, and sunlight conditions are conducive to excessive plant growth. However, loadings throughout the entire year contribute to high phosphorus concentrations during this critical period. Critical loadings for TSS impairments occur during wet weather events, which result in upland and stream bank erosion. Wet weather events can occur at various times during the year, but are especially prevalent in spring and summer.

   Seasonal variation in the phosphorus and TSS loads is captured in the SWAT model used for the TMDL analysis. First, SWAT uses daily time steps for weather data and water balance calculations. Loads were calculated by SWAT using a 23-year (1977-2000) long-term hydrologic simulation period, which minimizes the potential influence of climate dependant factors and provides a more representative estimate of average conditions. Second, output from SWAT is on a daily time step (i.e. daily basis), but was summarized on an average annual basis for the TMDL analysis. Therefore, all possible flow conditions are taken into account for load calculations.

<u>Margin of Safety</u>

9. **Comment:** Why is an MOS for TSS needed? Applying a 10% implicit margin of safety seems unnecessarily stringent. (Kaukauna, CSWEA, City of Appleton)

   Response: An MOS is required by EPA in a TMDL. A 10% MOS was included for TSS to account for any error that may be associated with the predicted reduction goals for biotic solids in the main stem of the Lower Fox River (when factoring it into the WLAs). The 10% is applied to the target for TSS therefore "distributing" the TSS among all the load allocations in the TMDL and not placing additional stress on one sector vs. another (WLA vs. LA).

10. **Comment:** WDNR should incorporate additional MOS for TP and TSS to account for uncertainties in meeting the load reductions, either through reduced load capacity or unallocated loads. (Burkholder, MEA and Clean Wisconsin)

    Response: The current MOS in the TMDL is sufficient for accounting for potential uncertainties in meeting the load reduction. The MOS can be reviewed in the future as new data become available.

Reasonable Assurance

11. **Comment:** In order to meet the technical feasibility requirement for load allocations the WDNR must present a plan to overcome the budgetary and institutional barriers that face the voluntary nonpoint source program in the state. Otherwise, the WDNR must assume that nonpoint source loading will stay at baseline levels, and assign the load outside of MOS and future growth to point sources. (MEA and Clean Wisconsin)

    Response: WDNR has worked closely with EPA to ensure that the TMDL meets all applicable regulatory requirements. EPA has indicated that the federal regulations under 40 CFR Part 132 do not require "technical feasibility" for load allocations and do not apply to this TMDL (Dave Werbach, EPA, per. Communication with Nicole Clayton). WDNR has indicated in public meetings that an implementation plan will be developed after the TMDL is approved. That plan will identify the necessary actions and activities that can be taken to achieve the nonpoint source allocations. That plan will also allow for detailed steps to be defined that recognize both the budgetary and institutional resources available. Development of that plan will occur with broad representation of affected stakeholders and will strive to remain true to the load and waste load allocations outlined in the approved TMDL. That being said, adjustments to the allocations may be necessary to achieve the end goal of meeting water quality on the Lower Fox River Basin and Lower Green Bay.

12. **Comment:** The TMDL must include a timeline section that incorporates reviewable milestones for achieving the technical, institutional and budgetary steps necessary to ensure that the agricultural reductions can in fact be achieved. (MEA and Clean Wisconsin)

    Response: Current federal regulations do not require a specific timeline or identifiable milestones for achieving load allocations to be specified in the TMDL (40 CFR 130). However, WDNR believes that milestones are appropriate for inclusion in a detailed implementation plan and will assist in the keeping stakeholders focused on the ultimate goal of achieving water quality standards in the Lower Fox River Basin and Lower Green Bay. Including this information in the implementation plan will allow WDNR to utilize the myriad of state and federal assistance programs, policies, funding sources, and relevant laws available at the time of plan development to most effectively address pollutant reduction goals.

Upstream Sources

13. **Comment:** The TMDL should be conducted for the Upper Fox/Wolf Basin to address TP and TSS loading from Lake Winnebago. (Burkholder, GBMSD, Borsuk, Kaukauna , City of De Pere)

    Response: WDNR is working in partnership with other entities, including the United States Geological Survey to collect relevant data throughout the Upper Fox and Wolf River basins (including Lake Winnebago) in preparation for the development of a TMDL. WDNR anticipates completion of this project within the next five years – dependent upon available funding.

14. **Comment:** Please consider using a more equitable reduction (proportional to the loading) for Lake Winnebago (outlet) until the Wolf River and Upper Fox River TMDLs are complete. (Vande Hey, CSWEA, City of Appleton, MEG, League of Wisconsin Municipalities)

    Response: This was considered early in the TMDL development process. However, based on conversations with various researchers studying the Lake Winnebago system, a 40% TP reduction and a 48% TSS reduction are the most munificent reductions we can assume from Lake Winnebago, since naturally it is a eutrophic/hypereutrophic lake. Reducing the phosphorus concentration leaving the lake by greater than 40% at the outlet of the lake may not be possible given that part of the phosphorus input to Lake Winnebago likely originates from internal lake loading (released from bottom sediment). In addition, many of the subwatersheds within the UFWR Basins have low yields and encompass vast areas of upland forest and wetlands, where reduction potential is minimal; although some of the phosphorus from wetlands may be reduced in the long-term if upland agricultural areas that drain to those wetlands reduce their phosphorus export. In contrast to the UFWR Basins, land use in the LFR Basin is dominated by agriculture and urban areas, with relatively few areas that are low contributors (overall, soils and slopes are very similar). Sources of TSS and TP in the LFR Basin are clearly more concentrated as compared to sources in the UFWR Basins (see attached yield maps for annual TP and TSS loading on a sub-basin scale). Further studies by the USGS and WDNR are now being conducted to determine what measures would be needed to reduce the phosphorus loading from Lake Winnebago by 40% through the development of the UFWR TMDLs.

<u>**Wastewater Treatment Facilities**</u>

15. **Comment:** WDNR has violated federal regulations by allocating reductions to point sources before determining what nonpoint source reductions will realistically occur. All reductions necessary to achieve water quality must be allocated to point sources after allocating the LA to nonpoint sources. (MEA and Clean Wisconsin)

    Response: In accordance with the provisions of the Great Lakes Water Quality Initiative, NPDES/WPDES permits for point sources in the Great Lakes Basin must include appropriate water quality-based effluent limitations to meet the water quality criteria for toxic pollutants listed in Tables 1-4 of Appendix F of 40 CFR 132.6. The same federal requirements do not apply to other pollutants, including those in Table 5 of Appendix F unless state-specific requirements apply. Neither phosphorus nor TSS are included in Tables 1-4 and therefore are not required by federal law.

    Similarly, federal law does expressly specify a hierarchy of which sources should be reduced "first." In reflection of the provisions of 40 CFR Part 130, US EPA guidance (1991) states that "... the TMDL process is a rational method for weighing the competing pollution concerns and developing an integrated pollution reduction strategy for point and nonpoint sources" (see Page 15). The EPA Nutrient Protocol (1999) states on page 7-2 that "an appropriate balance should be struck between point source (PS) and nonpoint source (NPS) controls in establishing the formal TMDL components."

    Currently, EPA gives state water quality management agencies the flexibility to determine the appropriate allocation strategy for the pollutants of concern (considering watershed characteristics) and "technical feasibility" is to ensure the allocations are not impossible (e.g., a load allocation of zero, will need some explanation on how that will be achieved).

16. **Comment:** Regulating the point source dischargers will not have an environmental affect on [the main stem] river quality. The regulatory community should recognize the complexity and impact of nonpoint sources, and legacy TP and TSS loads. (City of Appleton)

    Response: WDNR believes that the best approach to achieving water quality improvements includes reducing the loads of TP and TSS from all contributors, including point sources, nonpoint sources, and legacy loads. Current federal and state policies and regulations are in place that require more immediate and direct action from point sources via the NPDES/WPDES program. WDNR cannot ignore those regulations on the premise that the regulatory requirements associated with them will not result in clear and demonstrable changes in water quality in the near term. Recent changes to Wisconsin Administrative Code NR 217 expand the ability of WDNR and the regulated community – both point and nonpoint – to collaborate on integrated approaches to achieve the reduction goals stated in the TMDL.

    Regardless of the available regulatory tools, WDNR does recognize the complexity of the different sources. In fact, the TMDL recognizes the distinction between the relative contributions of point and nonpoint sources within the Lower Fox River Basin depending on whether or not the focus is on the main stem of the river, the tributaries, or Lower Green Bay proper. Specifically, information available to WDNR indicates that point sources make up 81% of the TP load that is directly discharged to the main stem of the Lower Fox River itself with the remainder being contributed by other sources. When one considers the total loading to the entire basin, including Lower Green Bay, the point sources contribute approximately 30% of the TP load. One can infer by these differences that controlling the point source load to the main stem is of critical importance to facilitating measurable differences in the water quality of the main stem.

    With respect to "legacy" pollutants, WDNR believes that new contributions to the system far exceed the load attributed to the mobilization of legacy pollutants. When future efforts to control point and nonpoint sources are implemented successfully, it may be necessary to re-evaluate the contributions and effects associated with legacy pollutants. In the meantime, on-going and/or new studies to evaluate the effects of PCB remediation efforts involving sediment removal/capping may be able to help ascertain the impact of legacy loads on water quality.

17. **Comment:** We recommend that the daily LAs and WLAs be re-calculated using draft guidance developed by USEPA in *Options for Expressing Daily Loads in TMDLs*, Draft, June 22, 2007. Dividing by 365 is an over-simplification and may lead to confusion on the public and third parties when loads are exceeded on a daily basis. (CSWEA)

    Related Comment: The wasteload allocations for point sources of TP and TSS need to be based on the WLA per day as a daily maximum, not a daily average. (Burkholder)

    Response: WDNR does not envision including daily maximum effluent limitations in WPDES permits that simply reflect a division of the annual WLA (expressed in lbs/yr.) by 365. WDNR may express permit limits as daily maximums, weekly averages, monthly averages, or annual totals consistent with 40 CFR Part 122.44(d)(1)(vii), which does not require permit limits to be expressed in the same form as wasteload allocations. Federal requirements state that WLA-based permit limits need only be "consistent with the assumptions and requirements" with the approved wasteload allocations.

18. **Comment:** We object to the use of EPA's Technical Support Document for Water Quality based Toxics Control to derive WQBELs from the WLAs. The technical support document focuses on

both acute and chronic effects of toxic substances and suggests that effluent limits be set low enough to prevent acute toxicity. Applying such an analysis to TP would be inappropriate as acute toxicity is not an issue. (MEG)

Response: The method discussed in the Fox River TMDL deals with converting wasteload allocations to permit effluent limits. The method is not limited to deriving WQBELs from WLAs for toxic substances. It may be used to convert WLAs from an approved TMDL. The method deals with effluent variability and the potential for effluent limit exceedances, not with toxicity.

19. **Comment:** We recommend that design flows or maximum daily flow rate be used to determine the WLAs for this TMDL. (CSWEA, WPSC-Pulliam)

    Response: If the maximum design flow were used in the TMDL analysis in place of the actual flow, the WLAs necessary to meet the TMDL would require greater percent reductions for each facility, as well as a lower concentration for the facilities in the main stem (i.e., 0.135 mg/L instead of 0.20 mg/L).

20. **Comment:** The current method for calculating TSS for WWTFs penalizes facilities that have already achieved significant solids removal. It is unfair to penalize the best-performing facilities by imposing more stringent limits on them than on those currently discharger higher levels of TSS. WWTFs currently discharge below their current limits. TSS should be evaluated in a different way. (CSWEA, MEG, Wisconsin Paper Council, WPSC-Pulliam, GBMSD).

    Response: The WLAs for TSS in the TMDL were based on the average current discharge from WWTFs (for the LFR main stem). In many cases, the current discharge is well below each facility's current permit limit. Although several comments were received on the current methodology for TSS allocations, no alternative methods were proposed that would still meet overall TSS water quality goals for the TMDL. In order to protect downstream uses and adhere to antidegradation policies outlined in Wisconsin Administrative Code NR 102.01 (3) and NR 104.02 (5), an increased TSS load is not allowed. It is assumed that as facilities take initiatives to improve their reduction of TP, TSS will be reduced as part of this effort.

<u>Specific WWTF Comments</u>

21. **Comment:** WDNR was involved in the Village of Wrightstown early facility planning and is on record as stating that the existing standard of 1.0 mg/L for phosphorus would not change. With point source facilities contributing to only 20% of the phosphorus pollution, this does not seem equitable compared to nonpoint pollution loadings and the cost is far too great. (Village of Wrightstown)

    Response: Technology-based effluent limitations for phosphorus have been included in WPDES permits dating back to 1991. Those limits are reflective of the level of performance expected with conventional wastewater treatment practices and are not reflective of the site-specific needs to meet water quality standards in lakes, rivers, and streams. For the past 30 years, WDNR has been exploring and actively researching the levels of total phosphorus necessary to protect fish and aquatic life as well as recreational uses of Wisconsin's surface waters. In the past five years, WDNR has been very active in communicating efforts to develop numeric water quality criteria for total phosphorus and has never gone on record as saying any category of or individual point source facility would be exempt from meeting those criteria.

On December 1, 2010, water quality criteria were adopted in Wisconsin and will be considered by WDNR as staff prepare WPDES permits for point sources. In addition, the TMDL expresses WLAs which must also be included in WPDES permits and those WLAs are based upon meeting in-stream targets which reflect the Wisconsin criteria.

Regarding the equity of treatment between point and nonpoint discharges, WDNR included provisions in recently revised administrative rules governing the discharge of phosphorus that expand the ability of WDNR and the regulated community – both point and nonpoint – to collaborate on integrated approaches to achieve the reduction goals stated in the TMDL. In the interim, effluent limits to meet WLAs must be a part of NPDES/WPDES permits issued following federal approval of the TMDL.

Also, please note that wastewater dischargers contribute nearly 37% of the phosphorus loading in the entire LFR Basin (see Figure 19); further, wastewater dischargers contribute close to 81% of the phosphorus loading within just the Lower Fox River main stem sub-basin.

22. **Comment:** The current annual discharge calculated for the baseline loads of TSS (2003-2007) for Cellu Tissue was significantly lower than recent years. During 2009, the total annual TSS discharge to the Fox River was approximately 72,000 lbs. The historical average used for Cellu Tissue does not truly represent loadings during full operation (as the mill machines were operating sporadically in fiscal years 2003 and 2004. We request that the waste load allocations for TSS be assigned equal to our current annual discharge loads (2005-2009), as we understand was the intended procedure outlined in the TMDL development document. (Cellu Tissue)

    Response: Wasteload allocations for Cellu Tissue (Permit #0000680) were adjusted.

23. **Comment:** Please be more transparent on how “baseline” loads were calculated for WPDES permittees that do not have limits for TP in their current permits. (WPSC-Pulliam-provided another methodology in their comments).

    Response: Baseline loads were calculated in the same way for all permitted facilities, regardless of whether or not the facility has limits for TP in its current permits. As discussed in the TMDL report, baseline loads were calculated using an average of actual loads reported to WDNR in Discharge Monitoring Reports between 2003 and 2009 (1-7 year averaging period).

24. **Comment:** When TMDL allocations were developed for WWTFs, sediment was not considered. As part of the allocations, please consider identifying sediment reductions for WWTFs. Although, additional phosphorus reductions at WWTFs will also likely result in sediment reductions. (Vande Hey)

    Response: WWTFs only constitute 2.5% of the total TSS loading in the Lower Fox River Basin. The TMDL does not require additional reductions from baseline loading from WWTFs for TSS (note: baseline loading is not equivalent to current permit limits, it is equivalent to current discharge from the WWTFs). As you state, it is expected that if WWTFs install additional treatment for phosphorus, this will result in additional TSS reductions.

Reserve Capacity

25. **Comment:** Why is the WLA from GW Partners not being used to reduce what other WWTP's need to reduce? There is already an MOS and new development should be regulated when it occurs and will need to meet current WDNR standards and this TMDL as enforced. (Kaukauna)

    Response: The GW Partners Facility has an active permit (See WPDES Permit No. 0001121), and therefore a reserve capacity was set aside to support a new owner of that facility. If that permit expires, this load or "reserve capacity" will be available for WPDES permits that are new or would like to expand on the Lower Fox River main stem. This is different than the MOS expressed in the TMDL, which is a required component of a TMDL to account for potential uncertainty in the analysis.

26. **Comment:** The TMDL must allocate a greater amount of reserve capacity for future growth or new or expanded dischargers cannot be allowed without revising the TMDL. (Burkholder, MEA and Clean Wisconsin)

    Response: Various discussions with stakeholders involved in the TMDL process (especially the Lower Fox River Technical Team), agreed that because of the load reductions needed, and the flexibility to potentially trade water quality credits in the basin, additional reserve capacity was not needed for this TMDL. This is a not a federally-required component of a TMDL. If new or expanded dischargers would like to obtain a permit (with a WLA greater than zero), the TMDL will need to be modified, or they will need to seek out an allocation elsewhere in the basin. Because of Wisconsin's current rules and regulations (Wisconsin Administrative Code NR 151 and NR 216) future growth already has a more stringent requirement to meet water quality standards, and therefore reserve capacity is not needed.

Storm Water and Municipal Separate Storm Sewer Systems (MS4s)

27. **Comment:** Why is urban MS4 runoff considered a "point source"? (Kaukauna)

    Response: The EPA Memorandum "Establishing TMDL WLAs (wasteload allocation) for Stormwater Sources and NPDES Requirements Based on those WLAs" dated November 22, 2002, clarifies existing EPA regulatory requirements for establishing WLAs for stormwater discharges. It states that NPDES-regulated stormwater discharges must receive a WLA in a TMDL. A point source is any entity or facility that holds an NPDES (CWA §122.1: The NPDES program requires permits for the discharge of "pollutants" from any "point source" into "waters of the United States.") For stormwater permitting this includes MS4s, construction sites, and industrial facilities.

28. **Comment:** Please consider developing allocations for the Urban (non-regulated) land use category. Urban (non-regulated) land uses generate 20% of phosphorus and 12% of sediment baseline loads within urban areas. (Vande Hey, Ostrom, City of Appleton)

    Response: Allocations are assigned to the non-permitted urban area through the load allocation. Wisconsin Administrative Code NR 216 allows the issuance of a permit to urban areas that are currently not permitted but are determined through a water quality analysis to be a significant source of pollutants. Issuance of a permit would require the municipality to comply with Wisconsin Administrative Code NR 151 reductions of 40% for any established urban area.

29. **Comment:** Please consider the most restrictive pollutant when preparing urban (MS4) wasteload allocations and agricultural load allocations. (Vande Hey, City of Appleton)

Response: TMDLs were independently established for TP and TSS based on what is needed to meet the numeric water quality targets. WDNR recognizes that there are a few sub-basins in which achieving the allocation for TP may also result in a greater reduction in TSS than is required in the TMDL report, however, this is dependent on what methods are used to attain the reductions.

30. **Comment:** When TMDL allocations were developed for construction sites, phosphorus was not considered. As part of allocations, please consider identifying phosphorus reductions for construction sites. 80% sediment reductions at construction sites will also likely result in 60% phosphorus reductions. The TMDL should also describe a procedure for accounting for the reduction of TP when agricultural land is converted to urban land. (Vande Hey, City of Appleton, City of De Pere)

Response: A correlation between TSS reduction and TP reduction is highly variable and is based on the soil test P values of the soil at the construction site. The 80%-60% cited in this comment is likely from SLAMM, which does not simulate construction site erosion. Phosphorus generally remains trapped in the upper ½-inch soil layer and is distributed deeper through tillage operations. This tillage layer is also generally characterized as the topsoil layer. The first step in most construction activities is to strip and stockpile the topsoil. This effectively removes much of the phosphorus from the active portion of the construction site. An alternative to this approach is to require soil testing at construction sites for each of the different soil profiles exposed during construction and calculation of any potential phosphorus loss through a modeling exercise for each construction site.

The conversion of agricultural land to urban land is a TMDL implementation issue.

31. **Comment:** Please consider listing the County and DOT allocations in the TMDL report, similar to the other Urban MS4s. The MS4 WLA should not reflect the contribution from separate entities (industry, DOT, county roads) and should not be made the responsibility of the MS4s. (Vande Hey, City of Appleton, Village of Allouez, Brown County Planning Commission, City of De Pere, League of Wisconsin Municipalities, Village of Bellevue).

Response: As part of EPA's stormwater guidance, WLAs for entities may be lumped in a TMDL. County and DOT allocations were lumped with the Urban MS4 WLAs. During implementation planning, MS4s will have the option of removing industry, DOT, and county roads when modeling to see if they are in compliance with the TMDL. This is consistent with current Wisconsin Administrative Code NR 151 guidance which allows municipalities to take credit or enter into agreements with industries and WisDOT facilities.

32. **Comment:** According to the TMDL, the Garners Creek Sub-Basin appears to be 7,037 acres in size. According to municipal storm sewer system maps and 2 foot contour maps, the Garners Creek Sub-Basin appears to be 7,552 acres in size or more. As such, the municipal sub-basin appears to be 7% larger than the TMDL sub-basin. TMDL allocations (lbs/year) are influenced by sub-basin size. Please consider modifying the watershed size since it will likely be more difficult for the MS4 to modify allocations after the TMDL is finalized. There may be similar concerns within other sub-basins (see maps below). (Vande Hey)

General related comment: The TMDL watershed delineations vary significantly from the actual watershed boundaries in some cases, especially in urban areas. Since the allocations will be in pounds and not in percent removal, this results in unbalanced allocations. How will this be addressed? (City of Appleton)

Response: Sub-basins within the TMDL were delineated using SWAT. All land area is accounted for and assigned to a sub-basin. Depending on how sub-basins are delineated, for example placement of pour points or detail of the DEM, slight differences can be expected. For purposes of the TMDL, the TMDL sub-basins should be used and WDNR will not be modifying sub-basin boundaries.

33. **Comment:** It is not clear in the report if the TMDL is based on the same average annual baseline load for each Urban MS4 and each sub-basin (i.e. 275 lbs/acre for sediment and 0.5 lbs/acre for phosphorus). The Urban MS4 baseline load will vary by municipality. The Urban MS4 baseline load will also vary by sub-basin. For example, the WinSLAMM baseline TSS load in one sub-basin may be 419 lbs/acre and in another sub-basin the WinSLAMM baseline TSS load may be 237 lbs/acre. In this example, the municipal-wide average baseline is 272 lbs/acre TSS. Since the baseline loads in each sub-basin are used to determine the Urban MS4 allocations, it is important that the baseline loads be accurate within each sub-basin and within each municipality. (Vande Hey, Village of Allouez, City of De Pere)

    Related Comment: The use of average pollutant loads results in unbalanced allocations. Municipalities and consultants must have access to the model used to develop the TMDL. For urban subbasins that have WinSLAMM TSS or TP loads less than the average value used in the TMDL, it will be much more problematic to achieve WLAs. (City of Appleton)

    Response: During the development of the TMDL, complete data from all of the MS4 communities in the Lower Fox River Basin were not available. Also, any available SLAMM modeling for the MS4 communities was only for the established urban areas as required in Wisconsin Administrative Code NR 151. The TMDL applies to the entire MS4, often including what is characterized as 'new development' in Wisconsin Administrative Code NR 151.

    The load calculated for the MS4s was used to help proportion the available total allocation between the major sources – point source, agricultural, urban, and background. The urban load used in the TMDL represents the best estimate available given the scale of the TMDL and available data. As implementation proceeds, it is expected that better municipal data will become available. If these data indicate that modifications to the TMDL are warranted, they can be evaluated at that time.

34. **Comment:** Is there any guarantee that urban MS4 runoff will not have to follow Point Source WLA requirements? (Kaukauna)

    Response: The WLAs for each MS4 are identified in the TMDL in the tables and also in Appendix D. MS4 communities will be required to review their existing storm water management plans and show compliance with the WLAs. Some communities (such as the MS4 of Kaukauna) may drain to more than one water body, and, therefore, receive a WLA for each water body (Kaukauna MS4 drains to Apple, Kankapot, Plum, and Garner Creeks and the Lower Fox River main stem). The reductions stipulated in the TMDL need to be met within each subwatershed.

35. **Comment:** Will 2010 census data be used to re-define regulated areas? (Kaukauna)

Response: It was not anticipated that 2010 Census data would identify new MS4 areas to be assigned WLAs by the TMDL. If in the future, if additional MS4 permits are issued in the basin, the TMDL WLA and LA numbers may need to be adjusted or amended.

36. **Comment:** Construction site allocations are based on the annualized change in urban land use from 2001 to 2004. Historic trends for new development may not be a good indicator of future trends. Also, this methodology does not consider redevelopment construction sites that occur within each sub-basin. Please consider reviewing WDNR permit databases to determine how many construction sites were for redevelopment projects versus new development projects. Are the acreage allocations in Table 4 reasonable? (Vande Hey, Kaukauna, City of Appleton)

Response: Given the highly variable nature of construction sites, WDNR used an average condition looking at changes in urbanization over a multi-year period.

37. **Comment:** How does the WDNR justify using wetlands for stormwater clean-up? Are wetlands still considered "waters of the state"? Isn't using wetlands for clean-up creating a contaminated area to be cleaned up in the future (Kaukauna)?

Response: Approximately 42% of the original wetlands in the Lower Fox River Basin have been lost. Restoration of original wetlands is an option for improving water quality and restoring the landscape to its natural state. Appendix F defines the potentially restorable wetland (PRW) based on the presence of hydric soils that were once under saturated conditions (a wetland or water body). This definition is also predicated on the assumption that wetland restoration is not feasible in urban areas. This analysis was not intended for stormwater clean-up, but instead focused on the restoration of PRWs in agricultural areas to reduce pollutant loading and remove sources of pollutants.

38. **Comment:** Will WDNR have time to gather actual stream bank contributions to calibrate the model if serious TSS issues are shown to exist in a stream? (Kaukauna)

Response: The calculation of sediment from erosion of stream banks is not considered in the model; rather, a desk calculation using historic bank locations and erosion rates is included. It is included in the current TMDL model indirectly through the calibration process with actual monitoring data.

39. **Comment:** Was any weight given to newer results with regard to TP data after the fertilizer ban took effect in WI? Will this change in society satisfy the reduction needs, or in WDNR opinion will there still be significant requirements to meet MEP in communities? (Kaukauna)

Response: The TP fertilizer ban may help reduce how much phosphorus is being applied in urban areas. However, the P ban did not immediately turn off all P contributions from lawns. The primary reason for having a P ban is that the soil already has more than enough P from past practices and no more needs to be added to sustain a healthy lawn. Until the P in the soil is drawn down, over many years of not applying additional P, P will still be delivered during rain events that wash off soil from lawns. As mentioned earlier, MS4s will need to re-evaluate their stormwater management plans to make sure they are in compliance with WLAs expressed in the TMDL.

MEP does not apply in TMDLs.

Monitoring

40. Comment: Adequate future monitoring should be an identified component of the Plan with the appropriate level of commitment to ensure that sufficient data will be available to measure progress. (GBMSD Burkholder, MEA and Clean Wisconsin)

Response: Consistent with the Department's Statewide Monitoring Strategy, follow-up monitoring is a regular feature of Wisconsin's efforts to determine if applied management has been successful. This monitoring is currently referred to as "Tier 3 monitoring" and includes evaluation of the efficacy of TMDL implementation efforts. In addition, EPA requires states receiving federal Clean Water Act funds to periodically document the level of success of pollution remediation efforts supported by those funds. Accordingly, WDNR will dedicate available resources to monitoring to document any water quality changes associated with eventual implementation of the TMDL.

Agriculture

41. Comment: How will the TMDL impact my dairy operation (CAFO)? (Brick, Harke)

Response: Producers in the TMDL area are currently required to be in compliance with statewide agricultural performance standards (e.g., meet tolerable soil loss or "T," eliminate direct runoff to waters of the state, implement a nutrient management plan) as is currently required under state law (Wisconsin Administrative Code NR 151.02). In some agricultural areas of the Lower Fox River Basin, agricultural reductions for TSS and TP will be needed beyond those achieved through compliance with existing state performance standards. If additional reductions from agriculture are identified through the TMDL implementation planning process, WDNR will need to create a targeted performance standard.

42. Comment: We are dead against the WDNR draft TMDL for the Lower Fox River Basin. Why are you making farms reduce nitrogen and phosphorus levels? It is a known fact that golf courses, parks, lawns, geese, waterfowl, septic and city water treatment plants are much more disastrous than farm lands. (Vanden Elzen)

Related Comment: Why is agriculture the primary focus of the TMDL when there are several other factors? WDNR does little to account for other sources of phosphorus and suspended solids such as in-stream sediment loads, residential onsite septic systems, golf courses, wildlife, waterfowl, and domestic pets. (Brick, Harke, DBA)

Response: The draft TMDL only addresses TP and TSS, not nitrogen. The purpose of a TMDL is to look at all the potential sources of the pollutants causing the impairments (TP, TSS) and then determine the contribution coming from each source and identify what reductions are needed from each source. Once the sources are identified, each source is given a reduction in order to meet water quality goals. The TMDL analysis did quantify what was coming from agriculture, golf courses, parks, lawns, sewage treatment plants, etc.

In some subwatersheds in the Lower Fox River Basin, agriculture *is* the primary source of TP and TSS to local water bodies. Water quality data from the last 30 years show that agriculture is the greatest contributor of TP and TSS in the Lower Fox River Basin. Given that agriculture is the most significant contributor to impairments in the LFR Basin, the TMDL identifies that a majority of the load reductions come from this sector.

The additional sources mentioned above were also considered during the TMDL modeling, but they contribute very small percentages of TP and TSS to local waterways. For example, the amount of phosphorus coming from golf courses is minimal (0.3% of the load) compared to agricultural sources in the Lower Fox River Basin (46%).

Pollutant loads from wastewater treatment plants were also quantified and make up ~16% of the total pollutant load. Over the past 20 years, they have made significant strides in reducing their discharge due to state and federal regulations. Still, municipalities (stormwater runoff) and waste water treatment facilities will be required to reduce their loads by significant amounts in this TMDL.

43. **Comment:** The proposed load reductions assigned to agriculture are clearly not equitable and in fact, the Department's explanation of these reductions calls into question the scientific basis for the entire TMDL. For these reasons, we respectfully request the Department significantly revise the load reductions assigned to agriculture before finalizing the Draft LFR TMDL. (DBA)

    Response: Please refer to the response #41 above, as agriculture does make up the majority of the contribution of TP and TSS loading, this sector is assigned reductions proportional to the load after other loading reductions from permitted entities have been made. The allocation strategies are clearly defined in Appendix C of the TMDL. On December 2, 2009, a stakeholder meeting was held at the Fox Valley Technical College in Appleton, with an open forum for interested parties to provide suggestions on how to improve the allocation strategies. More than 80 people attended this meeting, and small group discussions were beneficial. Based on comments received, the TSS allocations were adjusted for the final draft TMDL to make sub-basin reductions more equitable.

44. **Comment:** WDNR should use Snap-plus software to assess nonpoint loading and assign reductions on a site-specific basis. Because this information is readily available, WDNR must use site-specific information to establish agricultural load allocations. (MEA and Clean Wisconsin)

    Response: The potential for site-specific reductions will need to be addressed via the TMDL implementation planning process and will depend on the data that are available regarding individual sites or fields. WDNR agrees that SNAP-Plus software can be an extremely useful tool to identify potential risk of nutrient loading from cropped fields. While the amount of acreage covered under a nutrient management plan (NMP) increases every year, a significant portion of the cropped acreage in the state is not covered under a NMP. In addition, many NMPs can and have been developed without the use of SNAP-Plus. Over time, the number of farms and amount of cropped acreage falling under an NMP and developed using SNAP Plus will increase and become more readily available. Funding for county and WDNR staff to help assist with collecting data and modeling at this scale of the TMDL is currently needed.

45. **Comment:** What will be the cost to comply with the TMDL (for Dairy Operations, Farmers)? (Brick, Harke, Vanden Elzen)

    Response: Costs will vary depending on an operation's current management practices and associated level of pollutant delivery compared to needed reductions in delivery. Operations that have poor management practices (high soil erosion, high phosphorus soils, direct runoff from feedlots to surface waters) are more likely to incur more costs than producers that are already in compliance with state agricultural performance standards. In addition, operations in subwatersheds with more significant pollutant contributions may need to implement additional BMPs to reduce TP or TSS. Cost sharing is available through a variety of federal, state, and local funding programs and in many cases must be offered before a farmer can be required to meet the required nonpoint pollutant reductions. The Targeted Runoff Management Grant Program is WDNR's primary program for funding TMDL-related agricultural projects. Landowners are encouraged to seek low-cost, innovative approaches for water quality improvement. Adaptive management strategies or phased implementation, as allowed by law, may be recognized as a mechanism to achieve water quality goals in a cost-effective, equitable manner.

46. **Comment:** Agriculture should not be responsible for naturally occurring sources of phosphorus and sediment (Harke).

    Response: WDNR does not hold agriculture responsible for natural background sources of TP and TSS in the TMDL. Before determining load allocations for the TMDL, natural sources of phosphorus and sediment (background soil levels, sources from wetlands and forested areas) were determined and the target or goals of the TMDL are not set lower than these natural background levels (e.g., natural background in this TMDL area is about 0.03 to 0.04 mg/L TP, while the targets for the streams and rivers are 0.075 and 0.1 mg/L TP, respectively). The load allocations assigned to agriculture reflected in the TMDL, are from croplands, barnyards (feedlots) and pasture only.

47. **Comment:** The TMDL report states that the discharge from CAFOs from farm fields is unregulated, however this is not true since all CAFOs must adhere to a Nutrient Management Plan to make sure farming practices do not exceed T loss for any given field and that only nutrients meeting crop needs are applied. The positive influence of nutrient management planning was not included in the report. (Ostrom)

    Response: Section 4.1.4 of the TMDL report states "Land application of manure from CAFOs, however, is not included in the assumption of zero discharger. "Loading of phosphorus and sediments from land spreading is accounted for in the nonpoint source loads. WDNR recognizes that CAFOs are adhering to nutrient management plans. More stringent nutrient management plans and tillage practices may be needed (on various sizes and types of farms, not just CAFOs) as further modeling is conducted on a farm-by-farm basis through the TMDL implementation planning process. If more stringent targeted performance standards are needed, the Department will comply with existing rules and regulations to implement the TMDL.

<u>**Miscellaneous**</u>

48. **Comment:** Any TMDL requirements need to be integrated with the new NR 102 and NR 217 rule package. The recently passed NRB resolution to establish a TMDL implementation work group should provide significant assistance in this process. (GBMSD)

    Response: TMDLs alone are not regulatory tools. However, implementation of TMDLs does occur through other state laws and regulations. WDNR recognizes the need to connect newly revised rules with TMDLs and agrees that the formation of a TMDL implementation work group is needed to assist in this process.

49. **Comment:** My concern is that once you reach acceptable water quality, there will still be some pollution getting in there and nothing more will be done to reduce it since it meets the standards. I don't want the water quality to simply meet a standard. I want it to be the best it can possibly be! (Thundercloud)

    Response: A TMDL is defined as the total amount of a pollutant a body of water can receive and still meet water quality standards. Wisconsin's water quality standards, whether narrative or numeric, are set to meet designated uses (in that people can fish and swim in the waters of the state). It is important to recognize that even if we shut off all the anthropogenic sources of phosphorus and total suspended solids, there would still be a small amount in our surface waters because both of these naturally occur. This is considered "natural background" and also factored in while determining targets for the TMDL.

50. **Comment:** I am supportive of the TMDL, especially the application of adaptive management which will allow flexibility as water quality objectives are approached. Our mass balance model agrees with the projections outlined in Appendix A; however, estimates over the past 15 years show that the ratio of loading of total dissolved P to total P has increased in recent years. This may make it difficult to reach Secchi Depth and blue green algae objectives since the phosphorus still entering Green Bay will be more available to the algae. (Dolan)

    Response: Comment noted. If the narrative water quality goal for Lower Green Bay is not met once the watershed is meeting target loads outlined in the TMDL, the TMDL may be amended in the future.

51. **Comment:** The TMDL allocations do not appear to consider compliance costs. Please consider developing TMDL allocations based solely on cost. An Optimization Analysis to show the "most cost effective combination of restoration scenarios that will achieve TMDL targets for TP and TSS…" was included in the original scope of work by EPA and not included in the final report. (Vande Hey, CSWEA, City of Appleton, Village of Allouez, MEG, GBMSD)

    Response: Costs *were* considered early in the process as part of TMDL development using cost data provided by several communities and facilities in the basin. However, after considering several methodologies, costs could not be the basis of the allocation strategies for the LFR Basin TMDL because there is a high degree of variability for each municipal and industrial WWTF, MS4, and agricultural BMP. Regardless, the contractor made some general assumptions and a load and cost optimization analysis was completed for the TMDL. This resulted in no optimal scenario as maximum implementation of all of the BMPs in the agricultural sector (~10 being reviewed at maximum (feasible) implementation rates) could not meet water quality standards. Although evaluating costs is one of the "approved" methods by EPA for assigning allocations in a TMDL, the primary goal of the TMDL is to meet water quality standards. Costs may be considered during TMDL implementation and updating the optimization model may be necessary to find the best scenarios by thinking outside of the box and getting the "biggest bang for the buck" as we move forward to meet water quality goals in the LFR Basin.

52. **Comment:** Pollutant trading may provide a more cost-effective means to meet TMDL allocations. When does WDNR anticipate completing state-wide statutes, rules, and trading ratios for "pollutant trading"? (Vande Hey)

    Response: WDNR's July 1, 2011 Water Quality Trading Report to the Natural Resources Board includes recommendations on statutory changes and guidance development for water quality trading. Statutory changes need to be made by the Legislature and guidance will be developed over the next year in consultation with stakeholders. The report recommended against the drafting of rule language.

53. **Comment:** Overall the draft Fox River TMDL report appears to be a well-developed and thorough document. We commend the WDNR for the high level of public participation in this TMDL, particularly in the early stages. (CSWEA)

    Response: Thank you. WDNR had many engaged partners (including but not limited to UW-GB, UW-Extension, UW-Sea Grant, Oneida Nation, GBMSD, and all the Technical Team, Outreach and Ad Hoc Science Team Members) throughout TMDL development to encourage public participation. This TMDL has been nationally recognized for its public participation efforts during TMDL development and we hope this will continue with local support through TMDL Implementation Planning.

54. **Comment:** The City does not agree that stakeholder participation and input was adequate for the development of this plan. Explanation of the plan to those most impacted by it did not occur. We have been given 30 days, over a holiday, in which to read and try to understand the plan. Multiple sessions to explain the science, modeling, assumptions, etc. should have occurred for all those impacted by the plan. (City of Appleton)

    Response: WDNR made reasonable efforts to involve stakeholders throughout the development of the TMDL. Every Technical Team meeting was posted for public noticed on WDNR's "Meeting and Hearing Calendar" website. These meetings were open meetings that provided an opportunity for any interested party to attend to learn more about the TMDL development process. Local officials (county and city) were sent a letter regarding the TMDL early in the process, which explained that WDNR would be happy to meet to discuss the TMDL and how individuals may be impacted. On December 2, 2010, an all-day allocation strategy meeting was held at the Fox Valley Technical College in Appleton to explain the different components of the TMDL and provided an opportunity for active participation, including stakeholders' ability to make informal comments in a small group setting to WDNR regarding the TMDL. Lastly, WDNR invited the City of Appleton to participate on the Technical Team. The City declined to participate (letter dated to Sue Olson on September 22, 2008 and declined, invite further extended to Chris Shaw and declined).

55. **Comment:** The portion of the title "and Watershed Management Plan" is confusing, particularly since the implementation plan has not yet prepared for this TMDL. (CSWEA)

    Response: As noted in section 7.2, Oneida Nation has been actively involved with the development of the TMDL. Because TMDLs may not be written within reservation boundaries, the contractor has included Oneida's "Watershed Management Planning" effort as part of a chapter of this TMDL. Additional language was added in the Introduction of the report to further explain the title.

56. **Comment:** A better map showing rivers and subwatersheds upstream of Lake Winnebago may be helpful. (CSWEA)

    Response: The TMDL was written for the Lower Fox River Basin (from the Outlet of Lake Winnebago to Lower Green Bay). Upstream sources will be accounted for through the development of the Upper Fox/Wolf TMDL and the maps requested will be included in that report.

57. **Comment:** A nitrogen TMDL is needed to protect and restore water quality in the LFR Basin and Lower Green Bay. (Burkholder)

    Response: Currently there are no numeric water quality standards for nitrogen in Wisconsin, and therefore, no surface waters listed on the 303(d) Impaired Waters List. Adhering to the Clean Water

Act, WDNR is required to develop TMDLs for 303(d) Impaired Waters. WDNR recognizes that nitrogen may be a pollutant of concern caused by anthropogenic sources, but more monitoring data is needed to determine nitrogen-related impairments in Wisconsin surface waters. In addition, BMPs installed to implement the TMDL and capture phosphorus may also reduce nitrogen loading to surface waters.

<u>Implementation Stormwater</u>

58. **Comment:** Please consider MS4 permits that are in compliance with Phase II requirements in compliance with the TMDL. (CSWEA)

    Response: Meeting Phase II requirements may go a long way toward meeting the TMDL requirements, however, the Phase II requirements are separate from the pollutant reduction goals specified in the TMDL. Meeting Phase II requirements does not mean that the water quality goals specified in the TMDL are being met.

59. **Comment:** The report should clarify in the text that MS4s should refer to the "Sub-Basin Loading Summary" chart to identify the required allocations per subwatershed. (Brown County Planning Commission)

    Response: This language is included in section 6.1.2 of the TMDL report. In addition to showing each MS4's WLA on pages 42-86, Appendix D includes additional tables to summarize each MS4's WLA by subwatershed and in total (for both TP and TSS). This will be important to refer to during implementation planning.

60. **Comment:** The Lower Fox River mainstem is significantly high in reduction needs for MS4s. Why is this? Can this be accomplished and will municipalities have a longer term schedule to get to the higher percentages needed? Has the Department considered some communities can not meet requirements in their Phase II permits, yet go above and beyond those requirements as outlined in the TMDL? (Brown County Planning Commission, City of De Pere)

    Related Comment: The City does not support the plan because it sets numeric limits that cannot be met by current technology, unless the removal of existing affordable housing for the placement of structural stormwater management practices is considered a technology. New technologies may exist in 20-30 years, but no plan should go on that long without multiple updates. Until such time as that technology exists, municipalities and industries are a target for lawsuits. (City of Appleton)

    Response: Reductions are higher in the main stem reach of the Lower Fox because of the higher loadings coming from sources in the Lower Fox main stem sub-basin. The TMDL sets reduction goals to meet water quality but does not specify implementation methods or timelines. It is anticipated that extended implementation timelines, pollutant trading, and other implementation tools will be available to municipalities to help meet TMDL allocations.

61. **Comment:** Will trading % among the subwatersheds be allowed, since all watersheds drain to Lower Green Bay the net effect overall is likely the same. (Village of Allouez, City of De Pere)

    Related Comment: How will "averaging" for stormwater be accommodated once the TMDL is approved (example, the municipality is currently meeting 40% by averaging two sets of outfalls-will this be the case if both sets of outfalls are in two different watersheds?) (Brown County Planning Commission).

Response: TMDL reductions are specified for impaired segments. Municipalities can average reductions provided that the allocations for specific impaired segments are maintained. Also, municipalities that drain to the same impaired segment can share loads and reductions provided that the overall target is met.

62. **Comment:** It is unclear from the Draft TMDL how the new TSS allocations will be integrated with WDNR's recently-approved NR 151 rule package. There is no reference to NR 151 in the TMDL or how those provisions will be integrated into the NR 151 process. In the absence of an integrated plan, the TMDL must make clear that the proposed allocations will not be enforceable in MS4 permits until an implementation plan is developed. (League of Wisconsin Municipalities)

    Response: The municipal permits already contain language regarding requirements for evaluation and implementation of TMDL allocations.

63. **Comment:** Please consider a formal implementation plan to show how draft allocations for MS4s (up to 65% in some cases) may be met through trading and watershed permitting. (City of De Pere, League of Wisconsin Municipalities)

    Related Comment: We request a graduated approach to water quality improvement be implemented for the Lower Fox River Basin and an initial [MS4] waste load allocations be established that is lower than the longer term goal. As reductions are accomplished upstream, further improvements can be required in the LFR Basin. (Village of Bellevue)

    Response: TMDL development is completed to identify the reductions needed to meet water quality standards. TMDL implementation plans are not required by EPA. However, WDNR recognizes the need to be flexible and is working on creating a water quality trading framework that may be used in TMDL implementation planning.

64. **Comment:** Because of the close proximity of Austin Straubel International Airport (ASIA) within the Village of Ashwaubenon, and ultimately the Fox River, consideration and clarification needs to be made on how the FAA recommends wet detention ponds 10,000 ft. from AISA. This greatly impacts any ability the Village has in meeting mandated water quality goals. (Village of Ashwaubenon)

    Response: WDNR is aware of FAA concerns about wet detention ponds and other possible wildlife attractants near airports. The FAA Advisory Circular 150/5200-33B dated 8/28/2007, *Hazardous Wildlife Attractants on or near Airports*, makes recommendations for existing and new stormwater management facilities within a specified separation zone. For municipalities affected by the FAA recommendations, WDNR believes that a thoughtful analysis of stormwater treatment alternatives that assesses the appropriateness of a given treatment practice within the separation zone will provide a good balance between FAA concerns and the state's effort to attain water quality goals. To that end, WDNR is considering what resources and guidance municipalities need to make appropriate storm water planning decisions where wildlife attractants are a concern.

65. **Comment:** The TMDL implementation plan should allow for municipalities and landowners to receive credit (e.g., through water quality trading) for projects that remove P-laden sediment, improve habitat, and stabilize stream and river banks. (CSWEA, City of Appleton)

    Response: Credit can be given for reductions that occur from sources that are assigned allocations in the TMDL. This would not include improved habitat but could include removal of P-laden sediment and stabilization of streams and riverbanks. Stabilization of stream and riverbanks may be viable given that the pollutant loading models used in the TMDL were calibrated to monitoring data that includes loads from stream and river banks.

66. **Comment:** Bank Erosion is a major source of TSS in some communities; will WDNR recognize bank stabilization projects as solutions to TSS requirements and to reduce requirements in upland areas of the community? (Kaukauna, Vande Hey, Village of Allouez)

    Response: A stream naturally moves and may be eroding in one area while depositing sediment in another. However, in urban settings the flows can become flashy and erosive, scouring out the stream and speeding up the natural process. Armoring of the banks in critical locations may become necessary for stability. There are means to calculate the rate of erosion and to estimate the amount of sediment released to the stream. A requirement under Public Education and Outreach section 2.1.4 in the MS4 permit reads: "Promote the management of stream banks and shorelines by riparian landowners to minimize erosion and restore and enhance the ecological value of waterways." The permit does not require stream bank stabilization because it is focused on TSS which is a surrogate for pollutants from urban surfaces.

Implementation Wastewater

67. **Comment:** How will the load reduction goals be translated into individual WPDES permits? (GBMSD)

    Response: As mentioned in Section 7.1.1., once the TMDL is approved by EPA, limits will be incorporated into permits consistent with Wisconsin Administrative Code NR 217.

68. **Comment:** We agree that it makes sense to transfer LAs to MS4 WLAs as land is urbanized but suggest that wording be change to include transfer from LAs to WWTF WLAs too. (CSWEA)

    Response: A framework for transferring LAs for agricultural areas to WLAs for urbanized areas or WWTFs does not currently exist. EPA policy requires a modification of the TMDL for the reallocation of LAs to WLAs. WDNR has discussed the issue with EPA and is awaiting guidance from EPA on how to proceed to avoid modification of the TMDL for transfers between LAs and WLAs.

69. **Comment:** We oppose the imposition of new permit limits before the formal implementation plan has been developed. (MEG, City of Appleton, GBMSD)

    Related Comment: The implementation procedures must reflect the same flexibility that we are asking of the Lower Fox River TMDL to accommodate results from the Upper Fox River TMDL. It appears that the adaptive management provisions included in the final version of proposed changes to NR 217 could provide for this flexibility. We strongly urge the Department to provide as much implementation flexibility as possible for WPDES permit holders, including use of adaptive management. (Wisconsin Paper Council)

    Related Comment: It is critical that the final TMDL for the Lower Fox River allow for the adjustment of load allocations based on completion of the Upper Fox River TMDL. Implementation of the Lower Fox River TMDL should be delayed until corresponding studies have been completed for the rest of the Upper Fox/Wolf Basin (Wisconsin Paper Council, MEG, Village of Allouez)

Response: Upon federal approval of the TMDL, WDNR will work to seek the maximum flexibility in timelines associated with implementation of Wasteload Allocations. In doing so, WDNR will utilize all available tools – including flexible approaches to control pollutants in administrative rules as well as timing of permit issuances – to ensure that stakeholders can collaborate for the most effective options to implement the TMDL.

70. Comment: Nonpoint source load allocations cannot be enforced if cost-share funding is not available. This will be a burden on point sources with little improvement in water quality, since nonpoint source loading is a significant portion of the loading. With that in mind, TMDL related-WLA should not be included into permits until after the implementation plan is written and significant funding is secured for nonpoint source controls. (CSWEA, City of Appleton, GBMSD)

Response: Please see response for Comment #69.

71. Comment: Because of the potential for modifying the TMDL and WLAs in the future, any TMDL-related WPDES permits limits should be accordingly adjustable and not subject to additional antidegradation and antibacksliding regulations. (CSWEA)

Response: TMDLs are able to be modified in the future as new science and technology is available. However, any antidegradation and antibacksliding regulations for impaired water bodies in the State of Wisconsin would still apply regardless of a TMDL situation.

72. Comment: MEG recommends that the WDNR's implementation plan include:

- Maximum flexibility in how load reductions are achieved including watershed based trading.
- Allow for the application of specific allocation methodologies for particular reaches or stream segments within the Lower Fox River Basin.
- Account for the variability in ambient concentrations throughout the Lower Fox River Basin.
- Recognize and reflect the impact of legacy phosphorus and sediment loads.
- Consider cost-effectiveness and the net environmental benefit of alternatives.
- Include a stepped implementation approach whereby prior load reductions are recognized and additional reductions from those sectors are not required until all sectors have achieved required baseline conditions identified as part of the implementation plan.
- Include a detailed monitoring strategy for determining the impact of load reductions on water quality and biotic integrity.
- Contain an implementation schedule and target attainment timelines.
- Utilize cost-effectiveness and net environmental benefit as overarching considerations in defining final allocation methods.
- Consider a watershed based permitting approach to promote cost effective solutions and promote the likelihood of trading.

Response: Comment noted.

73. **Comment:** We strongly encourage costs to be considered during implementation planning for this TMDL. (CSWEA, Village of Ashwaubenon, City of Appleton, GBMSD)

    Response: Comment noted.

74. **Comment:** The creation of compliance schedules that allow POTWs to reduce TP and TSS over multiple WPDES permits would lessen the economic hardship on rate payers and similar to NR 217 setting reduced limit over to 2 or 3 permit cycles would allow for the treatment technology to mature (to reduce capital and O&M costs). (City of Appleton)

    Response: Please see response to Comment #69. WDNR realizes the importance of flexible schedules to comply with water quality standards and TMDL WLAs in permits.

<u>**Implementation Agriculture**</u>

75. **Comment:** The potential that most, if not all, the TP and TSS reductions needed from load reductions, will likely be imposed on WPDES permitted farms is troubling. It is unlikely there will be adequate cost share funding to broadly implement TP and TSS reductions on all farms in the LFR watershed. That leaves 15 CAFOs in the LFR watershed to bear the brunt of any TMDL implementation measures. (DBA)

    Response: As identified in the Reasonable Assurance Section (7.1) of the TMDL report, all crop and livestock producers in the LFR Basin will be required to comply with state agricultural performance standards and prohibitions in Wisconsin Administrative Code NR 151. Further reductions beyond this for CAFOs and non-CAFOs would be identified through the TMDL implementation planning process.

76. **Comment:** When WPDES CAFO permits are reissued will they contain additional land spreading restrictions that are "consistent with" the TP and TSS load reductions assigned to agriculture? WPDES permitted farms already comply with the most stringent nutrient management planning requirements (meet T and PI of 6) to meet crop needs. Imposing further limitations on tillage practices and nutrient application may well render fields in the LFR basin non-farmable which would have a devastating impact on the already struggling Wisconsin dairy industry. (DBA)

    Response: Further limitations on WPDES permitted CAFOs, if needed, will be identified through the implementation planning process. It should be noted that CAFOs have achieved PI's less than 6 using current farming BMPs. The impact of further reductions in PI requirements, should they occur, would be highly dependant on current farming practices and may or may not require significant changes at an operation.

77. **Comment:** Firm regulatory requirements and the need for cost-sharing for agricultural dischargers are necessary and must be implemented if water quality is to improve. (Village of Ashwaubenon, Village of Allouez, GBMSD, City of De Pere, Village of Bellevue)

    Response: WDNR agrees that state and local regulations, in conjunction with cost-sharing to address agricultural sources of TP and TSS, are a critical component of TMDL implementation.

78. **Comment:** WDNR should work with counties to develop nutrient management plans for priority farms in each sub-watershed. WDNR should set dates to perform on site monitoring in order to ensure the plans are being followed. (MEA and Clean Wisconsin)

    Response: It is expected that most compliance checks on non-permitted operations will occur through local agencies (counties, towns) with WDNR monitoring compliance for WPDES-permitted CAFOs.

<u>Other Implementation Comments</u>

79. **Comment:** Members of CSWEA-Wisconsin could be a valuable resource to WDNR on implementation issues such as cost-benefit evaluations, NPDES permit language, water quality trading and monitoring and would like to be involved as a partner in developing an implementation plan for the Lower Fox River Basin. (CSWEA)

    Response: Comment noted.