Status Report

# Adaptive Management Plan

Prepared For

## CITY OF PLYMOUTH UTILITIES

SHEBOYGAN COUNTY | WISCONSIN

NOVEMBER 6, 2018

McM. No. P0036-9-18-00491

NAV:jlh

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## I. INTRODUCTION

The City of Plymouth owns and operates a wastewater treatment facility (WWTF) which discharges to the Mullet River. The location of the WWTF is depicted in Figure 1. The City's new Wisconsin Pollutant Discharge Elimination System (WPDES) Permit includes a six-month average effluent total phosphorus (P) limit of 0.075 mg/L. As part of the City's Preliminary Alternatives Compliance Plan, the following compliance options were evaluated: WWTF technologies, adaptive management, water quality trading, and variance. The City selected Adaptive Management for implementation and permit compliance. This report summarizes the Adaptive Management Plan that is required for the City's next permit reissuance.

### A. Current City of Plymouth WWTF

The current City of Plymouth WWTF was constructed in 1979 and upgraded in 1992. Design criteria, process schematics, and an overall site plan for the current WWTF are provided in Appendix A. The average annual influent and effluent P concentrations and loadings for the City's current WWTF are summarized in Table 1-1 for years 2014, 2015, and 2016. Additional WWTF performance is provided in Appendix A. The City will not be able to meet the proposed six-month average effluent total P limit of 0.075 mg/L with its current WWTF facilities. Based on the City's Preliminary Alternatives Compliance Plan (dated July 29, 2016), filters are needed to achieve a P limit of 0.075 mg/L.

Table 1-1
Performance of Plymouth WWTF

| Year | Discharge MGD | Average Influent Total P | | Average Effluent Total P | |
|---|---|---|---|---|---|
| | | mg/L | lbs/day | mg/L | lbs/day |
| 2014 | 1.731 | 4.8 | 67 | 0.34 | 4.57 |
| 2015 | 1.558 | 5.8 | 75 | 0.66 | 8.68 |
| 2016 | 1.765 | 5.4 | 77 | 0.23 | 3.56 |
| Average | 1.690 | 5.3 | 73 | 0.41 | 5.78 |

## B. Tertiary Treatment Options for City of Plymouth WWTF

As part of the City's Preliminary Alternatives Compliance Plan, three (3) tertiary treatment or filter options were evaluated for meeting the future effluent P limit of 0.075 mg/L at the WWTF. The three (3) filtration options were evaluated using a 20-year present worth analysis. The simplified present worth analysis shows that cloth disk filters are the most cost effective tertiary treatment option for meeting the City's new total P limits.

Table 1-2
Tertiary Treatment Costs for Plymouth WWTF

| Opinion of Probable Cost (OPC) | Cont. Backwash Sand Filtration | Polyethylene Disk Filters | Cloth Disk Filters |
|---|---|---|---|
| Capital OPC | $4,514,000 | $2,153,000 | $1,757,000 |
| Comparative Annual OPC | $42,500 | $55,300 | $45,300 |
| Present Worth Annual OPC | $577,588 | $727,194 | $595,694 |
| Present Worth OPC | $5,091,588 | $2,880,194 | $2,352,694 |

## C. Adaptive Management Eligibility

Adaptive Management is a permit compliance strategy to achieve the Mullet River's phosphorus criterion in the most economically efficient manner and as soon as possible, taking into consideration the contributions from point and non-point sources. According to Wisconsin Department of Natural Resources (DNR), the Mullet River is a 303(d) listed water body that is impaired by excess phosphorus pollutants.

From 2013 to 2015, the City obtained grab samples from the Mullet River at Blueberry Lane, which is located just downriver of the City's WWTF discharge. As shown in Table 1-3, the Mullet River's six-month total phosphorus concentration for years 2013 to 2015 was an average of 0.14 mg/L at Blueberry Lane. The average 0.14 mg/L phosphorus concentration exceeds the 0.075 mg/L phosphorus criterion.

Table 1-3
Mullet River Sampling Data at Blueberry Lane

| Mullet River: Downriver of WWTF (Blueberry Ln) | Average Total Phosphorus Concentration (mg/L) | | | | | | |
|---|---|---|---|---|---|---|---|
| | May | June | July | Aug. | Sept. | Oct. | 6 Month (May to Oct) |
| 2013 | 0.11 | 0.12 | 0.16 | 0.15 | 0.13 | 0.13 | 0.14 |
| 2014 | 0.08 | 0.12 | 0.11 | 0.11 | 0.09 | 0.10 | 0.10 |
| 2015 | 0.20 | 0.18 | 0.18 | 0.21 | 0.18 | - | 0.19 |
| Average | 0.13 | 0.14 | 0.15 | 0.16 | 0.14 | 0.12 | 0.14 |

The Wisconsin DNR will allow a WWTF discharger to consider Adaptive Management as a compliance option, if at least 50% of total P to the receiving stream is from non-point sources. Adaptive Management allows dischargers to develop a management plan to reduce P levels in the receiving water so that it meets the 0.075 mg/L P criteria. For larger streams with several dischargers, this can be a cooperative partnership. The dischargers can work with non-point sources, such as agricultural or stormwater, to implement projects or practices to reduce P discharged to the receiving water. The Wisconsin DNR may allow a community up to three (3) permit terms or 15 years to implement the Adaptive Management Plan. The goal is to achieve the P standard in the receiving water within three (3) permit terms or the Water Quality Based Effluent Limit (WQBEL) within four (4) permit terms.

The City of Plymouth WWTF discharges to the Mullet River. The Wisconsin DNR's Pollutant Load Ratio Estimation Tool (PRESTO) results are provided in Appendix B for the Mullet River and the City's WWTF. According to the PRESTO results, the total P in the Mullet River at the City's WWTF discharge is 36% point sources and 64% non-point sources. More specifically, of the 11,425 pounds of total P in the Mullet River, the Wisconsin DNR indicates 4,129 pounds are from point sources and 7,296 pounds are from non-point sources. Since non-point sources are 64% of the total P load, the Mullet River is non-point source dominated and the City is eligible to use Adaptive Management for compliance.

## D. Adaptive Management Plan Components

Based on Wisconsin DNR guidance, an Adaptive Management Plan is to include nine (9) key components. The components are described as follows:

1. Identify partners.
2. Describe the watershed and determine load reduction goals.
3. Conduct a watershed inventory.
4. Identify where reductions will occur.
5. Describe management measures.

6. Estimate load reductions expected within permit term.
7. Identify how success will be measured.
8. Describe the financial security.
9. Provide an implementation schedule with milestones.

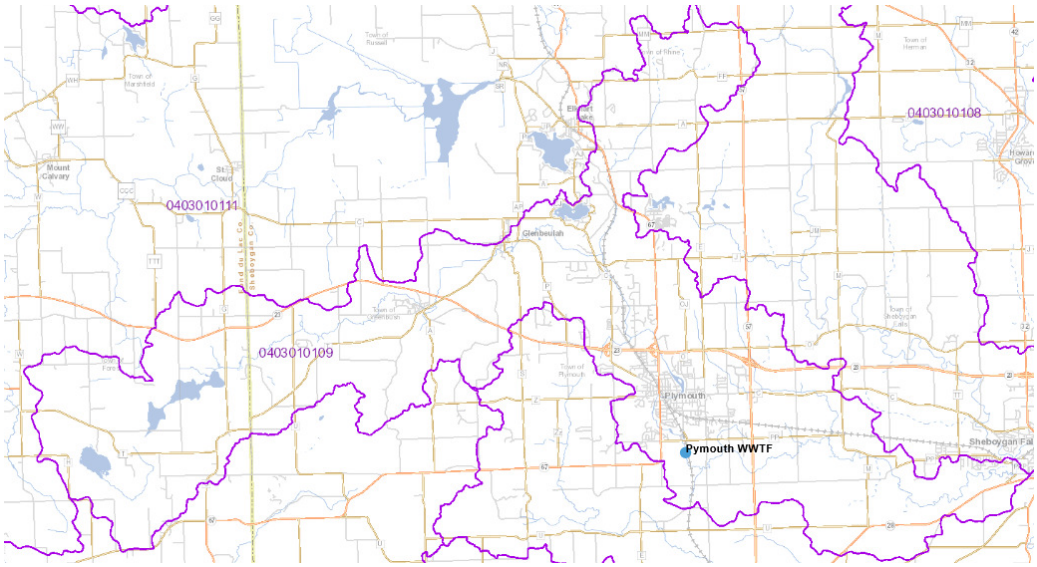
## II. WATERSHED DESCRIPTION

This watershed description provides general information about the Mullet River, including its watershed, natural resources, soils, and land uses. The City of Plymouth is located within the Sheboygan County portion of the Mullet River Watershed. The City of Plymouth WWTF location is depicted in Figure 1.

### A. Watershed

The Mullet River Watershed is 88 square miles in size and is located in eastern Fond du Lac and western Sheboygan counties. The Mullet River drains into the Sheboygan River, which drains into Lake Michigan. As shown in Exhibit 2-1, the Hydrologic Unit Code (HUC) 10 for the Mullet River Watershed is 0403010109.

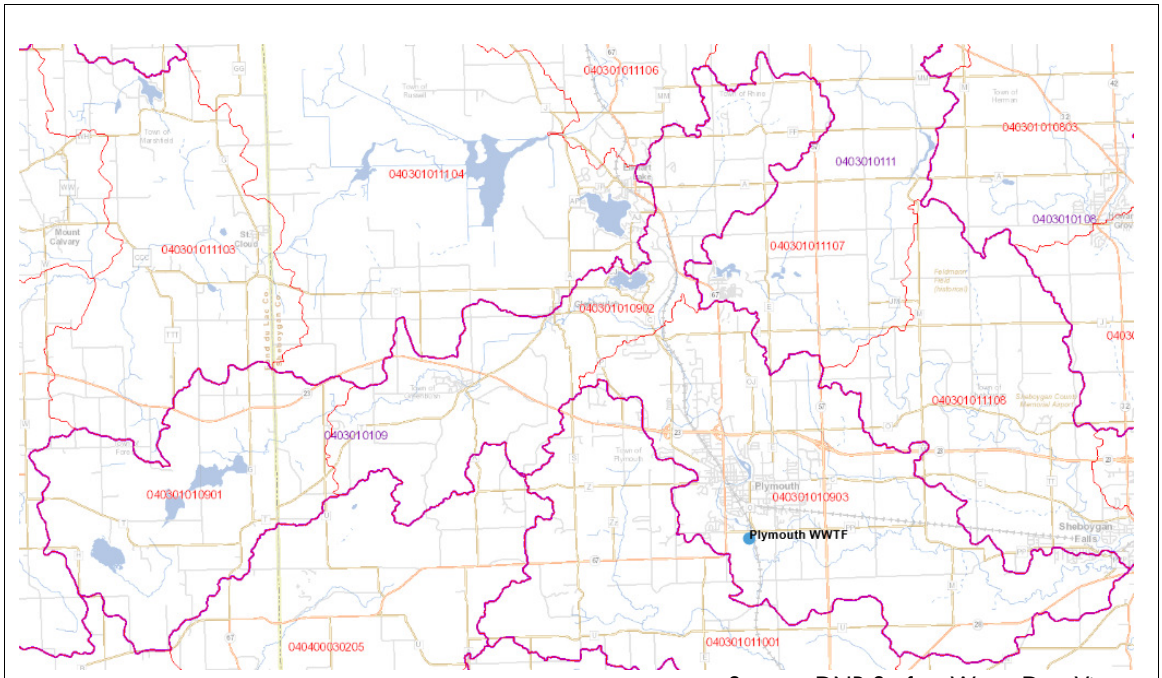
Exhibit 2-1
Mullet River HUC 10




Source: DNR Surface Water Data Viewer

The Mullet River Watershed is subdivided into three (3) sub-watersheds: Upper, Middle and Lower Mullet River. The three (3) sub-watersheds or Hydrologic Unit Code (HUC) 12 boundaries are depicted in Exhibit 2-2 and summarized in Table 2-1.

Exhibit 2-2
Mullet River HUC-12



Source: DNR Surface Water Data Viewer

Table 2-1
Sub-Watershed

| Sub-Watershed | HUC-12 | Area (acres) |
|---|---|---|
| Upper Mullet River | 040301010901 | 13,337 |
| Middle Mullet River | 040301010902 | 16,505 |
| Lower Mullet River | 040301010903 | 21,039 |

The portion of the Mullet River Watershed that is located upriver of the City's WWTF is depicted in Figure 2. The watershed area depicted in Figure 2 is the Action Area for the City's Adaptive Management Plan. The Action Area includes the Upper Mullet River Sub-Watershed, Middle Mullet River Sub-Watershed, and the portion of the Lower Mullet River Sub-Watershed that is located upriver of Blueberry Lane. Blueberry Lane was selected as the downriver location for the Action Area since the road crossing provides a convenient location for river sampling.

## B. Natural Resources

Natural resource features include surface waters (lakes, rivers, streams), wetlands, and endangered or threatened resources. Natural resource features located within the Mullet River Watershed are depicted in Figure 3. Some of these natural resource features are protected with a special regulatory designation such as areas of special natural resource interest, 303(d) impaired waters, and endangered or threatened species. To prevent collection or disturbance of sensitive species, endangered and threatened resources are not depicted in Figure 3.

Areas of Special Natural Resource Interest (ASNRI) include designated State natural resource areas, trout streams, outstanding or exceptional resource waters, wild rice waters, and other special or sensitive natural resource areas. ASNRI often include surface waters which are not significantly impacted by human activities and provide valuable fisheries, unique hydrological or geological features, outstanding recreational opportunities, or unique environmental settings. Although no outstanding or exceptional resource waters are located within the watershed, there are several Class 2 trout streams located within the watershed.

Impaired water bodies are degraded surface waters which are not meeting water quality standards or their potential uses, such as fishing and swimming, due to pollutants and poor water quality. The US Environmental Protection Agency requires each State to update its 303(d) impaired waters list every two (2) years. The lower segment of the Mullet River is 303(d) listed for excess phosphorus. Recently, the Wisconsin DNR decided to develop a Total Maximum Daily Load (TMDL) for the west shore of Lake Michigan, including the Mullet River Watershed. A TMDL development schedule has not yet been established by Wisconsin DNR.

The Mullet River has three (3) distinct river segments:

1. The lower Mullet River (River Mile 0.0 to 17.8) is a warm water segment that extends from the confluence of Sheboygan River to upstream of the STH 67 crossing located north of Plymouth. This 17.8-mile reach of the Mullet River is classified as a Warm Water Sport Fishery. This segment of the Mullet River is a 303(d) listed water body that is impaired by excess phosphorus. The Meyer Park and Mill Pond impoundments are located along this river segment.
2. The middle Mullet River (River Mile 17.8 to 23.7) is a cold water segment that extends from upstream of STH 67 to the confluence with Otter Pond, which is located just downriver of Glenbeulah. This 5.9-mile reach of the Mullet River is classified as a Class 2 Trout Fishery and contains natural springs. The Camp Evelyn Girl Scout impoundment is located along this river segment. The Northern Moraine Utility Commission WWTF discharges to groundwater, but is located along this middle river segment.
3. The upper Mullet River (River Mile 23.7 to 39.7) is a warm water segment that starts at Otter Pond near Glenbeulah and terminates at Mullet Lake. This 16.0-mile reach of the Mullet River is classified as a Warm Water Sport Fishery. The river segment runs through the Kettle Moraine State Forest, Mullet Creek State Wildlife Area, and Old Wade State Park. A dam forms the Glenbeulah Mill Pond, and two (2) additional impoundments are within the Mullet Creek Wildlife area.

Three (3) endangered species and ten (10) threatened species are located within the watershed. The endangered and threatened species are summarized in Table 2-2.

Table 2-2
Endangered & Threatened Species

| Common Name | Scientific Name | Type | Status |
|---|---|---|---|
| Cerulean Warbler | Dendroica cerulea | Bird | THR |
| Acadian Flycatcher | Empidonax virescens | Bird | THR |
| Hooded Warbler | Wilsonia citrina | Bird | THR |
| Red-shouldered Hawk | Buteo lineatus | Bird | THR |
| Queensnake | Regina septemvittata | Snake | END |
| Butler's Gartersnake | Thamnophis butleri | Snake | THR |
| Eastern Ribbonsnake | Thamnophis sauritus | Snake | END |
| Blanding's Turtle | Emydoidea blandingii | Turtle | THR |
| Slippershell Mussel | Alasmidonta viridis | Mussel | THR |
| Ellipse | Venustaconcha ellipsiformis | Mussel | THR |
| Rainbow Shell | Villosa iris | Mussel | END |
| Yellow Gentian | Gentiana alba | Plant | THR |
| Snow Trillium | Trillium nivale | Plant | THR |

## C. Soils

Soil information was obtained from the U.S. Department of Agriculture (USDA) Soil Survey of Sheboygan County and Fond du Lac County, Wisconsin. The USDA classified soil types into four (4) hydrologic soil groups (HSG). The four (4) hydrologic soil groups (i.e. A, B, C, and D) are classified according to the minimum infiltration rate of the soil column. Group A soils have the highest permeability rate or lowest runoff potential, whereas Group D soils have the lowest permeability rate or highest runoff potential. The HSGs are depicted in Figure 4.

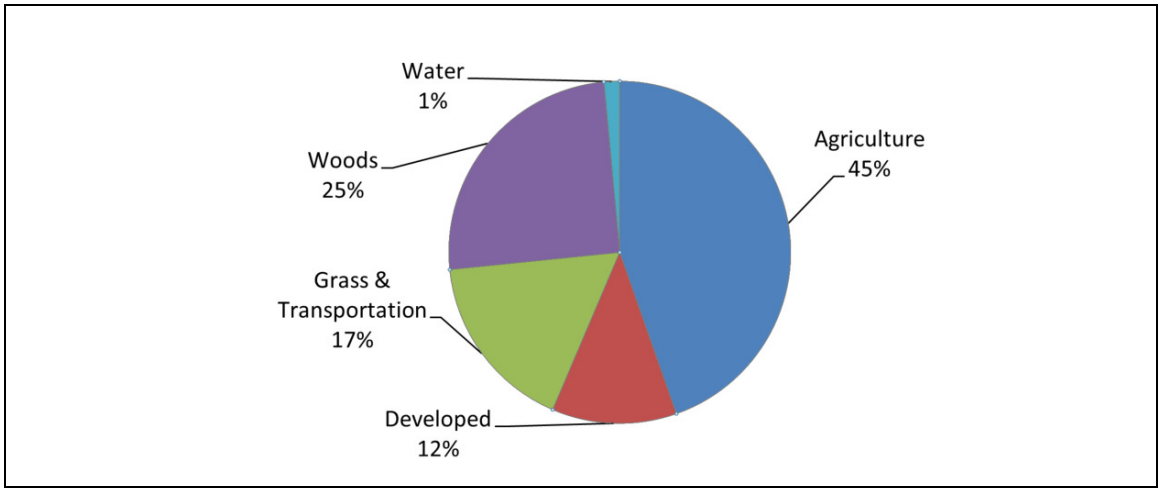
## D. Land Uses

Current land uses are depicted in Figure 5. Land uses within the City of Plymouth were obtained from the City. Land uses within other communities were obtained from the Bay Lakes Regional Planning Commission and Fond du Lac County. Current land uses for the entire HUC-10 Mullet River Watershed are summarized in Table 2-3 and Exhibit 2-3.

Table 2-3
Current Land Uses

| Land Use | Mullet River Watershed (acres) | | | | |
|---|---|---|---|---|---|
| | Upper | Middle | Lower | Total | |
| Agriculture | 6,420 | 5,067 | 11,216 | 22,703 | 45% |
| Developed | 487 | 1,643 | 3,872 | 6,002 | 12% |
| Grass & Transportation | 2,569 | 2,888 | 3,180 | 8,637 | 17% |
| Woods | 3,566 | 6,642 | 2,576 | 12,784 | 25% |
| Water | 295 | 265 | 195 | 754 | 1% |
| Total | 13,337 | 16,505 | 21,039 | 50,880 | 100% |

Exhibit 2-3
Current Land Uses




## III. WATERSHED INVENTORY

This watershed inventory identifies potential phosphorus sources within the portion of the Mullet River Watershed located upriver of the Blueberry Lane crossing. Potential phosphorus sources are classified as either point or non-point sources of pollution. Point source pollution originates from a single discrete source, such as a WWTF. Non-point source pollution originates from many diffuse sources. Non-point source pollution is generally caused by rainfall or snowmelt. During a rainfall or snowmelt, runoff picks up and carries away the pollutant and before depositing into a lake, river, stream, wetland, etc.

### A. Municipal WWTF Permit

A municipal WWTF is classified as point source pollution. There are two municipal WWTFs located within the Mullet River Watershed. The two municipal WWTFs locations are depicted in Figure 2 and are described as follows:

- The Northern Moraine Utility Commission WWTF provides wastewater treatment for Elkhart Lake, Crystal Lake, Glenbeulah, and Greenbush. Effluent from the Northern Moraine WWTF discharges to three (3) seepage ponds located along the Mullet River, just downriver of Glenbeulah. The Northern Moraine WWTF discharges to groundwater.
- The Plymouth WWTF provides wastewater treatment for the City of Plymouth. Effluent from the Plymouth WWTF discharges directly into the Mullet River, just south of CTH PP. The Plymouth WWTF discharges phosphorus to the Mullet River. These phosphorus discharges are discussed throughout this report, including potential compliance options.

The Plymouth WWTF currently discharges at an average P concentration of 0.41 mg/L. The Plymouth WWTF's permit limit is a P concentration of 0.075 mg/L. As such, based on current flows, the Plymouth WWTF needs to reduce P by 1,724 pounds per year [1.690 MGD x (0.41 mg/L – 0.075 mg/L) x 8.34 x 365 days/year = 1,724 lbs/year].

## B. Industrial Facility Permit

An industrial facility is classified as point source pollution. There are two (2) industrial facilities located within the Mullet River Watershed. The two (2) industrial facilities are described as follows:

- The Baker Cheese Facility is located at N5279 County Highway G, St. Cloud, Wisconsin. Baker Cheese has a WPDES Permit from the Wisconsin DNR. The industrial facility is located in the Fond du Lac County portion of the Mullet River Watershed.
- The Sartori Foods Facility is located at 12 West Main Street, Plymouth, Wisconsin. Sartori discharges non-contract cooling water and reverse osmosis water into the Mullet River via the City of Plymouth's storm sewer system. The industrial facility is located in the Sheboygan County portion of the Mullet River Watershed. The phosphorus discharge from Sartori is approximately 61 pounds per year. Representatives from the City of Plymouth, Sartori Foods, and McMahon Associates, Inc. already met to discuss partnering opportunities.

## C. General WPDES Permit

A General WPDES Permit is classified as point source pollution. General WPDES Permits are issued for a variety of sources and activities, including non-metallic mining, industrial site stormwater, and construction site stormwater. Most of these permits include standard conditions or require the use of standard best management practices for compliance.

## D. Municipal Stormwater Permit (Urban)

A Municipal Stormwater Permit is classified as point source pollution. The Wisconsin DNR issues a WDPES Municipal Stormwater Permit to a municipality if the municipality is connected to an urbanized area that has a population of 50,000 or more. The Wisconsin DNR also issues a Municipal Stormwater Permit to an isolated municipality if the municipality has a population of 10,000.

No permitted municipalities are located within the watershed. Developed urban areas within the watershed are dispersed. The City of Plymouth is the most populated municipality with a 2017 population of 8,455. When the City reaches the 10,000-population threshold, the Wisconsin DNR will likely issue a WPDES Municipal Stormwater Permit to the City of Plymouth.

## E. Non-Regulated Urban Stormwater

Non-regulated urban stormwater is classified as non-point source pollution. Each municipality located within the watershed is currently classified as non-regulated urban stormwater. As shown in Figure 2, the following Sheboygan County municipalities are partially located within the watershed: City of Plymouth, Village of Elkhart Lake, Village of Glenbeulah, Town of Greenbush, Town of Lyndon, Town of Plymouth, and Town of Rhine. The following Fond du Lac County municipalities are also partially located within the watershed: Town of Forest and Town of Osceola. Urban areas within the City of Plymouth with a high risk for phosphorus loss will be identified in 2019 as part of the City-Wide Stormwater Management Plan.

## F. CAFO Permit

A Concentrated Animal Feeding Operation (CAFO) is classified as point source pollution. The Wisconsin DNR issues a WDPES Permit to a farm in which 1000 animal units or more are raised in confinement. CAFOs are essentially large animal raising operations. No permitted CAFO operations are currently located within the watershed.

## G. Barnyards

Barnyards are classified as non-point source pollution, unless the farm operation is large enough to be classified a CAFO. Barnyards are the portion of a farm where animals are concentrated when not located in a pasture or field. Barnyards can contain significant amounts of manure due to the concentration of animals within the barnyard. Farm buildings and water sources are typically located in close proximity to the barnyard for purposes of feed storage, animal watering, etc. Barnyards can be a significant source of phosphorus. Barnyards with a high risk for phosphorus loss will be identified during implementation. During implementation, barnyards will be inventoried and evaluated using one or more of the following techniques: available information on file with the County, windshield observations, and/or site meetings with landowners. The NRCS BARNY spreadsheet tool will be used to estimate phosphorus loads and potential phosphorus reductions associated with potential best management practices. Best management practices will be ranked based on phosphorus load and cost-effectiveness. The City will focus its implementation efforts on higher ranked barnyards.

## H. Cropland

Cropland is classified as non-point source pollution. The potential for phosphorus discharge from a cropland area varies with crop type, drain tiles, phosphorus soil tests, erosion potential, etc. There are many variables that influence the phosphorus discharge from a field. During implementation, cropland will be evaluated using one or more of the following techniques: reviewing nutrient management plans on file with the County, SNAP-Plus evaluations, and/or site meetings with landowners. These techniques will be used to estimate phosphorus loads and potential phosphorus

reductions associated with potential best management practices. Best management practices will be ranked based on phosphorus load and cost-effectiveness. The City will focus its implementation efforts on higher ranked cropland.

1. Crop Types

Table 3-1 summarizes cropland acres located upriver of the Blueberry Lane river crossing. The acres of each crop were approximated using the 2014 Wisconsin Agricultural Statistics for Sheboygan County. The proposed crop types and rotations were discussed with the Sheboygan County for reasonableness.

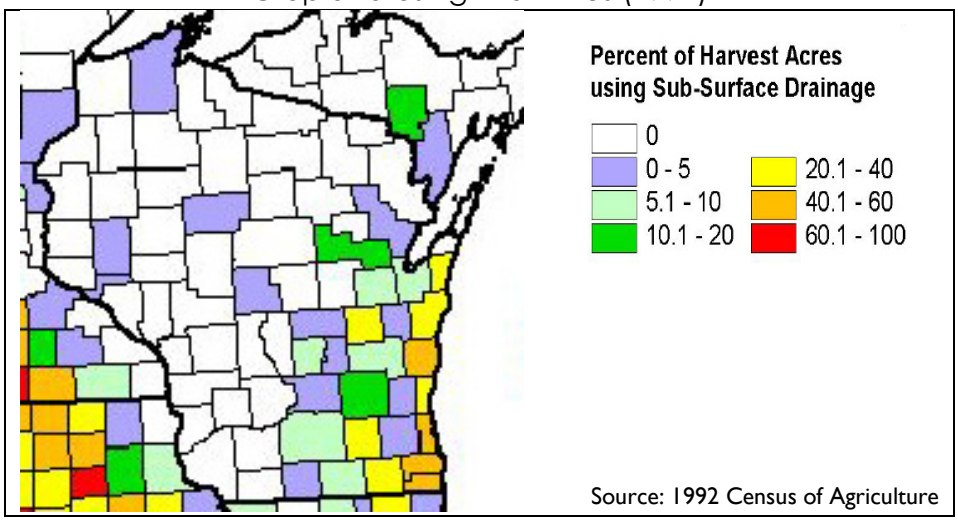
Table 3-1
Crop Types

| Upriver of Location | Crop (acres) | | | | | |
|---|---|---|---|---|---|---|
| | Corn Grain | Corn Silage | Soybean | Wheat | Hay | Total |
| City Station 17 (Blueberry Lane) | 3,463 | 3,080 | 2,922 | 1,457 | 2,717 | 13,639 |
| | 25% | 23% | 21% | 11% | 20% | 100% |

2. Drain Tile

As part of the 1992 Census of Agriculture, NRCS collected data to assess soil and water trends on cropland. Exhibit 3-1 depicts the percent of cropland with drain tiles in each county, including Sheboygan County and Fond du Lac County. Based on Exhibit 3-1, the weighted average percent of cropland with drain tiles in the Mullet River Watershed is estimated to be 37%. The 37% estimate agrees with information from the Sheboygan County Planning and Conservation Department.

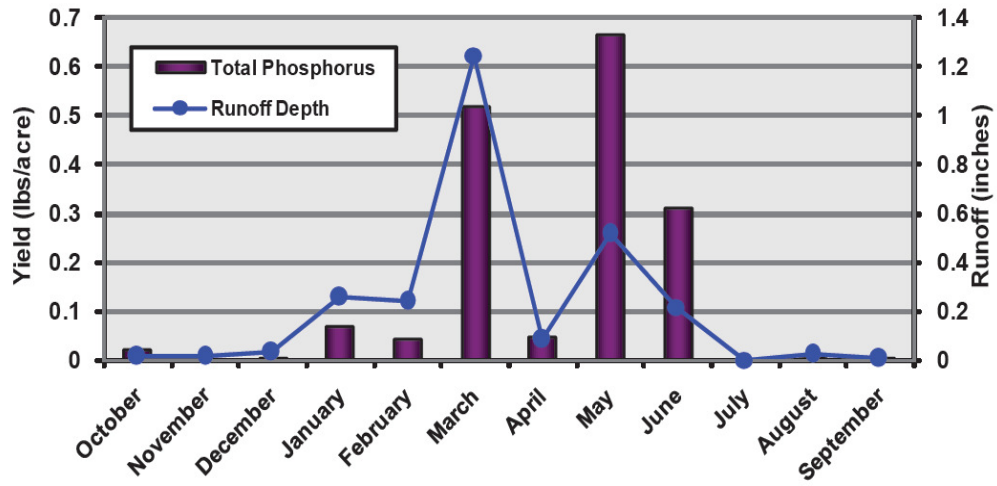
Exhibit 3-1
Cropland Using Drain Tiles (1992)



UW - Discovery Farms conducted scientific research at Pagel's Ponderosa Dairy (PPD) in Kewaunee County, Wisconsin. As part of the research, edge of field surface flows and drain tile flows were sampled. The study included three (3) drainage areas which were 20.5, 22.1, and 13.2 acres in size. Alfalfa was grown during field year 2004 and corn silage was grown during field years 2005 to 2008. As shown in Exhibit 3-2, phosphorus loss was highest during March, May, and June.

Exhibit 3-2

Average Surface Phosphorus Loss by Month

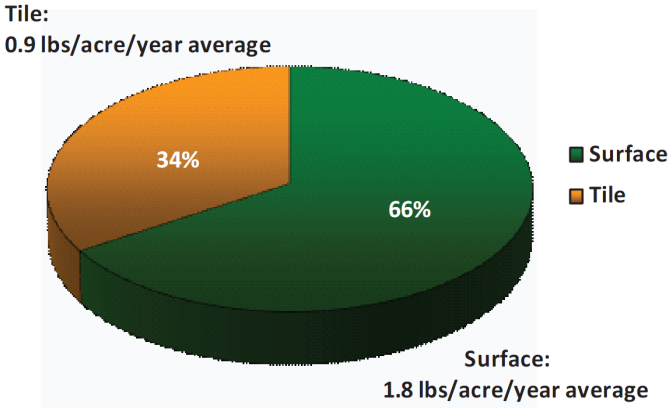



Source: Cooley, 2010

As shown in Exhibit 3-3, the drain tile phosphorus loss at PPD was 34% of the total loss. The surface loss was the most dominant phosphorus delivery pathway during field years 2005 to 2008. A corn silage crop was planted during field years 2005 to 2008. Field year 2004, which was an alfalfa crop, was not included in the Exhibit 3-2 and 3-3 results.

Exhibit 3-3

Average Phosphorus Loss in Surface & Drain Tile




Source: Cooley, 2010

Drain tile phosphorus loss is influenced by preferential flow paths through the soil profile. Preferential flow paths are formed by earthworms, decayed roots, soil cracks, and soil porosity. A preferential flow path provides a direct conduit between the soil surface and the drain tile for water, sediment, and phosphorus movement. Drain tile surface inlets can also provide a direct conduit. Preferential flow path risks can be reduced with precision manure/fertilizer applications (avoid tiles), soil tillage to disrupt preferential flow paths, installation of drain tile plugs, and other practices.

Drain tile phosphorus loss is a significant contribution. BMPs installed to reduce surface phosphorus loss may increase the drain tile phosphorus loss. Also, depending on the BMP type, BMPs installed to reduce drain tile phosphorus loss may increase the surface phosphorus loss.

3. Phosphorus Soil Tests

The University of Wisconsin - Madison mapped phosphorus soil tests within each county using available data from Department of Agriculture, Trade and Consumer Protection (DATCP) approved laboratories. Between years 2005 and 2009, the DATCP approved laboratories analyzed 1,079,408 soil samples from 403,708 fields. Exhibit 3-4 indicates the Statewide average soil phosphorus level was 51 parts per million (ppm) during the 2005 to 2009 period.

A closer review of Exhibit 3-4 indicates the average soil phosphorus level for Sheboygan County is 46 ppm and Fond du Lac County is 44 ppm. Using these average values, the weighted average soil phosphorus level within the Mullet River Watershed was 45 ppm during the 2005 to 2009 period. Recently, the Sheboygan County calculated a 34 ppm average soil phosphorus level from three (3) nutrient management plans located in the Mullet River Watershed. The three (3) nutrient management plans include 117 fields and comprise 1,040 acres. A more detailed inventory is needed to accurately predict average soil P levels.

The University of Wisconsin Extension (UW-Extension) developed recommended phosphorus soil test levels for agricultural crops and soil types in Wisconsin. The optimum soil test range depends on the following: type of crop, phosphorus contribution from subsoil, and soil type. Table 3-2 summarizes the recommended phosphorus soil test levels for crops typically planted within the Mullet River Watershed. Maintaining phosphorus and other elements within the optimum soil test range reduces the potential for environmental risks, while maintaining the likelihood of a good crop yield (Kelling, 1999). Based on Table 3-2, an average phosphorus soil test of 25 ppm appears to be the optimum for the typical crops in the Mullet River Watershed.

Exhibit 3-4
Wisconsin Phosphorus Soil Tests (2005 - 2009)

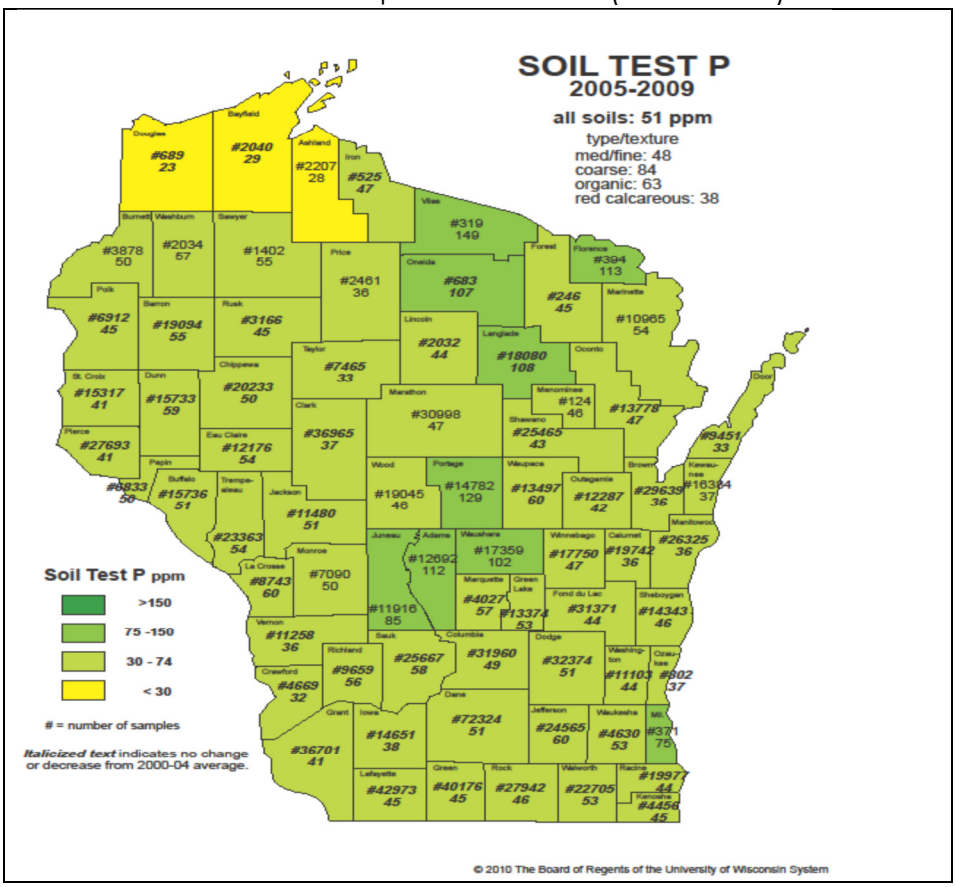



Table 3-2
Optimum Phosphorus Soil Tests

| Crop | Phosphorus Soil Test (ppm) | | | | |
|---|---|---|---|---|---|
| | Very Low | Low | Optimum | High | Very High |
| Corn | < 10 | 10 - 15 | 16 - 20 | 21 - 30 | > 30 |
| Hay (Alfalfa) | < 12 | 12 - 17 | 18 - 25 | 26 - 35 | > 35 |
| Hay (Red Clover) | < 12 | 12 - 17 | 18 - 23 | 24 - 30 | > 30 |
| Soybeans | - | <8 | 8 - 13 | 14 - 23 | > 23 |
| Wheat | < 12 | 12 - 17 | 18 - 25 | 26 - 35 | > 35 |

During implementation, phosphorus soil tests will be inventoried using one or more of the following techniques: reviewing nutrient management plans on file with the County and/or performing field soil sampling. These techniques will be used to estimate phosphorus loads and potential phosphorus reductions associated with potential best management practices. Best management practices will be ranked based on phosphorus load and cost-effectiveness. The City will focus its implementation efforts on higher ranked cropland areas and fields with higher soil phosphorus levels.

4. Erosion Vulnerability

The Wisconsin DNR developed a GIS based watershed tool to evaluate erosion potential within cropland. The Erosion Vulnerability Assessment for Agricultural Lands (EVAAL) provides a graphic depiction of cropland areas with high erosion vulnerability. EVAAL results can be cross referenced with phosphorus soil tests or SNAP-Plus results to identify cropland areas with high potential for phosphorus loss or that may benefit from a grass waterway. EVAAL results for a portion of the watershed are provided in Appendix C. EVAAL results will be developed for the remaining areas, as needed.

5. Phosphorus Discharge – Conventional Tillage

The SNAP-Plus (Soil Nutrient Application Planner) software was used to evaluate phosphorus discharges for cropland. The SNAP-Plus software is used by cropland producers to manage nutrients, particularly as it relates to manure and fertilizers. SNAP-Plus results for conventional tillage are provided in Appendix D.

## I. Streambanks

Streambank erosion is classified as a non-point source of pollution. The potential for P discharge from an eroded or unstable streambank varies with recession rate, soil type, P soil tests, etc. There are many variables that influence the P discharge from an eroded or unstable streambank. Streambanks with high P loss potential will be identified during implementation.

During implementation, streambanks will be inventoried and evaluated using one or more of the following techniques: available information on file with the County, windshield observations, and/or stream walks. The NRCS stream erosion lateral recession rate will be used to estimate phosphorus loads and potential phosphorus reductions associated with potential streambank restoration. Best management practices will be ranked based on phosphorus load and cost-effectiveness. The City will focus its implementation efforts on higher ranked stream restoration projects.

## J. Dam Impoundments

There are several dams along the Mullet River. The dams serve a variety of purposes, such as recreational, historical and wetland restorations. The dams can also trap P and increase water temperatures, which can result in sediment dredging and impairments, such as algae.

A comprehensive management plan for the City of Plymouth Mill Pond is provided in Appendix E. The plan was funded through a Wisconsin DNR Lake Planning Grant. The plan evaluates alternatives for the dam impoundment and associated open water area.

Table 3-3
Dam Impoundments

| Dam Name | Hydraulic Height | Owner |
|---|---|---|
| G Flowage, Mullet Creek State Wildlife Area | 3 feet | Wisconsin DNR |
| Steffes Flowage, Mullet Creek State Wildlife Area | 3 feet | Wisconsin DNR |
| Mullet Marsh Dam | 1 foot | Wisconsin DNR |
| Wade House Dam | n/a | Wis. Historical Society |
| Glenbeulah Dam | 12 feet | Village of Glenbeulah |
| Camp Evelyn Dam | 6 feet | Girl Scout Assn. |
| Plymouth Mill Pond Dam | 9 feet | City of Plymouth |

## IV. LOAD REDUCTION GOAL & PERMIT TERMS

The Adaptive Management (AM) Action Area is depicted in Figure 2, which includes the portion of the Mullet River Watershed that is located upriver of the Blueberry Lane river crossing (located near Plymouth WWTF effluent). The downriver location for the AM Action Area is tentatively set at the Blueberry Lane crossing, since the City has previous river sampling data at this road crossing.

### A. River Sampling

From 2013 to 2015, the City obtained grab samples from the Mullet River at various locations. A summary of the sampling results is provided in Tables 4-1 and 4-2 for the two (2) sampling locations depicted in Figure 1. As shown in Tables 4-1 and 4-2, the river's six-month total phosphorus concentration for years 2013 to 2015 was an average of 0.10 mg/L upriver of the City's WWTF discharge and 0.14 mg/L downriver of the City's WWTF discharge. Blueberry Lane is the first public road crossing of the Mullet River that is located downriver of the City's WWTF. Blueberry Lane provides a convenient sampling location that is also far enough downriver of the City's WWTF, such that adequate phosphorus mixing occurs in the river. Additional sampling results are provided in Appendix F.

Table 4-1
River Sampling Data at City Station 15 (Short Cut Road)

| City Station 15: Upriver of WWTF (Short Cut Rd) | Average Total Phosphorus Concentration (mg/L) | | | | | | |
|---|---|---|---|---|---|---|---|
| | May | June | July | Aug. | Sept. | Oct. | 6 Month (May to Oct) |
| 2013 | 0.06 | 0.08 | 0.10 | 0.08 | 0.08 | 0.07 | 0.08 |
| 2014 | 0.08 | 0.11 | 0.10 | 0.11 | 0.06 | 0.06 | 0.09 |
| 2015 | 0.12 | 0.11 | 0.11 | 0.19 | 0.19 | - | 0.14 |
| Average | 0.09 | 0.10 | 0.10 | 0.13 | 0.11 | 0.07 | 0.10 |

Table 4-2
River Sampling Data at City Station 17 (Blueberry Lane)

| City Station 17: Downriver of WWTF (Blueberry Ln) | Average Total Phosphorus Concentration (mg/L) | | | | | | |
|---|---|---|---|---|---|---|---|
| | May | June | July | Aug. | Sept. | Oct. | 6 Month (May to Oct) |
| 2013 | 0.11 | 0.12 | 0.16 | 0.15 | 0.13 | 0.13 | 0.14 |
| 2014 | 0.08 | 0.12 | 0.11 | 0.11 | 0.09 | 0.10 | 0.10 |
| 2015 | 0.20 | 0.18 | 0.18 | 0.21 | 0.18 | - | 0.19 |
| Average | 0.13 | 0.14 | 0.15 | 0.16 | 0.14 | 0.12 | 0.14 |

The Wisconsin DNR obtained grab samples from the Mullet River at Station 603253, which is located just east of the County Highway M bridge crossing. Sampling at this location was performed once each month between October 25, 2006 and September 10, 2007. This is the most recent Wisconsin DNR sampling data that is available near the City's WWTF discharge. Using this 2006 to 2007 data, the NR 217 rolling median total phosphorus was calculated by Wisconsin DNR to be 0.154 mg/L.

During implementation, the City will perform river sampling in accordance with the DNR guidance documents titled "Guidance for Implementing Wisconsin's Phosphorus Water Quality Standards for Point Source Discharges (dated February 8, 2017)" and/or "Adaptive Management Technical Handbook (dated January 7, 2013)".

## B. Required Phosphorus Load Reduction

The Plymouth WWTF discharges into the Mullet River between the two (2) sampling stations summarized in Tables 4-1 and 4-2. The Short Cut Road station is located upriver of the Plymouth WWTF and the Blueberry Lane station is located downriver of the Plymouth WWTF. The Plymouth WWTF effluent characteristics are summarized in Table 1-1. For convenience, average flows and P concentrations for the Plymouth WWTF and Mullet River are as follows:

- Plymouth WWTF avg. effluent flow (2014-2016) = 1.690 MGD
- Plymouth WWTF avg. P effluent concentration (2014-2016) = 0.41 mg/L
- Mullet River avg. flow at Blueberry Lane (PRESTO 50% flow exceedance) = 20.70 cfs = 13.38 MGD
- Mullet River avg. P concentration at Blueberry Lane (City sampling 2013-2015) = 0.14 mg/L
- Mullet River water quality criterion for P = 0.075 mg/L
- Unit conversion = 8.34

Using Wisconsin DNR guidance for Adaptive Management, the required phosphorus load reduction for the Mullet River at Blueberry Lane is calculated as follows:

- Step 1: Calculate current P load from WWTF.
  1.690 MGD x 0.41 mg/L x 8.34 x 365 days/year = 2,109 lbs/year
- Step 2: Calculate current P load in river at Blueberry Ln (downriver of WWTF).
  13.38 MGD x 0.14 mg/L x 8.34 x 365 days/year = 5,702 lbs/year
- Step 3: Calculate allowable P load in river at Blueberry Ln (downriver of WWTF).
  13.38 MGD x 0.075 mg/L x 8.34 x 365 days/year = 3,055 lbs/year
- Step 4: Calculate required P load reduction in river at Blueberry Ln (downriver of WWTF).
  5,702 lbs/year – 3,055 lbs/year = 2,647 lbs/year (46% P reduction)

For purposes of Adaptive Management, the total phosphorus load reduction required for the Mullet River at Blueberry Lane is 2,647 pounds per year.

The Adaptive Management Plan can extend over a 15 to 20-year period. The Plymouth WWTF effluent needs to satisfy the interim limits of 0.6 mg/L in the first 5-year permit term and 0.5 mg/L in the second and third 5-year permit terms. Within the Mullet River, the 0.075 mg/L water quality criterion needs to be achieved in the fourth 5-year permit term or the Plymouth WWTF needs to satisfy the 0.075 mg/L Water Quality Based Effluent Limit.

A portion of the 2,647 pound per year phosphorus reduction must be achieved in each 5-year permit term, such that the river experiences steady water quality improvement during the 15 to 20-year period. Water quality improvements in the river can be achieved through point source reductions, non-point source reductions, or a combination of point and non-point source reductions. Using Wisconsin DNR guidance for Adaptive Management, the minimum phosphorus reduction required for each of the 5-year permit terms is calculated as follows:

- Step 1: Calculate WWTF's percent contribution of current P load.
  2,109 lbs/year ÷ 5,702 lbs/year = 37.0%
- Step 2: Calculate WWTF's min. required P load reduction during first 5-year permit term.
  2,647 lbs/year x 37.0% = 979 lbs/year

For the first permit term, the Plymouth WWTF will need to reduce P by at least 979 pounds per year. The P reduction will be achieved through implementation of point and non-point source management practices identified within this Adaptive Management Plan. Computer models, such as SNAP-Plus and BARNY, will be used to calculate P reductions associated with agricultural sources. WinSLAMM will be used to calculate P reductions associated with urban sources. If management practices implemented during the first 5-year permit term do not show water quality improvement within the

Mullet River, the Adaptive Management Plan will be modified to offset additional P load in the subsequent 5-year permit terms.

After achieving a 979 pound per year reduction in the first 5-year permit term, an approximate 1,668 pounds per year reduction will be needed within the Mullet River during the two (2) remaining 5-year permit terms (2,647 lbs/year - 979 lbs/year = 1,668 lbs/year). The P reduction required within the two (2) remaining 5-year permit terms is calculated to be 834 pounds per year (1,668 lbs/year ÷ 2 remaining permit terms = 834 lbs/year). The estimated P reduction by permit term is summarized in Table 4-3.

Table 4-3
Phosphorus Reduction by 5-Year Permit Term

| Permit Term | P Reduction (lbs/year) |
|---|---|
| 1 | 979 |
| 2 | 1,813 |
| 3 | 2,647 |

The Plymouth WWTF currently discharges at average P concentration of 0.41 mg/L and the WWTF's permit limit is a P concentration of 0.075 mg/L. As such, the Plymouth WWTF needs to reduce P by 1,724 pounds per year [1.690 MGD x (0.41 mg/L – 0.075 mg/L) x 8.34 x 365 days/year = 1,724 lbs/year].

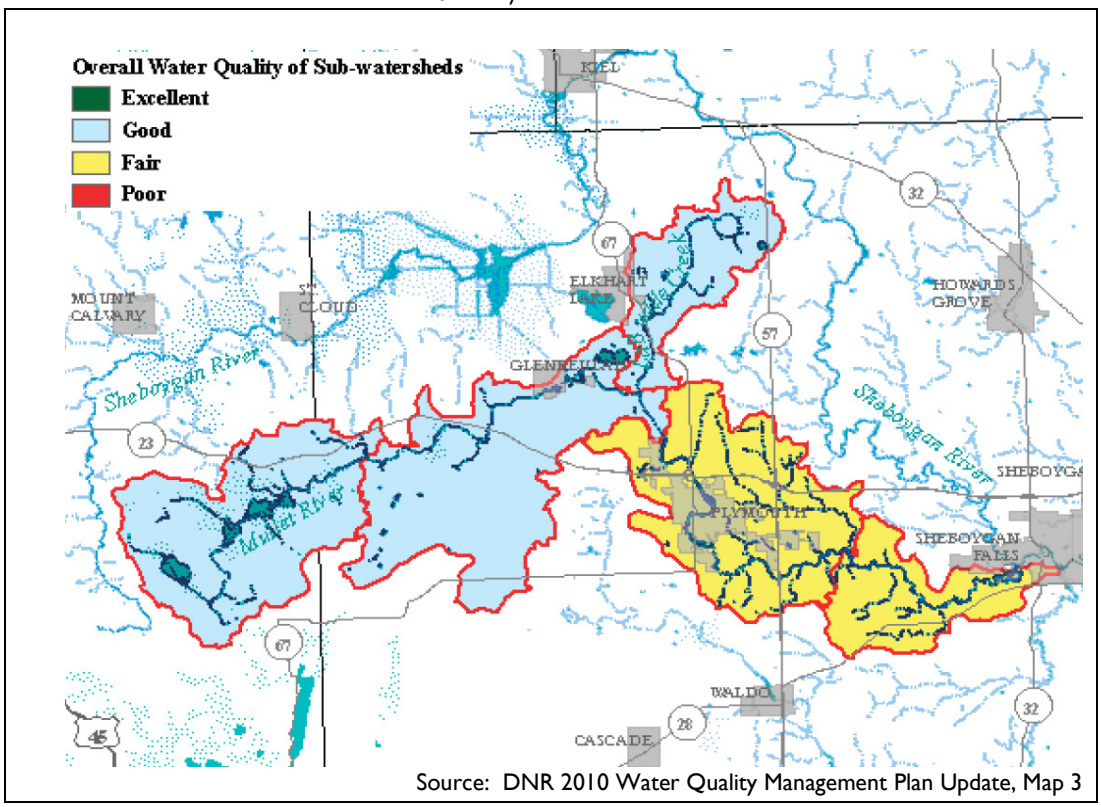
## V. MANAGEMENT PRACTICES & ANALYSIS

Point and non-point source management practices will be used to reduce P loads discharging to the Mullet River by 46%. During implementation, P load reductions provided by potential best management practices will be ranked based on P load, P load reduction, and cost-effectiveness of P load reduction. Higher ranked projects and critical areas with higher P load reductions will be used to focus the City's implementation efforts. The City will also focus its implementation efforts on cost-effective projects supported by both landowners and/or stakeholders.

As shown in Figure 5-1, the Wisconsin DNR's 2010 Water Quality Management Plan indicates the portion of the Lower Mullet River has the poorest water quality. As such, the portion of the Lower Mullet River Sub-Watershed located in the Action Area will likely be more extensively targeted for management practices due to its closer proximity to the City. Also, the effects of pollutant transport and impoundments have less of an influence if the pollutant reductions occur closer to the Plymouth WWTF effluent.

Exhibit 5-1

Overall Water Quality in Mullet River Watershed




Source: DNR 2010 Water Quality Management Plan Update, Map 3

Potential phosphorus load reduction locations and management practices for the Plymouth WWTF Adaptive Management Plan and Mullet River Action Area are described herein.

## A. WWTF Practices & Costs

The Plymouth WWTF discharges to the Mullet River, so modifications or optimization of the Plymouth WWTF will benefit the Adaptive Management initiative. The Plymouth WWTF currently discharges about 2,109 pounds of P per year into the Mullet River. The Plymouth WWTF can likely be optimized to a 0.3 mg/L effluent P concentration with the addition of a second chemical feed. Optimizing to a 0.3 mg/L effluent P concentration is anticipated to provide a 566 pound per year P reduction in the Mullet River.

Sartori Foods discharges non-contract cooling water and reverse osmosis water into the City of Plymouth's storm sewer. Sartori Foods currently discharges about 61 pounds of P per year into the Mullet River. The City understands that Sartori Foods intends to meet their 0.075 mg/L P effluent limit. As such, some P reduction will be associated with reducing the Sartori Foods P discharge. The City will continue communicating with Sartori Foods to determine their anticipated P reduction.

Other potential WWTF upgrades that reduce phosphorus discharges to the Mullet River are limited. As previously described, the Northern Moraine WWTF does not discharge into the Mullet River, but rather into three seepage ponds and eventually groundwater.

## B. Agriculture Management Practices & Costs

Potential agricultural Best Management Practices (BMPs) that reduce phosphorus discharges from agriculture sources are described as follows, including potential costs. The costs include the 2015 EQIP unit prices plus a 20% incentive cost for future repairs, a 10% contingency cost for EQIP shortages, and a 20% WQT transaction cost for administrative and legal. The present value costs for the cropland management practices are presented for the same 20-year facility-planning period that is used for WWTFs. This approach allows a more direct comparison of the NR 217 compliance options. The agricultural practices are as follows:

1. Soil Health (Nutrient Management Plan)

The purpose of soil health is to manage soils as a resource such that the soil has continued capacity to sustain plants, animals, and humans for future generations. Nutrient management is a practice that can help improve soil health on cropland. Nutrient management planning identifies if adequate phosphorus is available for crop growth and also helps to monitor the stabilizing of phosphorus soil tests or the progressive lowering of phosphorus soil tests to 25 ppm using manure management, fertilizer management, and plant harvesting. Phosphorus soil tests influence phosphorus loss to surface waters. As part of nutrient management planning, phosphorus soil tests are typically completed in 4-year cycles. For this study, the estimated cost for nutrient management planning is $28 per acre for a typical 4-year cycle or $7 per acre per year. Cropland areas currently operating with a nutrient management plan will be inventoried, as needed, to assist with targeting specific fields during implementation.

2. Soil Health (Mulch Till)

Mulch till is a management practice that can help improve soil health on cropland. Mulch till is a conservation system for tillage and planting that disturbs the full-width soil surface prior to planting. Mulch till also provides a crop residue such that 30% or more of the soil surface remains covered after planting (*EPA, 2007*). For this study, the estimated cost for mulch till is $18 per acre per year. Based on SNAP-Plus modeling, mulch tillage is estimated to provide 1 pound per year of P reduction on average in the Mullet River Watershed.

SNAP-Plus was used to evaluate phosphorus reduction benefits of converting conventional tillage to mulch tillage on cropland. SNAP-Plus results for conventional tillage are provided in Appendix D. The SNAP-Plus phosphorus reduction results associated with converting from conventional tillage to mulch

tillage are provided in Appendix G. These results can be used to target specific fields during implementation.

3. Soil Health (No Till or Zone Till)

No till is a management practice that can help improve soil health on cropland. No till is a conservation system for tillage and planting that does not disturb the soil from harvest to planting, except for strips up to 15% of the row width. No till also maintains crop residue such that greater than 85% or more of the soil surface remains covered after planting.

Zone till (strip till) is a management practice that can also help improve soil health. Zone till is a conservation system for tillage and planting that does not disturb the soil from harvest to planting, except for strips up to 30% of the row width. Zone till also maintains crop residue such that greater than 70% or more of the soil surface remains covered after planting.

No till and zone till may be at odds with the preferential flow path concerns associated with agricultural drain tiles. No till and zone till may not provide enough soil disturbance to break up preferential flow paths within the soil profile. Preferential flow paths can provide a direct conduit for water, sediment, and phosphorus movement between the soil surface and drain tile. For this study, the estimated cost for no till and zone till is $23 per acre per year. Based on SNAP-Plus modeling, no till and zone till are estimated to provide 3 pounds per year of P reduction on average in the Mullet River Watershed.

SNAP-Plus was used to evaluate phosphorus reduction benefits of converting conventional tillage to no or zone tillage on cropland. SNAP-Plus results for conventional tillage are provided in Appendix D. The SNAP-Plus phosphorus reduction results associated with converting from conventional tillage to no or zone tillage are provided in Appendix H. These results can be used to target specific fields during implementation.

4. Soil Health (Cover Crops)

Cover crops are a management practice that can help improve soil health on cropland. Cover crops are typically used for low residue crops. A cover crop of rye can be planted after corn silage, soybean, and other crops are harvested in the fall (*EPA, 2007*). For this study, the estimated cost for a cover crop is $71 per acre per year. Based on SNAP-Plus modeling, cover crops are estimated to provide 1.4 pounds per year of P reduction on average in the Mullet River Watershed.

EVAAL results can be cross-referenced with phosphorus soil tests or SNAP-Plus results to identify cropland areas with high potential for phosphorus loss or that

may benefit from cover crops. EVAAL results for a portion of the watershed are provided in Appendix C. EVAAL results will be developed for the remaining areas, as needed.

5. Prairie Restorations

Prairie restorations are a management practice that removes cropland from production. The cropland is planted in a perennial grass cover that is no longer farmed. The prairie restoration remains in place for several years or ideally, for the duration of the 20-year facility-planning period. The primary disadvantage with prairie restoration is that the management practice removes the cropland from production. Prairie restorations are very effective at rebuilding soil health and improving water quality. The life span of a prairie is estimated to be ten (10) years. The estimated cost is $862 per acre per year of prairie area, which includes an allowance land rental and lost net income from cropping the prairie area. Based on SNAP-Plus modeling, prairie restorations are estimated to provide 4 pounds per year of P reduction on average in the Mullet River Watershed.

EVAAL results can be cross referenced with phosphorus soil tests or SNAP-Plus results to identify cropland areas with high potential for phosphorus loss or that may benefit from prairie restorations. EVAAL results for a portion of the watershed are provided in Appendix C. EVAAL results will be developed for remaining areas, as needed.

6. Grass Waterways

A grass waterway is a management practice that stabilizes erosion prone waterways within cropland areas. The grass waterway used in conjunction with a cover crop or conservation tillage practice can reduce the trade ratio. The primary disadvantage of grass waterways is that the management practice removes some cropland from production. The estimated cost to initially establish a grass waterway is $169 per acre of cropland area. The life span of a grass waterway is estimated to be ten (10) years. The estimated cost is $38 per acre per year of cropland area (not grass waterway area), which includes an allowance land rental and lost net income from cropping the grass waterway area. It may not be necessary to include lost net income from cropping since the crop production is likely marginal in a waterway.

EVAAL results can be used to identify cropland areas that may benefit from grass waterways. EVAAL results for a portion of the watershed are provided in Appendix C. EVAAL results will be developed for remaining areas, as needed.

7. Vegetated Buffers

Vegetated buffers or filter strips (30 foot width) can be installed on both sides of streams that pass through cropland or farmsteads. The primary disadvantage of buffer or filter strips is that the management practice removes some cropland from production. The estimated cost to initially establish a filter strip is $680 per acre of filter strip area. The life span of a filter strip is estimated to be ten (10) years. The estimated cost is $70 per acre per year of cropland area (not filter strip area), which includes an allowance for land rental and lost net income from cropping the filter strip area.

EVAAL and SNAP-Plus results will be used to identify cropland areas with high potential for phosphorus loss or that may benefit from vegetated buffers. EVAAL results for a portion of the watershed are provided in Appendix C. EVAAL results will be developed for remaining areas, as needed. SNAP-Plus results for conventional tillage are provided in Appendix D.

8. Wetland Restoration

Wetlands can provide water quality, flood control and habitat benefits. Wetlands are effective at settling out and retaining sediment and phosphorus for both cropland and farmsteads. However, the capacity of wetlands to remove dissolved phosphorus is more limited. The primary removal mechanisms for dissolved phosphorus are adsorption to soil minerals, uptake by plants, and accumulation in organic matter. Fine-textured clay soils and soils with high organic content have more adsorption capacity for retaining nutrients. Available aluminum and iron in the soil also enhances phosphorus removal. Since drain tiles typically discharge into rivers and streams, wetland restorations may be most effective along these corridors. Wetland restorations along stream corridors have the potential to improve habitat and increase the corridor width, which may also create potential recreational opportunities. Wetlands within the center of an agricultural field may pose operational challenges for the crop producer.

For effective treatment, wetlands require a significant amount of land area. On a per unit area basis, wetlands are not particularly efficient at phosphorus reduction. With high loading rates, adsorption sites within the wetland become saturated and there is insufficient capacity. For optimal performance the wetland surface area should be 5% of the wetland's tributary drainage area. Depending on phosphorus inflows and operation / maintenance activities, a 60% phosphorus reduction is feasible for a wetland.

For purpose of this analysis, the wetland land requirements were assumed to be 7% of the wetland's tributary drainage area, which includes 5% for the wetland's surface area and 2% for other items such as side slopes, berms, and

access routes. The primary disadvantage of a wetland is that the management practice removes cropland from production. The estimated cost for a wetland is $15,000 to $45,000 per BMP acre.

It is noteworthy that a wetland can potentially release phosphorus, particularly if constructed on soils with significant amounts of legacy phosphorus. There are also instances where overloaded wetlands have become phosphorus sources. Accumulation of legacy phosphorus is also a concern for other management practices besides wetlands.

9. Streambank Restoration

Stream bank erosion, slumping, fallen trees, significant bank recession rates, and severe meanders can be unstable. Increased runoff during storms can also contribute to erosion and bank instability. Removing fallen trees, stabilizing stream banks, and improving vegetation along a stream corridor can reduce both soil erosion and P discharges. Some stream segments may not be easily accessible. The estimated cost and life span for stream restoration practices can vary significantly. These costs will be based on a case-by-case basis. Streams with high risk for phosphorus loss will be inventoried and targeted.

10. Other Agricultural Practices

Other agricultural BMPs include barnyard runoff control practices, milk house practices, manure storage, manure digesters, gypsum, cropland drain tile management, drain tile bioreactors, cropland critical plantings, etc. At this time, a good inventory of farmsteads and animal units is not available within the Mullet River Watershed. Also, some of these practices do not yet have NRCS Technical Standards.

## C. Urban Management Practices & Costs

Potential urban Best Management Practices (BMPs) that reduce phosphorus discharges from stormwater sources in the City of Plymouth are described as follows. A brief description of each BMP is provided, including potential costs.

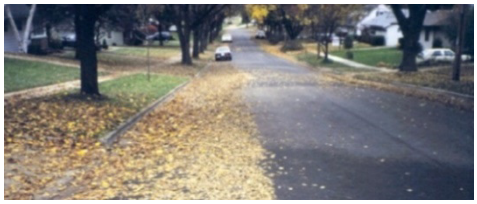
1. Street Sweeping

Street sweeping is effective at collecting large sediment particles (sand sized particles), trash, debris, spring seed fall, and autumn leaf fall. Limited pollutant removal occurs for fine-grained particles such as silt, clay and other small organic matter. The benefits of sweeping are significantly reduced when vehicles are parked along the curb. Street pollutants tend to accumulate within a few feet of the street's curb and gutter. Wind from traffic tends to blow pollutants toward the curb. The curb acts as a barrier and traps pollutants. For

streets without curb, wind from a passing vehicle tends to blow pollutants onto the adjacent grass.

The urban baseline phosphorus load includes a nominal phosphorus reduction for high-efficiency street sweeping twice per year along curb and gutter streets without parking controls. In order to avoid double counting, the pollutant reduction benefits of street sweeping are assumed to be already included within the baseline urban loads in the City. A 25% phosphorus reduction can be attained for street right-of-way sources if the City purchased a high-efficiency street sweeper, adopted a parking control ordinance, and swept its streets once every two weeks from early April to late November.

Exhibit 5-2
Spring & Fall Tree Litter



2. Municipal Leaf Collection

Modifying the City's municipal leaf collection program can reduce urban P discharges by up to 17% for medium density residential (2 to 6 units/acre) source areas. At this time, leaf collection credit is not available for other land uses or lower-density tree canopies. The P annual load reduction for this option may be assumed if the following conditions are met:

- Curb and gutter with storm sewer and light parking densities during street cleaning activities.
- An average of one (1) or more mature trees located between the sidewalk and curb for every 80 linear feet of curb. Where sidewalk is not present, trees within 15 feet of the curb may be counted toward tree cover. Generally, this equates to a tree canopy over the street (pavement only) of 17% or greater. Field investigations or aerials may be used to document tree cover.
- The municipality has an ordinance prohibiting residents from placement of leaves in the street and a policy stating that residents may place leaves on the terrace in bags or piles for collection.
- Municipal leaf collection provided at least four (4) times spaced throughout the months of October and November. Leaves may be pushed, vacuumed, or manually loaded into a fully enclosed vehicle, such as a garbage truck or covered dump truck. No leaf piles are left in the street overnight.

Status Report

- Within 24 hours of leaf collection, remaining leaf litter in the street must be collected using mechanical broom or vacuum assisted street cleaner. A brush attachment on a skid steer is not an acceptable equivalent.

3. Wet Detention Ponds

Wet detention ponds and wetland systems are typically the most cost effective urban management practice for large watersheds. Wet ponds and wetland systems are effective at removing phosphorus, sediment, and heavy metals pollutants. Pollutant removal within a wet pond or wetland is primarily due to gravity settling of particulate pollutants and sediment. Filtration, adsorption, and microbial decomposition remove additional pollutants, particularly if wetlands are planted.

Typically, wet detention ponds need a minimum water depth of 5 feet within a portion of the permanent pool to minimize re-suspension of previously removed sediment and phosphorus during a rainfall event. Wet detention ponds and wetland systems can also provide flood storage, habitat and recreation benefits.

To achieve an 80% total suspended solids reduction and a 60% total phosphorus reduction, a wet detention pond or wetland system needs to remove the 3 to 5 micron particle size. Generally, wet detention ponds are not recommended for small watersheds (< 15 to 20 acres). A wet pond located in a small watershed may develop stagnation problems and become a public nuisance.

Exhibit 5-3
Pond/Wetland

Source: McMahon Asscociates, Inc.

Table 5-1 identifies potential wet detention pond or wetland system retrofits within the City of Plymouth. The wet detention pond locations and watersheds are depicted in Figure 6. The approximate amount of land area that is needed to construct each wet detention pond is also identified in Table 5-1. Some wet ponds are proposed on land already owned by the City.

Table 5-1
Wet Detention Pond / Wetland Systems & Costs

| Wet Pond | Drainage Area IDs | Pond Land Area (acres) | Pond Watershed (acres) | P Reduction (lbs/year) | Capital Cost |
|---|---|---|---|---|---|
| City Utility Pond (Pond L9c) | L9e1-3, L9b-c | 5.7 | 150 | 76 | $1.17 million |
| Dairy Pond (Pond L9e2) | L9e2-3 | 2.8 | 88 | 46 | $0.69 million |
| River Pond (Pond L10d) | L10d-e | 2.5 | 81 | 44 | $0.43 million |
| Beth Pond (Pond L10e) | L10e | 1.5 | 44 | 23 | $0.35 million |
| School Pond (Pond L18i1) | L18i1 to 4 | 8.2 | 264 | 107 | $1.22 million |

4. Ordinances

The City of Plymouth plans to update its construction site and stormwater management ordinances to control water quality from urban development. The State of Wisconsin does not allow the City to regulate phosphorus until a TMDL is developed for the phosphorus pollutant. However, the City can regulate sediment using the provisions within NR 151. Sediment control at construction and post-construction sites will also provide some phosphorus control.

5. Other Urban Practices

Other urban BMPs considered for the City include catch basin sumps, grass swales, grass filter strips, bio-swales, rain gardens, bioretention, infiltration basins/trenches, proprietary devices, porous pavement, wet pond chemical applications, and mechanical treatment plants for stormwater. At this time, these BMPs are higher in cost than a wet detention pond or wetland system. Currently, the Wisconsin DNR is discussing chemical additions (alum, polymers) to wet detention pond / wetland systems to enhance phosphorus removal. Some of these new practices do not yet have technical standards.

## D. Combined Management Practices & Costs

The P reduction required during the first 5-year permit term is 979 pounds per year. As previously indicated, the Plymouth WWTF provides 566 pounds per year of P reduction if optimized to a 0.3 mg/L phosphorus concentration by adding a second chemical feed. As such, an additional P reduction of 413 pounds per year of P reduction (979 lbs/yr – 566 lbs/yr = 413 lbs/yr) is required for the first 5-year permit term. The additional 413 pounds per year of P reduction are anticipated to be provided in cropland areas.

Table 5-2 identifies the amount of cropland needed for various pounds per acre of P reduction. For the first 5-year permit term, 103 to 826 acres of cropland are needed for management practices. More specifically, Table 5-2 indicates 138 acres of cropland are required if the management practices provide an average 3 pound per acre reduction.

Table 5-2
First Permit Term - Cropland P Reduction

| P Reduction (lbs/acre) | Permit Term 1 Cropland (acres) |
|---|---|
| 0.5 | 826 |
| 1 | 413 |
| 2 | 207 |
| 3 | 138 |
| 4 | 103 |

P reductions generated by various cropland management practices are summarized in Table 5-3. Each cropland management practice in Table 5-3 provides pollutant reductions for 100% of the available cropland acres that are located upriver of Blueberry Lane, but do not drain to a natural closed depression. About 27% of the cropland is estimated to drain to a natural closed depression. Of the 13,639 acres of cropland located upriver of Blueberry Lane, approximately 9,956 acres no not drain to a natural closed depression. In Table 5-3, each BMP is applied to all 9,956 acres of cropland in order to better gauge the available P reduction that is potentially located upriver of the Blueberry Lane crossing.

Table 5-3
Available Cropland P Reduction (Upriver of Blueberry Lane)

| Cropland BMP | Cropland[1] (acres) | P Reduction (lbs/yr) | P Reduction (lbs/ac/yr) | Cost ($/lb/yr) |
|---|---|---|---|---|
| Mulch Till | 9,956 | 10,374 | 1.0 | $14 |
| No Till | 9,956 | 29,793 | 3.0 | $6 |
| Cover Crop | 9,956 | 13,812 | 1.4 | $28 |
| Prairie Restoration | 9,956 | 39,653 | 4.0 | $216 |

[1] Cropland acres located upriver of Blueberry Lane that don't drain to a natural closed depression.

## VI. IDENTIFYING PARTNERS

Partners are needed for an Adaptive Management Plan. These partners assist with plan development, education, outreach, and plan implementation. The City plans to enter into a Services Agreement with various partners. The Services Agreement will identify deliverables, milestones, and compensation.

Potential partners, their responsibilities for adaptive management, and communication strategies are described as follows:

## A. City of Plymouth

The City of Plymouth (i.e. Plymouth Utilities) is a governmental agency that owns and operates the Plymouth WWTF. The Plymouth WWTF provides wastewater treatment for the City of Plymouth. The Plymouth WWTF was constructed in 1979 and upgraded in 1992. Plymouth Utilities is the lead agency for this Adaptive Management Plan.

Plymouth Utilities will be responsible for financials, optimizing the Plymouth WWTF, verification of management practices, WWTF effluent sampling, river sampling, agreements, working and communicating with partners (i.e. County, McMahon Associates, Inc., landowners, agronomists, non-governmental agencies, etc.), and Wisconsin DNR Annual Reporting.

## B. McMahon Associates, Inc. Engineers

McMahon Associates, Inc. is a consulting firm that provides wastewater, stormwater, municipal, environmental, ecological, drinking water, architectural, and agricultural services. McMahon Associates, Inc. was established in 1909.

On behalf of the City, McMahon Associates, Inc. will be responsible for Adaptive Management Plan development, project management, budget review, agreement review, working and communicating with partners (i.e. City, County, landowners, agronomists, non-governmental agencies, etc.), education assistance, mapping, modeling, evaluation of effluent and river sampling, ordinances, stormwater design, and Wisconsin DNR Annual Reporting.

## C. Sheboygan County Planning & Conservation

The Sheboygan County Planning and Conservation Department (i.e. County) is a governmental agency that is "committed to providing sound information and knowledge on environmental issues that affect our community, protecting our county's natural resources, and, first and foremost, working with the public which we serve in a straightforward, honest approach".

The County will be responsible for educating, implementing management practices in agricultural areas, and preparing agreements which identify responsibilities, P reductions, cost sharing, and agreement duration. The County will be responsible for SNAP-Plus, BARNY or other agriculture modeling, as needed. The County will be responsible for working and communicating with partners (i.e. City, McMahon Associates, Inc., landowners, agronomists, non-governmental agencies, etc.).

## D. Fond du Lac County Land & Water Conservation

The Fond du Lac County Land and Water Conservation (LWCD) (i.e. County) is a governmental agency that "provides conservation planning assistance and technical service in the area of soil and water conservation to landowners, land users, and decision makers of Fond du Lac County".

Fond du Lac County LWCD may not be a partner until the second or third 5-year permit term. As previously mentioned, the cropland P reductions will be initially focused on properties located near the Plymouth WWTF.

## E. Agricultural Landowners & Producers

Partners for agricultural sources may include landowners, producers, and agronomists. Maps identifying current agricultural landowner locations and names are provided in Appendix I. The City hosted a biosolids and crop management workshop during December 2016. The workshop provided an opportunity to educate stakeholders about the nutrient value of bio solids, nutrient management planning, soil sampling, soil health, cover crops, improving water quality, and opportunities in the Mullet River Watershed. Several landowners, producers, and agronomists expressed interest in working with the City on nutrient reductions within the Mullet River Watershed. The City, County, and McMahon Associates, Inc. will continue working with these agricultural partners.

The landowners and producers will be responsible for signing agreements and installing agricultural management practices. Landowners and producers will also be responsible for maintaining management practices. Verification and inspection of management practice will be performed by the City or County.

## F. Other Organizations

Other organizations will likely be involved or have an interest in assisting with P reductions within the Mullet River Watershed. Currently, these organizations are not formal partners for Adaptive Management, but may contribute resources or expertise. These potential organizations including the following:

1. Sheboygan River Progressive Farmers

   The Sheboygan River Progressive Farmers is a non-governmental organization. Their mission is to "test and explore farming strategies that lead to improved soil health, greater farming efficiency, sustain profitability, and lessen the impact on the environment." Their goals are to "identify the most vulnerable fields that have potential to be improved with on farm conservation methods" and "work with the non-farming community to reach water quality goals and enhance the sense of community between rural and urban."

2. The Nature Conservancy

The Nature Conservancy is a non-governmental organization. The Nature Conservancy's mission is "to conserve the lands and waters on which all life depends. Our vision is a world where the diversity of life thrives, and people act to conserve nature for its own sake and its ability to fulfill our needs and enrich our lives."

3. Lakeshore Natural Resource Partnership (LNRP)

The LNRP is a non-governmental organization. The LNRP uses "education and coordination to support local communities' efforts to maintain or improve our natural resources. LNRP builds partnerships and collaborations, provides funding and support, and promotes a forum for discussion and action to advocate a balance between land use and natural resource management, the health of our lands and waters, conservation and protection."

4. Natural Resource Conservation Service (NRCS)

NRCS is a federal agency that is a part of the U.S. Department of Agriculture. NRCS's mission is to "provide resources to farmers and landowners to aid them with conservation. Ensuring productive lands in harmony with a healthy environment is our priority."

5. Farm Service Agency (FSA)

FSA is a federal agency that is a part of the U.S. Department of Agriculture. The FSA's mission is "to deliver timely, effective programs and services to America's farmers and ranchers to support them in sustaining our Nation's vibrant agricultural economy, as well as provide first-rate support for domestic and international food aid efforts."

6. U.S. Geological Survey (USGS)

USGS is a federal agency that is a part of the U.S. Department of Interior. "Water information is fundamental to national and local economic well-being, protection of life and property, and effective management of the Nation's water resources. The USGS works with partners to monitor, assess, conduct targeted research, and deliver information on a wide range of water resources and conditions including streamflow, groundwater, water quality, and water use and availability."

7. Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP)

DATCP is a State governmental agency. DATCP's mission is to "partner with all the citizens of Wisconsin to grow the economy by promoting quality food, healthy plants and animals, sound use of land and water resources, and a fair marketplace." DATCP provides grant programs to assist with implementation.

### G. Partner Summary

Partners and their anticipated roles and responsibilities for the Plymouth Adaptive Management Plan are summarized in Table 6-1.

Table 6-1
Partner Roles & Responsibilities

| Partner | Roles & Responsibilities |
|---|---|
| Plymouth Utilities | ▪ Financials, budgeting, and grants<br>▪ Communicating with partners and education<br>▪ Optimizing the Plymouth WWTF effluent<br>▪ Sampling of WWTF effluent and river<br>▪ Verification of installed management practices<br>▪ Wisconsin DNR Annual Reporting |
| McMahon Associates, Inc. | ▪ Adaptive Management Plan development<br>▪ Project management<br>▪ Budget review and assisting with grants<br>▪ Communicating with partners and education<br>▪ Inventorying, mapping, modeling and designing, as needed<br>▪ Evaluation of sampling data (effluent and river)<br>▪ Assisting with Wisconsin DNR Annual Reporting |
| Sheboygan County Planning & Conservation | ▪ Assisting with grants<br>▪ Communicating with partners and education<br>▪ Conducting field walks and site visits, as needed<br>▪ Inventorying, mapping, modeling and design, as needed<br>▪ Determining P load reductions, as needed<br>▪ Agreements, including cost share rates<br>▪ Verification of installed management practices |
| Agricultural Landowners & Producers | ▪ Sign agreements<br>▪ Install management practices<br>▪ Maintain management practices |

## VII. IMPLEMENTATION & MEASURING SUCCESS

The Plymouth WWTF and its partners will take the following steps to reduce P during the first 5-year permit term of the Adaptive Management Plan. These steps will be adapted or adjusted as the partners gain experience with implementation of management practices within the Action Area of the Mullet River Watershed.

Status Report

## A. Group Meetings

Group meetings will be used to initiate or maintain contact with a large group of landowners or stakeholders. Group meetings will be used to communicate, educate, answer questions, and discuss goals from a "big picture" perspective. Group meetings will be held as needed basis, such as with the Sheboygan River Progressive Farmers.

## B. Individual Site Visits

Site visits will be used to develop and maintain a working relationship with individual landowners. Site visits will be used to educate, answer questions, discuss concerns, and maintain communication in an individualized manner. Individual site visits will be held on an as needed basis.

## C. Data Collection

With landowner permission, data collection within the landowner's property can be performed. Data collection may consist of inventorying current conditions, conducting field walks, gathering nutrient management plans, performing soil tests, etc. ArcGIS will be used to collect and store data, when appropriate and feasible.

## D. Modeling

Models will be used for planning, design, and implementation of management practices. More specifically, models will be used to calculate the current P load (i.e. baseline condition) and the P load reduction associated a management practice. Percent P reduction will also be calculated. The following computer models will be used:

1. The SNAP-Plus Model (Soil Nutrient Application Planner)

   The Snap-Plus model will be used to calculate P losses associated with cropland runoff. SNAP-Plus will also be used to evaluate the P reduction benefits of cropland management practices such as tillage, cover crops, vegetated buffers and nutrient management.

2. The BARNY model (Wisconsin Barnyard Runoff Model)

   The BARNEY model will be used to calculate P losses associated with barnyard runoff. BARNY will also be used to evaluate the P reduction benefits of management practices such as vegetated buffers and other barnyard management practices.

3. The WinSLAMM model (Source Loading and Management Model for Windows)

The WinSlamm model will be used to calculate P losses associated with urban runoff. WinSLAMM will also be used to evaluate the P reduction benefits of management practices such as street sweeping, catch basin cleaning, municipal leaf collection, wet detention ponds, biofilters, and other urban management practices.

Other models may also be used, such as APEX, STEPL, or SWAT. Models will be approved by the Wisconsin DNR before use.

## E. Technical Standards

Technical Standards developed by the NRCS and Wisconsin DNR will be used to design, install and maintain the various management practices. If the City decides to pursue water quality trading in the future, it is important that management practices adhere to Technical Standards. Water quality trading credit is only provided to management practices that follow Technical Standards. Also, in order for results to be accurate, water quality models typically assume that NRCS and Wisconsin DNR Technical Standards are being followed.

## F. Determining Load Reductions

Model results will be used to calculate P load reductions for management practices. Model results will also be used to track P load reductions during each 5-year permit term. As previously indicated, the Plymouth WWTF is required to achieve a minimum 979 pound per year P reduction during the first 5-year permit term. The Plymouth WWTF will search for additional partners if the calculated reductions for planned management practices are less than the requirement.

## G. Landowner Agreements

Landowner agreements will be used to establish responsibilities. More specifically, agreements will likely identify an installation schedule, P reduction, cost share rate, agreement duration, and maintenance activities. If the Plymouth WWTF decides to pursue water quality trading in the future, it is important that agreements be executed prior to the management practice being implemented. Water quality trades also need to be registered with the State prior to the management practice being implemented.

## H. Installing Management Practices

After the landowner agreement is signed and the potential water quality trade is registered with the State, the management practice can be installed or implemented. The landowner will be responsible for installing, implementing, and maintaining the management practices.

## I. Verifying Management Practices

The County and Plymouth WWTF will verify that management practices are properly installed, implemented, and maintained by the landowner. Depending on the type of management practice, verifying inspections will be performed once per year. Verification inspections will be documented using forms and potentially GIS. Steps associated with the inspection will include the following: determine status of management measure, issue status determination to landowner, take corrective actions (if needed), document that required corrective actions are completed (if needed), and update data for modeling (if needed).

## J. WWTF & River Sampling

The Plymouth WWTF will perform effluent and river sampling. Effluent sampling will be used to verify WWTF performance and will be performed in accordance with the City's WPDES Permit. River sampling (monthly grab samples from May to October) will be used to monitor river P concentrations and loads. River sampling will be performed in accordance with the DNR guidance documents titled "Guidance for Implementing Wisconsin's Phosphorus Water Quality Standards for Point Source Discharges (dated February 8, 2017)" and/or "Adaptive Management Technical Handbook (dated January 7, 2013)".

## K. Annual Reporting

The Plymouth WWTF will prepare and submit Annual Reports to the Wisconsin DNR. McMahon Associates, Inc. and the County will provide information to assist with Annual Report preparation. The Annual Report will document progress with Adaptive Management implementation. More specifically, the reports will summarize effluent sampling results, river-sampling results, management practices installed in the prior year, P reductions achieved in the prior year, compliance with interim limits, educational activities in the prior year and modifications to the implementation schedule, if any.

## L. Implementation Schedule

Table 7-1 identifies an implementation schedule for the first 5-year permit term for the Plymouth WWTF. The schedule contains milestones for adaptive management implementation. The schedule will be updated as part of Annual Reporting, if needed.

Table 7-1
Implementation Schedule for First 5-Year Permit Term

| Task | Date |
|---|---|
| City sign agreement with County | Fall 2018 |
| County begin site visits with landowners | Fall 2018 |
| Landowners start signing agreements | March 2019 |
| Landowners start installing management practices | May 2019 |
| City begin river sampling (May to October) | May 2019 |
| City optimize WWTF to 0.3 mg/L P concentration | June 2019 |
| McMAHON complete City-Wide Stormwater Plan | December 2019 |
| Submit Annual Report to Wisconsin DNR for AM | May 15, 2019 |
| Submit Annual Report to Wisconsin DNR for AM | May 15, 2020 |
| Submit Annual Report to Wisconsin DNR for AM | May 15, 2021 |
| Submit Annual Report to Wisconsin DNR for AM | May 15, 2022 |
| McMahon Associates, Inc. update Adaptive Management Plan | April 2023 |
| Permit Renewal (Second 5-Year Permit Term) | Summer / Fall 2023 |

# VIII. FINANCIAL EVALUATION

This section summarizes the adaptive management implementation costs for the first 5-year permit term, including a certification of financial security.

## A. Opinions of Probable Cost

Table 8-1 summarizes the draft opinions of probable cost for anticipated adaptive management implementation costs during the first 5-year permit term. Costs include administration, education, sampling, WWTF optimization to 0.3 mg/L P, site visits, modeling, and non-point source management practices. Table 8-1 also identifies the responsible parties.

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)Table 8-1
Adaptive Management OPC Budget

| Task | Responsible Party | Permit Year | | | | | |
|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 |
| | | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| Treatment Upgrades Capitol Cost | P | | $30,000 | $0 | $0 | $0 | $0 |
| Treatment Operating & Maintenance Costs | P | | $7,500 | $7,500 | $7,500 | $7,500 | $7,500 |
| Adaptive Management Planning | M | $20,000 | $0 | $0 | $0 | $0 | $10,000 |
| Modeling & Technical Support | SC & M | $5,000 | $20,000 | $10,000 | $5,000 | $5,000 | $10,000 |
| BMP Implementation Costs | P, SC & M | | $50,000 | $50,000 | $50,000 | $50,000 | $50,000 |
| Outreach & Education | P, SC & M | $500 | $5,000 | $1,500 | $1,500 | $1,500 | $5,000 |
| In-Stream & Effluent Sampling | P | | $3,500 | $3,500 | $3,500 | $3,500 | $3,500 |
| Compliance Checking | P & SC | | $10,000 | $5,000 | $5,000 | $5,000 | $7,500 |
| Administration | P & M | $2,000 | $7,000 | $7,000 | $7,000 | $7,000 | $10,000 |
| Total | | $27,500 | $133,000 | $84,500 | $79,500 | $79,500 | $103,500 |

Plymouth Utilities (P), Sheboygan County (SC), McMahon Associates, Inc. (M)

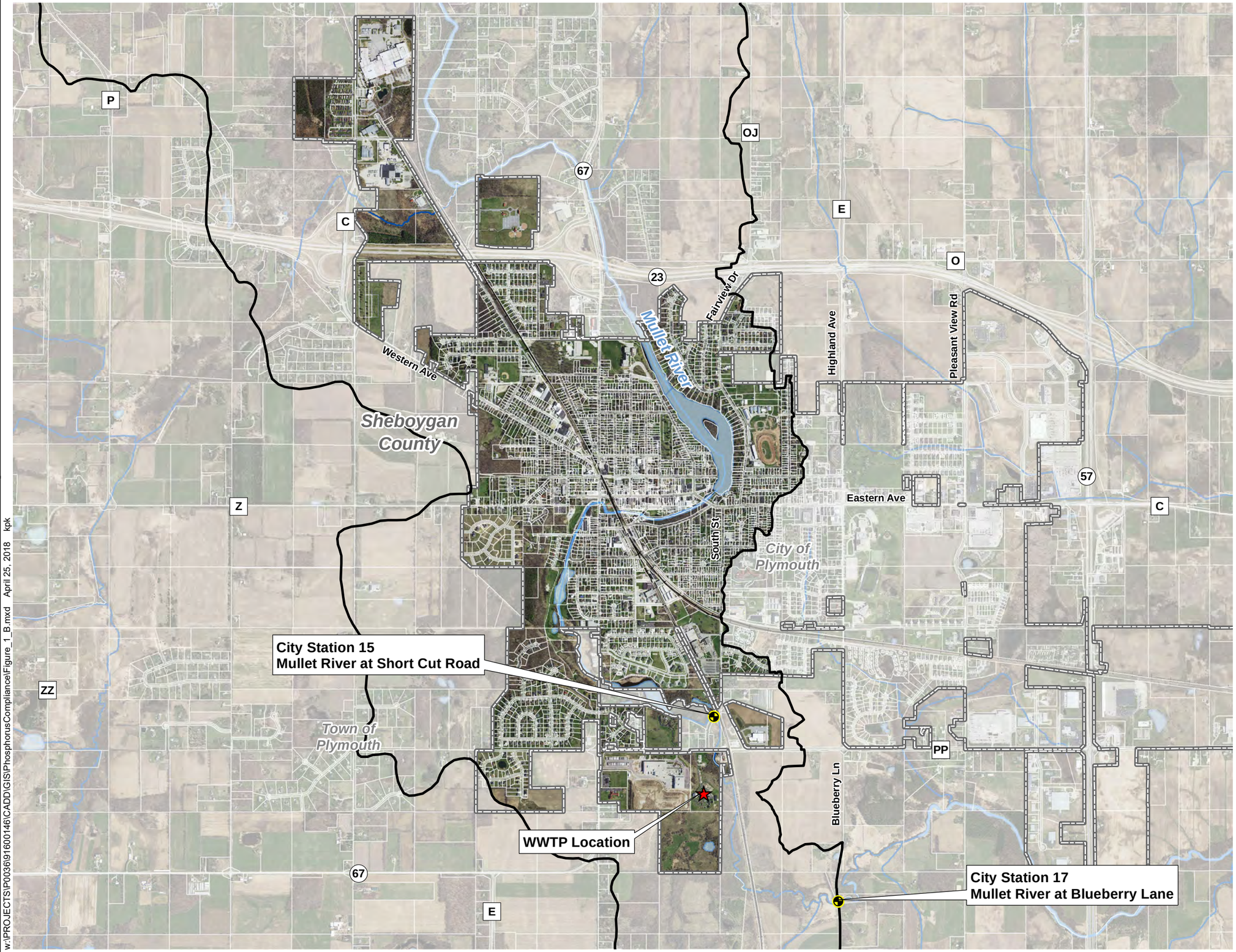
### B. Funding Sources

Plymouth Utilities currently plans to assume sole financial responsibility for adaptive management implementation costs. Plymouth Utilities will fund the implementation costs through user fees. Grants and other funding opportunities will also be investigated. Potential grant programs include, but are not limited to the following:

- Fund for Lake Michigan Grants
- Great Lakes Restoration Initiative (GLRI) Grants
- NRCS Regional Conservation Partnership Program (RCPP)
- Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) Grants
- Wisconsin DNR Targeted Runoff Management (TRM) Grants
- Wisconsin DNR Urban Non-Point Source and Storm Water Management (UNPS&SW) Grants

### C. Financial Security

A resolution from Plymouth Utilities is provided in Appendix J, which states that the financial resources needed for adaptive management implementation are feasible.




PLYMOUTH UTILITIES

**Mapped Features**

- Mullet River Adaptive Management Boundary
- Municipal Boundary
- Parcel Line
- Railroad Centerline
- Stream or River
- Surface Water
- City Station
- Wastewater Treatment Plant

Source: Sheboygan County, 2013-15.

Disclaimer: The property lines, right-of-way lines, and other property information on this drawing were developed or obtained as part of the County Geographic Information System or through the County property tax mapping function. McMAHON does not guarantee this information to be correct, current, or complete. The property and right-of-way information are only intended for use as a general reference and are not intended or suitable for site-specific uses. Any use to the contrary of the above stated uses is the responsibility of the user and such use is at the user's own risk.

0 2,000 4,000 Feet

McMAHON ENGINEERS ARCHITECTS
McMAHON ASSOCIATES, INC.

FIGURE #1
**WASTEWATER TREATMENT PLANT LOCATION**
WASTEWATER TREATMENT PLANT
ADAPTIVE MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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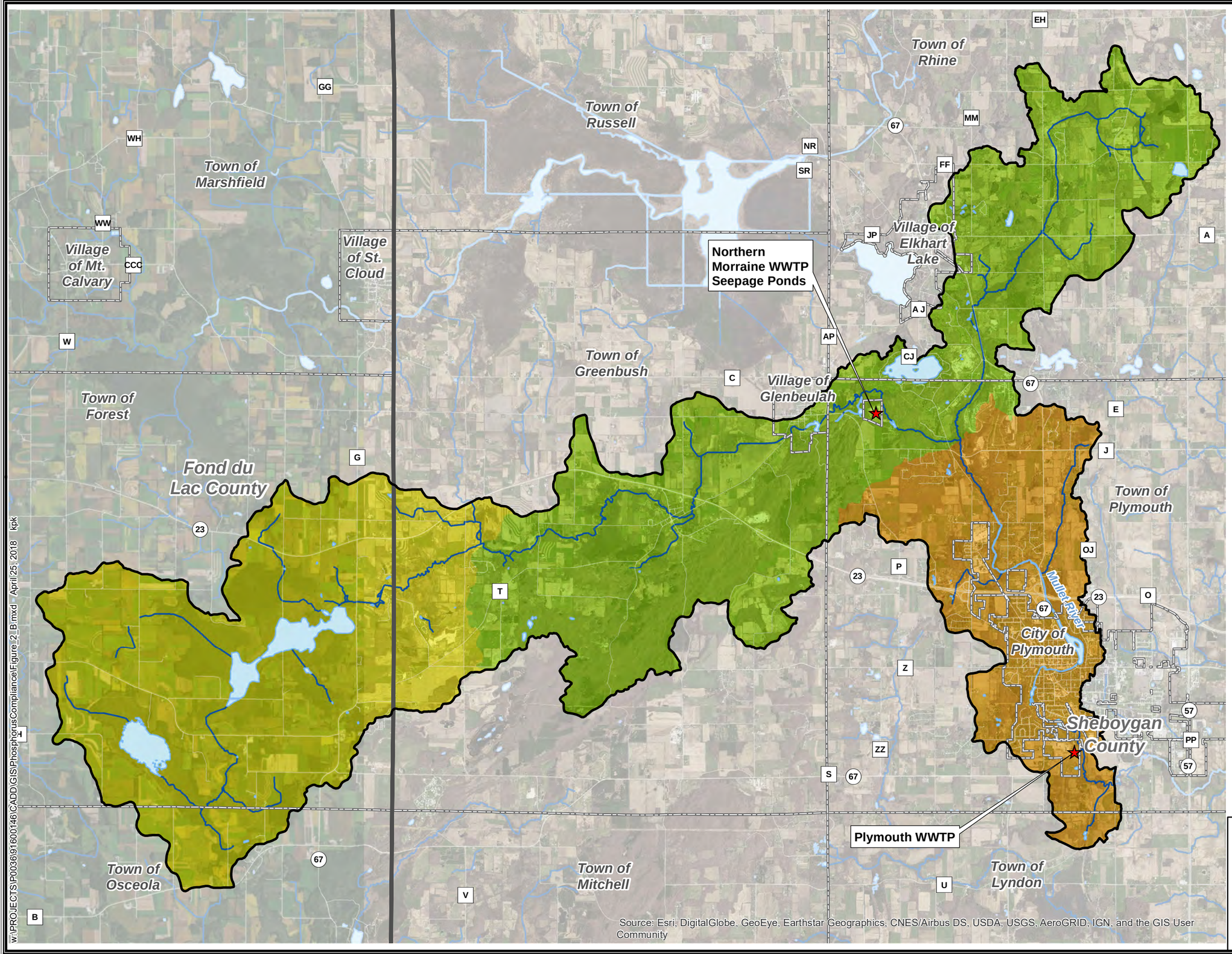


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

PLYMOUTH UTILITIES

**Mullet River Sub-Watersheds**

- Upper Mullet River
- Middle Mullet River
- Lower Mullet River

**Mapped Features**

- Mullet River Adaptive Management Boundary
- County Boundary
- Municipal Boundary
- Road Centerline
- Stream or River
- Surface Water
- Wastewater Treatment Facility

Source: Fond du Lac County, 2010; Sheboygan County, 2013-15; Wisconsin DNR, 2010.

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N

0 1 2 Miles

McMAHON ENGINEERS ARCHITECTS
McMAHON ASSOCIATES, INC.

FIGURE #2
**MULLET RIVER SUB-WATERSHEDS**
WASTEWATER TREATMENT PLANT
ADAPTIVE MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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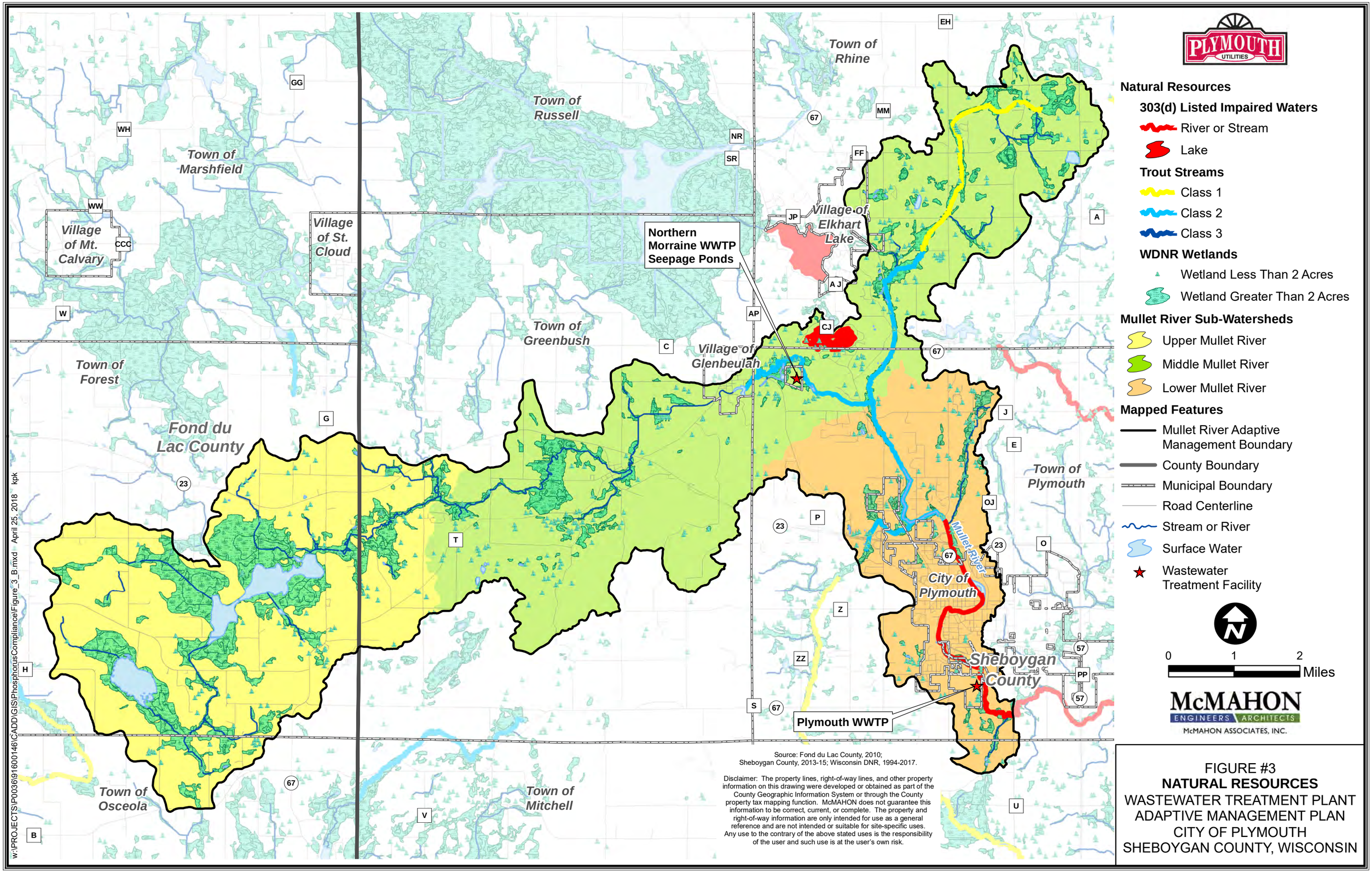
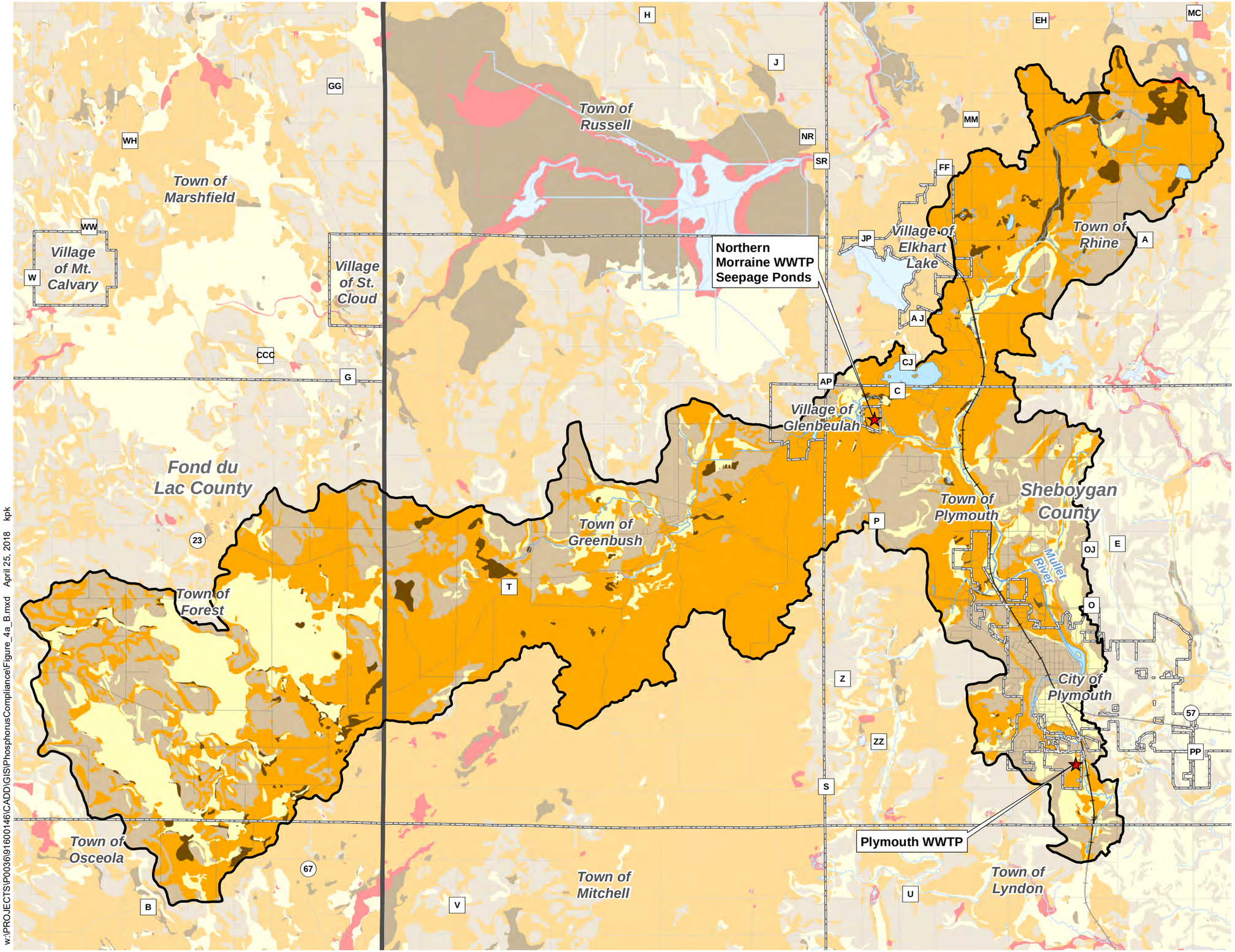



FIGURE #3
**NATURAL RESOURCES**
WASTEWATER TREATMENT PLANT
ADAPTIVE MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN




PLYMOUTH UTILITIES

## Hydrologic Soil Group (HSG)

- No HSG Designation
- HSG A
- HSG B
- HSG C
- HSG D

## Other Mapped Features

- Mullet River Adaptive Management Boundary
- Municipal Boundary
- Road Centerline
- Railroad Centerline
- Stream
- Surface Water
- Wastewater Treatment Facility

Source: Sheboygan County, 2013; Wisconsin DNR, 2010; USDA, 2015.

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N

0 1 2 Miles

McMAHON ENGINEERS ARCHITECTS
McMAHON ASSOCIATES, INC.

FIGURE #4a
**SOILS**
WASTEWATER TREATMENT PLANT
ADAPTIVE MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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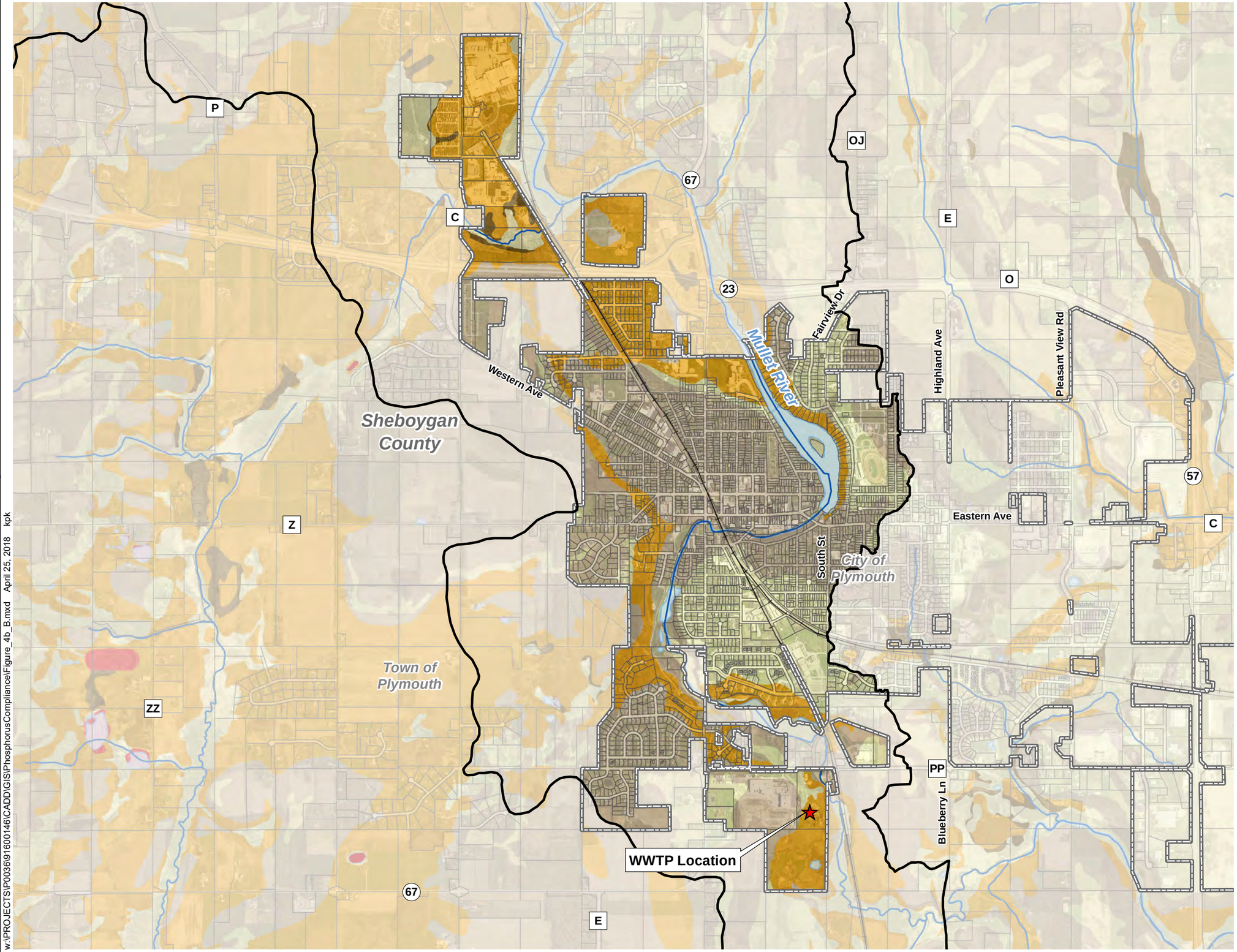


**Hydrologic Soil Group (HSG)**

- No HSG Designation
- HSG A
- HSG B
- HSG C
- HSG D

**Other Mapped Features**

- Mullet River Adaptive Management Boundary
- Municipal Boundary
- Parcel Line
- Railroad Centerline
- Stream
- Surface Water
- Wastewater Treatment Plant

Source :Sheboygan County, 2013; Wisconsin DNR, 2010; USDA, 2015.

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0 2,000 4,000 Feet

McMAHON ENGINEERS ARCHITECTS
McMAHON ASSOCIATES, INC.

FIGURE #4b
**SOILS**
WASTEWATER TREATMENT PLANT
ADAPTIVE MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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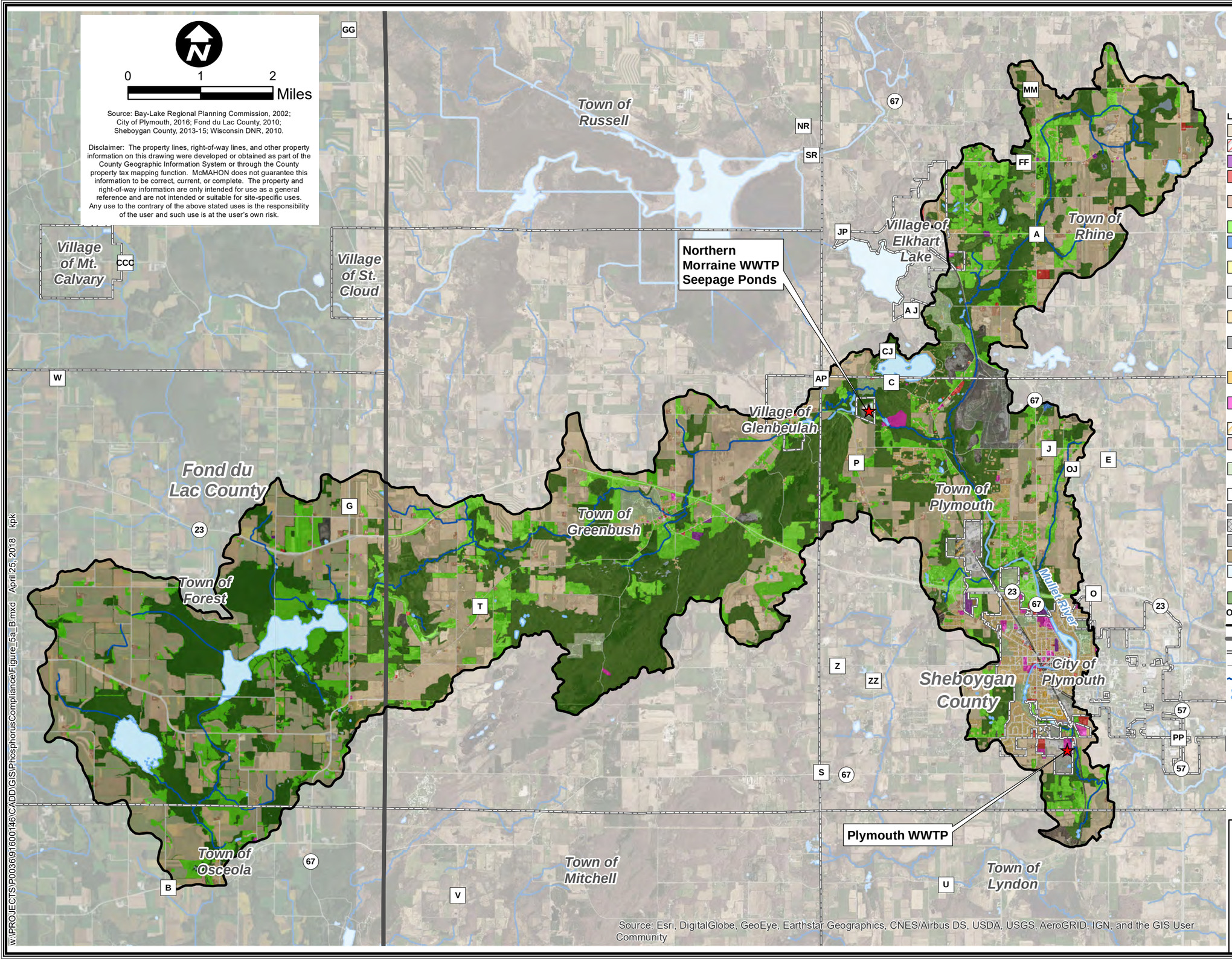


PLYMOUTH UTILITIES

**Land Use**

- AGRIC-Agriculture, including limited roads and buildings
- CDNTN-Downtown commercial and institutional areas
- CEM-Cemeteries, including grounds, roads, and buildings
- CSTRIP-Strip commercial areas (courthouses, police station, etc.)
- FRMSTD-Farmstead including limited houses, buildings, driveways, and parking areas
- GRASS-Undeveloped land that is vegetated with grass
- HOSP-Medical facilities, including nursing homes, hospitals, etc.
- LDR-Low density single-family residential (1/2 acre to 1.5 acre lots)
- LIGHTI-Light industrial areas (storage and distribution of goods for retail or sale)
- MDR-Medium density single-family residential (1/4 to 1/2 acre lots)
- MEDI-Medium industrial areas (lumber, junk, or auto salvage yard, ag. Co-op, oil tank farm, coal and salt storage, slaughter house)
- MFR-Multi-family residential (3 or more families, 1-3 story height)
- MISC-Miscellaneous facilities (churches, institutional property)
- MOBR-Mobile home or trailer park residential
- OFFPRK-Office parks (non-retail, multi-story, insurance, government)
- PARK-Outdoor recreational areas (golf course, arboretums, botanical gardens, municipal playgrounds, natural areas).
- PAVEMENT
- QUARRY-Aggregate extraction and excavation
- RAIL-Railroad ROW (Excludes road ROW, storage yards)
- RACE TRACK
- SUBR-Suburban residential (1.5 to 5 acre lots)
- WATER-Waters of the state and other open water (lakes, rivers, ponds, lagoons)
- WOODS-Undeveloped land that is vegetated with woods

**Other Mapped Features**

- Mullet River Adaptive Management Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream or River
- Surface Water
- Wastewater Treatment Facility

McMAHON ENGINEERS ARCHITECTS
McMAHON ASSOCIATES, INC.

FIGURE #5a
**CURRENT LAND USE**
WASTEWATER TREATMENT PLANT
ADAPTIVE MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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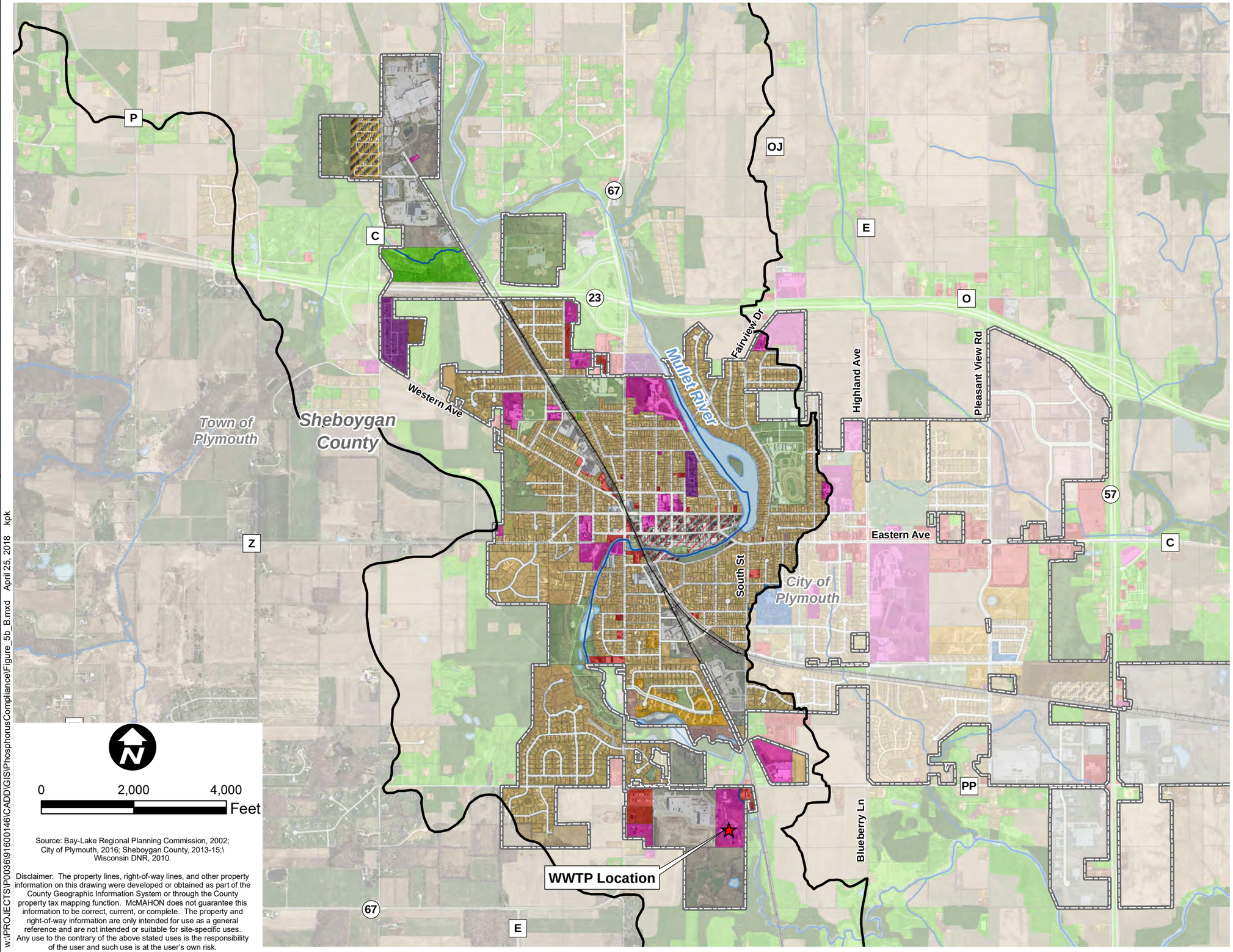


Source: Bay-Lake Regional Planning Commission, 2002; City of Plymouth, 2016; Sheboygan County, 2013-15;\ Wisconsin DNR, 2010.

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PLYMOUTH UTILITIES

**Land Use**

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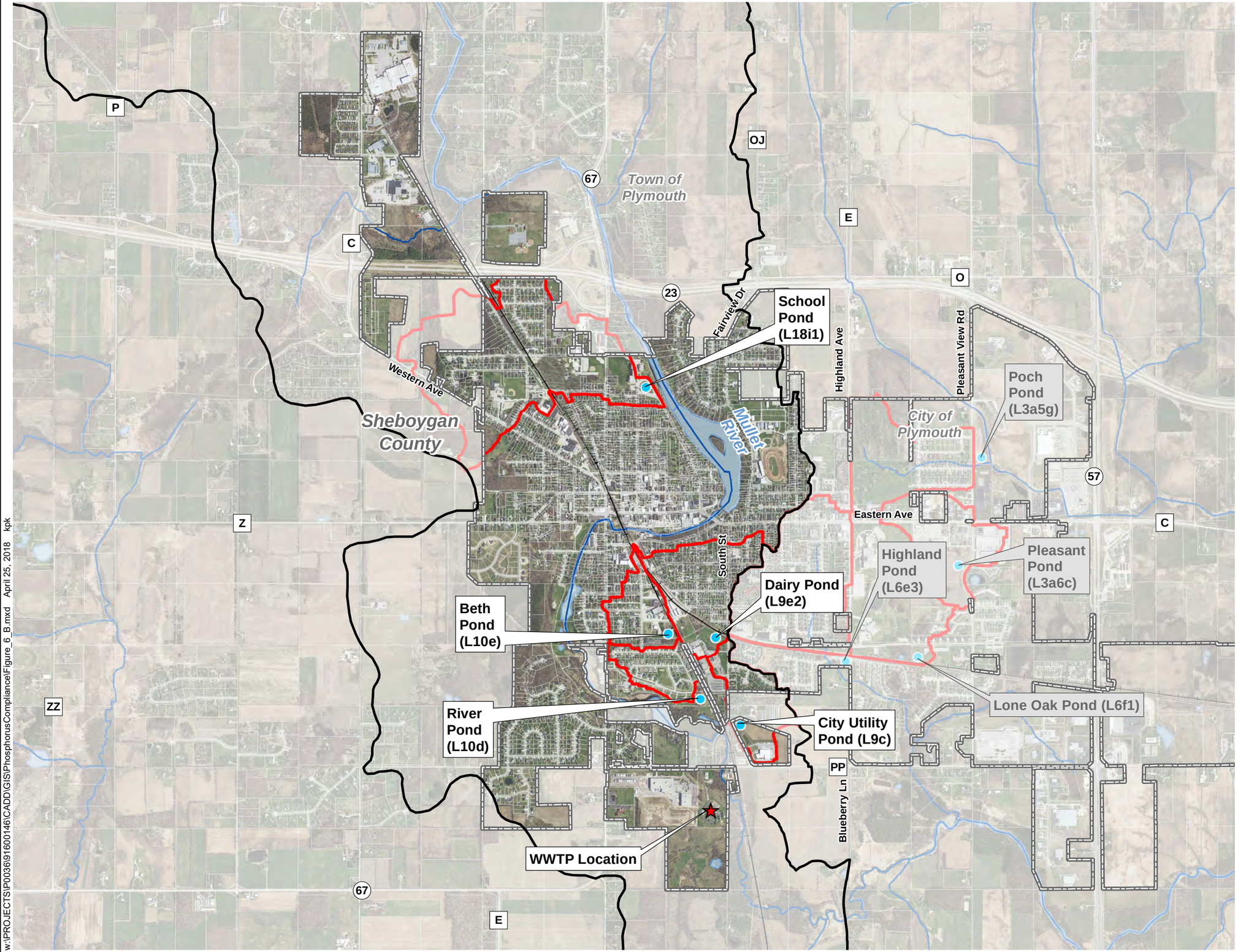
- LIGHTI-Light industrial areas (storage and distribution of goods for retail or sale)
- MDR-Medium density single-family residential (1/4 to 1/2 acre lots)
- MEDI-Medium industrial areas (lumber, junk, or auto salvage yard, ag. Co-op, oil tank farm, coal and salt storage, slaughter house)
- MFR-Multi-family residential (3 or more families, 1-3 story height)
- MISC-Miscellaneous facilities (churches, institutional property)
- MOBR-Mobile home or trailer park residential
- OFFPRK-Office parks (non-retail, multi-story, insurance, government)
- PARK-Outdoor recreational areas (golf course, arboretums, botanical gardens, municipal playgrounds, natural areas).
- PAVEMENT
- QUARRY-Aggregate extraction and excavation
- RAIL-Railroad ROW (Excludes road ROW, storage yards)
- RACE TRACK
- SUBR-Suburban residential (1.5 to 5 acre lots)
- WATER-Waters of the state and other open water (lakes, rivers, ponds, lagoons)
- WOODS-Undeveloped land that is vegetated with woods

**Other Mapped Features**

- Mullet River Adaptive Management Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream or River
- Surface Water
- Wastewater Treatment Facility

McMAHON ENGINEERS ARCHITECTS
McMAHON ASSOCIATES, INC.

FIGURE #5b
**CURRENT LAND USE**
WASTEWATER TREATMENT PLANT
ADAPTIVE MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN




Proposed Pond Location

Pond Watershed Boundary

**Other Mapped Features**

Mullet River Adaptive Management Boundary

Municipal Boundary

Parcel Line

Railroad Centerline

Stream or River

Surface Water

Wastewater Treatment Plant

Source: Sheboygan County, 2013-15.

Disclaimer: The property lines, right-of-way lines, and other property information on this drawing were developed or obtained as part of the County Geographic Information System or through the County property tax mapping function. McMAHON does not guarantee this information to be correct, current, or complete. The property and right-of-way information are only intended for use as a general reference and are not intended or suitable for site-specific uses. Any use to the contrary of the above stated uses is the responsibility of the user and such use is at the user's own risk.

0 2,000 4,000 Feet

McMAHON ENGINEERS ARCHITECTS
McMAHON ASSOCIATES, INC.

FIGURE #6
**POTENTIAL WET PONDS**
WASTEWATER TREATMENT PLANT
ADAPTIVE MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

w:\PROJECTS\P0036\91600146\CADD\GIS\PhosphorusCompliance\Figure_6_B.mxd April 25, 2018 kpk

# APPENDIX A

PLYMOUTH WWTF SCHEMATIC, DESIGN CRITERIA, & PERFORMANCE

The current City of Plymouth WWTF has the following design criteria:

**Flow**

- Average Daily Flow 1.80 MGD
- Maximum 30-Day Flow 2.23 MGD
- Maximum 24-Hour Flow 4.75 MGD
- Peak Hour Flow 7.17 MGD

**BOD**

- Average 6,400 lbs/day
- Maximum Month 7,616 lbs/day
- Maximum Day 14,552 lbs/day

**TSS**

- Average 3,650 lbs/day
- Maximum Month 4,071 lbs/day
- Maximum Day 9,340 lbs/day

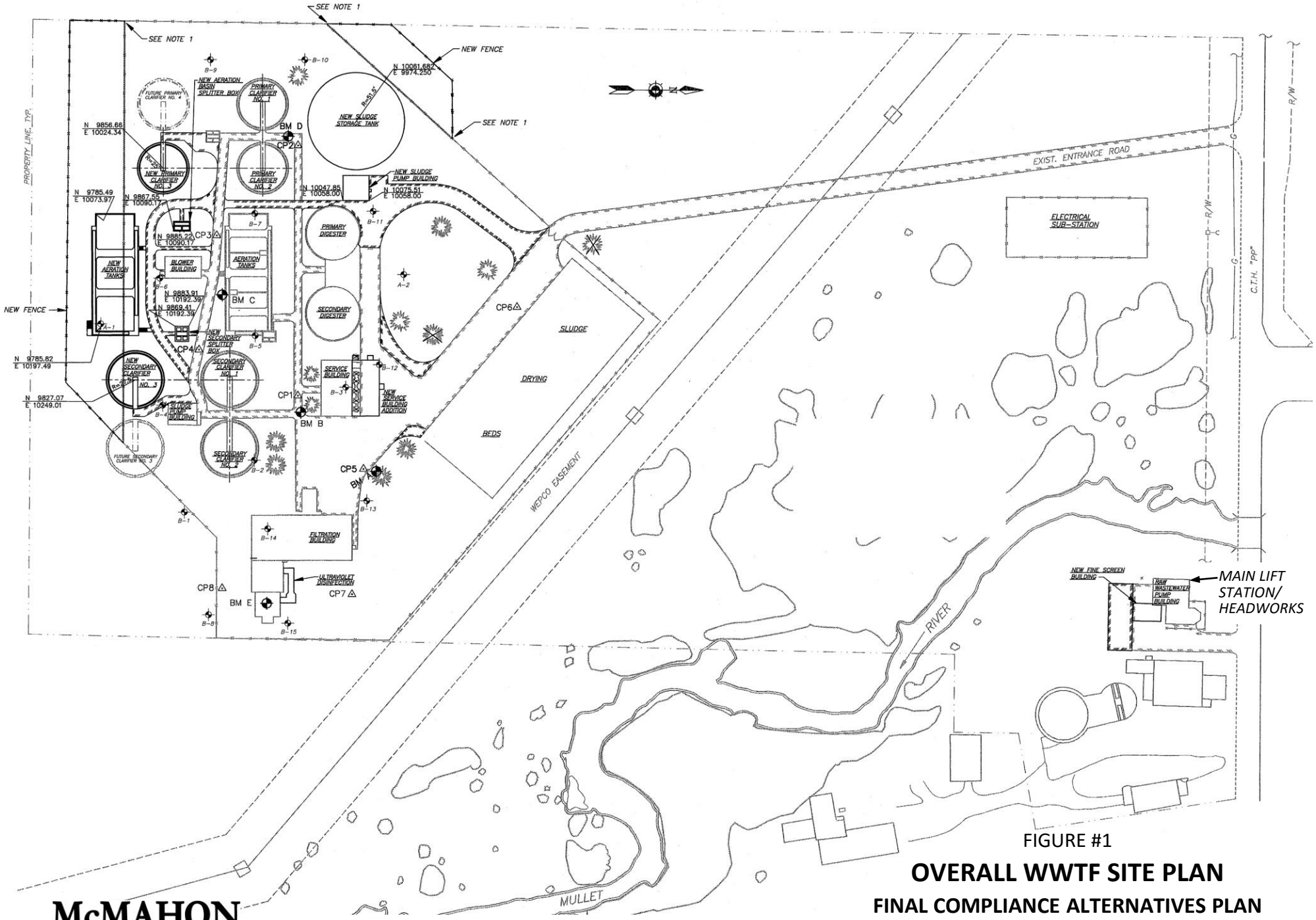



FIGURE #1

# OVERALL WWTF SITE PLAN

## FINAL COMPLIANCE ALTERNATIVES PLAN

CITY OF PLYMOUTH, WI

McM #P0036-9-16-00146.04 07/28/17

ID: PPT\2017\MCM WIS\Plymouth-WWTF Prelim Compliance Alts Plan.pptx CTO:jmk

McMAHON ENGINEERS ARCHITECTS

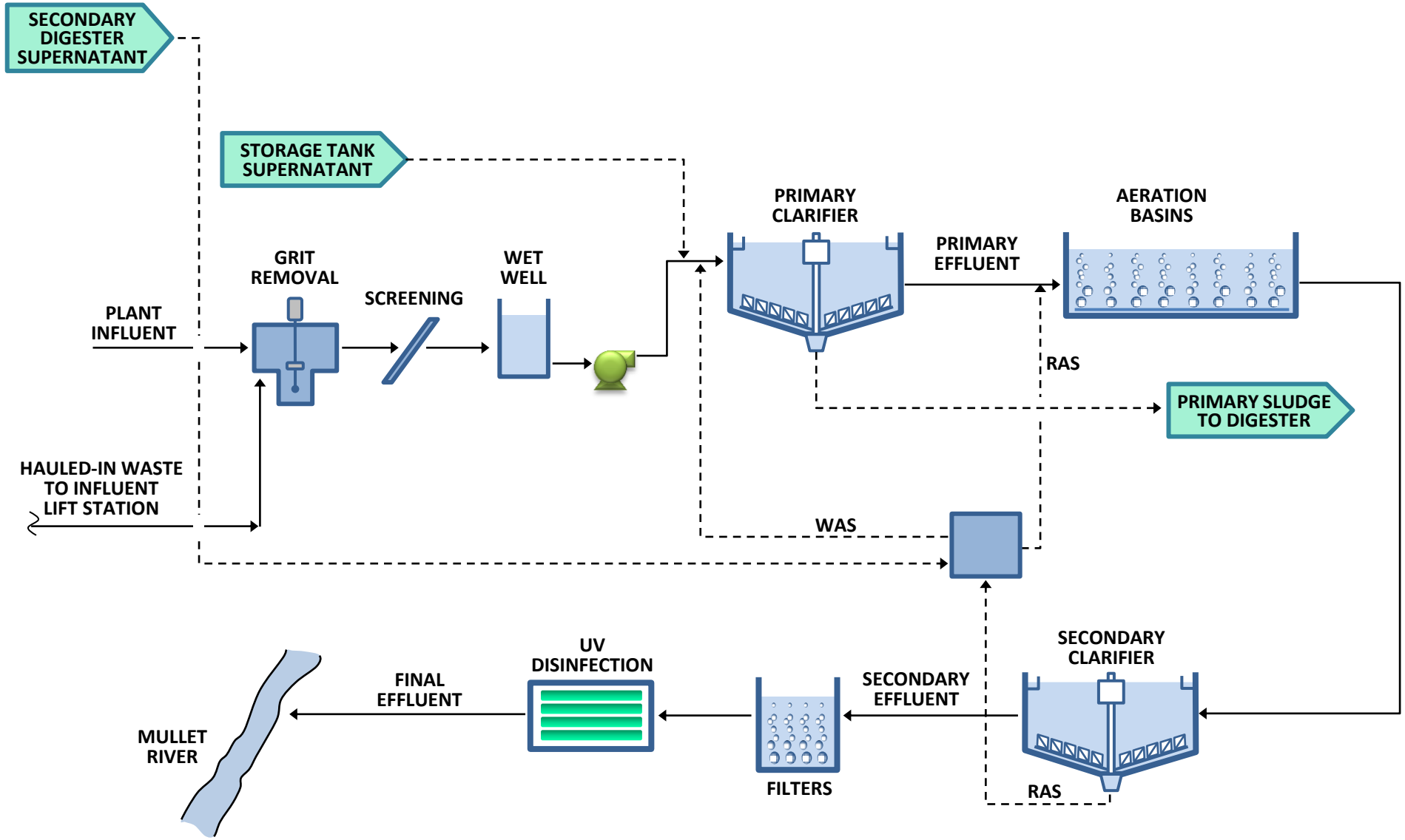



FIGURE #2

**WWTF LIQUID FLOW SCHEMATIC**

**FINAL COMPLIANCE ALTERNATIVES PLAN**

CITY OF PLYMOUTH, WI

McM #P0036-9-16-00146.04 07/28/17

ID: PPT\2017\MCM WIS\Plymouth-WWTF Prelim Compliance Alts Plan.pptx CTO:jmk

McMAHON ENGINEERS ARCHITECTS

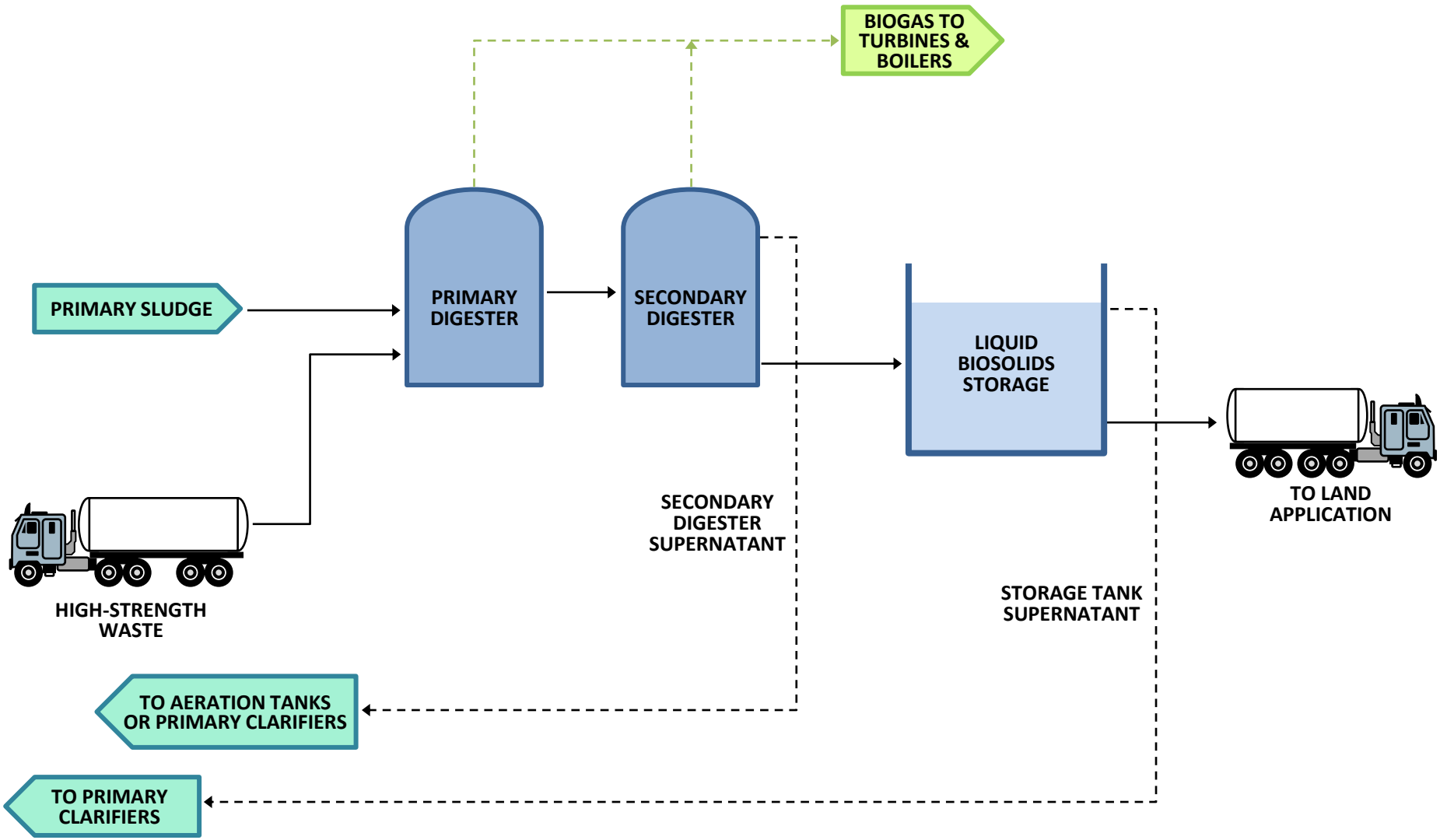



FIGURE #3

## WWTF SOLIDS FLOW SCHEMATIC

### FINAL COMPLIANCE ALTERNATIVES PLAN

CITY OF PLYMOUTH, WI

McM #P0036-9-16-00146.04 07/28/17

ID: PPT\2017\MCM WIS\Plymouth-WWTF Prelim Compliance Alts Plan.pptx CTO:jmk

McMAHON ENGINEERS ARCHITECTS

# Table #1
# City of Plymouth
# Wastewater Treatment Plant Performance Summary
## *2014*

| | Plant Influent | | | | | | | | | | Secondary Effluent | | | | Final Effluent | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Flow | | Total Phosphorus | | | | TSS | | | | TSS | | | | Total Phosphorus | | | |
| | MGD | | mg/L | | lbs/day | | mg/L | | lbs/day | | mg/L | | lbs/day | | mg/L | | lbs/day | |
| **Month** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** |
| January | 1.382 | 1.518 | 5.86 | 10.30 | 68.14 | 123.61 | 192 | 326 | 2222 | 3877 | 10.71 | 22.80 | 121 | 258 | 0.52 | 1.00 | 5.99 | 11.89 |
| February | 1.448 | 1.757 | 5.38 | 8.40 | 65.34 | 103.47 | 185 | 344 | 2255 | 5041 | 13.34 | 18.80 | 161 | 228 | 0.54 | 0.80 | 6.58 | 10.26 |
| March | 1.632 | 2.040 | 4.74 | 9.20 | 64.53 | 116.01 | 158 | 276 | 2152 | 3480 | 6.94 | 9.60 | 93 | 137 | 0.32 | 0.50 | 4.29 | 7.43 |
| April | 2.335 | 5.450 | 3.86 | 6.50 | 69.44 | 117.58 | 144 | 340 | 2632 | 6221 | 4.18 | 9.80 | 87 | 327 | 0.15 | 0.33 | 3.03 | 15.00 |
| May | 2.140 | 2.871 | 4.08 | 8.20 | 73.10 | 155.58 | 141 | 220 | 2493 | 4174 | 3.70 | 5.20 | 68 | 103 | 0.07 | 0.10 | 1.33 | 2.25 |
| June | 2.399 | 4.486 | 3.77 | 6.20 | 71.16 | 106.80 | 141 | 218 | 2695 | 4265 | 5.17 | 11.20 | 117 | 419 | 0.17 | 0.50 | 3.63 | 18.31 |
| July | 1.868 | 2.636 | 4.25 | 7.40 | 65.90 | 107.68 | 161 | 234 | 2486 | 3335 | 5.04 | 8.00 | 78 | 136 | 0.18 | 0.30 | 2.75 | 4.29 |
| August | 1.646 | 2.012 | 4.99 | 8.00 | 68.96 | 114.49 | 187 | 264 | 2567 | 3875 | 6.89 | 10.00 | 95 | 135 | 0.36 | 0.50 | 4.96 | 6.76 |
| September | 1.489 | 1.649 | 5.58 | 9.00 | 69.72 | 111.84 | 202 | 322 | 2523 | 4001 | 9.38 | 30.80 | 115 | 347 | 0.45 | 0.90 | 5.55 | 10.13 |
| October | 1.568 | 2.033 | 5.06 | 6.30 | 66.24 | 84.58 | 179 | 248 | 2340 | 3445 | 9.05 | 13.00 | 119 | 200 | 0.75 | 1.00 | 9.87 | 14.30 |
| November | 1.408 | 1.660 | 5.21 | 8.00 | 61.29 | 88.40 | 198 | 398 | 2330 | 4308 | 10.16 | 27.00 | 121 | 336 | 0.50 | 1.33 | 5.86 | 15.89 |
| December | 1.453 | 1.856 | 4.83 | 7.00 | 58.35 | 84.66 | 184 | 280 | 2229 | 3232 | 5.26 | 11.20 | 64 | 131 | 0.08 | 0.25 | 0.99 | 2.99 |
| **AVERAGE** | **1.731** | | **4.80** | | **66.85** | | **173** | | **2410** | | **7.48** | | **103** | | **0.34** | | **4.57** | |
| **MAX** | **2.399** | **5.450** | **5.86** | **10.30** | **73.10** | **155.58** | **202** | **398** | **2695** | **6221** | **13.34** | **30.80** | **161** | **419** | **0.75** | **1.33** | **9.87** | **18.31** |

# Table #2
# City of Plymouth
# Wastewater Treatment Plant Performance Summary
## *2015*

| | Plant Influent | | | | | | | | | | Secondary Effluent | | | | Final Effluent | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Flow | | Total Phosphorus | | | | TSS | | | | TSS | | | | Total Phosphorus | | | |
| | MGD | | mg/L | | lbs/day | | mg/L | | lbs/day | | mg/L | | lbs/day | | mg/L | | lbs/day | |
| **Month** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** |
| January | 1.416 | 1.620 | 5.69 | 9.30 | 67.48 | 113.34 | 200 | 274 | 2353 | 3702 | 6.59 | 10.00 | 77 | 115 | 0.14 | 0.26 | 1.65 | 3.31 |
| February | 1.246 | 1.393 | 6.47 | 11.40 | 67.64 | 124.64 | 212 | 364 | 2220 | 3980 | 8.23 | 15.40 | 85 | 166 | 0.17 | 0.40 | 1.77 | 4.41 |
| March | 1.367 | 2.396 | 5.59 | 8.00 | 63.49 | 91.61 | 189 | 278 | 2136 | 3156 | 6.88 | 9.40 | 78 | 108 | 0.14 | 0.30 | 1.56 | 3.63 |
| April | 1.755 | 2.752 | 4.92 | 8.80 | 70.92 | 126.07 | 169 | 328 | 2438 | 4590 | 4.74 | 10.00 | 67 | 139 | 0.57 | 1.10 | 8.37 | 15.55 |
| May | 1.594 | 2.290 | 5.22 | 9.00 | 69.09 | 129.63 | 196 | 322 | 2597 | 4047 | 4.93 | 7.40 | 66 | 91 | 0.80 | 1.30 | 10.51 | 17.30 |
| June | 1.848 | 2.850 | 4.67 | 9.20 | 70.41 | 144.02 | 179 | 388 | 2686 | 5381 | 4.06 | 5.80 | 61 | 85 | 0.92 | 1.60 | 13.91 | 28.52 |
| July | 1.518 | 1.795 | 5.94 | 9.40 | 75.44 | 132.72 | 211 | 422 | 2689 | 5958 | 5.11 | 7.80 | 65 | 100 | 0.68 | 1.40 | 8.61 | 19.04 |
| August | 1.379 | 1.603 | 5.87 | 9.10 | 67.86 | 102.38 | 216 | 348 | 2498 | 4159 | 7.40 | 11.40 | 83 | 123 | 1.06 | 3.00 | 11.98 | 33.43 |
| September | 1.490 | 1.840 | 6.16 | 8.60 | 76.84 | 108.18 | 202 | 268 | 2515 | 3385 | 7.92 | 14.80 | 99 | 180 | 1.10 | 2.50 | 13.77 | 36.83 |
| October | 1.432 | 1.717 | 7.10 | 11.70 | 85.14 | 142.46 | 240 | 406 | 2891 | 5585 | 6.15 | 14.40 | 74 | 206 | 0.90 | 1.70 | 10.61 | 20.19 |
| November | 1.638 | 2.263 | 6.64 | 12.30 | 91.10 | 167.97 | 215 | 466 | 2924 | 6176 | 6.90 | 14.60 | 93 | 177 | 0.85 | 1.60 | 11.52 | 20.86 |
| December | 2.009 | 3.333 | 5.36 | 11.00 | 88.80 | 156.51 | 188 | 400 | 3057 | 5928 | 6.65 | 10.20 | 113 | 211 | 0.60 | 1.10 | 9.93 | 19.46 |
| **AVERAGE** | **1.558** | | **5.80** | | **74.52** | | **201** | | **2584** | | **6.30** | | **80** | | **0.66** | | **8.68** | |
| **MAX** | **2.009** | **3.333** | **7.10** | **12.30** | **91.10** | **167.97** | **240** | **466** | **3057** | **6176** | **8.23** | **15.40** | **113** | **211** | **1.10** | **3.00** | **13.91** | **36.83** |

# Table #3
# City of Plymouth
# Wastewater Treatment Plant Performance Summary
## *2016*

| | Plant Influent | | | | | | | | | | Secondary Effluent | | | | Final Effluent | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Flow | | Total Phosphorus | | | | TSS | | | | TSS | | | | Total Phosphorus | | | |
| | MGD | | mg/L | | lbs/day | | mg/L | | lbs/day | | mg/L | | lbs/day | | mg/L | | lbs/day | |
| **Month** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** |
| January | 1.755 | 2.084 | 4.98 | 10.10 | 72.81 | 138.73 | 164 | 302 | 2396 | 4707 | 7.95 | 12.20 | 116 | 181 | 0.39 | 0.70 | 5.68 | 10.43 |
| February | 1.794 | 2.215 | 4.73 | 6.40 | 70.18 | 94.42 | 174 | 348 | 2580 | 5050 | 9.48 | 15.40 | 140 | 194 | 0.43 | 0.80 | 6.38 | 12.24 |
| March | 2.421 | 5.249 | 3.61 | 5.80 | 69.69 | 104.99 | 165 | 648 | 3142 | 11841 | 6.58 | 11.80 | 132 | 282 | 0.35 | 0.80 | 7.33 | 21.89 |
| April | 2.356 | 3.876 | 4.29 | 8.20 | 79.78 | 133.49 | 146 | 506 | 2684 | 8216 | 3.86 | 8.60 | 73 | 165 | 0.23 | 0.60 | 4.85 | 19.40 |
| May | 1.724 | 2.043 | 5.40 | 7.60 | 76.87 | 108.70 | 209 | 434 | 3019 | 6364 | 4.08 | 6.00 | 59 | 89 | 0.15 | 0.30 | 2.15 | 4.37 |
| June | 1.681 | 2.024 | 5.95 | 8.10 | 82.46 | 109.98 | 205 | 300 | 2872 | 5064 | 8.20 | 15.60 | 115 | 222 | 0.15 | 0.40 | 2.04 | 5.68 |
| July | 1.537 | 1.811 | 6.10 | 8.50 | 79.30 | 113.66 | 237 | 440 | 3043 | 5435 | 7.34 | 14.20 | 95 | 178 | 0.12 | 0.40 | 1.67 | 5.20 |
| August | 1.440 | 1.587 | 6.45 | 9.20 | 77.68 | 112.61 | 245 | 378 | 2946 | 4719 | 6.42 | 9.80 | 77 | 117 | 0.25 | 0.70 | 3.13 | 8.61 |
| September | 1.658 | 2.166 | 5.45 | 8.00 | 74.56 | 97.68 | 215 | 556 | 2920 | 6552 | 6.37 | 10.60 | 89 | 150 | 0.22 | 0.51 | 3.13 | 9.17 |
| October | 1.651 | 2.238 | 6.24 | 11.10 | 85.79 | 158.02 | 211 | 402 | 2888 | 579 | 7.34 | 12.20 | 101 | 168 | 0.20 | 0.41 | 2.84 | 7.30 |
| November | 1.539 | 2.020 | 6.05 | 8.40 | 78.23 | 104.94 | 207 | 380 | 2651 | 4671 | 7.16 | 9.20 | 92 | 133 | 0.13 | 0.28 | 1.73 | 3.92 |
| December | 1.624 | 2.144 | 5.67 | 7.70 | 77.36 | 112.63 | 184 | 258 | 2493 | 3719 | 6.93 | 12.80 | 93 | 167 | 0.13 | 0.26 | 1.80 | 3.70 |
| **AVERAGE** | **1.765** | | **5.41** | | **77.06** | | **197** | | **2803** | | **6.81** | | **98** | | **0.23** | | **3.56** | |
| **MAX** | **2.421** | **5.249** | **6.45** | **11.10** | **85.79** | **158.02** | **245** | **648** | **3142** | **11841** | **9.48** | **15.60** | **140** | **282** | **0.43** | **0.80** | **7.33** | **21.89** |

# Table #4
# City of Plymouth
# Wastewater Treatment Plant Performance Summary
## *Junuary - June 2017*

| | Plant Influent | | | | | | | | | | Secondary Effluent | | | | Final Effluent | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Flow | | Total Phosphorus | | | | TSS | | | | TSS | | | | Total Phosphorus | | | |
| | MGD | | mg/L | | lbs/day | | mg/L | | lbs/day | | mg/L | | lbs/day | | mg/L | | lbs/day | |
| **Month** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** | **ave** | **max** |
| Junuary | 1.738 | 2.074 | 5.00 | 7.40 | 70.80 | 102.85 | 155 | 220 | 2242 | 3350 | 6.75 | 9.60 | 98 | 146 | 0.16 | 0.31 | 2.36 | 4.09 |
| February | 1.912 | 2.684 | 5.10 | 7.50 | 80.30 | 105.21 | 155 | 242 | 2431 | 3423 | 7.65 | 11.40 | 123 | 198 | 0.35 | 2.04 | 5.87 | 37.74 |
| March | 2.328 | 3.326 | 3.59 | 5.20 | 69.90 | 99.86 | 124 | 228 | 2402 | 4660 | 5.97 | 8.40 | 116 | 170 | 0.34 | 0.57 | 6.56 | 11.15 |
| April | 2.626 | 4.285 | 3.38 | 5.60 | 71.89 | 97.37 | 120 | 210 | 2576 | 3865 | 4.70 | 9.00 | 104 | 210 | 0.45 | 0.66 | 9.78 | 17.58 |
| May | 2.201 | 3.568 | 4.62 | 12.90 | 82.86 | 220.01 | 176 | 492 | 3136 | 7731 | 4.93 | 8.00 | 91 | 133 | 0.29 | 0.43 | 5.35 | 12.29 |
| June | 1.982 | 2.285 | 5.13 | 7.70 | 85.92 | 143.14 | 189 | 324 | 3150 | 5412 | 7.11 | 9.60 | 117 | 156 | 0.52 | 0.31 | 2.36 | 4.09 |
| July | | | | | | | | | | | | | | | | | | |
| August | | | | | | | | | | | | | | | | | | |
| September | | | | | | | | | | | | | | | | | | |
| October | | | | | | | | | | | | | | | | | | |
| November | | | | | | | | | | | | | | | | | | |
| December | | | | | | | | | | | | | | | | | | |
| **AVERAGE** | **2.131** | | **4.47** | | **76.94** | | **153** | | **2656** | | **6.19** | | **108** | | **0.35** | | **5.38** | |
| **MAX** | **2.626** | **4.285** | **5.13** | **12.90** | **85.92** | **220** | **189** | **492** | **3150** | **7731** | **7.65** | **11.40** | **123** | **210** | **0.52** | **2.04** | **9.78** | **37.74** |

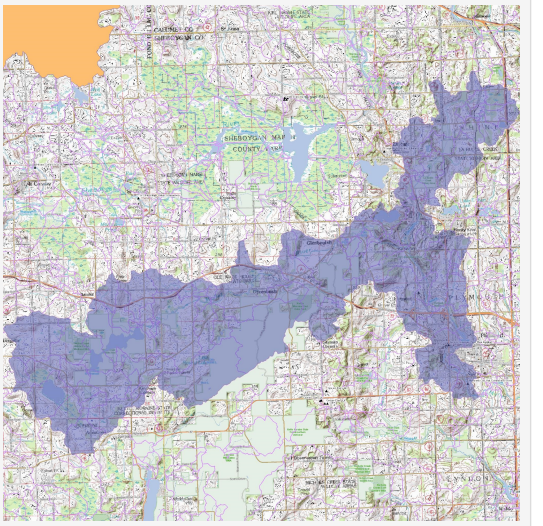
# APPENDIX B

PRESTO PHOSPHORUS ANALYSIS

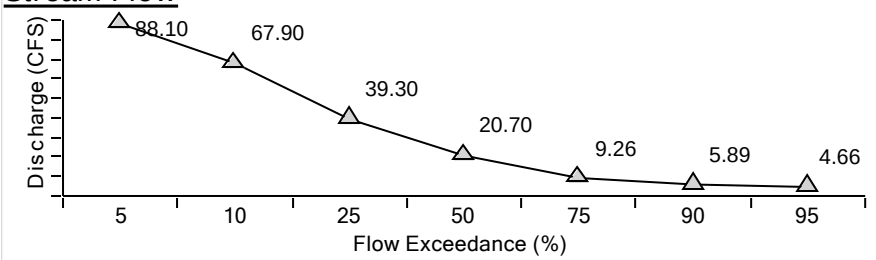
| Sample Point ID | Permit No. | Facility Name | Receiving Water | Major Basin | Watershed Area | Nonpoint Load * | 2009-2011 Avg. Upstream Point Source Load | 2009-2011 Avg. Point Source Load | Total Load * | Point : Nonpoint Source Ratio * | Nonpoint Source Dominated? | Model Flag |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | ($mi^2$) | (lbs) | (lbs) | (lbs) | (lbs) | (%) | | ** |
| 50093 | 31577 | GIBBSVILLE SANITARY DISTRICT | Onion River | Sheboygan | 84.5 | 21063 | 2100 | 574 | 23737 | 11:89 | Yes | |
| 48144 | 21679 | HOWARDS GROVE WASTEWATER TRTMT FAC | Pigeon River | Sheboygan | 48.8 | 16393 | 0 | 491 | 16884 | 3:97 | Yes | |
| 46876 | 1759 | JOHNSONVILLE SAUSAGE LLC | Sheboygan River | Sheboygan | 196.9 | 43270 | 4885 | 187 | 48342 | 10:90 | Yes | |
| 47526 | 20141 | KIEL WASTEWATER TREATMENT FACILITY | Sheboygan River | Sheboygan | 157.7 | 37894 | 1158 | 2948 | 42000 | 10:90 | Yes | |
| 46768 | 1309 | KOHLER COMPANY | Sheboygan River | Sheboygan | 425.2 | 104369 | 11948 | 105 | 116422 | 10:90 | Yes | |
| 49649 | 29335 | LAKELAND COLLEGE | Sheboygan River | Sheboygan | 192.9 | 41812 | 4106 | 779 | 46697 | 10:90 | Yes | |
| 46508 | 817 | LAKESIDE FOODS, INC. - BELGIUM PLANT | Unnamed | Sheboygan | 1.8 | 22 | 0 | 3 | 25 | 12:88 | Yes | |
| 50347 | 35963 | MOUNT CALVARY WASTEWATER TREATMENT FACILITY | Unnamed | Sheboygan | 6.2 | 2238 | 0 | 931 | 3169 | 29:71 | Yes | |
| 50424 | 36811 | ONION RIVER WASTEWATER COMMISSION | Onion River | Sheboygan | 36.9 | 5971 | 251 | 1100 | 7322 | 18:82 | Yes | |
| 48326 | 22233 | OOSTBURG WASTEWATER TREATMENT PLANT | Unnamed | Sheboygan | 0.2 | 92 | 0 | 592 | 684 | 87:13 | Speak with WDNR Basin Engineer | |
| ~~46858~~ | ~~1635~~ | ~~PENTAIR - PLYMOUTH PRODUCTS INC~~ | ~~Sheboygan River~~ | ~~Sheboygan~~ | ~~434.8~~ | ~~105468~~ | ~~12053~~ | ~~33~~ | ~~117554~~ | ~~10:90~~ | ~~Yes~~ | |
| 49775 | 30031 | PLYMOUTH CITY UTIL COMMISSION WWTF | Mullet River | Sheboygan | 56.3 | 7296 | 59 | 4070 | 11425 | 36:64 | Yes | |
| ~~47074~~ | ~~20460~~ | ~~PORT WASHINGTON WWTP~~ | ~~Lake Michigan~~ | ~~Sheboygan~~ | | | | ~~3270~~ | | | ~~No Result~~ | |
| 50675 | 41904 | SARTORI FOOD CORPORATION-WEST MAIN BUILDING | Mullet River | Sheboygan | 54.2 | 6950 | 0 | 59 | 7009 | 1:99 | Yes | |
| 48997 | 25411 | SHEBOYGAN WASTEWATER TREATMENT PLANT | Lake Michigan | Sheboygan | | | | 19020 | | | No Result | |
| 49211 | 26867 | ST CLOUD VILLAGE UTILITY COMMISSION | Sheboygan River | Sheboygan | 73.5 | 26175 | 931 | 227 | 27333 | 4:96 | Yes | |
| 48408 | 22471 | WALDO WASTEWATER UTILITY | Onion River | Sheboygan | 27.6 | 2760 | 0 | 251 | 3011 | 8:92 | Yes | |
| 46604 | 922 | WE - PORT WASHINGTON GENERATING STATION | Lake Michigan | Sheboygan | | | | 0 | | | No Result | |
| 46846 | 1589 | WISCONSIN POWER & LIGHT EDGEWATER GEN. STATION | Lake Michigan | Sheboygan | | | | 0 | | | No Result | |
| 50149 | 31861 | AMANI SANITARY DISTRICT | Wetland | St. Croix River | 0.1 | 32 | 0 | 16 | 48 | 33:67 | Yes | EC |
| 47521 | 20125 | AMERY CITY OF | Apple River | St. Croix River | 255.0 | 43501 | 820 | 843 | 45164 | 4:96 | Yes | |
| 50546 | 39039 | BURNETT DAIRY COOPERATIVE | Wood River | St. Croix River | 76.9 | 18356 | 0 | 99 | 18455 | 1:99 | Yes | |
| 50403 | 36706 | CLAYTON VILLAGE OF | Unnamed | St. Croix River | 1.6 | 564 | 0 | 820 | 1384 | 59:41 | Speak with WDNR Basin Engineer | |
| 48675 | 23639 | CLEAR LAKE VILLAGE OF | Unnamed | St. Croix River | 2.3 | 2671 | 0 | 357 | 3028 | 12:88 | Yes | |
| 48986 | 25356 | DEER PARK WASTEWATER TREATMENT FACILITY | Willow River | St. Croix River | 81.8 | 84583 | 357 | 136 | 85076 | 1:99 | Yes | |
| 51991 | 60429 | GRANTSBURG VILLAGE OF | Wood River | St. Croix River | 151.1 | 32685 | 99 | 1813 | 34597 | 6:94 | Yes | |
| 48799 | 24279 | HUDSON WASTEWATER TREATMENT FACILITY | Saint Croix River | St. Croix River | | | | 2245 | | | No Result | |
| 47129 | 2836 | LAKESIDE FOODS, INC. NEW RICHMOND | Willow River | St. Croix River | 181.1 | 167840 | 493 | 87 | 168420 | 0:100 | Yes | |
| 48095 | 21482 | LUCK VILLAGE OF | Wetland | St. Croix River | 1.2 | 368 | 0 | 825 | 1193 | 69:31 | Speak with WDNR Basin Engineer | |
| 48004 | 21245 | NEW RICHMOND WASTEWATER TREATMENT FACILITY | Willow River | St. Croix River | 195.5 | 160383 | 580 | 1183 | 162146 | 1:99 | Yes | |
| 48947 | 25020 | OSCEOLA VILLAGE OF | Saint Croix River | St. Croix River | | | | 533 | | | No Result | |
| 49662 | 29394 | RIVER FALLS MUNICIPAL UTILITY WWTF | Kinnickinnic River | St. Croix River | 120.0 | 44673 | 0 | 2162 | 46835 | 5:95 | Yes | |
| 49537 | 28835 | ROBERTS WASTEWATER TREATMENT FACILITY | East Twin Lake | St. Croix River | 0.0 | 2 | 0 | 156 | 158 | 98:2 | Speak with WDNR Basin Engineer | |
| 49558 | 28924 | SIREN VILLAGE OF | Wetland | St. Croix River | | | | 1209 | | | No Result | |
| 49813 | 30252 | SOMERSET WASTEWATER TREATMENT FACILITY | Apple River | St. Croix River | 545.3 | 69521 | 2137 | 427 | 72085 | 4:96 | Yes | |
| 47814 | 20796 | ST CROIX FALLS CITY OF | Saint Croix River | St. Croix River | | | | 2339 | | | No Result | |
| 58350 | 60984 | STAR PRAIRIE WASTEWATER TREATMENT FACILITY | Apple River | St. Croix River | 450.8 | 63940 | 1663 | 474 | 66077 | 3:97 | Yes | |
| 49543 | 28843 | WEBSTER VILLAGE OF | Unnamed | St. Croix River | 0.3 | 24 | 0 | 586 | 610 | 96:4 | Speak with WDNR Basin Engineer | |
| 58609 | 49191 | WI DNR GOV TOMMY THOMPSON FISH HATCHERY | Yellow River | St. Croix River | 61.3 | 3490 | 0 | 153 | 3643 | 4:96 | Yes | |
| 47457 | 4197 | WI DNR OSCEOLA FISH HATCHERY | Unnamed | St. Croix River | 0.1 | 7 | 0 | 334 | 341 | 98:2 | Speak with WDNR Basin Engineer | 0 |
| 47458 | 4201 | WI DNR ST CROIX FALLS HATCHERY | St. Croix River | St. Croix River | | | | 563 | | | No Result | |
| 47981 | 21199 | ALBANY WASTEWATER TREATMENT FACILITY | Sugar River | Sugar - Pecatonica | 463.4 | 373179 | 7735 | 457 | 381371 | 2:98 | Yes | |
| 48323 | 22225 | ARGYLE WASTEWATER TREATMENT FACILITY | East Branch Pecatonica River | Sugar - Pecatonica | 329.2 | 871278 | 4489 | 712 | 876479 | 1:99 | Yes | |
| 49611 | 29131 | BARNEVELD WASTEWATER TREATMENT FACILITY | East Branch Pecatonica River | Sugar - Pecatonica | 17.7 | 44376 | 548 | 1778 | 46702 | 5:95 | Yes | |
| 48616 | 23361 | BELLEVILLE WASTEWATER TREATMENT FACILITY | Sugar River | Sugar - Pecatonica | 174.2 | 106240 | 4232 | 210 | 110682 | 4:96 | Yes | |
| 47647 | 20419 | BELMONT WASTEWATER TREATMENT FACILITY | Bonner Branch | Sugar - Pecatonica | 5.6 | 7264 | 400 | 1218 | 8882 | 18:82 | Yes | |
| 47949 | 21105 | BLANCHARDVILLE WASTEWATER TREATMENT FACILITY | East Branch Pecatonica River | Sugar - Pecatonica | 217.2 | 562940 | 4104 | 385 | 567429 | 1:99 | Yes | |
| 49946 | 30805 | BLOOMFIELD MANOR WASTEWATER TREATMENT FAC | Pedler Creek | Sugar - Pecatonica | 1.7 | 1856 | 0 | 74 | 1930 | 4:96 | Yes | |
| 50109 | 31658 | BLUE MOUNDS WASTEWATER TREATMENT FACILITY | Unnamed | Sugar - Pecatonica | 0.6 | 161 | 0 | 548 | 709 | 77:23 | Speak with WDNR Basin Engineer | |
| 48224 | 21903 | BRODHEAD WASTEWATER TREATMENT FACILITY | Sugar River | Sugar - Pecatonica | 21.6 | 15467 | 0 | 668 | 16135 | 4:96 | Yes | 0 |
| 48650 | 23485 | BROOKLYN WASTEWATER TREATMENT FACILITY | Allen Creek | Sugar - Pecatonica | 10.9 | 1062 | 0 | 1272 | 2334 | 55:45 | Speak with WDNR Basin Engineer | |
| 50177 | 32051 | BROWNTOWN WASTEWATER TREATMENT FACILITY | Skinner Creek | Sugar - Pecatonica | 69.2 | 165631 | 53 | 315 | 165999 | 0:100 | Yes | |
| 47915 | 21016 | DARLINGTON WASTEWATER TREATMENT FACILITY | Pecatonica River | Sugar - Pecatonica | 273.2 | 470037 | 3122 | 472 | 473631 | 1:99 | Yes | |
| 49222 | 26913 | DODGEVILLE WASTEWATER TREATMENT FACILITY | Dodge Branch | Sugar - Pecatonica | 1.1 | 412 | 0 | 1054 | 1466 | 72:28 | Speak with WDNR Basin Engineer | |
| 48767 | 24139 | GRATIOT WASTEWATER TREATMENT FACILITY | Wolf Creek | Sugar - Pecatonica | 27.8 | 92378 | 0 | 312 | 92690 | 0:100 | Yes | |
| 50043 | 31330 | HOLLANDALE WASTEWATER TREATMENT FACILITY | Dodge Branch | Sugar - Pecatonica | 67.8 | 160450 | 1054 | 312 | 161816 | 1:99 | Yes | |
| 53170 | 54241 | KLONDIKE CHEESE CORP | Unnamed | Sugar - Pecatonica | 0.6 | 446 | 0 | 53 | 499 | 11:89 | Yes | |
| 65726 | 54470 | LACTALIS USA BELMONT INC | Bonner Branch | Sugar - Pecatonica | 5.6 | 6986 | 0 | 400 | 7386 | 5:95 | Yes | |
| 48123 | 21580 | LINDEN WASTEWATER TREATMENT FACILITY | Unnamed | Sugar - Pecatonica | 3.0 | 2580 | 0 | 719 | 3299 | 22:78 | Yes | |
| 52813 | 24597 | MADISON METROPOLITAN SEWERAGE DISTRICT WWTF | Badger Mill Creek | Sugar - Pecatonica | 15.5 | 844 | 0 | 3060 | 3904 | 78:22 | Speak with WDNR Basin Engineer | |
| 48899 | 24791 | MINERAL POINT WASTEWATER TREATMENT FACILITY | Brewery Creek | Sugar - Pecatonica | 6.9 | 14457 | 0 | 567 | 15024 | 4:96 | Yes | |
| 47627 | 20362 | MONROE WASTEWATER TREATMENT FACILITY | Honey Creek | Sugar - Pecatonica | 4.8 | 1666 | 0 | 4030 | 5696 | 71:29 | Speak with WDNR Basin Engineer | |
| 48909 | 24830 | MONTICELLO WASTEWATER TREATMENT FACILITY | West Branch Little Sugar River | Sugar - Pecatonica | 33.7 | 22754 | 0 | 922 | 23676 | 4:96 | Yes | |
| 47592 | 20281 | MOUNT HOREB WASTEWATER TREATMENT FACILITY | West Branch Sugar River | Sugar - Pecatonica | 1.8 | 1260 | 0 | 1172 | 2432 | 48:52 | Yes | |
| 47496 | 20061 | NEW GLARUS WASTEWATER TREATMENT FACILITY | Little Sugar River | Sugar - Pecatonica | 22.8 | 54483 | 0 | 1099 | 55582 | 2:98 | Yes | |
| 48158 | 21709 | ORFORDVILLE WASTEWATER TREATMENT FACILITY | Unnamed | Sugar - Pecatonica | 0.9 | 1259 | 0 | 1259 | 2518 | 50:50 | Yes | |
| 51040 | 46957 | PGP INTERNATIONAL INC | North Fork Juda Branch | Sugar - Pecatonica | 3.0 | 2557 | 0 | 476 | 3033 | 16:84 | Yes | |
| 50091 | 31569 | REWEY WASTEWATER TREATMENT FACILITY | Williams-Rewey Branch | Sugar - Pecatonica | 0.6 | 1881 | 0 | 144 | 2025 | 7:93 | Yes | |
| 50045 | 31348 | RIDGEWAY WASTEWATER TREATMENT FACILITY | Smith Conley Creek | Sugar - Pecatonica | 0.9 | 1981 | 0 | 412 | 2393 | 17:83 | Yes | |
| 48346 | 22292 | SOUTH WAYNE WASTEWATER TREATMENT FACILITY | Pecatonica River | Sugar - Pecatonica | | | | 447 | | | No Result | |
| 50152 | 31879 | WI DNR YELLOWSTONE LAKE STATE PARK WWTF | Unnamed | Sugar - Pecatonica | 0.6 | 938 | 0 | 0 | 938 | 0:100 | Yes | |
| 51166 | 50237 | AGROPUR INC LUXEMBURG | Unnamed | Twin - Door - Kewaunee | 0.2 | 201 | 0 | 316 | 517 | 61:39 | Speak with WDNR Basin Engineer | |
| 47796 | 20745 | ALGOMA WASTEWATER TREATMENT FACILITY | Ahnapee River | Twin - Door - Kewaunee | 116.7 | 59466 | 449 | 288 | 60203 | 1:99 | Yes | |
| 50332 | 35840 | BAILEYS HARBOR WASTEWATER TREATMENT FACILITY | Lake Michigan | Twin - Door - Kewaunee | | | | 31 | | | No Result | |
| 48664 | 23566 | CASCO WASTEWATER TREATMENT FACILITY | Casco Creek | Twin - Door - Kewaunee | 13.4 | 5368 | 0 | 264 | 5632 | 5:95 | Yes | |
| 48171 | 21741 | DENMARK WASTEWATER TREATMENT FACILITY | Unnamed | Twin - Door - Kewaunee | 1.9 | 3779 | 0 | 551 | 4330 | 13:87 | Yes | |
| 50327 | 35661 | EGG HARBOR WASTEWATER TREATMENT FACILITY | Lake Michigan | Twin - Door - Kewaunee | | | | 64 | | | No Result | |

# PRESTO-Lite Watershed Delineation Report

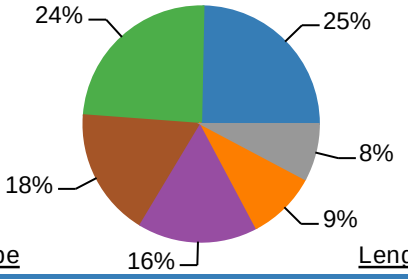
| | |
|---|---|
| Reach ID: 200055790 | |
| Watershed Name: Lower Mullet River | |
| Waterbody Name: Mullet River | |
| HUC08: Manitowoc-Sheboygan Rivers | |
| Watershed Area: 59.56 mi² | |
| Average Annual Precipitation: 33.58in | |



## Stream Flow

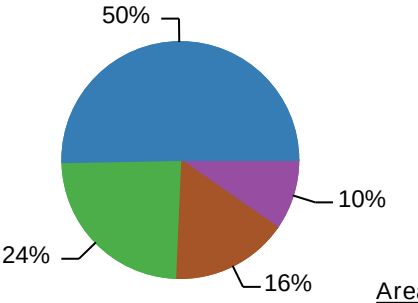



## Tributary Stream Type




| Type | Length |
|---|---|
| Cold Headwater | 20150 ft |
| Warm Headwater | 19668 ft |
| Cold Mainstem | 14337 ft |
| Macroinvertebrates | 13387 ft |
| Cool-Cold Headwater | 7726 ft |
| Coldwater | 6328 ft |
| Cool-Cold Mainstem | 0 ft |
| Large River | 0 ft |
| Warm Mainstem | 0 ft |

## Landcover




| Type | Area |
|---|---|
| Agriculture | 29.02 mi² |
| Forest | 13.84 mi² |
| Wetland | 9.25 mi² |
| Urban | 5.58 mi² |
| Barren | 0.78 mi² |
| Grassland | 0.35 mi² |

## PRESTO Phosphorus Load Estimate

| | |
|---|---|
| Avg. Annual Nonpoint Phosphorous Load (80% Confidence Interval) | 5,594 (2,617 - 11,957) lbs |
| Number of Facilities (Individual Facility Information below) | 2 |
| Avg. Annual Point-source Phosphorous Load (2010 - 2012 total of all facilities) | 3,830lbs |
| Most Likely Point : Nonpoint Phosphorous Ratio | 41% : 59% |
| Low Estimate Point : Nonpoint Phosphorous Ratio (Adaptive Management) | 24% : 76% |

## Adaptive Management Results

Facilities Discharging to the Lower Mullet River Watershed:

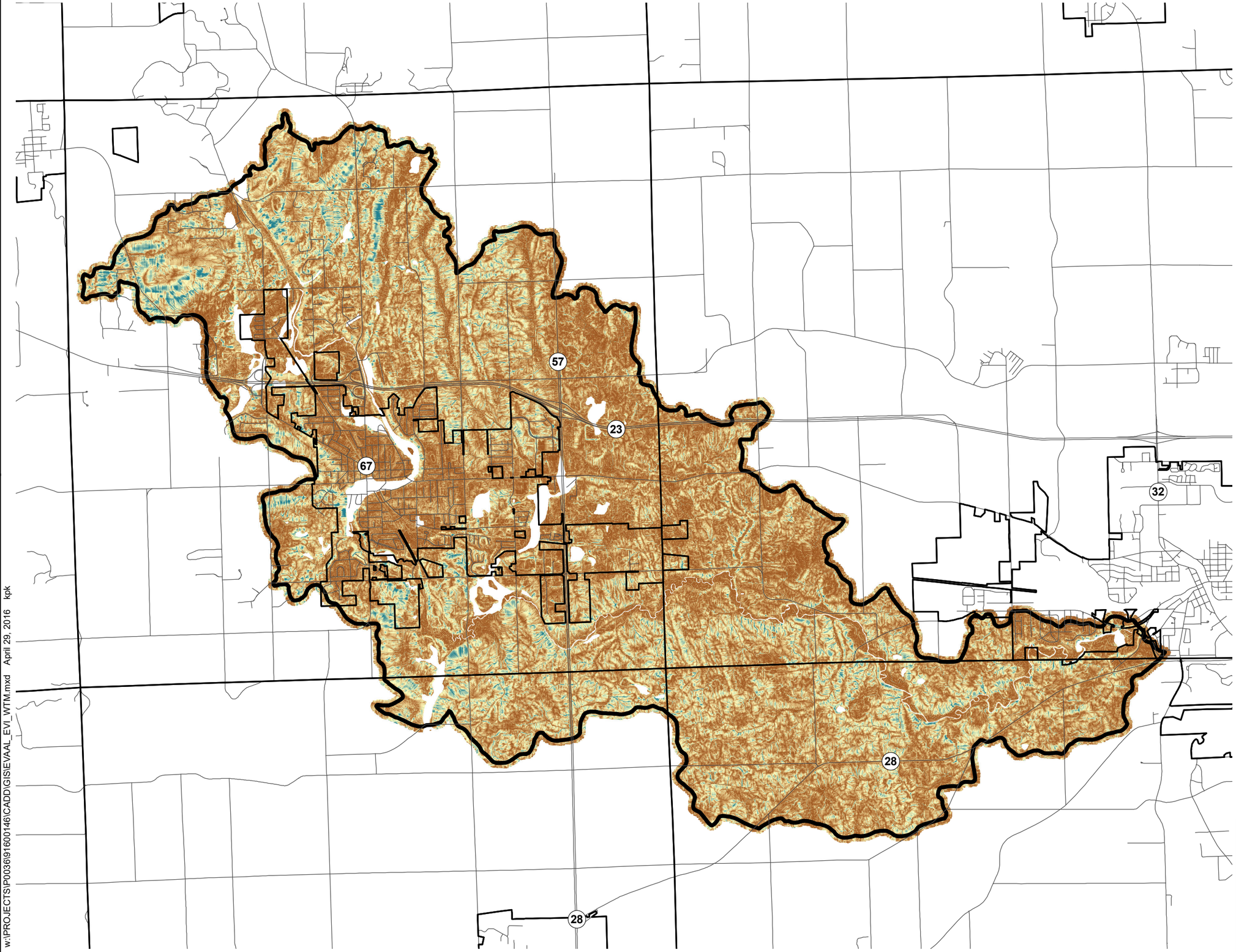
| Facility Name | Permit # | Outfall # | Waste Type | Receiving Water | Avg. Phosphorus Load (lbs.) (2010 - 2012) |
|---|---|---|---|---|---|
| PLYMOUTH CITY UTIL COMMISSION WWTF | 0030031 | 001 | Municipal | Mullet River | 3769 |
| SARTORI COMPANY-WEST MAIN BUILDING | 0041904 | 001 | Industrial | Mullet River | 61 |

## Watershed Analysis Limitations

- This analysis relies on pre-defined catchments from the Wisconsin Hydrography Data-Plus and may not delineate from the exact location required. When assessing phosphorus loads for specific facility in support of efforts such as adaptive management, care should be taken to ensure that additional downstream point sources do not exist. For adaptive management information related to specific facilities please reference the PRESTO website http://dnr.wi.gov/topic/surfacewater/presto.html
- Delineation of watersheds is based on a topographic assessment and therefore do not account for modified drainage networks such as stormwater sewer systems and ditched agriculture.
- If a watershed requires delineation from an exact location the user may use the desktop version of PRESTO that requires ESRI ArcGIS. The PRESTO tool and default datasets can be downloaded at http://dnr.wi.gov/topic/surfacewater/presto.html
- Data sources for this report originate from the WDNR's Wisconsin Hydrography Data-Plus value-added dataset and the point and non-point source loading information including in the WDNR's PRESTO model.
- If you have questions about the report generated from the PRESTO-Lite application please contact: DNRWATERQUALITYMODELING@wisconsin.gov

# APPENDIX C

EVAAL EROSION VULNERABILITY MAPS




PLYMOUTH UTILITIES

**Mapped Features**

Erosion Vulnerability Index

High : 13.5377

Low : -2.28917

Lower Mullet Watershed

Municipal Boundary

Road

Source: Sheboygan County, 2013-15.

Disclaimer: The property lines, right-of-way lines, and other property information on this drawing were developed or obtained as part of the County Geographic Information System or through the County property tax mapping function. McMAHON does not guarantee this information to be correct, current, or complete. The property and right-of-way information are only intended for use as a general reference and are not intended or suitable for site-specific uses. Any use to the contrary of the above stated uses is the responsibility of the user and such use is at the user's own risk.

N

0 5,000 10,000 Feet

McMAHON ENGINEERS ARCHITECTS

**EROSION VULNERABILITY INDEX**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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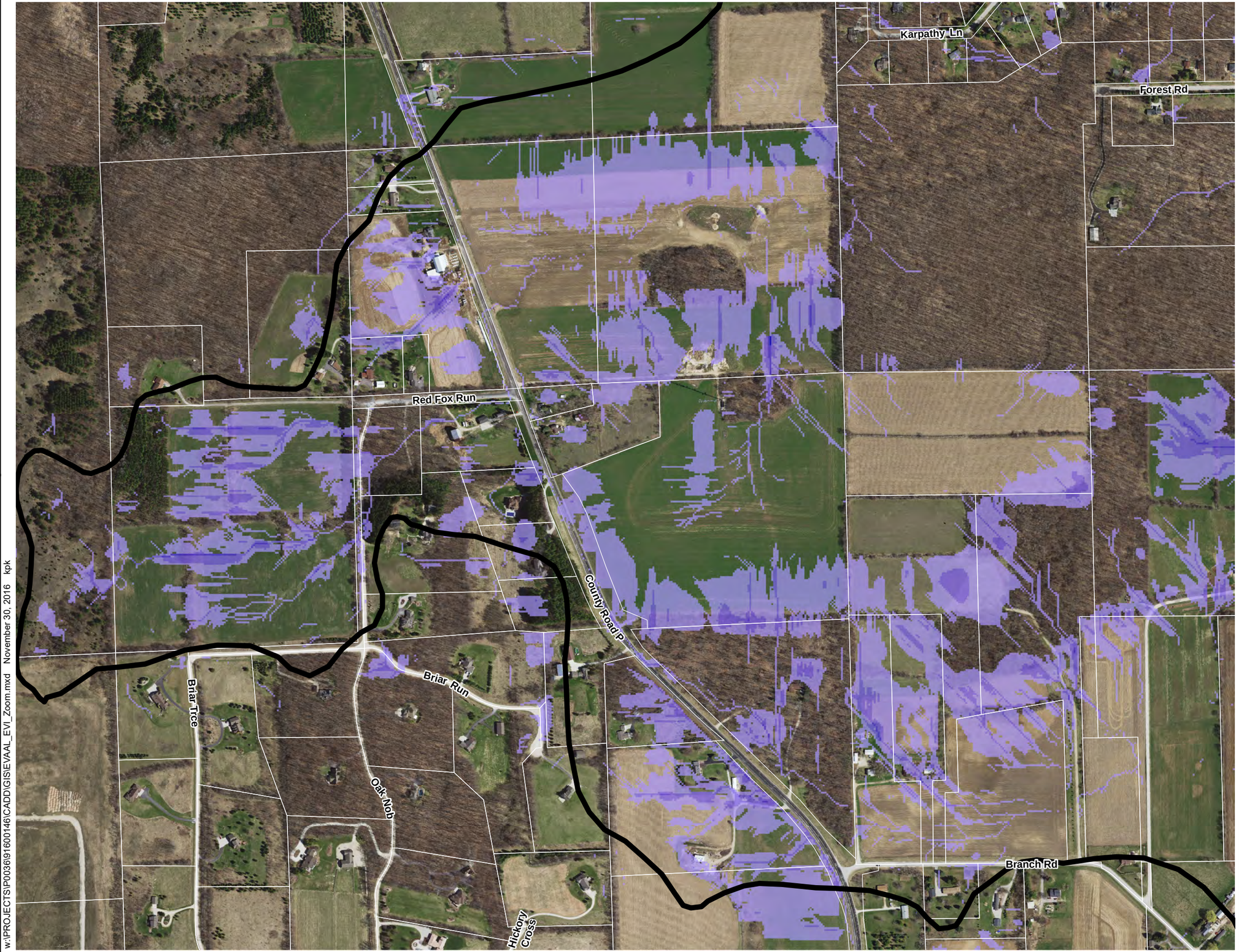


PLYMOUTH UTILITIES

**Erosion Vulnerability Index**

- (Clear) Less than 3
- 3 to 6
- 6 to 9
- 9 to 12
- Greater than 12

**Other Mapped Features**

- Lower Mullet HUC12 Boundary
- Municipal Boundary
- Parcel Line

Source: Sheboygan County, 2013-15.

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N

0 500 1,000 Feet

McMAHON ENGINEERS ARCHITECTS

**EROSION VULNERABILITY INDEX**
PLYMOUTH UTILITIES COMMISSION
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

w:\PROJECTS\P0036\91600146\CADD\GIS\EVAAL_EVI_Zoom.mxd November 30, 2016 kpk

PLYMOUTH UTILITIES

**Erosion Vulnerability Index**

- (Clear) Less than 3
- 3 to 6
- 6 to 9
- 9 to 12
- Greater than 12

**Other Mapped Features**

- Lower Mullet HUC12 Boundary
- Municipal Boundary
- Parcel Line

Source: Sheboygan County, 2013-15.

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N

0 500 1,000 Feet

McMAHON ENGINEERS ARCHITECTS

**EROSION VULNERABILITY INDEX**
PLYMOUTH UTILITIES COMMISSION
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

w:\PROJECTS\P0036\91600146\CADD\GIS\EVAAL_EVI_Zoom.mxd November 30, 2016 kpk

PLYMOUTH UTILITIES

**Erosion Vulnerability Index**

- (Clear) Less than 3
- 3 to 6
- 6 to 9
- 9 to 12
- Greater than 12

**Other Mapped Features**

- Lower Mullet HUC12 Boundary
- Municipal Boundary
- Parcel Line

Source: Sheboygan County, 2013-15.

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N

0 500 1,000 Feet

McMAHON ENGINEERS ARCHITECTS

**EROSION VULNERABILITY INDEX**
PLYMOUTH UTILITIES COMMISSION
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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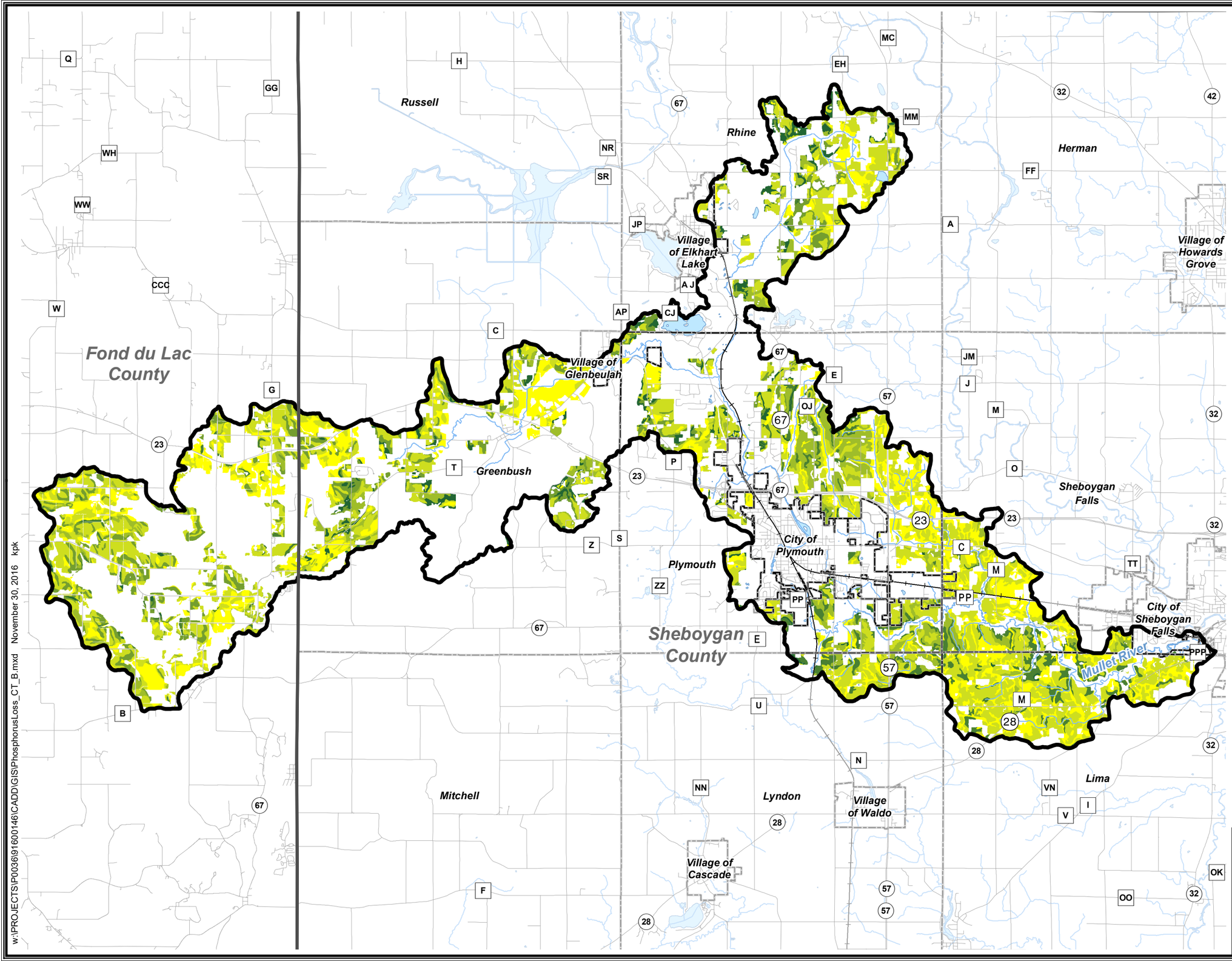
# APPENDIX D

SNAP-PLUS CROPLAND P LOSS MAPS (CONVENTIONAL TILLAGE)




PLYMOUTH WISCONSIN

**Phosphorus Loss Coventional Tillage (lbs/ac/yr)**

- Less than 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- Greater than 10

**Other Mapped Features**

- Mullet River HUC 12 Boundary
- County Boundary
- Municipal Boundary
- Road Centerline
- Railroad Centerline
- Stream
- Surface Water

Source: Sheboygan County, 2013; Wisconsin DNR, 2010; USDA, 2015.

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NOT TO SCALE

McMAHON ENGINEERS ARCHITECTS

**PHOSPHORUS LOSS**
PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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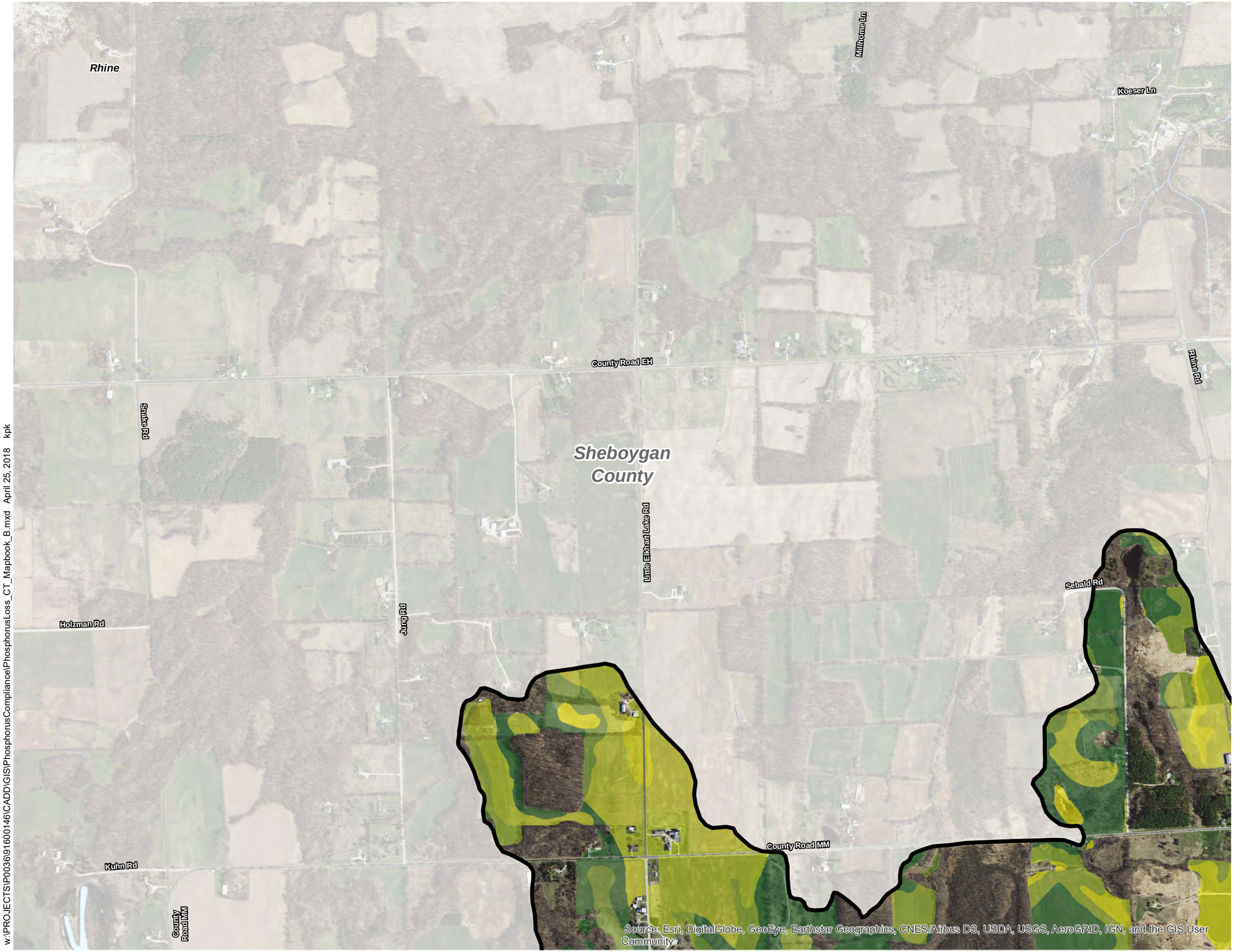


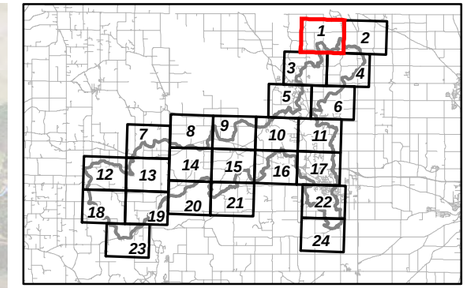


**Phosphorus Loss Conventional Tillage (lbs/ac/yr)**

- Less than 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- Greater than 10

**Other Mapped Features**

- Mullet River AM Area for Plymouth WWTF
- County Boundary
- Municipal Boundary
- Road Centerline
- Railroad Centerline
- Stream
- Surface Water

Source: Sheboygan County, 2013; Wisconsin DNR, 2010; USDA, 2015.

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0 1,000 Feet

PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 1 OF 24

**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**

PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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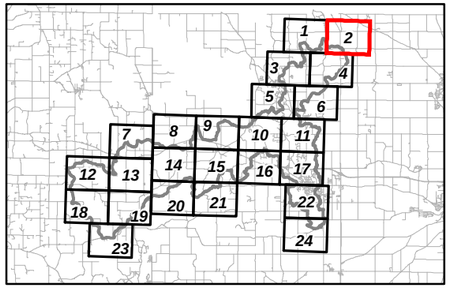


**Phosphorus Loss Conventional Tillage (lbs/ac/yr)**

- Less than 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- Greater than 10

**Other Mapped Features**

- Mullet River AM Area for Plymouth WWTF
- County Boundary
- Municipal Boundary
- Road Centerline
- Railroad Centerline
- Stream
- Surface Water

Source: Sheboygan County, 2013; Wisconsin DNR, 2010; USDA, 2015.

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0 1,000 Feet

PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 2 OF 24
**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**
PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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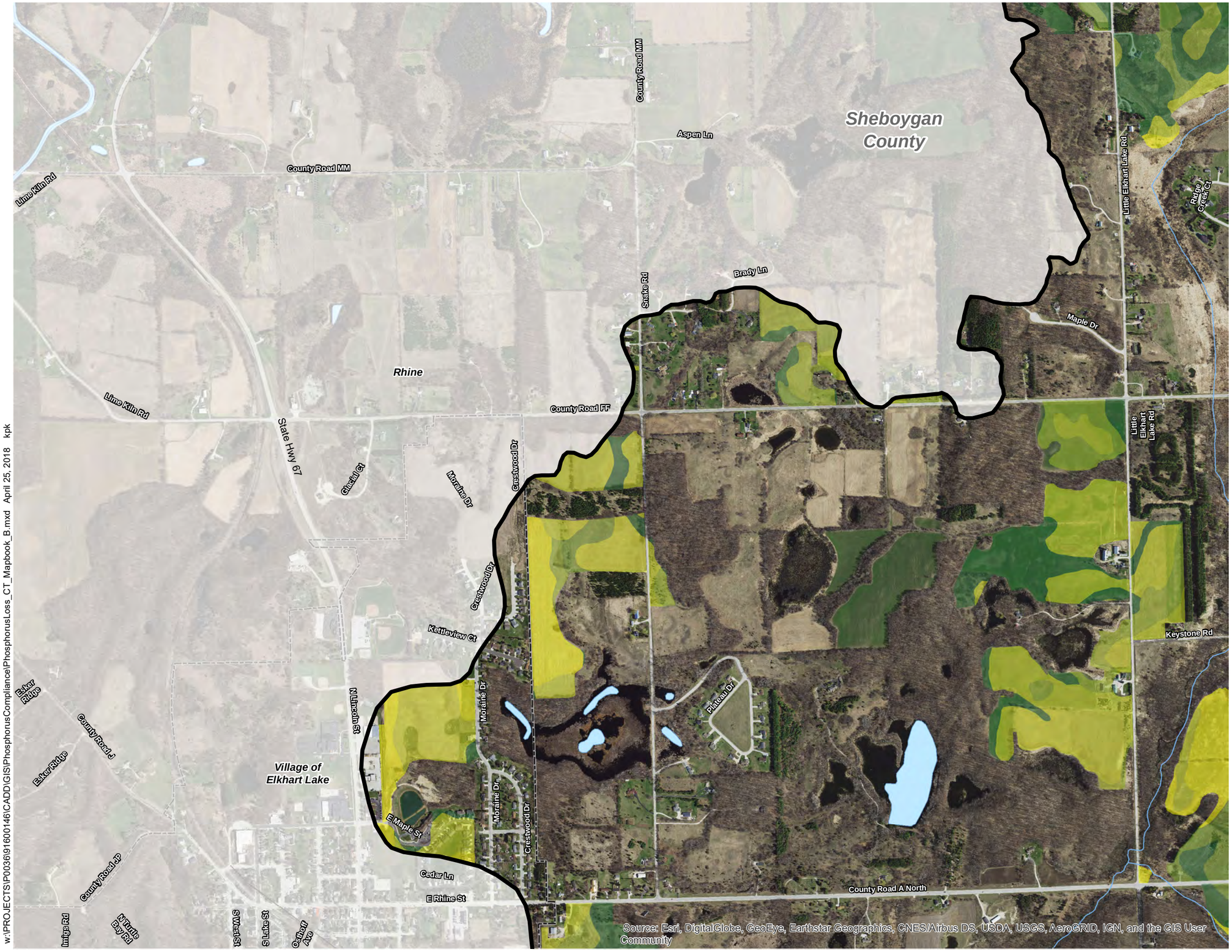


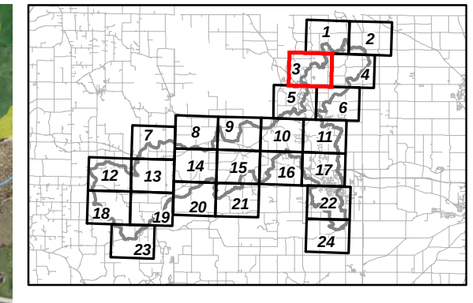


**Phosphorus Loss Conventional Tillage (lbs/ac/yr)**

- Less than 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- Greater than 10

**Other Mapped Features**

- Mullet River AM Area for Plymouth WWTF
- County Boundary
- Municipal Boundary
- Road Centerline
- Railroad Centerline
- Stream
- Surface Water

Source: Sheboygan County, 2013; Wisconsin DNR, 2010; USDA, 2015.

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0 1,000 Feet

PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 3 OF 24
**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**
PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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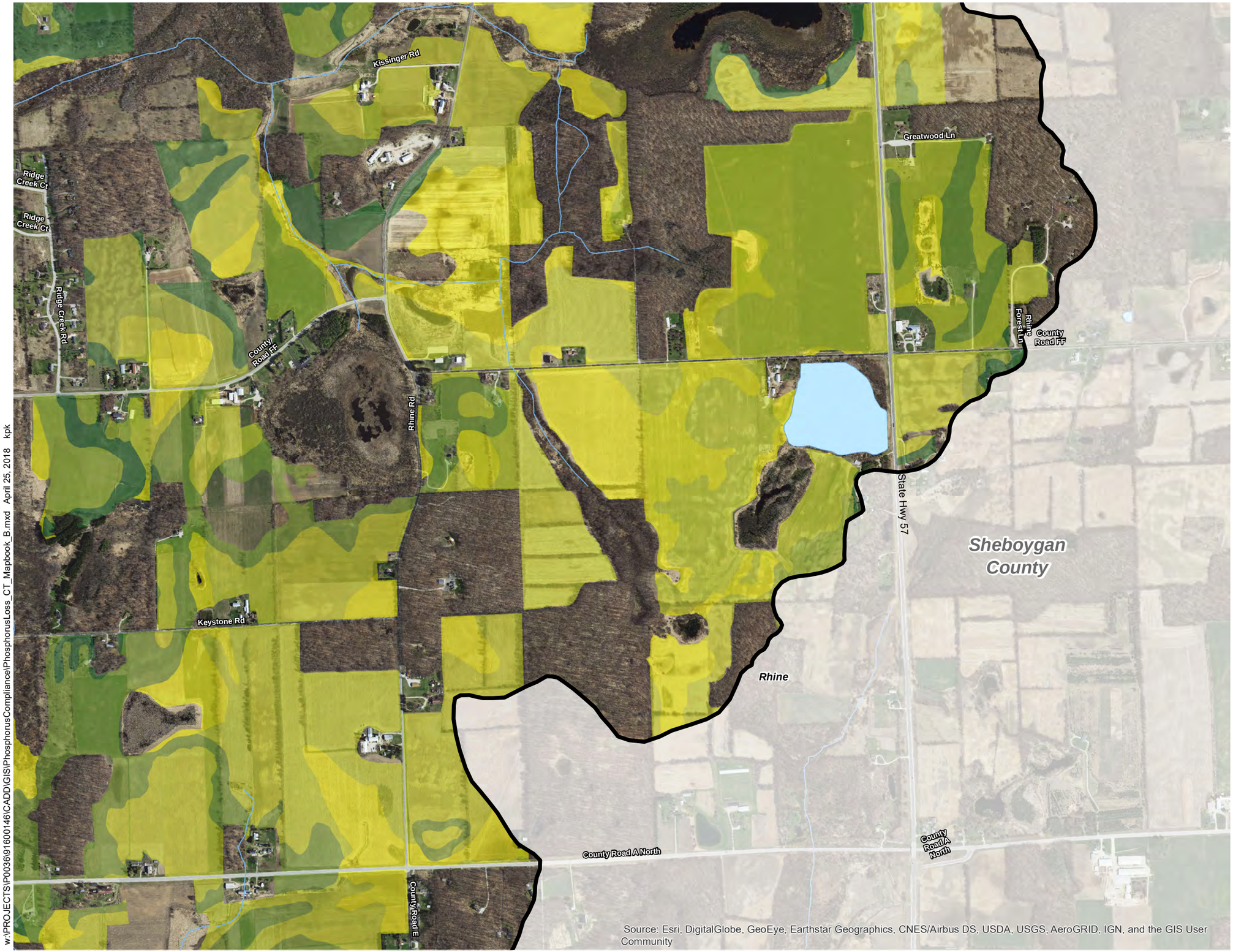
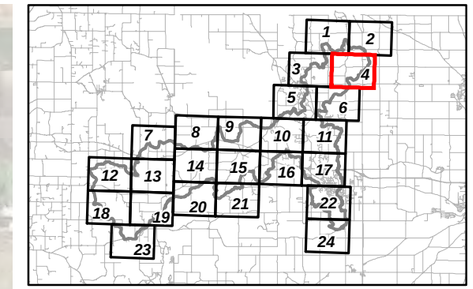



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community




**Phosphorus Loss Conventional Tillage (lbs/ac/yr)**

- Less than 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- Greater than 10

**Other Mapped Features**

- Mullet River AM Area for Plymouth WWTF
- County Boundary
- Municipal Boundary
- Road Centerline
- Railroad Centerline
- Stream
- Surface Water

Source: Sheboygan County, 2013; Wisconsin DNR, 2010; USDA, 2015.

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FIGURE 4 OF 24

**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**

PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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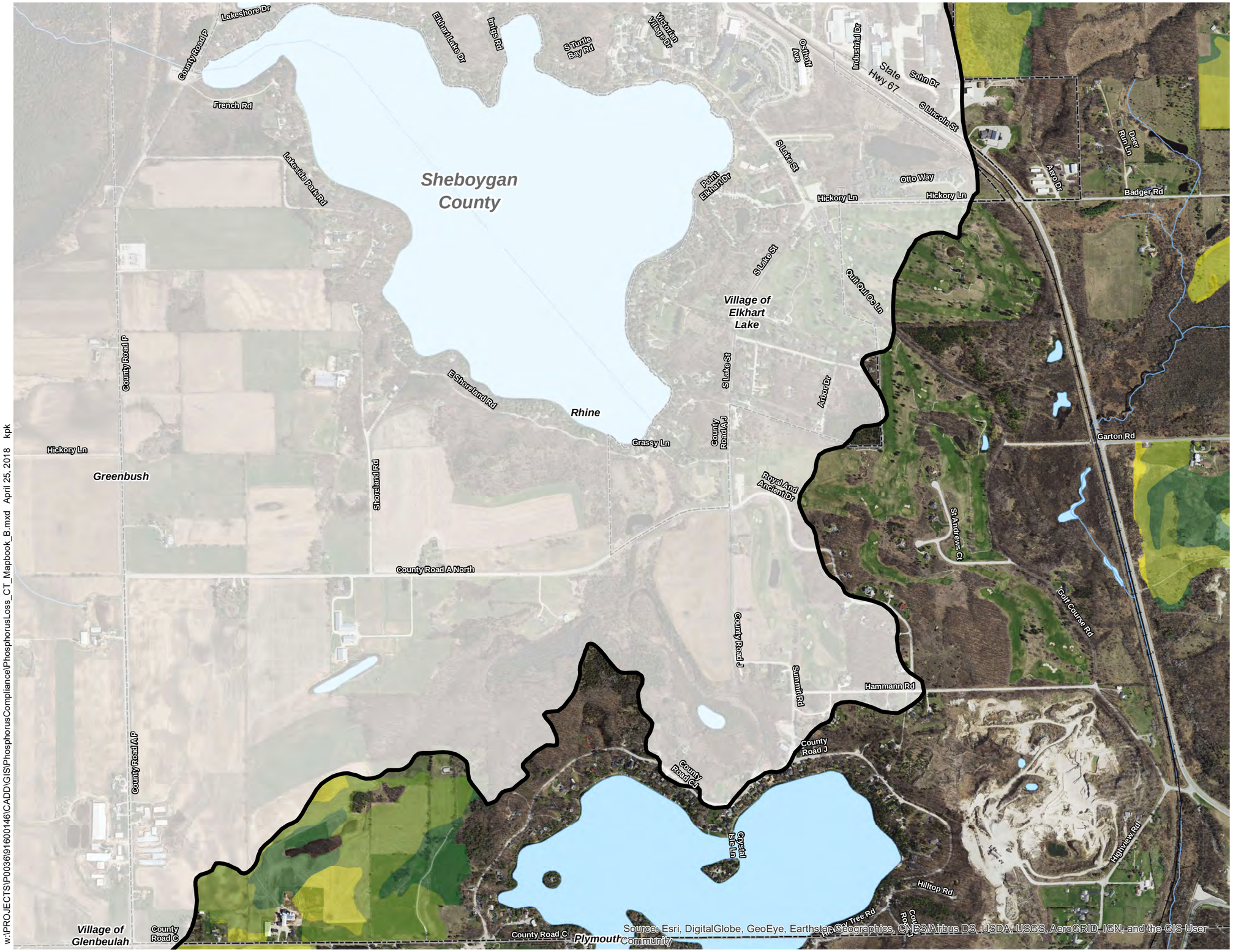


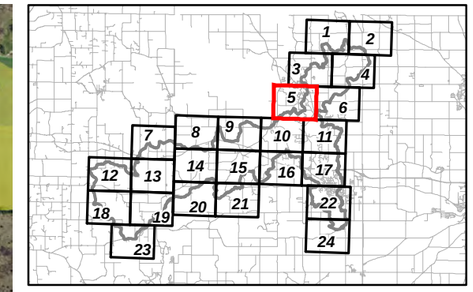


**Phosphorus Loss Conventional Tillage (lbs/ac/yr)**

- Less than 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- Greater than 10

**Other Mapped Features**

- Mullet River AM Area for Plymouth WWTF
- County Boundary
- Municipal Boundary
- Road Centerline
- Railroad Centerline
- Stream
- Surface Water

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 5 OF 24
**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**
PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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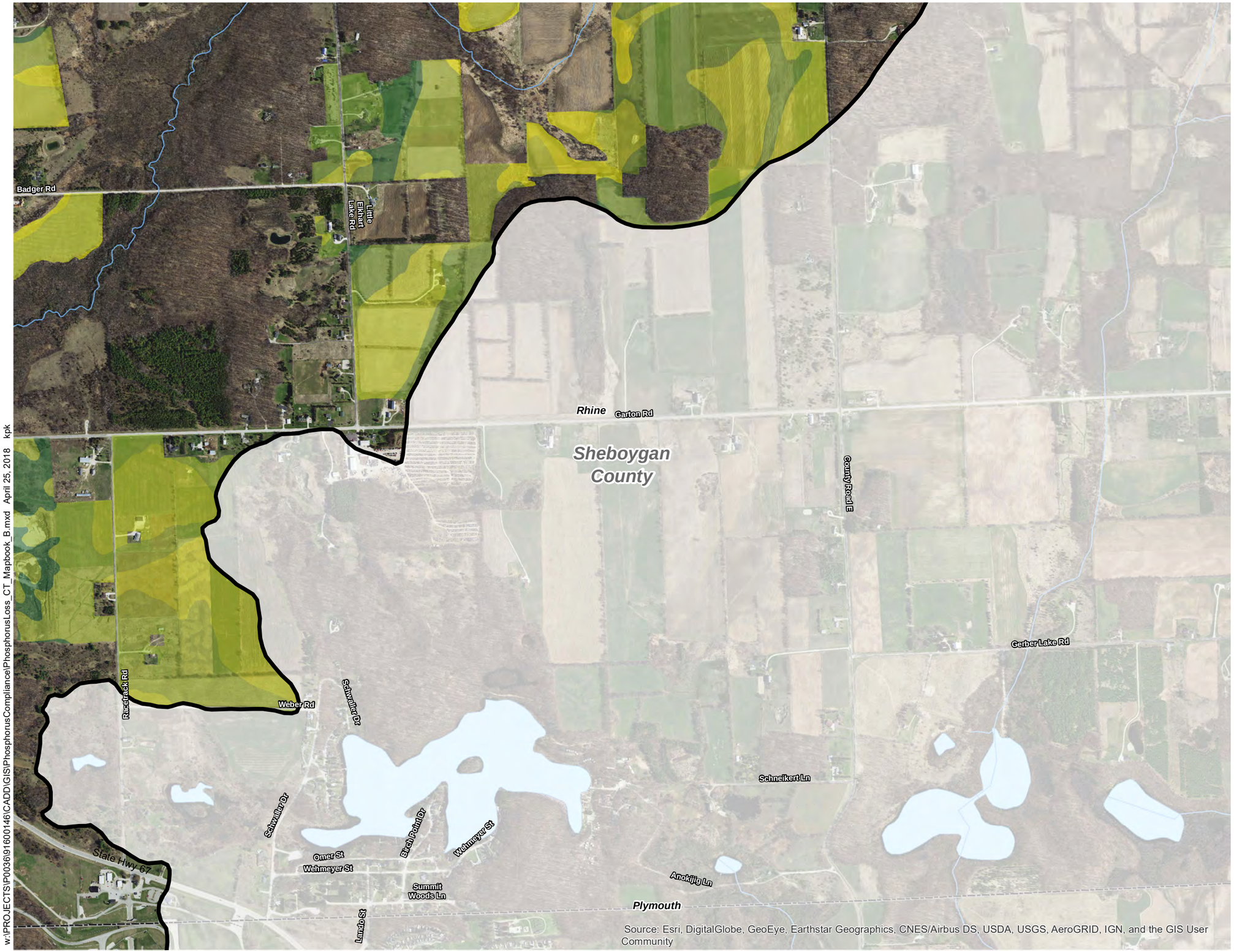
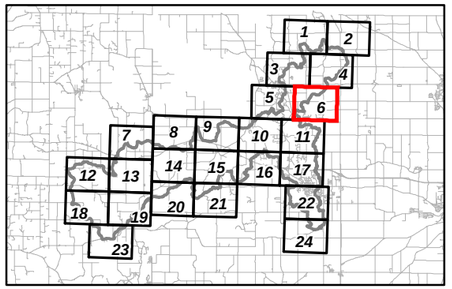



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community




**Phosphorus Loss Conventional Tillage (lbs/ac/yr)**

- Less than 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- Greater than 10

**Other Mapped Features**

- Mullet River AM Area for Plymouth WWTF
- County Boundary
- Municipal Boundary
- Road Centerline
- Railroad Centerline
- Stream
- Surface Water

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 6 OF 24

**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**

PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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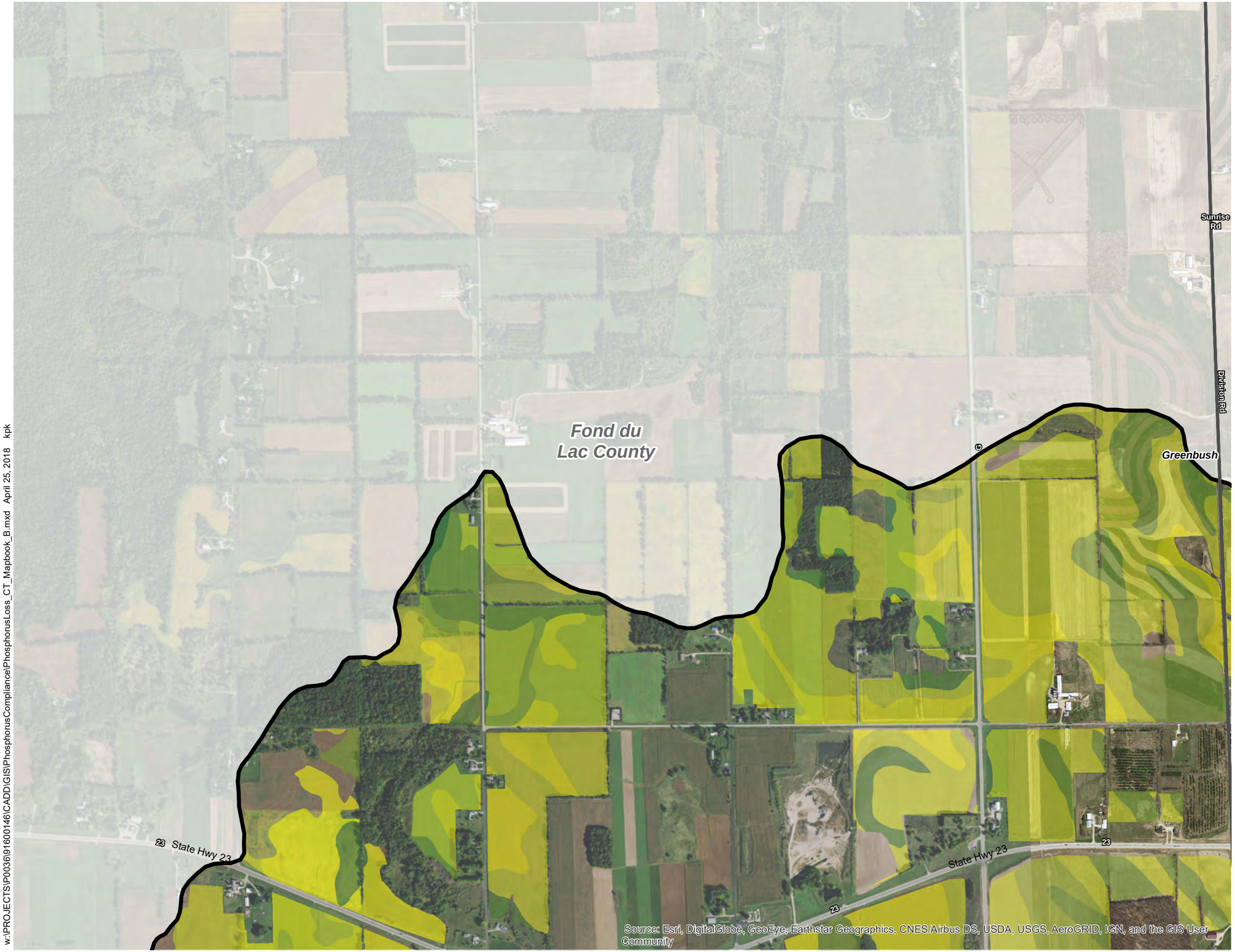


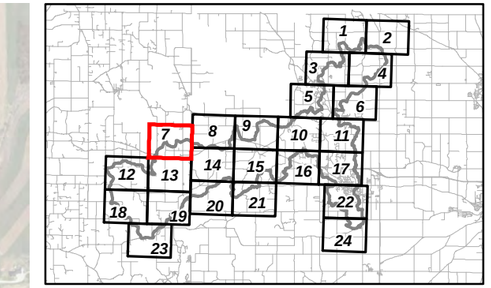


**Phosphorus Loss Conventional Tillage (lbs/ac/yr)**

- Less than 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- Greater than 10

**Other Mapped Features**

- Mullet River AM Area for Plymouth WWTF
- County Boundary
- Municipal Boundary
- Road Centerline
- Railroad Centerline
- Stream
- Surface Water

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 7 OF 24
**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**
PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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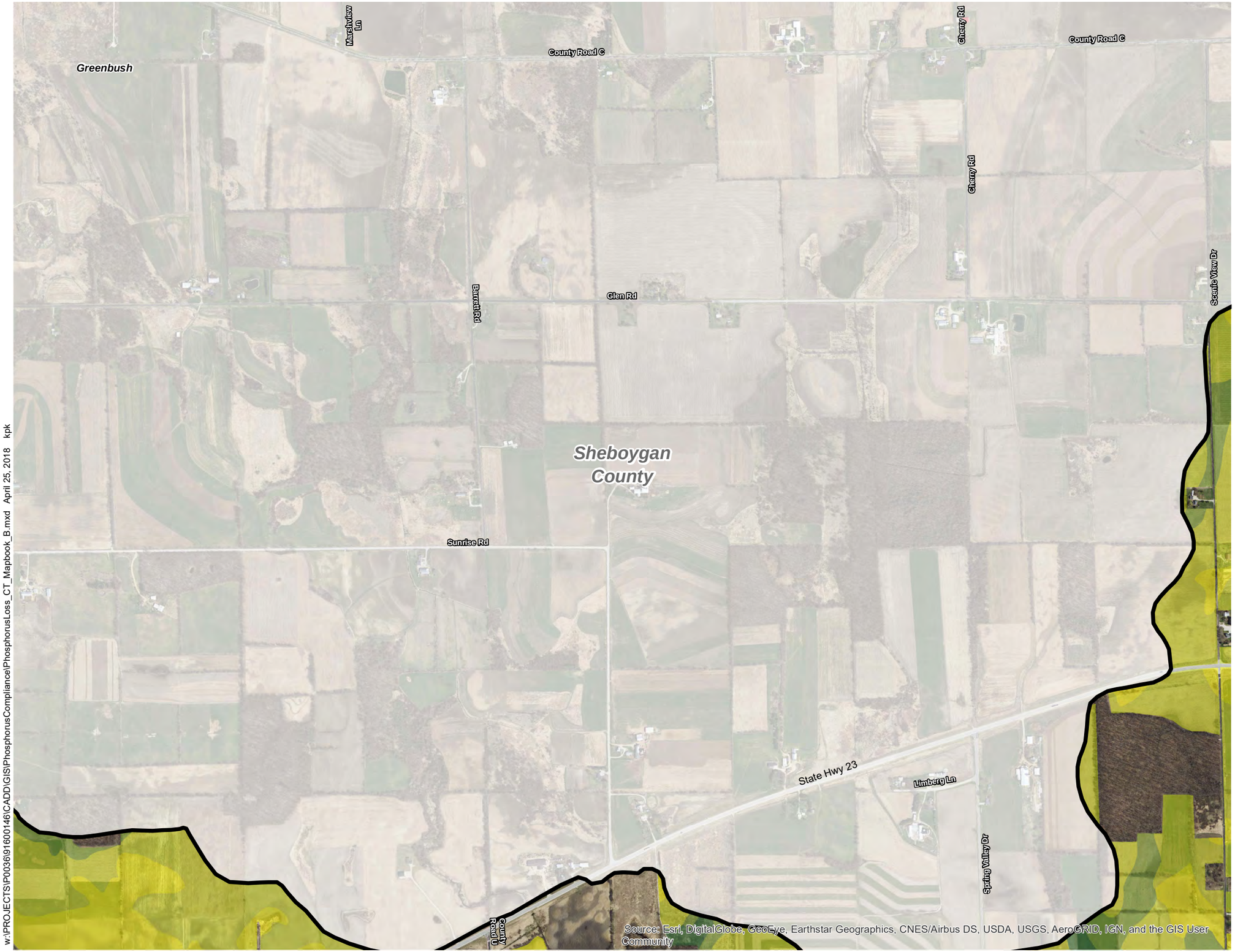


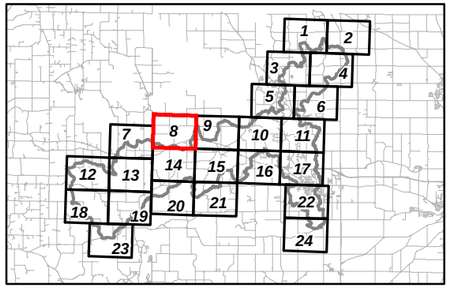


**Phosphorus Loss Conventional Tillage (lbs/ac/yr)**

- Less than 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- Greater than 10

**Other Mapped Features**

- Mullet River AM Area for Plymouth WWTF
- County Boundary
- Municipal Boundary
- Road Centerline
- Railroad Centerline
- Stream
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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 8 OF 24

**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**

PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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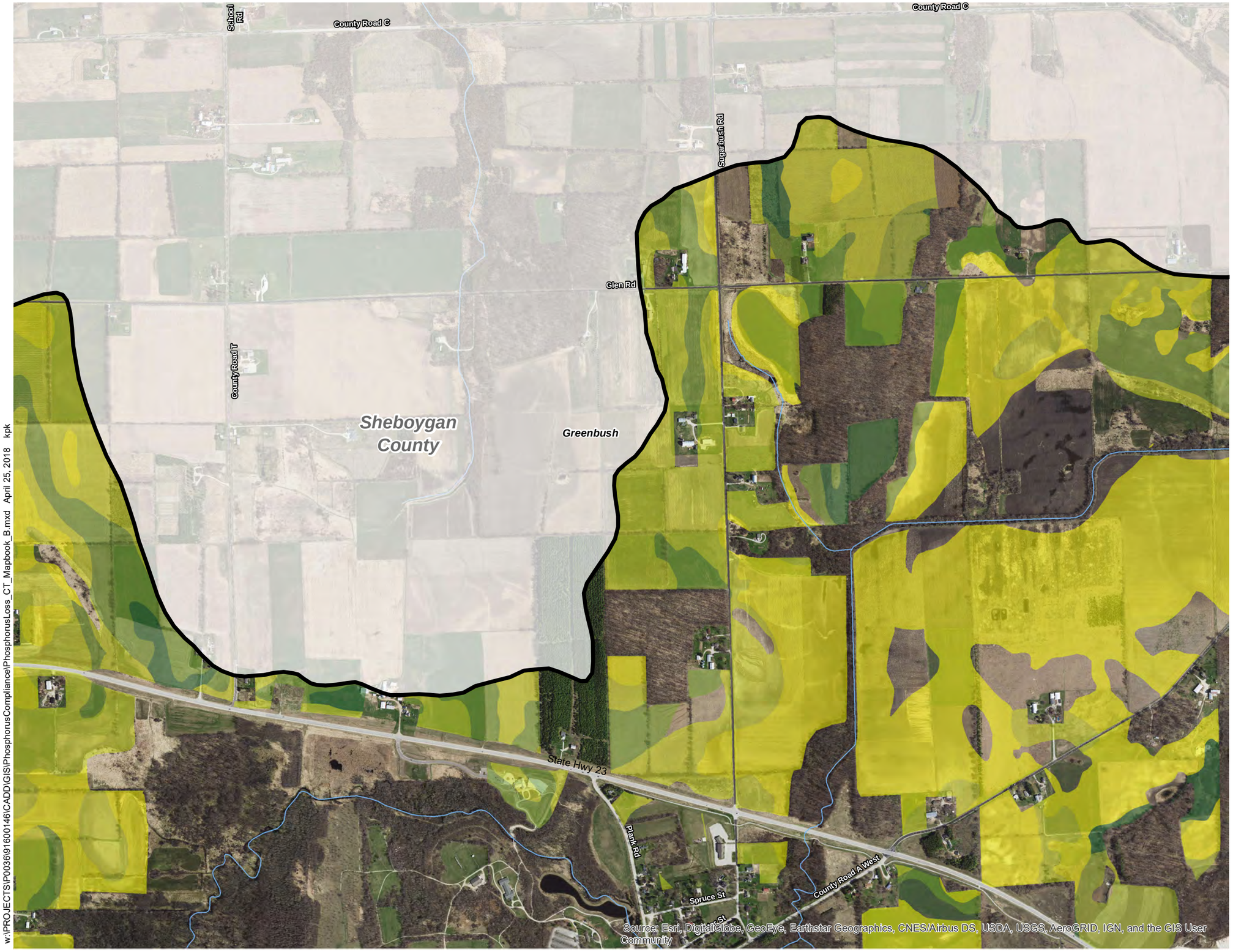


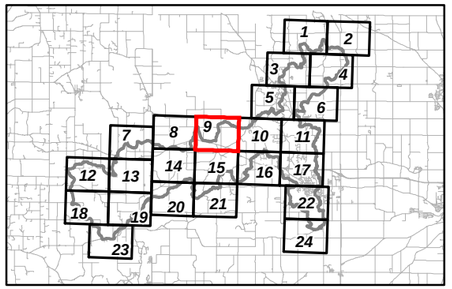


**Phosphorus Loss Conventional Tillage (lbs/ac/yr)**

- Less than 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- Greater than 10

**Other Mapped Features**

- Mullet River AM Area for Plymouth WWTF
- County Boundary
- Municipal Boundary
- Road Centerline
- Railroad Centerline
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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 9 OF 24

**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**

PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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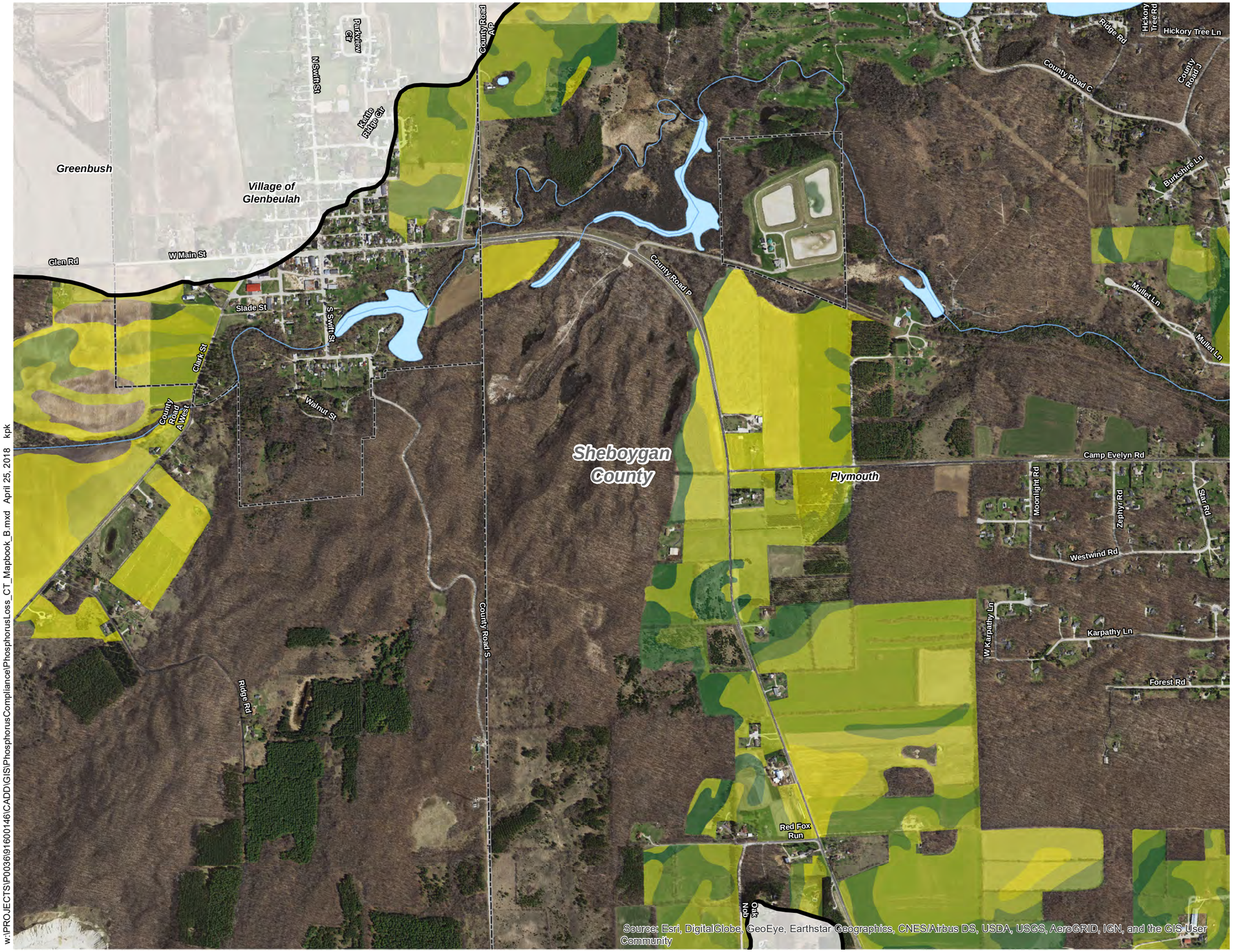


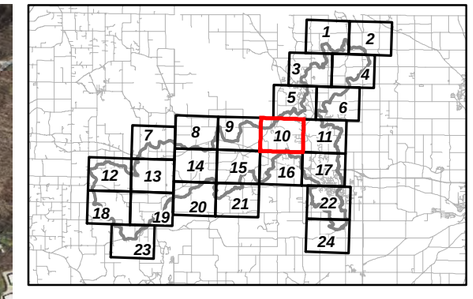


**Phosphorus Loss Conventional Tillage (lbs/ac/yr)**

- Less than 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- Greater than 10

**Other Mapped Features**

- Mullet River AM Area for Plymouth WWTF
- County Boundary
- Municipal Boundary
- Road Centerline
- Railroad Centerline
- Stream
- Surface Water

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 10 OF 24

**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**

PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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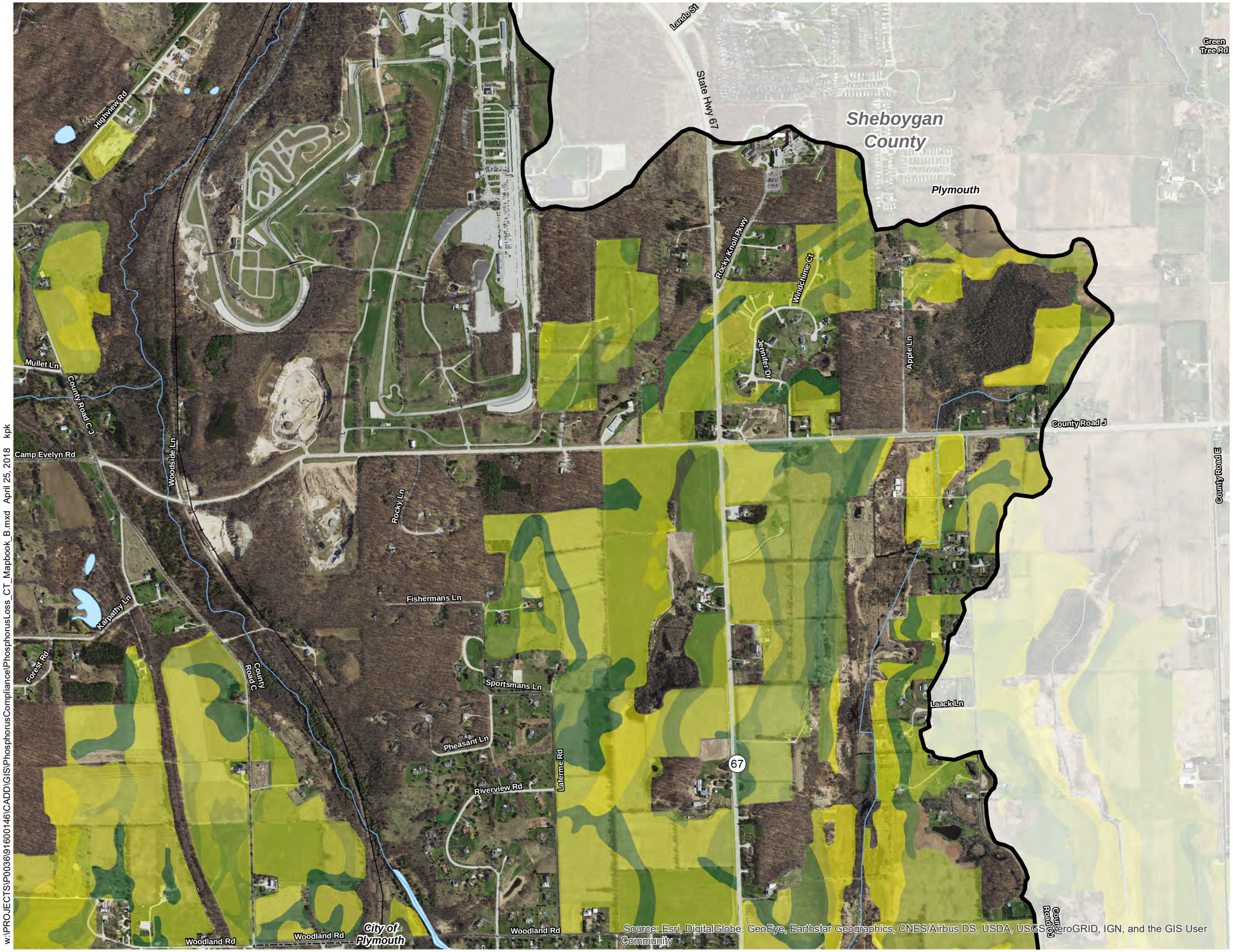


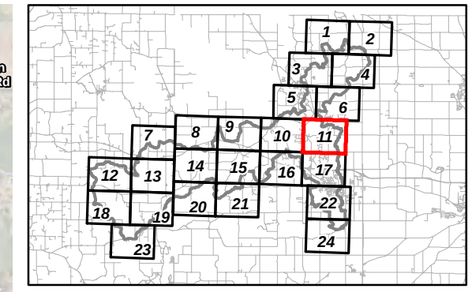


**Phosphorus Loss Conventional Tillage (lbs/ac/yr)**

- Less than 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- Greater than 10

**Other Mapped Features**

- Mullet River AM Area for Plymouth WWTF
- County Boundary
- Municipal Boundary
- Road Centerline
- Railroad Centerline
- Stream
- Surface Water

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 11 OF 24

**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**

PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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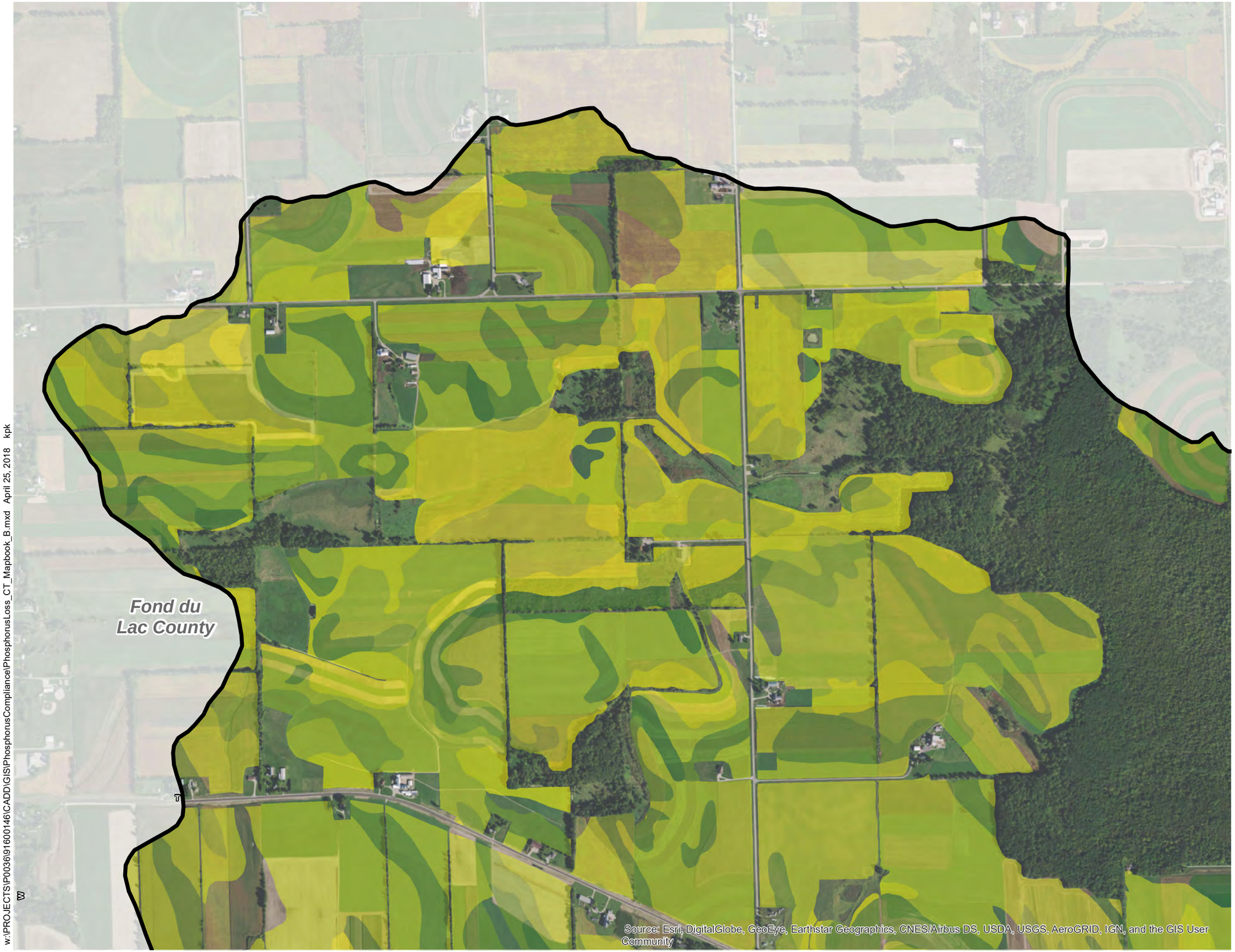


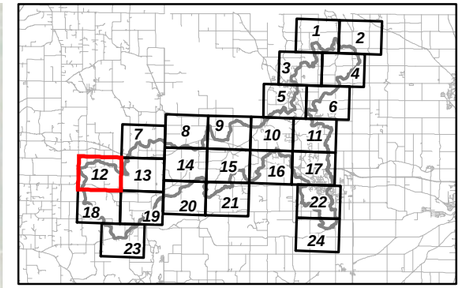


**Phosphorus Loss Conventional Tillage (lbs/ac/yr)**

- Less than 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- Greater than 10

**Other Mapped Features**

- Mullet River
- AM Area for Plymouth WWTF
- County Boundary
- Municipal Boundary
- Road Centerline
- Railroad Centerline
- Stream
- Surface Water

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0 1,000 Feet

PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 12 OF 24
**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**
PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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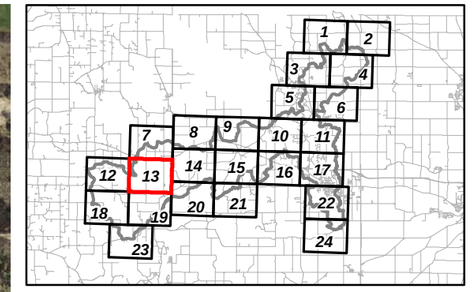


**Phosphorus Loss Conventional Tillage (lbs/ac/yr)**

- Less than 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- Greater than 10

**Other Mapped Features**

- Mullet River AM Area for Plymouth WWTF
- County Boundary
- Municipal Boundary
- Road Centerline
- Railroad Centerline
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- Surface Water

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0 1,000 Feet

PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 13 OF 24

**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**

PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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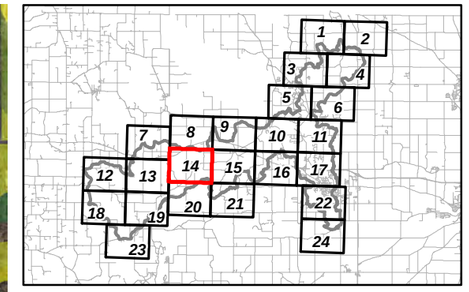


**Phosphorus Loss Conventional Tillage (lbs/ac/yr)**

- Less than 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- Greater than 10

**Other Mapped Features**

- Mullet River AM Area for Plymouth WWTF
- County Boundary
- Municipal Boundary
- Road Centerline
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0 1,000 Feet

PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 14 OF 24
**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**
PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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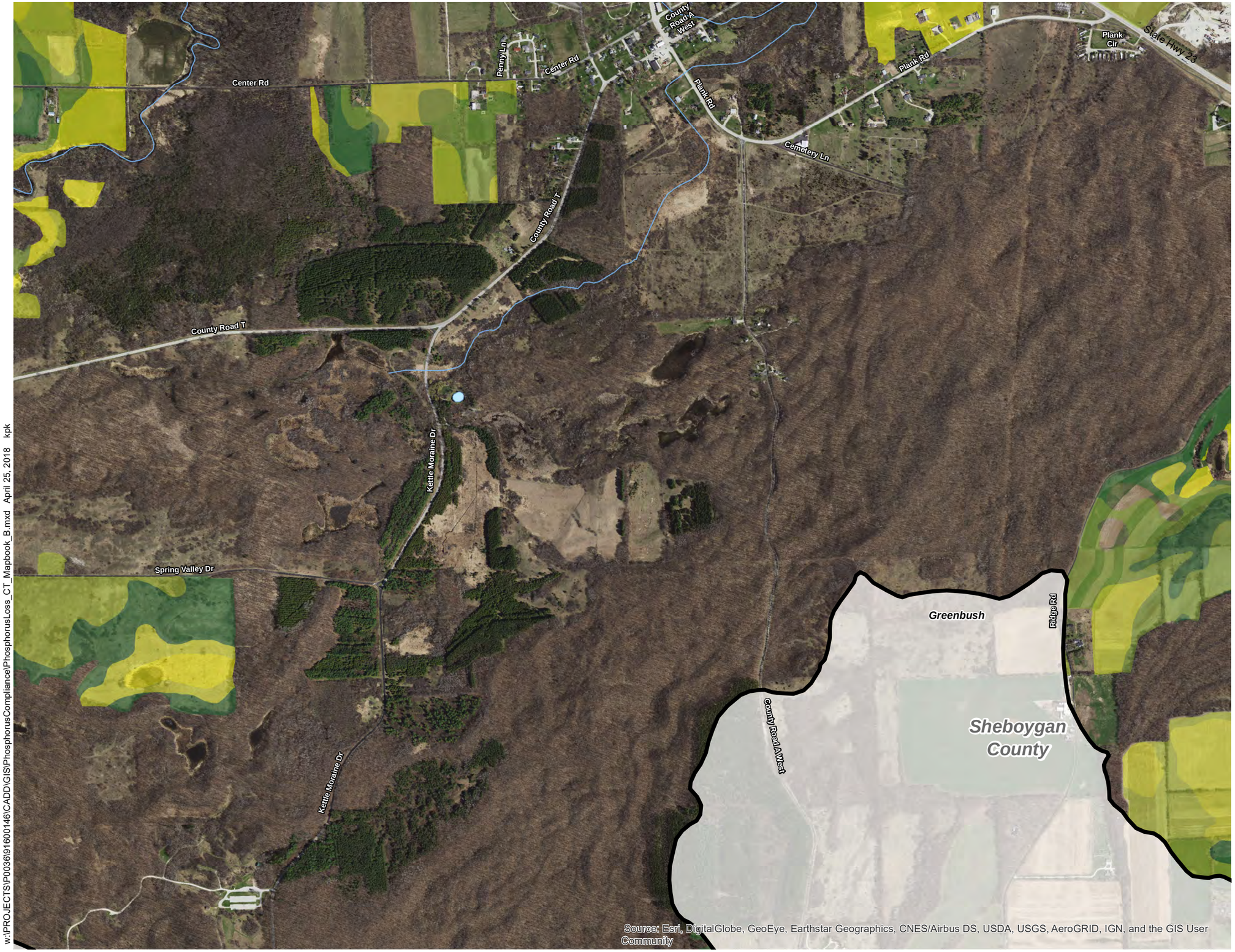


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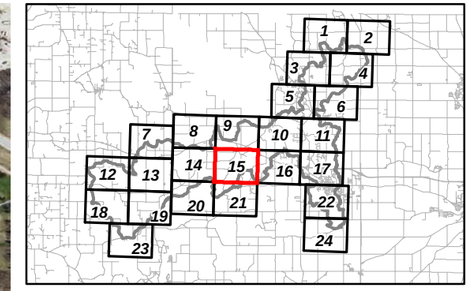


**Phosphorus Loss Conventional Tillage (lbs/ac/yr)**

- Less than 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- Greater than 10

**Other Mapped Features**

- Mullet River AM Area for Plymouth WWTF
- County Boundary
- Municipal Boundary
- Road Centerline
- Railroad Centerline
- Stream
- Surface Water

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 15 OF 24

**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**

PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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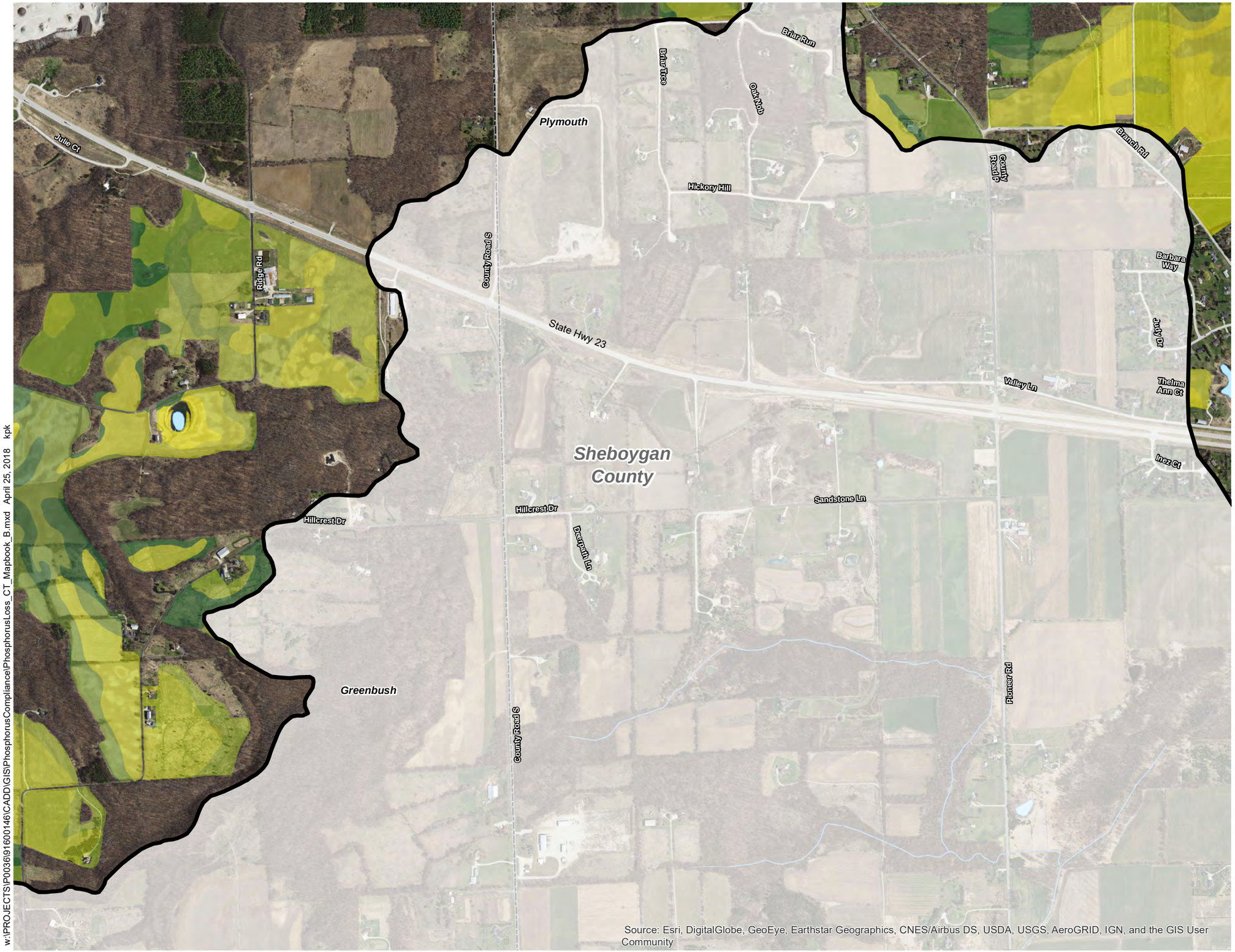


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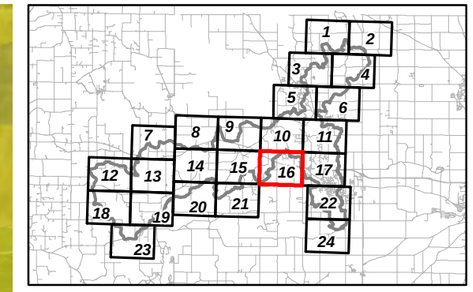


**Phosphorus Loss Conventional Tillage (lbs/ac/yr)**

- Less than 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- Greater than 10

**Other Mapped Features**

- Mullet River AM Area for Plymouth WWTF
- County Boundary
- Municipal Boundary
- Road Centerline
- Railroad Centerline
- Stream
- Surface Water

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 16 OF 24

**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**

PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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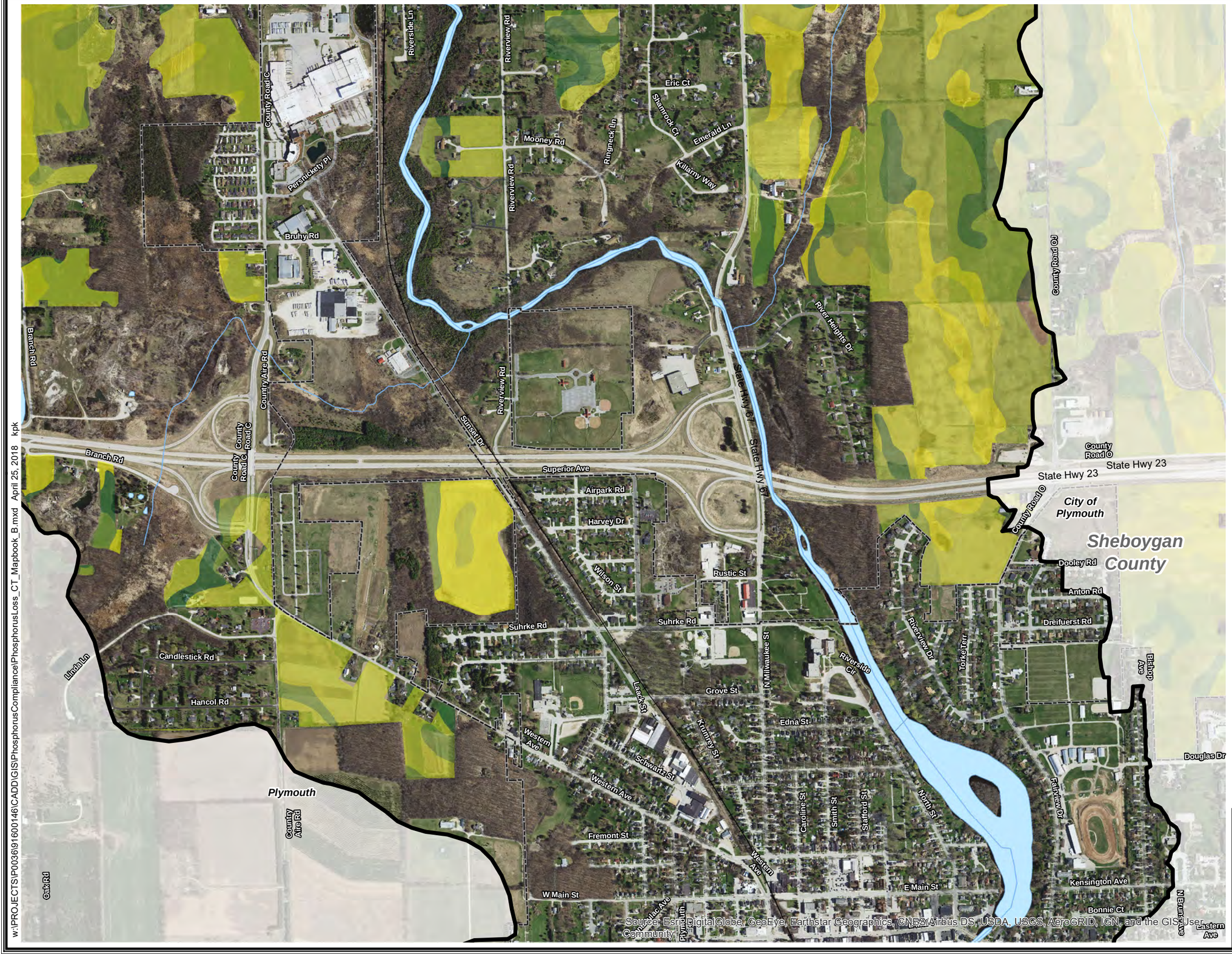


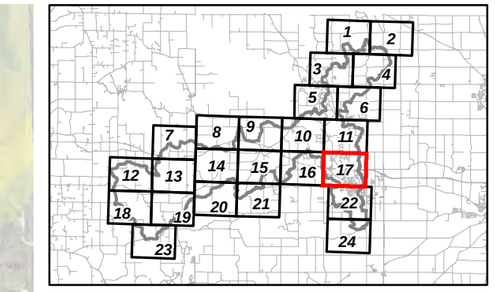


**Phosphorus Loss Conventional Tillage (lbs/ac/yr)**

- Less than 2
- 2 to 4
- 4 to 6
- 6 to 8
- 8 to 10
- Greater than 10

**Other Mapped Features**

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 17 OF 24

**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**

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SHEBOYGAN COUNTY, WISCONSIN

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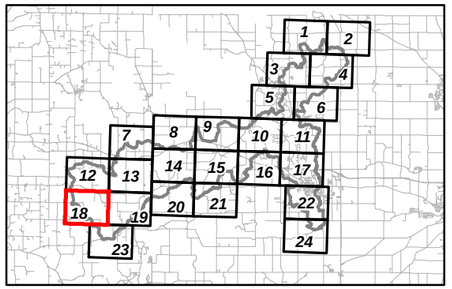


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PLYMOUTH UTILITIES

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FIGURE 18 OF 24

**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**

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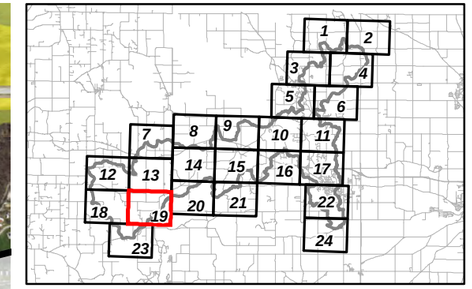
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 19 OF 24

**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**

PLYMOUTH WWTF
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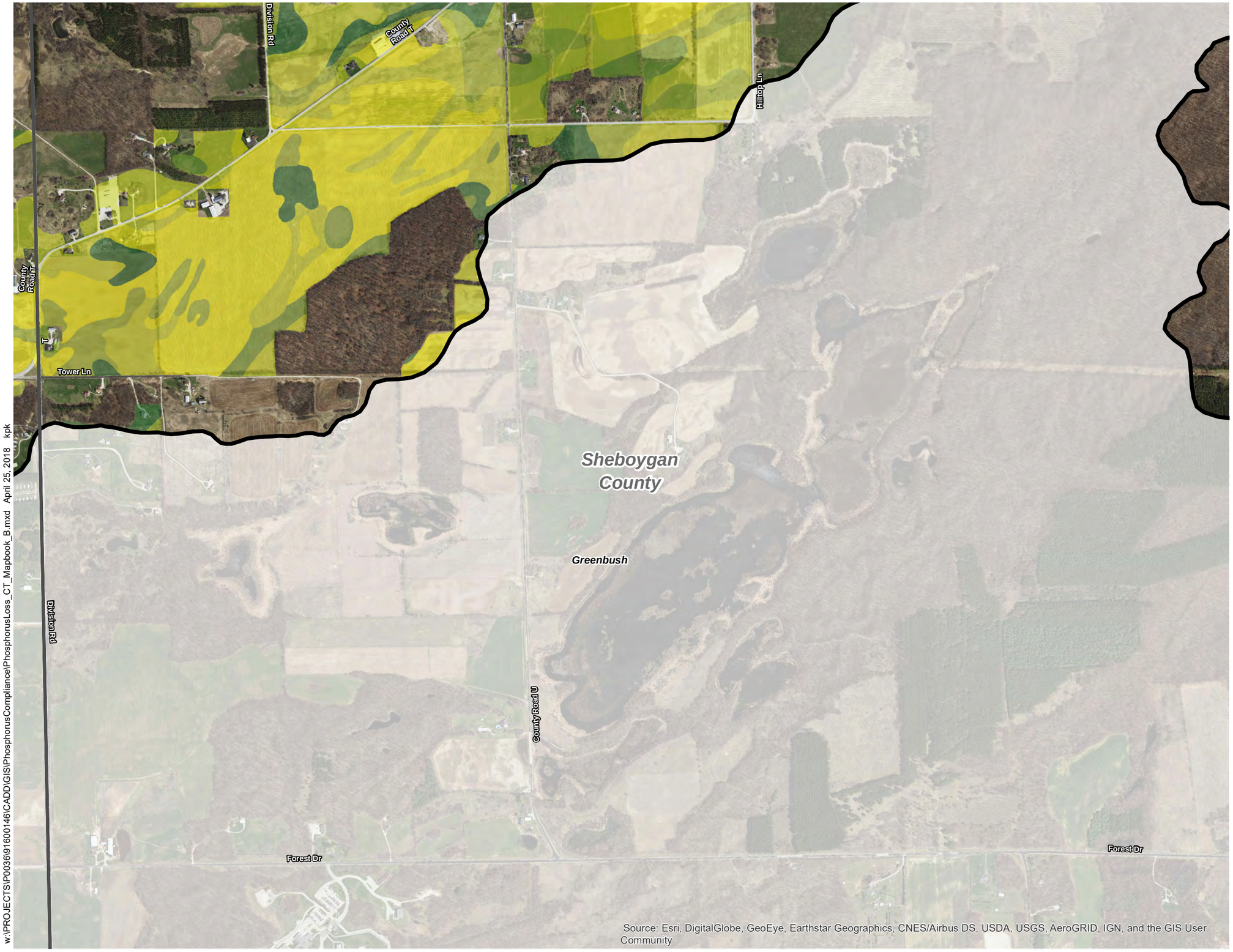
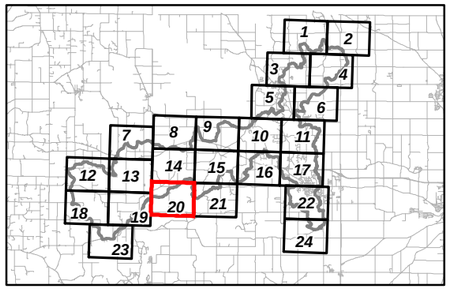



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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PLYMOUTH UTILITIES

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FIGURE 20 OF 24

**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**

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PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
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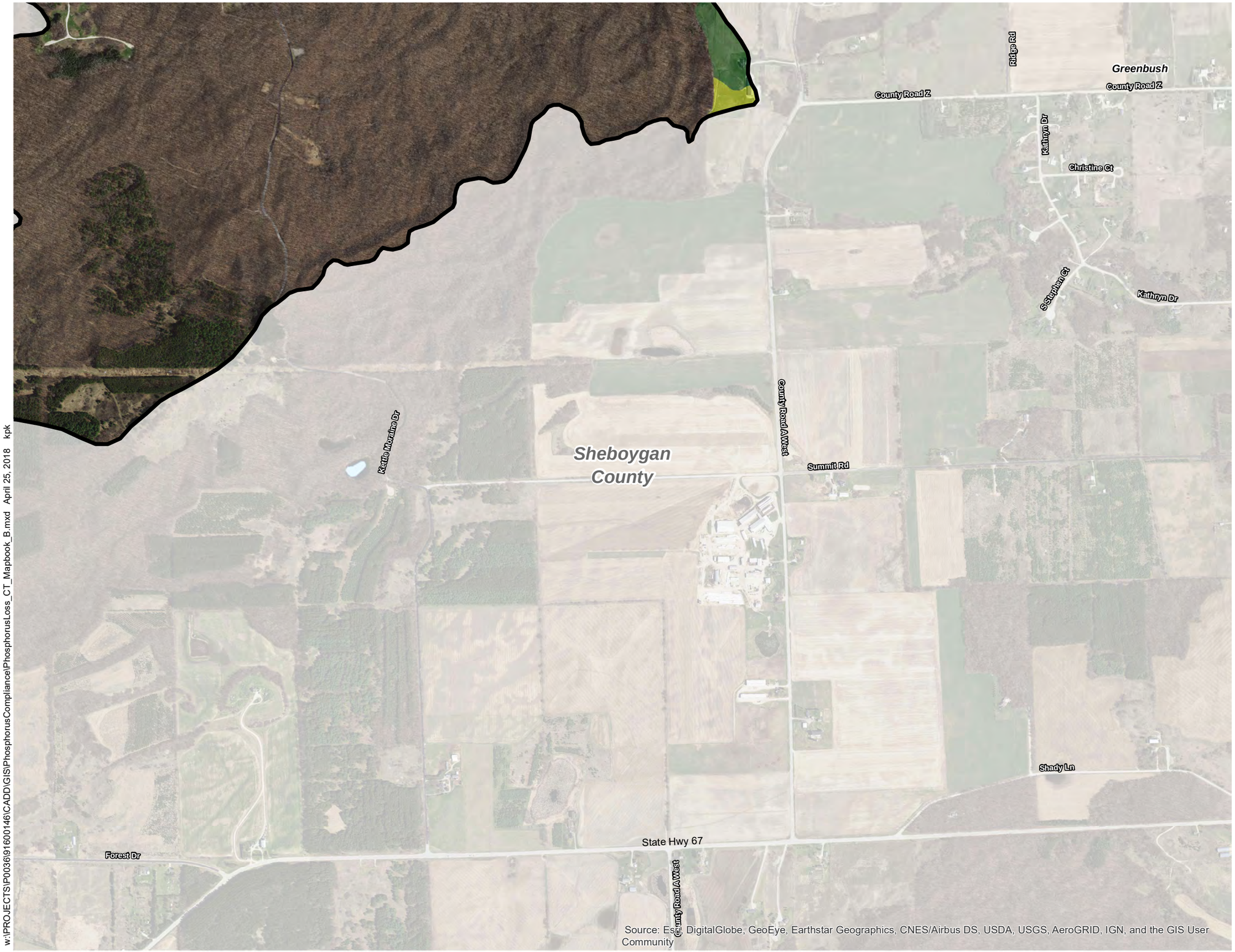


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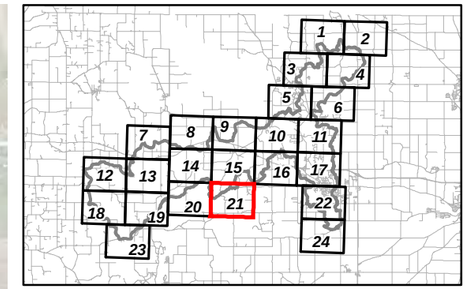


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FIGURE 21 OF 24

**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**

PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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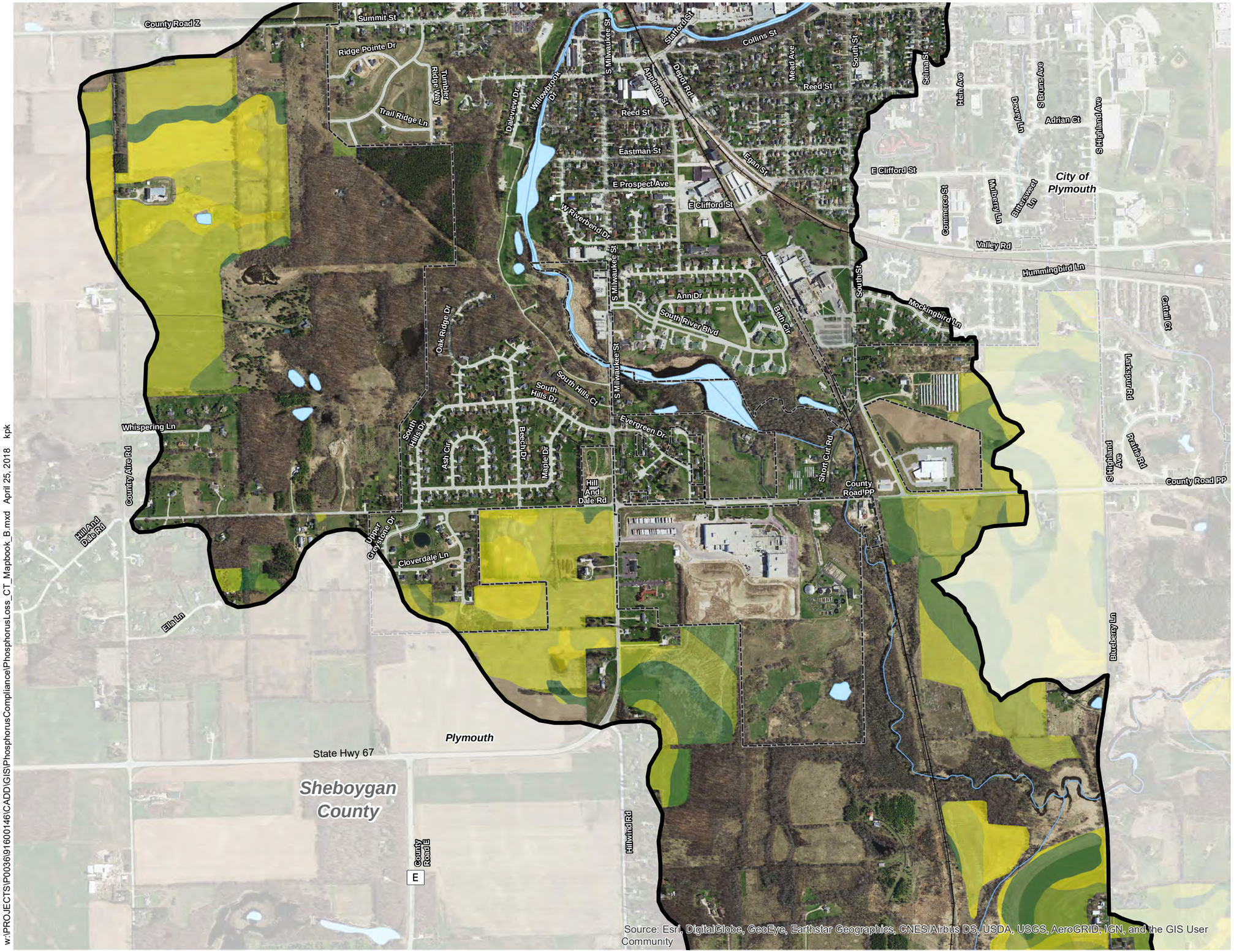
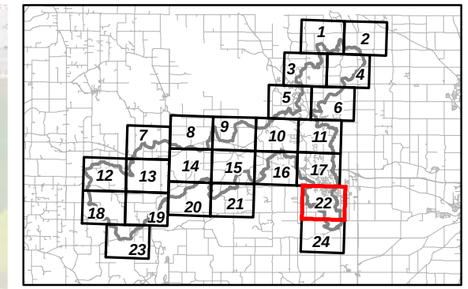



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 22 OF 24

**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**

PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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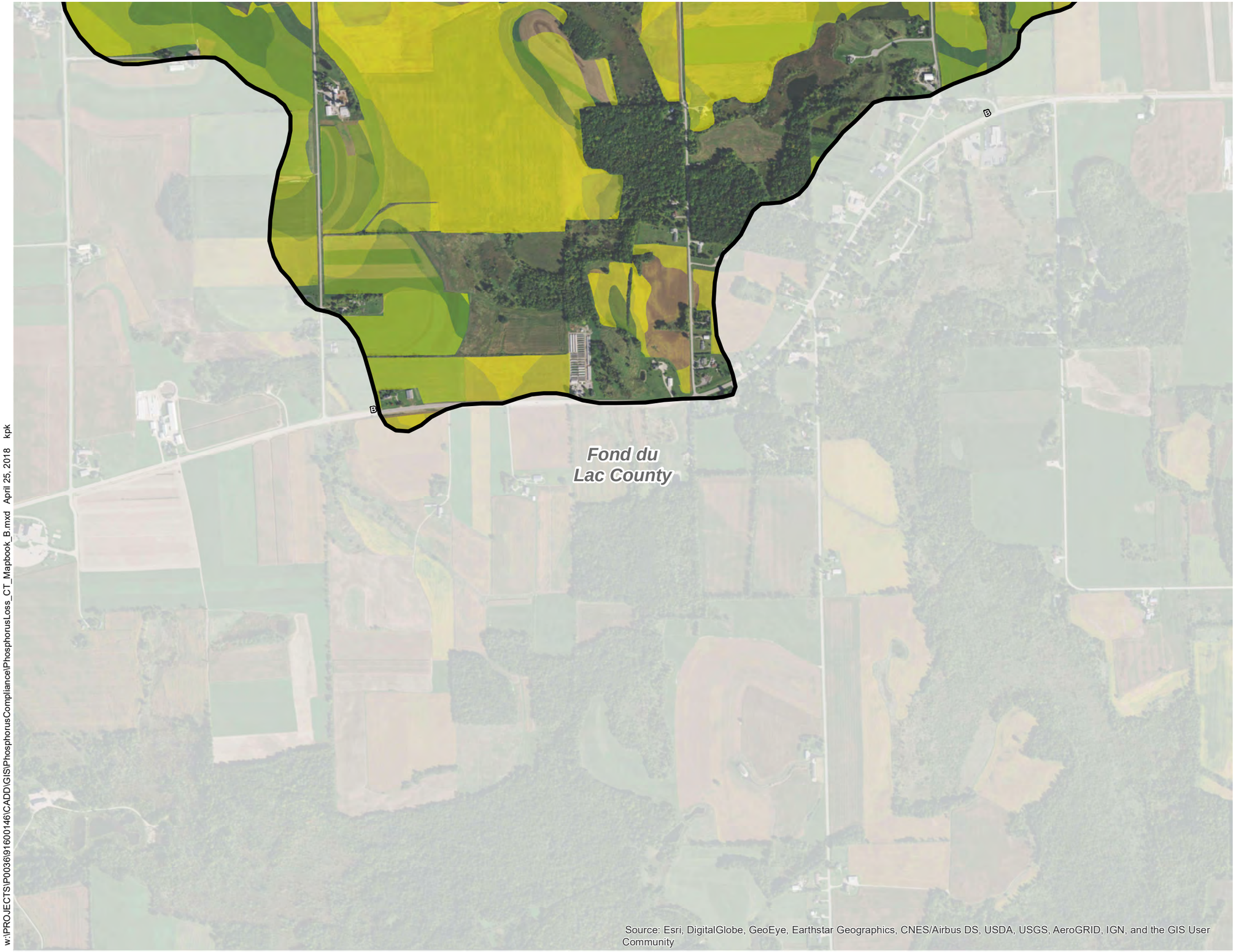
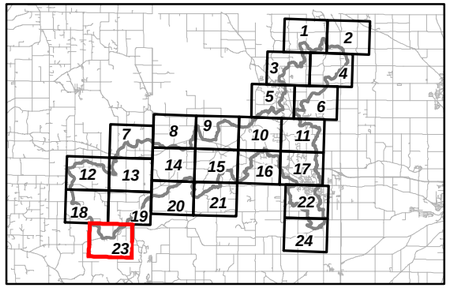



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 23 OF 24

**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**

PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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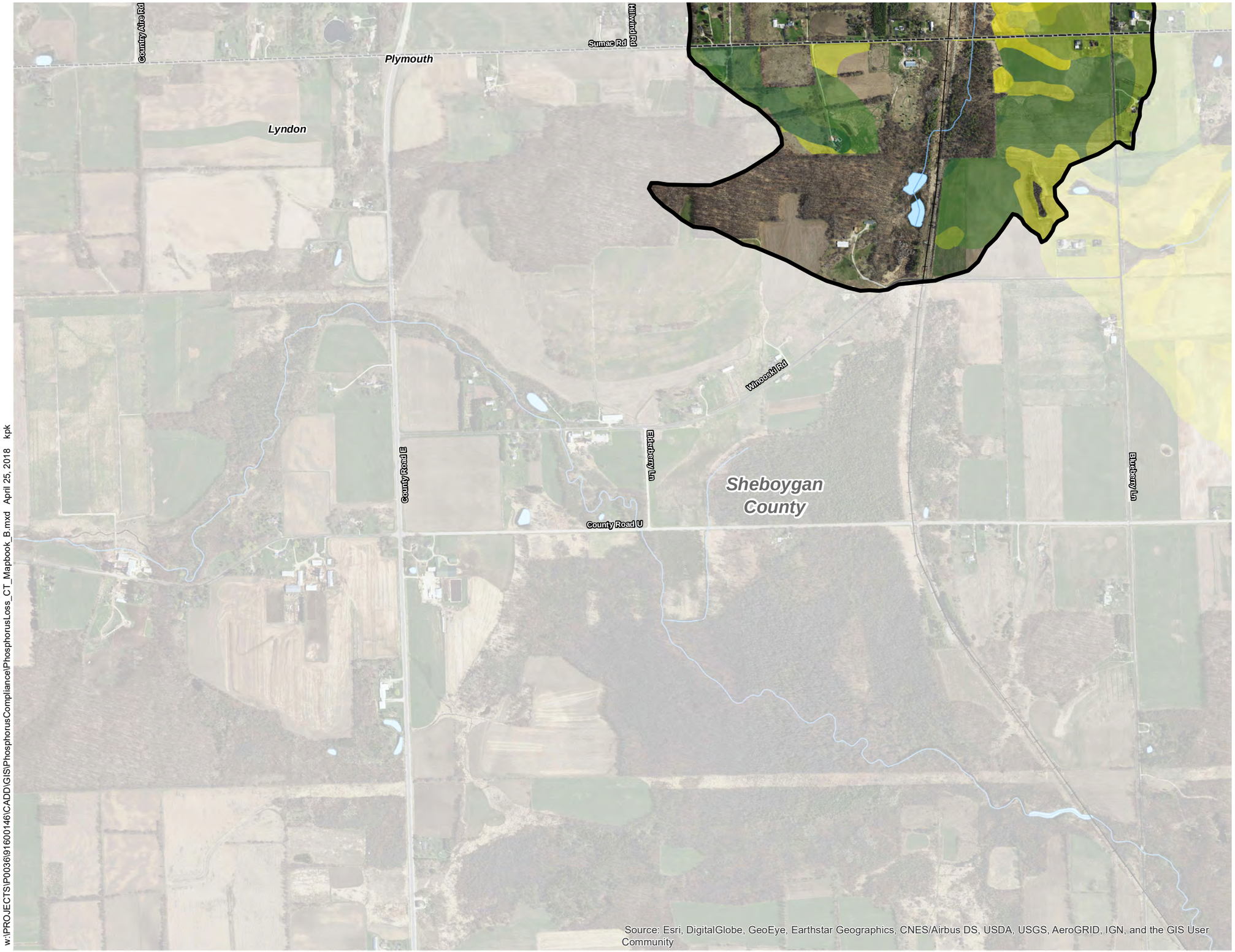


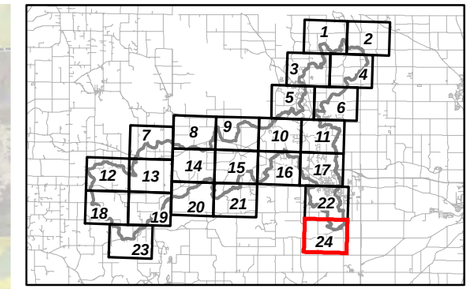


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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 24 OF 24
**PHOSPHORUS LOSS CONVENTIONAL TILLAGE MAPBOOK**
PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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# APPENDIX E

COMPREHENSIVE MANAGEMENT PLAN FOR PLYMOUTH MILL POND

# Plymouth Mill Pond

**Sheboygan County, Wisconsin**

# Comprehensive Management Plan

## January 2008

**Sponsored by:**

**Wisconsin Department of Natural Resources**
**Lake Management Grant Program**

PREPARED FOR:

**CITY OF PLYMOUTH**
**PLYMOUTH, WISCONSIN**

PREPARED BY:


Earth Tech, Inc.
4135 Technology Parkway
Sheboygan, WI 53083


**A BETTER TOMORROW**
made possible

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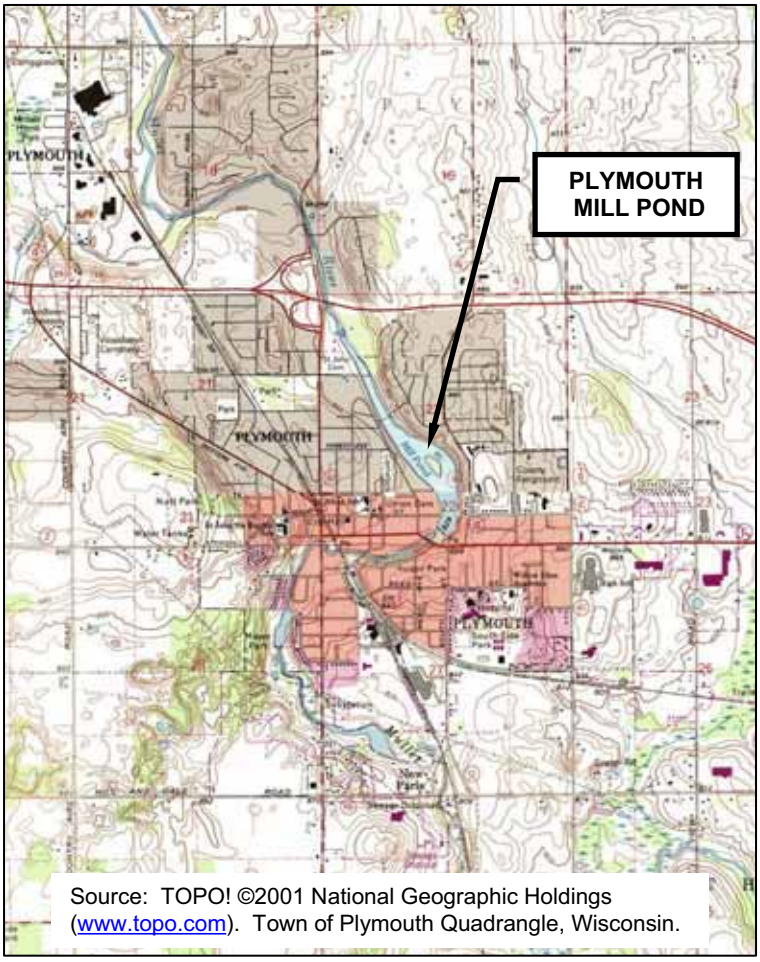
## INTRODUCTION

The Plymouth Mill Pond is a 41-acre impoundment of the Mullet River located in the City of Plymouth in Section 22, Township 15 North, Range 21 East in Sheboygan County, Wisconsin (Figure 1). The water body is maintained by a dam at the southern end of the pond and it extends north to State Trunk Highway 23 (STH 23). The City of Plymouth owns approximately 2 acres of property at the outlet of the Mill Pond. There is approximately 1,000 feet of shoreline on City school property including a recreational trail along the northwest side of the pond and a pedestrian foot bridge across the northern portion of the pond. The Mill Pond is utilized for boating, fishing, and public ice skating.

The Plymouth Mill Pond has been an amenity to the City and local residents since its conception in the mid-1800s. In recent years, however, degraded water quality has led to algal blooms and aquatic plant growth which have caused odor problems, impeded recreational use of the pond, and negatively impacted the aesthetics of the Mill Pond area. The Plymouth Mill Pond Committee (PMPC), consisting of volunteers, was founded to discuss alternatives for management and attain funding to improve the condition of this water body.




Source: TOPO! ©2001 National Geographic Holdings (www.topo.com). Town of Plymouth Quadrangle, Wisconsin.

**Figure 1. Plymouth Mill Pond Location Map**

The City of Plymouth and the Mill Pond Committee have applied for and been awarded Lake Planning Grant funds from the Wisconsin Department of Natural Resources (WDNR) to develop their Mill Pond Comprehensive Planning project. The project is split into three stages: Part I - Mill Pond Assessment (completed), Part II – Watershed Modeling/Alternatives Analysis (completed) and Part III – Comprehensive Management Plan. This document represents Part III of the Mill Pond Comprehensive Planning project.

The PMPC realizes that any management options that are recommended must have the support of both the local stakeholders and the regulatory community. Therefore, the PMPC has begun to implement a public involvement strategy. The City of Plymouth conducted a citizen input survey in 2005 to obtain the opinions of the general public, property owners, and local business owners about the current issues and future direction for the Mill Pond. This survey was prepared by the University of Wisconsin Extension-Sheboygan County (UWEX-SC) on behalf of the City of Plymouth. The survey results are presented in Appendix A. The majority of respondents indicated that the water quality of the Mill Pond was fair to poor and 87 percent of the respondents indicated that

the Plymouth Mill Pond was important to the community of Plymouth. This project has the support of the local community, and the citizens realize that improvements in the aquatic resource will be a benefit to the environment and will increase use of the Mullet River and the Mill Pond area as recreational resources.

## PURPOSE AND GOALS

The goal of Part III of the Plymouth Mill Pond Comprehensive Planning project is to develop a Comprehensive Management Plan for the long-term management of the pond that incorporates information from the Mill Pond Watershed Assessment, Water Quality Assessment, Macrophyte and Sediment Thickness Survey, and Alternatives Analysis. This management plan will guide the PMPC as they move forward with their efforts to improve the ecological, aesthetic, and recreational value of the Mill Pond. The specific objectives of this final phase of the planning process include:

- Development a long-term management plan for the Plymouth Mill Pond that includes water quality objectives, best management practices (BMPs), proposed ordinances, and any additional recommendations. The plan shall include a strategy for implementation, the agency responsible, specifics of what is needed, and a timeframe for completion. It will also determine if any of the recommended BMPs are eligible for a Lake Protection Grant.

- Coordination with the Sheboygan County Land & Water Conservation Department (LWCD) to obtain any information on known erosion control problems, identify critical sites, and develop objectives for land use management in the watershed.

- Coordination with the WDNR-BER to obtain recommended management actions for the protection of any known threatened and endangered resources in the project area.

- Determination the adequacy of existing land use plans, runoff control ordinances, enforcement, and other existing institutional programs relative to the protection of water quality.

- Coordination with the City of Plymouth, Town of Plymouth, Town of Greenbush, Town of Rhine, Town of Forest and Sheboygan County on the expansion of BMPs for development and make suggestions for other relevant land management ordinances.

- Preparation news releases and holding public information meetings to keep the public informed and involved in the planning process.

## BACKGROUND

### Pond History and Past Management Activities

The original mill dam was constructed in the late 1840s, but was washed out during a flood in 1906. The present dam was constructed in the 1950s. There is speculation that the Mullet River was rerouted when the mill dam was built, but there is no supporting evidence for this. The dam and Mill Pond are shown in roughly their present configuration in both the 1875 and 1889 plat books found in the Plymouth Historical Society Museum. The Mill Pond was drained down in the late 1950s. During this drawdown the river was on the east side of the island.

**Partnerships**

Implementing a long-term management plan for the Mill Pond will be most successful if the local citizens and the regulatory community work together to evaluate the needs of the pond and determine appropriate management goals. The PMPC has been working with a variety of local organizations to gather background data about the pond and to gather local and regulatory input regarding the project.

The PMPC has partnered with the UWEX-SC on the public outreach components of the project. UWEX-SC prepared the 2005 Citizen Input Survey and has performed some of the preliminary data analysis. A UWEX-SC representative has been involved with Mill Pond Committee meetings and has prepared news releases for the local papers. They are also coordinating and preparing the public information meetings for this project.

The PMPC has also been working with the Sheboygan County Land & Water Conservation Department (LWCD) to obtain existing land use information as well as any information on known erosion control problems. They will partner with the Sheboygan County LWCD on projects as appropriate including detailed soil erosion inventories, barnyard assessments, and the development and implementation of best management practices in the watershed including the identification of key locations for buffer strips.

The City will work closely with the Town of Plymouth and Sheboygan County on the development of best management practices for developments and other construction sites.

Both the Plymouth High School and the Sheboygan Area School District are very interested in participating in the collection of data to support the Mill Pond Assessment program. Both of these school systems have been active in the past with the Testing the Waters program.

The PMPC believes that the information gained through this project belongs to the local stakeholders and the WDNR to increase their database on the Mullet River and the Mill Pond. Therefore, the Committee has been sharing the project results in the following ways.

1. The WDNR has been invited to participate in the public participation process and has been provided with copies of the completed technical memoranda as they have become available. John Masterson, WDNR, is a regular attendee at the Mill Pond Committee meetings.

2. Committee meetings are open to the Public. The Plymouth Review and the Sheboygan Press are often in attendance and provide summary information in the local newspapers.

3. A committee meeting was held to present the findings of the Mill Pond Assessment (Part I). A second committee meeting was held to present the results of the Watershed Modeling/Alternatives Analysis (Part II). A third committee meeting will be held to present the Comprehensive Management Planning (Part III).

4. Copies of the technical memoranda will be available for review at the Plymouth Public Library at 130 Division Avenue in Plymouth ((920) 892-4416). Individuals desiring their own copies will be able to purchase copies for a nominal fee.

5. The water quality data will be submitted to the Plymouth High School Biology Department, when available, for the biology teachers to use with their classes as appropriate. The

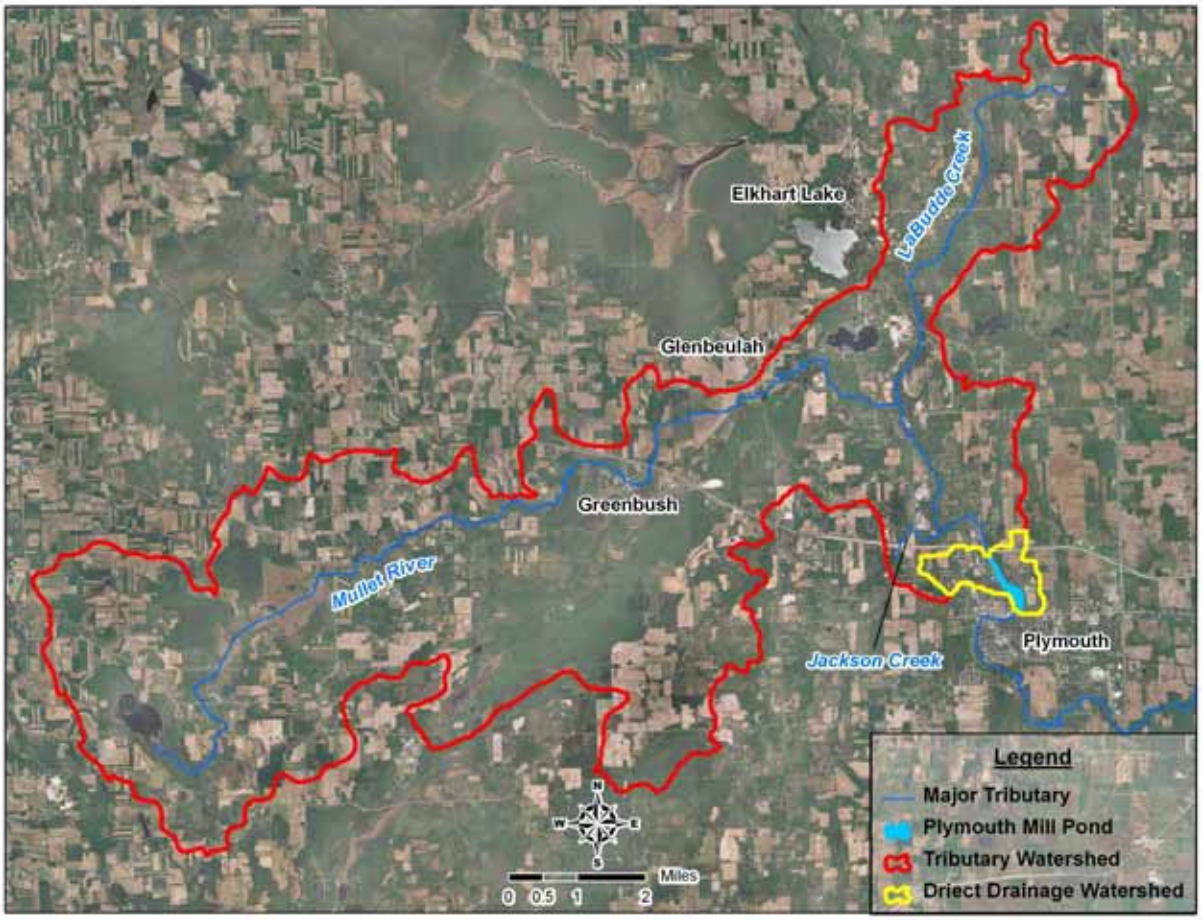
Plymouth High School will also be provided with copies of the completed technical memoranda as they become available.

6. The Mill Pond Committee will continue to look for ways to utilize the public outreach capabilities of the UWEX-SC.

## WATERSHED CHARACTERISTICS

### Physical Characteristics

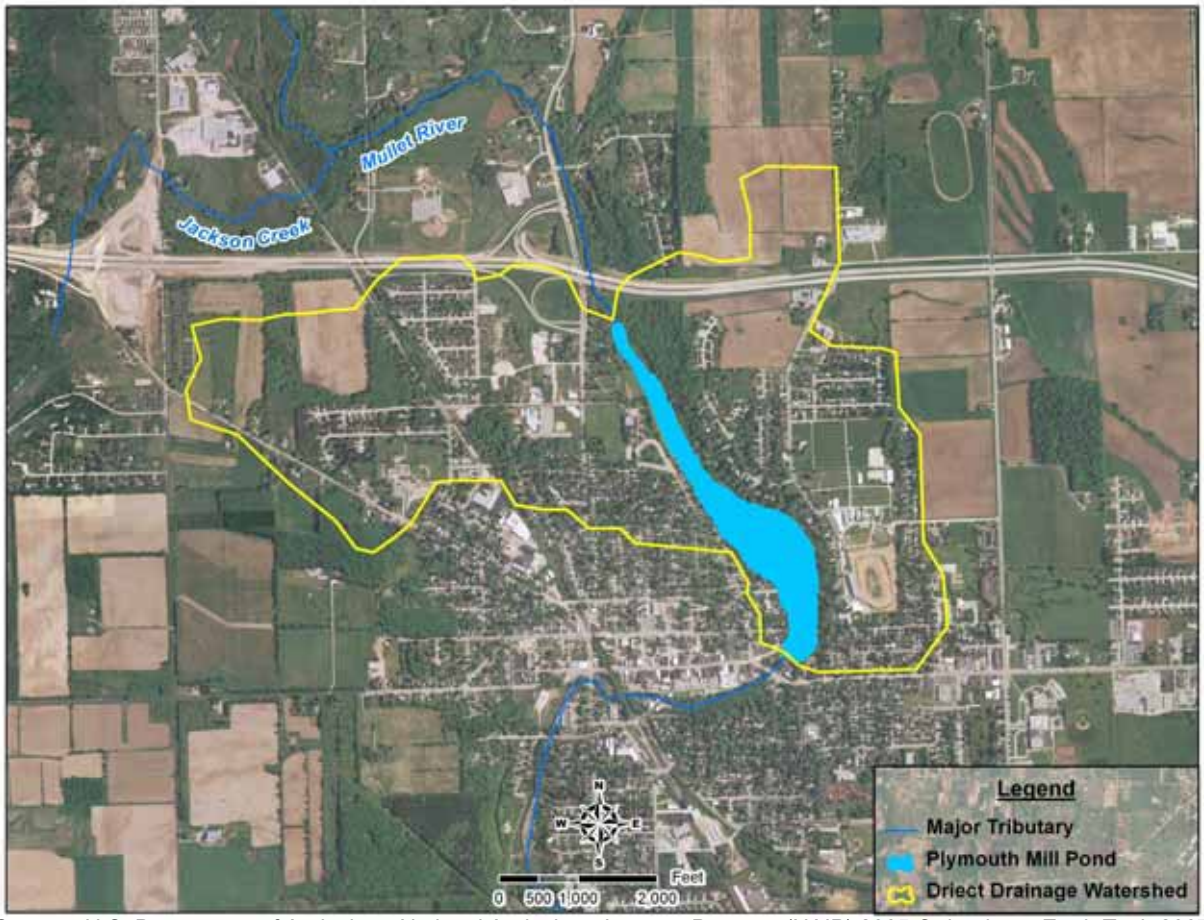
The Mullet River watershed tributary to the Mill Pond drains about 62 square miles in Fond du Lac and Sheboygan counties (Figure 2), and represents the upper two thirds of the Mullet River watershed. The tributary watershed extends from the Mullet Lake area of Fond du Lac County and continues east, gathering drainage from LaBudde Creek to the north near Elkhart Lake and Jackson Creek to the northwest of the City of Plymouth.




Source: U.S. Department of Agriculture National Agriculture Imagery Program (NAIP) 2005 Orthophoto, Earth Tech 2007

Figure 2. Plymouth Mill Pond Tributary and Direct Drainage Watersheds

The direct drainage watershed to the Mill Pond is approximately 1.1 square miles (715 acres) in size (Figure 3) and is located in the City of Plymouth. The direct drainage watershed extends west to County Trunk Highway (CTH) C, north to STH 23, and east to approximately 1,000 feet west of CTH E.




Source: U.S. Department of Agriculture National Agriculture Imagery Program (NAIP) 2005 Orthophoto, Earth Tech 2007

Figure 3. Plymouth Mill Pond Direct Drainage Watershed

## Geology and Soils

The Mill Pond tributary watershed is located in the Southeast Glacial Plains region of Wisconsin. The topography of this region is dominated by rolling till plain intermixed with lakes, outwash plains, and swamps. This landscape was formed by glaciers that covered the area approximately 11,000 years ago. The topography and distribution of soils resulted from glacial action which buried the underlying Niagara dolomite bedrock with unconsolidated deposits ranging from a few feet to several hundred feet in thickness (NRCS, 2007).

The Kettle Moraine, which runs through the middle of the Mill Pond watershed, is a dominant landscape feature in this region. The Kettle Moraine area has relatively steep topography that was created by glacial drift deposits from large masses of glacial ice. Casco and Rodman soils are dominant in the Kettle Moraine. The landscape in the eastern part of the watershed is dominated by drumlins where Hochheim and Theresa soils are dominant. These soils have formed in deposits of loamy material and glacial till. Outwash plains exist in the western part of the watershed. Soils in the western watershed are composed of glacial till that was sorted and deposited as stratified gravel and sand by glacial melt water. Casco and Fox soils have formed in the outwash region and are known to be good sources of sand and gravel (NRCS, 2007).

A majority of the soils in the Mill Pond watershed are part of the Casco-Fox-Rodman association. The soils in this association are well drained to excessively drained soils that have

a subsoil of mainly silty clay loam to sandy clay loam or gravelly sandy loam and are underlain by stratified gravel and sand outwash. Soils in this association are suited to growing all common farm crops; however, corn, small grain, and legumes are most commonly planted on these soils. Management concerns for crop cultivation include erosion control, maintaining organic matter content, available water capacity limitations, and fertility limitations. Areas that are not used for crops are used for pasture and wildlife habitat (NRCS, 2007).

## Land Use and Land Cover

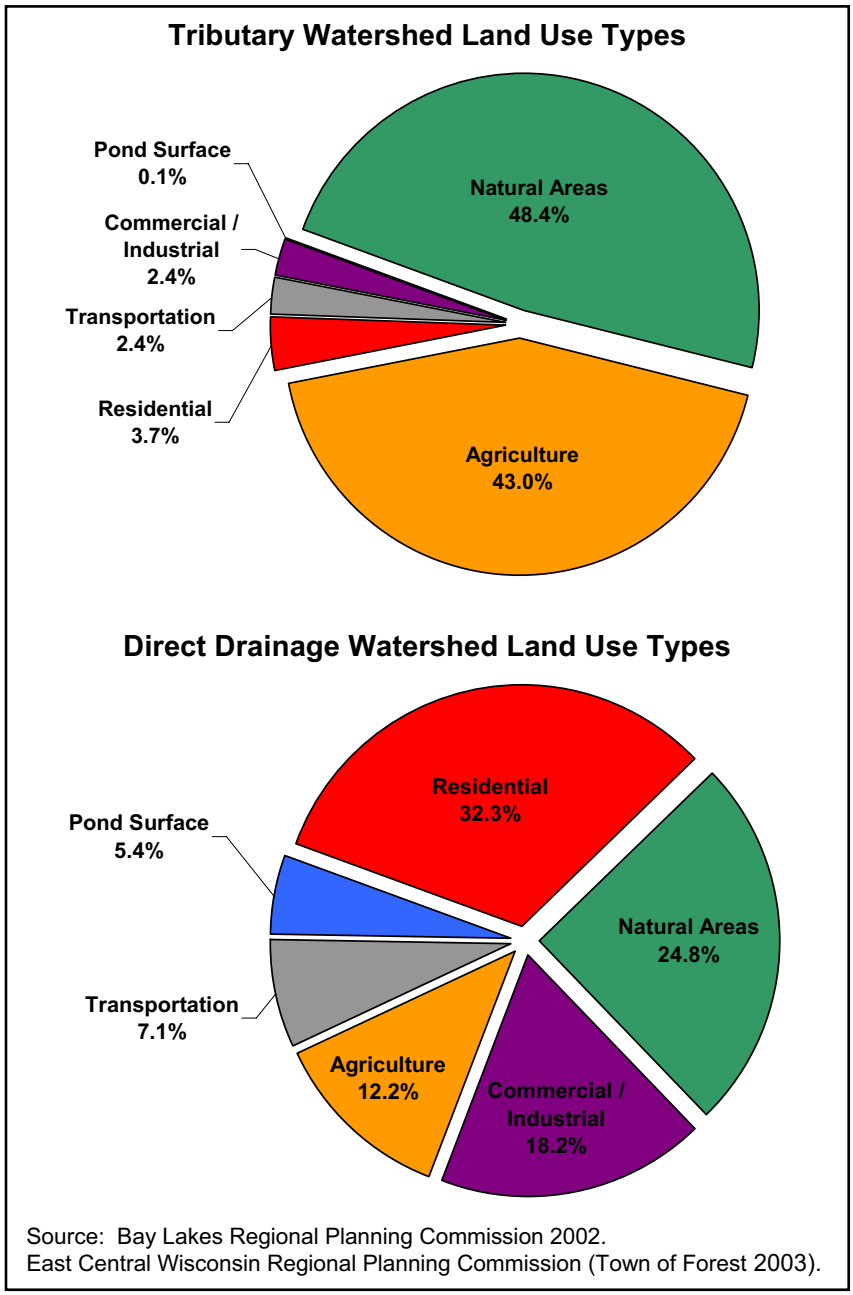



Chart 1. Plymouth Mill Pond Watershed Land Use Types

The native vegetation of the Mill Pond tributary watershed consisted of a mix of oak forests and maple-basswood forests; however, agricultural and urban land use practices have changed much of the landscape. Only about 10 percent of the native forests remain, and most of the natural communities that remain are associated with large moraines or in areas where the Niagara Escarpment occurs close to the surface (WDNR, 1999).

Current land use within the tributary and direct drainage watersheds was analyzed using a Geographic Information System (GIS) with the most current available land use data as well as aerial photo interpretation from a 2006 color aerial photograph. A summary of current land use within the two watersheds is illustrated in Chart 1.

The two dominant land uses in the tributary watershed are natural areas (48.4%) and agriculture (43.0%). The high percentage of natural area reflects the significant forested areas in the Kettle Moraine and the large wetland complexes that are associated with the Mullet River headwaters. The majority of urban land use is located in the City of Plymouth.

The two dominant land uses in the direct drainage watershed are residential (32.3%) and natural areas (24.8%); however, there is also a significant percent (18.2%) of commercial and industrial land use. The direct drainage watershed is dominated by developed land, in contrast to the tributary watershed, which is dominated by undeveloped land.

## POND CHARACTERISTICS

### Physical Attributes

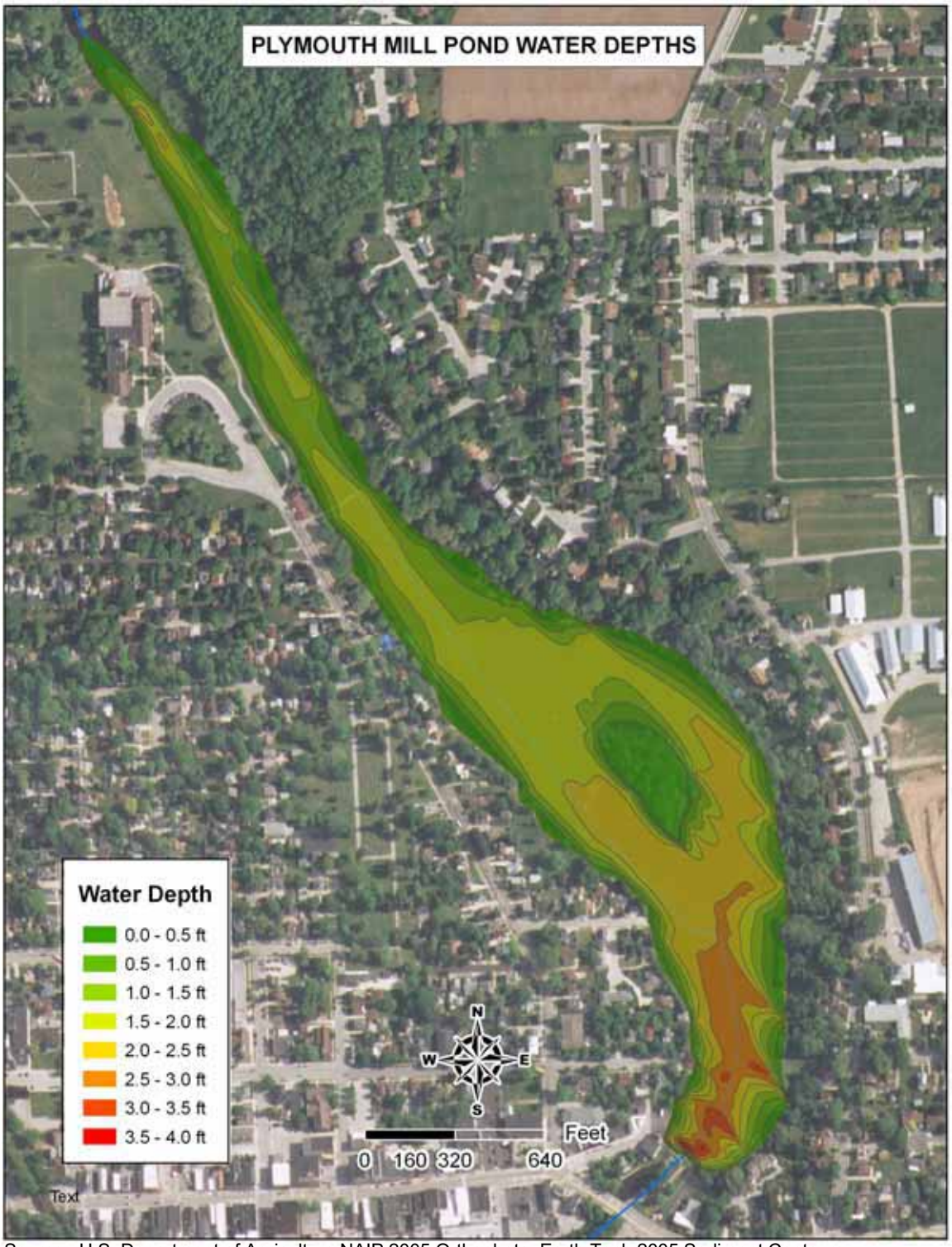
The Mill Pond is a 41-acre impoundment of the Mullet River that is located in the City of Plymouth. The Mill Pond has approximately 2 miles of shoreline that is dominated by residential land use. There is public access to the pond from several city streets and a recreational trail. The average water elevation of the pond ranges between 831.40 and 831.45 feet and the water depth ranges between 1 and 4.3 feet, with an average water depth of 1.8 feet. The volume of the pond basin is approximately 88,390 cubic yards and the flushing rate is approximately 400 times per year (residence time of 0.9 days).

The impoundment has a soft mud bottom and there is generally very little rooted aquatic vegetation. According to WDNR (WDNR, 1999), the Mill Pond supports a population of northern pike, largemouth bass, carp, and a variety of panfish. The Mill Pond attracts a variety of waterfowl and mammals, and multiple pair of Canada geese nest on the pond each year. Large algal blooms and a growing carp population have become management concerns for the Mill Pond.

### Bathymetry and Sediment Analysis

A bathymetric survey was conducted at the Mill Pond on September 30 and October 17, 2005. The depth to the top of soft sediment and the depth to hard bottom were measured at 197 points along 6 transects in order to determine the volume of soft sediment that has accumulated in the Mill Pond. Figure 4 shows water depths across the Mill Pond, and Figure 5 shows a 3-dimensional graphic that illustrates the volume of soft sediment in the impoundment. The total volume of accumulated soft sediment in the mill pond is approximately 180,000 cubic yards. The greatest accumulation of sediment occurs between the south end of the island and the dam where the sediment is between 6 and 7 feet thick. A memorandum containing the complete methodology and results of this sampling can be found in Appendix D.

A sediment quality assessment was conducted for the Mill Pond by WDNR on June 29, 1999. Samples were collected at two sample sites in the soft sediment that has accumulated behind the dam. The first site was 49 feet upstream from the dam and consisted of two cores. The top half from each core was composited for a single sample and the bottom of each core was composited for a second sample. This data provided the ability to look at sediment quality that represents different time periods. The sediment that is buried to the greatest depth represents deposition that would have settled at an earlier date. A third sample was collected 328 feet upstream in the mid-channel of the pond. Two cores were collected and composited to make a single sample. Analytical results are shown in Table 1. The pesticides (Aldrin, Alpha BHC, C-chlordane, Chlordane Alpha, Chlordane Gamma, Dieldrin, Endrin, Gamma BHC, Heptachlor, Nonachlor cis) were all less than the level of detection (Galarneau and Masterson, 2001).




Source: U.S. Department of Agriculture NAIP 2005 Orthophoto, Earth Tech 2005 Sediment Contours

**Figure 4. Plymouth Mill Pond Water Depths**

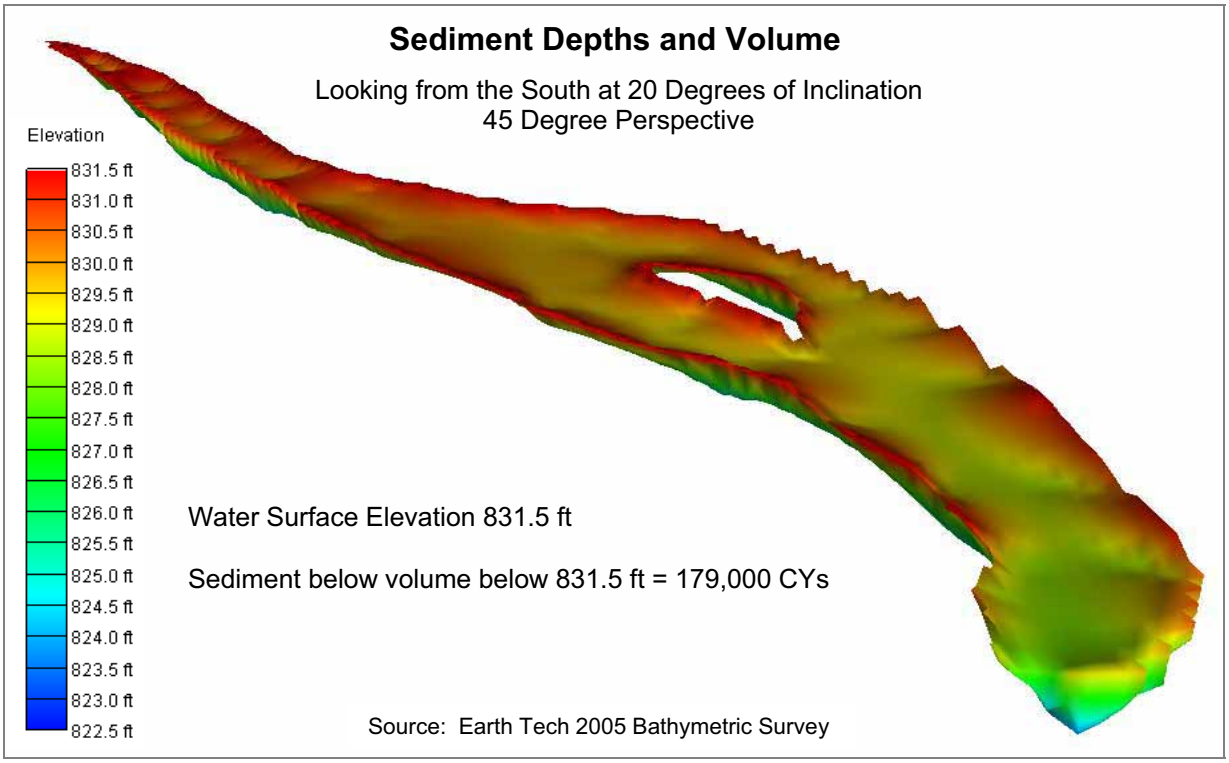



**Figure 5. Plymouth Mill Pond Sediment Depths and Volume**

**Table 1 - Sediment Quality Assessment for the Mill Pond. Collected June 18, 1999**

| Parameter | 49 ft upstream Top of core | 49 ft upstream Bottom of core | 328 ft upstream |
|---|---|---|---|
| ***METALS*** | mg/kg (ppm) | mg/kg (ppm) | mg/kg (ppm) |
| Arsenic | ND | ND | ND |
| Cadmium | 0.8 | 0.8 | 1 |
| Chromium (total) | 25 | 27 | 25 |
| Copper | 30 | 25 | 26 |
| Lead | 39 | 23 | 25 |
| Mercury | 0.1 | 0.099 | 0.1 |
| Nickel | 12 | 14 | 13 |
| Zinc | 100 | 81 | 170 |
| PAHs (total) | 0.775 | 0.717 | 18.55 |
| PCBs (total) | <0.05 | <0.05 | <0.05 |
| pp-DDE | 0.01 | ND | ND |
| pp-DDD | 0.02 | ND | 0.01 |
| Ammonia-N | 58.3 | 112 | 39.6 |
| Phosphorus (total) | 622 | 615 | 523 |
| TOC (Total Organic Carbon) | 68,800 | 59,900 | 70,400 |

The top-of-core sample from the sample site located 49 feet upstream had levels below the Threshold Effect Concentration (TEC) for PCBs, pesticides, and all metals except lead. The lead concentration was slightly over the TEC value of 36 ppm. The bottom-of-core sample from

the same site had levels below the TEC for PCBs, pesticides, and all the metals tested. There were no significant differences in concentrations between the top-of-core and bottom-of-core samples, which indicates that contaminant inputs from the surrounding watershed have not changed significantly over time. The sample taken 328 feet upstream had concentrations above the TEC value for Cadmium, Zinc, and PAHs (WDNR 2003).

Ammonia concentrations for two of the three samples in the Mill Pond exceed 50mg/L, the lower limit for contaminated soils, which suggests that benthic and epibethic communities may be at risk for toxicity. Though ammonia is readily released from sediments, it's toxicity in water is directly proportional to pH and temperature (EPA/USACE 1998). Most dissolved ammonia is utilized in phytoplankton and macrophyte production.

Phosphorus is also readily released from the sediment and causes surface water euthophication (NRCS 1994). Phosphorus concentrations in the Mill Pond range from 523 to 622 mg/kg. It is predicted that there is a net loss of phosphorus to the sediment of 374 pounds per year due to settling.

Sediment samples from the Plymouth Mill Pond were collected and analyzed by WDNR again in 2004. Results of this sampling were not available for review.

**Water Quality**

Historic

There is one set of water quality data for one sample location in the Mill Pond that was collected in 1979 by an unknown party. This water sample was collected in the deepest part of the pond located just north of the island. The results of the 1979 sample revealed a secchi depth of 49 inches, a phosphorus level of 38 ug/L, and a chlorophyll-*a* level of 6.85 ug/L (WDNR-SWIMS 1979) These parameters illustrate that over 20 years ago, the Plymouth Mill Pond was a relatively clear, yet productive body of water.

There is also existing water quality data for the segment of the Mullet River that lies within the Mill Pond watershed. The Mullet River downstream of STH 67 is classified as a Warm Water Sport Fish Community stream. Based on 1994 testing by the WDNR, water quality in this segment of the Mullet River was fair to good. Water chemistry and macroinvertebrate samples collected during 1994 indicated that point source dischargers, stormwater runoff, and cropland runoff within the watershed resulted in increased nutrients, sedimentation, and bacteria to the stream (Galarneau and Masterson, 2001). A set of water quality data has also been collected by Plymouth High School Students who have monitored nine biotic and abiotic parameters on the Mullet River 3 to 4 times per year for over 15 years as part of the "Testing the Waters" program. This data may be available to the City of Plymouth for future monitoring.

**Figure 6. Plymouth Mill Pond Water Quality Sampling Locations**

Current Conditions

Earth Tech collected water samples in the Mill Pond and on the Mullet River during the spring and fall of 2006. Water samples were collected during four sampling events (June, July, August, and October) at two locations in the Mill pond, as well as one location upstream of the Mill Pond and one downstream of the Mill Pond on the Mullet River (Figure 6).

Table 2 presents the water quality sample results for the four stations for each of the four sample events. Temperature, dissolved oxygen, pH and conductivity values were within the normal range for inland lakes and impoundments.

Secchi disc readings could only be measured at Station 3, because the secchi disc was visible all the way down to the substrate at Stations 1, 2, and 4. Chart 2 shows the measurements for secchi disk readings at Station 3 through the sampling period. The water was less clear in July and August, which is typical for lakes in Wisconsin. In late summer, more algae and plankton are suspended in the water column because the nutrient levels are higher at this time during the year.

Chart 3 shows the trend for total phosphorus through the sampling period. Total phosphorus levels peaked in July at all stations and were higher at Stations 2, 3, and 4 than at Station 1. Trends for chlorophyll-a, which is a measure of plant productivity, are shown in Chart 4. Chlorophyll-a levels were lowest at all stations in June, but increased considerably at all but Station 1 as the summer progressed. The additional input of phosphorus is a likely cause of the increase in chlorophyll-a.

Total phosphorus and chlorophyll-a levels were considerably higher at Stations 2, 3, and 4 than at Station 1, the upstream station. This result indicates that a considerable amount of phosphorus is entering Mill Pond from the areas directly adjacent to pond within the direct drainage watershed).

**Table 2 - Water Quality Sampling Results for the Mill Pond**

| Station | Date | Parameters | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Temp (C) | pH | DO (mg/L) | Cond. (µmhos/cm) | Secchi (m) * | Total P (µg/L) | Chl a (µg/L) |
| Upstream (Station 1) | 6/26/06 | 18.8 | 8.5 | 12.3 | 696 | NA | 64 | 3.89 |
| | 7/25/06 | 20.6 | 8.3 | 9.5 | 681 | NA | 86 | 4.32 |
| | 8/23/06 | 16.8 | 7.8 | 8.7 | 719 | NA | 61 | 2.54 |
| | 10/12/06 | 6.9 | 6.9 | 8.3 | 705 | NA | 44 | 1.44 |
| Pedestrian Bridge (Station 2) | 6/26/06 | 20.2 | 8.4 | 8.5 | 704 | NA | 78 | 5.74 |
| | 7/25/06 | 22.6 | 7.3 | 6.6 | 717 | NA | 123 | 6.45 |
| | 8/23/06 | 18.6 | 7.6 | 5.6 | 731 | NA | 98 | 14.6 |
| | 10/12/06 | 7.1 | 6.8 | 8.3 | 697 | NA | 49 | 27 |
| Deep spot Mill Pond (Station 3) | 6/26/06 | 20.3 | 8.1 | 6.5 | 683 | 1.07 | 94 | 10.9 |
| | 7/25/06 | 25 | 7.5 | 5.9 | 743 | 0.52 | 141 | 124 |
| | 8/23/06 | 22.7 | 7.2 | 4.6 | 766 | 0.61 | 93 | 32.2 |
| | 10/12/06 | 6.9 | 6.8 | 8.1 | 657 | 0.91 | 50 | 28.5 |
| Downstream (Station 4) | 6/26/06 | 20.2 | 8.1 | 7.2 | 682 | NA | 88 | 8.58 |
| | 7/25/06 | 25.9 | 8.3 | 7.9 | 698 | NA | 127 | 57.2 |
| | 8/23/06 | 22.6 | 7.5 | 6.5 | 737 | NA | 120 | 42.5 |
| | 10/12/06 | 6.5 | 6.8 | 8.1 | 658 | NA | 53 | 60.3 |

Notes:
* Secchi disc visibility reached the sediment at Stations 1, 2, and 4.

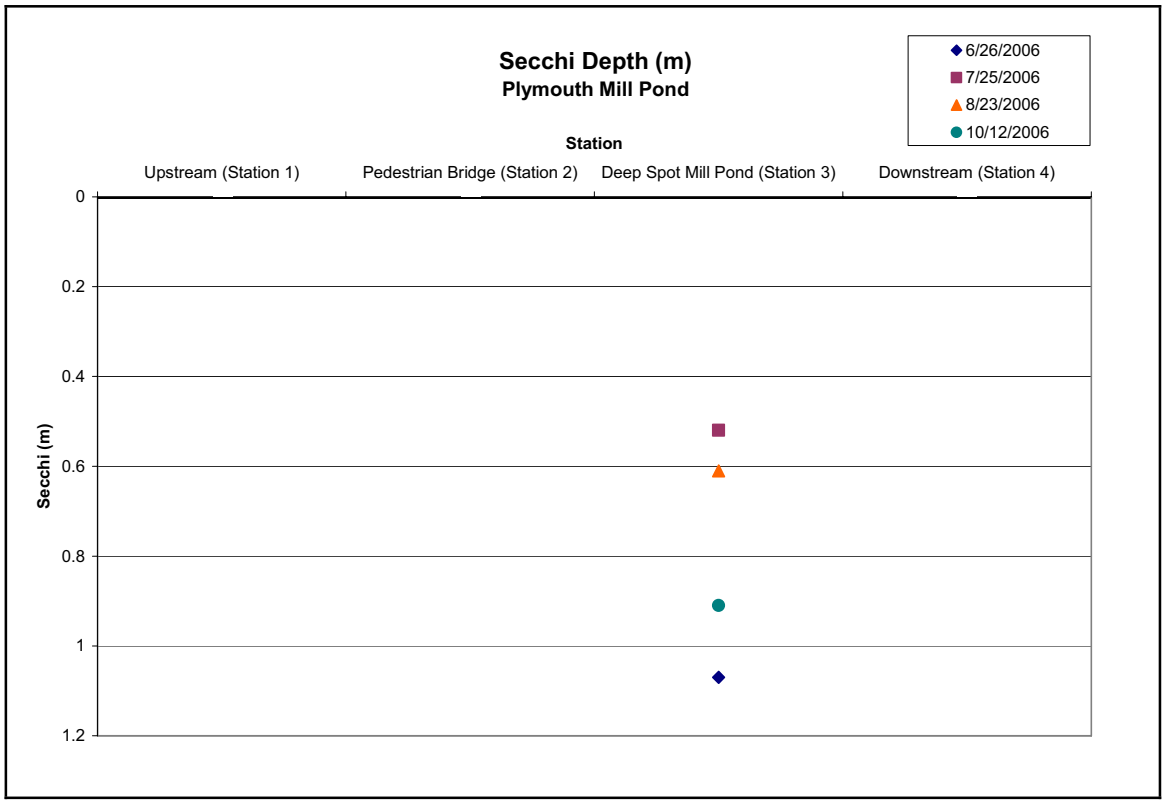



**Chart 2. Secchi Depths in the Plymouth Mill Pond**

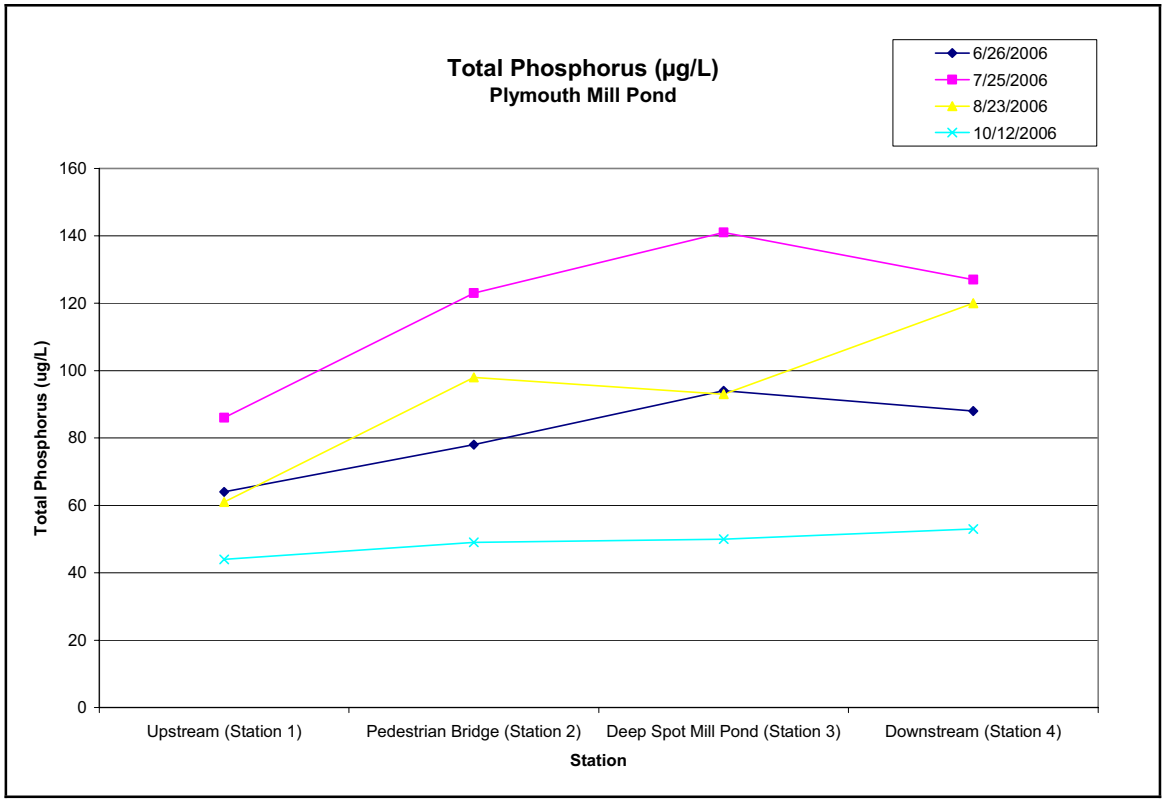



**Chart 3. Total Phosphorus Levels in the Plymouth Mill Pond**

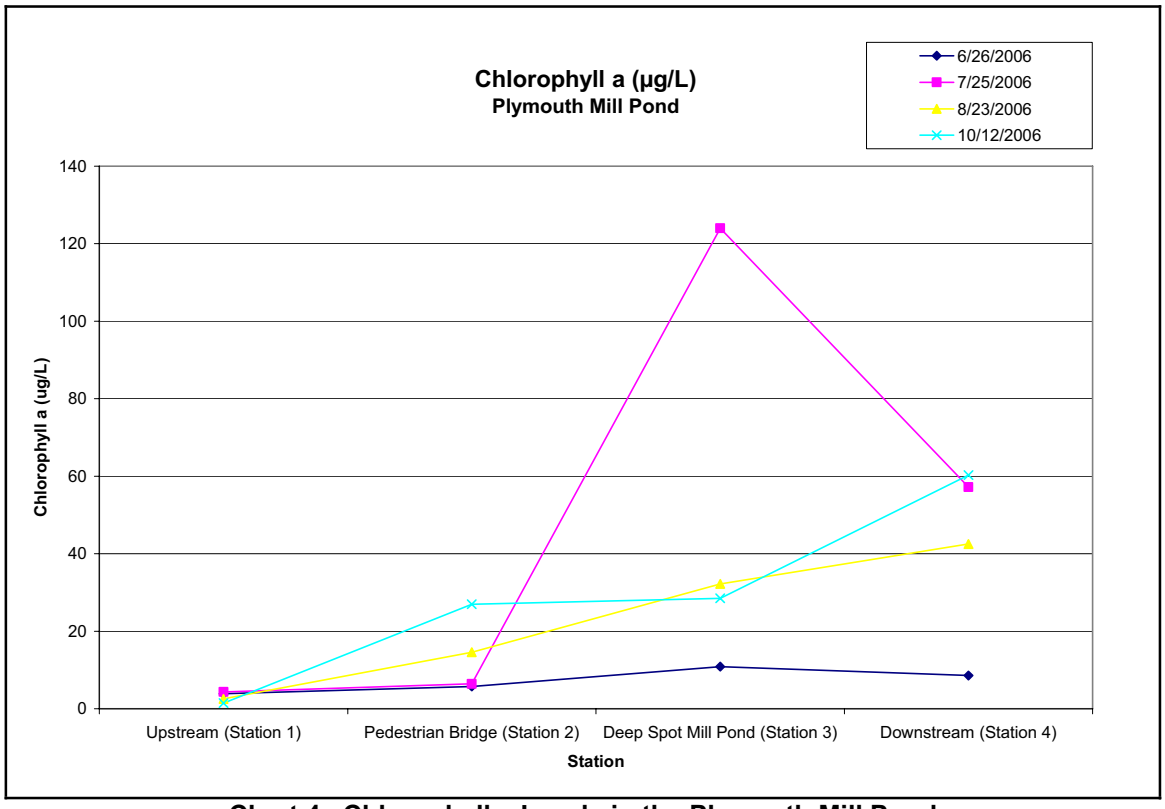
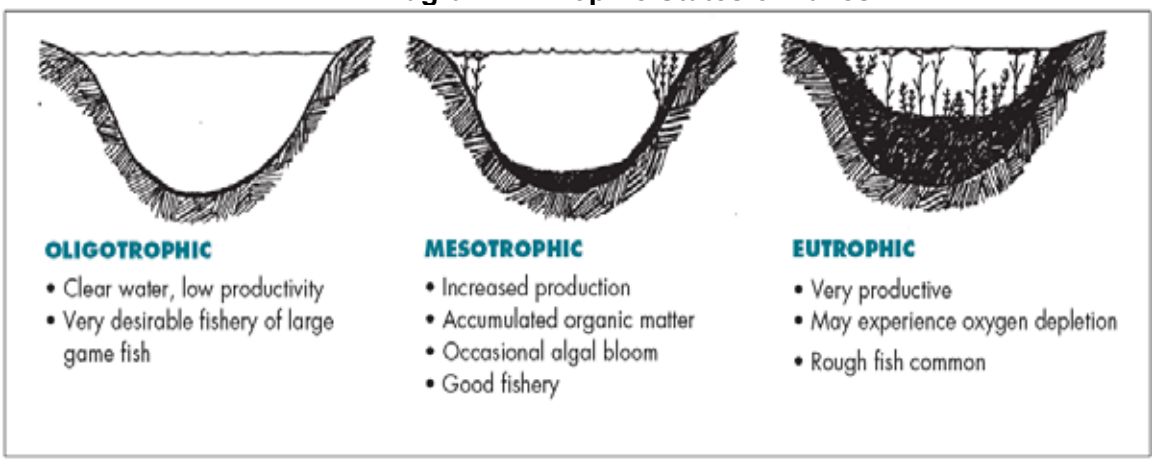



**Chart 4. Chlorophyll a Levels in the Plymouth Mill Pond**

Carlson's Trophic State Index (TSI) is one means available to examine the relationship between total phosphorus, chlorophyll-*a*, and secchi disk readings in a lake, and its overall productivity. TSI. The term "trophic state" refers to the level of productivity in a lake. Productivity refers to the amount of nutrients, plant, and fish biomass. Productivity and trophic state of lakes are typically classified into three categories: oligotrophic, mesotrophic and eutrophic, and are described and illustrated in Diagram A below.

**Diagram 1. Trophic States of Lakes**




Source: Shaw, Mechenich and Klessig, 2004.

The WDNR has modified Carlson's equations to form a Wisconsin Trophic State Index (WSTI) to better suit lakes in Wisconsin. Individual WTSI values for this study were calculated from the following WTSI equations:

Secchi: $WSTI_{SD} = 60 - (14.4 \ln SD)$,

Total P: $WSTI_{P} = 28.2 + (7.73 \ln TP)$, and

Chlorophyll a: $WSTI_{CHL} = 34.8 + (7.56 \ln CHL)$,

where SD = secchi depth in meters, TP = total phosphorus in parts per billion (ppb), and CHL = chlorophyll-*a* in ppb.

Chart 5 presents the trends for WTSI through the sampling period. According to WDNR, the WTSI values for the four stations were typical for eutrophic lakes, except for the chlorophyll-*a* at Station 1, which was typical for a mesotrophic lake. Based on these measurements, the Mill Pond should be considered a eutrophic system, meaning that it is very nutrient rich and contains abundant organic matter. The relationship among the chlorophyll-*a* and total phosphorus WTSI's in 2006 suggests that there is a high volume of algal biomass within the downstream end of the pond, with some limiting factor in the upstream end of the pond, such as the current of the river or nitrogen levels in the water.

Baseline water quality results suggest that the Mill Pond is a eutrophic system. Phosphorus entering the Mill Pond from both the watershed of the Mullet River and from the adjacent landscape is likely to promote the high density of macrophytes in the pond and the algal blooms that occur in the summer. Limiting the phosphorus entering the pond should positively affect the aquatic health and aesthetics of Mill Pond. A memorandum containing the complete methodology and results of the baseline water quality assessment can be found in Appendix C.

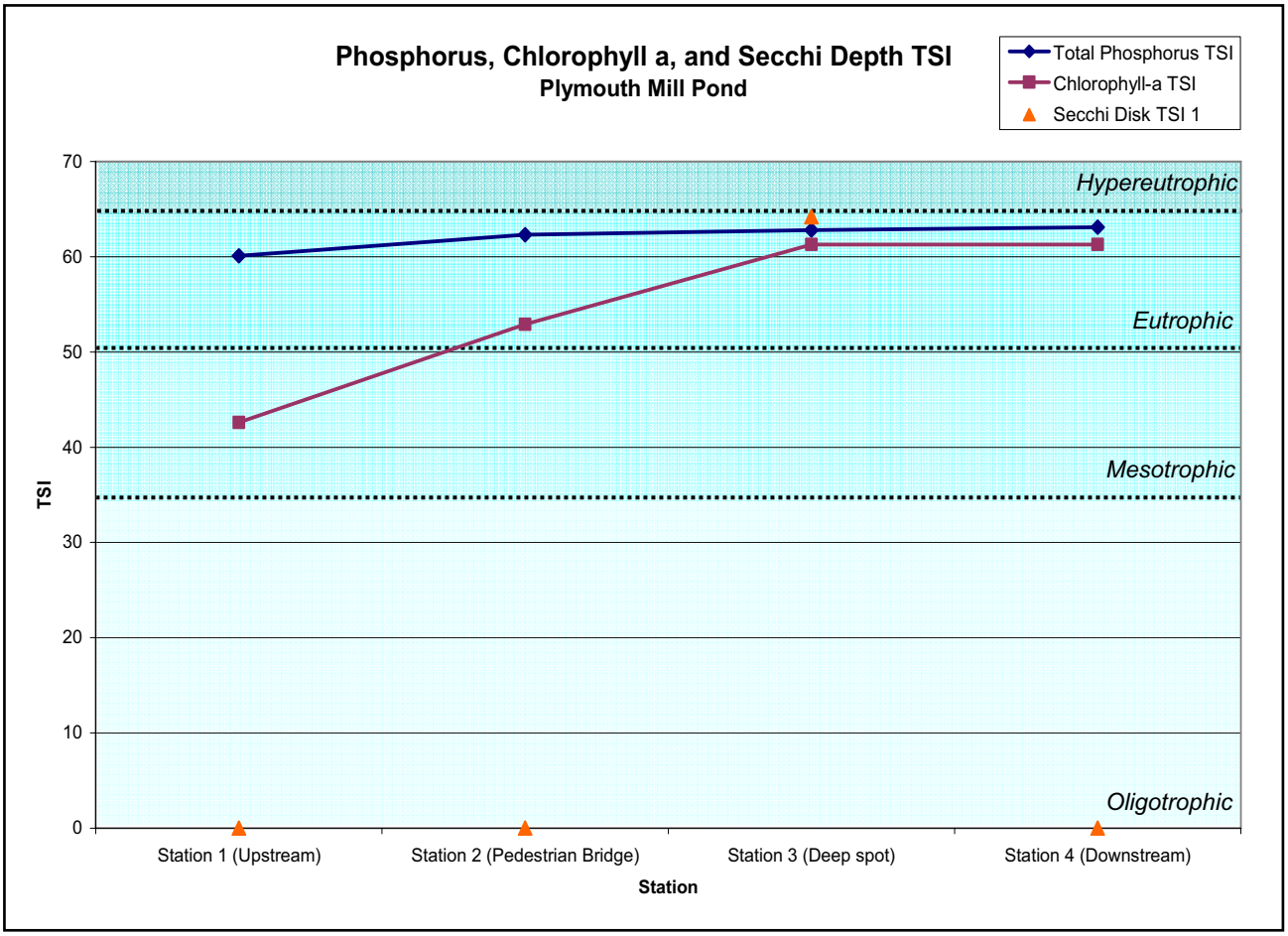
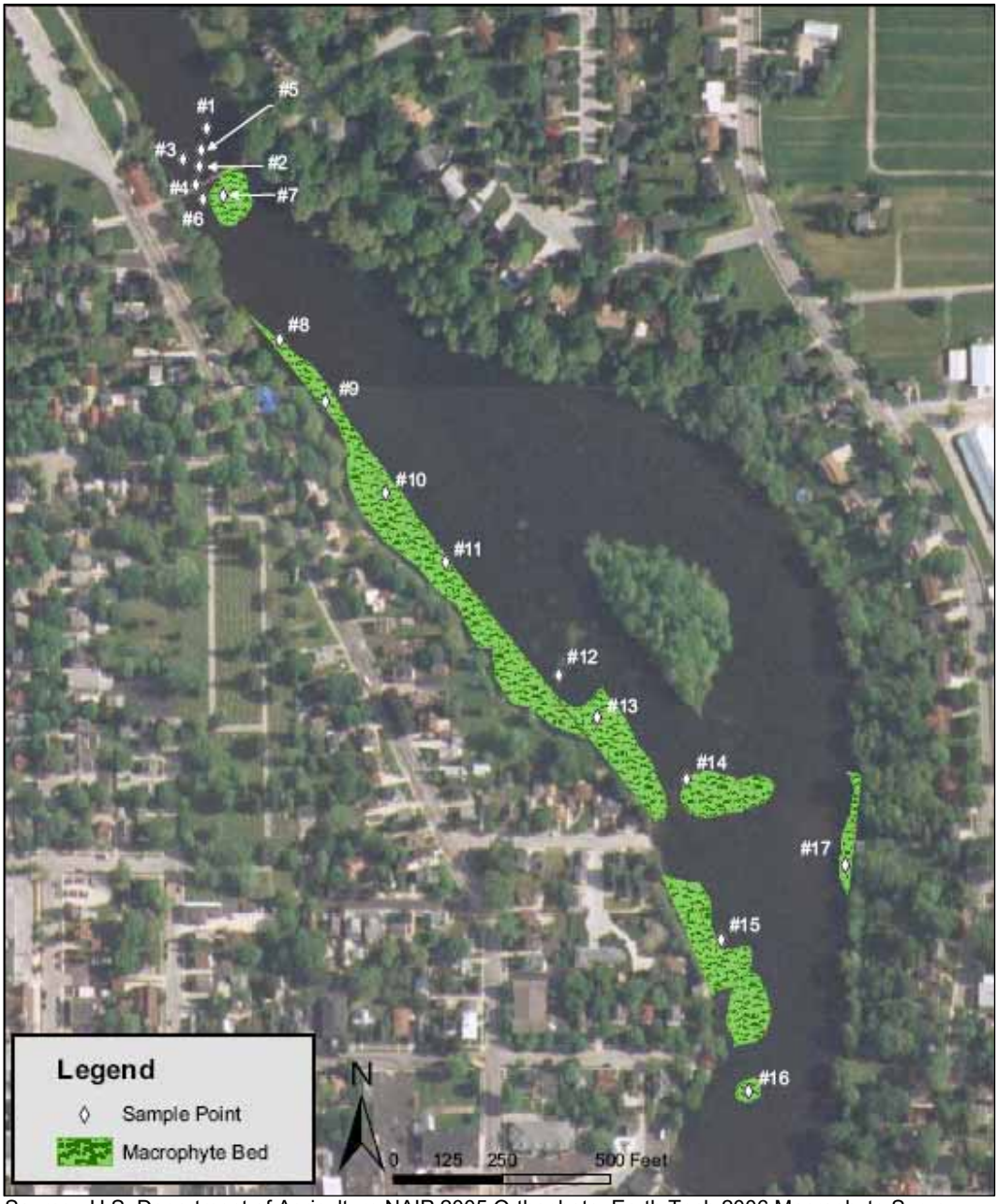



**Chart 5. Phosphorus, Chlorophyll-a and Secchi Depth TSI for Mill Pond as compared to TSI Ranges for Trophic States of Lakes (Carlson and Simpson, 1996).**

## Aquatic Vegetation

The macrophyte community was characterized at 17 locations within Mill Pond (Figure 6) on July 24 and 25, 2006. The sampling locations were chosen based on presence of visible macrophytes during the sampling dates.

The overall abundance of macrophytes was low at the time of the sampling. Approximately 10 percent of the pond was covered with macrophyte beds. The dominant species were sago pondweed (*Potamogeton pectinatus*) and curly-leaved pondweed (*P. crispus*) which were observed at most locations. Coontail (*Ceratophyllum demersum*) and duckweed (*Lemna minor*) accounted for the remaining species. Six macrophyte beds were identified and delineated as shown on Figure 7. The percent coverage of macrophytes within the beds ranged from 0 to 25 percent. No exotic species were observed during the macrophyte survey. A memorandum containing the complete methodology and results of this sampling can be found in Appendix D.




Source: U.S. Department of Agriculture NAIP 2005 Orthophoto, Earth Tech 2006 Macrophyte Survey

**Figure 7. Plymouth Mill Pond Macrophyte Populations**

## WATER QUALITY CONCERNS

In recent years, there have been reports of large algal blooms and excessive macrophyte growth in the Mill Pond that has resulted in diminished aesthetic and recreational value for users. These conditions are likely a result of the excess nutrients (nitrogen and phosphorus) that are available in the pond.

In more than 80 percent of Wisconsin's lakes, phosphorus is the key nutrient affecting the amount of algae and macrophyte growth. Impoundments, which have an average total

phosphorus concentration of approximately 65 µg/L (poor water quality index), tend to have higher phosphorus concentrations than other types of lakes. A total phosphorus concentration below 30 µg/L should be maintained to prevent nuisance algal blooms (Shaw, Mechenich and Klessig, 2004).

Data from the baseline water quality sampling indicated that the water coming into the Mill Pond has an average total phosphorus of 63.75 µg/L and the water in the pond has an average total phosphorus of 90.75 µg/L. This data shows us that the water coming into the Mill Pond from the Mullet River is considered to have a poor water quality index due to phosphorus loading from the Mullet River watershed. It also reveals that the direct drainage watershed is contributing additional phosphorus to the Mill Pond system. This phosphorus can originate from a variety of sources such as human and animal waste, soils erosion and sedimentation, and runoff from lawns and agricultural fields. Limiting the amount of nutrients entering surface waters from these sources will be they key to reducing the excess algae and macrophyte production in the Mill Pond.

John Masterson, of the WDNR Plymouth Service Center, was interviewed on the subject of potential impacts to surface water quality in the watershed. According to WDNR records, there are no point sources of pollution, such as wastewater discharges, to the Mullet River upstream of the Mill Pond, and there are no significant areas of non-point source pollution, such as large barnyards or badly eroded farm fields, in the watershed.

A field review of land use and potential nutrient sources in the Mill Pond watershed was conducted in 2006. Results from this field investigation revealed that general agricultural practices in the watershed appeared to be following good management practices from a water quality perspective. A few BMPs, such as low-till/no-till, maintenance of crop residues, vegetated filter strips, and field buffers, could be implemented to help reduce soil erosion during times when the fields are bare. In addition to large agricultural areas, substantial parts of the watershed are woodland, wetlands, or grassland. These natural areas are beneficial from a water quality aspect. The County Fairgrounds was the one area identified during the field review as a possible direct source of pollution and nutrients to the Mill Pond. Upon further investigation, it was found that several treatment practices were implemented within the Fairgrounds in 2004. The County coordinated with WDNR to install a sediment trap under the grandstand, a french drain in the infield and the west side of the racetrack, and sanitary sewer connections for the wash drains by the barn area. These practices provide a reasonable level of treatment for the stormwater runoff from the Fairgrounds and no further improvements were recommended by WDNR. A memorandum containing the complete watershed analysis can be found in Appendix B.

## ALTERNATIVES ANALYSIS

### Management Options

It was necessary to evaluate the feasibility and cost-benefit of potential water quality management options in order to help the PMPC make appropriate decisions regarding future Mill Pond management. Six management options that would potentially improve the Mill Pond water quality were selected and evaluated in this alternatives analysis. The analysis evaluated the no action alternative in addition to options of removing the dam, dredging the pond sediments, removing aquatic vegetation, drawing down the pond water level, and improving shoreline and urban stormwater management. A memorandum containing the complete Alternatives Analysis can be found in Appendix E.

Of the six alternatives considered, removal of the dam was disregarded because neither the City nor the Mill Pond Committee is interested in permanently draining Mill Pond.

Dredging the pond sediments is an option that would reduce available nutrients in the pond by removing the phosphorus that is bound to the pond sediments. There is currently a high content of phosphorus in the pond sediments that has the potential to dissolve into the water under low oxygen conditions. Removing this phosphorus source may help improve the pond water quality. While dredging the pond may eventually be necessary to restore water depth, this method is not likely to keep the Mill Pond free from excess algae because there will still be nutrients entering the pond system from other sources. This alternative is the most costly, with total costs potentially reaching $7 million. Dredging activities also have the potential to cause negative environmental impacts to the area surrounding Mill Pond.

Removal of the aquatic vegetation is another short term remedy for the Mill Pond. Removing the vegetation would be a temporary solution because the seeds located in the sediments and the surplus nutrients in the pond would allow vegetation to easily re-establish. For vegetation removal to be an effective remedy it would have to be done three or more times a year at a cost of up to $125,000 per removal.

Pond drawdown is an option that may bind some of the excess nutrients to the sediment as the sediments dry and compact. A drawdown may reduce the nutrients available to algae, but it will still be available to rooted macrophytes. The effects of a drawdown would be temporary because the sediments will loosen as they are re-saturated and the nutrients have the potential to re-dissolve into the water. This alternative is relatively cost effective and may provide some temporary benefits, but it should be used in conjunction with another alternative that would work to remove the source of nutrients in the pond system.

Shoreline management and urban stormwater management is an option that would help reduce the amount of sediment and nutrients entering the pond. This alternative has the greatest potential for providing long-term water quality improvements to the Mill Pond because it will help reduce the source of the problem. The County Extension Office and the local WDNR staff could hold public educational meetings, hosted by the City, to inform the public and the City employees on how to better protect the watershed of the Mill Creek from nutrient runoff and erosion.

No action is another possible alternative. This alternative would not provide any temporary or long-term improvements to the Mill Pond. The aquatic vegetation in the Mill Pond has not been as problematic in the past few growing seasons, so the Mill Pond Committee and the City may decide to monitor the Mill Pond over the next few seasons before they decide if further management of the Mill Pond system is necessary.

**Summary**

Below is an alternatives matrix summarizing some of the important aspects of each alternative. Short-term and long-term effectiveness relates to how well the alternative would reduce aquatic plant and algae growth. Implementability relates to how easily the alternative could physically be implemented.

**Alternatives Analysis Matrix**

| Alternative | Short-Term Effectiveness | Long-Term Effectiveness | Implementability | Public Acceptability | Cost |
|---|---|---|---|---|---|
| Dam Removal | High | high | high | low | $80,000 |
| Dredging | High | medium | medium | high | $7,000,000 |
| Aquatic Vegetation Removal | Medium | medium | medium | medium | $125,000/yr |
| Pond Drawdown | Medium | medium | high | medium | $500 |
| Shoreline and Stormwater Management | Medium | medium | medium | medium | unknown |
| No Action | Low | low | high | medium | $0 |

Though dredging has the potential to provide some short-term benefits to the Mill Pond, the high cost and secondary impacts of the dredging activities do not make it a feasible option at this time. However, due to the large sediment loading rate of the pond, dredging may need to be considered in the future in order to restore depth to the pond. Aquatic vegetation removal is also not a feasible option at this time because of the high cost and lack of long-term effectiveness. The alternatives analysis showed that the best means to improve the Mill Pond were to institute a process, with the assistance off the County Extension and the local WDNR offices, to educate the City employees and the public on how to better manage the nutrients and sediments entering the pond through the tributary and direct drainage watersheds of the Mill Pond. This process should be done in conjunction with a drawdown of the pond over the winter months, which would compact the sediments in the pond to increase water depth in the pond and potentially bind some of the nutrients in the compacted sediment. This solution would be the least costly, with the exception of no action, and can be implemented relatively quickly.

## MANAGEMENT OBJECTIVES

Management objectives for the Plymouth Mill Pond are split into two separate sections based on location within the watershed and dominant land use. The first set of objectives applies to properties within the Mill Pond's direct drainage watershed, which is located within Plymouth city limits. Most of the land in this watershed is developed and the land use is primarily residential and commercial. The second set of objectives applies to properties within the Mill Pond's tributary watershed that are outside of the Plymouth city limits. The land in this watershed is mostly undeveloped, and agricultural land use is the primary source of nutrients. Refer back to Chart 1 for land use details.

<u>City of Plymouth</u>

- Reduce available nutrient levels by way of a water level drawdown.
- Reduce phosphorus inputs through education and ordinances.
- Prevent exotic species introductions through education.
- Continue monitoring lake water quality and exotic species occurrence.
- Promote conservation through recreational activities and restoration of public open space.
- Ensure that septic systems located adjacent to the pond are operating correctly.

<u>Townships within the Tributary Watershed Outside of the City of Plymouth</u>

- Reduce soil erosion and sedimentation through installation of stream buffers and implementation of agricultural BMPs.

- Reduce nutrient loading through education and ordinances.
- Promote land conservation throughout the watershed.
- Protect any known threatened and endangered resources known to exist within the watershed through coordination with WDNR.

## IMPLEMENTATION PLAN

MANAGEMENT OBJECTIVES INSIDE THE CITY OF PLYMOUTH

**Management Action:** Draw down Mill Pond water levels to the baseline flow of the Mullet River.
**Timeframe:** Winter 2008-2009
**Facilitator:** City of Plymouth, Mill Pond Committee
**Description:** Drawing down the water level in the Mill Pond will allow suspended solids and soft sediment to settle and compact while locking nutrients into the compacted sediments. The settled sediments will increase water depth and provide a stable base for aquatic plant establishment. Aquatic plants will assist in the uptake of excess nutrients in the water. It is recommended that a water level drawdown be repeated every 2 years to ensure long-term effectiveness (NHDES, 2001).

**Action Steps**:

1. Release public announcement.
2. Remove the weir from the dam for a few months in order to allow a repeated freeze/dry cycle, which will allow for sediment compaction.
3. Clear large debris.
4. Restore water levels.

**Management Action:** Implement an educational series for local residents in the City of Plymouth to prevent introduction of exotic species, promote the establishment of buffer strips, and reduce phosphorus inputs.
**Timeframe:** 2008 and thereafter as needed
**Facilitator:** Mill Pond Committee and local WDNR and UWEX partners
**Description:** Limiting the amount of nutrients entering a body of water is an effective way to control excessive plant growth and algae blooms. Offer free educational programs that focus on the reduction of phosphorus inputs, the establishment of un-mowed stream buffers and rain gardens for stormwater retention and sediment control, and the prevention of invasive species colonization in and around the Mill Pond. Help residents understand their impacts and encourage local residents to make small changes in their lifestyle to help improve the quality of the Mill Pond.

**Action Steps:**

1. Select a schedule and location for speaker events and/or workshops.
2. Contact local partners and additional potential speakers to fill the scheduled dates.
3. Publish the schedule of events in local newspapers and media outlets. Organize local mailing.
4. Host events.
5. Seek out additional funding opportunities to further education and outreach.

**Management Action:** Continue to monitor lake water quality to measure progress.
**Timeframe:** In Progress
**Facilitator:** Plymouth High School, WDNR, Mill Pond Committee
**Description:** Water quality parameters have been established by WDNR and local high school students for sampling points along the Mullet River. Extend sampling points and parameters for further analysis. Baseline water quality data has been provided in this report and are available for comparison in future analyses. Results may be reported to local stakeholders to keep them updated on the status of the water quality of the pond.

**Action Steps:**

1. Coordinate with local school groups or volunteer organizations and WDNR to establish monitoring protocols and scheduling.
2. Seek additional grant opportunities for citizen monitoring.
3. Provide periodic reports for community extension and education.
4. Report datasets to WDNR for trend analyses.

**Management Action:** Adopt an ordinance to limit phosphorus applications through reduced lawn fertilizer use in order to prevent excess nutrients from entering the Mill Pond and the Mullet River.
**Timeframe:** Begin drafting in 2008
**Facilitator:** City of Plymouth and Mill Pond Committee
**Description:** Phosphorus levels in the Plymouth Mill Pond range from 40 µg/L to 140 µg/L, which are well above the recommended 30 µg/L for prevention of algal blooms in impoundments (Shaw, Mechenich and Klessig, 2004). Reference the Dane County ordinance (Dane County, 2007), which bans phosphorus inputs via fertilizers where there is no deficiency in nutrient levels, to draft a preliminary ordinance for the City of Plymouth. Utilize education and public awareness channels to build community support.

**Action Steps:**

1. Research Dane County ordinance (www.countyofdane.com/unified/information/ordinances.aspx).
2. Draft a preliminary ordinance for the City of Plymouth taking into account local requirements and current phosphorus levels.
3. Educate community members about the effects of high phosphorus levels to gain local support. For more information, see *Lake Tides, Volume 31 (3) and Volume 32 (4)*.
4. Finalize the ordinance for the municipality.

**Management Action:** Consider utilizing alternatives to road salt to improve the water quality of the Mill Pond. Road salt alternatives may include Calcium Magnesium Acetate (CMA) and Potassium Acetate (KA).
**Timeframe:** Begin planning in 2008.
**Facilitator:** Mill Pond Committee and City of Plymouth Public Works
**Description:** The pH levels in the Mill Pond range from 6.8 to 8.5 and are therefore, slightly basic or alkaline. The high alkalinity may be a result of the application of road salts in the urban watershed (*McGinley, 2006*). Research has shown that high concentrations of road salt, or sodium chloride (NaCl), can inhibit plant growth and encourage exotic, salt tolerant species, such as cattails or giant reed grass, to colonize an area and create a monoculture. During snow melt, road salts are released into lakes and streams through runoff and can cause decreased dissolved oxygen levels and increased nutrient loads which lead to eutrohphication (Wegner and Yaggi, 2001).

**Action Steps:**

1. Research current road salt applications and estimate volumes applied within the Mill Pond direct drainage area.
2. Research alternatives.
3. Weigh the costs and benefits of each alternative.

**Management Action:** Establish un-mowed vegetated buffer strips along the public shoreline of the Mill Pond.
**Timeframe:** 2008-2012
**Facilitator:** Mill Pond Committee, City of Plymouth, WDNR
**Description:** Establishing un-mowed buffers along the shoreline of the Mill Pond can serve both aesthetic and ecological purposes. Un-mowed shorelines prevent erosion and serve to filter runoff during snowmelt and rain events. Excess nutrients will be absorbed by the vegetation before the water enters the pond. Shoreline restorations in public areas may also open the door for local education opportunities. For more information on Wisconsin Stormwater Regulations, reference *Lake Tides, Volume 31 (4)*.

**Action Steps:**

1. Designate public space for shoreline restoration or buffer strip.
2. Coordinate with local agencies for stormwater regulations, plant recommendations and erosion control.
3. Install buffers.
4. Consider signage or public events to encourage local Mill Pond stakeholders to follow suit.

**Management Action:** Ensure that all septic systems adjacent to the Mill Pond are operating correctly.
**Timeframe:** Regularly
**Facilitator:** City of Plymouth
**Description:** Malfunctioning septic systems may release excess nutrients into groundwater sources.

**Action Steps:**

1. Perform routine checks on septic systems within the Mill Pond watershed, placing high priority on those adjacent to the water body.
2. Take corrective action for any malfunctioning system.

MANAGEMENT OBJECTIVES OUTSIDE THE CITY OF PLYMOUTH

**Management Action:** Encourage local participation in the Sheboygan County Land and Water Conservation (SCLWC) Stream Buffer Program.
**Timeframe:** 2008-2012
**Facilitator:** Mill Pond Committee and SCLWC
**Description:** The SCLWC is offering a cost sharing option for agricultural stream buffer construction for rural property owners. Three levels of participation are available, each with a one time fee and a 10-year maintenance requirement. More information can be found at http://www.co.sheboygan.wi.us/html/d_lc_bufferstrip.html .

**Action Steps:**

1. Coordinate with SCLWC to determine when contractors will be available to perform the work in the Mill Pond watershed.
2. Schedule public interest meeting with WDNR and SCLWC to educate local farmers about the program.
3. Facilitate contact lists and initiation of program.

**Management Action:** Implement an educational series for rural residents to prevent introduction of exotic species, promote native shoreline plantings as buffers, and promote sustainable agricultural practice methods that will reduce excess phosphorus, nitrate, and soil erosion in the watershed.
**Timeframe:** 2008 and thereafter as needed
**Facilitator:** Mill Pond Committee, SCLWC, and local WDNR and UWEX partners
**Description:** The Mullet River Watershed continues to be considered a high priority for selection of nonpoint source management projects and funding (Burzynski, Galarneau and Hackenberg, 2001). Facilitate free educational programs that focus on the reduction of nutrient inputs including synthetic fertilizers, pesticides, and manure, the installation of native plant shoreline buffers, sustainable farming practices, and the prevention and control of invasive species. Help farmers understand their impacts and encourage them to make small changes in their agricultural practice to improve the Mill Pond and the Mullet River.

**Action Steps:**

1. Select a schedule and location for speaker events and/or workshops.
2. Contact local partners and additional potential speakers to fill the scheduled dates.
3. Publish the schedule of events in local newspapers and media outlets. Organize local mailing.
4. Host events.

Seek out additional funding opportunities to further education and outreach.

**Management Action:** Coordinate with WDNR in order to protect known threatened and endangered resources within the Mill Pond watershed.
**Timeframe:** In progress
**Facilitator:** City of Plymouth, Mill Pond Committee
**Description:** There are three aquatic endangered resources that are known to occur in the Mullet River Watershed. Projects designed to protect or improve the water quality resource will benefit the protection of these listed resources. Continue to coordinate with DNR to insure that endangered resources are considered during the management implementation process.

**Action Steps**:

1. Review WDNR's response to the Endangered Resources Review Request once it has been received.
2. Incorporate recommendations provided by WDNR as appropriate.

Additional funding for management implementation may be available through the WDNR Lake Protection Grant Program. Specific tasks that would apply to the management of the Plymouth Mill Pond include lake management plan implementation, development of local regulations and shoreline habitat restoration. For more information regarding WDNR assistance, please refer to http://dnr.wi.gov/org/water/fhp/lakes/lakeprot.htm.

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# APPENDIX A

# CITIZEN INPUT SURVEY

| | |
|---|---|
| Mailed | 2,411 |
| Returned | 745 |
| Response Rate | 30.9% |

# CITY OF PLYMOUTH MILL POND
# FUTURE DIRECTIONS
# CITIZEN INPUT SURVEY
# COMPOSITE RESPONSES

| | |
|---|---|
| Business Owners | 79 |
| Property Owners | 70 |
| General Public | 596 |
| **Total Received** | **745** |

*The City of Plymouth Mill Pond, located in the central portion of the community, was created 150 years ago when a dam was constructed on the Mullet River. Over the years, the Mill Pond has been used for a variety of purposes. Sedimentation, weeds, and odors have surfaced as current issues facing the Mill Pond.*

*During the summer of 2005, the Plymouth City Council created a Mill Pond Committee to identify future directions. The committee, in cooperation with the Sheboygan County University of Wisconsin-Extension Office, developed this survey to obtain your opinions about the future of the Mill Pond. Please take a few minutes to complete the questions.* ***Your input is important and will be used!*** *The Mill Pond Committee is open to all ideas/opinions and looks forward to receiving yours. (Additional surveys are available for other members of your household by contacting The Plymouth City Clerk/Treasurer, Patricia Huberty, 128 Smith Street, Plymouth, WI 53073, (920) 893-1271, or, if other members of your household wish to use this survey, please have them mark their response with a different color pen/pencil.) Please return survey to location on back by* ***Monday, October 31, 2005.*** *Return postage is provided.*

## EXISTING CONDITIONS

***1. Your perception of the overall water "quality" of the Plymouth Mill Pond is: (check one)***

1.7% Excellent (13)
11.1% Good (83)
28.6% Fair (213)
38.1% Poor (284)
16.9% Don't know (126)
3.6% No response (26)

***2. In your opinion, what poses the most critical threats to the Mill Pond's water quality? (check all that apply)***

21.2% Declining water depth due to silt/sediment build-up (486)
10.3% Stormwater pipes that discharge directly into the Mill Pond (236)
8.4% Overland stormwater runoff from areas such as parking lots, roof tops, roadways, and lawns (194)
13.2% Wildlife, especially geese that are attracted to the Mill Pond (304)
13.4% Weeds (307)
7.4% Upstream wastewater treatment facility discharges (170)
10.5% Upstream sanitary and combined sewer overflows (242)
8.7% Upstream agricultural practices (201)
3.8% Upstream construction site erosion (88)
3.1% Other (specify) (71)

***3. On average during summers, aquatic plant/weed growth in the Mill Pond has been: (check one)***

5.0% Light – very little (37)
18.9% Moderate – just right (141)
28.9% Heavy – weeds limit my use of some of the Mill Pond (215)
9.2% Dense – weeds ruin my ability to enjoy the Mill Pond in any manner (69)
35.2% Don't know (262)
2.8% No response (21)

***4. Fishing on the Plymouth Mill Pond is: (check one)***

0.4% Excellent (3)
3.5% Good (26)
13.8% Fair (103)
28.6% Poor (213)
51.4% Don't know (383)
2.3% No response (17)

5. ***Which one of the following best describes the type of fish present in the Mill Pond?***

2.8% An equal balance of rough fish and game fish (21)
36.6% More rough fish than game fish (273)
0.7% More game fish than rough fish (5)
54.8% Don't know/don't fish the Mill Pond (408)
5.1% No response (38)

6. ***Are geese and gulls that are attracted to the Mill Pond a problem?***

51.4% Yes (383) 28.5% No (212) 15.7% Don't know (117) 4.4% No response (33)

***If yes, what is the problem?*** _____

7. ***On average during summers, have you experienced any odor from the Mill Pond?***

25.6% Yes (191) 53.9% No (401) 17.4% Don't know (130) 3.1% No response (23)

***If yes, which one of the following best describes the magnitude of the odor?***

22.0% Faint (51) 47.0% Mild (109) 28.4% Strong (66) 2.6% Overwhelming (6)

***Also if yes, what was the extent of the odor?***

26.0% Limited to the Mill Pond (57)
63.0% Extended just beyond the shoreline of the Mill Pond (138)
10.0% Extended several blocks from the Mill Pond (22)
1.0% The odor could be detected throughout Plymouth (2)

## POND USES

8. ***During the past 12 months, which of the following activities have you participated in, on, or around the Plymouth Mill Pond? (check all that apply)***

5.2% Fishing (99)
3.2% Boating (60)
0.9% Snowmobiling (17)
2.5% Picnicking (48)
24.4% Scenic enjoyment (461)
1.8% Other (specify) (35)
16.1% Hiking and/or biking on recreational trails (304)
15.8% Veteran's Memorial Trail use (300)
0.4% Ice fishing (7)
8.3% Ice skating (157)
0.1% Swimming (1)
14.0% Wildlife observation (265)
7.3% Haven't used the Plymouth Mill Pond for any activity during the past 12 months (139)

9. ***Currently during the winter months, a portion of the Mill Pond is used as a skating area for the community. How important is this skating area for the community?***

44.7% Very important (333) 33.3% Important (248) 13.9% Somewhat important (104)
4.6% Not important (34) 3.5% No response (26)

10. ***Public access to the Plymouth Mill Pond can best be described as:***

25.8% Not enough access (192) 49.8% Adequate access (371) 0.5% Too much access (4)
20.4% Don't know/no opinion (152) 3.5% No response (26)

*11. Is there a need to improve the safety around the Mill Pond dam/spillway?*

25.4% Yes (189.5) 43.7% No (325.5) 25.9% No opinion (193) 5.0% No response (37)

*12. If the island became available to the City of Plymouth, would you support developing the island as a park?*

25.1% Yes (187) 30.7% Yes, but not at taxpayers expense (229) 32.5% No (242)
9.0% No opinion (67) 2.7% No response (20)

*13. The island within the Mill Pond is currently about three acres. Would you favor enlarging the island?*

9.4% Yes (70) 6.3% Enlarge the island, but not with dredged materials from the Mill Pond (47)
64.7% No (482) 16.5% No opinion (123) 3.1% No response (23)

*14. If the island was developed as a park, would you support construction of a pedestrian bridge to access it?*

21.3% Yes (159) 30.8% Yes, but not at taxpayers expense (230) 37.9% No (282)
6.6% No opinion (49) 3.4% No response (25)

*15. If the island was developed as a park and a pedestrian bridge provided access to it, would you use the bridge/island park?*

37.2% Yes (277) 26.2% Maybe (195) 27.0% No (201) 8.7% Don't know (65) 0.9% No response (7)

*16. Stocking game fish in the Mill Pond is:*

14.6% Much needed (109) 26.3% Needed (196) 10.7% Slightly needed (80)
14.9% Not needed (111) 30.4% Don't know (226) 3.1% No response (23)

## AESTHETIC VALUES

*17. The aesthetic/scenic value of the Plymouth Mill Pond is important to you and your household.*

30.5% Strongly agree (227) 40.8% Agree (304) 19.1% Neutral (142)
4.6% Disagree (34) 2.6% Strongly disagree (20) 2.4% No response (18)

*18. The aesthetic/scenic value of the Plymouth Mill Pond is important to the community of Plymouth.*

37.2% Strongly agree (277) 43.6% Agree (325) 12.2% Neutral (91)
3.1% Disagree (23) 1.5% Strongly disagree (11) 2.4% No response (18)

*19. How important overall is the Plymouth Mill Pond to you and your household?*

20.5% Very important (153) 27.4% Important (204) 30.5% Somewhat important (227)
15.7% Not important (117) 3.5% No opinion (26) 2.4% No response (18)

*20. How important overall is the Plymouth Mill Pond to the community of Plymouth?*

31.2% Very important (233) 36.9% Important (275) 18.9% Somewhat important (141)
6.6% Not important (49) 3.8% No opinion (28) 2.6% No response (19)

*21. Is the Mill Pond important for tourism?*

54.3% Yes (404.5) 26.3% No (195.5) 17.4% Don't know/no opinion (130) 2.0% No response (15)

*22. In your opinion, do visitors/tourists to Plymouth view the Mill Pond positively or negatively?*

41.5% Positively (309)
45.3% Don't know/no opinion (338)
9.0% Negatively (67)
4.2% No response (31)

*23. What improvements would be beneficial to enhance the aesthetic value of the Plymouth Mill Pond?*

_____
_____
_____
_____
_____

## MANAGEMENT OPTIONS

*24. Over the long term, which one of the following management options would you prefer?*

37.7% Remove accumulated sediments in the Mill Pond (dredging) (308)
6.7% Use chemicals to control weeds in the Mill Pond (55)
17.8% Use mechanical cutters/harvesters to control weeds in the Mill Pond (145)
11.8% Drawdown/drain water out of the Mill Pond for a period of time to control weeds and allows sediments to compact (96)
10.9% Removal of the dam (eliminate the Mill Pond) (89)
7.5% Do nothing (61)
7.6% Other (specify) (62)

*25. To specifically address the weed problem within the Mill Pond, which one of the following management options would you prefer?*

34.4% Dredging (256)
9.4% Use chemicals/herbicides (70)
19.5% Use mechanical harvesters/cutters (145)
14.6% Drawdown/drain water out of Mill Pond for a period of time (109)
11.1% Do nothing (83)
9.8% No opinion (73)
1.2% No response (9)

## COST/FUNDING

*26. Costs associated with the Mill Pond and/or dam should be paid by: (check all that apply)*

16.8% All City of Plymouth taxpayers (304)
9.0% Special assessments on Mill Pond property owners (164)
8.7% Business and industry (158)
12.2% Community organizations (222)
23.1% Concerned citizens, donations, and fund raisers (420)
28.9% Grants and other government aid programs, if available (524)
1.3% Other (specify) (23)

*27. Are you willing to have tax dollars used for the Mill Pond?*

42.1% Yes (314) 45.0% No (335) 7.1% No opinion (53) 5.8% No response (43)

## OTHER ISSUES/COMMENTS

*28. Please describe any additional issues and/or comments regarding the Plymouth Mill Pond*

_____

## YOUR BACKGROUND/STATISTICAL INFORMATION

*29. What is your age?*

0.6% Under 18 (5)
0.6% 18 – 24 (5)
2.6% No response (19)
9.3% 25 – 34 (69)
16.0% 35 – 44 (119)
23.2% 45 – 54 (173)
19.9% 55 – 64 (148)
16.1% 65 – 74 (120)
11.7% 75 or older (87)

*30. Do you rent or own property in the City of Plymouth?*

1.7% Rent (13) 92.6% Own (690) 2.1% Rent and own (15) 3.6% No response (27)

*31. Do you consider yourself a seasonal City of Plymouth resident or permanent resident?*

1.3% Seasonal (10) 95.6% Permanent (712) 3.1% No response (23)

*32. How long have you lived in the City of Plymouth?*

9.4% Less than 5 years (70)
10.9% 5 – 10 years (81)
10.7% 50 years or longer (79)
15.7% 11 – 19 years (117)
10.7% 20 – 29 years (80)
15.8% Lifetime resident (118)
13.4% 30 – 39 years (100)
11.3% 40 – 49 years (84)
2.1% No response (16)

*33. How many members are in your household?*

14.2% 1 (106)
9.1% 5 (68)
42.8% 2 (319)
2.6% more than 5 (19)
11.3% 3 (84)
3.5% No response (26)
16.5% 4 (123)

*34. Do you feel the responses you provided in this survey are representative of your household?*

91.1% Yes (679) 0.4% No (3) 4.1% Not sure (30) 4.4% No response (33)

*35. Do you own property/reside on the Plymouth Mill Pond?*

9.4% Yes (70) 86.8% No (647) 3.8% No response (28)

*a. If yes, which of the following best describes why you chose property on the Plymouth Mill Pond*

38.2% The aesthetics/scenic quality of the Mill Pond (63)
3.0% Cost of property (5)
14.6% For recreation purposes (fishing, swimming, boating, etc.) (24)
3.6% Because of neighbors (6)
7.3% Other (specify) (12)
19.4% Privacy (32)
10.3% For investment purposes (17)
3.0% Family tradition (5)
0.6% Inherited property (1)

*b. If yes, please indicate the most important reasons why you own property on the Plymouth Mill Pond*

6.9% Fishing (12)
0.0% Swimming (0)
8.7% Boating (15)
9.8% Entertaining friends and relatives (17)
11.0% Holding property as an investment (19)
21.4% Observing wildlife (37)
35.8% Enjoying the view, peace and tranquility (62)
6.4% Other (specify) (11)

*c. If yes, please indicate the most important ways you actually use your property on the Plymouth Mill Pond*

7.1% Fishing (14)
0.0% Swimming (0)
11.7% Boating (23)
4.1% Other (specify) (8)
28.4% Observing wildlife (56)
36.0% Enjoying the view, peace and tranquility (71)
12.7% Entertaining friends and relatives (25)

***36. Do you own a business in the City of Plymouth?***

14.0% Yes (104)
78.1% No (582)
7.9% No response (59)

**OPTIONAL INFORMATION**

Name:_____
Address:_____
City/Zip:_____

**THANK YOU!!!**

**The City of Plymouth Common Council and Mill Pond Committee thank you for your input and cooperation.**

**Additional surveys for your household are available from The Plymouth City Clerk/Treasurer, Patricia Huberty, 128 Smith Street, Plymouth, WI 53073, (920) 893-1271.**

**Please mail survey to the location on last page by Monday October 31, 2005.**
**Return postage is provided.**

# APPENDIX B

# PLYMOUTH MILL POND BACKGROUND WATERSHED ASSESSMENT MEMORANDUM

EarthTech
A tyco International Ltd. Company

# Memo

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Date: May 8, 2007

To: Bill Immich, City of Plymouth Director of Public Works

Copy: Steve Grumann, Earth Tech

From: Bernie Michaud, Earth Tech

**Subject: Plymouth Mill Pond Background Watershed Assessment**

## Introduction

The purpose of this technical memorandum is to summarize background information on the Plymouth Mill Pond and the Mullet River watershed tributary to the mill pond. Also summarized are the findings of a windshield survey of the watershed looking for potential land use impacts to the water quality of the Mullet River and the mill pond. In addition a summary of information for known endangered resources in the project area is provided.

## Historical Review

Jim Stahlman, a member of the Plymouth Mill Pond committee provided the following history of the Plymouth Mill Pond. The original dam was constructed in the late 1840s, probably the spring of 1849. There is speculation that the river was rerouted when the dam was built but there is no supporting evidence for this and it is unlikely. The dam and mill pond are shown in roughly their present configuration in both the 1875 and 1889 plat books found in the Plymouth Historical Society Museum. Another dam and mill (Jones Mill) existed upstream on the Mullet River north of the present day Industrial Park in the 1870s and 1880s in the Town of Mankato. This dam was abandoned around 1900. The County Fairgrounds were started in 1897. In 1906 a flood washed out the Plymouth mill dam, which was later reconstructed. The present dam was constructed in the early 1950s. The mill pond was drained down in the late 1950s. During this drawdown the river was on the east side of the island.

## Watershed Delineation

The Mullet River watershed tributary to the Plymouth Mill Pond was delineated using a combination of Wisconsin Department of Natural Resources (WDNR) Mullet River watershed GIS information, City of Plymouth storm sewer drainage mapping, and U.S. Geological Survey (USGS) topographic quadrangle maps. The watershed drains about 62 square miles in Fond du Lac and Sheboygan counties as shown in the attached watershed map. The Mullet River originates at Mullet Lake and runs east, gathering drainage from La Budde Creek to the north near Elkhart Lake and Jackson Creek to the northwest of the City of Plymouth.

## Land Use

Based on WDNR GIS land use mapping and Earth Tech's windshield survey, the land use in the watershed is primarily agricultural with extensive wooded areas and significant wetland areas buffering the drainage ways of the Mullet River and its tributaries. Extensive areas of wetland also form the headwaters of the Mullet River. The majority of urban land use is in the City of Plymouth.

The Sheboygan County Land & Water Conservation Department (LWCD) was consulted regarding agricultural practices in the project area. The LWCD contact said they do not have information readily available in that regard and referred Earth Tech to WDNR.

## WDNR Background Information

John Masterson, of the WDNR Plymouth Service Center, was interviewed regarding potential impacts to surface water quality in the watershed. According to WDNR records, there are no point sources of pollution such as wastewater discharges to the Mullet River upstream of the mill pond. There are no significant sources of non-point source pollution, such as barnyards or badly eroded farm fields, in the watershed which stand out.

Curtis Nickels also of the WDNR Plymouth Service Center was interviewed about measures taken at the Sheboygan county Fairgrounds to reduce non-point source pollution. Over the last several years he has worked with the County Fairgrounds to install a sediment trap by the racetrack grandstands, a French drain in the infield, and another on the west side of the racetrack.

Sediment samples from the Plymouth Mill Pond were collected and analyzed by WDNR in 2004. Results of this sampling were not available for Earth Tech review. A review of online USGS water quality data revealed no data collected for the Mullet River.

## Watershed Windshield Survey

A windshield survey of the watershed to assess land use practices, as they would impact water quality, was conducted on June 20th, 2006. Eleven different locations were characterized throughout the watershed. These eleven locations are labeled on the attached watershed map. Photographs of the locations are included in Attachment A. The following is a summary of findings for each location.

### *Site 1) County Fairgrounds*

The County Fairgrounds are east of mill pond in the City of Plymouth. The fairgrounds drain directly to mill pond via storm sewers. The fairgrounds have a dirt racetrack for car racing with associated grand stands and barns for livestock. Midget car racing occurs throughout the summer with the County Fair occurring in late summer. This is when the livestock barns are most used, but at the time of the survey fresh horse manure was found near the barns.

The fairgrounds may be a significant source of non-point source pollution to Mill Pond. The dirt track racetrack could generate loadings of mud, oil, grease and gasoline. According to Curtis Nickels of the WDNR, a sediment trap by the racetrack grandstands, a French drain in the infield, and another on the west side of the racetrack has been installed in the past several years in an effort to prevent this non-point source pollution from entering the mill pond. There have been anecdotal observations of the storm sewer outfall going into Mill Pond from the race track area, flowing brown during rain storms. The areas near the barns are paved and are drained by storm sewer inlets. Manure from these areas could easily enter Mill Pond directly from these areas.

*Site 2) Bare Field West of CTH OJ*

This is a farm field bordering CTH OJ to the west and just north of State HWY 23. This field drains to the Mullet River upstream of the mill pond. At the time of the windshield survey on June 20th, the field was bare with no apparent crop showing. A crop may have been planted and it may not have been apparent at the time.

There was no significant erosion evident from the highway. The field slopes were not severe. It appeared that there was a green space buffer between the field and the river. Overall, as long as the field is vegetated with a crop or other cover, this field is probably not a major source of sediment to the Mullet River.

*Site 3) Oat Field by CTH J*

This site is an oat field just south of CTH J and west of State HWY 67. The field drains to the Mullet River upstream of Mill Pond. At the time of the survey the oats were well established. Non row crops, such as oats, provide good ground cover and have less potential sediment erosion than row crops, such as corn and soy beans.

*Site 4) Corn Field by CTH C*

This site is west of CTH C just north of Woodland Road. The field drains to the Mullet River north of the mill pond. At the time of the survey the corn appeared well established and the field well managed.

*Site 5) Bare Field West of Racetrack Road*

This is a farm field west of Racetrack Road and south of CTH JJ. This field drains to La Budde Creek southeast of Elkhart Lake. At the time of the windshield survey on June 20th, the field was bare with no apparent crop showing. A crop may have been planted and it may not have been apparent at the time.

There was no significant erosion evident from the highway. The field slopes were not severe. It appeared that there was a green space buffer between the field and the river. Overall, as long as the field is vegetated with a crop or other cover, this field is probably not a major source of sediment to La Budde Creek.

*Site 6) Corn Field at Southeast Corner of Racetrack Road and CTH JJ*

This corn field drains to the corner of this intersection with no apparent outlet. If this field did freely drain it would drain to La Budde Creek. There is an accumulation of eroded sediment at the corner of this field as well as an eroded flow path through the field as shown in the photo. The corn is not growing very well in this field as compared to other corn fields in the watershed, perhaps due to relatively poor soil conditions. If there is free drainage from this field, it could be a source of sediment to La Budde Creek.

*Site 7) La Budde Creek Near Golf Course Road*

La Budde Creek was observed at a bridge crossing near Golf Course Road southeast of Elkhart Lake and just west of the railroad tracks. The creek water was relatively clear and had aquatic vegetation growing on the bottom. The stream appears to have been straightened, probably due to the construction of the railroad tracks. Despite being straightened, the creek banks are well buffered with

dense vegetation. Field observation and map review indicates the most of La Budde Creek is well buffered with green space (woods and wetlands) throughout its course.

*Site 8) Glenbeulah Mill Pond*

The Glenbeulah Mill Pond is the largest man made impoundment on the Mullet River upstream from the Plymouth Mill Pond. Two smaller impoundments, Otter Pond and the Camp Evelyn Pond, are located within a mile downstream from the Glenbeulah Mill Pond. The Glenbeulah dam is an earthen dam with a concrete gated section located in a Village park.

The Glenbeulah Mill Pond has an accumulation of sediment along the upstream side of the dam. There is also aquatic vegetation growth, however it is not as abundant as that in the Plymouth Mill Pond. There is little development around the shores of the pond, and the Village of Glenbeulah is small compared to the City of Plymouth. The river flowing downstream of the dam is swift flowing and relatively clear but more turbid than La Budde Creek. There are clumps of filamentous algae growing on the shallow rocks below the dam. The Glenbeulah Mill Pond and the other two smaller impoundments downstream act as sediment traps to remove sediment before it reaches the Plymouth Mill Pond.

*Site 9) Bare Field North of CTH A*

This is a farm field north of CTH A about one mile northeast of the Village of Greenbush. To the north of the field is the Mullet River. At the time of the windshield survey on June 20$^{th}$, the field was bare with no apparent crop showing. A crop may have been planted and it may not have been apparent at the time.

There was no significant rill erosion evident from the highway. The field slopes were flat. There is a wooded buffer area between the field and the river. Overall, as long as the field is vegetated with a crop or other cover, this field is probably not a major source of sediment to the Mullet River.

*Site 10) CTH T and Spring Valley Road*

This site consists of farm field to the east and west of Spring Valley Road just north of CTH T about two miles west of the Village of Greenbush. These fields drain north to the Mullet River. The east field is in hay and the west field is in corn as shown in the photos. These fields appeared in good condition and there was a wooded buffer area along the river. These fields were typical of what was seen throughout the watershed.

*Site 11) Outlet to Mullet Marsh*

This site is the outlet to Mullet Marsh as it crosses CTH G. Mullet Lake and Mullet Marsh form the headwaters of the Mullet River. These two water bodies are surrounded by wetlands and are well buffered from sediments from the surrounding watershed. The flow at this outlet is rather sluggish. The water is clear but stained by tannins. Duckweed is present on the surface.

<u>Watershed Windshield Survey Summary</u>

Overall agricultural practices in the watershed appear to be following good management practices from a water quality perspective. While the survey did find three fields that were bare and possible sources of eroded sediment, it appeared that they were just planted or about ready to be planted. The majority of the farm fields were in good condition and planted in corn, oats, or hay. One eroded corn field was

found by Racetrack Road but it appeared to be an enclosed depression without a discharge to La Budde Creek. No large dairy herds or other livestock operations were seen. Substantial parts of the watershed are woodland, wetlands, or grassland that can be beneficial from a water quality aspect.

The one site that perhaps deserves some additional investigation is the County Fairgrounds. Given its proximity to and direct discharge to Mill Pond, non-point source pollution from this site could have a significant impact to the water quality of the pond. Drainage routes from both the racetrack and livestock area, as well as other possible pollutant sources, should be further investigated. If it is found that non-point source pollution from this site is making its way to the mill pond there are a number of practices that could be employed to try and improve the situation. These could include disconnecting the flow paths to the pond, removing the pollutant sources, or treating the runoff before it reaches the pond.

**Project Area Endangered Resources**

The Endangered Resources Review Request has been submitted to the WDNR Bureau of Endangered Resources. No results were available from WDNR prior to the date of this Technical Memorandum.

# ATTACHMENT A

# PHOTOGRAPHS

Photo Log – Plymouth Mill Pond Watershed Survey

Site 1 - Dirt Racetrack

Site 1 - Manure near livestock barns

Site 2 - Bare Farm Field West of CTH OJ

Site 3 - Oat Field South of CTH J

Site 4 - Corn Field West of CTH C

Site 5 - Bare Field West of Racetrack Road

Site 6 - Eroded Corn Field at SE Corner of Racetrack Road and Hwy. JJ

Site 7 - La Budde Creek

Site 8 - Glenbeulah Dam

Site 9 - Bare Field north of Hwy A looking toward the Mullet River

Site 10 - Alfalfa Field

Site 10 - Corn Field

Site 11 - Mullet Marsh Outlet

# APPENDIX C

# MILL POND BASELINE WATER QUALITY ASSESSMENT MEMORANDUM

EarthTech
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# Memo

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May 8, 2007

To: Bill Immich, City of Plymouth

From: Steve Grumann, Earth Tech

Subject: **Mill Pond Baseline Water Quality Assessment Technical Memorandum**

This technical memorandum summarizes the results of the baseline water quality sampling completed by Earth Tech during the summer and fall of 2006, at the Mill Pond located in Plymouth, Wisconsin. Components of the water quality sampling conducted by Earth Tech included field measurements (temperature, pH, dissolved oxygen, conductivity and water transparency) and laboratory analysis (total phosphorus and chlorophyll-*a*).

## SAMPLING METHODOLOGY

Water samples were collected by Earth Tech during four sampling events (June, July, August, and October) at two locations in Mill pond and two locations on Mullet River (Figure 1, Attachment A). Sample containers used were shipped in a sealed cooler from the State Hygienic Lab in Madison, WI to the Earth Tech office in Sheboygan, WI. Water samples were collected according to the Wisconsin Department of Natural Resources (WDNR) collection protocols with the following activities.

- Prior to arriving at the site, all field measurement equipment was examined to verify that it was in good operating condition. The sampling equipment was washed with an aqueous cleaner, using elevated temperature and pressure as appropriate. In the field, after each use, the sampling equipment was rinsed well with sample water before readings were taken.

- Sample preservatives and containers were prepared and used as necessary to comply with United States Environmental Protection Agency (USEPA) requirements for the analytes of interest.

- Sample labels were completed at the time of sample collection, noting the site identification, sample location, sample interval (as appropriate), preservative, sample analysis, and sample date.

- For each sample collected, the applicable sampling procedure was recorded in the field notes or on a Sampling Data Sheet. Laboratory chain-of-custody documentation and procedures were followed.

A small water craft was used by two Earth Tech employees to the Sample Stations 2 and 3 to obtain water samples in Mill Pond. While at the stations, sample containers were gently submerged into the water and allowed to fill. Preservation of the appropriate samples was done immediately after collection. Water quality field parameter measurements were taken at each

sample station after all water samples were acquired. GPS coordinates of each location were collected and recorded using a hand-held GPS unit (Trimble GeoXT™).

Water samples from Stations 1 and 4 were obtained by an Earth Tech employee who waded into the Mullet River. The employee gently waded from downstream working upstream to minimize disturbance of the sediments. Once in the thalweg of the stream, water samples were collected by submerging the sample containers until full. Preservation of the appropriate samples was done immediately after collection. Water quality field parameter measurements were taken at each sample station after all water samples were acquired. GPS coordinates were collected at each station.

All samples were shipped on ice in a sealed cooler to the State Hygienic Lab for chemical analysis following appropriate chain-of-custody procedures.

## RESULTS

Table 1, in Attachment B, presents the water quality sample results for the four Stations for each of the four sample events. Charts 1 through 4 in Attachment C show the trends for temperature, pH, dissolved oxygen, and conductivity, respectively, through the sampling period. Temperature, dissolved oxygen, pH and conductivity values were within the normal range for inland lakes and impoundments.

Secchi disc readings could only be measured at Station 3, because the secchi disc was visible all the way down to the substrate at Stations 1, 2, and 4. Chart 5 shows the measurements for secchi disk readings at Station 3 through the sampling period. The water was less clear in July and August, which is typical for lakes in Wisconsin. In late summer, more algae and plankton are suspended in the water column because the nutrient levels are higher in mid to late summer.

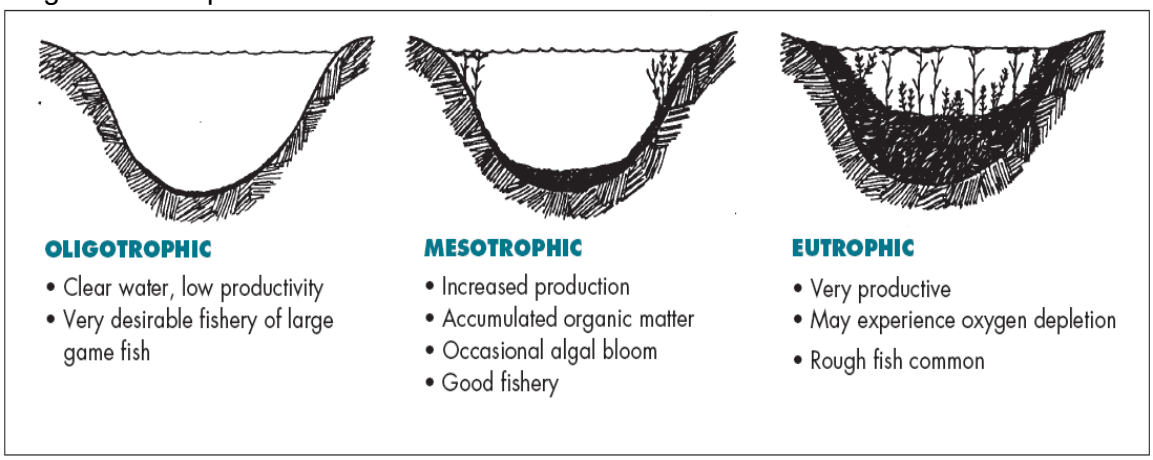
Chart 6 shows the trend for total phosphorus through the sampling period. Total phosphorus levels peaked in July at all stations and were higher at Stations 2, 3, and 4 than Station 1. Total phosphorus and chlorophyll-*a* levels were considerably higher at Stations 2, 3, and 4 than at Station 1, the upstream station. This result indicates that a considerable amount of phosphorus is entering Mill Pond from the area directly adjacent to pond rather than from upstream.

Chart 7 shows the trend for chlorophyll-*a* through the sampling period. Chlorophyll-*a* levels were lowest at all stations in June, but increased considerably at all but Station 1 as the summer progressed. The additional input of phosphorus is a likely cause of the increase in chlorophyll-*a*, a measure of plant productivity.

### Trophic status index

Trophic State Index (TSI) is a measurement for characterizing a lake's trophic state. The term "trophic status" refers to the level of productivity in a lake. Productivity refers to the amount of nutrients, plant, and fish biomass. Productivity and trophic state of lakes are typically classified into three categories: oligotrophic, mesotrophic and eutrophic, and are described and illustrated in Diagram A below.

Diagram A. Trophic States of Lakes




Source: University of Wisconsin Extension, Understanding Lake Data

Carlson's Trophic State Index (TSI) is one means available to examine the relationship between total phosphorus, chlorophyll-*a*, and secchi disk readings in a lake, and its overall productivity. The WDNR has modified Carlson's equations to form a Wisconsin Trophic Status Index (WSTI) to better suit lakes in Wisconsin. Individual WTSI values for this study were calculated from the following WTSI equations:

Secchi: $WSTI_{SD} = 60 - (14.4 \ln SD)$,

Total P: $WSTI_{P} = 28.2 + (7.73 \ln TP)$, and

Chlorophyll a: $WSTI_{CHL} = 34.8 + (7.56 \ln CHL)$,

where SD = secchi depth in meters, TP = total phosphorus in parts per billion (ppb), and CHL = chlorophyll-*a* in ppb.

The WTSI results are presented in Table 2 in Attachment B. Chart 8 presents the trends for WTSI through the sampling period. According to WDNR, the WTSI values for the four stations were typical for eutrophic lakes, except for the chlorophyll-*a* at Station 1, which was typical for a mesotrophic lake. Based on these measurements, Mill Pond should be considered a eutrophic system, meaning that it is very nutrient rich, containing abundant organic matter. The relationship among chlorophyll-*a* and total phosphorus WTSI's in 2006 suggests that there is a high volume of algal biomass within the downstream end of the pond, with some limiting factor in the upstream end of the pond, such as the current of the river or nitrogen levels in the water.

**CONCLUSIONS**

Baseline water quality results suggest that Mill Pond is a eutrophic system, receiving concentrations of phosphorus that is degrading its water quality. Phosphorus entering the Mill

Pond from both the watershed of the Mullet River and from the adjacent landscape are likely to promoting the high density of macrophytes in the pond and the algal blooms the occur in the summer. Limiting the phosphorus entering the pond should positively affect the aquatic health and aesthetics of Mill Pond.

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## ATTACHMENT A – FIGURES

FIGURE 1 – WATER QUALITY SAMPLING LOCATIONS

Source: USDA WI Farm Agency NAIP 2005, Earth Tech 2006

Spatial Reference: GCS_North_American_1983

**Figure 1 - Water Quality Sampling Locations, 2006**

**Mill Pond Project**
**City of Plymouth**
**Sheboygan County, Wisconsin**

December 8, 2006

88673

## ATTACHMENT B – TABLES

TABLE 1 – WATER QUALITY RESULTS SUMMARY

TABLE 2 – TROPHIC STATUS INDEX (TSI) RESULTS SUMMARY

**Table 1**

**Water Quality Results Summary**
**Mill Pond**
**Plymouth, Wisconsin**

| Station | Date | Parameters | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Temp (C) | pH | DO (mg/L) | Cond. (µmhos/cm) | Secchi (m) * | Total P (µg/L) | Chl a (µg/L) |
| Upstream (Station 1) | 6/26/06 | 18.8 | 8.5 | 12.3 | 696 | NA | 64 | 3.89 |
| | 7/25/06 | 20.6 | 8.3 | 9.5 | 681 | NA | 86 | 4.32 |
| | 8/23/06 | 16.8 | 7.8 | 8.7 | 719 | NA | 61 | 2.54 |
| | 10/12/06 | 6.9 | 6.9 | 8.3 | 705 | NA | 44 | 1.44 |
| Pedestrian Bridge (Station 2) | 6/26/06 | 20.2 | 8.4 | 8.5 | 704 | NA | 78 | 5.74 |
| | 7/25/06 | 22.6 | 7.3 | 6.6 | 717 | NA | 123 | 6.45 |
| | 8/23/06 | 18.6 | 7.6 | 5.6 | 731 | NA | 98 | 14.6 |
| | 10/12/06 | 7.1 | 6.8 | 8.3 | 697 | NA | 49 | 27 |
| Deep spot Mill Pond (Station 3) | 6/26/06 | 20.3 | 8.1 | 6.5 | 683 | 1.07 | 94 | 10.9 |
| | 7/25/06 | 25 | 7.5 | 5.9 | 743 | 0.52 | 141 | 124 |
| | 8/23/06 | 22.7 | 7.2 | 4.6 | 766 | 0.61 | 93 | 32.2 |
| | 10/12/06 | 6.9 | 6.8 | 8.1 | 657 | 0.91 | 50 | 28.5 |
| Downstream (Station 4) | 6/26/06 | 20.2 | 8.1 | 7.2 | 682 | NA | 88 | 8.58 |
| | 7/25/06 | 25.9 | 8.3 | 7.9 | 698 | NA | 127 | 57.2 |
| | 8/23/06 | 22.6 | 7.5 | 6.5 | 737 | NA | 120 | 42.5 |
| | 10/12/06 | 6.5 | 6.8 | 8.1 | 658 | NA | 53 | 60.3 |

Notes:
* Secchi disc visibility reached the sediment at Stations 1, 2, and 4.

## Table 2

## Trophic Status Index (TSI) Results Summary
## Mill Pond
## Plymouth, Wisconsin

| Site | Date | Secchi Disk TSI [1] | Total Phosphorus TSI | Chlorophyll- *a* TSI |
|---|---|---|---|---|
| Station 1 (Upstream) | 6/26/06 | *NA* | *60.3* | *45.1* |
| | 7/25/06 | *NA* | *62.6* | *45.9* |
| | 8/23/06 | *NA* | *60.0* | *41.8* |
| | 10/12/06 | *NA* | *57.5* | *37.6* |
| | Average | *NA* | *60.1* | *42.6* |
| Station 2 (Pedestrian Bridge) | 6/26/06 | *NA* | *61.9* | *48.0* |
| | 7/25/06 | *NA* | *65.4* | *48.9* |
| | 8/23/06 | *NA* | *63.6* | *55.1* |
| | 10/12/06 | *NA* | *58.3* | *59.7* |
| | Average | *NA* | *62.3* | *52.9* |
| Station 3 (Deep spot) | 6/26/06 | *59.0* | *63.3* | *52.9* |
| | 7/25/06 | *69.4* | *66.5* | *71.2* |
| | 8/23/06 | *67.1* | *63.2* | *61.0* |
| | 10/12/06 | *61.4* | *58.4* | *60.1* |
| | Average | *64.2* | *62.8* | *61.3* |
| Station 4 (Downstream) | 6/26/06 | *NA* | *62.8* | *51.0* |
| | 7/25/06 | *NA* | *65.6* | *65.4* |
| | 8/23/06 | *NA* | *65.2* | *63.1* |
| | 10/12/06 | *NA* | *58.9* | *65.8* |
| | Average | *NA* | *63.1* | *61.3* |

Notes:
[1] = Secchi disk readings not available for Stations 1, 2, and 4 because the disk was visible to the bottom of the pond at these locations.

**ATTACHMENT C – CHARTS**

CHART 1 – TEMPERATURE TRENDS
CHART 2 – Ph TRENDS
CHART 3 – DISSOLVED OXYGEN TRENDS
CHART 4 – CONDUCTIVITY TRENDS
CHART 5 – SECCHI DISC READING TRENDS
CHART 6 – TOTAL PHOSPHORUS TRENDS
CHART 7 – CHLOROPHYLL-*a* TRENDS
CHART 8 – WTSI TRENDS

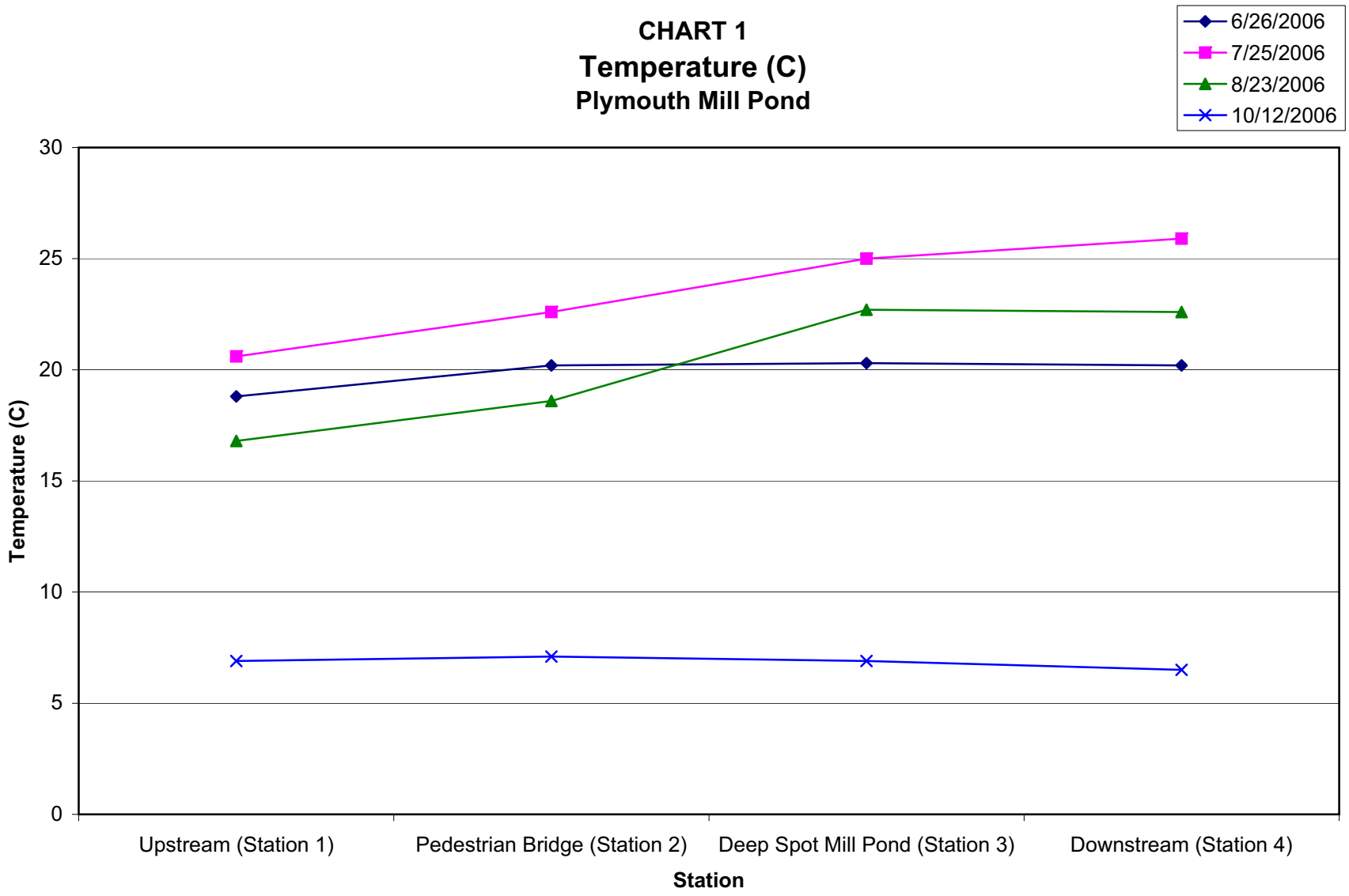
CHART 1
Temperature (C)
Plymouth Mill Pond
6/26/2006
7/25/2006
8/23/2006
10/12/2006
30
25
20
15
10
5
0
Temperature (C)
Upstream (Station 1)
Pedestrian Bridge (Station 2)
Deep Spot Mill Pond (Station 3)
Downstream (Station 4)
Station

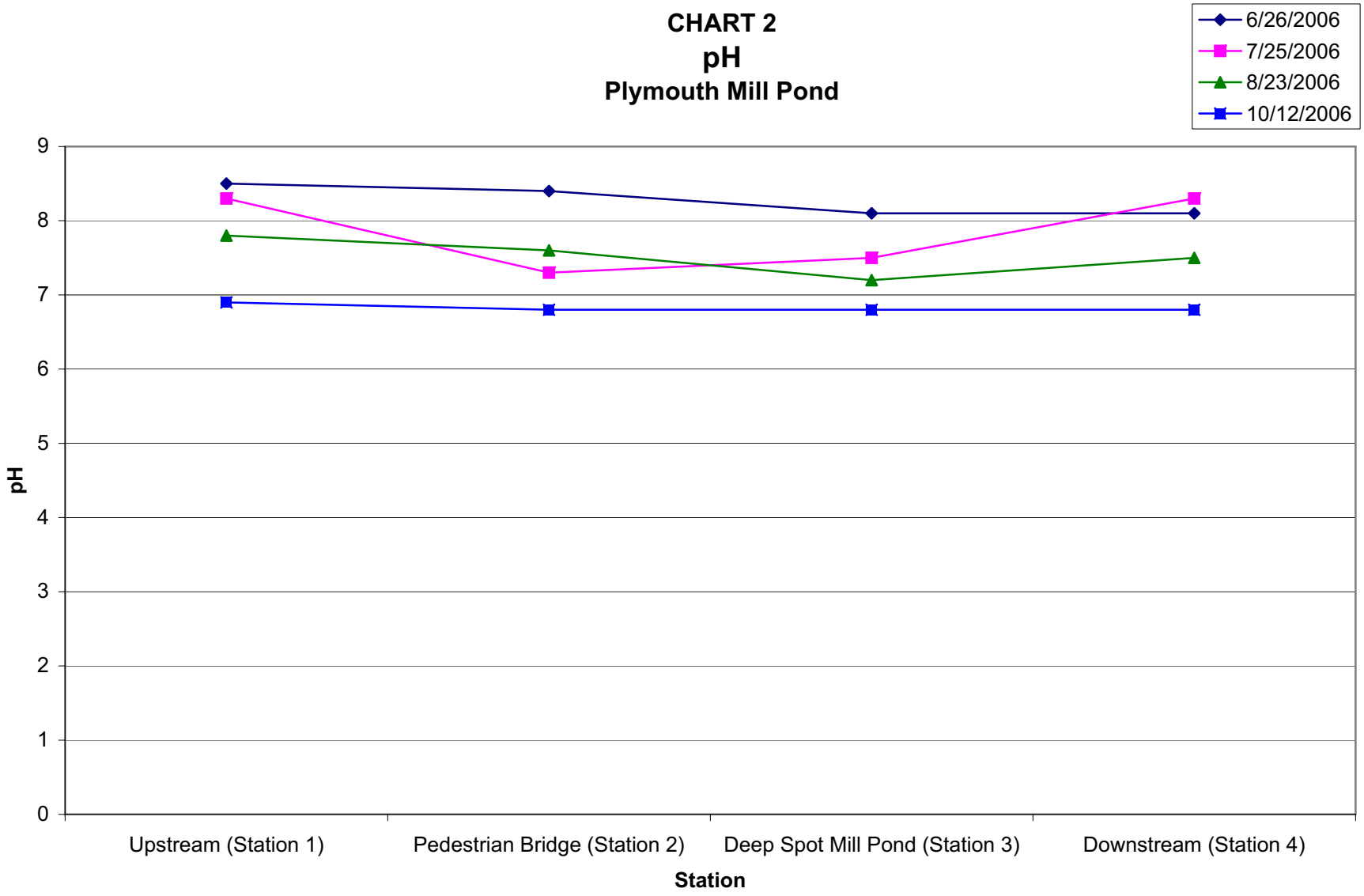
CHART 2
pH
Plymouth Mill Pond
6/26/2006
7/25/2006
8/23/2006
10/12/2006
9
8
7
6
5
4
3
2
1
0
pH
Upstream (Station 1)
Pedestrian Bridge (Station 2)
Deep Spot Mill Pond (Station 3)
Downstream (Station 4)
Station

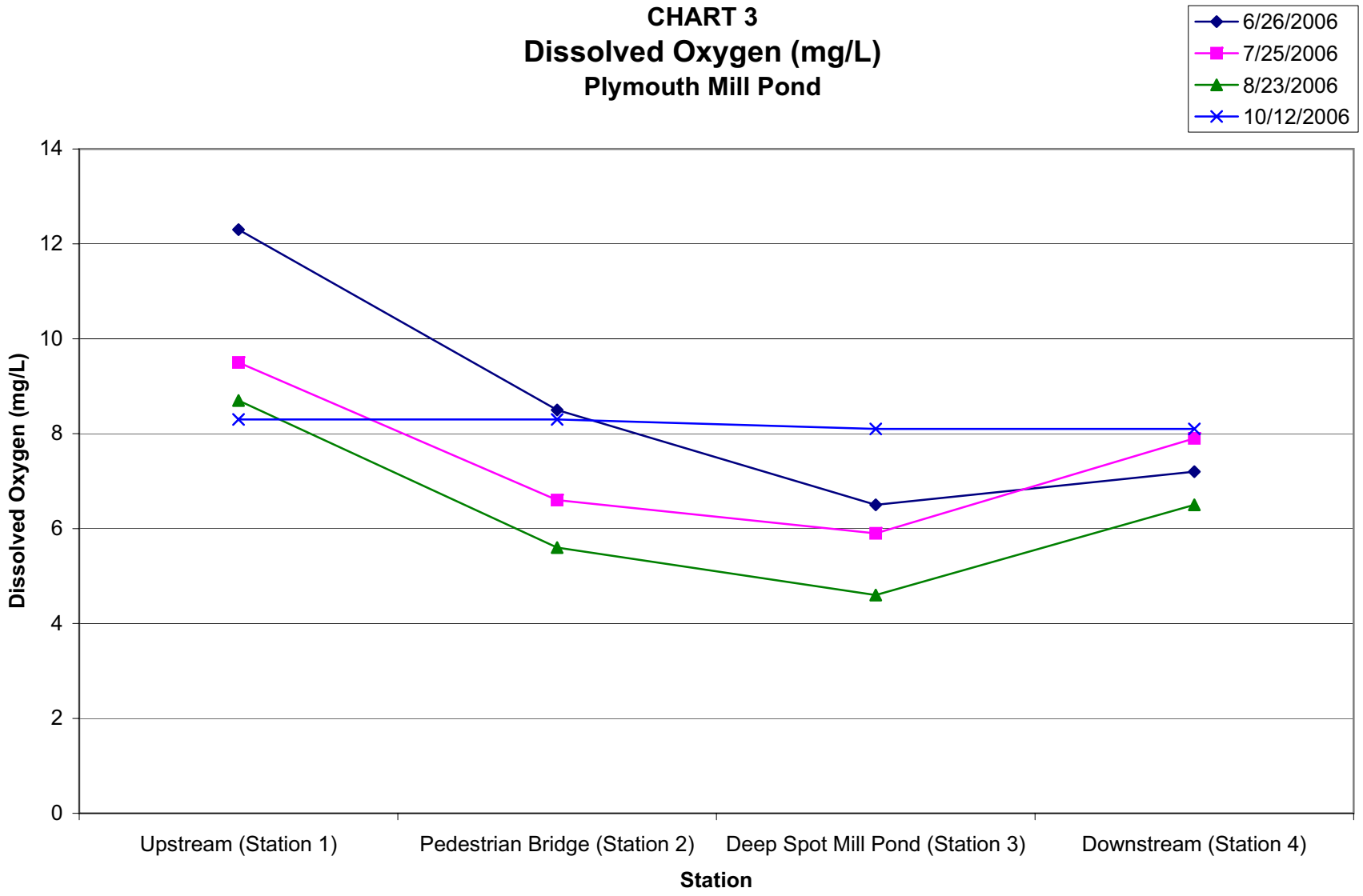
CHART 3
Dissolved Oxygen (mg/L)
Plymouth Mill Pond
6/26/2006
7/25/2006
8/23/2006
10/12/2006
Dissolved Oxygen (mg/L)
14
12
10
8
6
4
2
0
Upstream (Station 1)
Pedestrian Bridge (Station 2)
Deep Spot Mill Pond (Station 3)
Downstream (Station 4)
Station

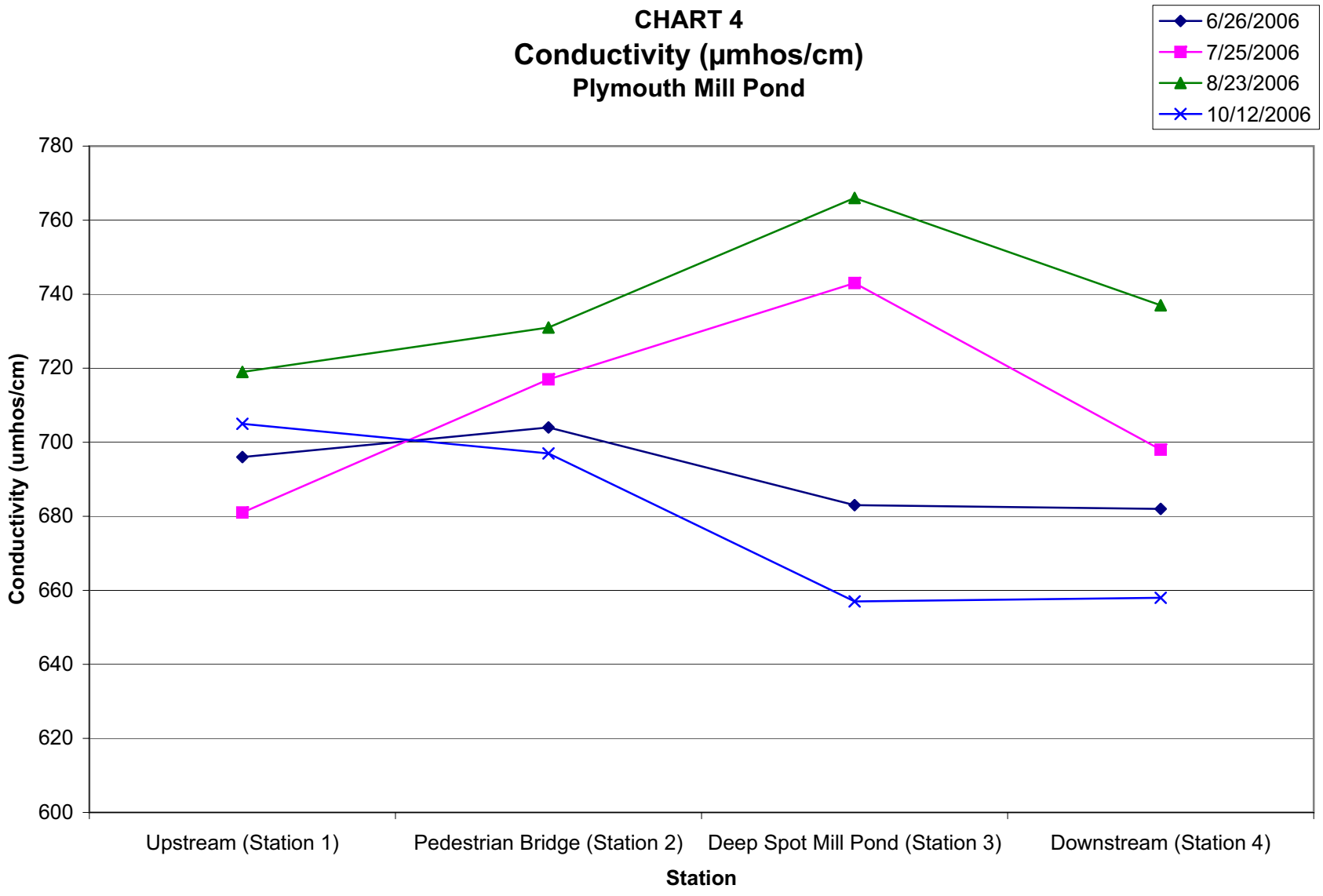
CHART 4
Conductivity (µmhos/cm)
Plymouth Mill Pond
6/26/2006
7/25/2006
8/23/2006
10/12/2006
780
760
740
720
700
680
660
640
620
600
Conductivity (umhos/cm)
Upstream (Station 1)
Pedestrian Bridge (Station 2)
Deep Spot Mill Pond (Station 3)
Downstream (Station 4)
Station

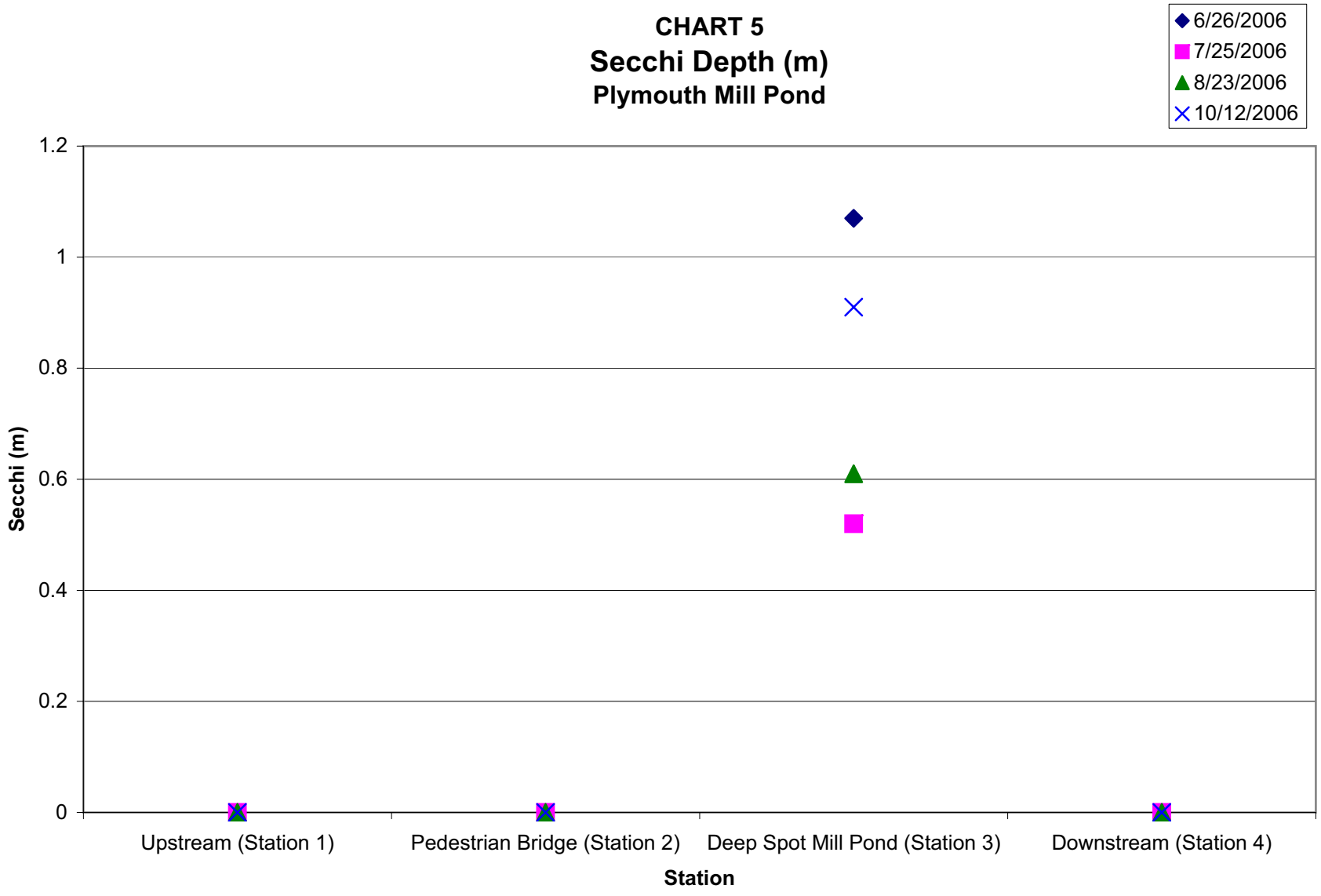
CHART 5
Secchi Depth (m)
Plymouth Mill Pond
6/26/2006
7/25/2006
8/23/2006
10/12/2006
1.2
1
0.8
0.6
0.4
0.2
0
Secchi (m)
Upstream (Station 1)
Pedestrian Bridge (Station 2)
Deep Spot Mill Pond (Station 3)
Downstream (Station 4)
Station

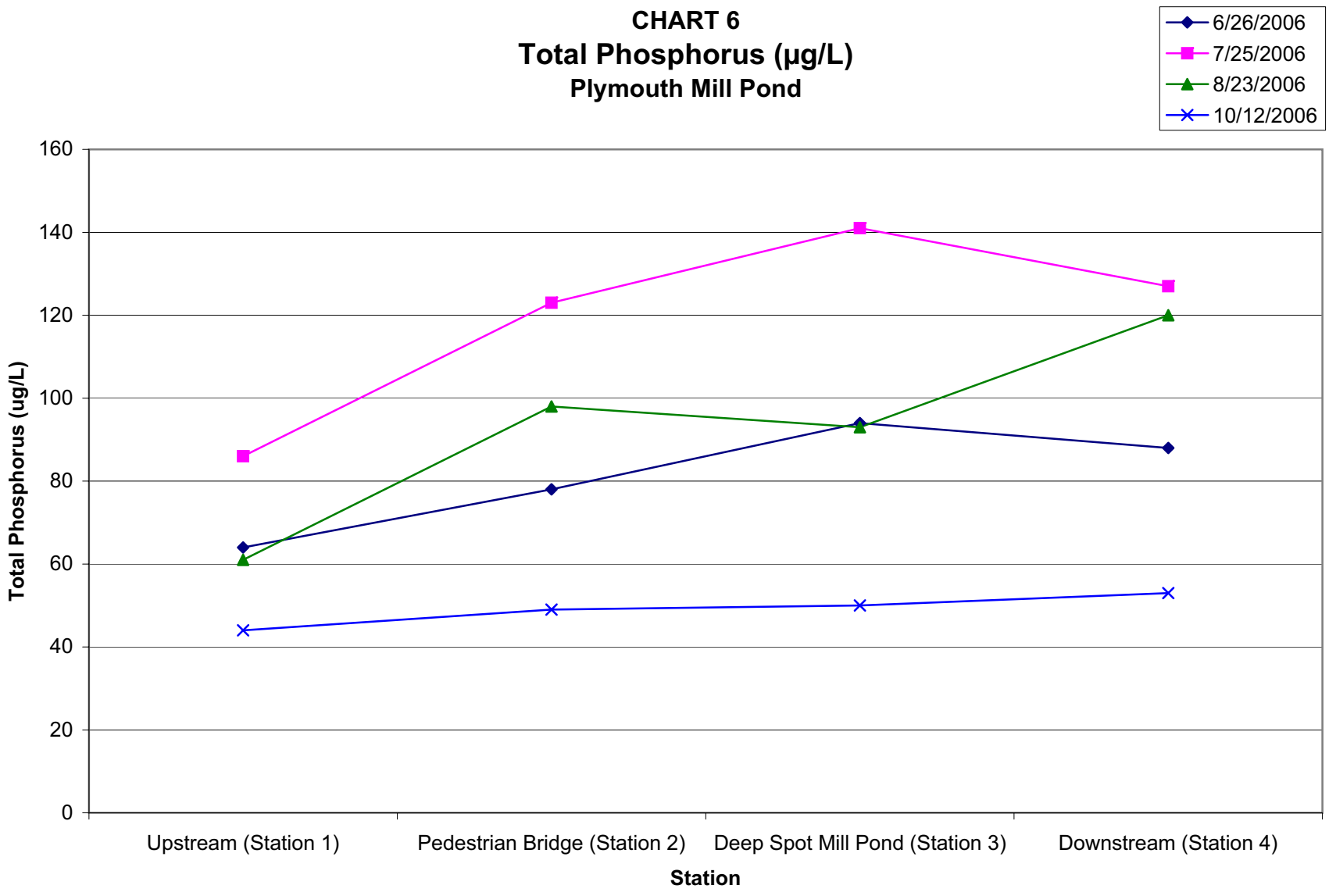
CHART 6
Total Phosphorus (µg/L)
Plymouth Mill Pond
6/26/2006
7/25/2006
8/23/2006
10/12/2006
160
140
120
100
80
60
40
20
0
Total Phosphorus (ug/L)
Upstream (Station 1)
Pedestrian Bridge (Station 2)
Deep Spot Mill Pond (Station 3)
Downstream (Station 4)
Station

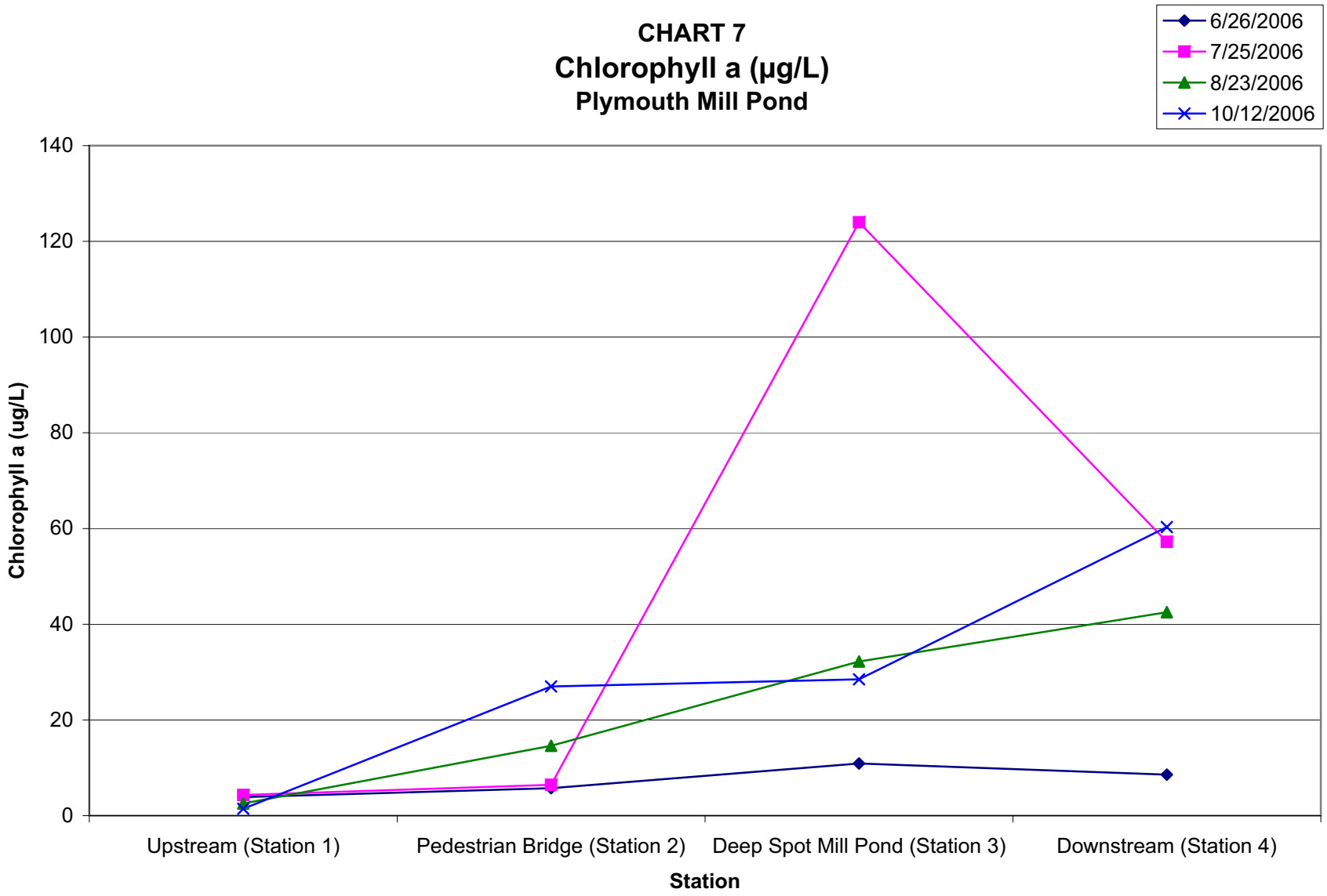
CHART 7
Chlorophyll a (µg/L)
Plymouth Mill Pond
6/26/2006
7/25/2006
8/23/2006
10/12/2006
Chlorophyll a (ug/L)
140
120
100
80
60
40
20
0
Upstream (Station 1)
Pedestrian Bridge (Station 2)
Deep Spot Mill Pond (Station 3)
Downstream (Station 4)
Station

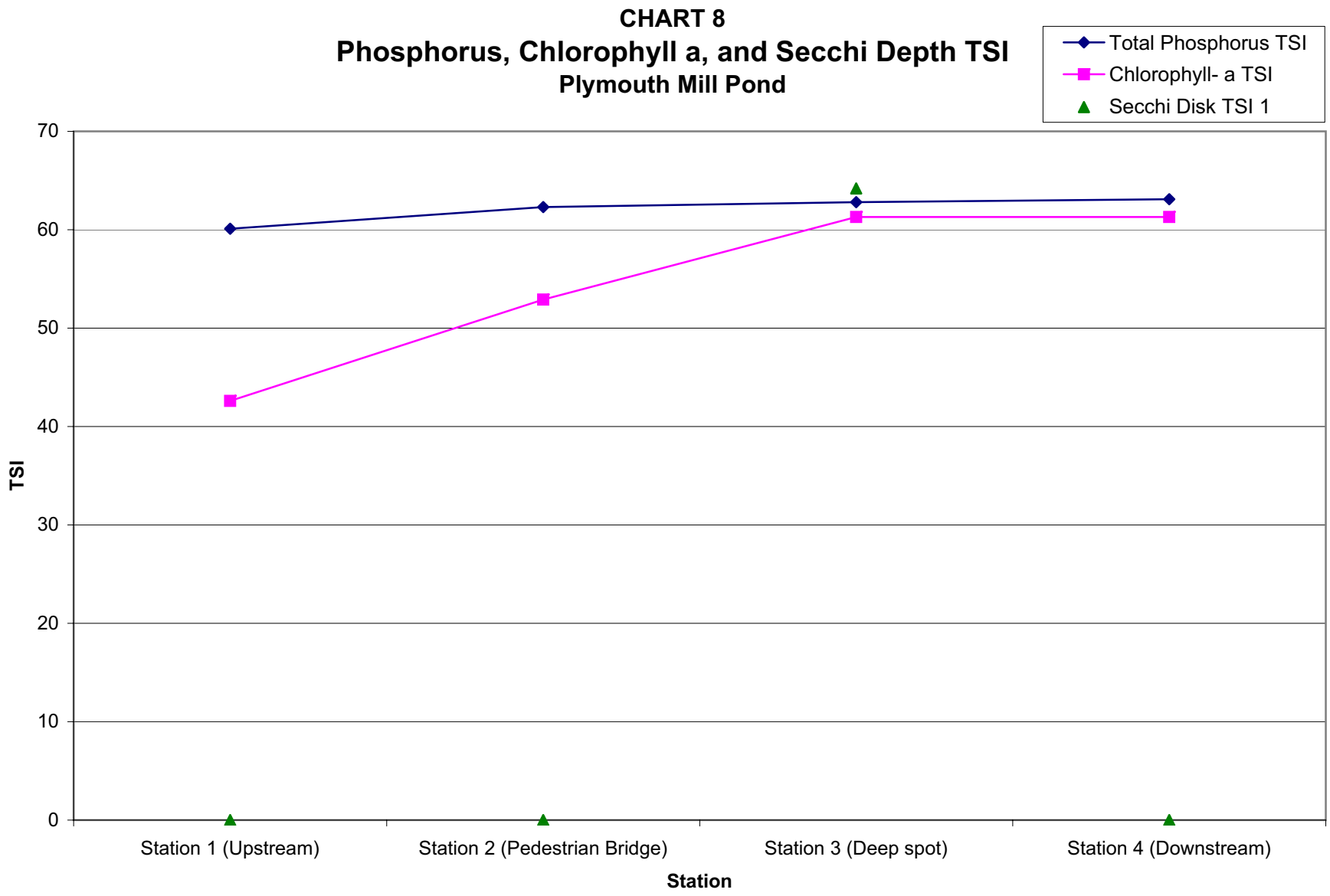
CHART 8
Phosphorus, Chlorophyll a, and Secchi Depth TSI
Plymouth Mill Pond
Total Phosphorus TSI
Chlorophyll- a TSI
Secchi Disk TSI 1
70
60
50
40
30
20
10
0
TSI
Station 1 (Upstream)
Station 2 (Pedestrian Bridge)
Station 3 (Deep spot)
Station 4 (Downstream)
Station

# APPENDIX D

# MILL POND MACROPHYTE AND SEDIMENT THICKNESS SURVEY MEMORANDUM

EarthTech
A tyco International Ltd. Company

# Memo

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May 8, 2007

To: Bill Immich, City of Plymouth

From: Steve Grumann, Earth Tech

Subject: **Mill Pond Macrophyte and Sediment Thickness Survey**

This technical memorandum summarizes the results of the macrophyte (aquatic plant) and sediment thickness survey completed by Earth Tech on July 24th and 25th, 2006 at the Mill Pond located in Plymouth, Wisconsin. Components of the macrophyte survey included field identification of macrophytes in Mill Pond, percent coverage determination of the dominant macrophyte species, field delineation and a GPS-survey of locations of macrophyte beds within Mill Pond. Components of the sediment survey included water depth to sediment, depth to native hardpan, soft sediment thickness, and GPS-surveyed locations of the survey points.

## SAMPLING METHODOLOGY

### Macrophyte Survey

The macrophyte community was sampled at 17 locations within Mill Pond (Figure 1, Attachment A). The sampling locations were chosen based on presence of visible macrophytes during the sampling dates. Deviations from the proposed sampling plan were made. Instead of sampling a grid throughout Mill Pond for macrophytes, the sampling was confined to locations where macrophytes were visible during the survey.

A canoe was used to paddle around Mill pond, seeking out any areas that had visible macrophytes. When a location was found, macrophytes were physically pulled from the lake and identified to species. The coordinates of each location were recorded using a hand-held GPS unit. Beds of macrophytes that were large enough to delineate were done so by paddling the canoe around the bed while logging GPS positions. Percent coverage of macrophytes was visually estimated to the nearest 5 percent in the beds.

### Sediment Depth Methods

Water depth to top of sediment and depth to hardpan were measured at 13 locations through out Mill Pond (locations 5 through 17). The 13 locations were surveyed using a hand-held GPS unit (Figure 1, Attachment B). A secchi disc was used to measure the depth from the top of the water to sediment by slowly lowering the secchi disc until it rested on top of the sediment. The depth from the top of the water to the hardpan was measured by manually pushing a metal sounding pole into the sediment until it could no longer be advanced. The thickness of sediment was calculated by subtracting the depth to sediment from the depth to hardpan.

## RESULTS

### Macrophyte Sampling

The overall abundance of macrophytes was low during the sample period. Approximately 10 percent of the pond was covered with macrophyte beds. The dominant species were sago pondweed (*Potamogeton pectinatus*) and curly-leaved pondweed (*P. crispus*) which occur at most locations. Coontail (*Ceratophyllum demersum*) and duckweed (*Lemna minor*) accounted for the remaining species. Six macrophyte beds were identified and delineated and are shown on Figure 1 (Attachment A). The percent coverage of the macrophytes within the beds ranged from 0 to 25 percent. The beds were not densely covered, but were the only areas that had sufficient density to consider as a macrophyte bed. Table 1, in Attachment B, summarizes the macrophyte sampling results at each sample location. Photographs of the macrophyte beds are included in Attachment C.

### Sediment Depth

Sediment thickness ranged from 0.5 to 5.5 feet. Table 2 in Attachment B summarizes the sediment thickness measurements. As shown in Table 2 and Figure 1, the thicker sediment was observed in the upper reach of Mill Pond. This may result from the water velocity quickly diminishing as it reaches the pond and releasing the entrained sediment from the Mullet River.

## RECOMMENDATIONS

In recent years there have been reports of large algal blooms and excessive macrophyte growth in the Mill Pond contributing to low aesthetic and recreational value for users. These conditions are often the result of excess nutrient availability (nitrogen and phosphorus) to aquatic plants. In late July 2006, when field work was completed for this study, algal blooms and the presence of excessive macrophytes were not observed, suggesting that a lack of nutrients may have been limiting the growth.

Possible sources of nutrients that may influence the aquatic vegetation in Mill Pond include upstream agricultural runoff from Mullet River watershed, runoff containing fertilizer from landowners adjacent to the pond, excrement from waterfowl (geese) using the pond, and septic system leakage into the Mullet River and Mill Pond, among others.

Limiting the amount of nutrients entering a water body is an effective way to control excessive plant growth and algae blooms. Landowners adjacent to the lake should use only the recommended amount of fertilizer and apply it only in the fall. Landowners should use a no- or low-phosphorus fertilizer. A strip of un-mown, unfertilized lawn should be established on the shore of the pond to serve as a filter strip to keep fertilizers from entering the pond. Lawn clippings and fallen leaves should be collected so that they do not end up in the pond and create additional nutrient loads when they decompose. In addition, any septic system located near the pond should be checked to make sure it is operating correctly and not draining directly into the pond.

Many geese were observed using the pond near the middle school. A lawn mowed directly down to the water's edge of a pond, void of surrounding shrubs and trees, is ideal goose habitat. Planting a hedge row near the shoreline or leaving an un-mown strip of grass next to the water's edge will deter geese from using the pond. These measures will not keep all geese away from the pond, but should greatly decrease the number of geese using the pond and adjacent lawns.

Preventative measures to limit aquatic macrophytes are the best way to keep aquatic macrophytes from becoming nuisance. However, once they become established at nuisance levels, various management tools can be used to keep them under control. These measures include:

**Chemical herbicides**: Only those chemicals registered with the U.S. EPA and Wisconsin's Department of Agriculture, Trade, and Consumer Protection (DATCP) may be used in Wisconsin. Table 3 lists the chemicals approved for use in Wisconsin. When using chemicals, it is important to correctly identify the plants and the appropriate chemical for the plant beforehand. Be certain that treatment occurs at the proper time and dosage. In order to apply chemicals in liquid form, the applicator must be licensed with the State of Wisconsin. A permit from the WDNR is also required prior to application.

**Manual/Mechanical Harvesting:** This includes hand-pulling, raking, or mechanically removing the plants. The WDNR may require an Aquatic Plant Management Plan before it issues a permit for these control methods. Mechanical control requires a permit*;* while manual control *may* require a permit. The local WDNR Water Management Specialist should be contacted to determine if a permit is necessary.

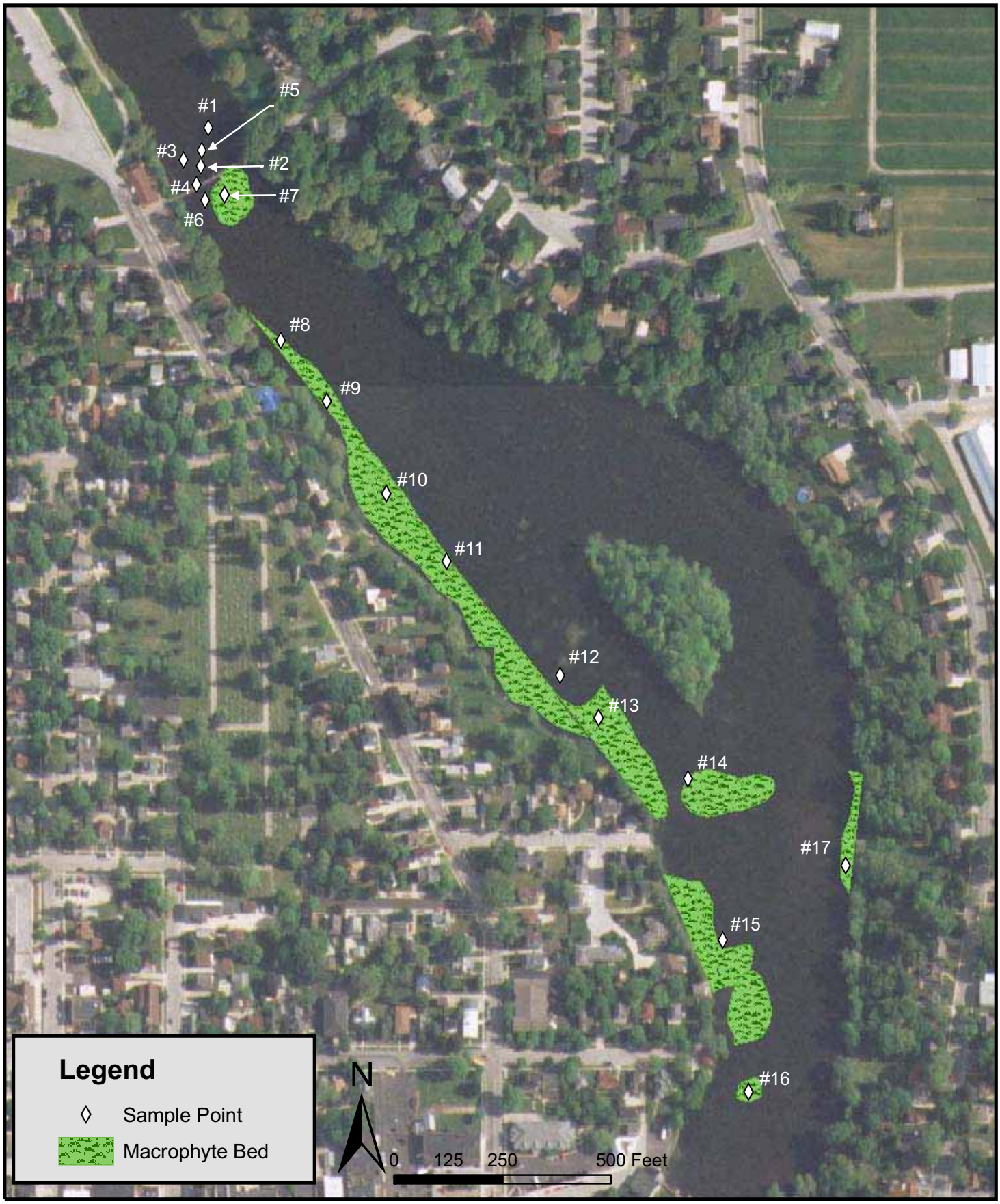
**Physical:** This method includes bottom plant barriers (plastic sheets, hay bails) and water level draw-downs. These methods are used only in special circumstances. Because they involve placing structures on the bed of a lake and/or affect lake water level, a Chapter 30 or 31 permit from the WDNR will most likely be needed.

**Biological:** This method includes herbivores and bacteria. It is illegal to transport or stock carp or crayfish in Wisconsin. Biological control of aquatic plants requires a permit form the WDNR.

Earth Tech recommends that based on the size of Mill Pond and the time and costs associated with dredging and/or manually or mechanically harvesting vegetation, chemical control of nuisance plants would be the best option to control vegetation in Mill Pond. Preventative measures should be initiated to control the growth of aquatic plants and algal blooms, but if large algal blooms and macrophyte beds still occur, treatment of the pond with the appropriate chemicals could provide a short-term solution that would be cost effective and easy to implement.

# ATTACHMENT A

# FIGURES




Source: USDA WI Farm Agency NAIP 2005, Earth Tech 2006

Spatial Reference: GCS_North_American_1983

**Figure 1 - Sample Locations and Macrophyte Bed Delineations**

**Mill Pond Project**
**City of Plymouth**
**Sheboygan County, Wisconsin**

November 21, 2006

88673

# ATTACHMENT B

# TABLES

**TABLE 1**
**Mill Pond Macrophyte Survey Results**
**Plymouth, Wisconsin**

| Sample Site | Coordinates (WI State Plane) | | Species Present | Percent Coverage |
|---|---|---|---|---|
| | Northing | Easting | | |
| 1 | 645989 | 645989 | *Potamogeton pectinatus* (Sago pondweed)<br>*Potamogeton crispus* (curly-leaved pondweed) | <10 |
| 2 | 2503186 | 645900 | *Potamogeton pectinatus* (Sago pondweed)<br>*Potamogeton crispus* (curly-leaved pondweed) | <10 |
| 3 | 2503146 | 645913 | *Potamogeton pectinatus* (Sago pondweed)<br>*Potamogeton crispus* (curly-leaved pondweed) | <10 |
| 4 | 2503178 | 645858 | *Potamogeton pectinatus* (Sago pondweed)<br>*Potamogeton crispus* (curly-leaved pondweed) | <10 |
| 5 | 2503187 | 645935 | *Potamogeton pectinatus* (Sago pondweed)<br>*Potamogeton crispus* (curly-leaved pondweed)<br>*Ceratophyllum demersum* (coontail)<br>*Lemna minor* (common duckweed) | <10 |
| 6 | 2503200 | 645821 | *Potamogeton pectinatus* (Sago pondweed)<br>*Potamogeton crispus* (curly-leaved pondweed)<br>*Lemna minor* (common duckweed) | <10 |
| 7 | 2503244 | 645835 | *Potamogeton pectinatus* (Sago pondweed)<br>*Potamogeton crispus* (curly-leaved pondweed) | 15 |
| 8 | 2503385 | 645504 | *Potamogeton pectinatus* (Sago pondweed)<br>*Potamogeton crispus* (curly-leaved pondweed) | 15 |
| 9 | 2503497 | 645368 | *Potamogeton pectinatus* (Sago pondweed)<br>*Potamogeton crispus* (curly-leaved pondweed)<br>*Lemna minor* (common duckweed) | 20 |
| 10 | 2503641 | 645160 | *Potamogeton pectinatus* (Sago pondweed) | 25 |
| 11 | 2503786 | 645009 | *Potamogeton pectinatus* (Sago pondweed)<br>*Potamogeton crispus* (curly-leaved pondweed)<br>*Lemna minor* (common duckweed) | 15 |
| 12 | 2504058 | 644756 | *Potamogeton pectinatus* (Sago pondweed)<br>*Potamogeton crispus* (curly-leaved pondweed)<br>*Lemna minor* (common duckweed)<br>*Ceratophyllum demersum* (coontail) | Not Measured |
| 13 | 644661 | 2504150 | *Potamogeton pectinatus* (Sago pondweed)<br>*Potamogeton crispus* (curly-leaved pondweed)<br>*Lemna minor* (common duckweed)<br>*Ceratophyllum demersum* (coontail) | 25 |
| 14 | 644528 | 2504360 | *Potamogeton pectinatus* (Sago pondweed)<br>*Potamogeton crispus* (curly-leaved pondweed)<br>*Ceratophyllum demersum* (coontail) | 15 |
| 15 | 644160 | 2504455 | *Potamogeton pectinatus* (Sago pondweed)<br>*Potamogeton crispus* (curly-leaved pondweed)<br>*Lemna minor* (common duckweed) | 10 |
| 16 | 643814 | 2504526 | *Potamogeton pectinatus* (Sago pondweed)<br>*Potamogeton crispus* (curly-leaved pondweed)<br>*Ceratophyllum demersum* (coontail) | 20 |
| 17 | 644342 | 2504732 | *Potamogeton pectinatus* (Sago pondweed)<br>*Potamogeton crispus* (curly-leaved pondweed)<br>*Ceratophyllum demersum* (coontail) | 20 |

**TABLE 2**
**Mill Pond Sediment Survey Results**
**Plymouth, Wisconsin**

| Sample Site | Coordinates (WI State Plane | | Depth to sediment (ft) | Depth to hardpan (ft) | Sediment Thickness (ft) |
|---|---|---|---|---|---|
| | Northing | Easting | | | |
| 5 | 2503187 | 645935 | 1.7 | 4.8 | 3.1 |
| 6 | 2503200 | 645821 | 1.3 | 5.9 | 4.6 |
| 7 | 2503244 | 645835 | 1.3 | 5.8 | 4.5 |
| 8 | 2503385 | 645504 | 1.2 | 6.7 | 5.5 |
| 9 | 2503497 | 645368 | 1.5 | 6.3 | 4.8 |
| 10 | 2503641 | 645160 | 1.7 | 4.4 | 2.7 |
| 11 | 2503786 | 645009 | 1.7 | 4.0 | 2.3 |
| 12 | 2504058 | 644756 | 1.9 | 4.5 | 2.6 |
| 13 | 2504150 | 644661 | 1.9 | 5.0 | 3.1 |
| 14 | 2504360 | 644528 | 2.0 | 5.3 | 3.3 |
| 15 | 2504455 | 644159 | 2.3 | 6.9 | 4.6 |
| 16 | 2504526 | 643814 | 2.8 | 3.3 | 0.5 |
| 17 | 2504732 | 644342 | 1.7 | 3.3 | 1.6 |

**TABLE 3**

**Aquatic Herbicides Approved for Use in Wisconsin[1]**
**Plymouth, Wisconsin**

| Chemical (Trade Names) | Management Summary | Management Implications |
|---|---|---|
| Copper Compounds (multitude of trade names) | Broad spectrum algaecides used to control both planktonic and filamentous algae. No weekly carryover benefits. | Non-selective and will kill algae within 72 hours. Some algae are resistant. Algae can return within 10 days. |
| Diquat Dibromide (Reward®, Diquat) | Broad spectrum, contact herbicides that are effective on submersed aquatic plants. No carryover benefits. | Non-selective and will kill plants within 10-14 days. Not effective in turbid waters. Consumption restrictions apply. |
| Endothal Acid (Aquathol®, Hydrothol®) | Broad spectrum, contact herbicides that are effective on many submersed aquatic plants. No carryover benefits. | Non-selective and will kill plants within 10-14 days. Fish consumption, drinking, and irrigation restrictions apply. |
| Glyphosate (Rodeo®) | Broad spectrum and systemic (will kill roots). Herbicides used with a surfactant to control emergent and floating plants. | Non-selective and requires the use of a surfactant to ensure uptake by plants. Commonly used for control of purple loosestrife. |
| 2,4-D (Aquakleen, Aquacide, Navigate®, Weedtrine, among others) | Controls only dicotyledons (broad leaf plants such as water lilies, watershield, and water milfoil) with some potential for multiple year control. | Does not control the majority of aquatic plant species found in Wisconsin. Commonly used for control of Eurasian water milfoil. Drinking and irrigation restrictions apply. |
| Fluridone (Sonar®) | Broad spectrum herbicide that may be dosed selectively for some plants. May have some multiple year control. | Very water soluble and works best when entire pond is treated. Kills plants slowly (20-60 days). Most useful for duckweed control. Irrigation restrictions apply. |

Notes:
[1]Modified from the WDNR.

# ATTACHMENT C

# PHOTOGRAPHS

Mill Pond, looking northeast from southern end of the pond.

Mill Pond, near the pedestrian foot bridge.

Macrophytes near the pedestrian foot bridge.

Duckweed floating near southwest end of Mill Pond.

Macrophytes on west side of Mill Pond.

Macrophyte bed, looking down from pedestrian foot bridge.

# APPENDIX E

# PLYMOUTH MILL POND ALTERNATIVES ANALYSIS

# Alternatives Analysis
# Mill Pond
# Plymouth, Wisconsin

*Prepared for:*

**City of Plymouth**
**128 Smith Street**
**Plymouth, WI  53073**

*Prepared by:*

**Earth Tech, Inc.**
**4135 Technology Parkway**
**Sheboygan, WI  53083**

**October 2007**

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1 Project Location Map

## LIST OF ATTACHMENTS

**Attachment**

1 Sediment Loading Analysis
2 Lake Modeling Analysis

# 1.0 INTRODUCTION AND PURPOSE

The Plymouth Mill Pond has been an amenity to the City and local residents since the mid-1800s. However, in recent years, degraded water quality has lead to algal blooms and aquatic plant growth which have caused odor problems, impeded recreational use of the lake, and negatively impacted the aesthetics of the Mill Pond area. The City of Plymouth and their volunteer Mill Pond Committee have applied for and received grants from the Wisconsin Department of Natural Resources (WDNR) to determine the underlying cause of the degraded conditions and develop a comprehensive plan of action to improve the condition of the Mill Pond.

The Mill Pond is located in the heart of the downtown area of Plymouth in Sheboygan County, Wisconsin in Section 22, Township 15 North, Range 21 East (Figure 1). The Mill Pond is a 41-acre (including the island) lake created by the dam across the Mullet River and extends from the Plymouth dam north to State Trunk Highway (STH) 23. The City of Plymouth owns approximately 2 acres of property at the outlet of Mill Pond. There is approximately 1,000 feet of shoreline on City school property including a recreational trail along the northwest side of the lake and a pedestrian foot bridge across the northern portion of the lake. The Mill Pond is utilized for boating, fishing, and public ice skating. Prior to the recent infestation of aquatic macrophytes, the lake was navigable from the upper end of the lake to the dam. Restoration of the Mill Pond would lead to improved water quality, increased use of the lake as a recreational resource, improved civic pride, and would improve the look of the City to tourists and the local citizenry.

As indicated in the State of the Sheboygan River Basin (WDNR, October 21, 2001), the Mullet River is a high priority for the WDNR and one of the objectives of the WDNR is to work with the City of Plymouth to address safety and water quality issues associated with the Plymouth Mill Pond and its dam. It is anticipated that the WDNR will utilize the information gathered from this project and add it to their dataset for the Sheboygan River Basin and the management plan developed as part of this project will complement WDNR basin planning. There are three aquatic endangered resources that are known to occur in the Mullet River Watershed. Projects designed to protect or improve the water quality resource will benefit the protection of these listed resources.

Although the City, the Mill Pond Committee, and the citizens of Plymouth have some ideas related to long-term management of the lake, there is little data related to the underlying problems related to the current degraded condition and there has been no formal evaluation of potential alternatives. An assessment of the feasibility and cost-benefit of various options is required for the City and the Mill Pond Committee to make sound decisions related to the management of the lake. This report contains an evaluation of the potential long-term management alternatives to solve the problems associated with poor water quality.

# 2.0 SUMMARY OF ALTERNATIVES

There were six alternatives assessed in this analysis. The alternatives studied during this analysis, with a brief description, follows.

**Remove Mill Pond Dam**

Removal of the Mill Pond Dam is noted in this report as an alternative, but since this alternative will not meet the goals of the Mill Pond Committee or the City of Plymouth, this alternative was not studied in detail in this analysis.

**Dredge Pond**

This alternative will involve dredging the existing sediments from the Mill Pond by either mechanical or hydraulic dredging techniques. Dredging the pond would remove the nutrients that are stored in the sediments from the pond system. If mechanical techniques are used, the pond may need to be drained before dredging could begin, depending on the type of dredging used. Hydraulic dredging could be done without draining the pond. Both techniques would require a nearby area to dry the sediments before disposing of them.

**Vegetation Removal**

This alternative would involve mechanically harvesting the vegetation in the pond. Harvesting the vegetation would remove the material from the pond and remove the nutrients associated with the vegetation breaking down over the winter months from the pond system.

**Pond Drawdown**

This alternative would involve drawing down the water in the pond. If the pond is drawn down, the sediments would compact and bind some of the nutrients from reentering the system when the water levels are brought back up to the normal elevation.

**Shoreline Preservation and Urban Stormwater Management**

This alternative involves educating the public and municipal employees on how to employ proper shoreline preservation techniques and fertilizer and sediment management throughout the City.

**No Action**

This alternative will involve making no changes to the Mill Pond system.

# 3.0 DISCUSSION OF EACH ALTERNATIVE

Each of the six alternatives are discussed in detail in this section.

## 3.1 REMOVE MILL POND DAM

As previously stated, removing the Mill Pond Dam is not in the interest of the Mill Pond Committee or the City of Plymouth. Since this alternative would result in the loss of the Mill Pond altogether, no further consideration of this alternative will be made in this Alternatives Analysis. An estimated cost for the removal and restoration of the Mill Pond area is $80,000, based on other dam removals done in the state. There is a WDNR dam removal grant program that would cover half of this cost.

## 3.2 DREDGE POND

The results of the 2005 bathymetric survey showed that there is approximately 180,000 cubic yards of soft sediment accumulated on the bottom of the Mill Pond. The depth of these sediments range up to 6.8 feet deep with an average depth of 1.8 feet. One management alternative is to remove these sediments by dredging. The sediment analysis conducted for this project estimated that sediment being carried into the Mill Pond by the Mullet River could be accumulating at a rate of 0.3 or 1.2 inches per year over the pond bottom, depending on the calculation method used (see Attachment 1). The table below shows the time it would take to refill areas that are dredged based on these accumulation rates. The time varies considerably depending on the accumulation rate used. The attached sediment analysis indicates that the method used to calculate the 1.2 inches/year accumulation rate is better suited to the Mill Pond than the other method.

| Sediment Accumulation Rate | Time to Fill 1.8 Feet of Depth | Time to Fill 6.8 Feet of Depth |
|---|---|---|
| 0.3 inches/year | 72 years | 272 years |
| 1.2 inches/year | 18 years | 68 years |

There are two different methods of dredging that can be done at the Mill Pond: mechanical and hydraulic. For the mechanical dredging method, the water in the pond can either be drained or left in place, depending on which method is used. One method involves draining the pond and entering the basin with an excavator. The other method involves floating a barge with an excavator and dredging from the barge. Once the sediment is excavated, the sediment will then be transported by truck to a drying area where the sediment will be allowed to dry prior to finally trucking to a disposal site. The excavation equipment, likely a track hoe or a dragline, will need to be able to deposit the material into a dump truck, which will transport the material to the drying site. In order to do this, either access to the pond edge will need to be gained from multiple points or the dump trucks will need to enter the bed of the Mill Pond. For the trucks to enter the bed of Mill Pond, a gravel road would need to be constructed in the bed of the pond to accommodate the trucks. This gravel bed would be removed after dredging is completed. Since the pond is primarily surrounded by private property and the gravel road in the pond bed would add additional impact to the pond and total cost to the project, mechanical dredging was not considered to be a cost effective option for dredging.

For hydraulic dredging, a barge holding the hydraulic pumps will need to enter the pond. The pumps will remove the sediments from the pond bottom through suction and pump the sediment to either trucks, to transport the material to the drying area, or directly to the drying area if possible. Benefits to this method over the mechanical method are that the pond does not have to be drained for the hydraulic method and that the material can be pumped up to 2 miles to a

drying area instead of having to transport it by truck, which will be a large cost savings. Once the material has sufficiently dried, it will need to be deposited at either a landfill or in an area agreed to by the Wisconsin Department of Natural Resources. The cost to dredge the entire 180,000 cubic yards of soft sediment in the Mill Pond by hydraulic methods has been estimated to be between $3.5 and $5.2 million not including disposal costs, which could be as much as $3.2 to $5.4 million if the material needs to be disposed in a landfill.

## 3.3 AQUATIC VEGETATION REMOVAL

This alternative involves removing the aquatic vegetation by mechanical means, such as raking or cutting. This alternative would remove the existing vegetation in the pond, thereby removing the nutrients tied up in the vegetation. Plants would either be cut with a floating harvester or raked from the pond bottom including the roots and deposited outside of the pond. This alternative may need to be done annually or more often because the plants will continue to grow after they have been cut or raked from the pond. To be an effective alternative, this method would need to be done regularly, as many as three times per year, at a cost of approximately $125,000 per time. Permits from the WDNR would need to be obtained to harvest the plants and a trucking and a disposal site would need to be identified to dispose of the vegetative material at an additional cost. In addition, there are shallow areas of the Mill Pond (the average depth is 1.2 feet) which would not be accessible to a floating harvester. While this alternative would keep parts of the pond free of floating vegetation, aquatic vegetation removal is not an effective long-term solution to controlling the nutrients in the Mill Pond; however it is a temporary solution and would need to be done regularly.

## 3.4 POND DRAWDOWN

This alternative will involve drawing the water level of the Mill Pond down to baseline flow of the Mullet River. Drawing the water in the pond down will allow the sediments in the pond to settle and compact. This may prevent some of the sediments from becoming resuspended in the water column and perhaps contributing to the nutrients in the water column. The lake modeling analysis done for the project (see Attachment 2) indicates that the sediments are probably not a large source of nutrients to the water column, although they would promote rooted aquatic plants growth. A second benefit of this method is that it would create more water depth in the pond. The average percent solids by weight of the sediment samples collected in the Plymouth Mill Pond on June 18, 1999 was 34 percent. This translates to 21 percent solids by volume if one assumes the dry density of the sediment is 120 pounds/cubic foot. Assuming that the sediments after drawdown achieve 60 percent solids by volume, then the average sediment depth of 1.8 feet would compact by 39 percent to 1.1 feet deep and the maximum sediment depth of 6.8 feet would compact to 4.1 feet deep.

While the cost for this alternative is minimal (approximately $500 for permitting), there will be some impact to the community, because the resource that the Mill Pond supplies to the community will not be available for several months. Although, when water starts to refill the Mill Pond basin, the sediments may re-suspend in the water column, reversing the desired effects of pond drawdown. Since the nutrients in the pond will also be available to rooted vegetation, the long-term effectiveness of this alternative is mostly unknown.

## 3.5 SHORELINE PRESERVATION AND URBAN STORMWATER MANAGEMENT

This alternative will involve educating the public and the City of Plymouth on better methods to manage the shoreline of the Mill Pond and proper erosion control and stormwater management within the City. The Water Quality assessment completed in 2006 indicated that nutrients and sediments coming into the Mill Pond from the immediate drainage area may have a

disproportionate water quality impact to the Mill Pond compared to the drainage area upstream of the pond. Therefore, improvements to the shoreline and the immediate urban drainage area may have the potential to most directly improve the Mill Pond water quality.

The education should stress the importance of establishing an unmowed buffer strip along the shoreline of the pond. Education also needs to include the proper methods and rates of fertilizer application of lawn on private and public property as well as keeping street gutters clear of grass clippings and other organic material. The City and the Mill Pond Committee could consider hosting educational meetings for the public and utilizing the County Extension office or the WDNR for support. The costs to the City and the Mill Pond Committee for this alternative would be minimal.

Urban stormwater management activities that the City can promote includes such activities as: vigorously enforcing construction site erosion control ordinances, street sweeping, catch basin cleaning, and implementing stormwater treatment systems such as detention ponds and sediment traps as required. The cost of these activities could be carried out as part of the normal operating budget of the City as well as costs incidental to new construction.

The Sheboygan County Fairgrounds was assessed for a potential source of stormwater pollution to the Mill Pond. Historically, runoff from the race track and the barn area did flow to the Mill Pond relatively untreated. Several treatment practices were constructed in 2004 with coordination between the County and WDNR. These include a sediment trap under the grandstand, a french drain in the infield and the west side of the racetrack, and sanitary sewer connections for the wash drains by the barn area. These practices provide a reasonable level of treatment for the stormwater runoff from the Fairgrounds and no further improvements are recommended.

### 3.6 NO ACTION

For this alternative, no action would be taken by the Mill Pond Committee or the City of Plymouth. The Mill Pond would be left as it is with no modifications to the pond or the watershed. There would be no cost for this alternative.

# 4.0 ANALYSIS OF ALTERNATIVES

Of the six alternatives considered, removal of the dam was disregarded because neither the City nor the Mill Pond Committee is interested in permanently draining Mill Pond.

Dredging the pond sediments is a viable alternative, but according to the results of the sediment modeling completed by Earth Tech in 2007 (Attachment 1), the pond may retain up to 1.2 inches of new sediment per year. While dredging the pond may eventually be necessary to restore water depth, this method is not likely to keep the Mill Pond from becoming infested with algae because there will still be nutrients entering the pond system from other sources. Dredging may limit the extent of rooted aquatic vegetation because these plants cannot grow in depths where sunlight cannot penetrate (the maximum measured water clarity was 1.07 meters) but they would persist in the shallower areas. In addition, this alternative is the most costly, with total costs possibly being as high as $7 million and would cause additional environmental impacts to the area surrounding Mill Pond.

Removal of the aquatic vegetation is another short term remedy for the Mill Pond. Removing the vegetation would only be a temporary solution because there will still be seeds located in the sediments with a surplus of nutrients in the pond. According to the lake eutrophication model completed by Earth Tech in 2007 (Attachment 2), the input of nutrients into the Mill Pond will still occur from runoff from adjacent properties and the watershed. Desirable plants would also be removed with the unwanted species. For vegetation removal to be an effective remedy it would have to be done three or more times a year. At a cost of up to $125,000 per time, this alternative is not cost effective.

Pond drawdown would also not be a good solution by itself. While it may bind some of the nutrients in the sediment, it will not remove the sources of nutrients or keep them from entering the pond. This alternative may be a good solution in conjunction with another alternative that would work to remove the source of nutrients in the pond system. In addition, this alternative would be an inexpensive way to increase water depth in the pond.

Shoreline management and urban stormwater management is the most effective alternative for reducing the nutrient inputs in the Mill Pond. This alternative, in conjunction with drawdown of the pond for a winter season, would reduce the nutrients in the pond system at a reasonable cost to the City and Mill Pond Committee. The County Extension Office and the local WDNR staff could hold public educational meetings, hosted by the City, to inform the public and the City employees on how to better protect the watershed of the Mill Creek from nutrient runoff and erosion.

No action is another possible alternative. While this alternative will not improve the Mill Pond nutrient problem, the last few seasons may have been an aberration from normal conditions in the Mill Pond. The Mill Pond Committee and the City may decide to wait and see what happens in the Mill Pond over the next few seasons and then decide if further management of the Mill Pond system is necessary.

Below is an alternatives matrix summarizing some of the important aspects of each alternative. Short-term and long-term effectiveness relates to how well the alternative would reduce aquatic plant and algae growth. Implementability relates to how easily the alternative could physically be implemented.

## Alternatives Analysis Matrix

| Alternative | Short-Term Effectiveness | Long-Term Effectiveness | Implementability | Public Acceptability | Cost |
|---|---|---|---|---|---|
| Dam Removal | high | high | high | low | $80,000 |
| Dredging | high | medium | medium | high | $7,000,000 |
| Aquatic Vegetation Removal | medium | medium | medium | medium | $125,000/yr |
| Pond Drawdown | medium | medium | high | medium | $500 |
| Shoreline and Stormwater Management | medium | medium | medium | medium | unknown |
| No Action | low | low | high | medium | $0 |

# 5.0 SUMMARY

Earth Tech completed an alternatives analysis to evaluate six different alternatives to improve the water quality of the Mill Pond in Plymouth, Wisconsin. The alternatives evaluated included removal of the Mill Pond Dam, dredging the pond, pond vegetation removal, drawdown of the pond, shoreline management and urban stormwater management, and no action. The analysis of the alternatives showed that the best means to improve the Mill Pond were to institute a process with the assistance off the County Extension and the local WDNR offices to educate the public and City employees on how to better manage the nutrients and sediments entering the pond in the immediate watershed of the Mill Pond. This process should be done in conjunction with a drawdown of the pond over the winter months to compact the sediments in the pond to increase water depth in the pond and potentially bind some of the nutrients in the compacted sediment. This solution would be the least costly, with the exception of no action, and can be implemented relatively quickly.

# ATTACHMENT 1

# SEDIMENT LOADING ANALYSIS

EarthTech
A tyco International Ltd. Company

# Memo

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| Madison, WI 53717 | | www.earthtech.com |

10/4/2007

To: Steve Grumann, Earth Tech

Copy: Bernie Michaud, Earth Tech

From: Theran Jacobson, Earth Tech

Subject: Plymouth Mill Pond Sediment Loading Analysis, Project No. 100540

This memorandum summarizes the results of the sediment loading analysis for the tributary area of the mill pond located in Plymouth, WI and the sediment removal efficiency methods evaluated for the mill pond.

**Methodology**

The average annual inflow to the Plymouth Mill Pond was determined by the evaluation of the Mullet River at the Greenbush, WI gauging station (U.S. Geological Survey (USGS) gauge station #04085746) that recorded flow data for the Mullet River for a five (5) year period from 2001 through 2005.

The unit-area sediment loading values were determined from the Onion River, an adjacent watershed with similar land use. The unit-area loading values from the Onion River were determined from a USGS study (USGS Fact Sheet FS-195-97).

The sediment trapping rate for the Plymouth Mill Pond was calculated using two different empirically derived methods; the Brune's curve and Churchill's curve methods. The methods determine the sediment removal rates for small to large reservoirs using a variety of input parameters. Brune's curve method uses the following input data: reservoir capacity and annual inflow. Churchill's curve method uses the following input data: reservoir capacity and length, and average daily inflow.

**Results**

The flow data for the Plymouth Mill Pond was calculated from a watershed area ratio from the flows recorded at the Greenbush, WI gauging station. The watershed area for the Mullet River at the Greenbush, WI gauging station is approximately 24.3 square miles (sq. mi.). The watershed area for the Plymouth Mill Pond downstream is approximately 62.2 sq. mi. The recorded flows from the Mullet River at Greenbush, WI were multiplied by the watershed area ratio (62.2 / 24.3 = 2.56) to determine the discharge rate into Mill Pond. The calculated average daily inflow to the Plymouth Mill Pond is approximately 26.7 cubic feet per second (cfs).

The average annual sediment loading to the Plymouth Mill Pond was calculated from a watershed area ratio from the unit-area loading results for the Onion River. The watershed

area for the Onion River is approximately 91.8 sq. mi. The average unit-area loading of total suspended solids for the Onion River is approximately 84 tons per sq. mi. (U.S. Dept. of the Interior, FS-195-97) based on two years of monitoring data. The average unit-area loads from the Onion River were multiplied by the watershed area ratio (62.2 / 91.8 = 0.68) to determine the unit-area loads to Mill Pond. The average sediment loading into the Mill Pond is estimated to be 3,540 tons TSS per year (tons-TSS/yr).

The sediment trapping rate of the Plymouth Mill Pond as estimated by the Brune's and Churchill's curve methods is 10% and 63% respectively. These are significantly different results. The following comparison of the two methods was found in a U.S. Bureau of Reclamation document; "As a guideline Brune's curve method should be used for large storage or normal ponded reservoirs and Churchill's curve method should be used for settling basins, small reservoirs, flood retarding structures, semi-dry reservoirs, or reservoirs that are continuously sluiced." (U.S. Dept of the Interior, 2006). This does not appear to provide clear cut guidance for which method to use in this situation. Several factors seem to favor the Churchill's curve method; the Plymouth Mill Pond is a smaller reservoir, the Churchill's method takes into account reservoir length (the mill pond is long and narrow), and it provides a more conservative result (higher trapping rate). At best these methods provide an approximation of what is happening in the mill pond and should be used as a guidance and the results of the two methods could be used as bracketing values.

To translate the amount of sediment trapped by weight to a depth of sediment, the density of the sediment must be known. The average bulk density of the sediment samples collected in the Plymouth Millpond on June 18, 1999 was 0.34 tons per cubic yard. The calculated depth of sediment deposited over the entire surface area of the Plymouth Mill Pond on an average annual basis is then estimated to be 0.3 inches for Brune's method and 1.2 inches for Churchill's method.

**Table 1: Sediment Removal Results for Brune's and Churchill's Curve Methods**

| Method | Sediment Loading (tons TSS / yr) | Average Daily Flow (cfs) | Pond Area (acres) | Reservoir Capacity (acre-feet) | Sediment Removal (%) | Weight Sediment Removed by Pond (tons / yr) | Sediment Deposited (inches/yr) |
|---|---|---|---|---|---|---|---|
| Brune's | 3,540 | 26.7 | 39.6 | 48.1 | 10 | 354 | 0.3 |
| Churchill's | 3,540 | 26.7 | 39.6 | 48.1 | 63 | 2,230 | 1.2 |

## References

U.S. Department of the Interior, Bureau of Reclamation, "Erosion and Sedimentation Manual", November 2006.

U.S. Department of the Interior, U.S. Geological Survey, "Unit-Area Loads of Suspended Sediment, Suspended Solids, and Total Phosphorus from Small Watersheds in Wisconsin" Fact Sheet Number: FS-195-97.

# ATTACHMENT 2

# LAKE MODELING ANALYSIS

EarthTech
A tyco International Ltd. Company

# Memo

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10/4/2007

To: Steve Grumann, Earth Tech

Copy: Theran Jacobson, Earth Tech

From: Bernie Michaud Earth Tech

Subject: Plymouth Mill Pond Lake Modeling, Project No. 100540

This memorandum summarizes the results of the lake water quality modeling of the Plymouth Mill Pond in Plymouth, Wisconsin.

**Methodology**

The Plymouth Mill Pond was modeled with the lake water quality model **Wisconsin Lake Modeling Suite** (WiLMS). The model estimated phosphorus concentrations in the pond based on physical attributes of the watershed, estimated river flows, and lake morphometry. The watershed area and watershed characteristics were assessed during Part 1 of this project. Additionally, river flow information was interpolated from available United State Geological Survey (USGS) river gaging station information from the nearest appropriate gaging location (see below). The bathymetric mapping created in 2005 was also used in the modeling.

The model was calibrated using the actual pond phosphorus concentrations measured as part of this project. The in-lake phosphorus cycling rate was also assessed using the model.

**Hydrologic and Morphometric Data**

The average annual inflow to the Plymouth Mill Pond was determined by the evaluation of the Mullet River at the Greenbush, WI gauging station (U.S. Geological Survey (USGS) gauge station #04085746) that recorded flow data for the Mullet River for a five (5) year period from 2001 through 2005. The watershed area for the Plymouth Mill Pond downstream is approximately 62.2 sq. mi. The recorded flows from the Mullet River at Greenbush, WI were multiplied by the watershed area ratio (62.2 / 24.3 = 2.56) to determine the discharge rate into the Plymouth Mill Pond. The calculated average daily inflow to the Plymouth Mill Pond is approximately 26.7 cubic feet per second (cfs) or 5.8 inches of runoff from the watershed.

The Plymouth Mill Pond is approximately 39.6 acres is area with a volume of approximately 48.1 acre-feet. The Mill Pond is shallow with a mean depth of 1.2 feet. The pond volume is small in relation to the inflow so the average pond flushing rate is 400 times per year.

The unit-area sediment loading values were determined from the Onion River, an adjacent watershed with similar land use. The unit-area loading values from the Onion River were determined from a USGS study (USGS Fact Sheet FS-195-97).

**Non-point Source Pollution Source Data**

Non-point source pollution from stormwater runoff is the largest source of phosphorus to the Plymouth Mill Pond. There are no known point sources of pollution of note. WiLMS estimates non-point phosphorus loading based on land uses in the watershed. The watershed land usage was estimated using USGS mapping and results of the windshield survey conducted in 2006. These results are shown in the table below. WiLMS estimated that the "most likely" loading of phosphorus from non-point source runoff is 19,477 pounds per year.

| **Land Use** | **acres** | **%** |
|---|---|---|
| Agricultural | 25,333 | 63.6% |
| Forest | 8,768 | 22.0% |
| Wetlands | 3,710 | 9.3% |
| Rural Residential | 1,536 | 3.9% |
| Medium Density Urban | 393 | 1.0% |
| High Density Urban | 28 | 0.1% |
| Pond Surface | 40 | 0.1% |
| | | |
| **Total** | **39,808** | **100%** |

The average annual phosphorus loading to the Plymouth Mill Pond was also calculated using the unit-area loading results for Silver Creek near Ripon. The watershed area for Silver Creek is approximately 36.2 sq. mi. The average unit-area loading of total phosphorus for Silver Creek is approximately 283 pounds per sq. mi. (U.S. Dept. of the Interior, FS-195-97) based on nine years of monitoring data. This average unit-area load was multiplied by the Plymouth Mill Pond watershed area (62.2 sq. mi.) to arrive at an estimated average total phosphorus loading of 17,603 pounds per year. This correlates well with the loading calculated by the WiLMS model.

**In Pond Phosphorus Prediction**

The WiLMS model predicts in lake total phosphorus concentrations using 13 empirical regression equations. Each regression equation is derived from data from many lakes. The model identifies those equations which best fit the lake being modeled. In this analysis it was determined that the "Canfield-Bachmann Artificial Lake Model" and the "Reckhow, 1977 Lakes with qs>50 m/yr Model" best fit the parameter range values for the Plymouth Mill Pond.

These two empirical equations predict the Growing Season Mean (GSM) total phosphorus concentration (the mean for the months June, July, and August). The GSM total phosphorus concentration actually measured in the Plymouth Mill Pond in 2006 was **98 micrograms/liter (ug/l**). The model predictions are statistically derived and have a level of uncertainty in the results. The initial results are below.

Initial Phosphorus Concentration Predictions

| Equation | Low (ug/l) | Most Likely (ug/l) | High (ug/l) |
|---|---|---|---|
| Canfield-Bachmann | 124 | 283 | 452 |
| Reckhow qs>50m/yr | 119 | 300 | 522 |

Model Calibration

The model results above are well above the actual measured total phosphorus concentrations. The WiLMS model has a feature that back calculates what the total phosphorus loading from the watershed should be to arrive at the observed in lake total phosphorus concentration. This back calculation indicated the incoming phosphorus loading would be approximately 6,107 pounds per year. This is 69% less than the loading estimated by the WiLMS non-point source pollution estimator.

The WiLMS non-point source pollution estimator was adjusted to reduce the annual phosphorus loading by 69 %. This may be justified by the fact that the drainage ways and stream banks in the watershed appeared to be well buffered from surrounding land uses by woods, wetlands or other well vegetated areas during the 2006 windshield survey. In addition, the Mullet River at points upstream showed a high degree of clarity. Settling in the upstream Glenbeulah Mill Pond may also reduce the phosphorus load. The calibrated results are below.

Calibrated Phosphorus Concentration Predictions

| Equation | Low (ug/l) | Most Likely (ug/l) | High (ug/l) |
|---|---|---|---|
| Canfield-Bachmann | 42 | 100 | 166 |
| Reckhow qs>50m/yr | 37 | 93 | 163 |

**Internal Phosphorus Cycling**

Bottom sediments were assessed for being a potential source of phosphorus to the pond. WDNR sediment sampling from June 18, 1999 showed phosphorus concentrations in the sediment ranging from 523 to 622 mg/kg. Phosphorus in bottom sediments can be cycled back into the water column under the right conditions. The internal cycling occurs most frequently when the bottom lake water is stratified and anoxic. Phosphorus becomes soluble under anoxic conditions. The Plymouth Mill Pond does not stratify and become anoxic due to its shallow depth (it remains well mixed vertically). The WiLMS model was used to predict the internal phosphorus load from the sediments. It predicted that there is a net loss of phosphorus to the sediment of 374 pound per year due to settling.

**Discussion**

The WiLMS modeling showed that the loading of phosphorus to the Plymouth Mill Pond from watershed runoff is less than what is typically expected but nonetheless is the central reason why the Mill Pond exhibits eutrophic conditions. This is accentuated by the large amount of flow that is cycled through the Mill Pond.

Bottom sediments may not be releasing phosphorus back into the water column in significant amounts. However it would still be available to promote growth of rooted aquatic plants.

**References**

U.S. Department of the Interior, U.S. Geological Survey, “Unit-Area Loads of Suspended Sediment, Suspended Solids, and Total Phosphorus from Small Watersheds in Wisconsin” Fact Sheet Number: FS-195-97.

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# APPENDIX F

MULLET RIVER SAMPLING SUMMARY

2013 Total Phosphorus ( mg/L) at Mullet River Locations

| Date | 1- Division | 2- CTH U | 3- Spring Valley Road | 4 -Center Road | 5 - St. Hwy 23 | 6 - CTH T | 7 - CTH P | 8 - CTH C | 9 - CTH J | 10 - Woodland Road | 11 - Riverview Road | 13 - Cty Recreation Trail | Mill Pond | 14 - Meyer Park | 15 - Short Cut Road | WWTP Discharge | 16 - DS From WWTP Discharge | 17 - Blueberry |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5/13/2013 | | | | | | | | | | | 0.04 | | | | 0.05 | 0.40 | 0.12 | |
| 5/20/2013 | | | | | | | | 0.07 | | 0.08 | 0.07 | | | 0.10 | 0.05 | 0.90 | | 0.12 |
| 5/27/2013 | 0.10 | 0.09 | 0.10 | 0.08 | 0.10 | 0.10 | | | | | | | | | | | | |
| 5/28/2013 | | | | | | | | | | | | | | 0.09 | 0.08 | 0.28 | 0.13 | 0.10 |
| 6/3/2013 | | | | | | | | 0.14 | 0.13 | 0.11 | 0.12 | 0.17 | | 0.10 | 0.09 | 0.70 | 0.21 | 0.14 |
| 6/10/2013 | 0.09 | 0.12 | 0.12 | 0.12 | 0.11 | 0.33 | | | | | | | | 0.05 | 0.05 | 0.60 | 0.12 | 0.05 |
| 6/17/2013 | | | | | | | | | | | | | | 0.08 | 0.08 | 0.90 | 0.16 | 0.12 |
| 6/24/2013 | 0.16 | 0.24 | 0.18 | 0.18 | 0.15 | 0.15 | 0.11 | | | | | | | 0.08 | 0.10 | 1.20 | 0.28 | 0.16 |
| 7/1/2013 | | | | | | | | 0.18 | 0.14 | 0.15 | 0.13 | 0.14 | | 0.11 | 0.14 | 1.10 | 0.37 | 0.26 |
| 7/8/2013 | | | | | | | | | | | | | | 0.10 | 0.12 | 0.90 | 0.24 | 0.19 |
| 7/9/2013 | 0.36 | 0.38 | 0.22 | 0.20 | 0.21 | 0.22 | 0.13 | 0.18 | 0.14 | | | | | | | | | |
| 7/15/2013 | | | | | | | | | | | | | | 0.08 | 0.10 | 0.90 | 0.25 | 0.16 |
| 7/22/2013 | | | | | | | | | | | | | | 0.08 | 0.10 | 1.00 | 0.39 | 0.15 |
| 7/24/2013 | 0.28 | 0.14 | 0.14 | 0.14 | 0.12 | 0.12 | 0.10 | | | | | | | | | | | |
| 7/29/2013 | | | | | | | | | | | | | | 0.06 | 0.05 | 0.30 | 0.08 | 0.07 |
| 8/5/2013 | | | | | | | | 0.07 | 0.06 | 0.05 | 0.05 | 0.06 | | 0.05 | 0.07 | 1.60 | 0.41 | 0.21 |
| 8/12/2013 | 0.24 | 0.16 | 0.09 | 0.09 | 0.07 | 0.08 | 0.07 | | | | | | | 0.04 | 0.07 | 0.80 | 0.20 | 0.11 |
| 8/19/2013 | | | | | | | | | | | | | | 0.05 | 0.08 | 0.80 | 0.26 | 0.13 |
| 8/26/2013 | 0.39 | 0.25 | 0.11 | 0.11 | 0.09 | 0.10 | 0.07 | | | | | | | 0.08 | 0.09 | 0.80 | 0.29 | 0.15 |
| 8/30/2013 | | | | | | | | 0.11 | 0.08 | 0.07 | 0.07 | 0.06 | | | | | | |
| 9/3/2013 | | | | | | | | | | | | | | 0.08 | 0.10 | 1.00 | 1.15 | 0.22 |
| 9/4/2013 | 0.37 | 0.21 | 0.10 | 0.09 | 0.08 | 0.08 | 0.10 | | | | | 0.04 | | | | | | |
| 9/9/2013 | | | | | | | | | | | | | | 0.07 | 0.08 | 0.40 | 0.24 | 0.16 |
| 9/16/2013 | | | | | | | | 0.08 | 0.05 | 0.05 | 0.05 | 0.05 | | 0.07 | 0.08 | 0.40 | 0.14 | 0.08 |
| 9/23/2013 | 0.15 | 0.30 | 0.06 | | 0.06 | | | | | | | | | 0.06 | 0.06 | 0.70 | 0.18 | 0.11 |
| 9/30/2013 | | | | | | | | 0.09 | 0.07 | 0.05 | 0.06 | 0.06 | | 0.06 | 0.06 | 0.50 | 0.20 | 0.09 |
| 10/7/2013 | 0.11 | 0.06 | 0.07 | 0.09 | 0.06 | 0.08 | 0.06 | | | | | | | 0.12 | 0.09 | 0.40 | 0.15 | 0.09 |
| 10/14/2013 | | | | | | | | 0.06 | 0.05 | 0.04 | 0.04 | 0.04 | | 0.05 | 0.06 | 0.60 | 0.16 | 0.09 |
| 10/21/2013 | | | | | | | | | | | | | | 0.04 | 0.07 | 1.00 | 0.32 | 0.18 |
| 10/28/2013 | | | | | | | | 0.05 | 0.04 | 0.04 | 0.04 | 0.03 | | 0.04 | 0.08 | 0.90 | 0.30 | 0.16 |
| Average | 0.23 | 0.19 | 0.12 | 0.12 | 0.11 | 0.14 | 0.09 | 0.10 | 0.08 | 0.07 | 0.07 | 0.07 | | 0.07 | 0.08 | 0.76 | 0.26 | 0.14 |

2014 Total Phosphorus ( mg/L) at Mullet River Locations

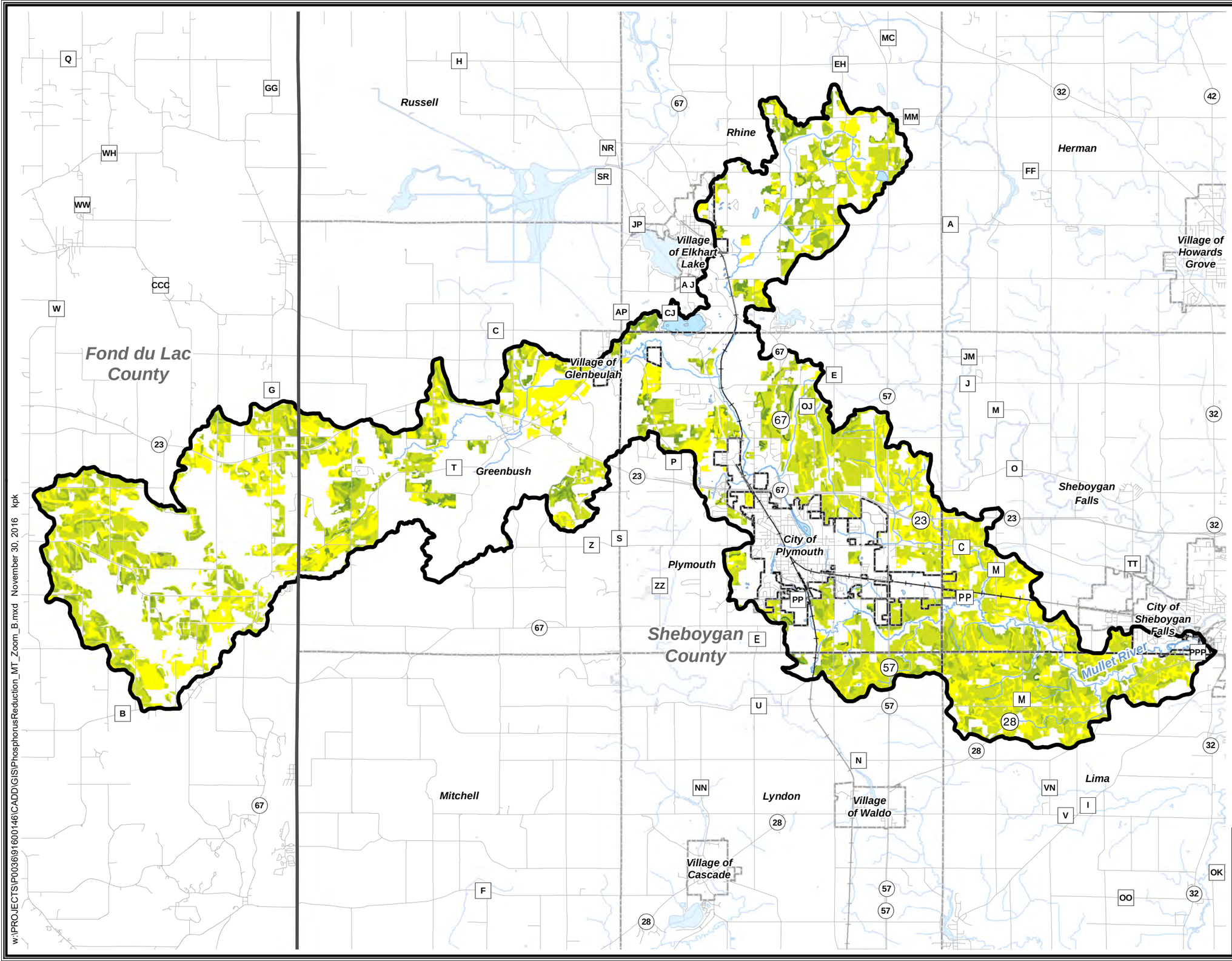
| Date | 1- Division | 2- CTH U | 3- Spring Valley Road | 4 -Center Road | 5 - St. Hwy 23 | 6 - CTH T | 7 - CTH P | 8 - CTH C | 9 - CTH J | 10 - Woodland Road | 11 - Riverview Road | 12 - STH 67 | 13 - City Recreation Trail | Mill Pond | 14 - Meyer Park | 15 - Short Cut Road | WWTP Discharge | 16 - DS From WWTP Discharge | 17 - Blueberry | 18 - Willow Road |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5/5/2014 | | | | | | | | 0.06 | 0.05 | 0.07 | 0.05 | | 0.05 | | 0.05 | 0.07 | 0.07 | 0.06 | 0.06 | |
| 5/13/2014 | | | | | | | | | | | | | | | 0.09 | 0.08 | 0.07 | 0.09 | 0.09 | |
| 5/19/2014 | 0.08 | 0.08 | 0.08 | 0.08 | 0.07 | 0.08 | 0.07 | 0.08 | 0.08 | 0.08 | 0.08 | 0.07 | 0.08 | | 0.07 | 0.08 | 0.07 | 0.08 | 0.08 | |
| 5/27/2014 | | | | | | | | | | | | | | | 0.09 | 0.10 | 0.07 | 0.08 | 0.08 | |
| 6/2/2014 | | | | | | | | 0.27 | 0.20 | 0.20 | 0.23 | 0.44 | 0.50 | | 0.09 | 0.10 | 0.12 | 0.10 | 0.11 | |
| 6/9/2014 | | | | | | | | | | | | | | | 0.07 | 0.09 | 0.12 | 0.09 | 0.10 | |
| 6/16/2014 | 0.11 | 0.10 | 0.17 | 0.11 | | 0.11 | 0.11 | | | | | | | | 0.06 | 0.08 | 0.17 | 0.13 | 0.09 | |
| 6/17/2014 | | | | | | | | 0.24 | 0.18 | 0.15 | 0.17 | | 0.17 | | | | | | | |
| 6/23/2014 | | | | | | | | | | | | | | | 0.09 | 0.12 | 0.21 | 0.12 | 0.13 | |
| 6/30/2014 | | | | | | | | 0.24 | 0.21 | 0.21 | 0.21 | | 0.19 | | 0.15 | 0.15 | 0.12 | 0.15 | 0.16 | |
| 7/14/2014 | 0.17 | 0.15 | | | | | 0.14 | 0.14 | 0.12 | 0.13 | 0.12 | | 0.12 | | 0.11 | 0.11 | 0.16 | 0.13 | 0.12 | |
| 7/21/2014 | | | | | | | | | | | | | | | 0.08 | 0.10 | 0.21 | 0.13 | 0.11 | |
| 7/28/2014 | | | | | | | | 0.10 | 0.08 | 0.07 | 0.07 | | 0.06 | | 0.08 | 0.10 | 0.27 | 0.11 | 0.10 | |
| 8/4/2014 | | | | | | | | | | | | | | | 0.08 | 0.10 | 0.35 | 0.19 | 0.11 | |
| 8/11/2014 | | | | | | | | 0.09 | 0.09 | 0.06 | 0.67 | | 0.05 | | 0.08 | 0.10 | 0.42 | 0.20 | 0.12 | |
| 8/18/2014 | | | | | | | | | | | | | | | 0.06 | 0.10 | 0.29 | 0.15 | 0.10 | 0.09 |
| 8/25/2014 | | | | | | | | | | | | | | | 0.12 | 0.14 | 0.26 | 0.14 | 0.13 | 0.14 |
| 8/26/2014 | 0.19 | 0.15 | 0.16 | 0.15 | 0.14 | 0.12 | 0.12 | | | | | | | | | | | | | |
| 9/2/2014 | | | | | | | | 0.12 | 0.08 | 0.10 | 0.11 | | 0.09 | | | | | | | |
| 9/8/2014 | 0.16 | 0.14 | 0.12 | 0.12 | 0.11 | 0.10 | 0.10 | | | | | | | | 0.08 | 0.08 | 0.26 | 0.11 | 0.09 | 0.15 |
| 9/15/2014 | | | | | | | | 0.09 | 0.07 | 0.06 | 0.07 | | 0.05 | | 0.05 | 0.06 | 0.61 | 0.19 | 0.11 | 0.08 |
| 9/22/2014 | 0.06 | 0.08 | 0.07 | 0.09 | 0.14 | 0.06 | 0.07 | | | | | | | | 0.05 | 0.06 | 0.43 | 0.19 | 0.09 | 0.06 |
| 9/29/2014 | | | | | | | | 0.06 | 0.06 | 0.04 | 0.04 | | 0.04 | | 0.04 | 0.05 | 0.51 | 0.13 | 0.08 | 0.05 |
| 10/6/2014 | | | | | | | | | | | | | | | 0.05 | 0.06 | 0.99 | 0.16 | 0.11 | 0.09 |
| 10/13/2014 | | | | | | | | 0.05 | 0.05 | 0.04 | 0.04 | | 0.03 | | | | | | | |
| 10/20/2014 | | | | | | | | | | | | | | | 0.06 | 0.06 | 0.66 | 0.12 | 0.10 | 0.08 |
| Average | 0.13 | 0.12 | 0.12 | 0.11 | 0.11 | 0.10 | 0.10 | 0.13 | 0.11 | 0.10 | 0.16 | 0.25 | 0.12 | | 0.08 | 0.09 | 0.29 | 0.13 | 0.10 | 0.09 |

2015 Total Phosphorus ( mg/L) at Mullet River Locations

| Date | 1- Division | 2- CTH U | 3- Spring Valley Road | 4 -Center Road | 5 - St. Hwy 23 | 6 - CTH T | 7 - CTH P | 8 - CTH C | 9 - CTH J | 10 - Woodland Road | 11 - Riverview Road | 13 - City Recreation Trail | Mill Pond | 14 - Meyer Park | 15 - Short Cut Road | WWTP Discharge | 16 - DS From WWTP Discharge | 17 - Blueberry | Fleet Farm | Willow Rd | Golf Course |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5/4/2015 | | | | | | | | 0.09 | 0.11 | 0.07 | 0.08 | 0.15 | | | | | | | | | |
| 5/11/2015 | | | | | | | | | | | | | | 0.10 | 0.11 | 0.90 | 0.40 | 0.13 | 0.04 | 0.13 | |
| 5/18/2015 | | | | | | | | 0.17 | 0.13 | 0.11 | 0.17 | 0.12 | | | | | | | | | |
| 5/26/2015 | | | | | | | | | | | | | | 0.18 | 0.14 | 0.60 | 0.29 | 0.26 | 0.17 | 0.24 | 0.10 |
| 6/1/2015 | | | | | | | | 0.16 | 0.20 | 0.20 | 0.11 | 0.12 | | | | | | | | | |
| 6/8/2015 | | | | | | | | | | | | | | 0.11 | 0.11 | 1.11 | 0.40 | 0.20 | | | |
| 6/15/2015 | | | | | | | | 0.21 | 0.17 | 0.13 | 0.18 | 0.18 | | | | | | | | | |
| 6/22/2015 | | | | | | | | | | | | | | 0.09 | 0.12 | 0.19 | 0.27 | 0.16 | | | |
| 6/29/2015 | | | | | | | | 0.19 | 0.12 | 0.13 | 0.13 | 0.10 | | | | | | | | | |
| 7/7/2015 | | | | | | | | | | | | | | 0.08 | 0.11 | 1.29 | 0.59 | 0.22 | | | |
| 7/14/2015 | | | | | | | | 0.15 | 0.11 | 0.11 | 0.06 | 0.07 | | | | | | | | | |
| 7/20/2015 | | | | | | | | | | | | | | 0.08 | 0.11 | 0.50 | 0.13 | 0.13 | | | |
| 7/27/2015 | | | | | | | | | 0.06 | 0.14 | 0.16 | 0.14 | | | | | | | | | |
| 8/3/2015 | | | | | | | | | | | | | | 0.11 | 0.14 | 0.25 | 0.15 | 0.19 | | | |
| 8/10/2015 | | | | | | | | 0.10 | 0.12 | 0.07 | 0.07 | 0.09 | | | | | | | | | |
| 8/17/2015 | | | | | | | | | | | | | | 0.15 | 0.25 | 1.11 | 0.64 | 0.23 | | | |
| 8/24/2015 | | | | | | | | 0.10 | 0.10 | 0.05 | 0.23 | 0.10 | | | | | | | | | |
| 9/8/2015 | | | | | | | | 0.14 | 0.17 | 0.21 | 0.39 | 0.17 | | | | | | | | | |
| 9/9/2015 | | | | | | | | | | | | | | 0.19 | 0.20 | 1.20 | 0.80 | 0.24 | | | |
| 9/21/2015 | | | | | | | | 0.69 | 0.41 | 0.19 | 0.11 | 0.07 | | | | | | | | | |
| 9/28/2015 | | | | | | | | | | | | | | 0.27 | 0.17 | 0.62 | 0.20 | 0.13 | | | |
| 10/5/2015 | | | | | | | | 0.11 | 0.11 | 0.06 | 0.04 | 0.04 | | | | | | | | | |
| Average | | | | | | | | 0.19 | 0.15 | 0.12 | 0.14 | 0.11 | | 0.14 | 0.14 | 0.78 | 0.39 | 0.19 | 0.10 | 0.18 | 0.10 |

# APPENDIX G

SNAP-PLUS CROPLAND P REDUCTION MAPS (MULCH TILLAGE)




PLYMOUTH WISCONSIN

## Phosphorus Reduction Mulch Tillage (lbs/ac/yr)

- Less than 1
- 1 to 2
- 2 to 3
- 3 to 4
- 4 to 5
- Greater than 5

## Other Mapped Features

- Mullet River HUC 12 Boundary
- County Boundary
- Municipal Boundary
- Road Centerline
- Railroad Centerline
- Stream
- Surface Water

Source: Sheboygan County, 2013; Wisconsin DNR, 2010; USDA, 2015.

Disclaimer: The property lines, right-of-way lines, and other property information on this drawing were developed or obtained as part of the County Geographic Information System or through the County property tax mapping function. McMAHON does not guarantee this information to be correct, current, or complete. The property and right-of-way information are only intended for use as a general reference and are not intended or suitable for site-specific uses. Any use to the contrary of the above stated uses is the responsibility of the user and such use is at the user's own risk.

NOT TO SCALE

McMAHON ENGINEERS ARCHITECTS

**PHOSPHORUS REDUCTION MULCH TILLAGE**
PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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**Phosphorus Reduction Mulch Tillage (lbs/ac/yr)**

- Less than 1
- 1 to 2
- 2 to 3
- 3 to 4
- 4 to 5
- Greater than 5

**Other Mapped Features**

- Lower Mullet HUC12 Boundary
- Municipal Boundary
- Parcel Line
- Stream

Source: Sheboygan County, 2013; Wisconsin DNR, 2010; USDA, 2015.

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0 500 1,000 Feet

McMAHON ENGINEERS ARCHITECTS

**PHOSPHORUS REDUCTION MULCH TILLAGE**
PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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PLYMOUTH WISCONSIN

**Phosphorus Reduction Mulch Tillage (lbs/ac/yr)**

- Less than 1
- 1 to 2
- 2 to 3
- 3 to 4
- 4 to 5
- Greater than 5

**Other Mapped Features**

- Lower Mullet HUC12 Boundary
- Municipal Boundary
- Parcel Line
- Stream

Source: Sheboygan County, 2013; Wisconsin DNR, 2010; USDA, 2015.

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N

0 500 1,000 Feet

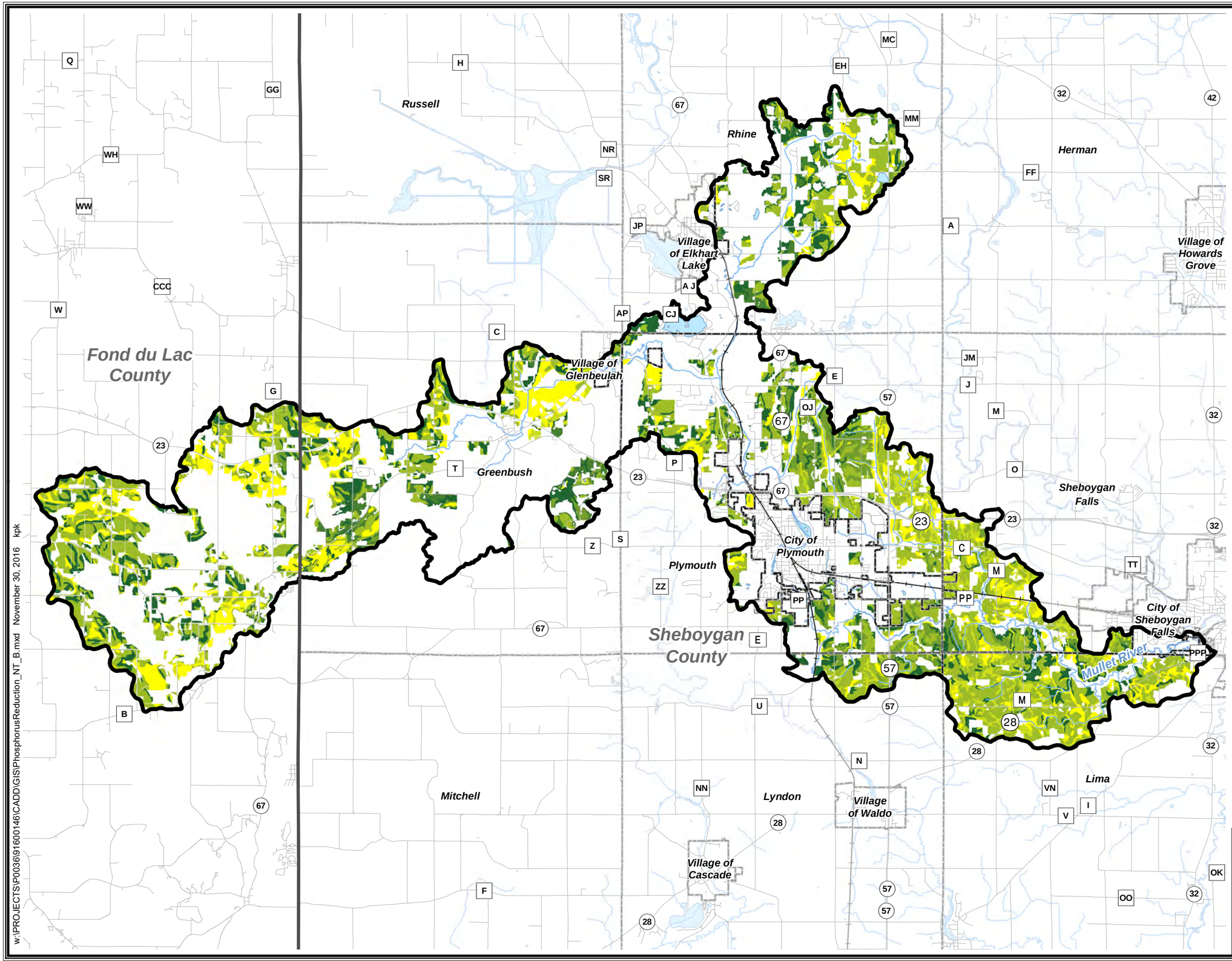
McMAHON ENGINEERS ARCHITECTS

**PHOSPHORUS REDUCTION MULCH TILLAGE**

PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

# APPENDIX H

SNAP-PLUS CROPLAND P REDUCTION MAPS (NO TILLAGE)




PLYMOUTH WISCONSIN

## Phosphorus Reduction No Tillage (lbs/ac/yr)

- Less than 1
- 1 to 2
- 2 to 3
- 3 to 4
- 4 to 5
- Greater than 5

## Other Mapped Features

- Mullet River HUC 12 Boundary
- County Boundary
- Municipal Boundary
- Road Centerline
- Railroad Centerline
- Stream
- Surface Water

Source: Sheboygan County, 2013; Wisconsin DNR, 2010; USDA, 2015.

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NOT TO SCALE

McMAHON ENGINEERS ARCHITECTS

**PHOSPHORUS REDUCTION**
**NO TILLAGE**
PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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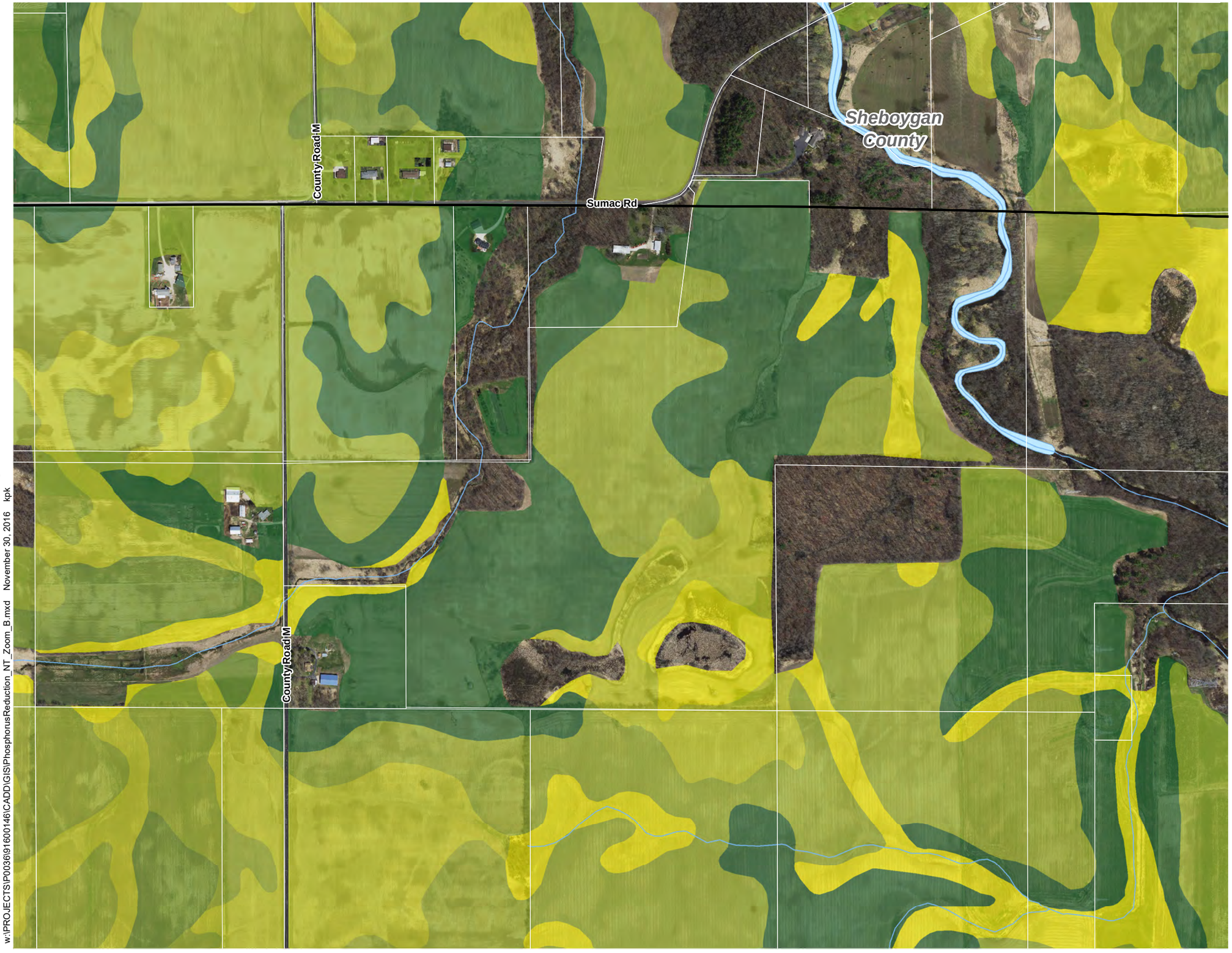


**Phosphorus Reduction**
**No Tillage**
**(lbs/ac/yr)**

- Less than 1
- 1 to 2
- 2 to 3
- 3 to 4
- 4 to 5
- Greater than 5

**Other Mapped Features**

- Lower Mullet HUC12 Boundary
- Municipal Boundary
- Parcel Line
- Stream

Source: Sheboygan County, 2013; Wisconsin DNR, 2010; USDA, 2015.

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0 500 1,000 Feet

**PHOSPHORUS REDUCTION**
**NO TILLAGE**
PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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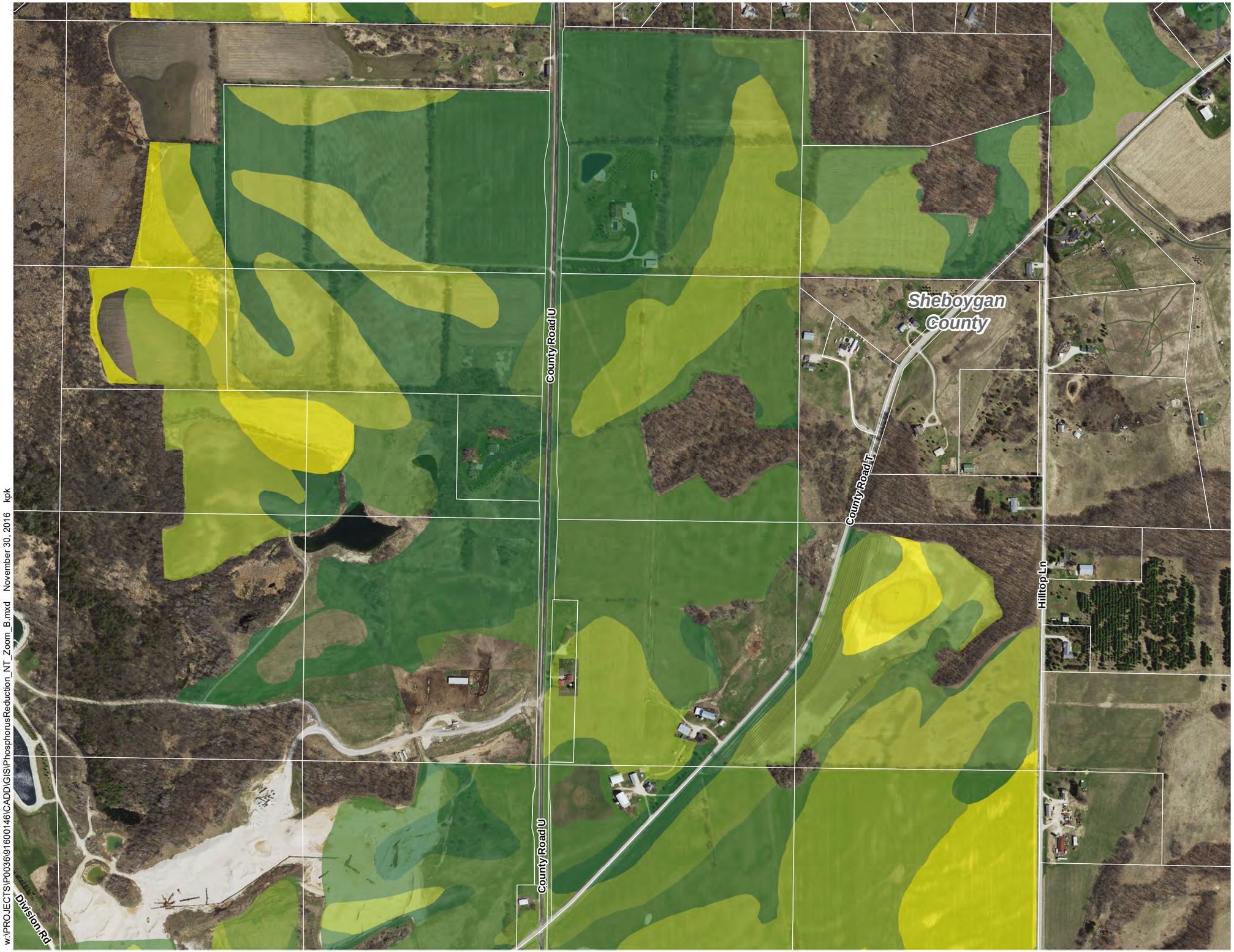


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PLYMOUTH WISCONSIN

**Phosphorus Reduction**
**No Tillage**
**(lbs/ac/yr)**

- Less than 1
- 1 to 2
- 2 to 3
- 3 to 4
- 4 to 5
- Greater than 5

**Other Mapped Features**

- Lower Mullet HUC12 Boundary
- Municipal Boundary
- Parcel Line
- Stream

Source: Sheboygan County, 2013; Wisconsin DNR, 2010; USDA, 2015.

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N

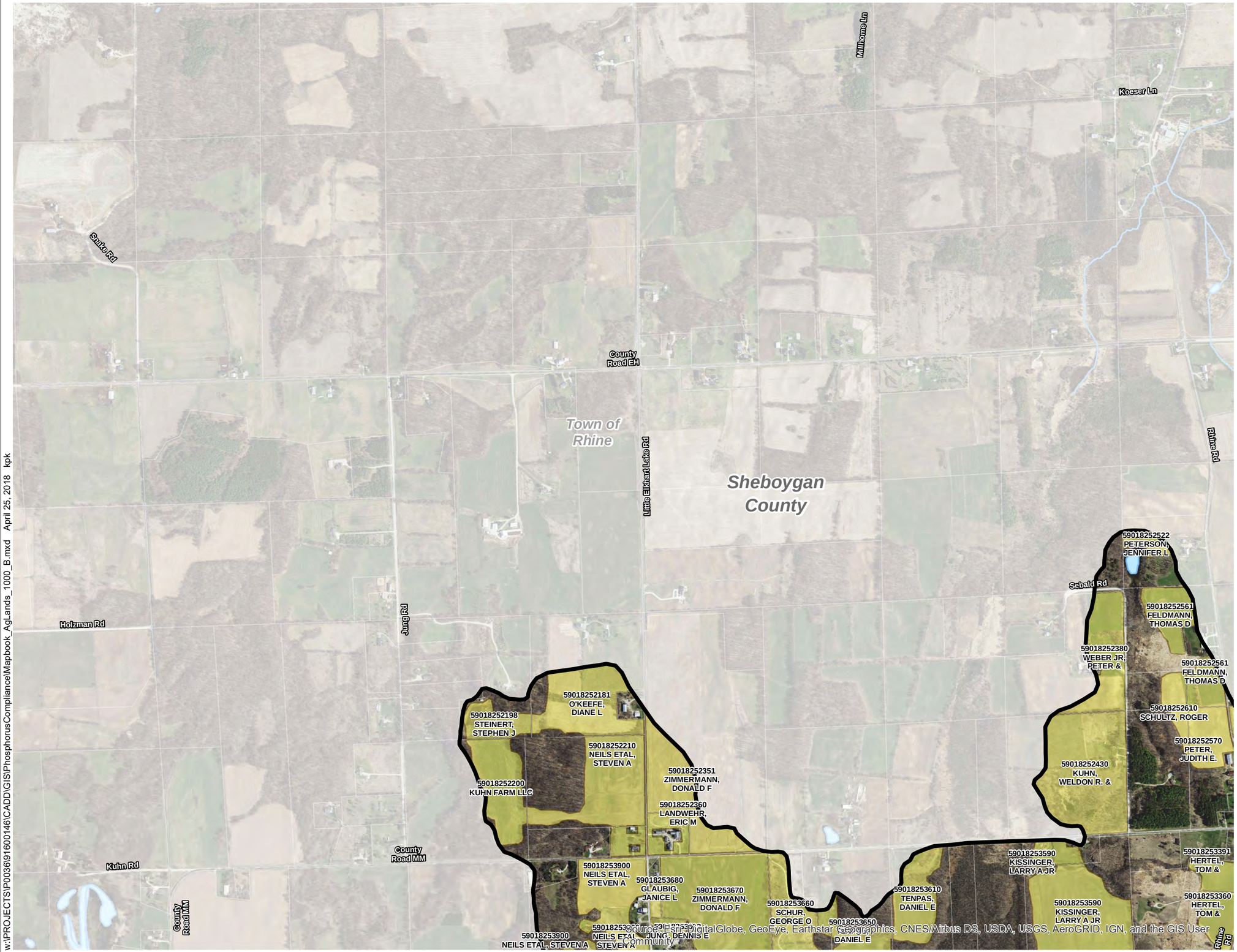
0 500 1,000 Feet

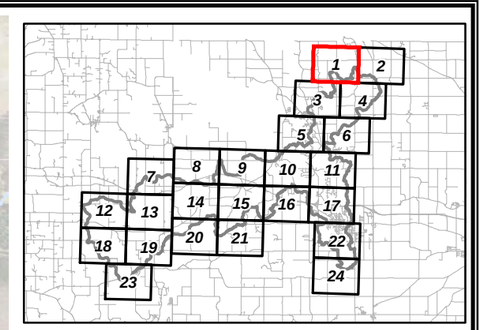
McMAHON ENGINEERS ARCHITECTS

**PHOSPHORUS REDUCTION**
**NO TILLAGE**
PLYMOUTH WWTF
PHOSPHORUS COMPLIANCE
PRIMARY ALTERNATIVES PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

# APPENDIX I

CROPLAND LANDOWNER MAPS




**Mapped Features**

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
- Surface Water

Source: Sheboygan County, 2013-15; Fond du Lac County, 2013; WDNR, 2008-12.

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N

0 1,000 2,000 Feet

PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 1 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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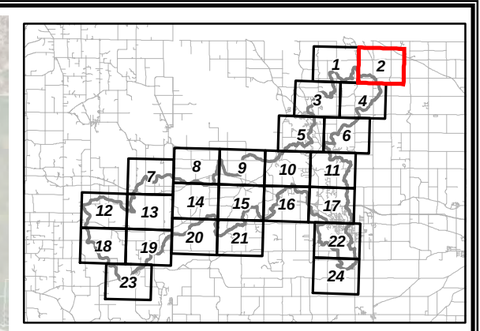


**Mapped Features**

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
- Surface Water

Source: Sheboygan County, 2013-15; Fond du Lac County, 2013; WDNR, 2008-12.

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N

0 1,000 2,000 Feet

PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 2 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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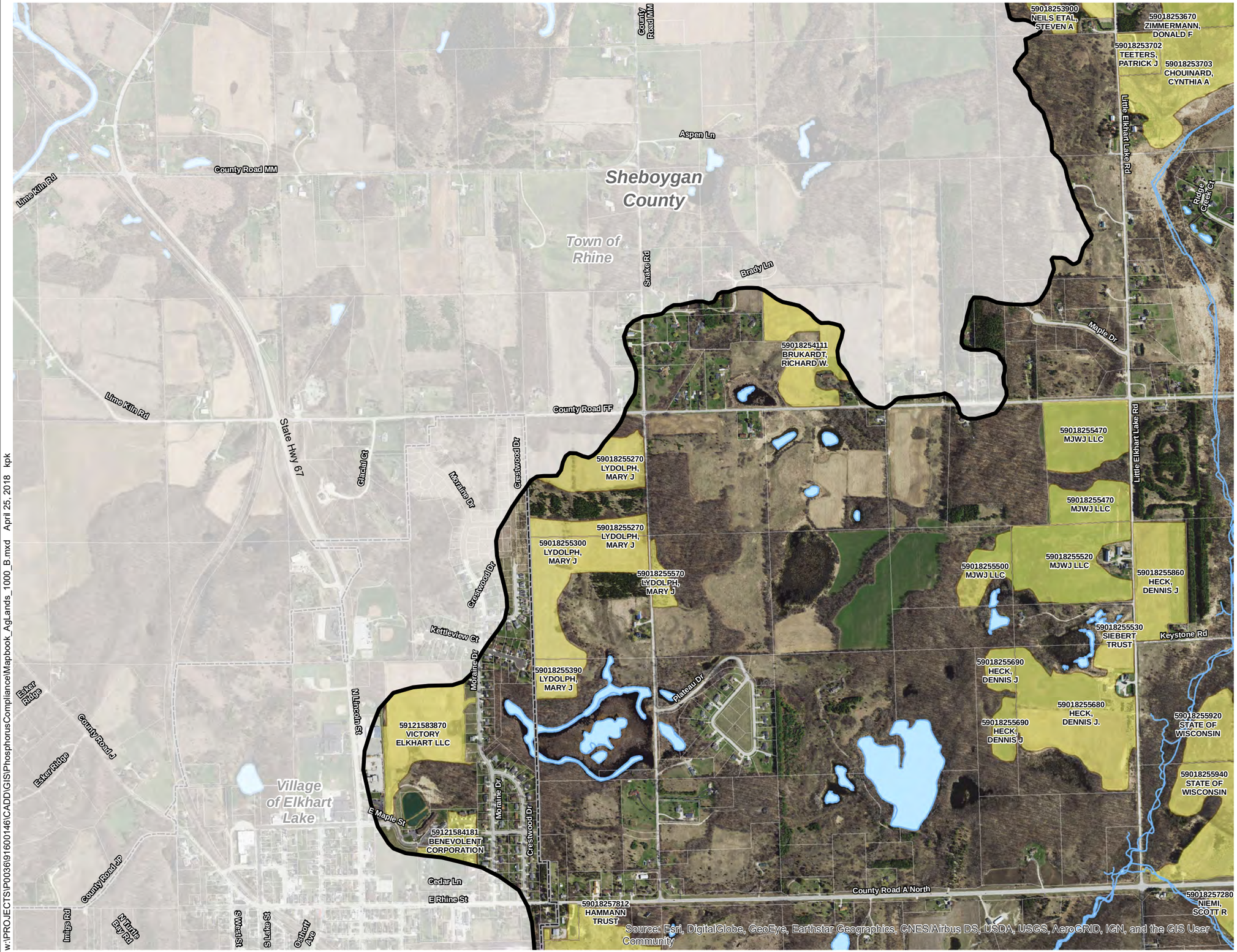


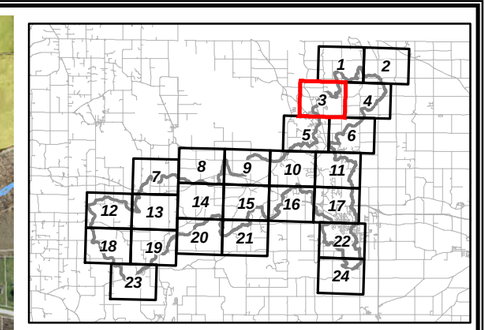


## Mapped Features

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
- Surface Water

Source: Sheboygan County, 2013-15; Fond du Lac County, 2013; WDNR, 2008-12.

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0 1,000 2,000 Feet

PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 3 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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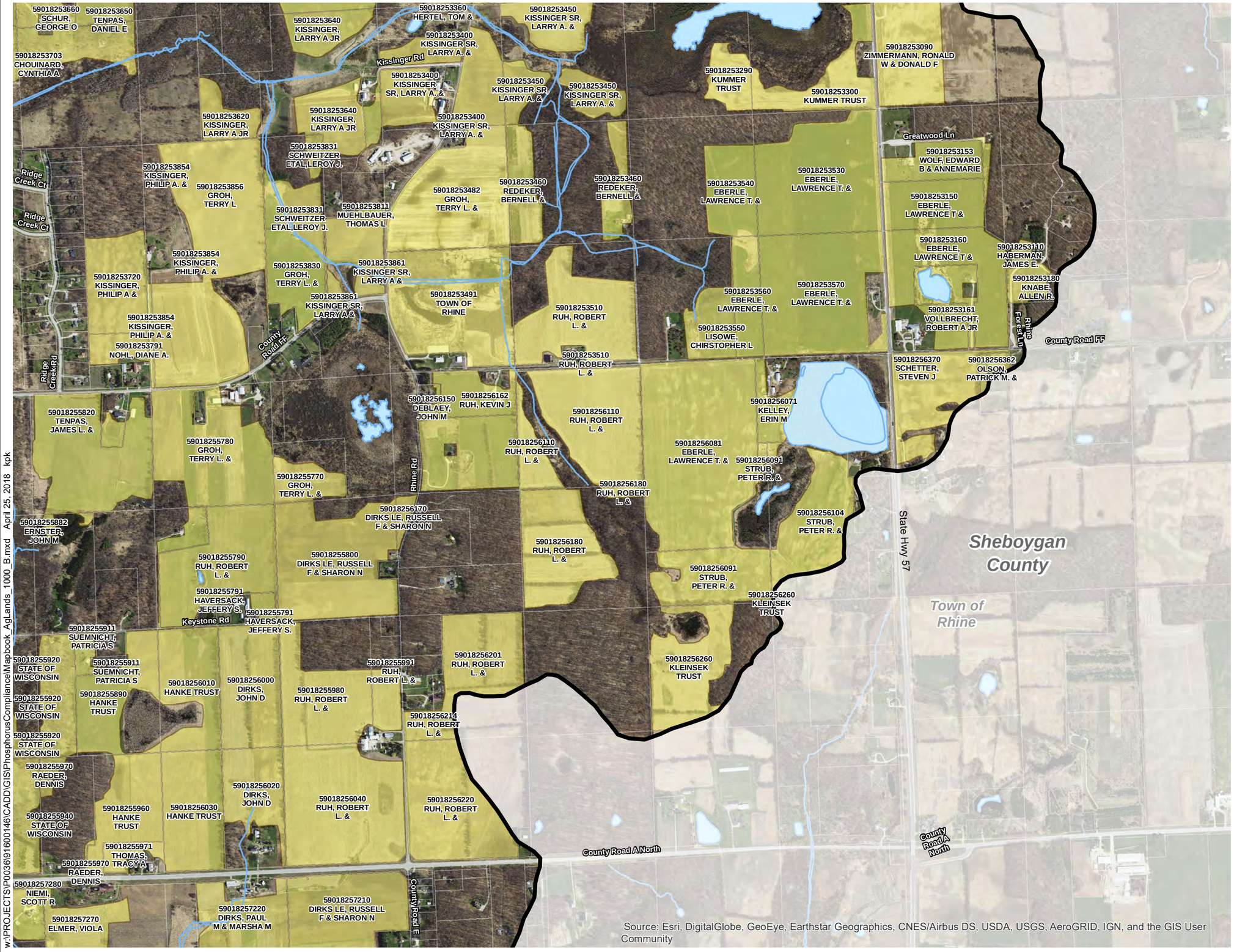


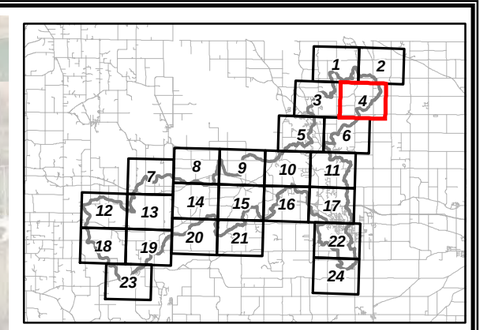


## Mapped Features

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
- Surface Water

Source: Sheboygan County, 2013-15; Fond du Lac County, 2013; WDNR, 2008-12.

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N

0 1,000 2,000 Feet

PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 4 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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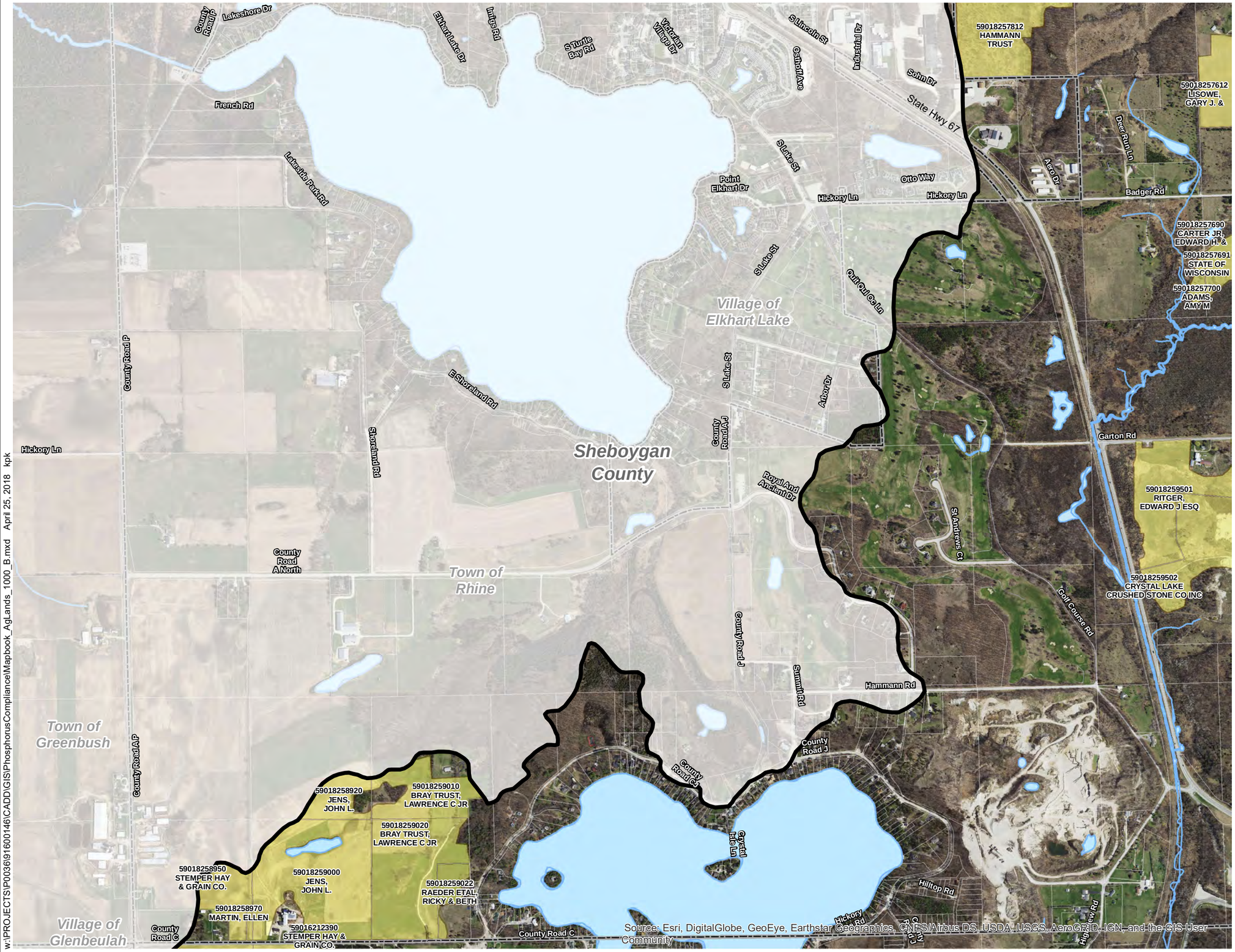


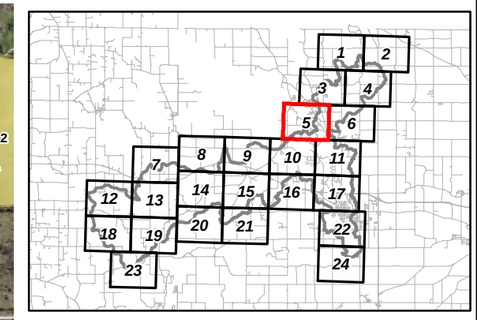


**Mapped Features**

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
- Surface Water

Source: Sheboygan County, 2013-15; Fond du Lac County, 2013; WDNR, 2008-12.

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N

0 1,000 2,000 Feet

PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 5 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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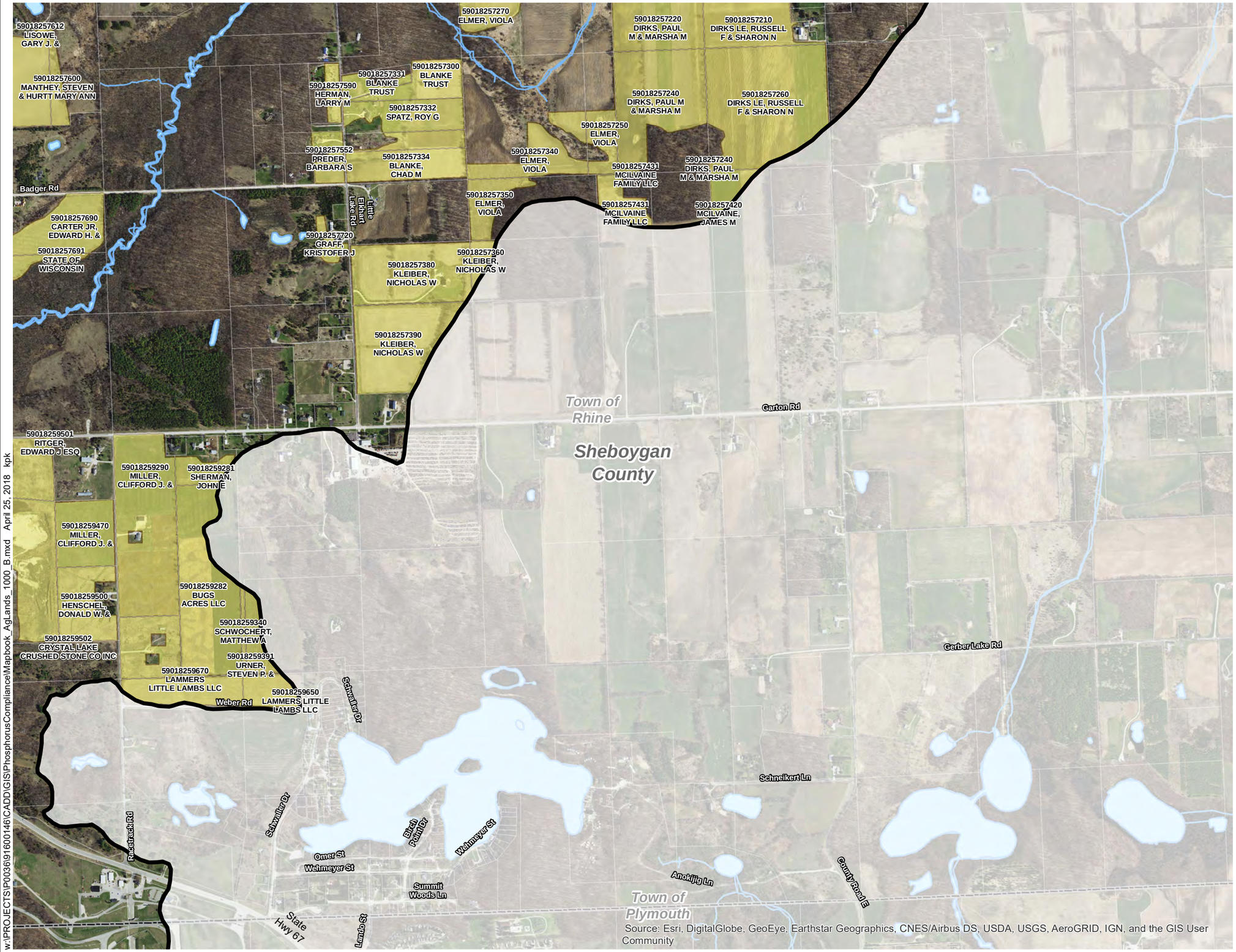


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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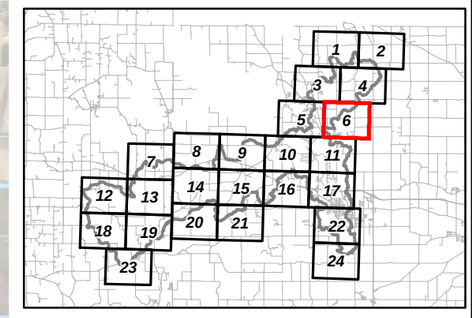


**Mapped Features**

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
- Surface Water

Source: Sheboygan County, 2013-15; Fond du Lac County, 2013; WDNR, 2008-12.

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N

0 1,000 2,000 Feet

PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

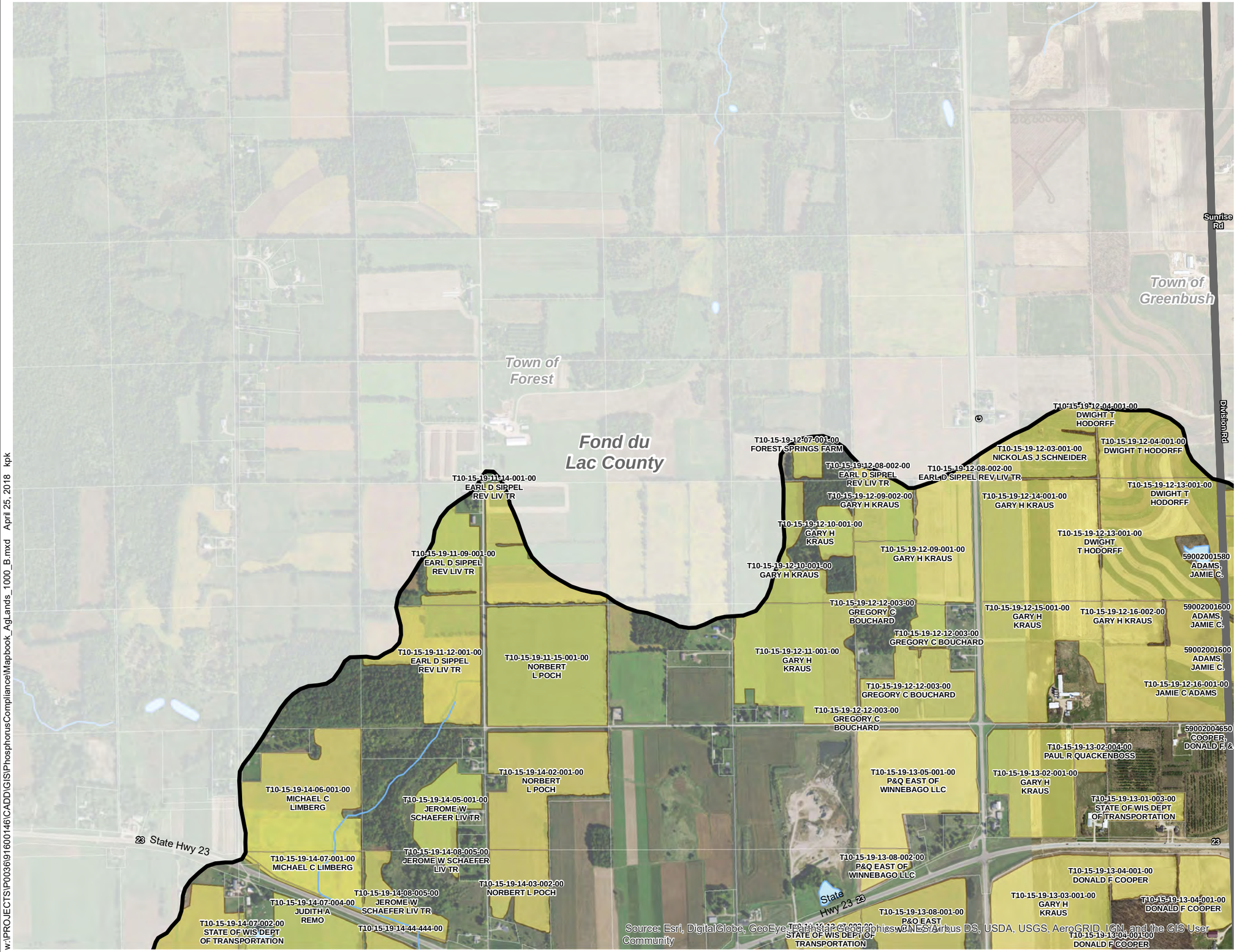
FIGURE 6 OF 24

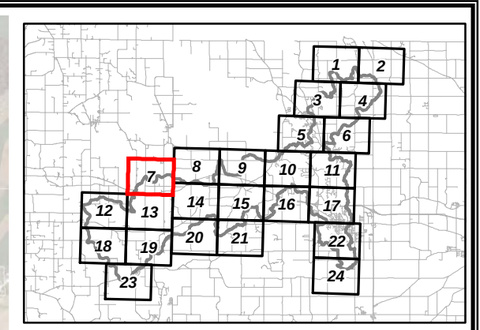
**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN




**Mapped Features**

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
- Surface Water

Source: Sheboygan County, 2013-15; Fond du Lac County, 2013; WDNR, 2008-12.

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N

0 1,000 2,000 Feet

PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 7 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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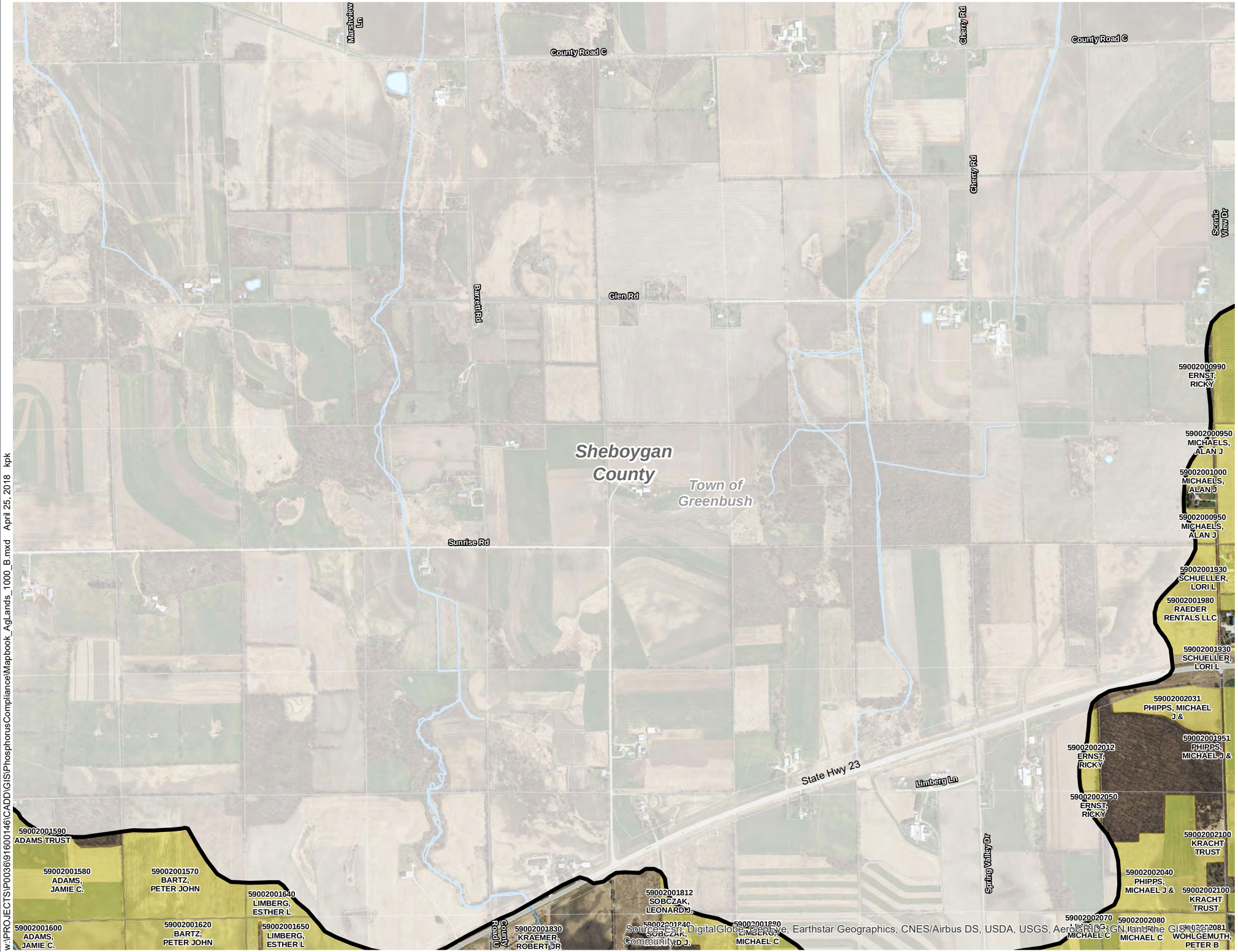


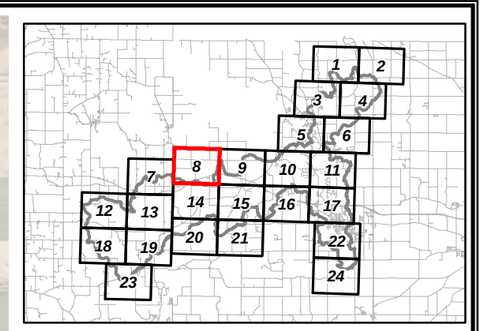


## Mapped Features

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
- Surface Water

Source: Sheboygan County, 2013-15; Fond du Lac County, 2013; WDNR, 2008-12.

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 8 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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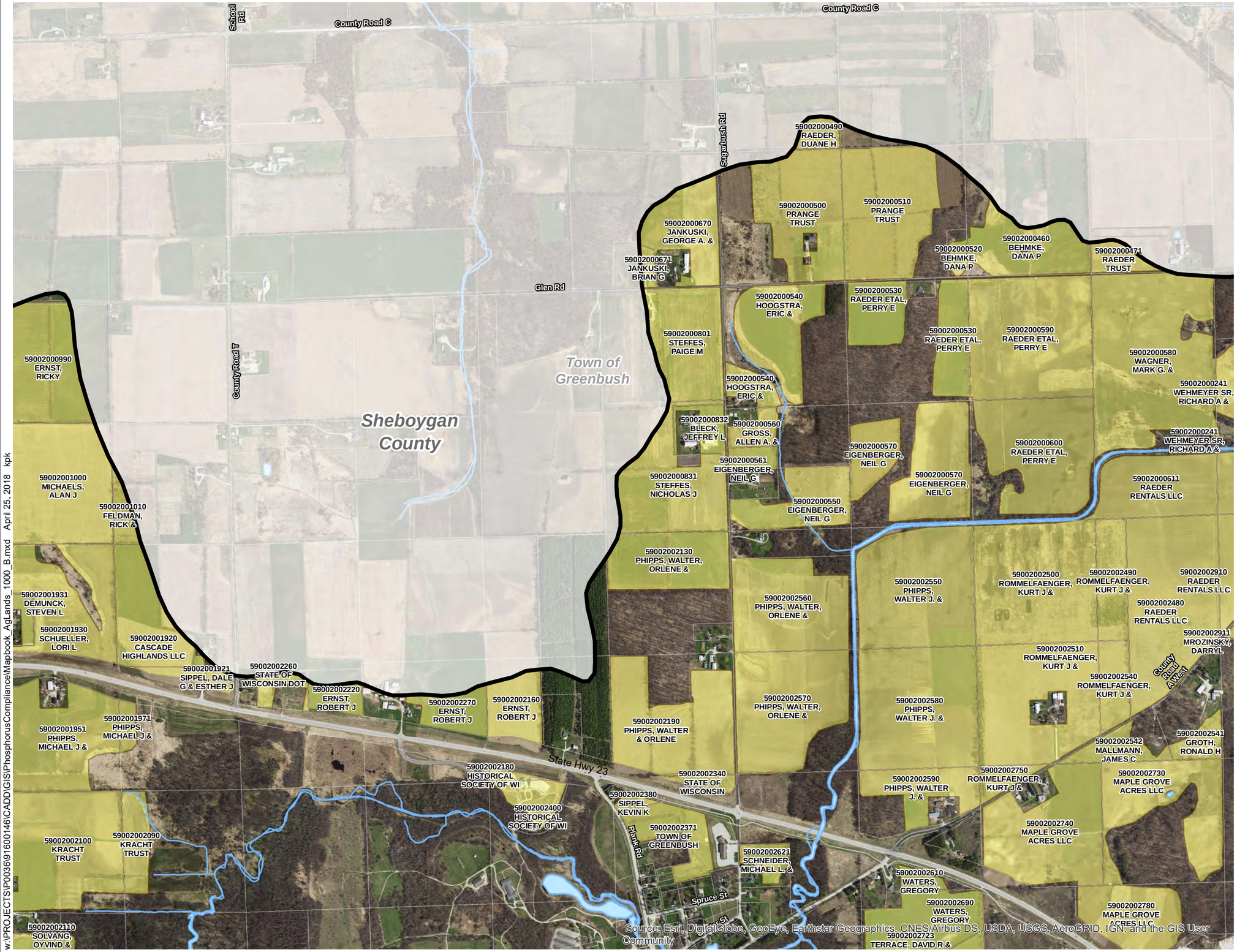


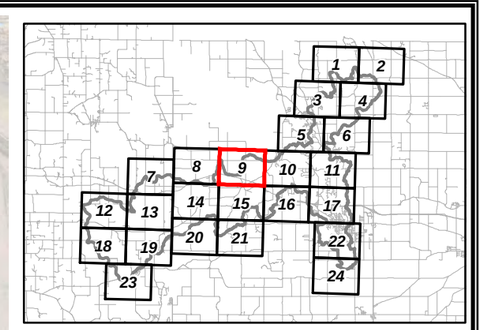


**Mapped Features**

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
- Surface Water

Source: Sheboygan County, 2013-15; Fond du Lac County, 2013; WDNR, 2008-12.

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 9 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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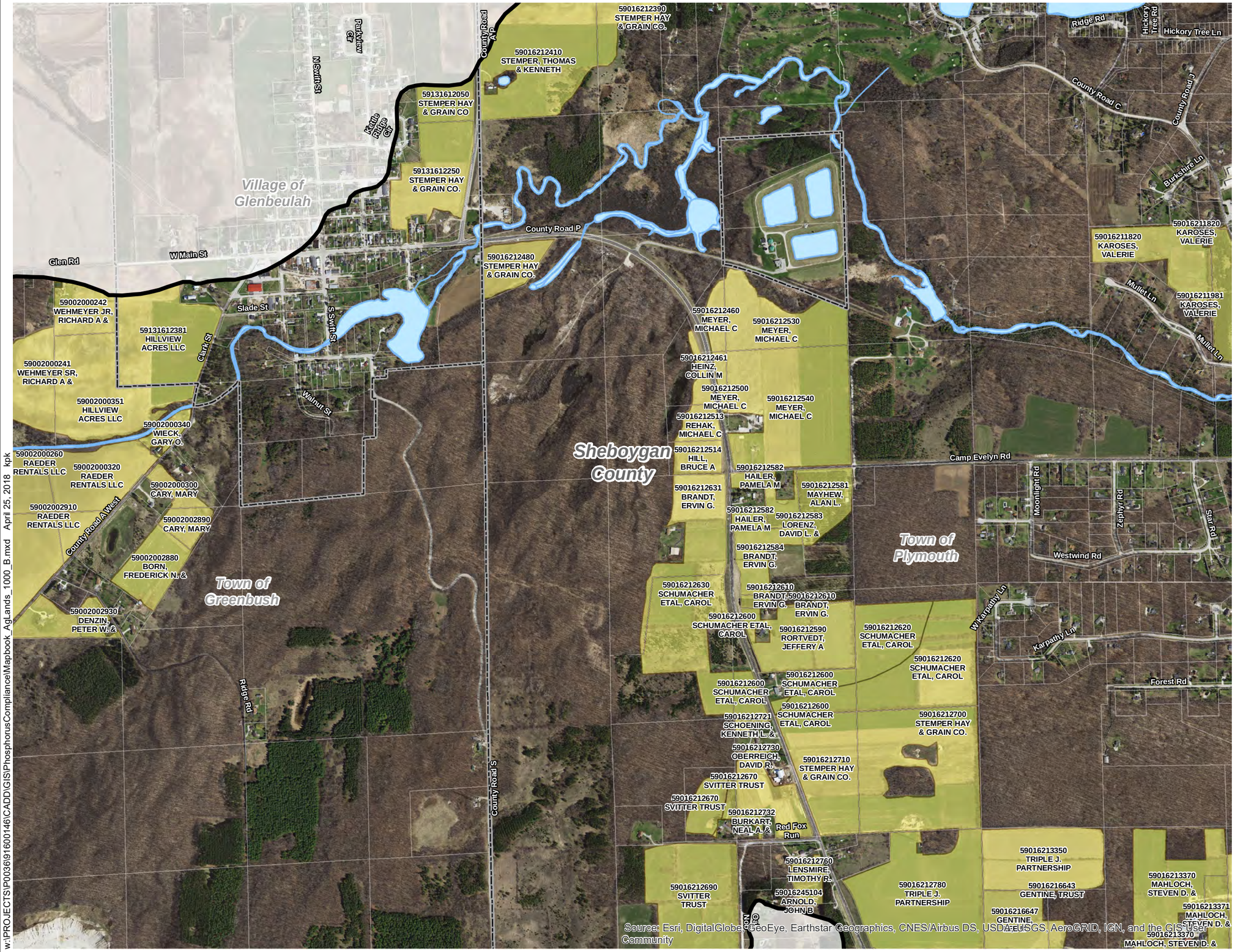


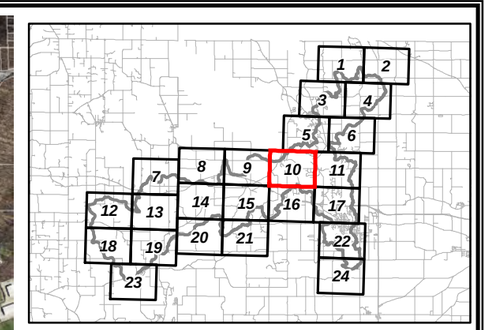


## Mapped Features

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
- Surface Water

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 10 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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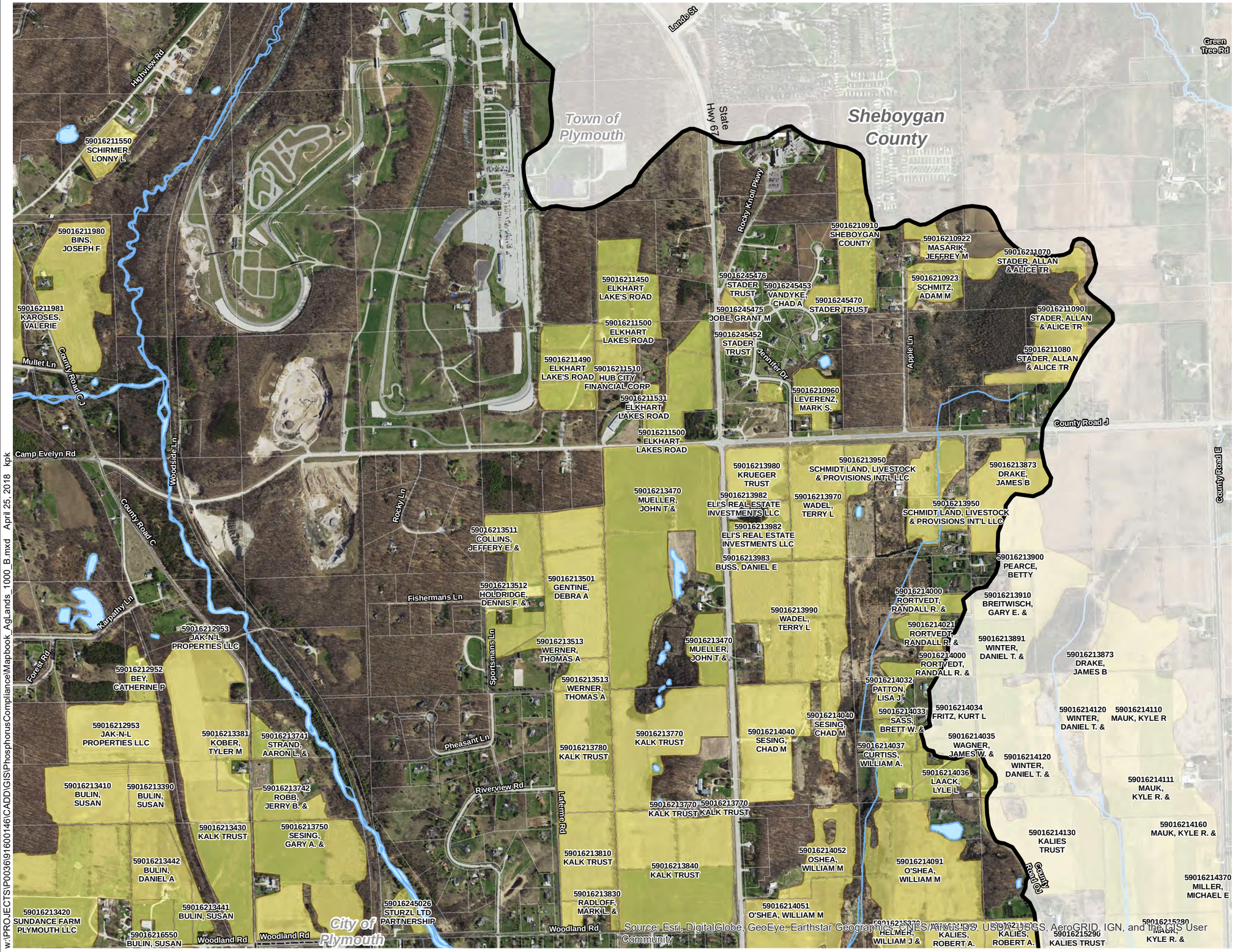


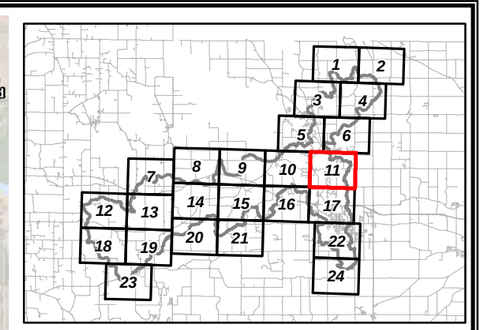


## Mapped Features

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
- Surface Water

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 11 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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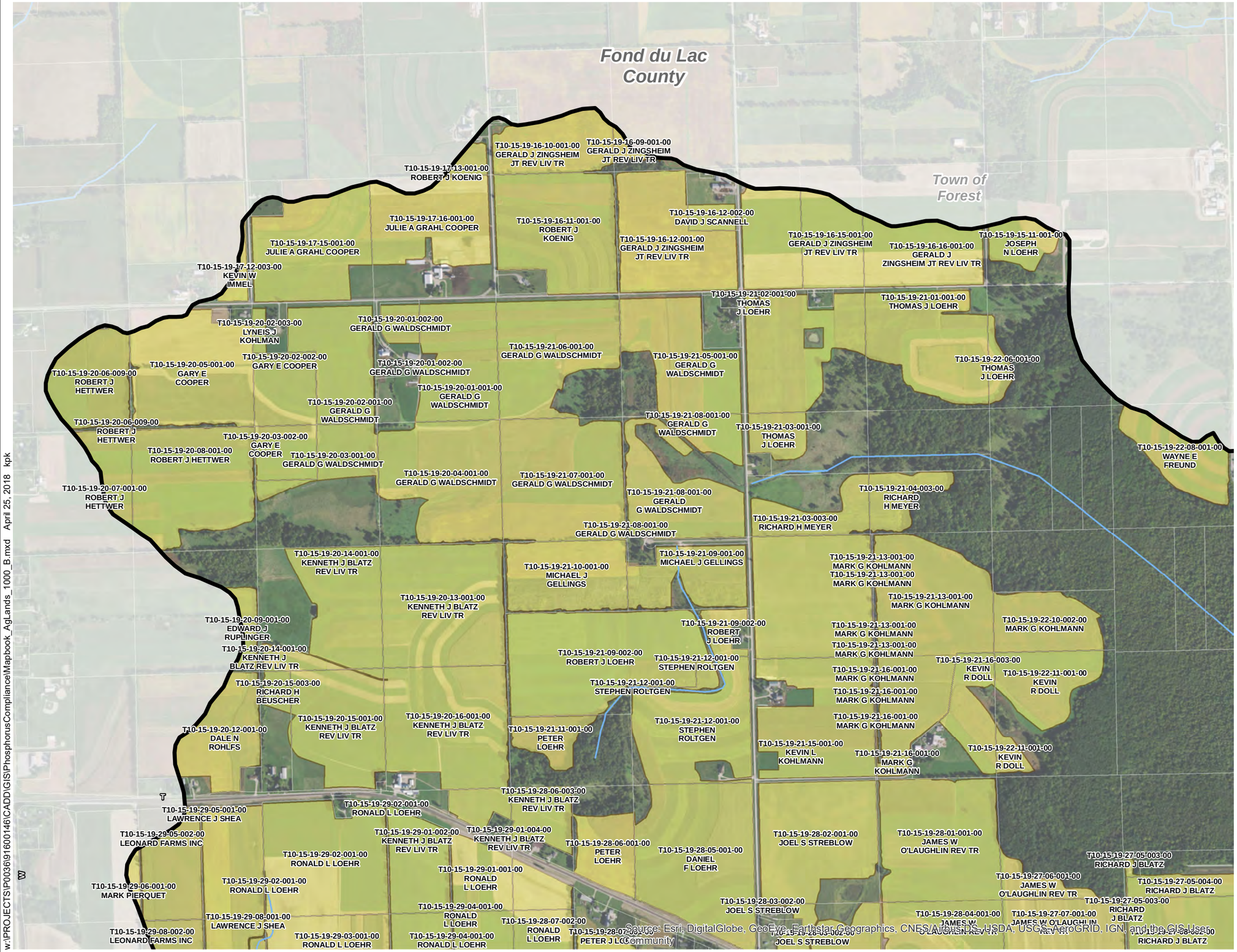


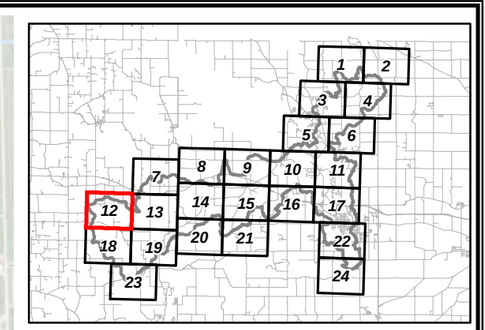


**Mapped Features**

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
- Surface Water

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 12 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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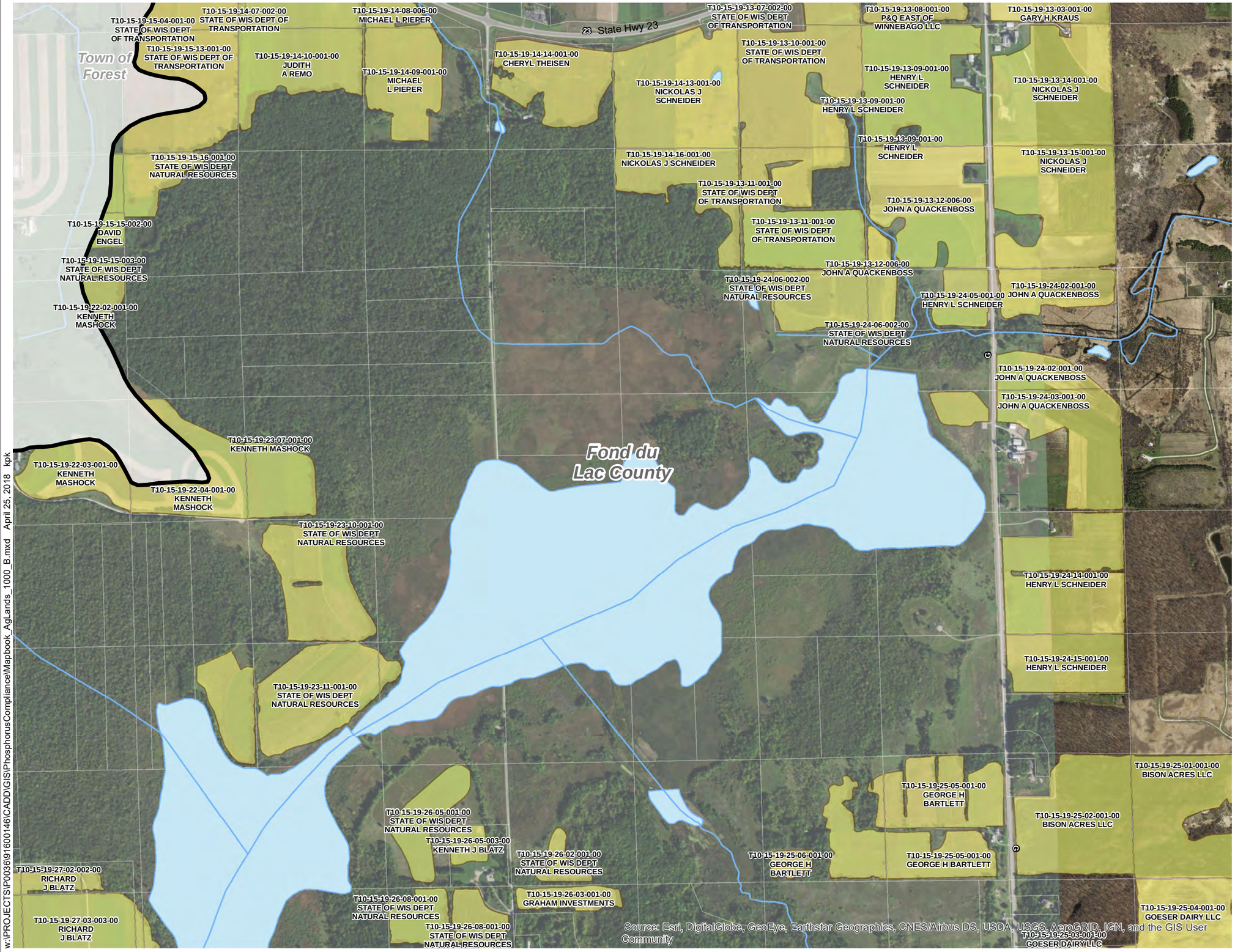


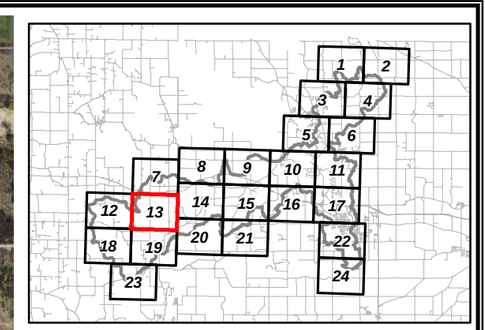


**Mapped Features**

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 13 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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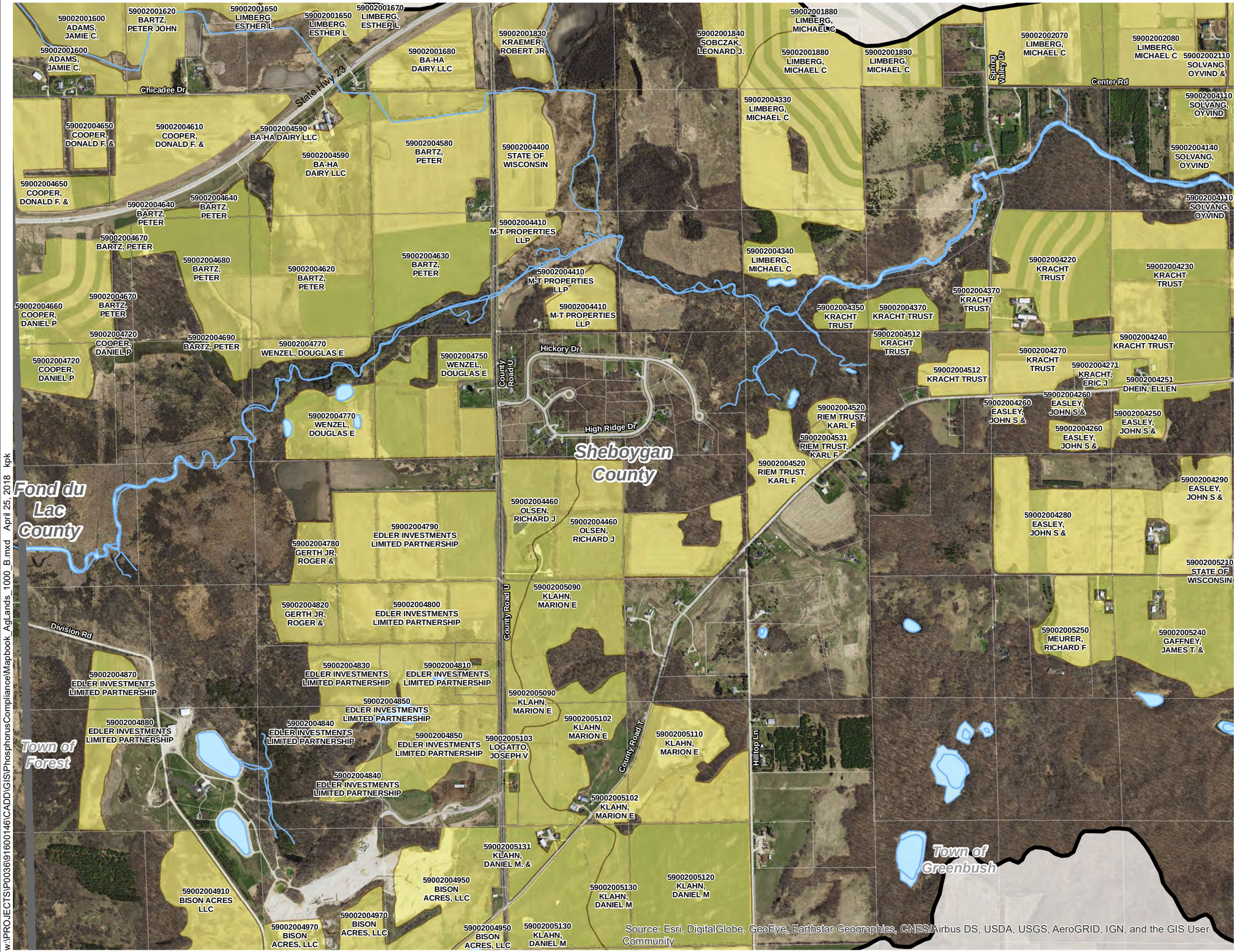


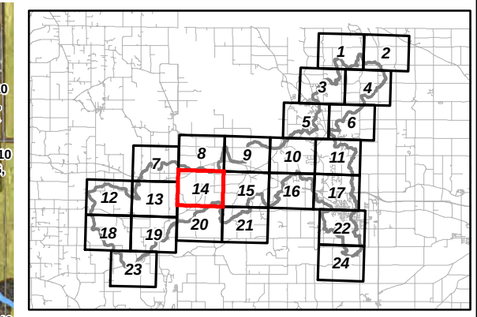


## Mapped Features

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 14 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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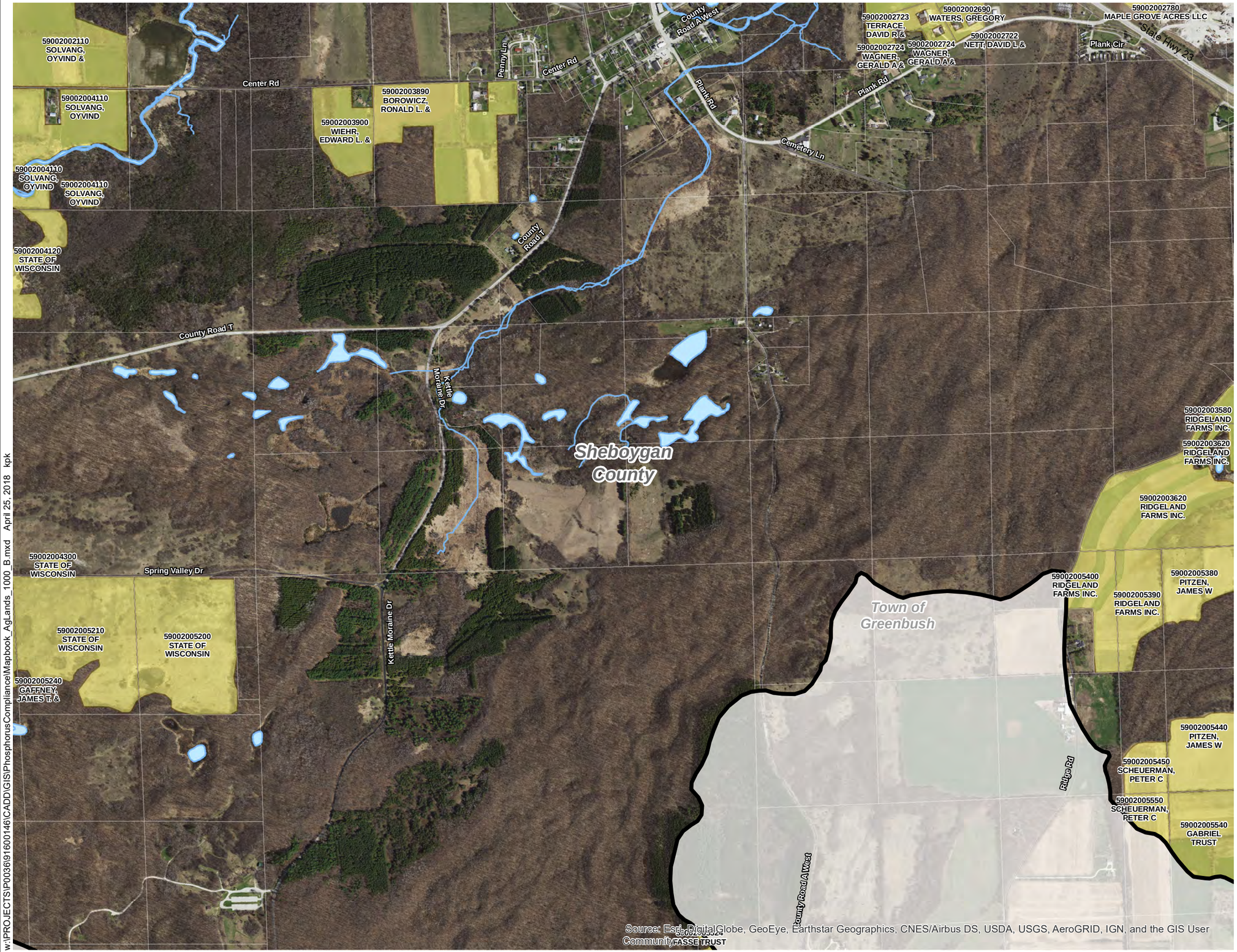


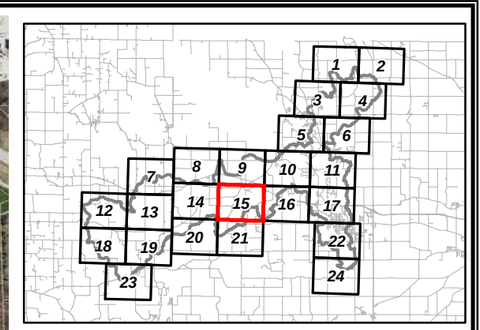


## Mapped Features

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 15 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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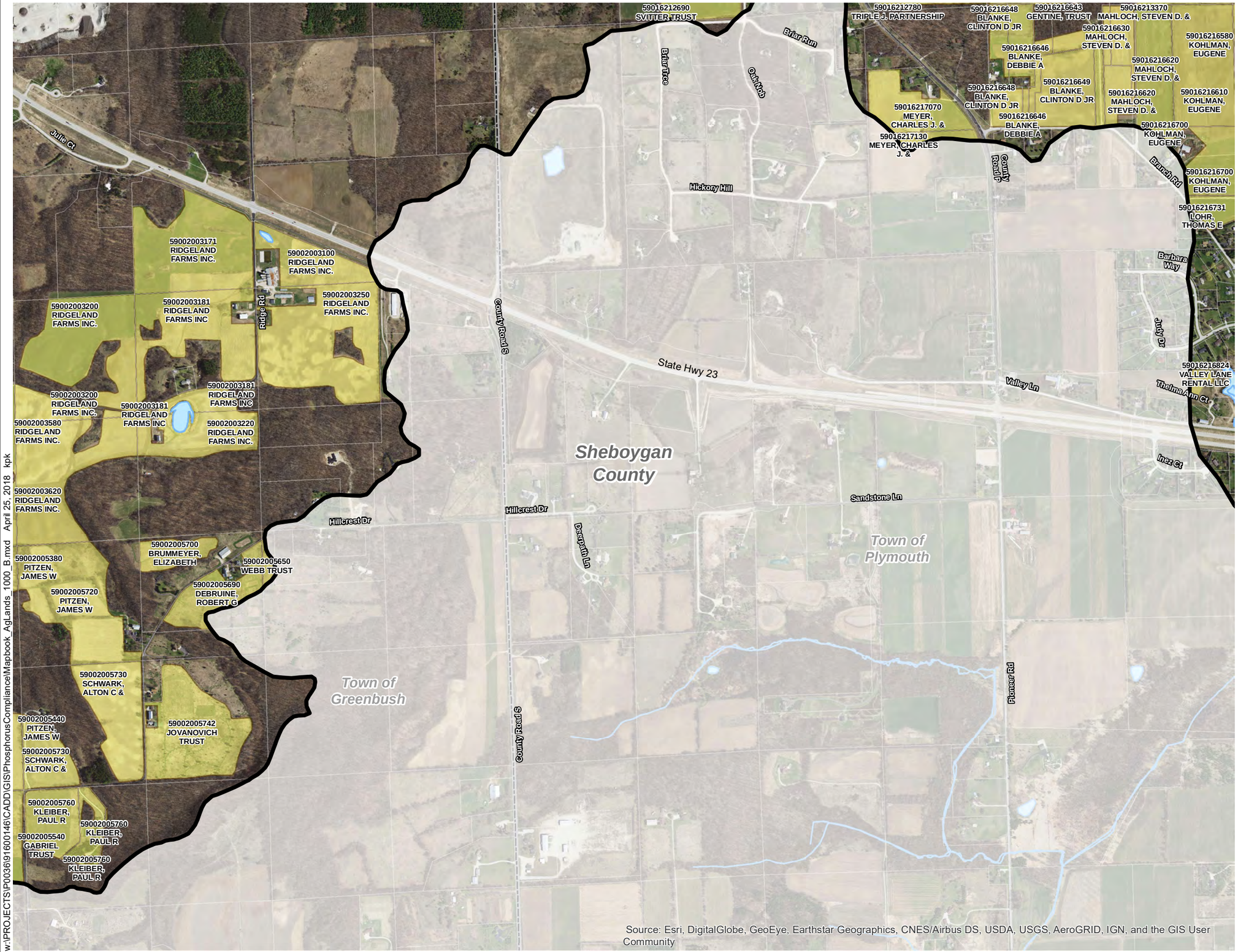
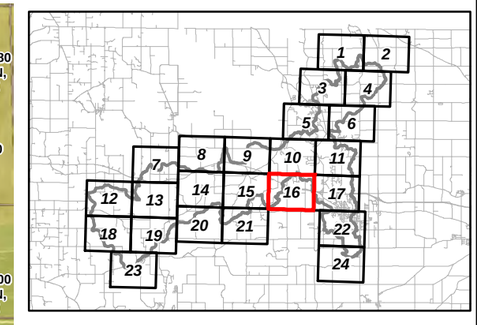



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community




**Mapped Features**

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
- Surface Water

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 16 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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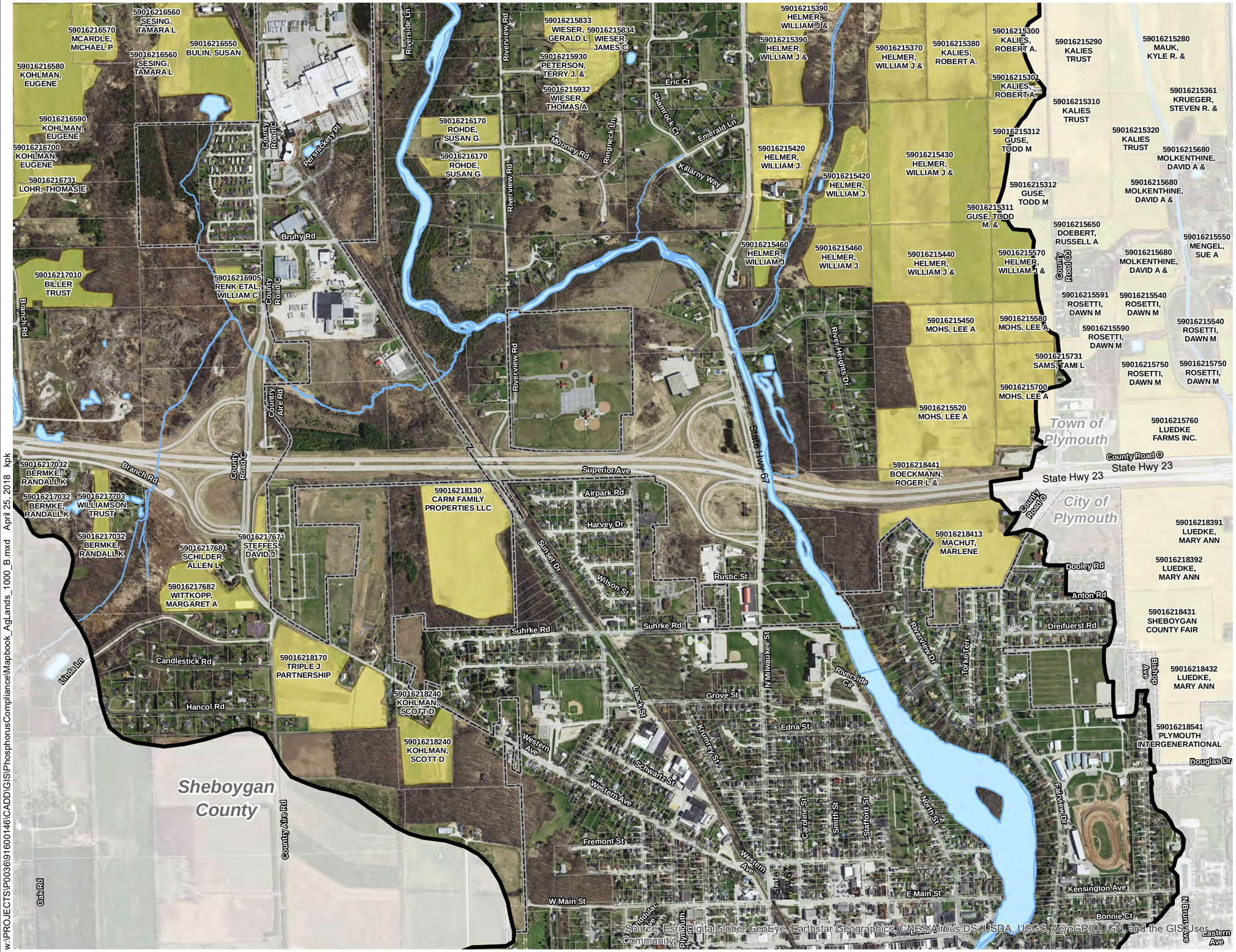


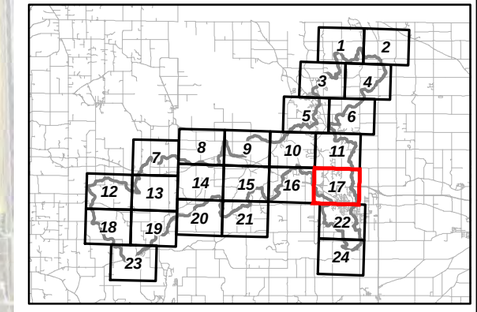


## Mapped Features

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 17 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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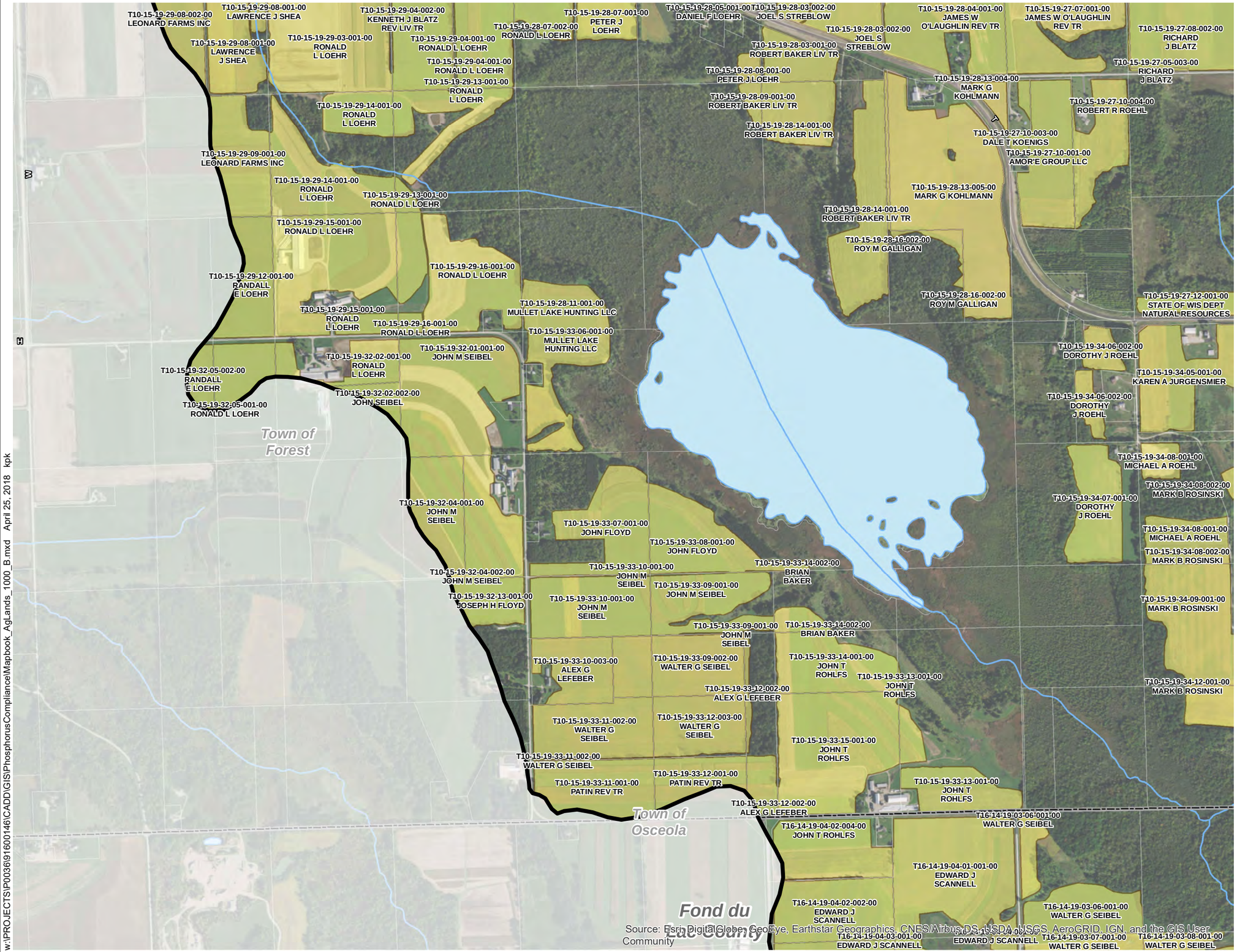


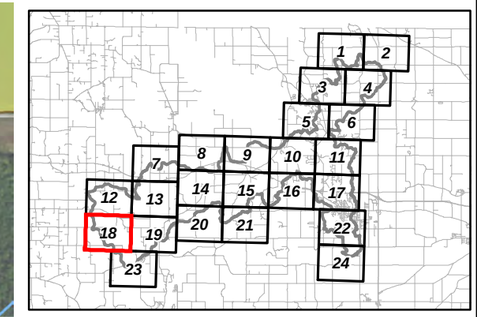


## Mapped Features

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 18 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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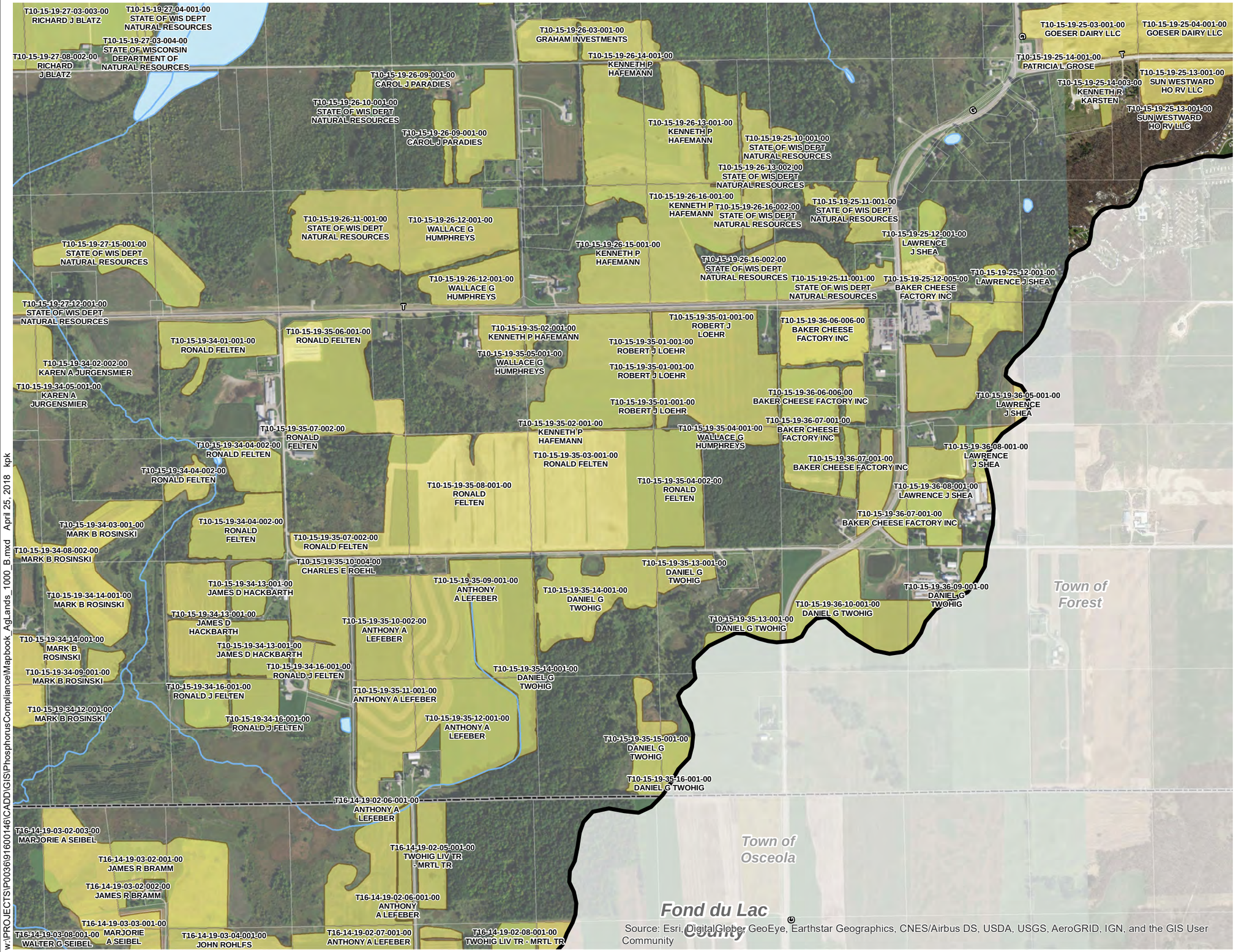
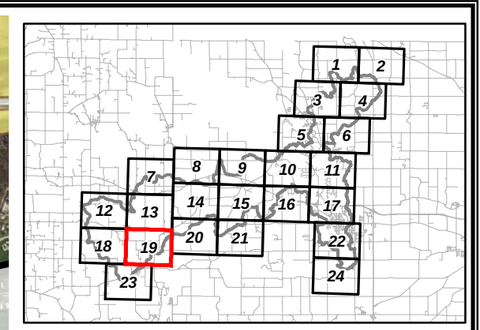



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community




## Mapped Features

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
- Surface Water

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 19 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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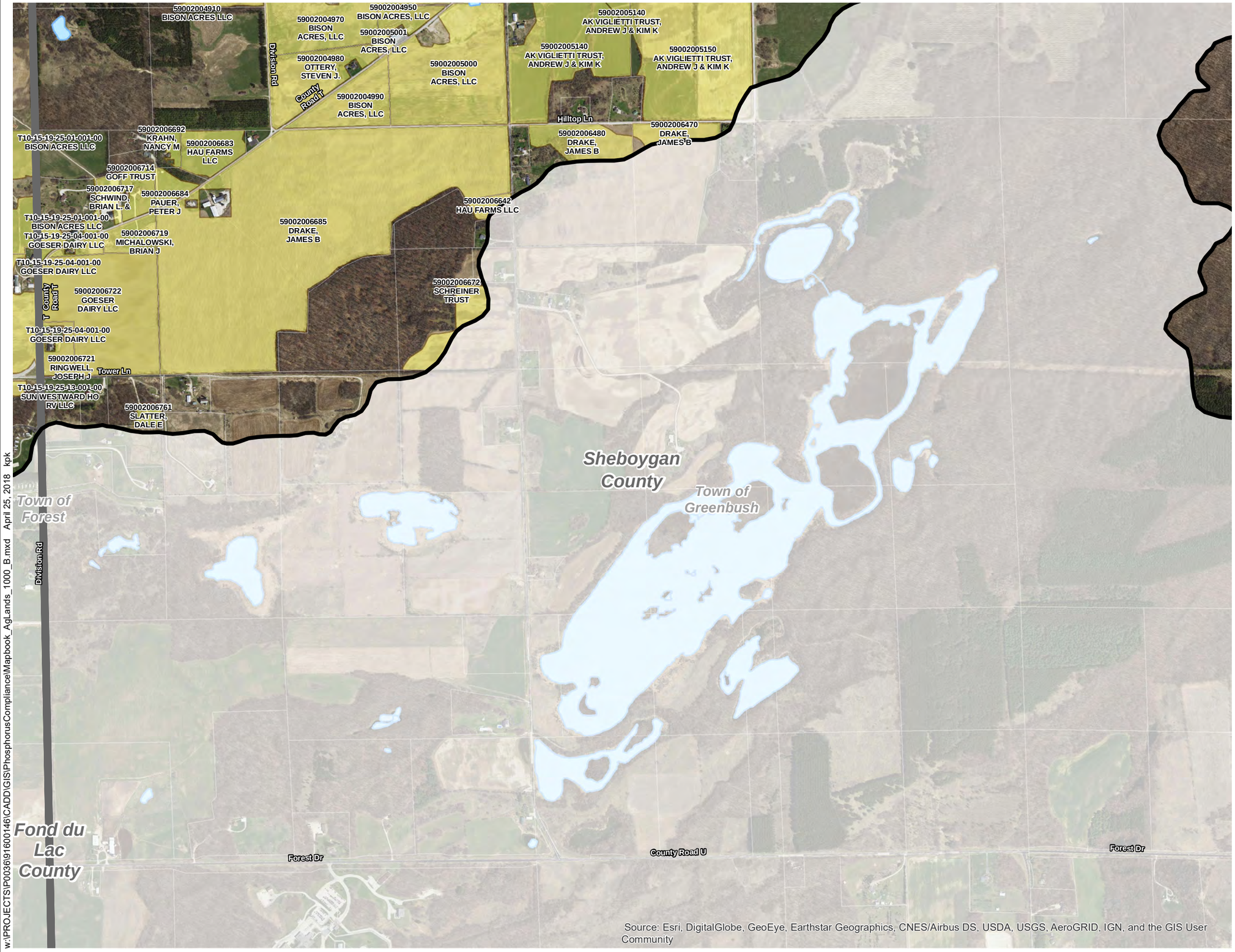


Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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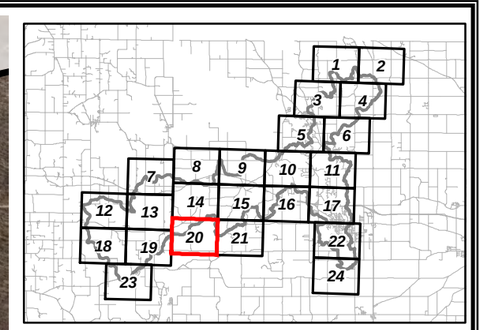


**Mapped Features**

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
- Surface Water

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

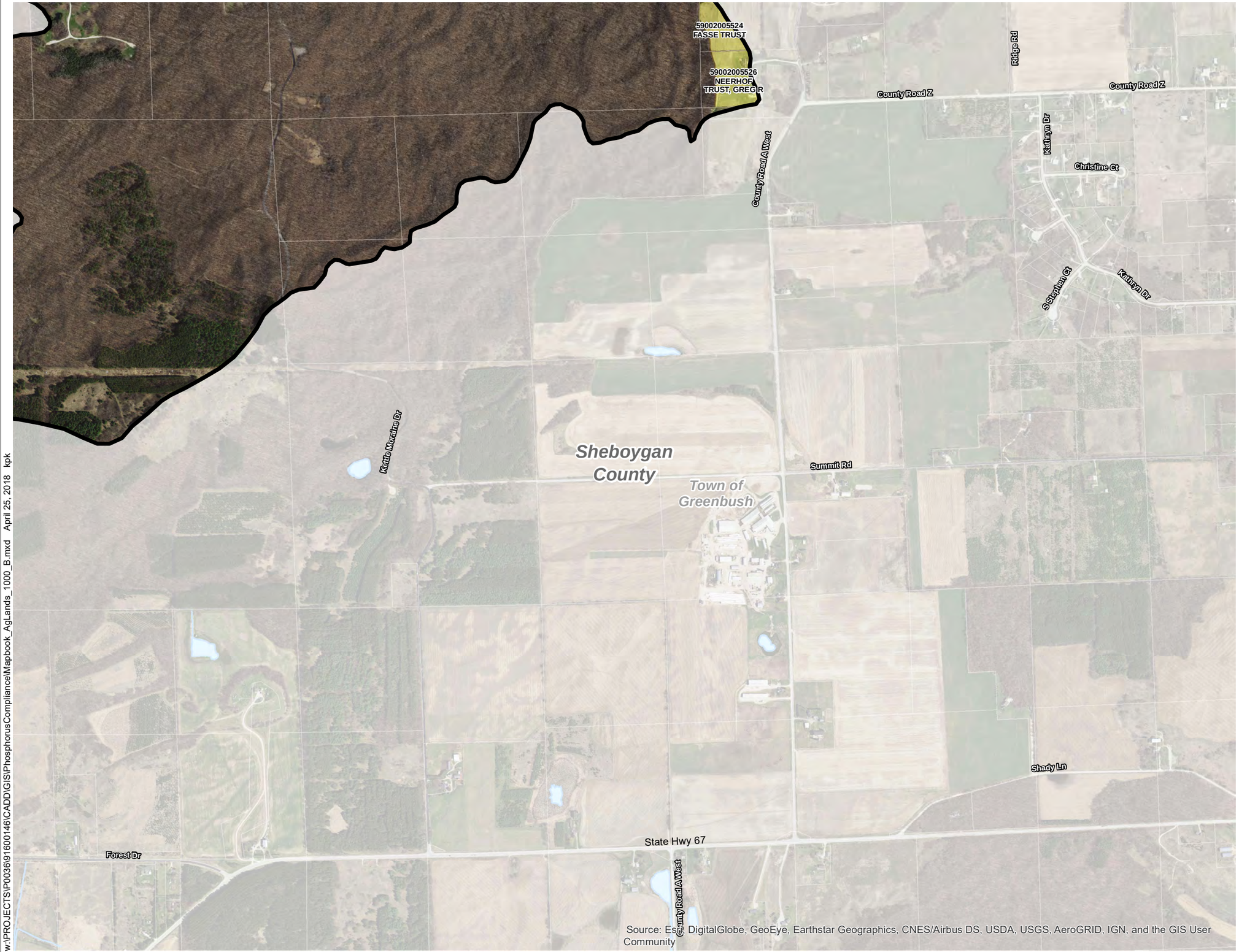
FIGURE 20 OF 24

**AGRICULTURAL LAND MAPBOOK**

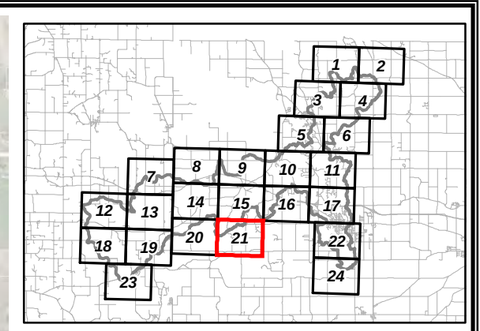
PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN




Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community




**Mapped Features**

- Agricultural Land
- HUC 12 Watershed Boundary
- County Boundary
- Municipal Boundary
- Parcel Line
- Stream
- Surface Water

Source: Sheboygan County, 2013-15; Fond du Lac County, 2013; WDNR, 2008-12.

Disclaimer: The property lines, right-of-way lines, and other property information on this drawing were developed or obtained as part of the County Geographic Information System or through the County property tax mapping function. McMAHON does not guarantee this information to be correct, current, or complete. The property and right-of-way information are only intended for use as a general reference and are not intended or suitable for site-specific uses. Any use to the contrary of the above stated uses is the responsibility of the user and such use is at the user's own risk.

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 21 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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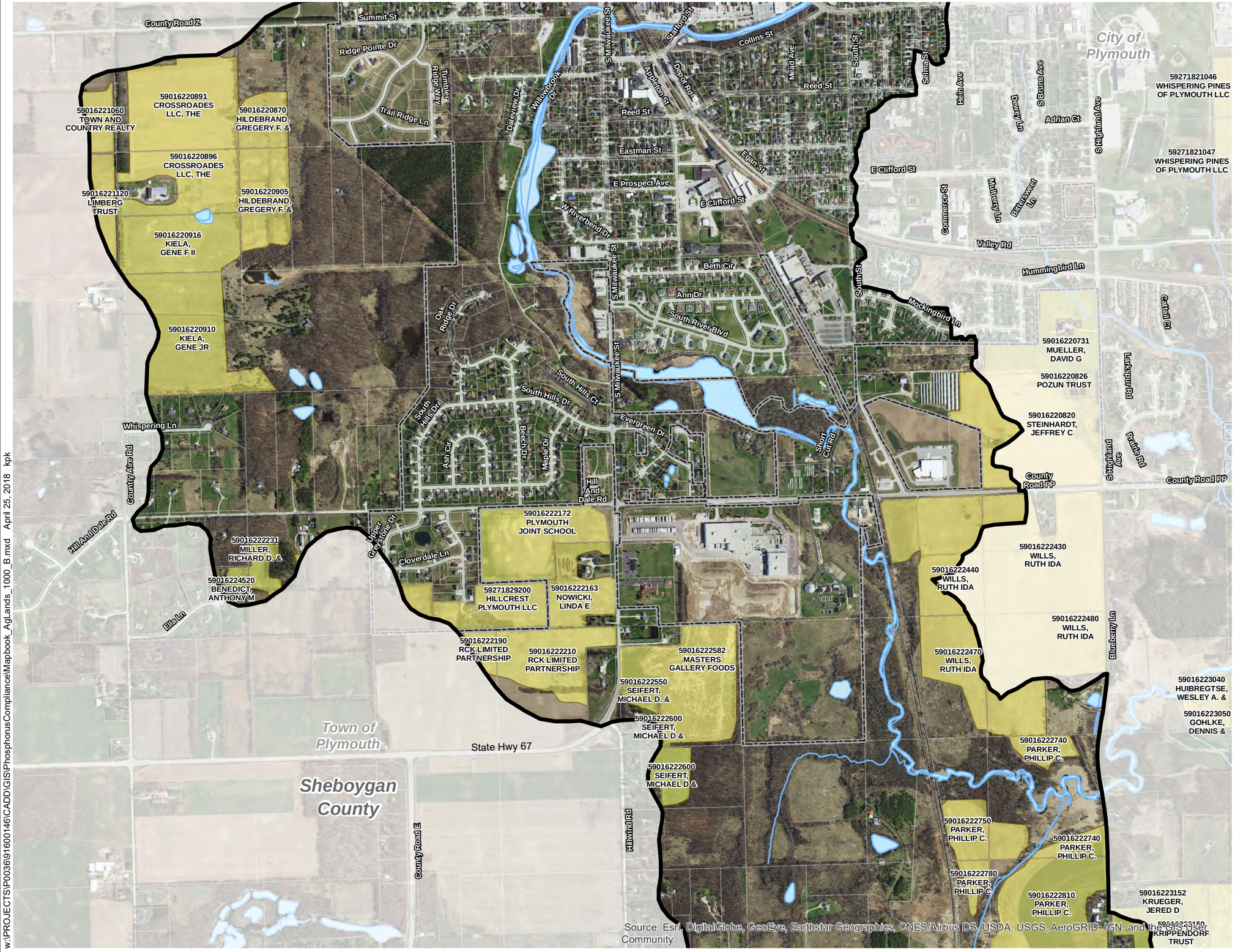


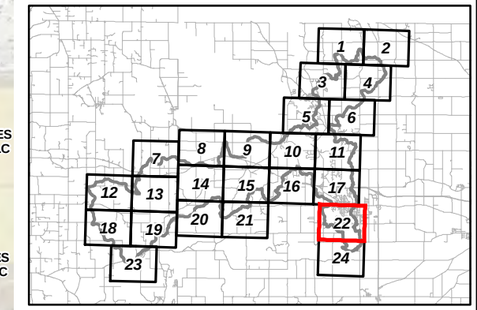


## Mapped Features

- Agricultural Land
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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 22 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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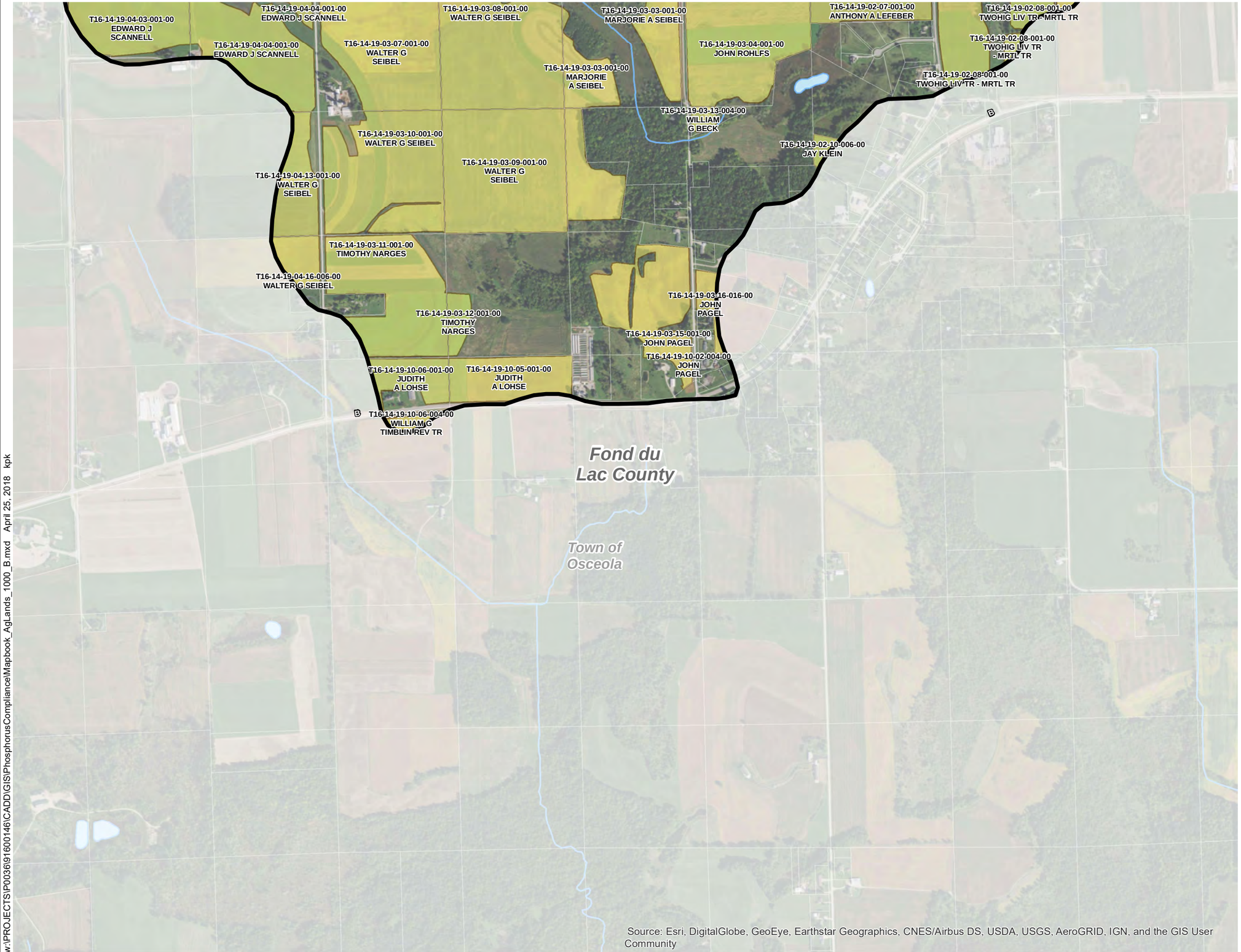


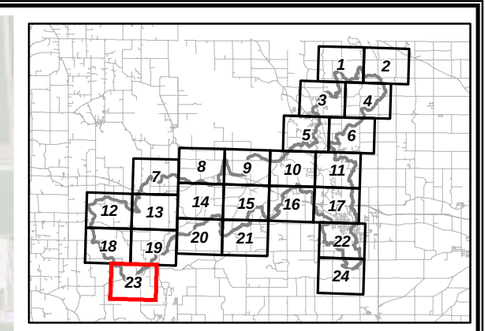


## Mapped Features

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 23 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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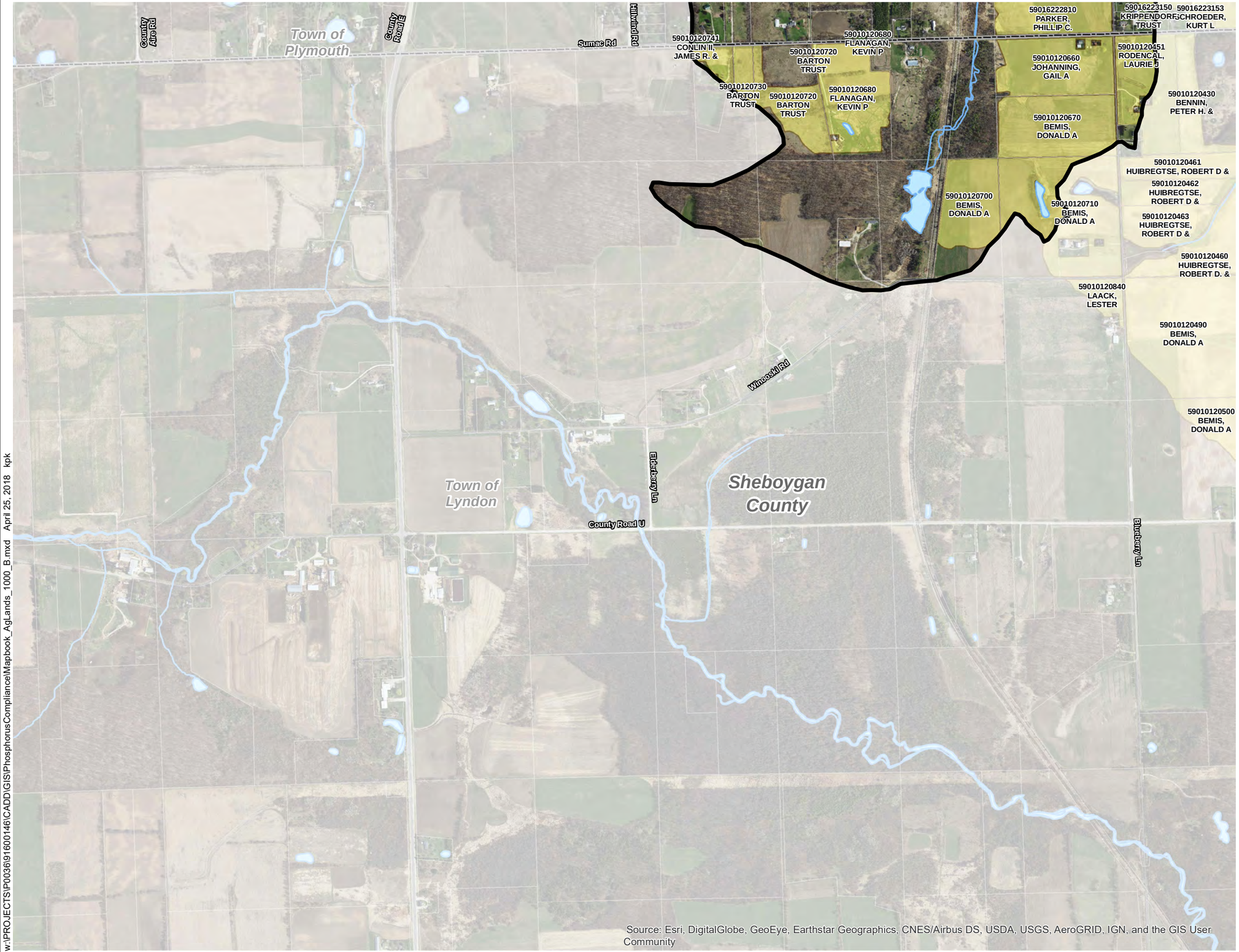
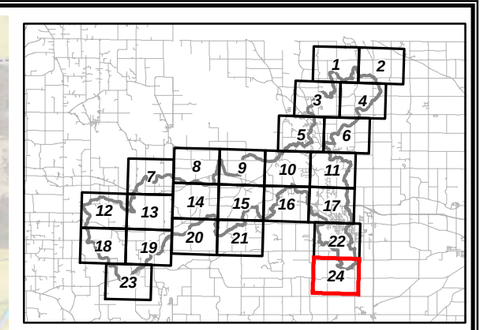



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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PLYMOUTH UTILITIES

McMAHON ENGINEERS ARCHITECTS

FIGURE 24 OF 24

**AGRICULTURAL LAND MAPBOOK**

PLYMOUTH UTILITIES COMMISSION

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN

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# APPENDIX J

FINANCIAL SECURITY RESOLUTION

CITY OF PLYMOUTH WISCONSIN

## RESOLUTION NO. 21 OF 2018

## A RESOLUTION ACKNOWLEDGING FINANCIAL OBLIGATIONS TO MEET REQUIREMENTS OF THE WISCONSIN POLLUTANT DISCHARGE ELIMINATION SYSTEM (WPDES) PERMIT AND ADAPTIVE MANAGEMENT PROGRAMS

**WHEREAS,** the City of Plymouth owns and operates a municipal wastewater treatment system; and

**WHEREAS,** the City of Plymouth intends to implement an Adaptive Management Program to comply with the water quality based effluent limits for phosphorus established by its Wisconsin Pollutant Discharge Elimination System (WPDES) Permit; and

**WHEREAS,** the City of Plymouth expects to finance the program with user charges and funds of Plymouth Utilities; and

**NOW, THEREFORE, BE IT RESOLVED,** by the Common Council of the City of Plymouth, Sheboygan County, Wisconsin, that it confirms that the City of Plymouth has the financial means and commitment to implement the project requirements during the next 5-year WPDES permit term, beginning upon the issuance of the permit in 2018.

This Resolution shall be effective as of the date of its passage by the Common Council.

Adopted this 31st day of July, 2018

**CITY OF PLYMOUTH**

CITY OF PLYMOUTH WISCONSIN INCORPORATED APRIL 1877 SEAL

Donald O. Pohlman, Mayor

**CERTIFICATION**

I hereby certify that the foregoing Resolution was duly adopted by the Common Council of the City of Plymouth on this 3rd day of August, 2018.

**Patricia Huberty**, Clerk/Treasurer