Stormwater Management Plan

City-Wide Stormwater Quality Management Plan

Prepared For
PLYMOUTH UTILITIES
SHEBOYGAN COUNTY, WISCONSIN

SEPTEMBER 23, 2019

McM. No. P0036-9-18-00188

AWS:car

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1.0 INTRODUCTION

At the request of the City of Plymouth, McMahon Associates, Inc. (McMAHON) prepared the following City-Wide Stormwater Quality Management Plan. The City obtained an Urban Non-Point Source and Stormwater Planning (UNPS&SW) Grant from the Wisconsin Department of Natural Resources (WDNR) to assist with preparation of the plan.

The City of Plymouth anticipates needing an NR 216 Municipal Separate Storm Sewer System (MS4) Permit from WDNR when its population reaches 10,000 persons. The proposed planning activities will assist the City with pro-actively meeting these future MS4 stormwater regulations. In addition, these planning activities will assist the City reduce Total Phosphorus (TP) and Total Suspended Solids (TSS) loads discharging into the Mullet River from the City's stormwater system and developed urban area.

Relationship to Other Plans

This Stormwater Quality Management Plan compliments and is part of efforts to implement recommendations contained in other existing resource management plans. These related resource management plans include the following:

- The City of Plymouth Comprehensive Plan (Vandewalle & Associates, dated July 12, 2011) has the following water quality recommendations: provide essential municipal services and facilities including stormwater management facilities, require development projects to include City-approved stormwater management facilities and continue to update studies and plans on a regular basis.

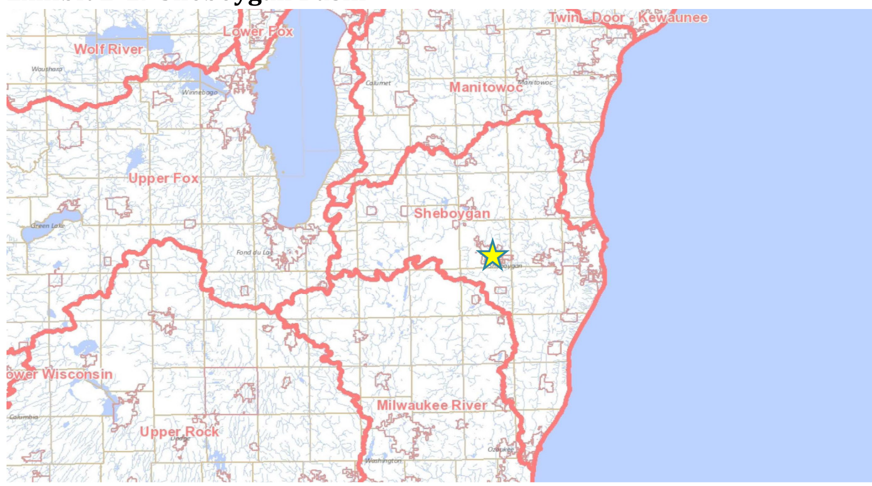
2.0 OVERVIEW OF STUDY AREA

The City of Plymouth is located in Sheboygan County, Wisconsin. The study area for this Stormwater Management Plan is depicted in Figure 1. The study area contains approximately 3,443 acres of area which is the City's municipal boundary. As shown in Figure 2, several Municipal Separate Storm Sewer System (MS4) jurisdictions are located within and directly adjacent to the City.

Basins

The WDNR divided the state into 24 basins or Water Management Units (WMU). The City's study area is located in the Sheboygan Basin. The basin boundaries are similar to the federally designated 8-digit Hydrologic Unit Code (HUC) boundaries.

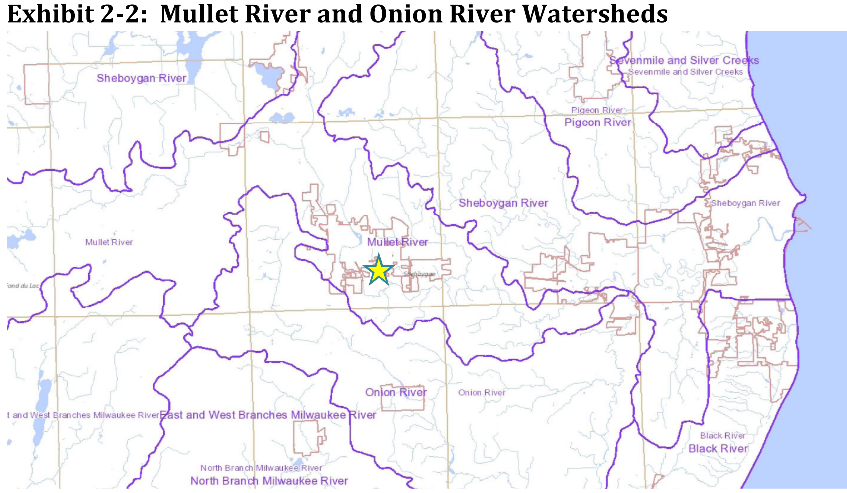
Exhibit 2-1: Sheboygan Basin



Watersheds

The WDNR divided the Northeast Lakeshore Basin into six watersheds and the study area is located in two of these watersheds: Mullet River (SH05) & Onion River (SH04).

Exhibit 2-2: Mullet River and Onion River Watersheds



Sub-Watersheds

For purposes of this Stormwater Management Plan, the City was divided into two sub-watersheds. The sub-watersheds are depicted in Figure 3 and summarized in Table 2-1. The sub-watersheds were delineated after considering the locally designated stormwater planning boundaries and federally designated 12-digit HUC boundaries.

Table 2-1

Sub-Watersheds

Sub-Watershed	WDNR Watershed	WDNR Basin Name
Mullet River	Lower Mullet River (040301010903)	Mullet River (SH05)
Onion River	Upper Onion River (040301011001)	Onion River (SH04)

Natural Resources

Natural resource features include surface waters (lakes, rivers, streams), wetlands, and endangered or threatened resources. Natural resource features located in the study area are depicted in Figure 4. Some of these natural resource features are protected with a special regulatory designation such as outstanding resource water, exceptional resource water, 303(d) impaired water, endangered species, and threatened species. Natural resource features located in the study area with one of these special regulatory designations are identified below.

Outstanding and exceptional resource waters are pristine 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. For example, cold water trout streams and natural waterfalls are typically classified as outstanding or exceptional resource waters. The City does not discharge stormwater runoff into any outstanding resource waters or exceptional resource waters.

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 EPA requires each state to update its 303(d) impaired waters list every two years, including Wisconsin. The City's study area discharges stormwater runoff into two 303(d) impaired waters:

- Mullet River: Mullet River is a 303(d) impaired water body due to point and non-point source pollution. Pollutants of concern include total phosphorus. Impairments include water quality use restrictions. The attainable use for Mullet River is warm water dependent sport fishery and the designated use is warm water sport fishery. Currently, Mullet River is not supporting its attainable use.

- Onion River: Onion River is a 303(d) impaired water body due to point and non-point source pollution. Pollutants of concern include total phosphorus. Impairments include degraded biological community. The attainable use for Onion River is a fish & aquatic life community. Currently, Onion River is not supporting its attainable use.

Endangered and threatened resources are wild animal and plant species which are either in danger of extinction throughout all or a significant portion of its range or likely to become endangered in the foreseeable future. Typically, the location of an endangered or threatened species is tracked in Wisconsin's Natural Heritage Inventory and is only identified by Township. Sensitive species that are particularly vulnerable to collection or disturbance are only identified by county. The Natural Heritage Inventory maps and species lists are routinely updated by WDNR. To prevent collection or disturbance of sensitive species, endangered and threatened resources are not depicted in Figure 4.

Cultural Resources

Cultural resources are places of cultural significance. Some cultural resources are protected with a special regulatory designation such as archeological sites and historical sites. The Wisconsin Historical Society's register indicates there are seventeen historical sites located within the study area. Archeological sites may be located within the study area, but cannot be disclosed by law. The State of Wisconsin maintains maps and a computer database on the location and nature of archaeological sites. Special permission is required to view these maps and databases. The location of archaeological sites is exempt from public disclosure to prevent collection or disturbance of valuable artifacts.

Remediation & Waste Disposal Sites

Remediation sites are places where cleanup of environmental soil or groundwater contamination is on-going or completed. Remediation sites may involve hazardous wastes, underground storage tanks, or other contaminant sources. Waste disposal sites are places where solid wastes are stored. Understanding the location of remediation and waste disposal sites is an important consideration when evaluating potential stormwater retrofit locations. The approximate location of WDNR identified remediation sites (open and closed sites) and waste disposal sites (not archived) are depicted in Figure 4.

Soils

Soil information is from the Natural Resource Conservation Service/U.S. Department of Agriculture web soil survey for Sheboygan County. The U.S. Department of Agriculture has classified soil types into four Hydrologic Soil Groups (HSG). The four HSGs (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 2018 update to the Sheboygan County hydrologic soil groups was used. Hydrologic soil groups are depicted in Figure 5.

MS4 System

The municipal separate storm sewer system (MS4) consists of publicly owned or operated conveyance systems including streets, curbs, gutters, catch basins, storm sewers, swales, channels, culverts, and occasionally bridges. The MS4 system is depicted in Figure 6.

The MS4 system contains several structural Best Management Practices (BMPs). The structural BMPs are depicted in Figure 7 and summarized in Table 2-2. Structural BMPs include wet detention ponds, dry detention ponds, biofilters, proprietary devices, and other devices. Some of these structural BMPs are publicly owned and others are privately owned. Table 2-2 identifies the public and private BMP's the City has legal maintenance authority over.

Table 2-2

Structural BMPs

BMP ID	BMP Name	Type of Structural BMP	BMP Owner	Maintenance Agreement
L3a4b	Walmart Southeast	Wet Pond	Private	No
L3a4c	Walmart Northeast	Wet Pond	Private	No
L3a4d	Walton Drive Pond	Wet Pond	Private	No
L3a4f	Aurora Health Center East	Wet Pond	Private	No
L3a5d	Walmart Southwest	Wet Pond	Private	No
L3a5e1a	First National Bank North	Biofilter	Private	No
L3a5e2a	First National Bank South	Biofilter	Private	No
L3a5e4	Pleasant View Townhomes	Wet Pond	Private	No
L3a5i	East Towne Estates South	Wet Pond	Private	No
L3a5m	Plymouth Intergenerational	Wet Pond	Private	No
L3a5p	Aurora Health Center West	Wet Pond	Private	No
L3a6c1	Kwik Trip	Hydroworks Manhole	Private	No
L3a7a	Village Neighborhood	Wet Pond	City	Yes
L3a7b	Briarwood Cottages II East	Wet Pond	Private	No
L3b1b	Country Visions Coop West	Wet Pond	Private	No
L3b1c	Country Visions Coop East	Wet Pond	Private	No
L3b2a	Oshkosh Cold Storage East	Wet Pond	Private	No
L3b3b	East Industrial Park East	Wet Pond	City	Yes
L3b3c	East Industrial Park West	Wet Pond	City	Yes
L3b4a	Glacier Transit	Wet Pond	Private	No
L3b5b	JJ Trucking	Wet Pond	Private	No
L3b5d	Weber C Store	Wet Pond	Private	No
L4a	Oshkosh Cold Storage West	Wet Pond	Private	No
L6c3	Great Lakes Cheese	Wet Pond	Private	No
L6c4b	Wisconsin Plastic Products	Wet Pond	Private	No
L6d2	Eagle Hills	Wet Pond	City	Yes
L6f2a	Plymouth High School North	Biofilter	Private	No
L6f2b	Plymouth High School South	Biofilter	Private	No
L6f5	Briarwood Cottages II West	Wet Pond	Private	No
L8b	Masters Gallery Foods East	Wet Pond	Private	No
L8b-1	Suchon Funeral Home	Dry Pond	Private	No
L8c	Masters Gallery Foods West	Wet Pond	Private	No

Table 2-2

Structural BMPs

(continued)

BMP ID	BMP Name	Type of Structural BMP	BMP Owner	Maintenance Agreement
L9b	Plymouth Utilities Center	Wet Pond / Infiltration	City	Yes
L9e2a	Clifford Mini Storage	Wet Pond	Private	No
L11e1	Hill & Dale Development	Wet Pond	Private	No
L13d	Tumbler Ridge Subdivision	Wet Pond	Private	No
L18b1	Fairview Elementary	Underground Pond	Private	No
L21c1	Plymouth Foam South	Underground Pond	Private	No
L21c2	Plymouth Foam Parking	Wet Pond	Private	No
L21c4	Plymouth Foam North	Underground Pond	Private	No
L21d1	Sargento Foods North Yard	Infiltration Basin	Private	No
L21d2	Sargento Foods South	Bioswale	Private	Yes
L21d3	Sargento Foods Central	Infiltration Basin	Private	Yes

The MS4 system is based on available records. The MS4 system contains three different types of surface drainage: curb & gutter, grass swales, and areas not served by a control measure. The types of surface drainage are depicted in Figure 8.

WPDES Industrial Permits

As shown in Figure 9 and summarized in Table 2-3, there are six industrial operations with coverage under a WPDES Industrial Permit that are currently located within the City. WPDES Industrial Permits are regulated by the WDNR. Some WPDES Industrial Permits may allow discharges into the MS4 system during dry weather. Understanding the location of the WPDES Industrial Permitted sites is important to effective implementation of the City's stormwater program.

Table 2-3

WPDES Industrial Permits

I.D.	Facility Name	Facility Address
1	BPB Mfg. Inc. Plymouth Plant	1415 Pilgrim Road
2	Cedar Grove Warehousing	802 South Street
3	Great Lakes Cheese of WI, LLC	2602 County Road PP
4	Johnson School Bus Service Inc	808 Valley Drive
5	Plymouth Foam Products Inc	1800 Sunset Drive
6	Sartori Company West Main Building	12 W. Main Street

Drinking Water System

The City of Plymouth has a ground water supply which consists of seven active wells in four different aquifers. Storage is provided by three reservoirs. Overall, the City has 65 miles of water main. According to Plymouth Utilities 2018 Annual Drinking Water Quality Report, the system's contaminant levels were below levels allowed by state and federal regulations.

Land Uses

The location of publicly owned parks, recreational areas, open lands, and municipal facilities are depicted in Figure 9. Understanding the location of publicly owned land is important to effective implementation of the municipal stormwater program.

Land uses on or before October 1, 2004 are depicted in Figure 10 and summarized in Table 2-4. Table 2-4 summarizes the 2004 land uses located within the study area. For purposes of the NR 151 pollutant analysis, undeveloped sites less than 5 acres are shown to be developed based on adjoining land uses. Undeveloped sites greater than 5 acres are shown as agriculture, woods, grass, or another undeveloped open space, as appropriate.

Current land uses (2018) are depicted in Figure 11 and summarized in Table 2-4 for the study area. For purposes of the Total Maximum Daily Load (TMDL) pollutant analysis, the undeveloped in-fill sites are shown as agriculture, grass, woods, wetland or another undeveloped open space, as appropriate. Future land uses are depicted in Figure 12 and summarized in Table 2-4 for the study area. For purposes of the TMDL pollutant analysis, the future land uses generally match the Current (2018) land uses, except the appropriate undeveloped sites are converted to a future land use based on adjoining land uses and information from the City.

Table 2-4

Land Uses

	2004 Land Use		Current Land Use		Future Land Use	
Land Use	**(acres)**	**(%)**	**(acres)**	**(%)**	**(acres)**	**(%)**
Residential						
Low Density	58	1.7%	90	2.6%	98	2.9%
Med Density	856	24.8%	951	27.6%	1,060	30.8%
Mobile Home	29	0.8%	29	0.8%	30	0.9%
Multi-Family	83	2.4%	115	3.3%	166	4.8%
Suburban	19	0.5%	18	0.5%	26	0.8%
Commercial						
Commercial Strip	88	2.6%	93	2.7%	111	3.2%
Downtown Commercial	32	0.9%	32	0.9%	32	0.9%
Office Park	49	1.4%	103	3.0%	137	4.0%
Shopping Center	32	0.9%	32	0.9%	52	1.5%

Table 2-4

Land Uses

(continued)

Land Use	2004 Land Use (acres)	2004 Land Use (%)	Current Land Use (acres)	Current Land Use (%)	Future Land Use (acres)	Future Land Use (%)
Institutional						
Hospital	14	0.4%	18	0.5%	18	0.5%
Misc. Institutional	79	2.3%	96	2.8%	159	4.6%
School	117	3.4%	117	3.4%	117	3.4%
Industrial						
Light Industrial	324	9.4%	452	13.1%	768	22.3%
Open Space						
Cemetery	19	0.5%	23	0.7%	28	0.8%
[1]Park	241	7.0%	241	7.0%	251	7.3%
Railroad	54	1.6%	54	1.6%	54	1.6%
[2]Undeveloped	1,237	35.9%	866	25.1%	227	6.6%
Highway/Freeway/Rural Rd	113	3.3%	114	3.3%	107	3.1%
TOTAL	3,443	100.0%	3,443	100.0%	3,443	100.0%

[1]Includes grass and water associated with stormwater ponds/facilities.

[2]Undeveloped land includes agriculture, grass, woods, wetlands, and open water.

3.0 NR 151 POLLUTANT ANALYSIS

Performance Standard

Pursuant to the Municipal Stormwater Discharge (MS4) Permit and NR 151.13, MS4 permitted communities are required to reduce the TSS load by 20% and 40% for urban areas developed before October 1, 2004. The TSS reductions are calculated from a baseline load that does not include any stormwater BMPs, such as street sweeping and wet ponds. As previously mentioned, the City currently does not have a MS4 Permit and is not yet required to meet the NR 151.13 requirements but desires to work toward compliance as cost effective and dual purpose opportunities arise. The MS4 permitted communities compliance schedules for the required TSS reductions are as follows:

- A 20% TSS reduction is required within 2 years of receiving MS4 Permit coverage. The City has not yet received permit coverage from the WDNR. At such a time the City receives a MS4 Permit from WDNR, the City will be required to achieve the 20% TSS reduction before 2 years from that date.

- For MS4 permitted communities, a 40% TSS reduction is required before March 31, 2013. If the 40% reduction could not be achieved by March 31, 2013, the permitted community would be required to prepare a long-term stormwater management plan that identifies the control measures already implemented, the control measures to be implemented, and a schedule for achieving the 40% TSS reduction. As part the MS4 Permit, MS4 permitted communities are required to track phosphorus, but no NR 151.13 performance standard is provided for phosphorus.

The 2011 Wisconsin Act 32 modified the compliance schedule for the NR 151.13 performance standards. According to Wisconsin Act 32, the WDNR may enforce MS4 permitted communities compliance date for achieving the 20% TSS reduction, but the WDNR is currently prohibited from enforcing a specific compliance date for achieving the 40% TSS reduction. Also, the 2011 Wisconsin Act 32 requires that the pollutant reduction benefits associated with all structural BMPs implemented before July 1, 2011 must be maintained.

Methodology

The NR 151 pollutant analysis uses the Source Loading and Management Model for Windows (WinSLAMM Version 10.2.1). WinSLAMM is a stormwater quality model that predicts runoff volumes and non-point source pollution loads for urban land uses. WinSLAMM also calculates the amount of pollutant removal provided by BMPs such as street sweeping, catch basin cleaning, grass swales, grass filter strips, biofiltration, infiltration basins, wet detention ponds, permeable pavement, proprietary devices, and other BMPs. The NR 151 pollutant analysis uses the series of small rainfall events that occurred between March 29, 1968 and November 25, 1972 in Green Bay, Wisconsin. For purposes of MS4 Permit compliance, this 5-year rainfall series was determined by the WDNR to represent an average annual rainfall condition for municipalities located in the northeast portion of Wisconsin.

The NR 151 pollutant analysis uses data files developed by the United States Geological Survey (USGS) and WDNR for the WinSLAMM model. The data files identify typical runoff volumes, pollutant concentrations, pollutant distributions, pollutant deliveries, and pollutant particle size distributions for typical urban stormwater runoff. The WinSLAMM data files obtained from the USGS and used in the NR 151 pollutant analysis are as follows:

- WisReg - Green Bay Five Year Rainfall.ran
- WI_GEO03.ppdx
- WI_SL06 Dec06.rsv
- V10.1 WI_avg01.pscx
- WI_Res and Other Urban Dec06.std
- WI_Com Inst Indust Dec06.std
- Freeway Dec06.std
- Nurp.cpz

The NR 151 pollutant analysis is based on the standard land use files developed by the WDNR for WinSLAMM. The standard land use files identify the amount of roof, parking lot, driveway, sidewalk, street, and lawn source areas which are typical for each standard land use. The standard land use files also identify the amount of connected imperviousness for each source area.

The NR 151 pollutant analysis uses the WinSLAMM batch processor to generate baseline (no-controls) pollutant loads for each standard land use file. Baseline pollutant loads for each drainage and BMP catchment area are calculated using batch processor database files and GIS. A WinSLAMM model is developed for each existing and proposed structural BMP to determine the BMP's pollutant reduction. The pollutant reduction provided by each BMP is then applied to each drainage or BMP catchment area, as appropriate.

Analysis Area

The NR 151 pollutant analysis uses the study area depicted in Figure 1 and the 2004 land uses depicted in Figure 10. For purposes of the NR 151 pollutant analysis, the study area contains 3,443 acres. For cities, the NR 151 pollutant analysis uses the entire municipal boundary. Per WDNR guidance, the following areas are either prohibited from inclusion or classified as optional for inclusion in the NR 151 pollutant analysis.

- Agricultural Areas: Lands zoned for agricultural use and operating as such are prohibited from inclusion in the NR 151 pollutant analysis. Of the 3,443 acres within the study area, 576 acres are classified as agriculture and consequently, are excluded from the analysis.

- Internally Drained Areas: Internally drained areas with natural infiltration are prohibited from inclusion in the NR 151 pollutant analysis. There are no known internally drained areas located within the 2004 developed urban area.

- Waters of the State: Waters of the state are optional for inclusion in the NR 151 pollutant analysis. Lakes, rivers, streams and mapped wetlands are classified as "waters of the state". Of the 3,443 acres within the study area, 227 acres are classified as "waters of the state" and consequently, are excluded from the analysis.

- Undeveloped Lands Over 5 Acres: Undeveloped lands over 5 acres are prohibited from inclusion in the NR 151 pollutant analysis. These areas will be classified as new development in the future and subject to NR 151.12 or 151.24 performance standards when developed. Of the 3,443 acres within the study area, 391 acres are classified as undeveloped lands over 5 acres (in 2004) and consequently, are excluded from the analysis.

- State & County Highways: State freeways, state truck highways, and county highways are excluded from the NR 151 pollutant analysis. The Wisconsin Department of Transportation (WisDOT) is responsible for pollutant loads from state freeway and state trunk highway right-of-way's and Sheboygan County is responsible for pollutant loads from county highway right-of-ways. The only time the City is responsible for pollutant loads from a state or county highway right-of-way is if the highway is classified as a "connecting highway" by the WisDOT or if the City has a bridge structure that allows a City street to cross over the state or county highway. Of the 3,443 acres within the study area, 30 acres are classified as State (WisDOT) MS4 jurisdiction and 67 acres are classified as County MS4 jurisdiction. The combined 97 acres of state and county highway right-of-way are excluded from the analysis.

- Riparian Areas: Riparian areas are optional to include in the NR 151 pollutant analysis. Riparian areas are private properties that do not discharge runoff into the City's MS4, but rather discharge directly into a river, stream, or lake. Riparian areas that discharge directly into Mullet River, Onion River or other navigable streams without passing through the City's MS4 are depicted in Figure 8. Of the 3,443 acres within the study area, 499 acres are classified as riparian and consequently, are excluded from the analysis.

- MS4 "A" to "B": Areas that discharge into an adjacent municipality's MS4 (Municipality B) without passing through the City's MS4 (Municipality A) are optional to include in the NR 151 pollutant analysis. These areas are shown in Figure 8. Many of these areas are located along state and county right-of-ways where runoff from private property drains directly into a State or County MS4 and then discharges directly into a river, stream, or lake. Of the 3,443 acres within the study area, 243 acres are classified as MS4 "A" to "B" and consequently, are excluded from the analysis.

- WPDES Industrial Permits: Industrial facilities permitted under NR 216 are optional to include in the NR 151 pollutant analysis. The City plans to achieve the required TSS and TP reductions for these industrial permitted areas for the following reasons: the City has legal authority to regulate stormwater runoff; the City has legal authority to charge a stormwater utility fee; it is difficult to determine which portions of an industrial site are covered by a WPDES Industrial Permit; and the pollutant load is the City's responsibility if the WPDES Industrial Permit is terminated or certified "No Exposure" in the future. For purposes of the NR 151 pollutant analysis, industrial areas with coverage under a WDPES Industrial Permit are included in the analysis.

Based on the prohibited and optional areas mentioned above, the NR 151 pollutant analysis applies to the remaining 1,410 acres of developed urban areas that existed on October 1, 2004. Note that all areas in the Onion River Sub-Watershed are within the exclusion areas listed above and are not be part of the developed urban area.

Baseline Condition

The NR 151 baseline loads for the 1,410 acres of developed urban area are summarized in Table 3-1. These baseline or "no control" loads exclude the pollutant reduction benefits of existing BMPs. Per NR 151.13, the baseline or "no control" loads are used to determine the 20% and 40% TSS load reduction.

Table 3-1

NR 151 Pollutant Analysis - Baseline Loadings (WinSLAMM)

Sub-Watershed	Urban Area (acres)	Baseline TSS Load (lbs/yr)	Required Load Reduction				Baseline TP Load (lbs/yr)
			TSS (%)	TSS (lbs/yr)	TSS (%)	TSS (lbs/yr)	
Mullet River	1,410	358,732	20%	71,746	40%	143,493	1,124

As shown in Table 3-1, the baseline TSS and TP loads are 358,732 pounds per year and 1,124 pounds per year, respectively. Based on the TSS baseline load, the City is required to achieve a composite 71,746 pound per year TSS reduction in order to achieve compliance with the 20% TSS reduction contained in NR 151.13.

2019 Best Management Practices

Several BMPs qualified for NR 151 pollutant reduction credit in 2019: High efficiency sweeper with no parking control ordinance (once every four weeks along collector and arterial streets, and once every six weeks along local roads), grass swales, five wet detention ponds, one infiltration basin and one bioswale. The 2019 BMPs are depicted in Figure 13. As shown in Table 3-2, the 2019 BMPs provided a 26,418 pound per year TSS reduction and a 51.7 pound per year TP reduction. As such, when the City receives an MS4 Permit from WDNR, additional BMPs are needed within the City's 2004 developed urban area to satisfy the 20% TSS reduction contained in NR 151.13.

Table 3-2

NR 151 Pollutant Analysis - 2019 BMPs (WinSLAMM)

		TSS			TP		
			Load Reduction			Load Reduction	
Sub-Watershed	Urban Area (acres)	Baseline Load (lbs/yr)	(lbs/yr)	(%)	Baseline Load (lbs/yr)	(lbs/yr)	(%)
Mullet River	1,410	358,732	26,418	7.4%	1,124.0	51.7	4.6%

For reference, more detailed water quality results for the NR 151 analysis can be found in Appendix B.

4.0 TMDL POLLUTANT ANALYSIS

A TMDL is the maximum amount of a pollutant that a water body can receive and still meet water quality standards. The goal of a TMDL is to improve water quality so the impaired water body meets it's loading capacity and is no longer considered impaired. A total phosphorus and total suspended solids TMDL is currently being developed by WDNR for the Northeast Lakeshore, which includes the Mullet River and Onion River. The WDNR anticipates completing the Northeast Lakeshore TMDL development during 2022, including approval by the US Environmental Protection Agency (EPA).

As shown in Figure 6, the City's storm sewer system discharges to two impaired Northeast Lakeshore TMDL waterways: Mullet River and Onion River. These two impaired waterways are specifically part of the proposed Northeast Lakeshore TMDL. Since the Northeast Lakeshore TMDL has not been completed, this City-Wide Stormwater Quality Management Plan will likely need to be updated following completion of the TMDL for the Mullet River Sub-Watershed. Although no TMDL pollutant load reductions are currently identified for the Mullet River Sub-

Watershed, baseline pollutant loadings and current BMP reductions are included in this TMDL analysis.

Performance Standard

Upon completion, the TMDL will identify waste load allocations for each Municipal Stormwater Discharge Permit (MS4) Permitted entity. TMDL's require specific TP and TSS reductions that vary by sub-watershed. The TP and TSS waste load allocations and reductions have not yet been identified for the City's developed urban area. Typically, a MS4 Permit cannot be reissued without a waste load allocation that is consistent with an EPA approved TMDL

Methodology

The TMDL pollutant analysis uses the WinSLAMM Version 10.2.1. WinSLAMM is a stormwater quality model that predicts runoff volumes and non-point source pollution loads for urban land uses. WinSLAMM also calculates the amount of pollutant removal provided by BMPs such as street sweeping, catch basin cleaning, grass swales, grass filter strips, biofiltration, infiltration basins, wet ponds, proprietary devices, and other BMPs.

The TMDL pollutant analysis uses the series of small rainfall events that occurred between March 29, 1968 and November 25, 1972 in Green Bay, Wisconsin. For purposes of MS4 Permit compliance, this 5-year rainfall series was determined by the WDNR to represent an average annual rainfall condition for municipalities located in Northeast Wisconsin.

The TMDL pollutant analysis uses data files developed by the USGS and WDNR for the WinSLAMM model. The data files identify typical runoff volumes, pollutant concentrations, pollutant distributions, pollutant deliveries, and pollutant particle size distributions for typical urban stormwater runoff. The WinSLAMM data files obtained from the USGS and used in the TMDL pollutant analysis are as follows:

- WisReg - Green Bay Five Year Rainfall.ran
- WI_GEO03.ppdx
- WI_SL06 Dec06.rsv
- V10.1 WI_avg01.pscx
- WI_Res and Other Urban Dec06.std
- WI_Com Inst Indust Dec06.std
- Freeway Dec06.std
- Nurp.cpz

The TMDL pollutant analysis is based on the standard land use files developed by the WDNR for WinSLAMM. The standard land use files identify the amount of roof, parking lot, driveway, sidewalk, street, and lawn source areas which are typical for each standard land use. The standard land use files also identify the amount of connected imperviousness for each source area.

The TMDL pollutant analysis uses the WinSLAMM batch processor to generate baseline (no-controls) pollutant loads for each standard land use file. Baseline pollutant loads for each drainage and BMP catchment area are calculated using batch processor database files and GIS. A WinSLAMM model is developed for each existing and proposed structural BMP to determine the BMP's pollutant reduction. The pollutant reduction provided by each BMP is then applied to each drainage or BMP catchment area, as appropriate.

Analysis Area

The TMDL pollutant analysis uses the study area depicted in Figure 1, the Sub-Watersheds depicted in Figure 3, and the current (2018) land uses depicted in Figure 11. For purposes of the TMDL pollutant analysis, the study area contains 3,443 acres. For Cities, the TMDL pollutant analysis uses the entire municipal boundary. Per WDNR guidance, the following areas are either prohibited from inclusion or classified as optional for inclusion in the TMDL pollutant analysis.

- Agricultural Areas: Lands zoned for agricultural use and operating as such are optional to include in the TMDL pollutant analysis. Of the 3,443 acres within the study area, 355 acres are classified as agriculture and consequently, are excluded from the analysis.

- Internally Drained Areas: Internally drained areas with natural infiltration are prohibited from inclusion in the TMDL pollutant analysis. There are no known internally drained areas located within the 2019 developed urban area.

- Waters of the State: Waters of the state are optional for inclusion in the TMDL pollutant analysis. Lakes, rivers, streams and mapped wetlands are classified as "waters of the state". Of the 3,443 acres within the study area, 227 acres are classified as "waters of the state" and consequently, are excluded from the analysis.

- State and County Highways: State freeways, state truck highways, and county highways are excluded from the TMDL pollutant analysis. The WisDOT is responsible for pollutant loads from state freeway and state trunk highway right-of-way's and Sheboygan County is responsible for pollutant loads from county highway right-of-ways. The only time the City is responsible for pollutant loads from a state or county highway right-of-way is if the highway is classified as a "connecting highway" by the WisDOT or if the City has a bridge structure that allows a City street to cross over the state or county highway. Of the 3,443 acres within the study area, 30 acres are State (WisDOT) MS4 jurisdiction and 67 acres are County MS4 jurisdiction. The combined 97 acres of state and county highway right-of-way are excluded from the analysis.

- Riparian Areas: Riparian areas are optional to include in the TMDL pollutant analysis. Riparian areas are private properties that do not discharge runoff into the City's MS4, but rather discharge directly into a river, stream, or lake. Riparian areas that discharge directly into Mullet River, Onion River or other navigable streams without passing through the City's MS4 are depicted in Figure 8. Of the 3,443 acres within the study area, 755 acres are classified as riparian and consequently, are excluded from the analysis.

- MS4 "A" to "B": Areas that discharge into an adjacent municipality's MS4 (Municipality B) without passing through the City's MS4 (Municipality A) are optional to include in the TMDL pollutant analysis. These areas are shown in Figure 8. Many of these areas are located along state and county right-of-ways where runoff from private property drains directly into a State or County MS4 and then discharges directly into a river, stream, or lake. Of the 3,443 acres within the study area, 312 acres are classified as MS4 "A" to "B" and consequently, are excluded from the analysis.

- WPDES Industrial Permits: Industrial facilities permitted under NR 216 are optional to include in the TMDL pollutant analysis. The City plans to achieve the required TSS and TP reductions for these industrial permitted areas for the following reasons: the City has legal authority to regulate stormwater runoff; the City has legal authority to charge a stormwater utility fee; it is difficult to determine which portions of an industrial site are covered by a WPDES Industrial Permit; and the pollutant load is the City's responsibility if the WPDES Industrial Permit is terminated or certified "No Exposure" in the future. For purposes of the TMDL pollutant analysis, industrial areas with coverage under a WDPES Industrial Permit are included in the analysis.

Based on the prohibited and optional areas mentioned above, the TMDL pollutant analysis will apply to the remaining 1,677 acres of developed urban areas that existed in 2019. Note that all areas in the Onion River Sub-Watershed are within the exclusion areas listed above and are not be part of the developed urban area.

Baseline Condition

The TMDL baseline loads for the 1,677 acres of developed urban area are summarized in Table 4-1. These baseline or "no control" loads exclude the pollutant reduction benefits of existing BMPs. Per WDNR guidance, the "no control" loads are used in conjunction with the adjusted TP and TSS percent reductions to determine the required load reductions.

Table 4-1

TMDL Pollutant Analysis – Baseline Condition (WinSLAMM)

Sub-Watershed	Urban Area (acres)	TP Baseline Load (lbs/yr)	TMDL TP Reduction Required (lbs/yr)	TSS Baseline Load (lbs/yr)	TMDL TSS Reduction Required (lbs/yr)
Mullet River	1,677	1,297	TBD	416,367	TBD

The TMDL baseline loads from WinSLAMM are also summarized by land use in Table 4-1 and Exhibit 4-1. These baseline or "no control" loads exclude the pollutant reduction benefits of existing BMPs. As shown in Table 4-2 and Exhibit 4-1, residential land use comprises the majority of land area and pollutant loads.

Table 4-2

TMDL Baseline Loads by Land Use (WinSLAMM)

Land Use	Area (acres)	Area (%)	TP (lbs/yr)	TP (%)	TSS (lbs/yr)	TSS (%)
Residential	724	43%	371	29%	73,060	18%
Commercial	170	10%	134	10%	53,997	13%
Industrial	135	8%	86	7%	57,717	14%
Institutional	114	7%	90	7%	27,248	6%
Open Space	246	15%	117	9%	21,145	5%
Street and Highway ROW	289	17%	500	38%	183,200	44%
Totals	1,677	100%	1,297	100%	416,367	100%

Appendix A contains a list of TMDL baseline pollutant yields (pounds per acre per year) and baseline loads (pounds per year) from WinSLAMM for TP and TSS. The baseline pollutant yields and loads are ranked by both drainage area and BMP catchment area from highest to lowest within the Mullet River Sub-Watershed. The figures in Appendix A depict the TMDL baseline pollutant yields and loads by drainage area and BMP catchment area.

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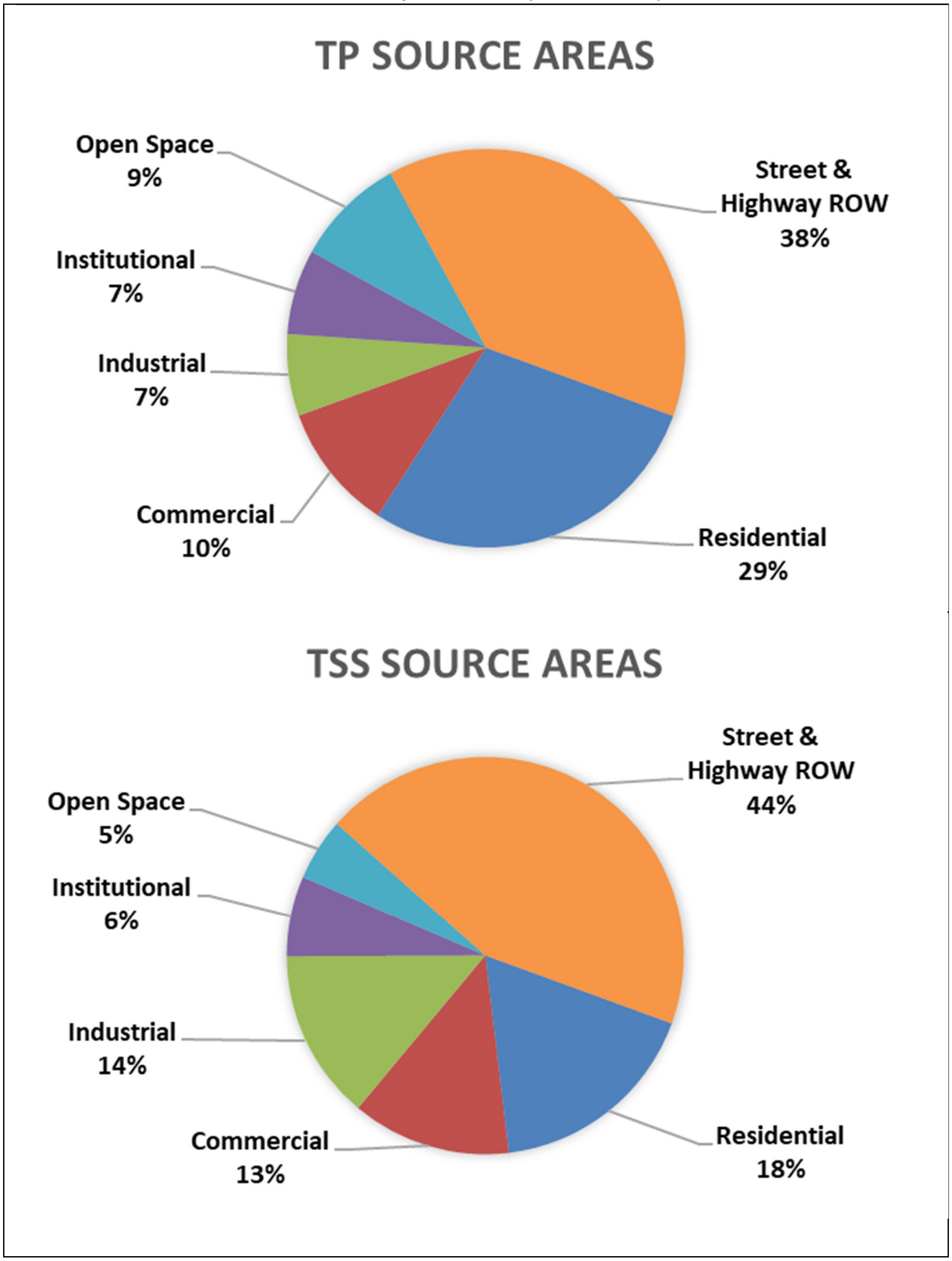
Exhibit 4-1: TMDL Baseline Loads by Land Use (WinSLAMM)



2019 Best Management Practices

Several BMPs qualified for TMDL pollutant reduction credit in 2019: High efficiency sweeper with no parking control ordinance (once every four weeks along collector and arterial streets, and once every six weeks along local roads), grass swales, seven wet detention ponds. The 2019 BMPs are depicted in Figure 13. Water quality results for each sub-watershed are summarized below.

- Mullet River: Table 4-3 indicates the 2019 BMPs provided a 5.6% TP reduction within the Mullet River Sub-Watershed. Also, Table 4-3 indicates the 2019 BMPs provided a 9.5% TSS reduction within the Mullet River Sub-Watershed.

Table 4-3

TMDL Pollutant Analysis - 2019 BMPs (WinSLAMM)

		TP			TSS		
			Provided Load Reduction			Provided Load Reduction	
Sub-Watershed	City MS4 (acres)	Baseline Load (lbs/yr)	(lbs/yr)	(%)	Baseline Load (lbs/yr)	(lbs/yr)	(%)
Mullet River	1,677	1,297	72	5.6%	416,367	39,561	9.5%

For reference, more detailed water quality results for the TMDL analysis can be found in Appendix B.

5.0 POLLUTANT REDUCTION ANALYSIS

WinSLAMM (version 10.2.1) was used in conjunction with national literature to analyze the stormwater quality benefits and cost-effectiveness of proposed urban stormwater BMPs such as street sweeping, catch basin cleaning, grass swales, grass filter strips, biofiltration, infiltration basins, wet detention ponds, proprietary devices, and mechanical/biological treatment.

The capital costs contained in Tables 5-1 through 5-17 include the estimated present value capital costs for the BMP. The capital costs include an allowance for construction, land acquisition, engineering, legal, and contingency costs. The 20-year costs provided in the tables are the estimated present value costs per pound of TSS removed during a 20-year period. The 20-year costs include an allowance for capital costs and long-term operation and maintenance costs. The 20-year period was determined to be a reasonable life cycle or planning period for evaluating BMP cost-effectiveness. A longer planning period would improve the cost-effectiveness of structural BMPs (e.g. wet detention pond) as compared to non-structural BMPs (e.g. street sweeping). The results of the pollutant reduction analysis are summarized herein. More detailed water quality results are provided in Appendix B.

Street Sweeping

Street sweeping is effective at collecting large sediment particles (sand sized particles), trash, debris and leaves. Limited pollutant removal occurs for fine-grained particles such as silt, clay, metals and nutrients. Research indicates that street pollutants tend to accumulate within 3 feet of the street's curb and gutter. Wind turbulence from traffic tends to blow pollutants toward the curb. The curb acts as a barrier and traps pollutants. For streets without curb, wind turbulence generated by a passing vehicle tends to blow pollutants onto the adjacent grass area. As such, for street sweeping to be effective, the street must have curb.

The effectiveness of a municipal street sweeping program depends on the type of street sweeper, number of curb-miles, sweeping frequency, traffic volume, time of year, rainfall, and operator knowledge. In addition, the benefits of sweeping are significantly reduced when vehicles are parked along the curb. Whenever a street sweeper needs to maneuver around a parked car, the pollutants under the car are not removed. As such, the more cars parked along a street, the less pollutant removal.

There are two types of street sweeper: mechanical and high efficiency. Mechanical street sweepers use a broom to remove pollutants from the street surface and high efficiency street sweepers use a vacuum system to remove pollutants. Typically, the high efficiency sweeper is more effective at removing pollutants as compared to the mechanical sweeper. The City currently utilizes a high efficiency sweeper with no parking control ordinance (once every four weeks along collector and arterial streets, and once every six weeks along local roads). Table 5-1 summarizes the average annual TP costs per pound for various City-wide sweeping routines. Table 5-1 identifies the percent reduction for the street right-of-way only.

Table 5-1

Street Sweeping

Sweeper Type, Frequency and Parking Controls for Street Corridor Land Uses	Pollutant Load Reduction TSS (%)	Pollutant Load Reduction TP (%)	Avg. Annual TP Cost ($/lb)
H.E. Sweeper (Once every 8 weeks, with parking ordinance)	18%	13%	$534
H.E. Sweeper (Once every 6 weeks, with parking ordinance)	20%	14%	$623
H.E. Sweeper (Once every 4 weeks along arterial/collector, once every 6 weeks along local, with parking ordinance)	21%	15%	$646
H.E. Sweeper (Once every 4 weeks, with parking ordinance)	22%	16%	$831
H.E. Sweeper (Once every 8 weeks, no parking ordinance)	9%	6%	$1,118
H.E. Sweeper (Once every 2 weeks, with parking ordinance)	32%	23%	$1,174
H.E. Sweeper (Once every 6 weeks, no parking ordinance)	10%	7%	$1,323
H.E. Sweeper (Once every 4 weeks along arterial/Collector, once every 6 weeks along local, no parking ordinance) *	10%	7%	$1,366
H.E. Sweeper (Once every week, with parking ordinance)	41%	31%	$1,778
H.E. Sweeper (Once every 4 weeks, no parking ordinance)	12%	8%	$1,783
H.E. Sweeper (Once every 2 weeks, no parking ordinance)	15%	11%	$2,508
H.E. Sweeper (Once every week, no parking ordinance)	22%	16%	$3,506

*City's current sweeper type, frequency and parking controls

As shown in Table 5-1, street sweeping every 8 weeks with a high efficiency street sweeper and adoption of a parking control ordinance is the most cost-effective street sweeping program for the City. The City currently sweeps every 4 weeks with a high efficiency street sweeper along collector / arterial streets and every 6 weeks along local streets. The City does not currently have a parking control ordinance for its street sweeping program.

Municipal Leaf Collection

The municipal leaf collection program can help reduce phosphorus in urban stormwater runoff. Based on research conducted by the WDNR and USGS, 43% of the annual phosphorus load from a medium density residential neighborhood is discharged during the fall season. The research also indicates that a 40% phosphorus reduction is achieved during the fall season if the following conditions are satisfied: medium density residential neighborhood, curb and gutter drainage system, light on-street parking densities during the leaf collection operation, an average of one street tree per 80 feet of curb length, and a municipal ordinance that prohibits residents from placing or storing leaves on the street surface. Leaves may be pushed onto the street during the municipal collection operation, but no leaf pile can remain on the street surface overnight. In order to achieve the 40% phosphorus reduction during the fall season, the leaf collection operation needs to be provided at four equally spaced times during the leaf collection season (two-month period during October and November per WDNR) and the operation also needs to be followed by high efficiency street sweeping within 24-hours of the leaf collection.

Table 5-2 identifies the percent reduction for a leaf collection program which includes only the medium density residential land use (no alleys) with curb and gutter surface drainage. Since leaf collection phosphorus reductions depend on street sweeping, Table 5-2 includes both leaf collection and street sweeping program credits. Figure B-4 within Appendix B depicts the City streets where the leaf collection program needs to be performed in order to achieve the phosphorus reductions identified within Table 5-2. Note that the results in Table 5-2 include all street right-of-way and leaf collection areas within the City's developed urban area.

Table 5-2

Leaf Collection / Street Sweeping

Sweeper Type, Frequency and Parking Controls for Street Corridor Land Uses	Pollutant Load Reduction TSS (%)	Pollutant Load Reduction TP (%)	Avg. Annual TP Cost ($/lb)
Leaf Collection System Only[1]	0%	14%	$532
H.E. Sweeper (Once every 8 weeks, with parking ordinance)	18%	19%	$543
H.E. Sweeper (Once every 4 weeks along arterial/collector, once every 6 weeks along local, with parking ordinance)	20%	20%	$578
H.E. Sweeper (Once every 6 weeks, with parking ordinance)	20%	20%	$590
H.E. Sweeper (Once every 8 weeks, no parking ordinance)	9%	16%	$636
H.E. Sweeper (Once every 4 weeks, with parking ordinance)	23%	21%	$655
H.E. Sweeper (Once every 4 weeks along arterial/collector, once every 6 weeks along local, no parking ordinance) *	10%	17%	$691
H.E. Sweeper (Once every 6 weeks, no parking ordinance)	10%	17%	$705
H.E. Sweeper (Once every 4 weeks, no parking ordinance)	11%	17%	$796

Table 5-2

Leaf Collection / Street Sweeping

(continued)

Sweeper Type, Frequency and Parking Controls for Street Corridor Land Uses	Pollutant Load Reduction TSS (%)	TP (%)	Avg. Annual TP Cost ($/lb)
H.E. Sweeper (Once every 2 weeks, with parking ordinance)	32%	24%	$844
H.E. Sweeper (Once every 2 weeks, no parking ordinance)	15%	19%	$1,080
H.E. Sweeper (Once every week, with parking ordinance)	41%	27%	$1,359
H.E. Sweeper (Once every week, no parking ordinance)	22%	21%	$1,778

*City's current sweeper type, frequency and parking controls

[1] Includes fall leaf collection followed by street sweeping (sweep 4 times in October and November).

Catch Basin Cleaning

Catch basin cleaning is effective at collecting large sediment particles (sand sized particles), trash, debris and leaves. Limited pollutant removal occurs for fine-grained particles such as silt, clay, metals and nutrients. Catch basin sumps are effective for parking lots and streets that serve a small drainage area (less than 1 acre). Ideally, a catch basin sump has a minimum 3 foot depth to prevent scouring of previously settled pollutants during a rainfall.

The City currently has a limited number of catch basin sumps within their MS4 system. Table 5-3 summarizes the average annual TP costs per pound reduced for street catch basin cleaning, including the costs to add catch basin sumps as part of a street retrofit or reconstruction project for various land use corridors.

Table 5-3

Street Catch Basin Cleaning

Street Corridor Land Use	Pollutant Load Reduction		Avg. Annual TP Cost ($/lb)		
	TSS (%)	TP (%)	Cleaning	Retrofit & Cleaning	Reconstruct & Cleaning
Commercial Corridors	16%	14%	$155	$1,207	$994
Industrial Corridors	16%	9%	$132	$969	$800
Institutional Corridors	18%	16%	$106	$924	$758
Residential Corridors	13%	11%	$220	$910	$770
Open Space Corridors	9%	7%	$122	$462	$393

Table 5-4 summarizes the average annual TP costs per pound reduced for parking lot catch basin cleaning, including the costs to add catch basin sumps as part of a parking lot retrofit or reconstruction project for various land use corridors.

Table 5-4

Parking Lot Catch Basin Cleaning

Street Corridor Land Use	Pollutant Load Reduction TSS (%)	TP (%)	Avg. Annual TP Cost ($/lb) Cleaning	Retrofit & Cleaning	Reconstruct & Cleaning
Commercial Corridors	15%	13%	$339	$2,662	$2,192
Industrial Corridors	14%	10%	$338	$2,481	$2,047
Institutional Corridors	17%	14%	$302	$2,624	$2,154
Residential Corridors	14%	11%	$877	$3,687	$3,118
Open Space Corridors	12%	8%	$379	$1,439	$1,225

Based on WDNR Guidance, the City cannot obtain water quality credit for both catch basin cleaning and street sweeping. In the City, street sweeping is a priority since sweeping helps maintain aesthetics, reduces public complaints, and reduces catch basin grate clogging. For these reasons, the City prefers street sweeping as compared to catch basin cleaning.

Grass Swales

Grass swales remove pollutants from concentrated stormwater by filtration through the grass and infiltration into the soil. The filtering capacity depends on the flow depth in the swale as compared to the grass height. Typically, when the flow depth is above the grass, filtering is minimal and scouring of previously settled pollutants is a concern. The water quality benefits of a grass swale are largely determined by the infiltrating capacity of underlying soils and depth to groundwater. For instance, a grass swale located in sandy soil has a much higher pollutant removal as compared to a grass swale located in clay soil. Other factors influencing grass swale performance include longitudinal swale slope, swale cross section, and flow volume. WDNR Technical Standard 1005 – Vegetated Infiltration Swale discusses design criteria for grass swales.

Grass swales are typically located along streets. As shown in Figure 8, the City's streets are drained almost entirely via curb and gutter with limited grass swales. As shown in Figure 5, soils in the City are predominately clay (HSG C and D) with a portion of silt soils (HSG B). As such, typically the infiltrating capacity of the underlying soils is minimal. Detailed water quality results and costs for the City's existing grass swales can be found in Appendix B. Table 5-5 summarizes the cost and water quality benefits of the City constructing grass swales along an urban street as a street retrofit or reconstruction project.

Table 5-5

Grass Swales

BMP	Pollutant Load Reduction		Avg. Annual TP Cost ($/lb)			
	TSS (%)	TP (%)	Retrofit		Reconstruct	
			Sand	Clay	Sand	Clay
Grass Swales	14%	11%	$3,511,233	$20,845,601	$1,359,837	$7,857,848

The percent reductions provided in Table 5-5 are for clay soils, but the cost per pound provides a range depending on soil type.

Grass Filter Strips

Grass filter strips remove pollutants from stormwater by filtration through the grass and infiltration into the soil. The filtering capacity of a grass filter strip depends on its longitudinal slope, length and grass density. The water quality benefits of a grass filter strip are largely determined by the infiltrating capacity of underlying soils. A grass filter strip located in sandy soil has a higher pollutant removal as compared to a grass filter strip located in clay soil.

Grass filter strips are effective for parking lots that serve small drainage areas (less than 1 acre). Typically, grass filter strips need to be a minimum of 20 feet long, but at least as long as the contributing impervious surface length. A 64 foot wide parking lot would typically require a 64 foot long grass filter strip. As such, grass filter strips require a significant amount of land area as compared to other BMPs.

In order for a grass filter strip to be effective, the stormwater flowing into the filter strip cannot be concentrated within a swale, ditch, channel, gutter, or other similar conveyance system. Rather, the stormwater must be flowing across the surface of a parking lot, lawn or other ground surface in a very thin sheet of dispersed water.

As shown in Figure 8, the City does not currently have any grass filter strips. As shown in Figure 5, soils in the City are predominately clay (HSG C and D), but there are limited areas of sand and silt soils (HSG A and B). Due to the land requirements and predominately clay soils in the City, the construction and land costs to retrofit a grass filter strip are high as compared to the water quality benefit provided. Table 5-6 summarizes the cost and water quality benefits of a grass filter strip retrofit of a parking lot.

Table 5-6

Grass Filter Strips

BMP	Pollutant Load Reduction TSS (%)	Pollutant Load Reduction TP (%)	Avg. Annual TP Cost ($/lb)
Grass Filter Strips – Retrofit Parking Lot (Clay Soil)	95%	91%	$2,480

Biofiltration Devices

Biofiltration devices remove pollutants from stormwater by filtration through an engineered soil mixture. Typically, the engineered soil is a minimum of two feet deep and consists of a sand and compost mixture. A diverse mix of prairie flowers, grasses, shrubs and/or trees are typically planted in a mulch layer located above the engineered soil. During a rainfall, stormwater is temporarily stored above the mulch layer until it can be filtered through the engineered soil. A perforated underdrain pipe located beneath the engineered soil collects the filtered water and discharges it into an adjacent storm sewer or other conveyance system. Biofiltration devices are effective for small drainage areas (less than 2 acres).

Biofiltration devices are called a “bioretention” device when the native soils located beneath the engineered soil layer are permeable and the majority of stormwater infiltrates into the native soils. In sandy soils, it may be feasible to eliminate the perforated underdrain pipe to further increase infiltration. Bioretention devices are used to recharge groundwater and improve stormwater quality, whereas biofiltration devices are primarily used to improve stormwater quality. WDNR Technical Standard 1004 – Bioretention for Infiltration discusses design criteria for bioretention and biofiltration.

Biofiltration devices are sometimes called a “bio-swale” if the device contains a longitudinal slope to facilitate flow conveyance. Bio-swales are typically installed within parking lots or along streets and have a linear configuration. Bio-swales can be used to recharge groundwater and/or improve stormwater quality. As such, a bio-swale may or may not include a perforated underdrain pipe.

Proprietary biofiltration devices are also available to achieve pollutant reductions. The proprietary devices are pre-manufactured structures which are typically placed along a street or within a parking lot island. The structure is filled with engineered soil with an underdrain system for biofiltration. Examples of proprietary biofiltration devices include Filterra®, TreePod™, UrbanGreen™, and many other products.

Biofiltration devices are able to obtain 100% TSS and TP credit for stormwater that is infiltrated into the underlying soil and an 80% TSS and 0% TP removal credit for stormwater that is filtered through the engineered soil layer and is discharged via an underdrain. Therefore, in clay soils, a biofiltration device is an effective BMP for TSS reduction but is ineffective for TP reduction due to limited soil infiltration. Biofiltration is much more effective for TP reduction in sandy soils due to higher soil infiltration rates (refer to following "bioretention" device discussion). As shown in Figure 5, the City is comprised of mostly clay soils. As such, biofiltration devices were not included in the analysis since TP is the pollutant of concern for the proposed Northeast Lakeshore TMDL.

Sand Filters

A sand filter is similar to a biofiltration device except the engineered soil consists of 100% sand meeting one of the gradation options specified in Technical Standard 1004. Per WDNR guidance, a sand filter may obtain 80% TSS and 35% TP reduction for the filtering component of the devices. The WDNR is currently researching development of an engineered soil mixture that would achieve a greater TP removal credit than a sand filter. The costs to incorporate sand filters into a street or parking lot retrofit or reconstruction project are summarized in Table 5-7. The percent reductions provided in Table 5-7 are for clay soils, but the cost per pound provides a range depending on soil type.

The costs to incorporate sand filters into a street retrofit or reconstruction project are summarized in Table 5-7 for sand and clay soils. The percent reductions provided in Table 5-7 are for clay soils, but the cost per pound provides a range depending on soil type.

Table 5-7

Street Sand Filters

	Pollutant Load Reduction		Avg. Annual TP Cost ($/lb)			
			Retrofit		Reconstruct	
Street Corridor Land Use	TSS (%)	TP (%)	Sand	Clay	Sand	Clay
Commercial Corridors	80%	35%	$3,266	$9,663	$1,879	$6,178
Industrial Corridors	80%	35%	$1,734	$5,010	$930	$3,120
Institutional Corridors	80%	35%	$2,218	$6,276	$1,189	$3,909
Residential Corridors	80%	35%	$2,664	$7,097	$1,429	$4,420
Open Space Corridors	80%	35%	$2,585	$6,807	$1,386	$4,240

The costs to incorporate sand filters into a parking lot retrofit or reconstruction project are summarized in Table 5-8 for sand and clay soils. The percent reductions provided in Table 5-8 are for clay soils, but the cost per pound provides a range depending on soil type.

Table 5-8

Parking Lot Sand Filters

Parking Lot Land Use	Pollutant Load Reduction		Avg. Annual TP Cost ($/lb)			
	TSS (%)	TP (%)	Retrofit		Reconstruct	
			Sand	Clay	Sand	Clay
Commercial Corridors	80%	35%	$9,832	$25,081	$6,117	$15,664
Industrial Corridors	80%	35%	$9,942	$27,979	$6,055	$17,042
Institutional Corridors	80%	35%	$7,972	$23,924	$4,856	$14,572
Residential Corridors	80%	35%	$9,850	$14,234	$6,000	$8,670
Open Space Corridors	80%	35%	$3,564	$29,183	$2,171	$17,775

Proprietary biofiltration devices are also available to achieve pollutant reductions. The proprietary devices are pre-manufactured structures which are typically placed along a street or within a parking lot island. The structure can be filled with biofiltration engineered soil or sand and an underdrain system for biofiltration. Examples of proprietary biofiltration devices include Filterra®, TreePod™, UrbanGreen™, and many other products. The costs to incorporate proprietary biofiltration into a street or parking lot retrofit or reconstruction project for sand and clay soils are summarized in Table 5-9. The percent reductions provided in Table 5-9 are for clay soils, but the cost per pound provides a range depending on soil type.

Table 5-9

Proprietary Biofiltration

BMP Location	Pollutant Load Reduction		Avg. Annual TP Cost ($/lb)			
	TSS (%)	TP (%)	Retrofit		Reconstruct	
			Sand	Clay	Sand	Clay
Proprietary Sand Filter-Street	80%	35%	$5,627	$18,035	$5,001	$16,027
Proprietary Sand Filter-Parking Lot	80%	35%	$19,635	$56,113	$16,967	$48,619

Rain Gardens

Bioretention devices are sometimes called a "rain garden" if the device does not contain an engineered soil layer. Although pollutant removal is provided, rain gardens are typically installed for groundwater recharge purposes rather than stormwater pollutant removal. Often, runoff from a residential roof, patio, sidewalk or driveway is directed to a rain garden. These residential source areas have a low pollutant load but generate a significant amount of runoff volume. Whenever a source area has a high pollutant load (i.e. street or parking lot), an engineered soil layer is recommended to provide a higher capacity filter media. A high capacity filter media reduces the device's surface area, ponding duration, and clogging potential. If stormwater is allowed to pond on the surface of a rain garden, bioretention device, or biofiltration device for more than 24 hours, the plants may become diseased or die due to wet conditions or poor system hydrology. The costs to retrofit rain gardens on private residential property are summarized in Table 5-10.

Table 5-10

Rain Gardens

BMP	Pollutant Load Reduction TSS (%)	Pollutant Load Reduction TP (%)	Avg. Annual TP Cost ($/lb)
Rain Garden – Retrofit Residential Lot	98%	98%	$14,959

Infiltration Basins

An infiltration basin is a water impoundment constructed over a highly permeable soil. The purpose of an infiltration basin is to temporarily store stormwater and allow it to infiltrate through the bottom and sides of the infiltration basin. Pollutants are removed by the filtering action of the underlying soil. The primary functions of an infiltration basin are to provide groundwater recharge, reduce runoff volumes, and reduce peak discharge rates. The secondary function of an infiltration basin is water quality. WDNR Technical Standard 1003 – Infiltration Basin discusses design criteria for infiltration basins.

Infiltration basins require pretreatment to prevent clogging and failure. WDNR Technical Standard 1003 - Infiltration Basin requires a pretreatment system to reduce the TSS load entering an infiltration basin by 60% for a residential land use and 80% for a commercial, industrial, or institutional land use. Typically, a wet detention pond or biofiltration device is used as the pretreatment system. The pretreatment system prevents the infiltration basin from failing and helps reduce the risk of groundwater contamination due to pollutants contained in stormwater. Not all stormwater runoff should be infiltrated due to concern for groundwater contamination.

In order for an infiltration basin to be feasible, the depth to groundwater typically needs to be 5 feet or more and the soil needs to be a loam, silt or sand. As shown in Figure 5, soils in the City are predominately clay (HSG C and D). Sand and silt soils are found in limited locations in the City (HSG A and B). As such, the feasibility of an infiltration basin is very limited within the City.

Finally, a significant amount of the water quality benefit is provided by the infiltration basin's pretreatment system. Typically, the pretreatment system is a wet detention pond or biofiltration device. From a water quality perspective, an infiltration basin is not cost effective after considering the pretreatment costs. As such, infiltration basin costs are not included in the analysis; rather pretreatment system costs are included in the analysis (i.e. wet detention ponds and biofiltration devices).

Hydrodynamic Separator Devices

Hydrodynamic separator devices are pre-manufactured underground devices which use cyclonic separation to provide pollutant reduction for stormwater. Hydrodynamic separator devices are typically placed in place of a storm sewer manhole within a storm sewer discharge pipe and are typically used to treat smaller (< 2 acre) drainage areas. Collected pollutants are typically removed with a vacuum truck. Examples of hydrodynamic separators include Vortechs®, CDS™, Aqua-Swirl®, and many other products. The costs to incorporate hydrodynamic separators into a street retrofit or reconstruction project are summarized in Table 5-11.

Table 5-11

Street Hydrodynamic Separator Devices (HSD)

	Pollutant Load Reduction		Avg. Annual TP Cost ($/lb)	
Street Corridor Land Use	**TSS (%)**	**TP (%)**	**Retrofit**	**Reconstruct**
Commercial Corridors	21%	18%	$3,379	$2,702
Industrial Corridors	23%	13%	$3,468	$2,767
Institutional Corridors	23%	20%	$2,626	$2,098
Residential Corridors	21%	17%	$3,069	$2,462
Open Space Corridors	21%	17%	$2,837	$2,259

The costs to incorporate hydrodynamic separators into a parking lot retrofit or reconstruction project are summarized in Table 5-12.

Table 5-12

Parking Lot Hydrodynamic Separator Devices (HSD)

	Pollutant Load Reduction		Avg. Annual TP Cost ($/lb)	
Parking Lot Land Use	**TSS (%)**	**TP (%)**	**Retrofit**	**Reconstruct**
Commercial Corridors	19%	16%	$7,293	$5,824
Industrial Corridors	20%	16%	$8,784	$7,008
Institutional Corridors	20%	15%	$7,366	$5,885
Residential Corridors	21%	15%	$10,403	$8,376
Open Space Corridors	31%	20%	$9,506	$7,570

Stormwater Filtration Devices

Stormwater filtration devices are pre-manufactured underground stormwater treatment systems that use filters to reduce pollutants in stormwater. The filters are typically media filled cartridges which can be customized to target specific pollutants placed within a pre-cast or cast-in-place underground concrete structure and are typically used to treat smaller (< 2 acre) drainage areas.

As clogging occurs within the filters, they can be cleaned underground and/or replaced when clogged. Examples of Stormwater Filtration include Stormfilter®, Perk Filter™, Aqua-Filter™, and many other products. The costs to incorporate stormwater filtration into a street retrofit project or a street reconstruction project are summarized in Table 5-13.

Table 5-13

Street Stormwater Filtration Devices

	Pollutant Load Reduction		Avg. Annual TP Cost ($/lb)	
Street Corridor Land Use	**TSS (%)**	**TP (%)**	**Retrofit**	**Reconstruct**
Commercial Corridors	38%	38%	$3,765	$3,267
Industrial Corridors	43%	26%	$3,751	$3,235
Institutional Corridors	42%	42%	$2,831	$2,442
Residential Corridors	39%	35%	$3,278	$2,832
Open Space Corridors	39%	35%	$3,082	$2,657

The costs to incorporate hydrodynamic separators into a parking lot retrofit or reconstruction project are summarized in Table 5-14.

Table 5-14

Parking Lot Stormwater Filtration Devices

	Pollutant Load Reduction		Avg. Annual TP Cost ($/lb)	
Parking Lot Land Use	**TSS (%)**	**TP (%)**	**Retrofit**	**Reconstruct**
Commercial Corridors	36%	34%	$10,522	$9,997
Industrial Corridors	39%	37%	$11,998	$11,369
Institutional Corridors	39%	35%	$10,024	$9,500
Residential Corridors	42%	34%	$13,859	$13,142
Open Space Corridors	61%	45%	$13,031	$12,347

Permeable Pavement

Permeable pavement is a pavement system which allows stormwater to drain through paved surfaces into the underlying soil or to an underground reservoir for treatment. In addition to pollutant reduction, permeable pavement is also used to reduce peak flow rates and stormwater runoff volumes for development sites. Permeable pavement includes but is not limited to: pervious concrete or asphalt, pervious pavers and open jointed blocks. WDNR allows for 100% TSS and TP credit for the volume of runoff that infiltrates into the native soil. Any runoff that discharges through an underdrain pipe receives a 55% TSS and 35% TP credit. The costs to incorporate a permeable pavement into a street retrofit project or a street reconstruction project are summarized in Table 5-15.

Table 5-15

Permeable Pavement

	Pollutant Load Reduction		Avg. Annual TP Cost ($/lb)			
			Retrofit		Reconstruct	
BMP Location	**TSS (%)**	**TP (%)**	**Sand**	**Clay**	**Sand**	**Clay**
Permeable Pavement-Street	55%	35%	$6,741	$12,987	$4,877	$9,397
Permeable Pavement-Parking Lot	55%	35%	$22,546	$27,003	$15,546	$18,620

Wet Detention Ponds / Wetland Systems

Wet detention ponds and wetland systems are effective at removing sediment, nutrients, heavy metals, oxygen demanding compounds, hydrocarbons, and bacteria. Pollutant removal within a wet pond and wetland system is primarily due to gravity settling of particulate pollutants and sediment. Filtration, adsorption and microbial decomposition also remove pollutants, particularly within a wetland system. WDNR Technical Standard 1001 – Wet Detention Pond discusses design criteria for wet detention ponds.

Typically, a wet detention pond or wetland system must contain a minimum water depth of 5 feet within a portion of the permanent pool to minimize re-suspension of pollutants during a rainfall event. The WDNR requires that wet detention ponds and wetland systems be sized using the National Urban Runoff Project (NURP) particle size distribution. To achieve an 80% reduction in TSS, a wet detention pond or wetland system typically needs to remove the 3 to 5 micron sediment particle.

Existing dry detention ponds located in the City were evaluated to determine the feasibility of converting into wet detention ponds. Currently, WDNR does not allow water quality credit for dry detention ponds. Existing dry detention ponds located within the City are depicted in Figure 7 and summarized in Table 2-2. Generally, wet detention ponds are not recommended for small watersheds (less than 15 to 20 acres in clay soil). A wet detention pond located in a small watershed may develop stagnation problems and become a public nuisance. Public acceptance of stormwater BMPs is important to the success of the City's stormwater program.

In the 2002 version of the NR 151 rule, BMPs associated with post-construction sites containing new development may not be located in navigable waters to receive credit for meeting any performance standard in Chapter NR 151. This restriction has been retained in the revised rule. Also, in the 2002 version of the rule, BMPs for existing development, re-development or in-fill development could receive water quality credit for wet detention ponds/wetland systems constructed within both perennial and intermittent streams if all applicable permits are received. As of January 1, 2011, NR 151.003 only allows water quality credit for newly constructed wet detention ponds/wetland systems constructed within intermittent streams for which all applicable permits are received.

A cost analysis was completed to determine the most cost-effective retrofits within the City. As part of the analysis, aerial photographs were used to identify potential undeveloped properties that could be used for a retrofit. The location of storm sewer pipes and the watershed size in relation to the undeveloped property was also considered. Table 5-16 summarizes the cost and water quality benefits of those wet detention ponds/wetland systems within the Mullet River, Sub-Watershed analyzed for the City (partial list of analyzed ponds). A detailed structural BMP cost analysis can be found in Appendix C and includes the full list of ponds and other BMP's analyzed for all sub-watersheds within the study area. BMP Concept drawings for the facilities listed in Table 5-16 and are also provided in Appendix C.

Table 5-16

Potential Wet Detention Ponds / Wetland Systems

Wet Detention Pond / Wetland System	Drainage Area (acres)	Pollutant Reduction TSS (%)	Pollutant Reduction TP (%)	Capital Costs	Capital & O&M Costs Over 20 Years	Avg. Annual TP Cost ($/lb)
Mill Pond	158	59%	41%	$182,100	$293,781	$372
School Pond Alt 1	264	60%	42%	$270,530	$415,631	$415
School Pond Alt 2	283	59%	42%	$369,450	$514,551	$474
Greytone South Pond	11	80%	56%	$5,000	$22,778	$523
Highland Pond	149	68%	50%	$398,210	$542,703	$577
Slayer Pond	54	61%	45%	$165,840	$225,243	$660
River Pond	81	72%	50%	$365,830	$520,653	$914
Poch Pond	102	76%	53%	$414,360	$579,999	$916
Beth Pond	44	82%	58%	$260,750	$409,983	$1,133
Dairy Pond	88	81%	56%	$452,710	$641,682	$1,214

In addition to wet detention ponds, underground detention is another alternative to provide similar pollutant reduction, allowing for full build out of a proposed development site. The detention may be provided with a permanent pool of water in an underground piping system allowing for pavement above the stormwater device. The sediment accumulation is typically removed by vacuum truck or other method. The underground detention system is more expensive than wet detention ponds, but maximizes development area of sites.

Enhanced Settlement

In the future, the City may want to investigate the feasibility of adding polymers or flocculants such as Alum to wet detention ponds to enhance pollutant removal efficiencies. Polymer or flocculent additions will likely require installation of mechanical injection systems. The WDNR is currently discussing if Wisconsin will allow the use of polymers and flocculants in wet detention ponds. This TMDL pollutant analysis will likely require updating after WDNR guidance documents regarding the use of polymer and flocculants in ponds is completed. Table 5-17 summarizes the cost and water quality benefits of those wet detention ponds with Enhanced Settlement (ES) treatment analyzed for the City. A detailed structural BMP cost analysis can be found in Appendix C and includes the full list of ponds and other BMP's analyzed for all sub-watersheds within the study area.

Table 5-17

Potential Wet Detention Ponds with Enhanced Settlement Treatment

Wet Detention Pond With Enhanced Settlement Treatment	Drainage Area (acres)	Pollutant Reduction		Capital Costs	Capital & O&M Costs Over 20 Years	Avg. Annual TP Cost ($/lb)
		TSS (%)	TP (%)			
Mill Pond with ES	158	90%	85%	$345,773	$1,350,259	$752
School Pond Alt 2 with ES	283	90%	85%	$566,496	$1,848,394	$774
School Pond Alt 1 with ES	264	90%	85%	$463,310	$1,714,020	$801
Highland Pond with ES	149	90%	85%	$566,633	$1,638,656	$974
Poch Pond with ES	102	90%	85%	$536,579	$1,291,944	$1,241
River Pond with ES	81	90%	85%	$492,949	$1,273,322	$1,253
Slayer Pond with ES	54	90%	85%	$281,566	$883,228	$1,285
Beth Pond with ES	44	90%	85%	$354,690	$886,895	$1,609
Dairy Pond with ES	88	90%	85%	$579,272	$1,389,722	$1,685
Greytone South Pond w/ES	11	90%	85%	$29,821	$196,489	$2,833

Mechanical/Biological Treatment Facilities

Mechanical/biological treatment facilities are not currently used in Wisconsin, with the exception of combined sewer systems that treat wastewater and stormwater. A mechanical/biological treatment facility would be difficult to implement for stormwater given the number of storm sewer outfalls located within the City. Significant storm sewer pumping would likely be needed to convey stormwater from each outfall to a regional stormwater treatment facility, similar to a wastewater treatment facility. As a result, stormwater treatment facilities are not typically cost effective BMPs. A mechanical/biological treatment facility and associated pumping systems are estimated to have an average annual cost that is well above $30,000 per pound of TP removed. In addition, diverting low flows from all storm sewer outfalls to a regional treatment facility may dry up existing wetlands and streams located near the City's current storm sewer outfalls.

NR 151 Alternatives

Two alternatives were evaluated for purposes of the achieving compliance with the 20% TSS reduction contained in NR 151.13. Additionally, two alternatives were evaluated for achieving a 40% TSS reduction. Each alternative identifies a combination of existing and proposed BMPs, including modifications to the street sweeping program.

- 20% TSS Alternative 1: As shown in Figure 14, the 20% Alternative 1 includes the existing wet ponds (with legal maintenance authority) and the following street sweeping program: HE Sweeper once every week with a parking control ordinance.

- 20% TSS Alternative 2: As shown in Figure 15, the 20% Alternative 2 includes the existing 2019 BMPs (with legal maintenance authority), obtaining maintenance authority for all existing BMPs in Table 2-2 and the following street sweeping program: HE Sweeper once every four weeks with a parking control ordinance.

- 40% TSS Alternative 1: As shown in Figure 16, the 40% Alternative 1 includes the existing wet ponds (with legal maintenance authority), obtaining maintenance authority for all existing BMPs in Table 2-2 and the existing street sweeping program; HE Sweeper once every four weeks along collector and arterial streets and once every six weeks along local streets without a parking control ordinance. The 40% Alternative 1 includes construction of seven wet ponds including Dairy Pond, Highland Pond, Mill Pond, Poch Pond, River Pond, School Pond (Alternative 1) and Slayer Pond.

- 40% TSS Alternative 2: As shown in Figure 17, the 40% Alternative 2 includes the existing wet ponds (with legal maintenance authority), obtaining maintenance authority for all existing BMPs in Table 2-2 and proposed pond construction including six ponds. In addition, the 40% Alternative 2 includes the following street sweeping program: HE Sweeper once every 4 weeks with establishment of a parking control ordinance. Proposed ponds include Highland Pond, Mill Pond, Poch Pond, River Pond, School Pond (Alternative 1) and Slayer Pond.

The pollutant analysis summary for the alternatives is shown below in Figure 5-18. The proposed street sweeping and leaf collection program and costs associated with the proposed structural BMPs are provided in Table 5-19. The capital costs provided in Table 5-19 are the estimated present value capital costs for the proposed structural BMPs. The capital costs include an allowance for construction, land acquisition, engineering, legal, and contingency costs

Note that obtaining maintenance agreements for the existing BMPs in Table 2-2 includes those BMPs located within excluded areas. This modeling approach allows the City to claim water quality credit when advantageous to improve the composite percent removal provided for TSS and TP. Therefore, the developed urban area's size increases to 1,484 acres and its baseline loading increases to 386,507 lbs/yr and 1,171 lbs/yr of TSS and TP, respectively.

For reference, more detailed water quality results for the NR 151 analysis can be found in Appendix B.

Table 5-18

NR 151 Pollutant Analysis - 2019 BMPs (WinSLAMM)

City MS4 Alternative	Urban Area (acres)	TSS Baseline Load (lbs/yr)	TSS Load Reduction (lbs/yr)	TSS Load Reduction (%)	TP Baseline Load (lbs/yr)	TP Load Reduction (lbs/yr)	TP Load Reduction (%)
1 (20%)	1,410	358,732	72,157	20.1%	1,124.0	147.0	13.1%
2 (20%)	1,484	386,507	77,319	20.0%	1,171.1	141.7	12.1%
1 (40%)	1,484	386,507	158,231	40.9%	1,171.1	346.1	29.6%
2 (40%)	1,484	386,507	155,980	40.4%	1,171.1	336.6	28.7%

Table 5-19

NR 151 Alternatives Analysis

City MS4 Alternative	Proposed Street Sweeping* Type of Sweeper	Proposed Street Sweeping* Sweeping Frequency	Proposed Street Sweeping* Parking Controls	Proposed Structural BMPs Capital Costs
1 (20%)	H.E.	Once per week	Yes	$0.0
2 (20%)	H.E.	Once per 4 weeks	Yes	$125,000
1 (40%)	H.E.	Current	No	$2.4 million
2 (40%)	H.E.	Once per 4 weeks	Yes	$2.0 million

* Street sweeping begins March 29 and ends November 25 of each year. High efficiency (H.E.). Mechanical (M).,
Current Sweeping Frequency: Once per 4 weeks (Collector/Arterial Streets), and Once per 6 weeks (Local Roads)

Wastewater Total Phosphorus Analysis

For purposes of this study, alternatives were prepared to show percent reductions provided by utilizing different street sweeping patterns and establishment of a municipal leaf collection program. Furthermore, the proposed BMPs which are part of the 40% NR 151 alternative 2 was included to illustrate the phosphorus reductions that would be provided for the current (TMDL) analysis area. The results of the total phosphorus analysis are shown in table 5-20 and a detailed table is included in Appendix B.

Table 5-20

Wastewater Total Phosphorus Analysis

No.	Sweeping Pattern	Parking Controls	Leaf Collection	Obtain EBMP MA's	Future Develop-ment	Area (ac)	lbs/yr	%	lbs /yr	%
1	Current*					1,677	39,561	9.5%	72	5.6%
2	Current		X			1,677	39,561	9.5%	122	9.4%
3	Current	X				1,677	55,449	13.3%	105	8.1%
4	Current	X	X			1,677	55,449	13.3%	184	14.2%
5	HE 1/week	X				1,677	87,770	21.1%	173	13.3%
6	HE 1/week	X	X			1,677	87,770	21.1%	232	17.9%
7	HE 1/week	X	X		X	2,077	229,003	38.6%	456	27.3%
8	Current[1]	X	X	X	X	2,193	345,521	54.6%	697	40.0%
9	Current[1]	X	X	X	X	2,193	360,381	57.0%	719	41.2%

* Current System includes using a High Efficiency (HE) sweeper without parking controls (sweeping Once every 4 weeks for Collector and Arterial Streets
and Once every 6 weeks for Local Streets) and Existing BMP's where the City has Maintenance Authority or Ownership.
1 Construct 6 proposed ponds shown on Figure 17 (NR 151 40% Alternative 2). Includes Highland, Mill, Poch, River, School Pond Alt. 1, and Slayer Ponds.

6.0 IMPLEMENTATION AND RECOMMENDATIONS

Below are various recommendations for the City to consider when implementing the Stormwater Quality Management Plan and working toward MS4 Permit compliance.

Resource Management Plans

The City's Comprehensive plan was mentioned in Section 1.0 of this Stormwater Quality Management Plan. It is recommended that the priorities and recommendations contained in these resource management plan be incorporated into this plan by reference.

Plan of Action

The City may be required to develop a Plan of Action for stormwater quality after the City's becomes a permitted MS4 and upon completion of the Northeast Lakeshore TMDL. It is recommended that pollutants of concern associated with the Northeast Lakeshore TDML be targeted during implementation. Pollutant loads and pollutant yields depicted in Figures A1 through A8 can be used to target specific drainage areas with heavier pollutant loads or yields. In addition, the pollutant load and BMP analysis contained in this report can be used to target specific source areas with a heavier load or BMPs with a more favorable cost.

Public Education and Public Involvement

Public education and public involvement are recommended during development and implementation of proposed BMPs. Potential stakeholders include the general public, elected officials, City Staff, developers, regulatory entities, individual property owners and other regulated entities. Although this stormwater quality management plan includes a cost versus benefit analysis, the plan does not take into consideration intangibles such as public sentiment, public opinion, land availability, etc.

Redevelopment Sites

It is recommended that the City evaluate public/private partnerships with landowners when developing and implementing its future stormwater BMPs. As required by NR 151.12 and the City's Post-Construction Stormwater Management Ordinance, redevelopment sites with 1 acre or more of land disturbance are required to achieve a TSS reduction. Compliance with the TSS reduction is only required when a construction project occurs on the site. As such, these redevelopment sites do not have a specific timeline for achieving a TSS reduction. Nonetheless, when redevelopment occurs on commercial, industrial, institutional and multi-family residential parcels, stormwater quality improvements will be required. Public/private partnerships provide an opportunity to work together such that both the landowner and City benefit.

For example, redevelopment of a 20 acre shopping center may provide an opportunity to increase the site's TSS reduction to 80% or provide an opportunity to provide water quality treatment for other nearby properties or streets. In some instances, cost sharing can be used as a financial incentive or the City cost share through of public/private partnership with the landowners. Typically, it is more cost effective to incorporate stormwater quality improvements into an already planned construction project as compared to retrofitting a BMP without considering other construction activities in the watershed.

Inter-Governmental Agreements

It is recommended that the City evaluate inter-governmental agreements when developing and implementing stormwater BMPs. It may be more cost effective to work together with adjoining municipal jurisdictions, such as the WisDOT or Sheboygan County Highway Department. Also, it may be beneficial to work together with adjoining cities, villages and townships to construct a mutually beneficial stormwater BMP, share equipment, restore a wetland, or improve water quality using other methods.

Water Quality Trading

It is recommended that the City evaluate the feasibility and cost effectiveness of water quality trading when developing and implementing its stormwater BMPs. The cost for achieving compliance with TMDL allocations is not uniform among dischargers and source areas. As such, compliance with TMDL allocations may be more cost-effectively achieved by trading with other dischargers. Water quality trading is allowed between wastewater treatment facilities, agricultural landowners, and other urban stormwater dischargers. In order to be eligible for water quality trading, specific criteria needs to be satisfied. The WDNR recently developed a water quality trading framework for Wisconsin. This framework has led to two additional guidance documents for trading implementation.

Stream, Shoreline and Channel Stabilization

It is recommended that the City undertake high priority stream, shoreline and channel stabilization projects to reduce the discharge of sediment and phosphorus pollutants associated with bed, bank or steep slope erosion. In addition to the water quality benefits, stabilization projects provide an opportunity to improve habitat, remove invasive species, and potentially restore wetland areas. Grant funding is available to assist with stabilization projects.

Capital Improvement Plan

It is recommended that the City develop a 5-year to 20-year capital improvement plan based on this stormwater quality management plan. We recommend that the capital improvement plan include ample time for public education, public input, BMP design, land acquisition, regulatory permits, grant applications, financing, and construction. The capital improvement plan should also take into consideration other local capital improvement projects, such as street reconstruction projects, utility projects, and private development projects.

Financing Plan

It is recommended that the City develop a financing plan. The financing plan will allow the City to implement its proposed stormwater BMPs and 5-year Capital Improvement Plan. Below is a discussion of various funding sources which may be available to the City. Depending on the project, funding options may be used individually or in combination.

- Debt/Bonds: General obligation and revenue bonds may be used to secure funding for stormwater projects. Property taxes and revenue fees are used for long-term debt payments.

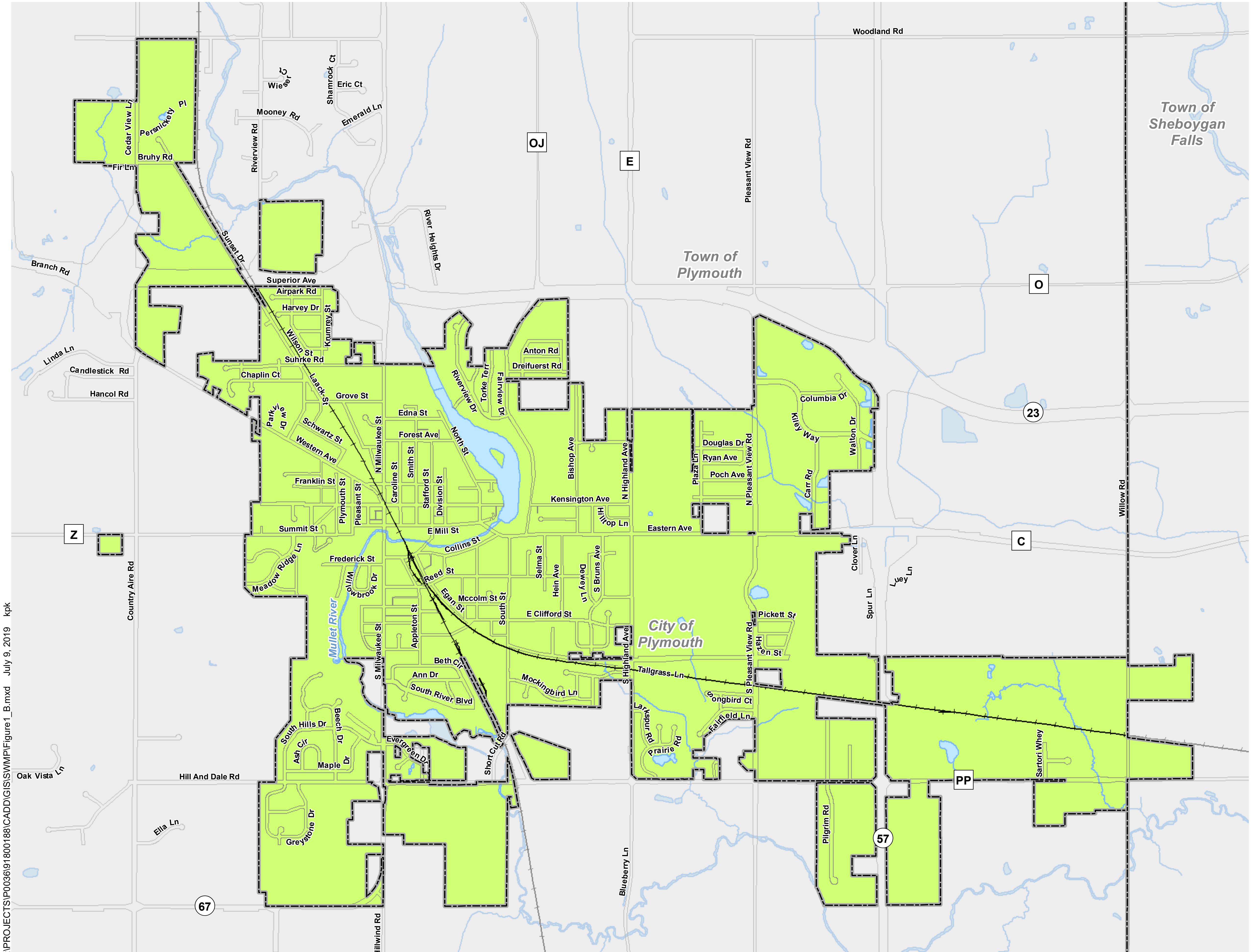
- Special Assessments: Special assessments may be used to generate funds for a specific project. Property owners that benefit from the project pay the assessment fee. Typically, other funding sources are needed to pay for project costs until property owners pay the assessment.

- Impact Fees: Impact fees may be charged to developers for stormwater projects that benefit the development. Impact fees are usually paid during initial stages of development. Typically, projects include regional stormwater facilities or improvements to deficient downstream infrastructure. Often, other funding sources are needed to pay for project costs until developers and property owners are required to pay the impact fee. Impact fees are recommended as needed to fund the municipal stormwater program.

- Tax Incremental Financing (TIF) District: TIF Districts may be used by Cities and Cities to fund stormwater projects that benefit property located within the District. Property value increases within the TIF District generate additional tax revenue that is used for long-term debt payments.

- Stormwater Utility: Stormwater utilities are similar to sanitary and water utilities. Stormwater utilities generate revenue for stormwater related projects by charging property owners an annual service fee. Annual service fees are based upon the amount of runoff generated by a specific property. Properties with more impervious area (i.e. roofs, parking lots, driveways, etc.) are charged a higher fee as compared to properties with less impervious area. All properties, including tax exempt properties, pay the service fee. Rate adjustments are recommended as needed to fund the municipal stormwater program.

- Grants/Loans: State and federal grant/loans are available for certain stormwater projects. Typically, only a certain percent of the total project cost is eligible for grant/loan money with remaining revenues to be generated by the applicant. Below are a few grant/loan programs which the City may or may not be familiar with. Grant applications are recommended.
  - Urban Non-Point Source and Stormwater Construction Grant
  - Targeted Runoff Management Construction Grant
  - Great Lakes Basin Program
  - Community Development Block Grant
  - Clean Water Fund



Legend

- Study Area

Other Mapped Features

- Municipal Boundary
- Right-of-Way Line (Approx.)
- Railroad Centerline
- Stream
- Surface Water

Source: Sheboygan County, 2016-19.

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 ASSOCIATES, INC. 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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0 2,000 4,000 Feet

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FIGURE 1
STUDY AREA
STORMWATER MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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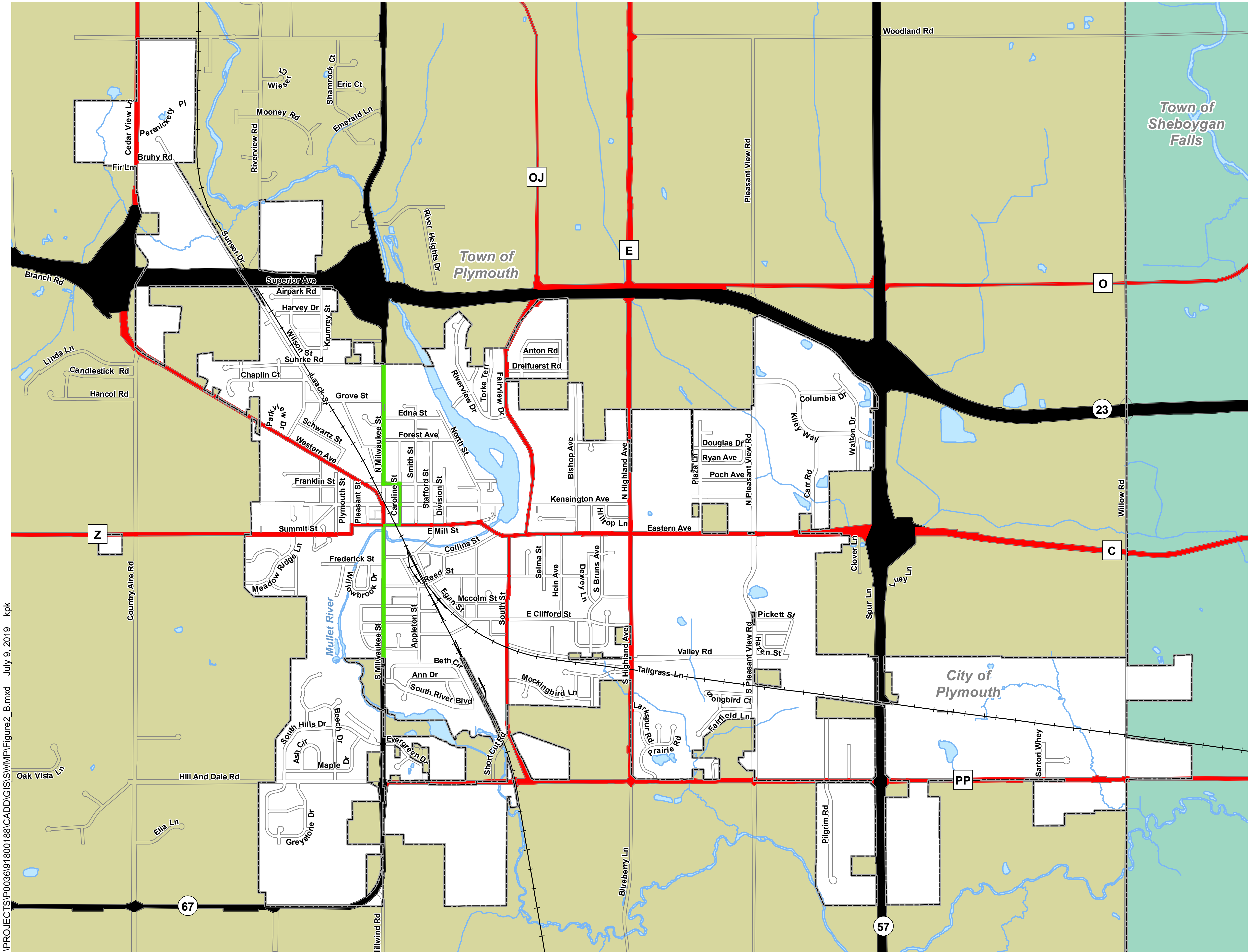

CITY OF PLYMOUTH WISCONSIN

Municipal Jurisdiction

- City of Plymouth
- Town of Plymouth
- Town of Sheboygan Falls

Highway Jurisdiction

- Connecting Highway
- County Trunk Highway
- State Trunk Highway
- State Freeway (NA)

Other Mapped Features

- Right-of-Way Line (Approx.)
- Railroad Centerline
- Stream
- Surface Water

Source: Sheboygan County, 2016-19, WDOT, 2017-19.

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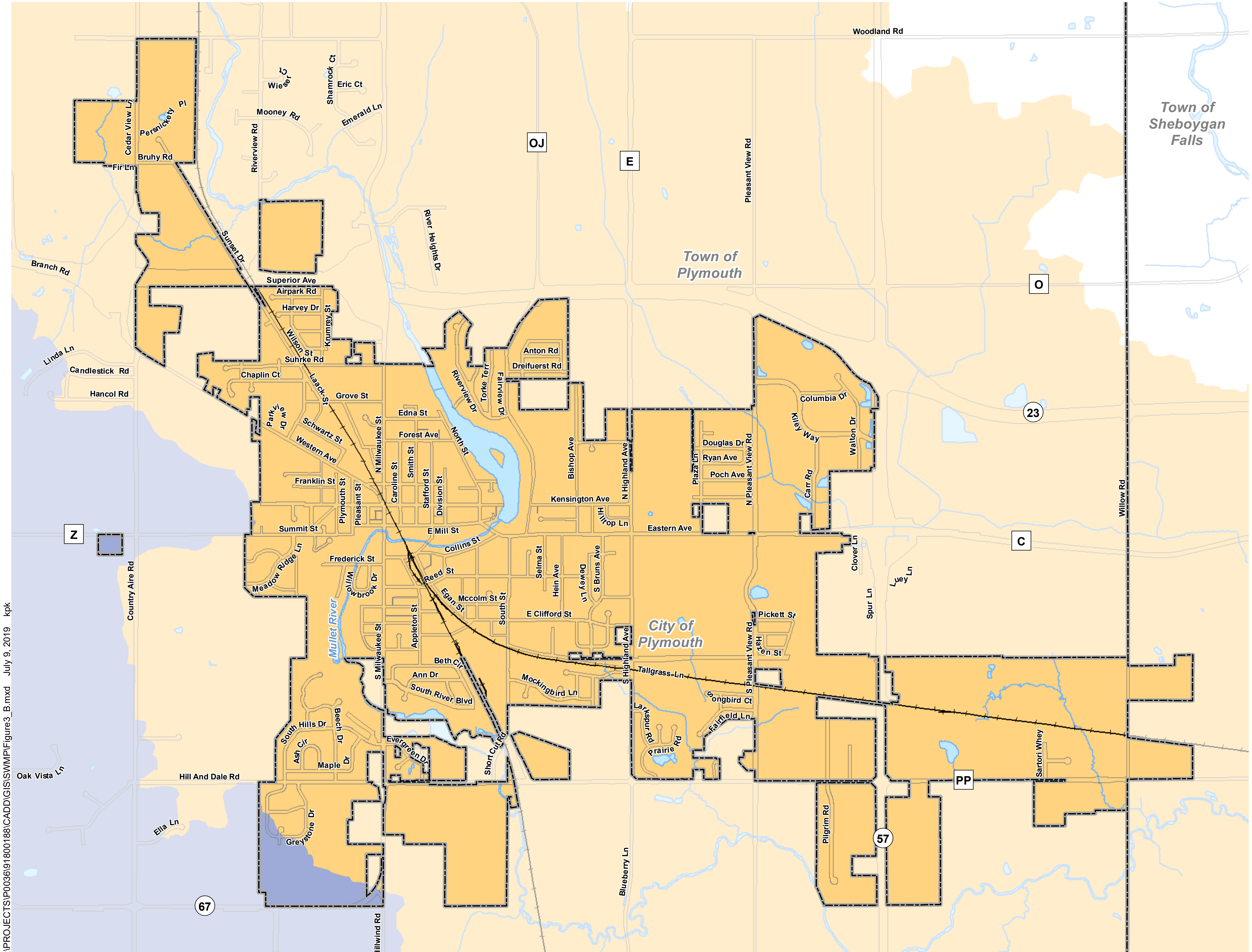
FIGURE 2
MS4 JURISDICTION
STORMWATER MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN



Sub-Watersheds

- Lower Mullet River
- Upper Onion River

Other Mapped Features

- Municipal Boundary
- Right-of-Way Line (Approx.)
- Railroad Centerline
- Stream
- Surface Water

Source: Sheboygan County, 2016-19.

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 ASSOCIATES, INC. 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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McMAHON ENGINEERS ARCHITECTS
McMAHON ASSOCIATES, INC.

FIGURE 3
SUB-WATERSHEDS
STORMWATER MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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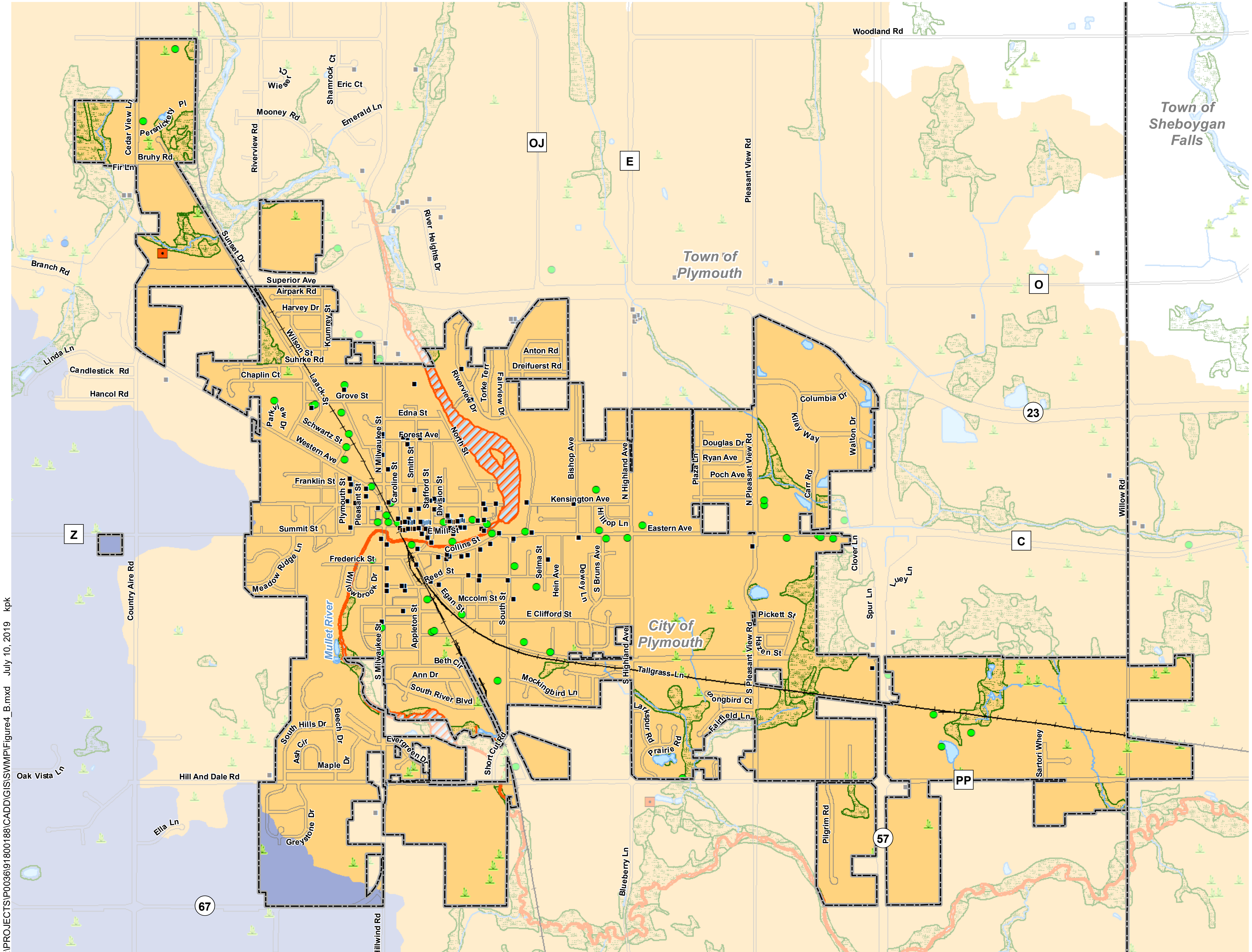

Natural Resources

- WDNR Wetland Inventory (Less Than 2 Acres)
- WDNR Wetland Inventory (2 Acres and Greater)
- WDNR 303(d) Impaired Waters
- Surface Water
- Stream

Sub-Watersheds

- Lower Mullet River
- Upper Onion River

Other Mapped Features

- Historic Site and ID
- Historic Waste Disposal Site
- Open DNR Remediation Site
- Closed DNR Remediation Site
- Municipal Boundary
- Right-of-Way Line (Approx.)
- Railroad Centerline

Source: Sheboygan County, 2016-19.

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FIGURE 4
NATURAL RESOURCES
STORMWATER MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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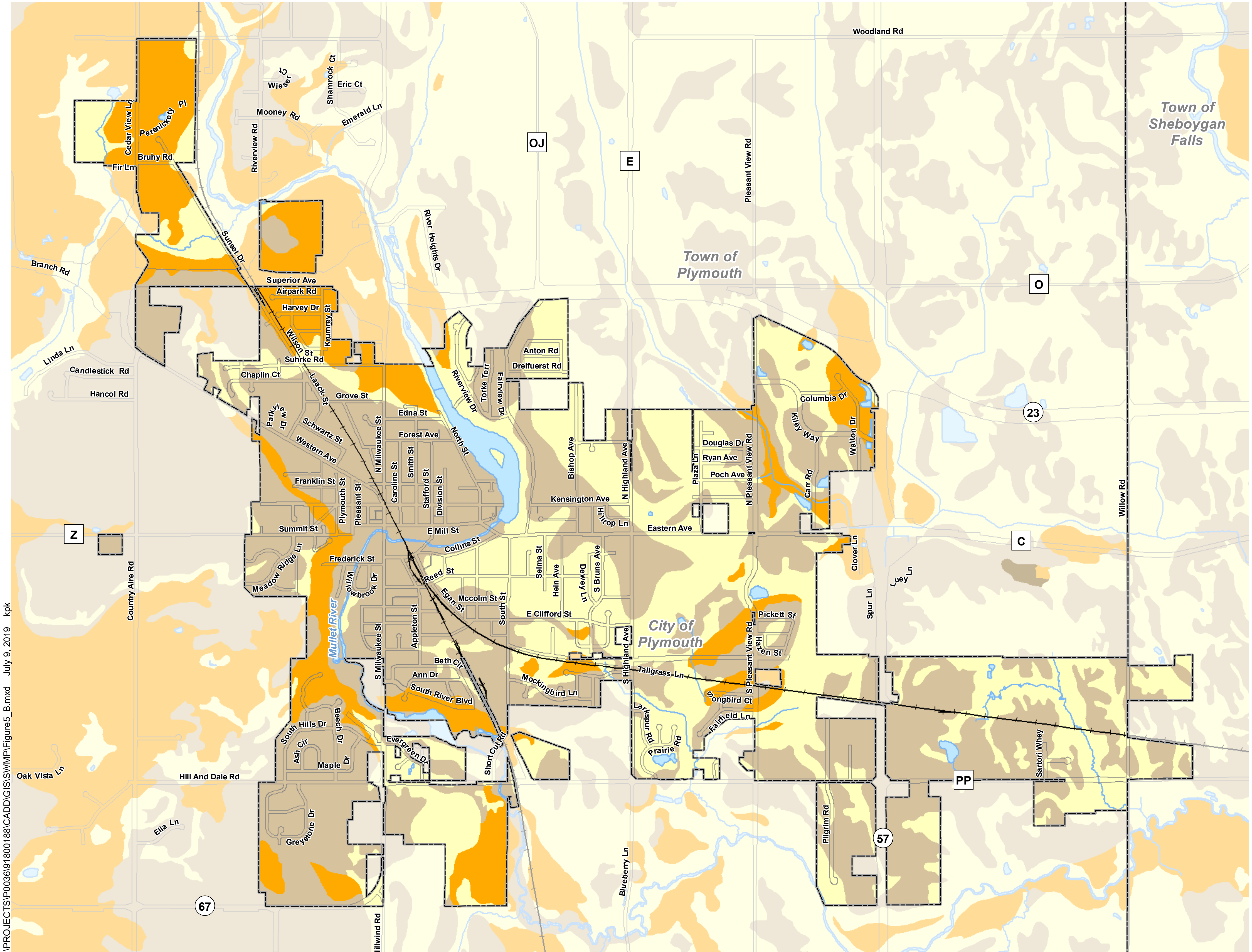

Hydrologic Soil Group (HSG)

- HSG A
- HSG B
- HSG C
- HSG D

Other Mapped Features

- Municipal Boundary
- Right-of-Way Line (Approx.)
- Railroad Centerline
- Stream
- Surface Water

Source: Sheboygan County, 2016-19, USDA, 2018.

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FIGURE 5
SOILS
STORMWATER MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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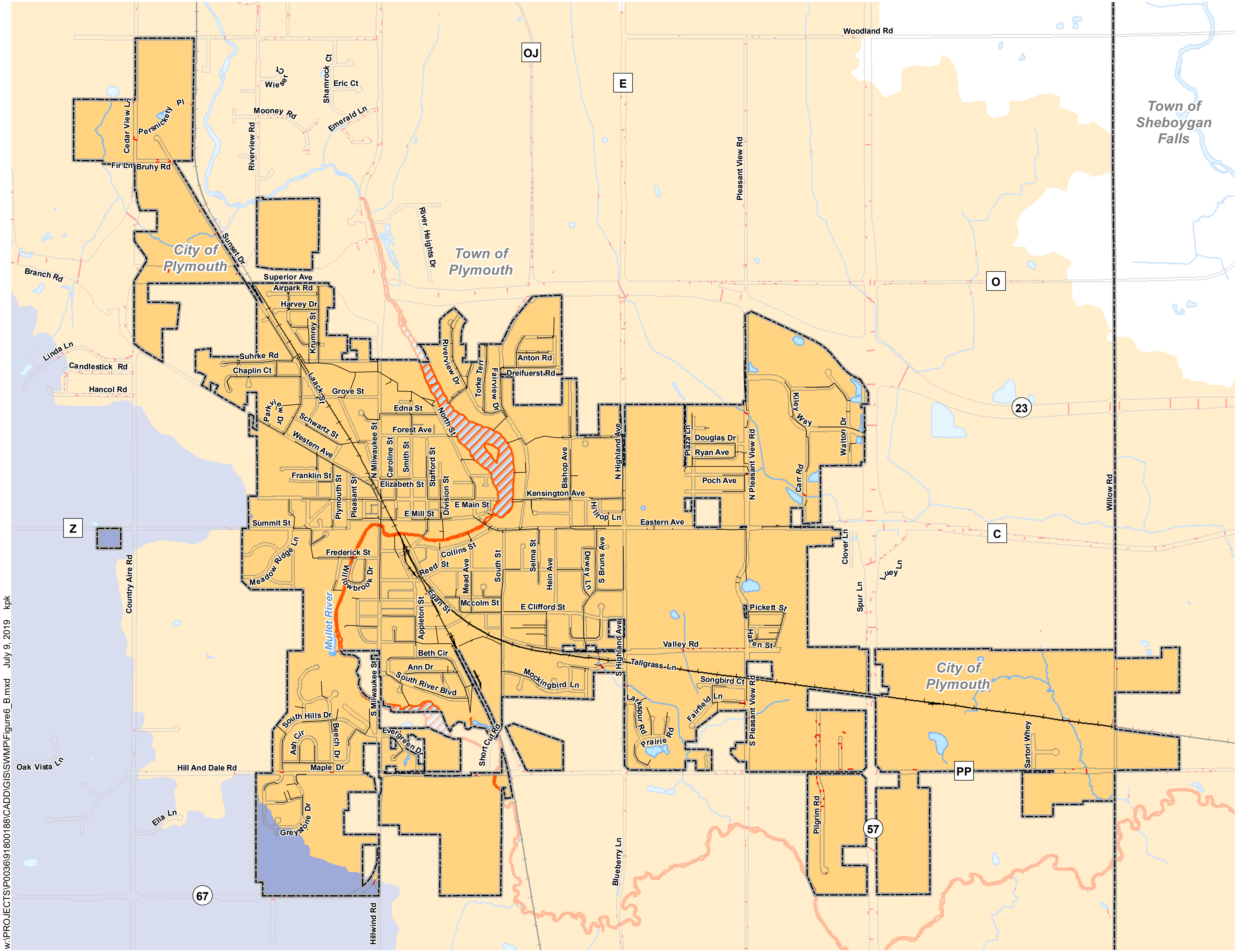

CITY OF PLYMOUTH WISCONSIN

MS4 Drainage System

- Storm Sewer System
- Culvert

Sub-Watersheds

- Lower Mullet River
- Upper Onion River

Other Mapped Features

- Municipal Boundary
- Right-of-Way Line (Approx.)
- Railroad Centerline
- Stream
- Surface Water
- 303(d) Impaired Waters

Source: Sheboygan County, 2016-19.

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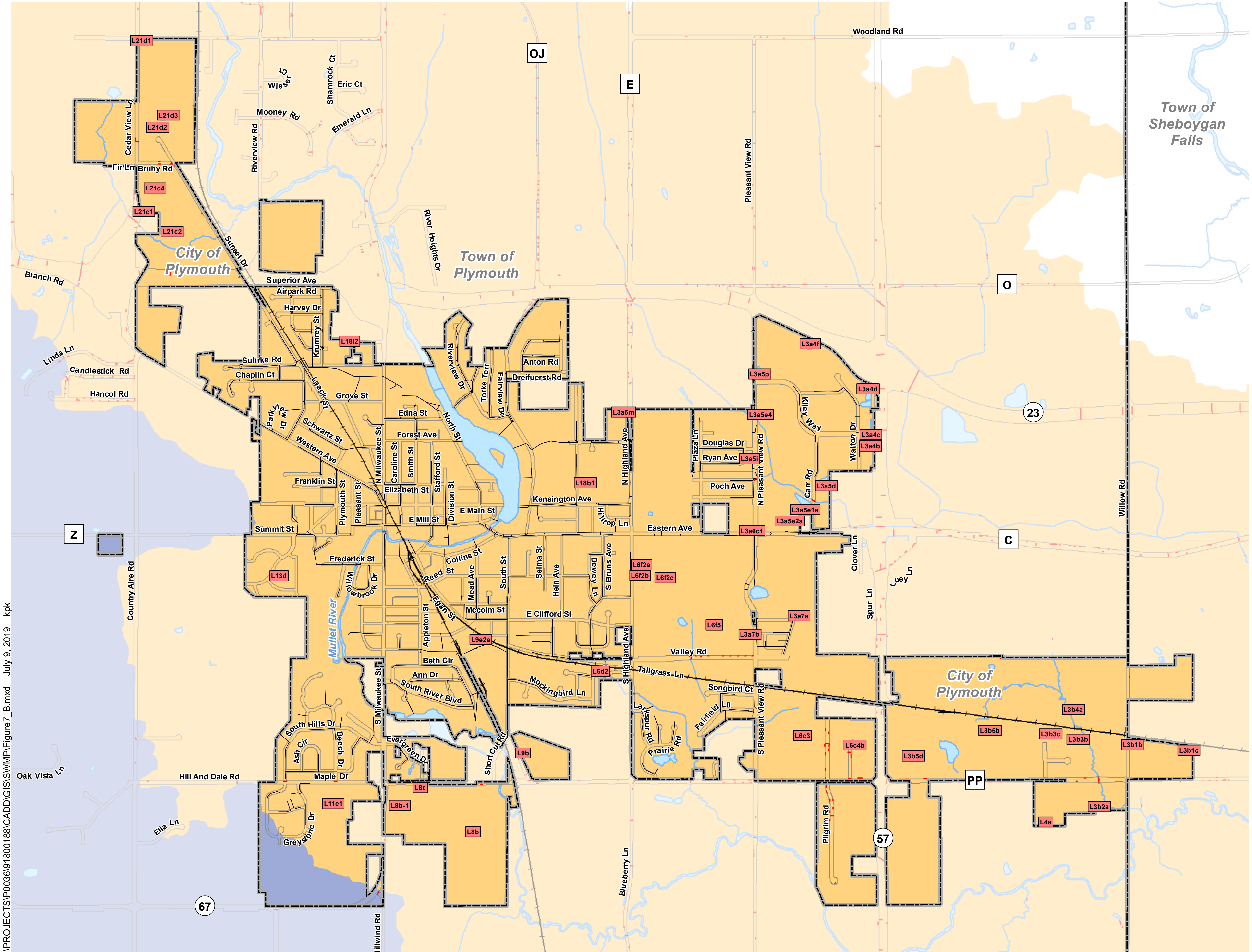
FIGURE 6
MS4 SYSTEM
STORMWATER MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN



CITY OF PLYMOUTH WISCONSIN

MS4 Drainage System

- Structural BMP ID
- Storm Sewer System
- Culvert

Sub-Watersheds

- Lower Mullet River
- Upper Onion River

Other Mapped Features

- Municipal Boundary
- Right-of-Way Line (Approx.)
- Railroad Centerline
- Stream
- Surface Water

Source: Sheboygan County, 2016-19.

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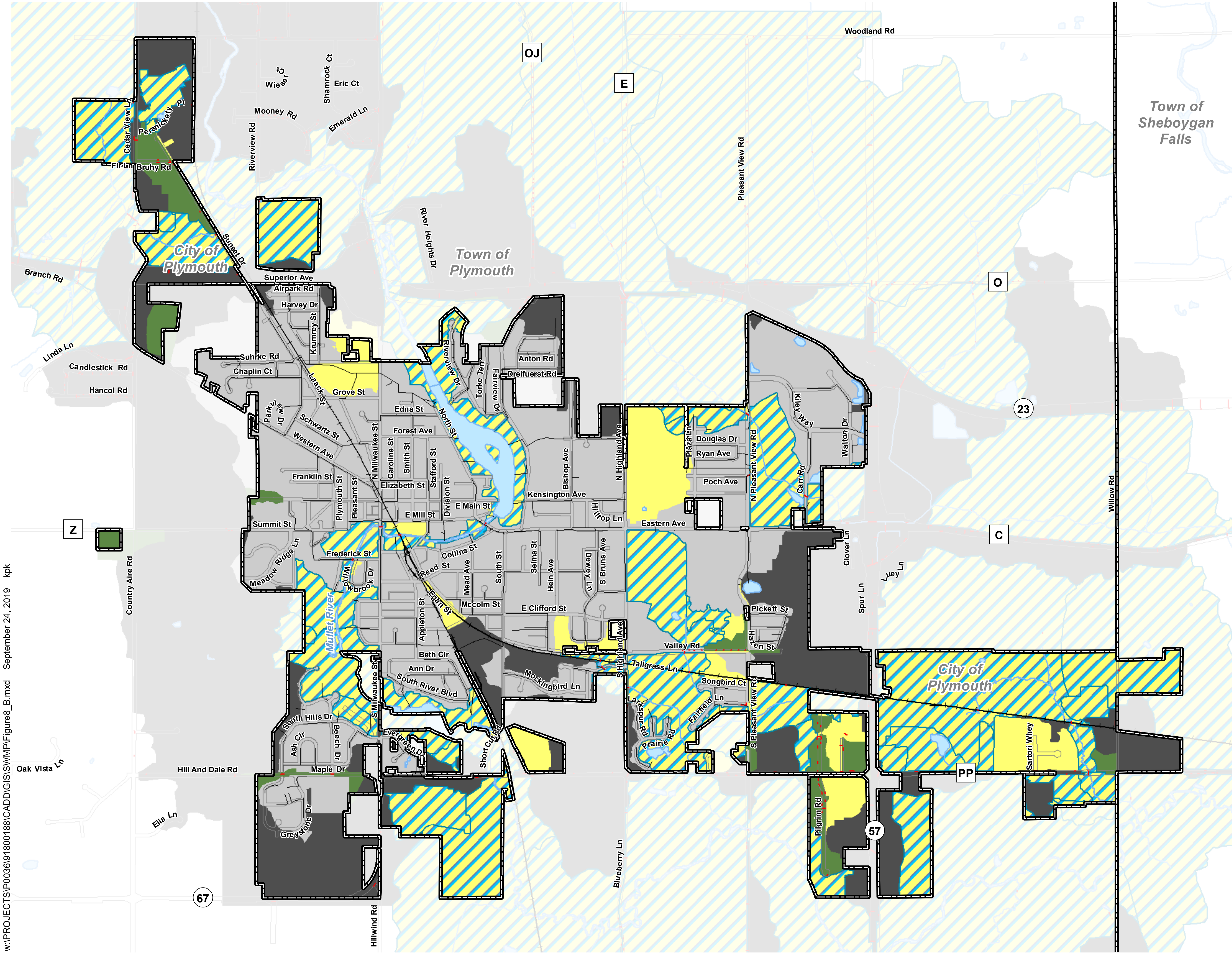
FIGURE 7
STRUCTURAL BMPs
STORMWATER MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN



CITY OF PLYMOUTH WISCONSIN

Surface Drainage

- Curb and Gutter
- No Controls
- Grass Swale

MS4 Drainage System

- Storm Sewer System
- Culvert

Other Mapped Features

- Municipal Boundary
- Right-of-Way Line (Approx.)
- Railroad Centerline
- Stream
- Surface Water
- MS4 'A' to 'B' Area
- Riparian Area

Source: Sheboygan County, 2016-19.

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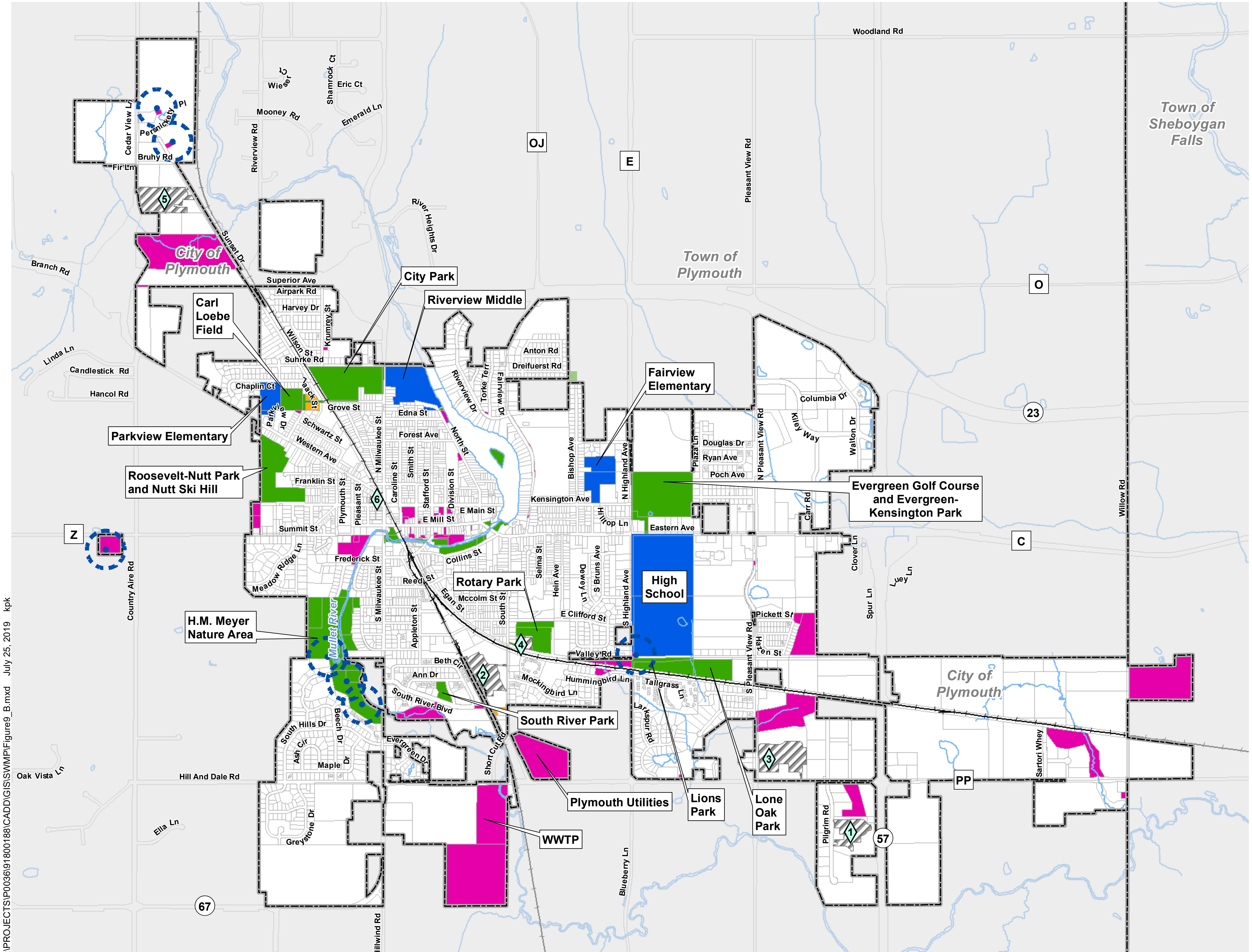
FIGURE 8
SURFACE DRAINAGE
STORMWATER MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN



WPDES Industrial Permit

- WPDES Industrial Permit and ID

Publicly Owned Property

- City of Plymouth Owned Lands
- Public Parks and Recreation
- School District Property
- County Owned Lands
- State Owned Lands
- Municipal Well and 400' Radius Buffer

Other Mapped Features

- Municipal Boundary
- Right-of-Way Line (Approx.)
- Railroad Centerline
- Stream
- Surface Water

Source: Sheboygan County, 2016-19.

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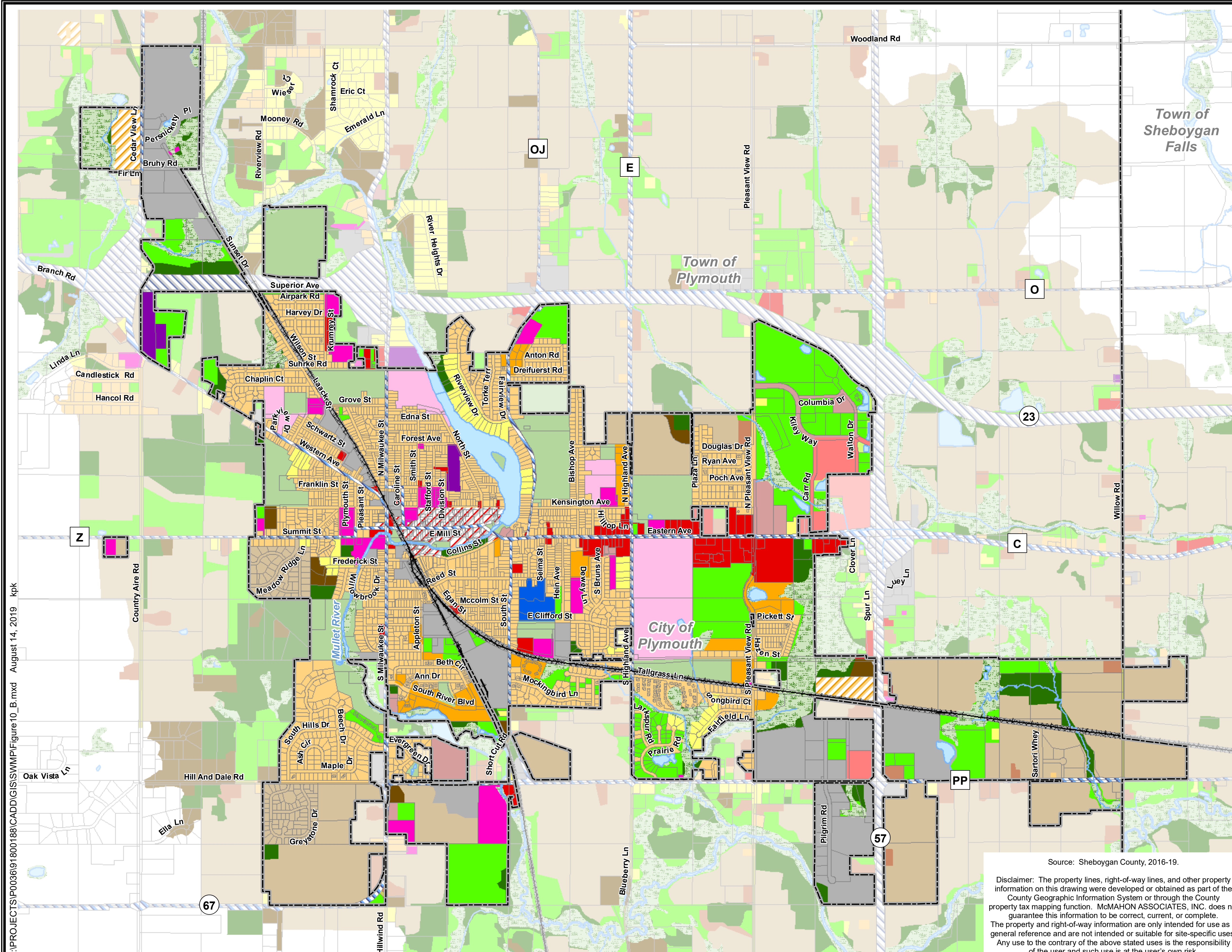
FIGURE 9
WPDES INDUSTRIAL PERMITS
STORMWATER MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN



CITY OF PLYMOUTH WISCONSIN

SLAMM Standard Land Uses

Residential

- LDR - Low Density Single Family Residential (0.5 acre to 1.5 acre lots)
- MDR - Medium Density Single Family Residential (0.25 acre to 0.5 acre lots)
- MDRA - Medium Density Single Family Residential w/Alleys (0.25 acre to 0.5 acre lots)
- HDR - High Density Single Family Residential (0.125 acre lots or smaller)
- HDRA - High Density Single Family Residential w/Alleys (0.125 acre lots or smaller)
- MFR - Multi-Family Residential (3 or more families, 1-3 story height)
- HRR - High Rise Residential (1.5 acre to 5 acre lots, > 3 story)
- SUBR - Suburban Residential (1.5 acre to 5 acre lots)
- MOBR - Mobile Home or Trailer Park Residential

Institutional

- SCHOOL - Public or Private School
- UNIV - University, College, Technical School, etc.
- HOSP - Medical Facilities including Nursing Homes, Hospitals, etc.
- MISC - Miscellaneous Facilities (Churches, Institutional Property)

Commercial

- CDNTN - Downtown Commercial and Institutional Areas
- CSTRIP - Strip Commercial Areas (Courthouses, Police Stations, etc.)
- SHCNTR - Shopping Centers (parking lot is 2.5 times building area)
- OFFPRK - Office Parks (non-retail, multi-story, insurance, government)

Industrial

- LIGHTI - Light Industrial Areas (storage and distribution of goods for retail or sale)
- MEDI - Medium Industrial Areas (lumber, junk, or auto salvage yard, ag., co-op, oil tank farm, coal and salt storage, slaughter house)
- AIRPRT - Airport Facilities
- QUARRY

Open Space

- CEM - Cemeteries, including grounds, roads, and buildings)
- PARK - Outdoor Recreational Areas (golf course, arboretums, botanical gardens, municipal playgrounds, and natural areas)
- RAIL - Railroad ROW (Excludes road ROW, storage yards)
- FRMSTD - Farmsteads, including limited houses, buildings, driveways and parking areas
- AGRIC - Agriculture fields
- GRASS - Undeveloped land that is vegetated (Excludes road ROW)
- GRASS_SWPOND - Vegetated land around a stormwater pond (Excludes road ROW)
- WOODS - Forested or Wooded Areas with Leaf Litter
- WETLND - DNR Wetland Inventory Map
- WATER - Waters of the State and Other Open Waters
- WATER_SWPOND - Open water associated with stormwater pond

Transportation

- FREE - Limited Access Highways and Interchanges, including vegetated ROW
- HWY - State or County Highway
- RURALRD - Rural Road

Other Mapped Features

- Municipal Boundary
- 2004 Right-of-Way Line (Approx.)
- Current Parcel of Right-of-Way Line
- Railroad Centerline
- Streams

0 2,000 4,000 Feet

McMAHON ENGINEERS | ARCHITECTS

McMAHON ASSOCIATES, INC.

Source: Sheboygan County, 2016-19.

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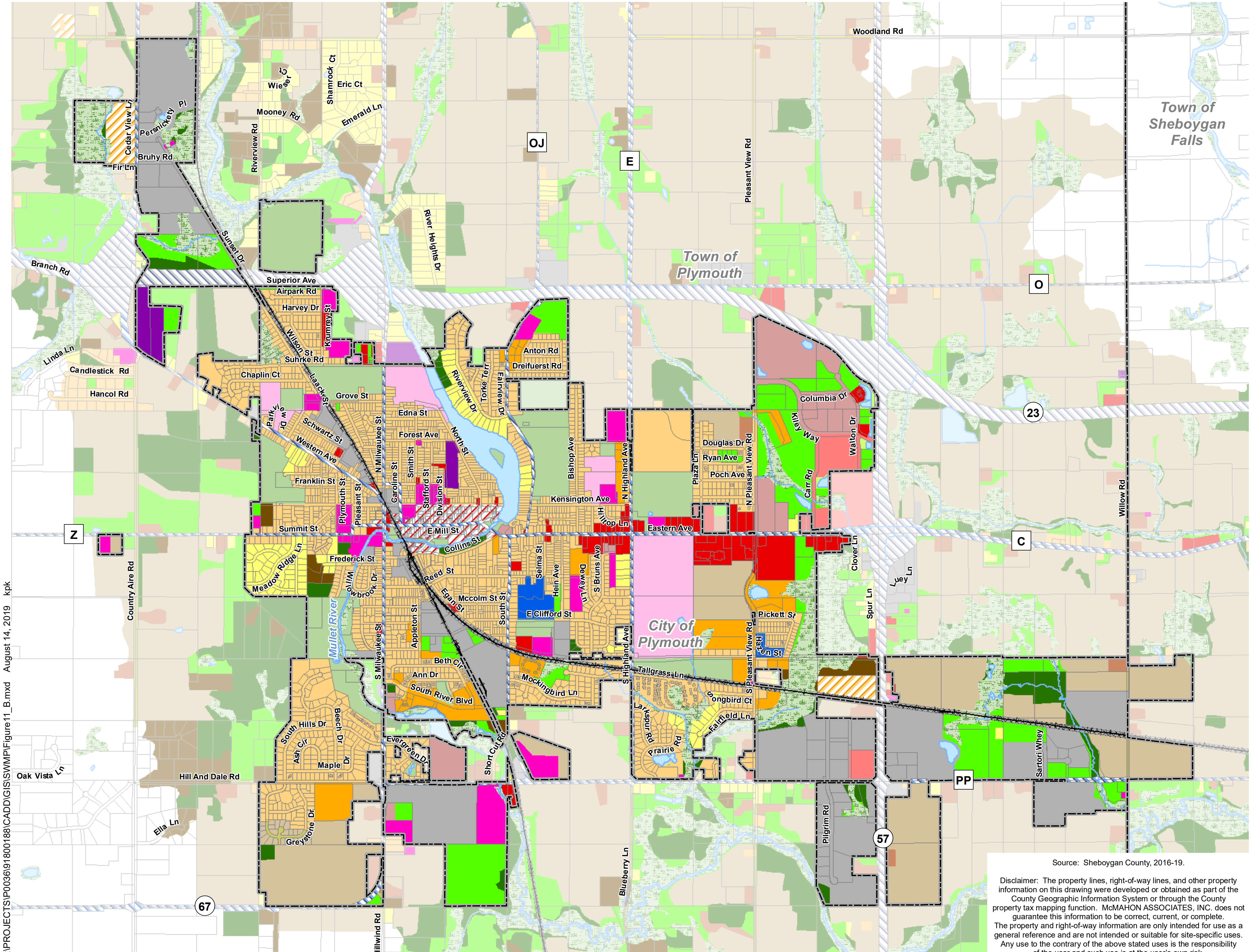
FIGURE 10

2004 LAND USE

STORMWATER MANAGEMENT PLAN

CITY OF PLYMOUTH

SHEBOYGAN COUNTY, WISCONSIN



SLAMM Standard Land Uses

Residential

- LDR - Low Density Single Family Residential (0.5 acre to 1.5 acre lots)
- MDR - Medium Density Single Family Residential (0.25 acre to 0.5 acre lots)
- MDRA - Medium Density Single Family Residential w/Alleys (0.25 acre to 0.5 acre lots)
- HDR - High Density Single Family Residential (0.125 acre lots or smaller)
- HDRA - High Density Single Family Residential w/Alleys (0.125 acre lots or smaller)
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- HRR - High Rise Residential (1.5 acre to 5 acre lots, > 3 story)
- SUBR - Suburban Residential (1.5 acre to 5 acre lots)
- MOBR - Mobile Home or Trailer Park Residential

Institutional

- SCHOOL - Public or Private School
- UNIV - University, College, Technical School, etc.
- HOSP - Medical Facilities including Nursing Homes, Hospitals, etc.
- MISC - Miscellaneous Facilities (Churches, Institutional Property)

Commercial

- CDNTN - Downtown Commercial and Institutional Areas
- CSTRIP - Strip Commercial Areas (Courthouses, Police Stations, etc.)
- SHCNTR - Shopping Centers (parking lot is 2.5 times building area)
- OFFPRK - Office Parks (non-retail, multi-story, insurance, government)

Industrial

- LIGHTI - Light Industrial Areas (storage and distribution of goods for retail or sale)
- MEDI - Medium Industrial Areas (lumber, junk, or auto salvage yard, ag., co-op, oil tank farm, coal and salt storage, slaughter house)
- AIRPRT - Airport Facilities
- QUARRY

Open Space

- CEM - Cemeteries, including grounds, roads, and buildings)
- PARK - Outdoor Recreational Areas (golf course, arboretums, botanical gardens, municipal playgrounds, and natural areas)
- RAIL - Railroad ROW (Excludes road ROW, storage yards)
- FRMSTD - Farmsteads, including limited houses, buildings, driveways and parking areas
- AGRIC - Agriculture fields
- GRASS - Undeveloped land that is vegetated (Excludes road ROW)
- GRASS_SWPOND - Vegetated land around a stormwater pond (Excludes road ROW)
- WOODS - Forested or Wooded Areas with Leaf Litter
- WETLND - DNR Wetland Inventory Map
- WATER - Waters of the State and Other Open Waters
- WATER_SWPOND - Open water associated with stormwater pond

Transportation

- FREE - Limited Access Highways and Interchanges, including vegetated ROW
- HWY - State or County Highway
- RURALRD - Rural Road

Other Mapped Features

- Municipal Boundary
- Parcel of Right-of-Way Line
- Railroad Centerline
- Streams

0 2,000 4,000 Feet

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Source: Sheboygan County, 2016-19.

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FIGURE 11
CURRENT LAND USE
STORMWATER MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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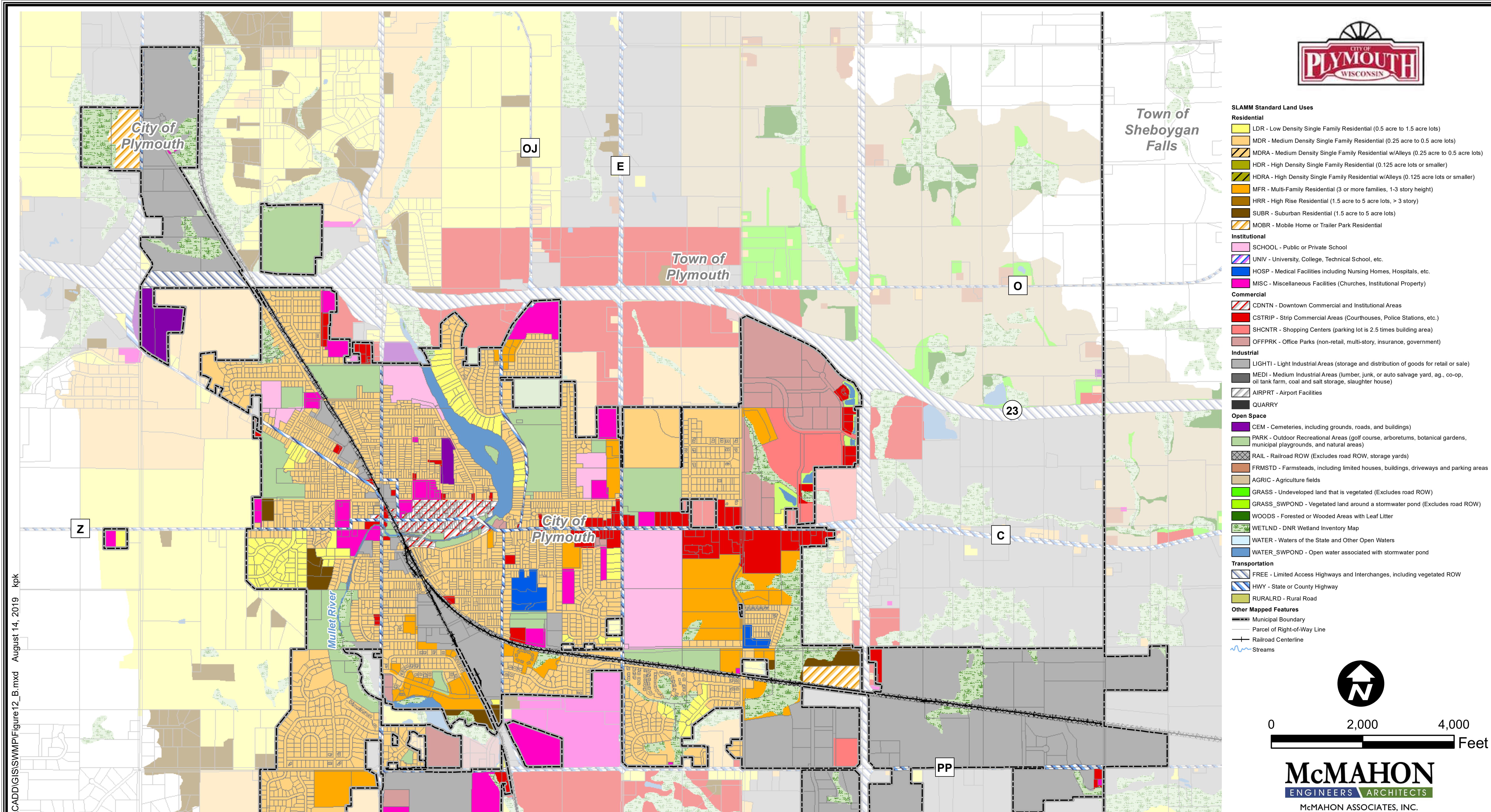

Source: Sheboygan County, 2016-19.

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FIGURE 12
FUTURE LAND USE
STORMWATER MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

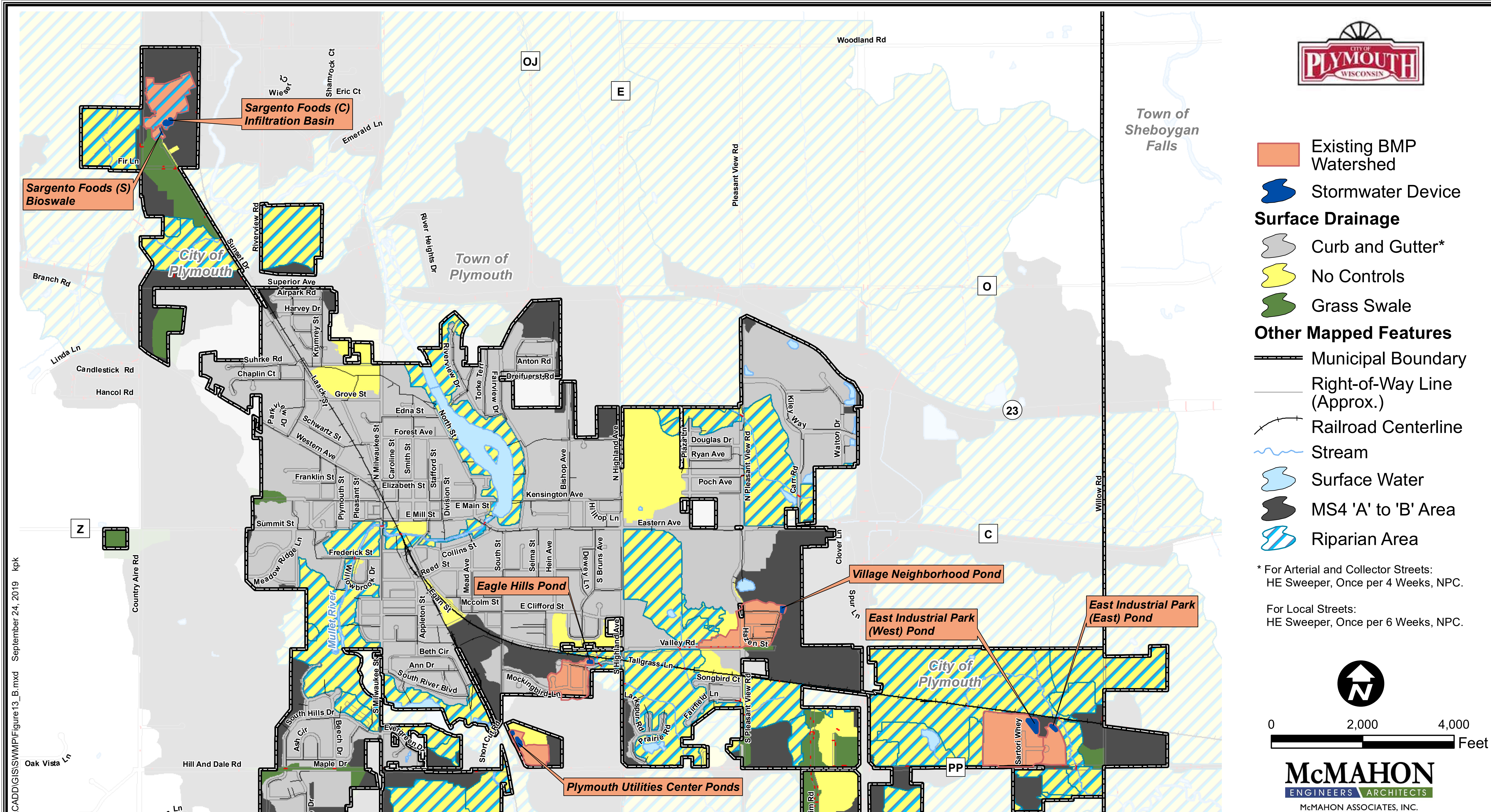


FIGURE 13
2019 BMPs
STORMWATER MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

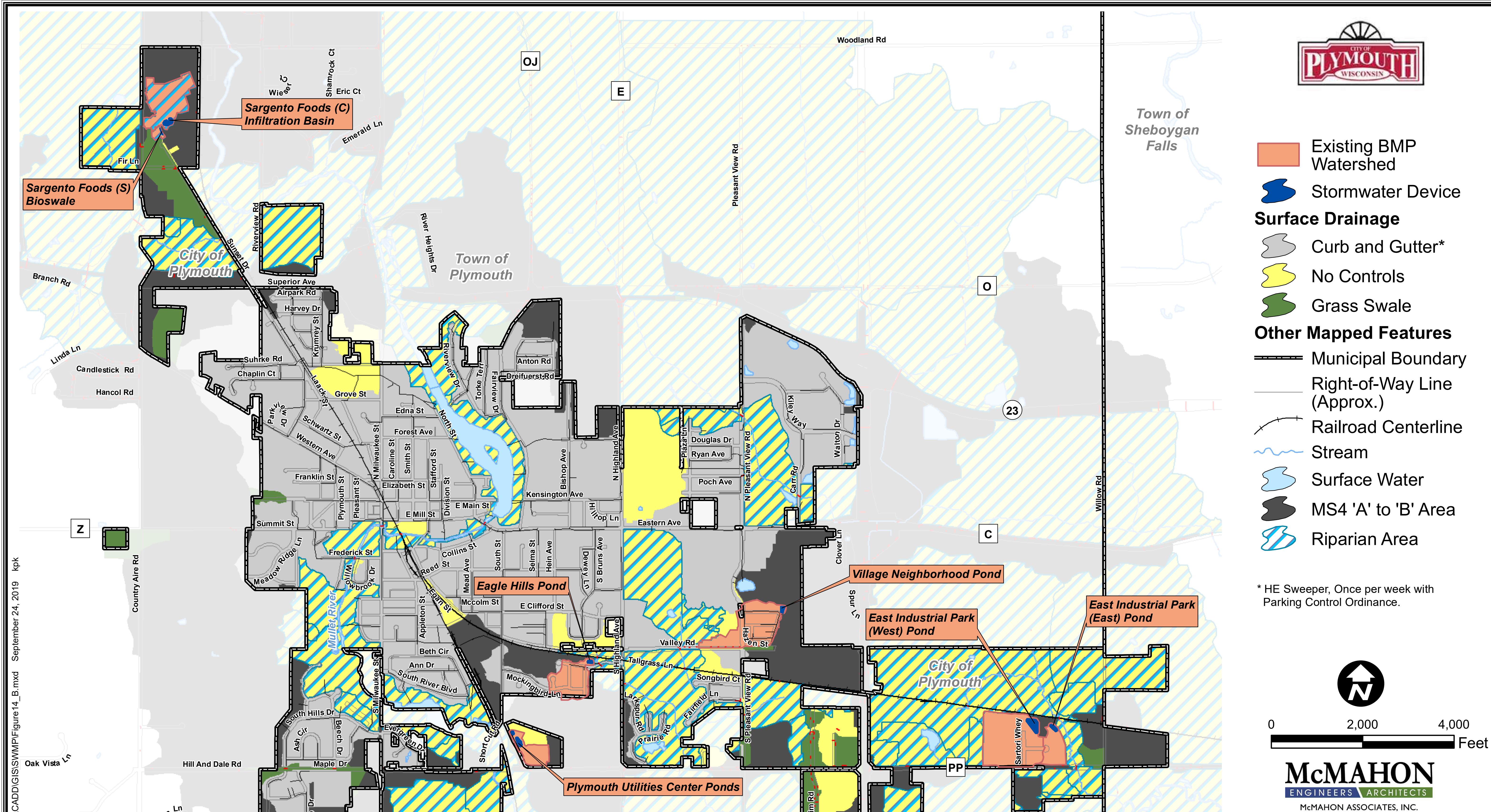


FIGURE 14
ALTERNATIVE 1
NR 151 - 20% TSS REDUCTION
STORMWATER MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

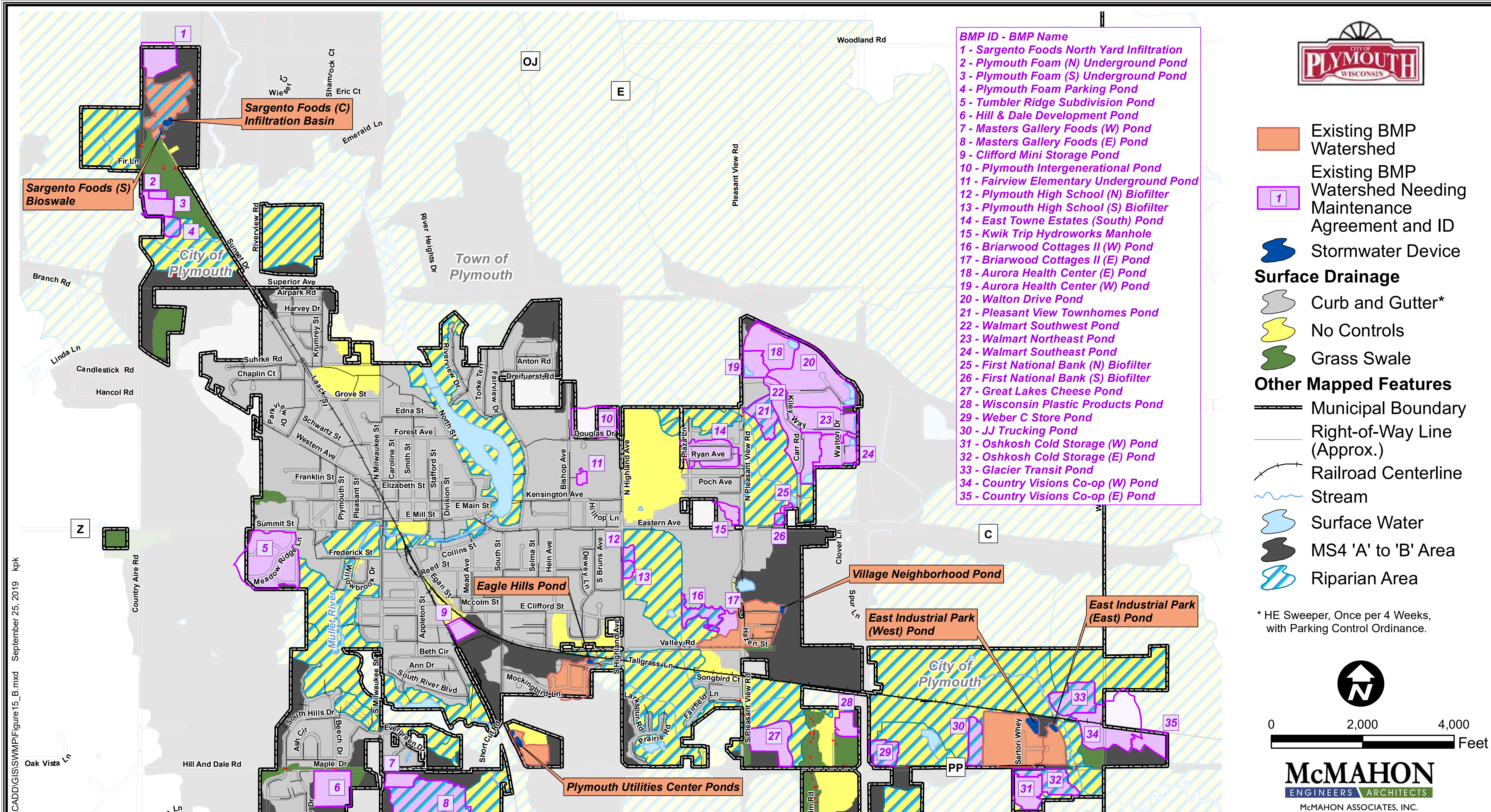
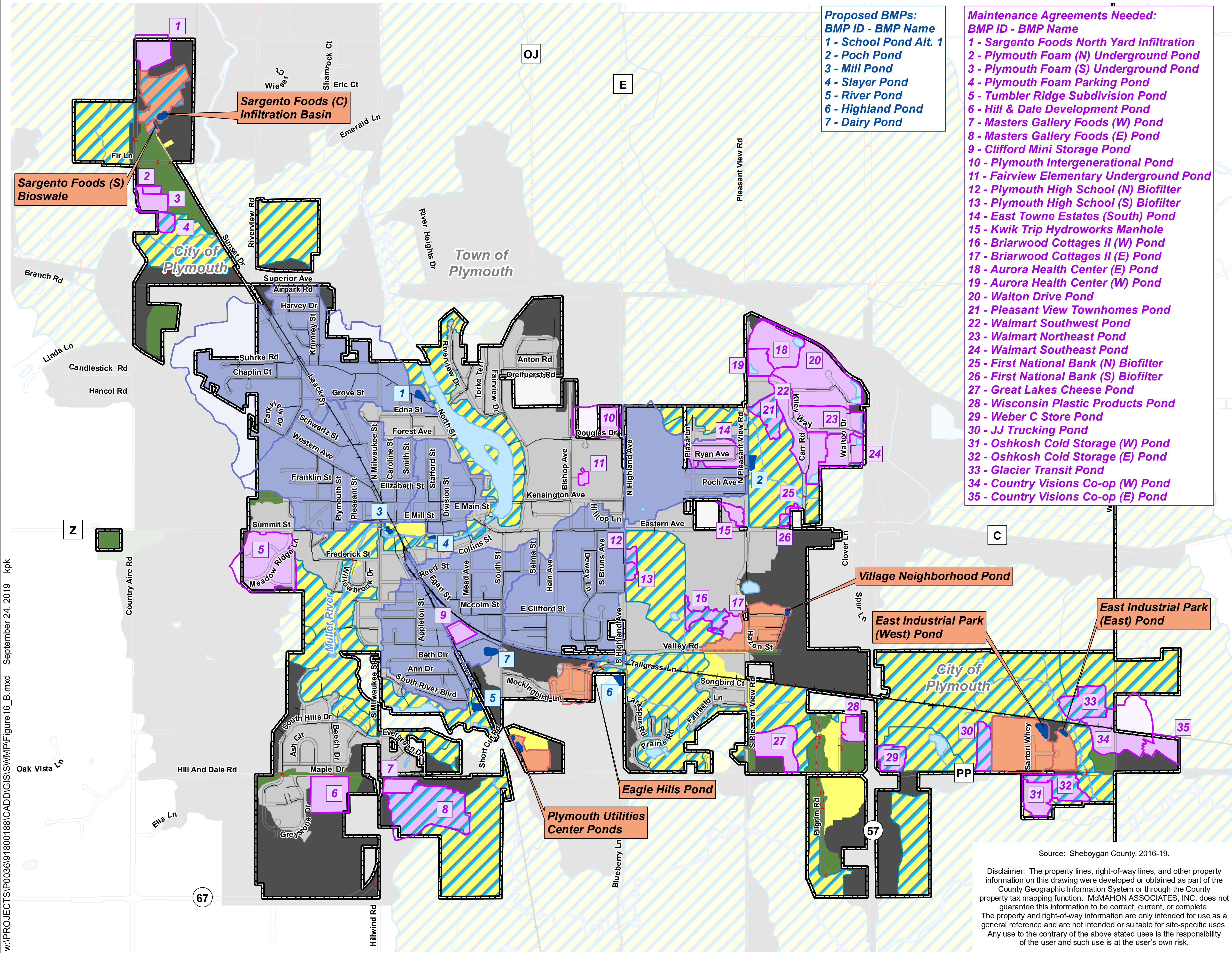


FIGURE 15
ALTERNATIVE 2
NR 151 - 20% TSS REDUCTION
STORMWATER
MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN



Existing BMP Watershed

Existing BMP Watershed Needing Maintenance Agreement and ID

Proposed BMP Watershed

Stormwater Device

Surface Drainage

Curb and Gutter*

No Controls

Grass Swale

Other Mapped Features

Municipal Boundary

Right-of-Way Line (Approx.)

Stream

Railroad Centerline

Surface Water

MS4 'A' to 'B' Area

Riparian Area

* For Arterial and Collector Streets: HE Sweeper, Once per 4 Weeks, NPC.

For Local Streets: HE Sweeper, Once per 6 Weeks, NPC.

0 2,000 4,000 Feet

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Source: Sheboygan County, 2016-19.

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FIGURE 16
ALTERNATIVE 1
NR 151 - 40% TSS REDUCTION
STORMWATER MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN

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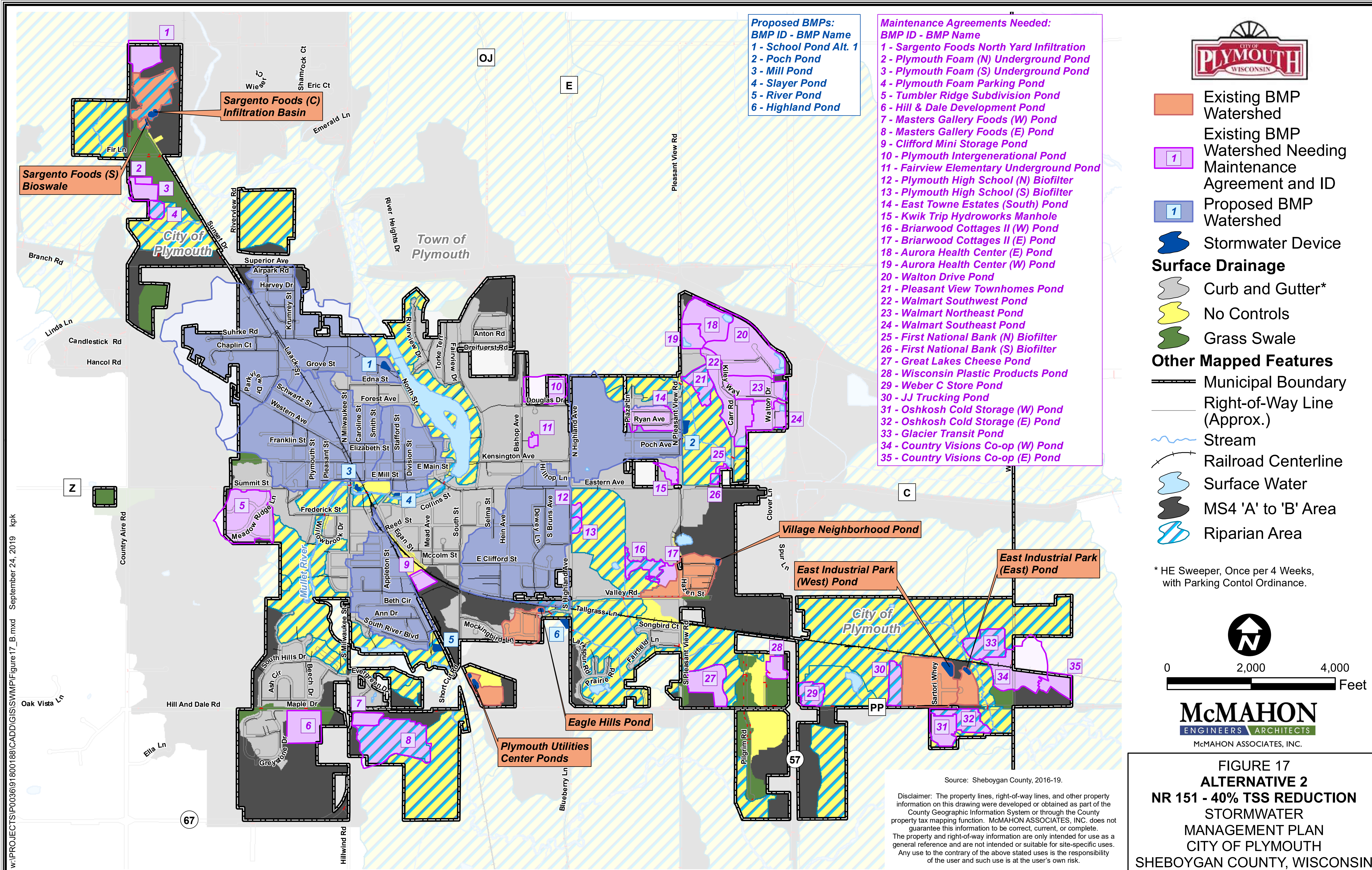

FIGURE 17
ALTERNATIVE 2
NR 151 - 40% TSS REDUCTION
STORMWATER
MANAGEMENT PLAN
CITY OF PLYMOUTH
SHEBOYGAN COUNTY, WISCONSIN