Gull and Augusta Creeks Watershed Management Plan: the Four Township Watershed Area

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1 Introduction

Four townships around Gull Lake in Kalamazoo and Barry counties have been the focus of considerable attention regarding water resource values and protection, led by the Four Townships Water Resources Council. The Four Townships Watershed Area (FTWA) encompasses these townships plus remaining watersheds of streams that originate in the four townships. The FTWA possesses a rich diversity of surface waters in good ecological condition. These surface waters - lakes, streams, and wetlands - are highly valued by local residents for recreational and aesthetic reasons, and many of the local residents live on or close to lakes, often in dense residential development. The local landscape is underlain by groundwater aquifers of good water quality that for the most part meet drinking water requirements except for some wells with elevated nitrate. None of these waters exists in isolation because the permeable soils of the area promote exchanges of water between the land surface, groundwater, streams, lakes, and wetlands. Thus the entire hydrologic system is vulnerable to the degradation of water quality in the case of contaminants that are mobile in groundwater systems (e.g., nitrate, atrazine). Wetlands are abundant in the FTWA and they serve to improve water quality because they are often situated at the interface between groundwater, surface runoff, and lakes and streams, where they remove excess nutrients, sediments, and contaminants.

As a more rural watershed, the focus of watershed management in the FTWA is oriented to protection and preservation of the high quality natural landscapes to project the good water quality enjoyed in most stretches of the river network. The watershed management plan (WMP) pays some attention to localized stormwater issues, especially more densely developed areas around popular inland lakes and small villages. There is a general concern about row-crop and animal agriculture in rural areas of the watershed. Future residential and urban development as well as intensification of agriculture present challenges for the protection of these water resources, and as such the WMP focuses on both protection and restoration in some cases. Good stewardship of the water resources and the ecosystems they support requires a sound scientific understanding of their nature and of potential threats. Equally important is an educated public that supports the protection of our connected land and water resources through local long term planning as well as through individual actions. By producing this WMP, the Four Township Water Resources Council (FTWRC) hopes to contribute to the goals of protection of water resources throughout the watershed and improvement of water quality in key water bodies.

The natural areas in the FTWA support diverse plant and animal life. A recent inventory of natural features found that some of the landscape is still dominated by native vegetation essentially similar to the vegetation that existed in the FTWA a century ago. For this reason, the FTWRC has focused extensive resources on addressing the challenge of how to accommodate development and land use changes while protecting our shared natural heritage. Much of the original WMP of 2011 and projects pre-dating the WMP involved developing and promoting land use planning policies and tools that

protect natural resources. In updating the original WMP, the overall focus shifted from land use planning and policy to habitat management and protection.

The FTWA is a priority for protection and preservation among southern Michigan watersheds because a relatively high percentage of its natural land cover remains in good condition in spite of increasing development pressure throughout the region. The WMP is intended to guide individuals, businesses, organizations and governmental units to work cooperatively to ensure the water and natural resources necessary for future growth and prosperity are improved and protected. It can be used to educate watershed residents on how they can improve and protect water quality, encourage and direct natural resource protection and preservation, and inspire and steer land use planning and zoning that will protect water quality in the future. Implementation of the plan will require stakeholders to work across township, county, and other political boundaries.

1.1 About the Council

The issues of managing growth and curbing urban sprawl are being discussed across the state and the nation. For almost two decades, the FTWRC has been researching, documenting, and promoting approaches to help address these issues locally, from a long range planning perspective. In equal parts, the natural resources of the FTWA will be protected based on collective decisions made at the local level over the long term and decisions made by private landowners on privately held parcels. Township and county master plans and zoning can provide the general framework for protection, but individual landowners ultimately will make many of these decisions and their cumulative actions will determine the future state of water resources in the FTWA.

Living in a landscape so richly endowed with groundwater, lakes, streams and wetlands, we have a special responsibility to care for our water resources. Citizens and their ever-changing leaders and governments need to understand and appreciate these resources to properly manage and protect them now and into the future.

The FTWA retains much of the rural charm that has been lost in other parts of the state. Recognizing this fact, the FTWRC was established in 1994 with the mission of retaining the rural character and natural features that make the Four Townships special. The FTWRC is a volunteer, non-profit group whose mission is to assist with the development and implementation of land use strategies that retain the rural environment currently enjoyed by township residents, protecting lakes, streams, drinking water, agriculture, and open space.

Over the years, the FTWRC has convened the community in many settings, often attracting a regional audience. With the participation of citizens and leaders, the FTWRC has already planned and implemented a series of efforts to preserve, protect and repair the ecosystem and water resources. In recent years, the FTWRC has become more active with local lake associations and other partners interested in better managing habitat and invasive species. Moving forward, the FTWRC wishes to promote more collaboration with lake associations, residents, non-governmental

organizations, and landowners to restore and protect natural habitats and curb aquatic invasive species.

1.2 Purpose of Watershed Plan

This Four Township Watershed Area Management Plan was created by the FTWRC for the community. This plan primarily serves three purposes:

1. Prioritize future land use and resource protection and restoration needs.
2. Reference and document existing watershed products and past efforts.
3. Qualify as a United States Environmental Protection Agency Nine Elements approved watershed management plan.

This WMP was original created as part of the FTWA planning project, which was funded with a Clean Water Act Section 319 grant administered by the Michigan Department of Environmental Quality (MDEQ), Nonpoint Source Program. The Southwest Michigan Land Conservancy (SWMLC) in collaboration with the Kalamazoo River Watershed Council was awarded the grant in 2008. At that time development of the FTWA Management Plan relied on stakeholder input, agency support, and existing planning information generated by the FTWRC since 1994. The 2017 update was done by the FTWRC with assistance from the Kalamazoo River Watershed Council, which involved a non-point source pollution watershed inventory and updated water quality monitoring information. The overall health of a watershed can be difficult to determine and generalize. Characterizations and recommendations in this plan are based on the best available data and modeling including modeling conducted for the Kalamazoo River Watershed Management Plan (KRWC, 2010).

1.3 What is a Watershed?

A watershed is the area of land that drains to a stream, river or lake. This drainage could be underground (i.e., by groundwater flow) as well as over the land surface. The Watershed Concept is important in the management of water resources because it helps people to understand the hydrologic linkage between the land surface and nearby water bodies. Knowledge of watershed boundaries is needed to understand whether human activities far from lakes and streams can potentially affect the water quality of these surface waters through surface runoff and groundwater flow. Watershed boundaries are often estimated from the slope of the land surface (topography), under the assumption that groundwater flow as well as surface runoff occur in the downhill direction. This assumption is generally true, although in the gently rolling glacial terrain common in southern Michigan, the delineation of watersheds based on topography alone can be difficult. This is because some areas do not slope downward to reach a stream valley, even though water from such areas may drain towards a stream by groundwater flow.

Streams draining smaller watersheds combine to form larger watersheds. For example, in southern Michigan, small streams flow into larger rivers, which in turn flow into the Great Lakes system, whose waters ultimately drain to the Atlantic Ocean. Watersheds can be delineated at each of these levels, with each larger watershed composed of sub-

watersheds. This hierarchy of watersheds is important to keep in mind because it helps us to realize how small streams can, in a cumulative way, produce an impact on the water quality of Lake Michigan and other downstream waters. Watersheds ignore political boundaries such as township and county lines; they obey only gravity and the movement of water. To manage a watershed as a whole, it is critical to consider the entire watershed, rather than just the part within the local jurisdiction of a township or county.

The FTWRC was formed with the watershed concept in mind. Watersheds can unite us as a community because caring for a watershed is a community responsibility. Watershed scale issues are long term, longer in fact than the terms of most any elected official or watershed resident; thus planning and watershed action must occur over decades and planning products must stand the test of time, be scientifically based, and be readable. Most importantly planning products must be available and education of stakeholders from elected officials down to landowners must be consistent over time.

2 Watershed Description

2.1 Geography

Past work of the FTWRC explored land-use models and treated the Four Townships of Prairieville, Barry, Richland, and Ross as a model regional planning area (Figure 1).

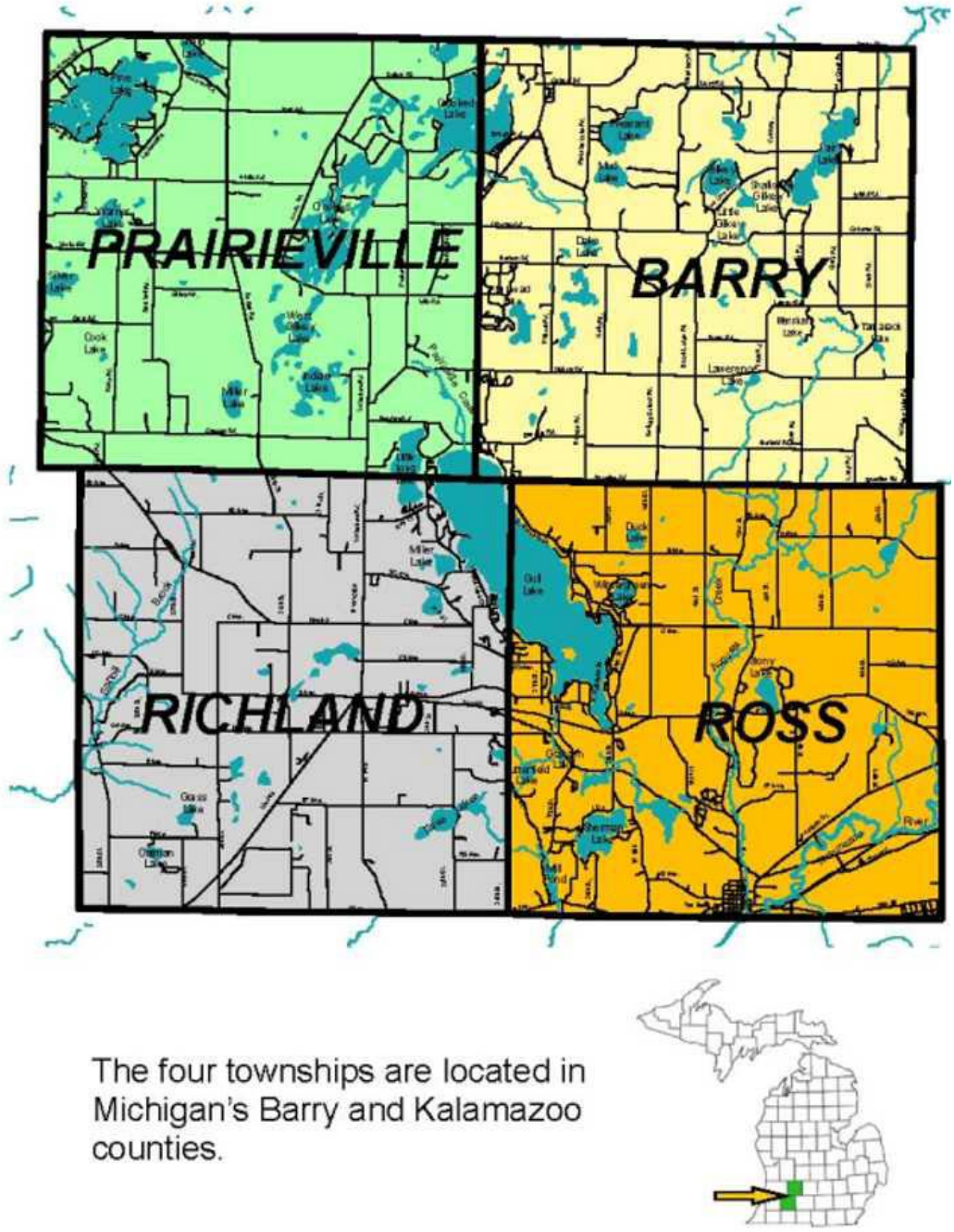

Figure 1. Original Four Township Area

This plan covers some geographic portions of subwatersheds located outside of the original jurisdictional boundaries of the Four Townships (Figure 2).

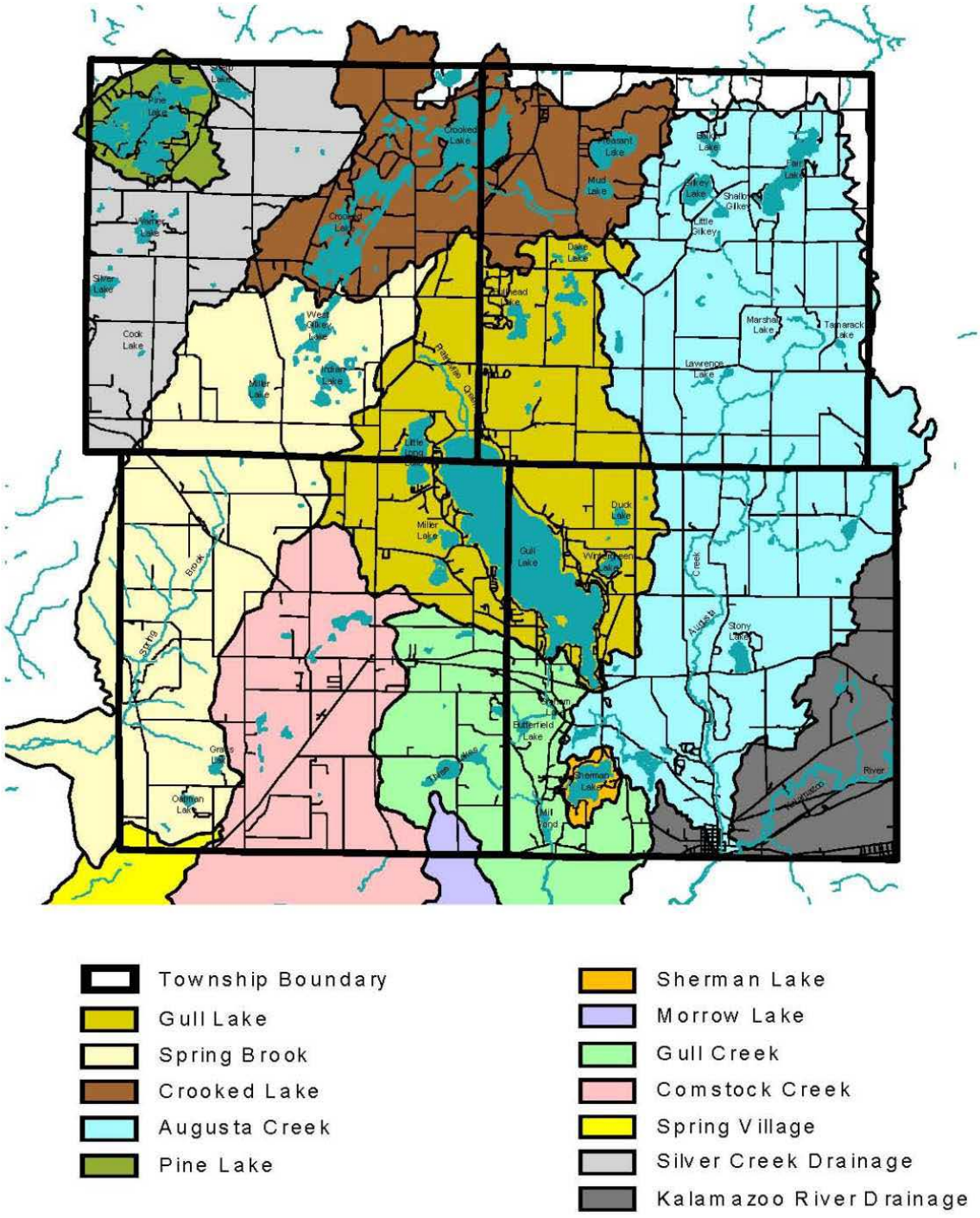

Figure 2. Subwatersheds of the Original Four Township Area

This plan refers to the complete grouping of subwatersheds as the Four Township Watershed Area (FTWA). The FTWA encompasses approximately 170 square miles in

Kalamazoo and Barry Counties (Figure 3) and includes the complete subwatersheds for Gull Creek, Spring Brook, Comstock Creek, and Silver Creek in addition to Gull Lake and Augusta Creek (the two subwatersheds lying almost entirely within the four townships).

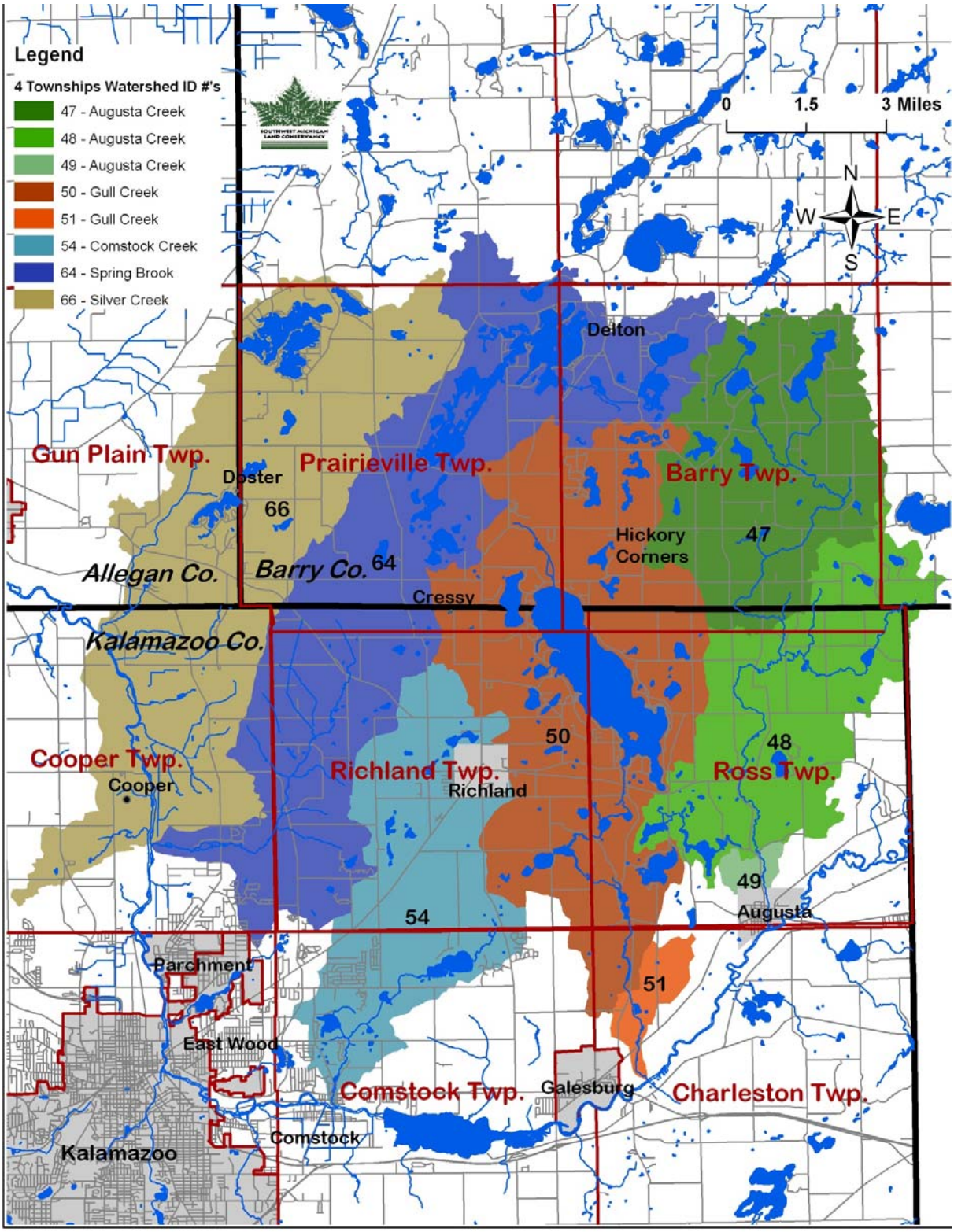

Figure 3. Watersheds included within the Four Township Watershed Area (FTWA) and the original four township boundaries. Major governmental jurisdictions are labeled. Subwatershed delineations are labeled as 47-51, 54, 64, and 66 per the Michigan Department of Natural Resources and Environment.

The Kalamazoo River flows across the southeastern corner of Ross Township on its way to Lake Michigan, and receives drainage from contributing subwatershed areas within the FTWA. The FTWA is a convenient Watershed Management Unit to reference, and is one of several other Watershed Units (Figure 4) in the larger Kalamazoo River Watershed being managed for nonpoint source pollution reduction, stormwater, and targeted impairments such as excess phosphorus (KRWC, 2010).

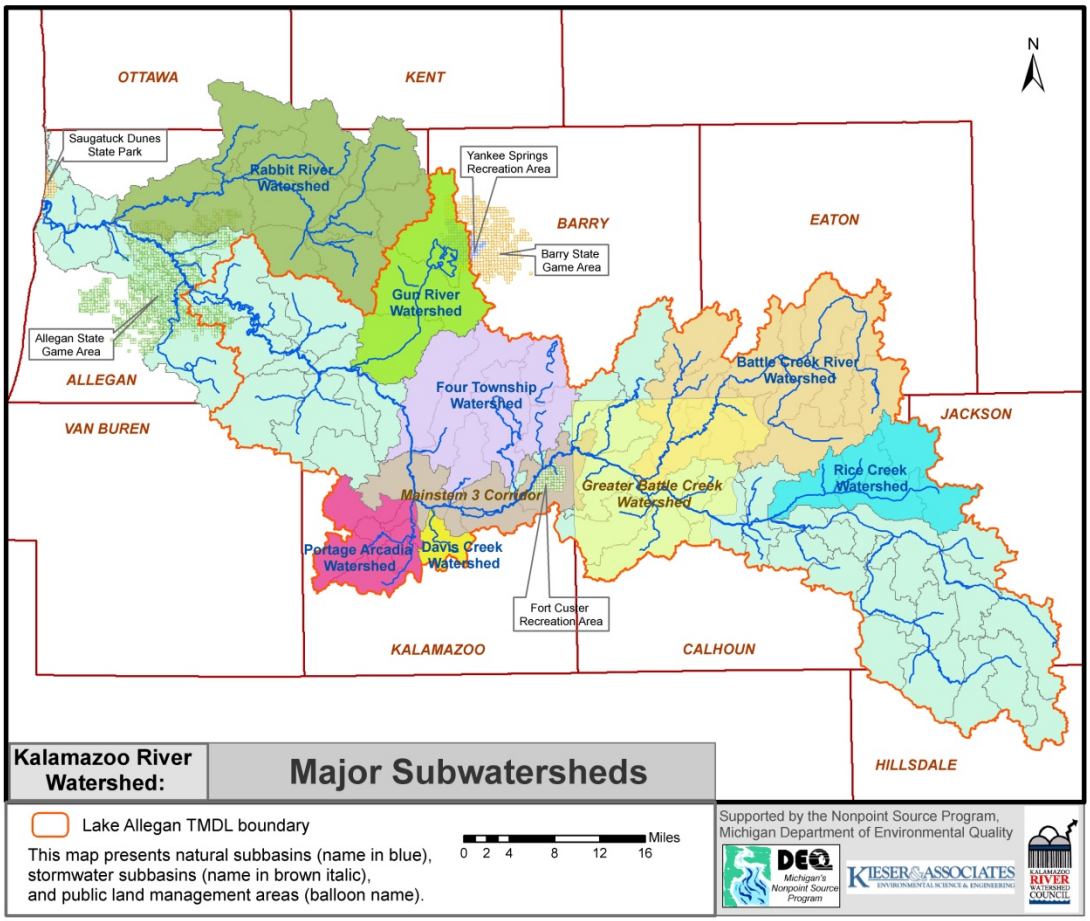

Figure 4. Kalamazoo River Watershed major subwatershed management units, programs, and features.

Watersheds are typically identified by Hydrologic Unit Codes (HUCs). HUCs were developed to provide official boundaries for watersheds. HUCs identify a geographic area, which includes part or all of a surface drainage basin. The United States is divided into successively smaller hydrologic units. The units are classified into six levels starting with large areas such as the Great Lakes Region (2-digit) down to small areas (14-digit). Often for management purposes, agencies focus on the smaller 14-digit HUC subwatershed level.

Each subwatershed has slopes, soils and other conditions, which direct runoff to the receiving waterbody. Table 1 lists the acreage and 14-digit HUC for each subwatershed, as well as the governmental units included in the subwatershed. Throughout the plan, the HUCs are labeled as subwatersheds 47-51, 54, 64, and 66, per the MDEQ. HUCs are not referenced except for in Table 1. Figure 3 also displays the MDEQ subwatershed identification numbers (47-64).

Table 1. Four Township Watershed Area Subwatersheds and Governmental Units

Map ID #	14-Digit HUC* (subwatershed name)	Total Area (sq. miles)	Governmental Units**
47	04050003040060 (Augusta Creek Upper)	19.1	Barry Twp, Ross Twp; Barry Co, Kalamazoo Co
48	04050003040060 (Augusta Creek Middle)	17.7	Ross Twp, Barry Twp; Barry Co, Kalamazoo Co
49	04050003040070 (Augusta Creek Mouth)	1.0	Ross Twp; Kalamazoo Co; Village of Augusta
50	04050003040080 (Gull Creek)	35.7	Barry Twp, Prairieville Twp, Ross Twp, Richland Twp, Charleston Twp, Comstock Twp; Barry Co, Kalamazoo Co
51	04050003040090 (Gull Creek Mouth)	1.8	Charleston Twp; Kalamazoo Co
54	04050003040120 (Comstock Creek)	18.3	Richland Twp, Comstock Twp; Kalamazoo Co; Village of Richland; City of Comstock
64	04050003050090 (Spring Brook)	38.6	Prairieville Twp, Richland Twp, Barry Twp, Cooper Twp; Barry Co, Kalamazoo Co
66	04050003050110 (Silver Creek)	36.8	Prairieville Twp, Cooper Twp, Gun Plain Twp; Allegan Co, Barry Co, Kalamazoo Co

*HUC – Hydrologic Unit Code
**for the purposes of this plan, Bedford, Johnstown, Hope, and Orangeville Townships are not considered

2.2 Climate

Precipitation varies in amount from year to year, and this variation has a myriad of consequences for human activities such as agriculture as well as for natural ecosystems. In dryer years, crop yields can be adversely affected by lack of water. Water levels in streams and especially lakes fall to where they may impede recreational uses and negatively impact aquatic life. Wetlands that normally persist all year may dry completely.

Wetter years, in contrast, are generally less harmful but may produce undesirable flooding of property and excessive soil moisture for crops, depending on the timing of the precipitation. Precipitation amounts have been monitored since 1929 at several locations on the Kellogg Biological Station property, located within the four-township area. This record shows a mean annual precipitation of 36.4 inches, with annual totals varying from a minimum of 21.6 inches to a maximum of 48.5 inches. These annual totals include both rainfall and the water contained in snow or other frozen forms.

The proximity of the FTWA to Lake Michigan and prevailing westerly winds moderates the climate and produces some lake effect precipitation during the fall and winter months. The climate is also influenced by the Maritime Tropical air mass, which tends to be a relatively warm and humid air mass. The average growing season (consecutive days with low temperatures greater than or equal to 32 degrees) is 148 days.

The FTWA lies within the Southern Michigan, Northern Indiana Till Plains (SMNITP) ecoregion. Ecoregions are delineated by their climates, soils, vegetation, land slope and land use.

The FT Water Atlas (1998) contains extensive documentation about precipitation and climate.

2.3 Geology, Hydrology and Soils

The geological features, hydrology and soils of the FTWA, combined with relatively low impervious surface cover and abundance of intact natural land cover, make streams in the FTWA among the most hydrologically stable systems in southern lower Michigan.

The waterways of the FTWA are typical of rivers in the SMNITP ecoregion in that they: 1.) have good quality headwaters, 2.) are generally slow flowing, and 3.) are often bordered by extensive wetlands (Figure 5).

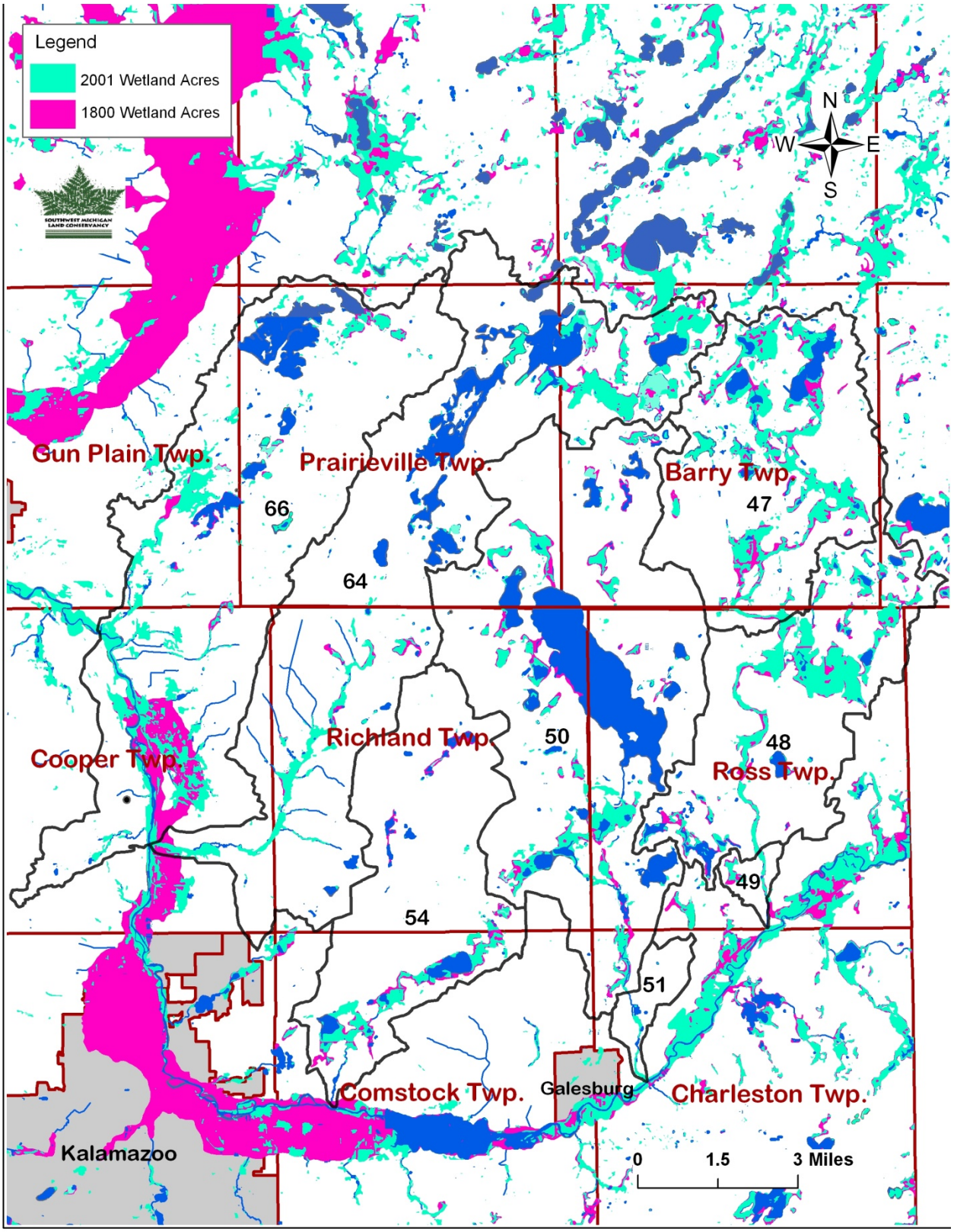

Figure 5. Four Township Watershed Area current and historic wetlands per the Michigan Department of Natural Resources and Environment.

Ditching and channelizing has been used throughout this ecoregion to drain areas that were too wet for settlement and agriculture, but most of the FTWA could not readily be drained and thus retains much of its original wetlands. The FTWA is a priority for conservation because it contains more wetlands and natural stream channels than many other watersheds in the SMNITP ecoregion (MDEQ Integrated Report 2010).

Virtually all of Michigan's topography and hydrology has been influenced by glacial action. Repeated advances of continental ice sheets eroded the pre-existing rock and soils and then re-deposited these materials as sediments as the ice advanced, melted and retreated during several cycles. These glacial materials were deposited as sands, gravels, silts and clays, as well as various mixtures, and vary in thickness within the watershed area from approximately 130 feet to over 400 feet. Ice movement and its meltwater influenced the patterns and distributions of various landforms, such as moraines and stream valleys. The meltwater created large rivers, which deposited glacial materials throughout the region. These glacial deposits and their associated landforms provide a foundation for the hydrology, soil types and land cover that exist today.

The National Cooperative Soil Survey publishes soil surveys for each county within the U.S. These soil surveys contain predictions of soil behavior for selected land uses, and also highlight limitations and hazards inherent in the soil, general improvements needed to overcome the limitations, and the impact of selected land uses on the environment. The soil surveys are designed for many different users. Planners, community officials, engineers, developers, builders, etc., use the surveys to help plan land use, select sites for construction, and identify special practices needed to ensure proper performance.

The soils in the four-township area are very permeable to water, therefore much of the precipitation infiltrates the soils and moves across the landscape via groundwater flow paths. Hydrologic soil groups can help determine which portions of the watershed are more important for groundwater recharge.

Soils in the watershed range from dominance by clay and silt to sand and organic materials (Figure 6).

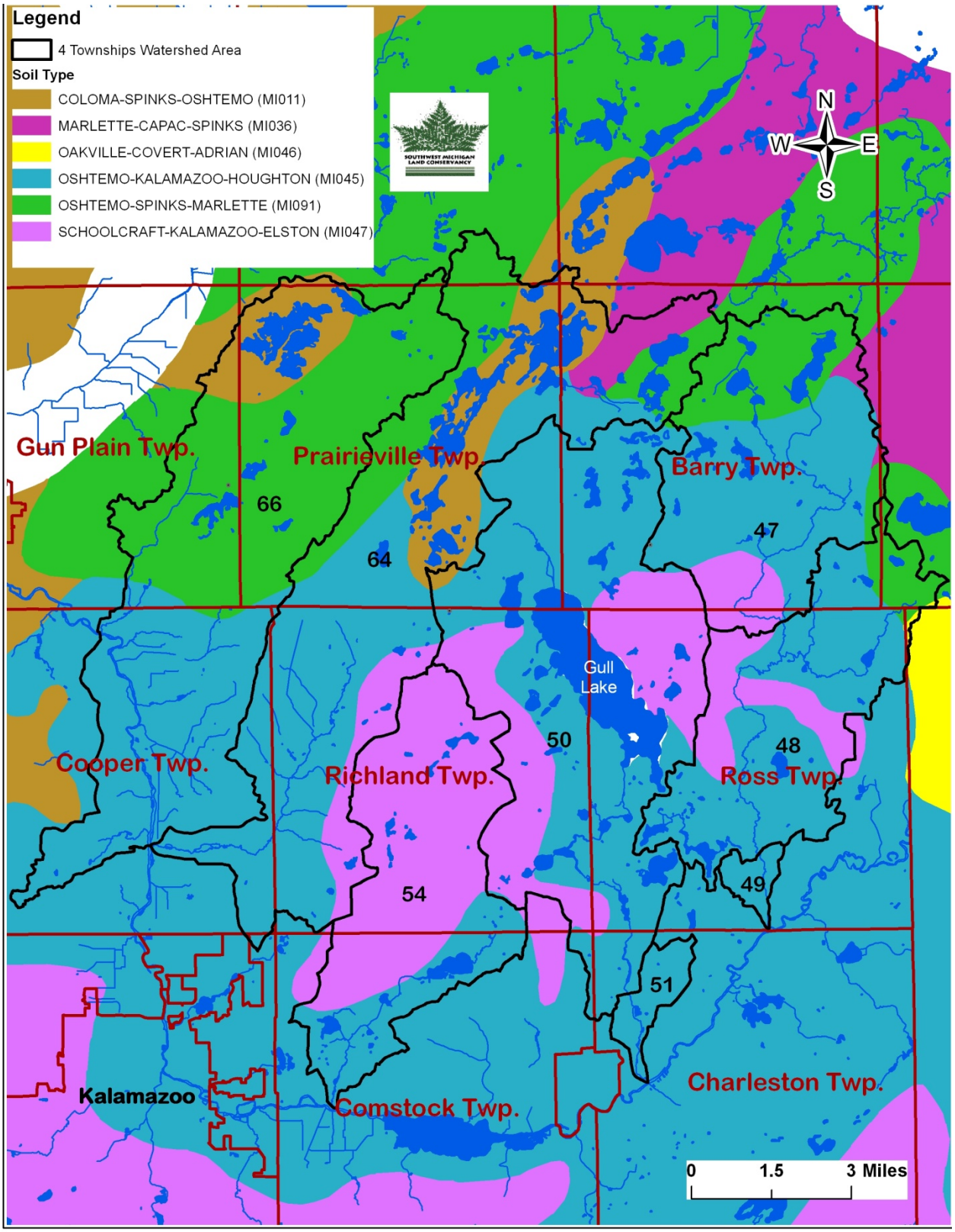

Figure 6. Soils within the Four Township Watershed Area (STATSGO).

Group A soils are mostly sandy and loamy types of soils with a low runoff potential and high infiltration rate even when thoroughly wetted. Group A soils have an infiltration rate of 1.0-8.3 inches/hour. These coarse soil types allow water to infiltrate and recharge the groundwater supply. Group B soils dominate the FTWA and are intermediate with an infiltration rate of 0.5-1.0 inches/hour. Group C & D soils are not present.

Soils include:

- COLOMA-SPINKS-OSHTEMO (MI011); group A/B
- MARLETTE-CAPAC-SPINKS (MI036); group B
- OAKVILLE-COVERT-ADRIAN (MI046); group A
- OSHTEMO-KALAMAZOO-HOUGHTON (MI045); group B
- OSHTEMO-SPINKS-MARLETTE (MI091); group B
- SCHOOLCRAFT-KALAMAZOO-ELSTON (MI047); group B

Another important characteristic of soils is whether they are considered hydric. Hydric soils are defined as poorly or somewhat poorly drained soils. These soils are one of the indicators of wetlands, but many have been drained for building or agricultural purposes. Although wetland regulations do not apply to all hydric soil areas, they are poorly suited for development, especially for septic fields. Septic systems installed in areas with unsuitable soils are prone to failure, which can lead to nutrient and bacteria pollution of groundwater and surface water. The Four Township GIS, or Geographic Information System (2001), documents previous work in the FTWA and displays areas with septic system limitations. The GIS also includes a data layer that combines wetlands, buffers, hydric soils and steep slopes into a classification map that displays environmentally sensitive lands (contact the FTWRC for further information http://www.ftwrc.org).

2.4 Land Cover

Natural land cover in the FTWA exists in fragments within a mosaic of agricultural practices and residential land as well as some commercial development. However, despite these competing land uses, significant portions of natural land cover remain. Some of the largest natural areas are depressional wetlands as well as forested floodplain corridors along several waterways. The larger areas of upland forest tend to be the more sloping lands with poor soils that were abandoned from agriculture in the early and mid 1900s; virtually all uplands and most forested wetlands in the FTWA were deforested between ca. 1850 and 1930.

As seen in Table 2, land cover in the FTWA is dominated by farmland (44%) and forest (25%).

Table 2. Four Townships Watershed Area Land Cover based on the 2001 Lower Peninsula Land Cover/Use Theme (MiGDL, 2007), derived from classification of Landsat Thematic Mapper imagery (compiled by Baas, 2009). Low-intensity urban land cover is underestimated in the FTWA because most residential development does not occupy enough area to show on the satellite image-derived land cover.

Land Cover Category	Area (%)
Low intensity urban	1.41
High intensity urban	0.43
Transportation	2.71
Farmland	44.46
Open land/parks	8.79
Forest	25.12
Water	4.82
Forested wetlands	4.46
Non-forested wetlands	7.70
Sand/soil/bare	0.09
Total	100

Table 3 displays further land cover breakdowns by subwatershed. Urban land cover is low overall and concentrated in the Comstock Creek Subwatershed and at the Augusta Creek mouth; both of these creeks terminate amidst communities along the Kalamazoo River. Transportation is a significant land cover as well, often as dominant as other built categories (e.g., residential, commercial/industrial).

Table 3. Land Cover Percentage Breakdown from Nonpoint Source Modeling of Phosphorus Loads in the Kalamazoo River/Lake Allegan Watershed for a Total Maximum Daily Load, 2001.

Map ID #	14-Digit HUC* (subwatershed name)	Forest Open	Agricultural	Residential	Commercial Industrial	Transportation	Water Wetland
47	04050003040060 (Augusta Creek Upper)	40.5	47.4	1.0	0.1	1.6	9.4
48	04050003040060 (Augusta Creek Middle)	56.4	32.6	0.9	0.1	1.0	9.0
49	04050003040070 (Augusta Creek Mouth)	66.8	18.0	2.5	1.0	1.3	10.3
50	04050003040080 (Gull Creek)	38.3	41.3	1.5	0.3	1.7	16.7
51	04050003040090 (Gull Creek Mouth)	37.8	53.8	1.2	0.2	2.0	4.9
54	04050003040120 (Comstock Creek)	36.4	49.5	5.2	0.7	3.1	5.0
64	04050003050090 (Spring Brook)	41.8	42.3	2.0	0.2	2.1	11.7
66	04050003050110 (Silver Creek)	47.7	38.7	1.9	0.2	2.3	9.1

Low-intensity urban land cover, which typically includes residential development, is underestimated in the FTWA because most residential development does not occupy enough area to show on the satellite image-derived land cover, even along lakes where it is quite dense (Figure 7). This land is instead classified as forest/open.

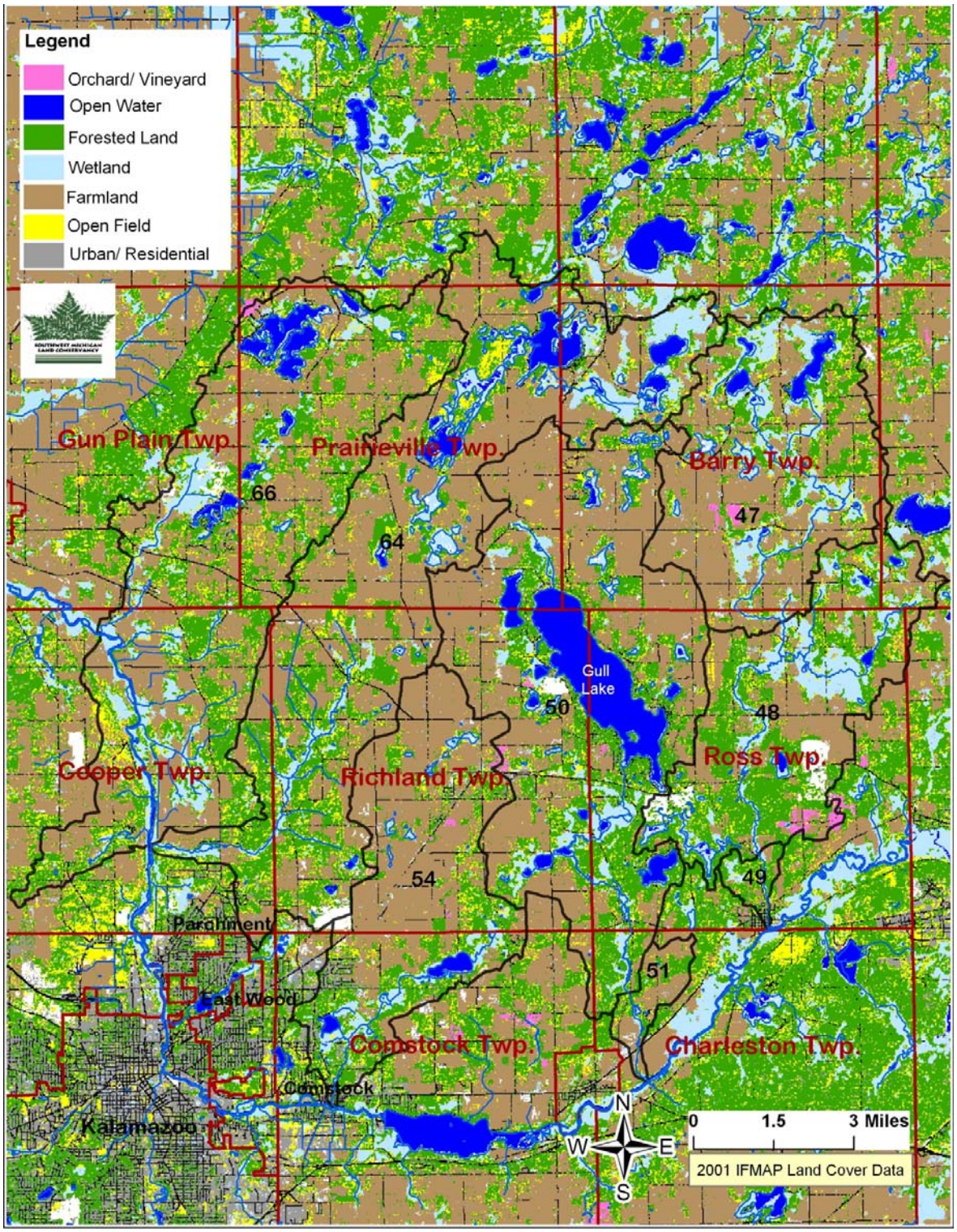

Figure 7. Four Townships Watershed Area land cover based on the 2001 Lower Peninsula land cover/use theme (MiGDL, 2007)

2.5 Loading

A runoff model was created for the Kalamazoo River Watershed Management Plan (2010). This modeling exercise included the FTWA. Runoff volume and pollutant loading was estimated based on rainfall, soil type, and current land use. A second model was used to predict land use in the year 2030. Runoff and pollutant loading was then estimated for the year 2030, based on the modeled land use change. Table 4 contains model results for the FTWA. See Appendix 6 for the full model report and methodology. This modeling exercise produced information that can be used to understand and communicate current and predicted future pollutant loading by subwatershed and by local jurisdiction (e.g., township). This information can be used to guide local communities as planning, zoning, and ordinance decisions are made.

Table 4. Subwatershed runoff volumes and loads of total suspended solids (TSS), and total phosphorus (TP). Model estimates for 2001 and projections for 2030 are from the Kalamazoo River Watershed Management Plan (2010).

	ID#		Runoff Volume (acre-feet/year)			TSS (tons/yr)			TP (lbs/yr)		
Stream		**HUC**	**2001**	**2030**	**Change**	**2001**	**2030**	**Change**	**2001**	**2030**	**Change**
Headwaters Augusta Creek	47	030505	1,337	1,438	101	245	254	9	1,349	1,447	98
Augusta Creek	48, 49	030506	1,073	1,168	94	186	194	8	1,042	1,137	95
Gull Creek	50, 51	030507	2,827	3,195	368	521	554	33	2,943	3,313	370
Comstock Creek	54	030601	1,899	2,135	236	354	374	19	2,039	2,275	236
Spring Brook	64	030605	3,457	3,939	482	613	655	42	3,391	3,874	483
Silver Creek	66	030607	6,087	7,385	1,299	1,074	1,183	109	6,146	7,475	1,329

Build out loading estimates demonstrate that typical conversion of natural land to agricultural or urban use results in increased loading to surface water bodies. Management practices can reduce such loading on a site by site basis and will be detailed later in the Watershed Plan.

2.6 Dams and Barriers

Dams and barriers in the watershed pose issues with recreational use and also with the fragmentation of habitat. Many of these dams are obsolete (not serving any function) and they are generally low head and found in rural areas. Low head dams are artificial structures, which are less than 15 feet in height and extend across the river channel. There are no active hydroelectric dams; three dams are being used for recreational lake level control structures.

Dams of particular note include one at the mouth of Augusta Creek, where the stream was long ago diverted into a mill race; the dam is currently owned and managed by the Knappen Mill Company. A couple of small low-head dams exist along the upper reaches of Augusta Creek and cause backflooding onto the floodplain; another low-head dam exists on Gull Creek south of G Avenue. Mill ponds formed by dams exist along Gull Creek above G Avenue, and Comstock Creek above Comstock. Two impoundments create backflooding of wetlands on Ransom Brook, a tributary of Augusta Creek that enters north of EF Avenue. In spite of these small dams, streams in the four-township area are largely unaltered and thus maintain their natural flow regimes, although in some cases there have been historical alterations to their

channels. The small dams that serve no purpose could readily be removed, thereby restoring the natural hydrology in the riparian wetlands.

Control structures to regulate lake levels include a sluice-gate dam at the Gull Lake outflow, managed by the Gull Lake Association to draw water levels down in the winter, as well as a new weir to stabilize the water level in Upper Crooked Lake, managed by the Barry County Drain Commissioner. The water level in artificial Lake Doster is regulated by a control structure. Each of these control structures results in higher average water levels than the original unregulated lake systems would have had, and they serve the purpose of enhancing the value of the lake shorelines for residential development and recreational use.

In addition to low head dams, other fish passage barriers were identified in 2016 during the watershed inventory project (see Appendix 9). Most often the barriers were perched or blocked culverts, which fragment fish habitat. Correcting culvert problems and removing these barriers will reconnect important stretches of creek and increase the different habitat types available to fish and other aquatic wildlife.

3 Community Profile

3.1 History of Region

In the not so distant past, the FTWA was largely undeveloped. Family farms dotted the countryside. Visitors arrived at area lakes by railcar to relax and enjoy summer resorts and cottages. The pace of life was slower in those days and the “big city” was far away.

Time has changed that. The “big city” is now just a short commute. One can live in the Four Townships Watershed Area and quickly commute to Kalamazoo, Grand Rapids, Battle Creek, and even Lansing. In many respects, the Four Townships are in a state of transition. While many of the vestiges of the past are still with us, change is upon us. In some cases, change is occurring so rapidly we have little time to consider if such changes are good for the present, let alone the future.

3.2 Demographics

Residential growth since 1960 has doubled the population in the western half of the FTWA, which is closer to the City of Kalamazoo, and this growth is increasingly spreading further into the FTWA. Information on land use and socioeconomic characteristics of the four townships are available in the FTWRC Issues Paper (1997) which can be found at the Council website http://www.ftwrc.org.

From 1982 to 1992, Michigan lost 854,000 acres of farmland, an average of 133 square miles per year. Nearly 70% of all farmland lost in Michigan was located below a line drawn from Bay City to Grand Rapids, the location of the state's most productive farmland. Those areas experiencing the fastest rate of farmland loss include counties in southeastern Michigan and those around Grand Rapids, Kalamazoo, and Traverse City. Some of these counties experienced as much as 25% reduction in farmland in the last decade.

It is important to understand the characteristics of the population in the watershed. By having a better understanding of the people, water quality related management and outreach efforts can be tailored to be more effective for the intended audience(s).

3.3 Future Growth and Development

The FTWA has abundant natural and water resources that attract businesses, residents, and recreationalists. Over the next few decades, the FTWA is expected to see population growth and land use change, especially from expanding urban areas. This development is expected to spur further loss of natural areas and open spaces.

For the long-term prosperity and health of these communities, the water quality and natural resources need to be recognized for their important role in the current and future economic development of the region. It will be imperative to have thoughtful and sensitive planning of these and other developments to ensure that the water quality and natural resources and the services they provide are protected.

While growth within the Four Townships is inevitable, it need not be a bad thing. If we can work to accommodate development while preserving our natural features, we can essentially have our cake and eat it too. It was once stated that for every complex problem there is an answer that is clear, simple, and wrong. No one simple approach will address all the potential problems associated with increased development. Instead, a combination of approaches must be employed. Several of these approaches are discussed herein and a prioritized action plan is provided for all citizens and local decision makers in the Four Township Watershed Area.

Urban sprawl has been occurring at an alarming rate across Michigan and within the FTWA, and although the pace has slowed with the recent economic downturn, demand for residential development is expected to continue over the long term. The problems of urban sprawl and loss of rural character can only be addressed through implementation of sound growth management practices. To be successful, growth management will require considerable foresight, planning, and public input. However, the stakes are high; if we fail to act now, tree-lined roads, unobstructed vistas, clean water, farmlands, woodlands, and villages which collectively embody our rural character may be lost forever. This will be especially true if we simply react to growth rather than making deliberate choices about what community attributes we want preserved.

4 Resource Management

Federal, state, county and, local governmental units and their agencies have shared responsibility for the management and protection of water, land, and other natural resources. Local entities are obligated to comply with federal and state environmental statutes, county level ordinances and local ordinances. In the case of surface water protection, the federal and state laws generally provide a national or statewide strategy for water quality protection. Because of their broad-scale nature there are often gaps in protection efforts. This presents opportunities for county and local governmental units to enact ordinances or standards that will support a more comprehensive water quality protection strategy, and to tailor those strategies to local conditions.

4.1 Land Use and Water Quality

The way land is managed, patterns of land use in relation to natural resources, and especially the way water is managed all impact the quality of water and the ecology of lakes, rivers, streams and shorelands. The authority to regulate land use rests primarily with local governments, largely through master plans and zoning ordinances. In addition, counties and state government have the authority to enact ordinances that could affect the management of land. For example, a statewide regulation of residential phosphorus-containing fertilizer went into effect for the State of Michigan in 2012.

It is essential to plan for land uses with respect to existing natural features, soils and drainage patterns to lessen the impacts to water quality. Certain uses and activities should be located in areas where their impacts to water will be minimized. From a watershed perspective, land use will not only affect the immediate area, but also downstream areas and water bodies.

Once the placement of different future land uses (high density residential, low density residential, commercial, industrial, etc) are determined with respect to soils, natural features, water bodies and drainage patterns, there should be great attention to how the land is developed. Land development can have a significant impact on water quality. The impacts to water quality that commonly result directly from development activity and increased drainage can be minimized through the use of smart growth and low impact development techniques. For more information on low impact development techniques, see the Michigan Low Impact Development Manual (http://www.semcog.org/lowimpactdevelopment.aspx) or USEPA Green Infrastructure documentation (https://www.epa.gov/green-infrastructure).

4.2 Roads and Water Quality

Roads are a land use that can have substantial impacts on water quality. Roadway networks and right-of-ways make up a significant portion of built land in the FTWA (Table 3). Controlling roadway-related pollution during project planning, construction and ongoing maintenance is important. For example, the salting and sanding of roads during the winter can be a major pollution concern, and special road deicers are typically limited to use in the most sensitive areas due to high costs. MDOT and County Road Commissions are responsible for the construction and maintenance of most roads

in the FTWA. However, the management of local roads is often shared with townships, cities and villages. In addition, many cities and villages have their own road systems, which they maintain. The Southeast Michigan Council of Governments (SEMCOG) published a guidance document designed to promote good planning practices and endorse consideration and integration of environmental issues into transportation projects. This guidance document is available on-line at www.swmpc.org/downloads/enviro_transpo_guidance.pdf. The MDEQ maintains design and maintenance standards for road stream crossings through the Water Resources Division (http://www.michigan.gov/deq/0,4561,7-135-3313_3684_15299---,00.html).

Transportation corridors are recognized as significant public areas where improved road/stream crossings and stormwater management practices can be integrated with road improvements or repairs. Over several years the FTWRC worked with Road Commissions to identify and improve crossings and install numerous signs that identify waterbodies at road/stream crossings (Figure 8). Crossing signs serve to remind commuters of their proximity to water bodies.

In 2016 the FTWRC inspected all major road/stream crossings in the watershed and evaluated each crossing for common sources of nonpoint pollution. Twenty-one crossings had documented problems, including road runoff, gully erosion, streambank erosion, misaligned or perched culverts, stormwater inputs, and various other issues. A full description is included in Appendix 9.

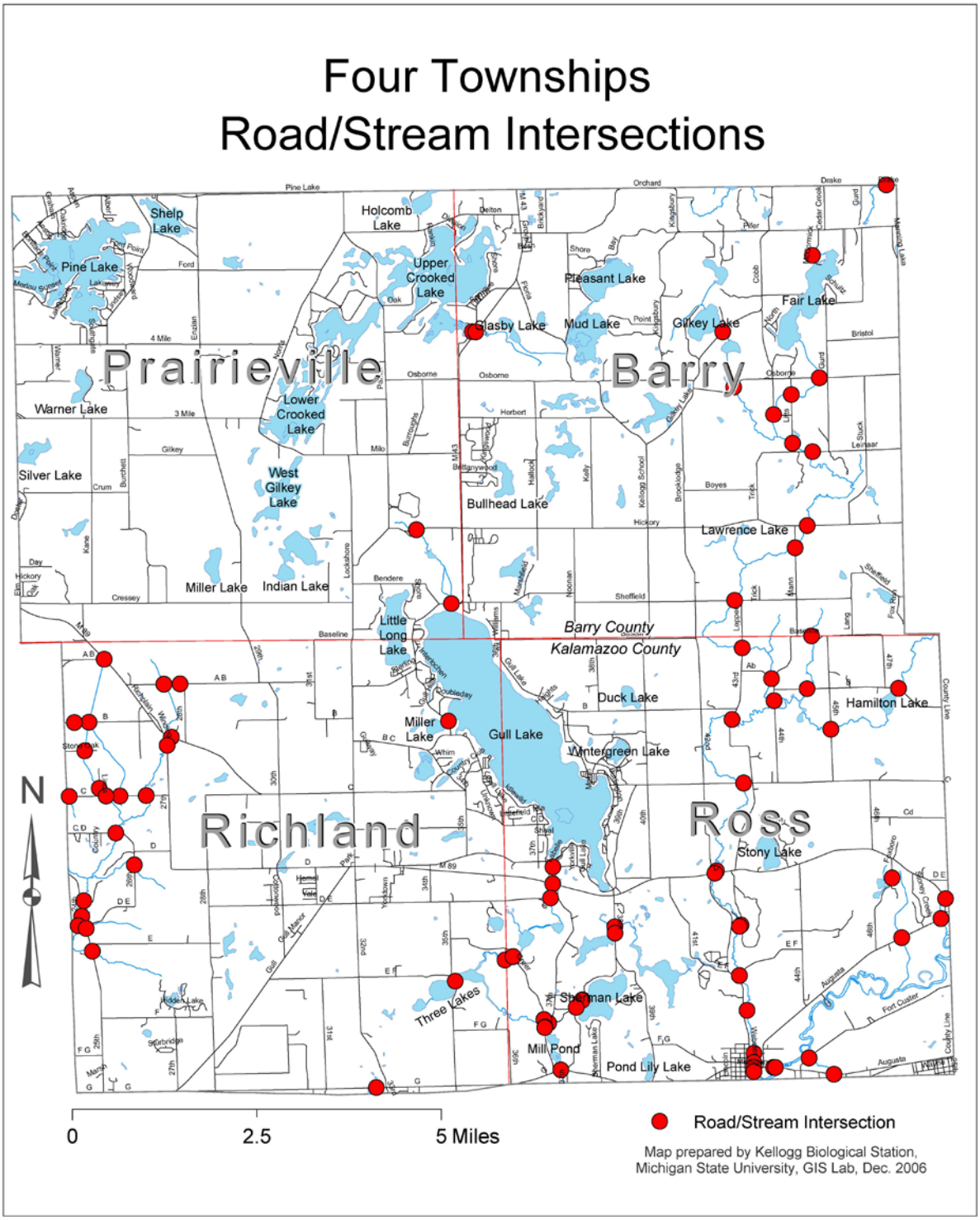

Figure 8. Road/stream crossing signage project implemented by the Four-Township Water Resource Council in the late 2000s.

4.3 Regulatory Authority and Water Resources

The FTWA spans a number of government jurisdictions, with most area in three counties (Allegan, Barry and Kalamazoo) and eight townships (Barry, Charleston, Comstock, Cooper, Gunplain, Prairieville, Richland, Ross) with a very small amount of land in Johnstown and Orangeville Townships in Barry County. There are two villages (Augusta and Richland), one city (Galesburg), but no tribal lands.

Water Bodies (rivers, drains, streams, lakes)

The MDEQ regulates water bodies in the watershed based on the Natural Resources and Environmental Protection Act, PA 451, part 301 Inland Lakes and Streams. This statute regulates the dredging, filling, construction and any structural interference with the natural flow of a lake or stream. This act also regulates marina operations. Permits are needed for activities such as construction of docks or placing fill or structures in lakes and streams. The MDNR has the authority to regulate the number of boats and size of engines at MDNR access sites if human health or protected species are being impacted.

The MDEQ also regulates any discharges to lakes or streams such as those from industrial operations or municipal wastewater treatment plants through the National Pollutant Discharge Elimination System (NPDES) program. For a listing of NPDES permits in the watershed as of January 2017 see Appendix 1. Further the MDEQ administers the municipal stormwater permit program, which requires owners or operators of municipal separate storm sewer systems (MS4s) in urbanized areas to implement programs and practices to control quality and quantity of stormwater runoff. The Kalamazoo County Administration, Drain Commission, Road Commission, and City of Galesburg participate in the municipal stormwater permit program under a NPDES general permit which includes portions of the FTWA.

The approach to managing stormwater discharge in the general watershed permit involves protecting water quality and the downstream receiving waterbody channel. The water quality protection element requires a minimum treatment volume. The channel protection criterion requires a controlled release rate of stormwater. Most stream channel erosion occurs during extended bankfull flow conditions, not during extreme flooding. By controlling the release rate of stormwater, managers can avoid creating long periods of bankfull flow conditions downstream, thus preventing unnatural stream channel and bank erosion. Though most local governments in the FTWA are not stormwater permittees their local ordinances, master planning, zoning, and development practices can use principals described in the most recent 2016 general permit to protect valued local water resources. A selection of key elements of the general permit is included here for consideration:

> Ordinance/Regulatory Mechanism Applicability:
> The permit applicant is required to develop its post-construction storm water runoff control program through an ordinance or other regulatory mechanism to be implemented and enforced during the permit cycle. Examples of non-ordinance regulatory mechanisms include local permit programs and internal policies or procedures.

Water Quality Treatment Performance Standard:
The ordinance or regulatory mechanism shall incorporate the permit applicant's water quality treatment volume performance standard. If the performance standard is contained in a separate specification manual, it is acceptable to adopt the manual by reference in the ordinance or regulatory mechanism. The Application specifies a minimum treatment volume that the permit applicant shall address to reduce or prevent the water quality impacts of storm water runoff. The treatment volumes specified are based on capturing and treating the volume of storm water that is the first to run off in a storm and expected to contain the majority of pollutants. This volume of runoff is often referred to as the "first flush." Sizing the BMPs to meet the Application requirements will ensure acceptable storm water treatment that minimizes water quality impacts.

A permit applicant may choose one or both of the following minimum treatment volume standards specified in the Application:

1) One inch of runoff generated from the entire project site (see below Calculate One Inch of Runoff from the Entire Project Site).

2) The calculated site runoff for the entire project site from the 90 percent annual non-exceedance storm for the region or locality according to one of the following (see below Calculate Runoff Generated by 90 Percent Annual Non-Exceedance Storm):

a. The statewide analysis by region for the 90 Percent Annual Non-Exceedance Storms summarized in a memorandum dated March 24, 2006, and available on the Internet at http://www.michigan.gov/documents/deq/lwm-hsu-nps-ninety-percent_198401_7.pdf.

b. The analysis of at least ten years of local published rain gauge data following the method in the memo "90 Percent Annual Non-Exceedance Storms" cited above. A minimum treatment volume standard to minimize water quality impacts.

Total Suspended Solids (TSS) Calculations:
The Application requires that the methods selected to treat the volume of water calculated above shall be designed on a site-specific basis to achieve either a minimum of 80 percent removal of TSS, as compared with uncontrolled runoff, or a discharge concentration of TSS that does not exceed 80 Milligram per Liter (mg/l). Where site conditions do not generate TSS concentrations greater than 80 mg/l, water quality treatment of the runoff is not required.

This Application requirement is based on TSS as a surrogate for other pollutants normally found in storm water runoff. Control of TSS to meet this requirement is expected to achieve control of other pollutants to an acceptable level that protects water quality. Determination of runoff quality and application of additional controls for other pollutants may be necessary to meet Application requirements where Total Maximum Daily Loads (TMDL) have been developed.

A permittee is in compliance with this requirement if the minimum treatment volume from a project site is treated by properly designed BMPs that achieve either 80 percent removal of TSS, or discharge 80 mg/l or less of TSS according to accepted literature. It is also important to note that new development will often meet the water quality treatment performance standard if the volume control specified in the channel protection requirement of this permit is achieved.

Channel Protection Performance Standard:
The ordinance or regulatory mechanism shall incorporate the permit applicant's channel protection performance standard. If the performance standard is contained in a separate specification manual, it is acceptable to adopt the manual by reference in the ordinance or regulatory mechanism. The Application specifies channel protection criteria that require maintaining the post-development project site runoff volume and peak flow rate at or below predevelopment levels for all storms up to the 2-year, 24- hour event. Pre-development level means the runoff flow volume and rate for the last land use prior to the planned new development or redevelopment. One of the biggest threats to stream water quality is excess sediment and

channel instability caused by the increased rate and volume of storm water runoff resulting from development. Stream forms and dimensions are determined by the geology and rainfall of the contributing watershed. When development occurs, the land cover is often changed in a way that alters the response of that land to rainfall. Even altering land cover from highly pervious (forest/woods) to less pervious (grass) reduces the ability for storm water runoff to be intercepted. Rainfall that infiltrated into the ground or was evaporated off the leaves and branches of trees or was soaked up by the roots of plants now runs off directly to a stream. The outcome is that the surface runoff from the pervious and impervious areas of development increases in both amount and rate and channel erosion results as the stream adapts to the new flow.

Compliance with this requirement is determined by calculating the existing ("pre-development") and post-development runoff volume and rate for the 2-year and smaller storm events. The method is described in the Department of Environmental Quality (DEQ) publication Computing Flood Discharges for Small Ungaged Watersheds, dated July 2003 (updated 2012) and available at http://www.michigan.gov/deq/0,4561,7-135-3313_3684_3724-9324--,00.html. If the post-development volume or rate exceeds the existing volume or rate, then appropriate controls or design changes shall be implemented to make the post-development runoff volume and rate equal to or less than the existing levels for all storms up to the 2-year, 24-hour event.

More information on this program is available within the MDEQ MS4 compliance assistance documents (http://www.michigan.gov/deqstormwater).

Each County Drain Commissioner is responsible for the administration of the Drain Code of 1956, as amended. The duties of the Drain Commissioner include the construction and maintenance of drains, determining drainage districts, apportioning costs of drains among property owners, and receiving bids and awarding contracts for drain construction. The Drain Commissioner also approves stormwater management in new developments and subdivisions and maintains lake levels where legal lake levels are established and control structures exist. In Kalamazoo County the soil erosion and sedimentation program is housed in the County Drain Commissioner's office. The County Enforcing Agent for the soil erosion program has the responsibility of ensuring earth change activities that are one or more acres in area and/or within 500 feet of a watercourse or lake do not contribute soil to water bodies. In Barry County the planning office is the designated Soil Erosion and Sedimentation Agent. And in Allegan County the Health Department – Environmental Health Division is the designated agent issuing Soil Erosion and Sedimentation permits. Of note, the Allegan County ordinance requires a permit for any project within 500 feet of a surface waterbody and/or stormwater inlet.

Wetlands

Michigan is one of two states that has the authority to administer section 404 of the Clean Water Act, dealing with wetland protection. The MDEQ regulates wetlands if they meet any of the following criteria:

1. Connected to one of the Great Lakes.
2. Located within 1,000 feet of one of the Great Lakes.
3. Connected to an inland lake, pond, river, or stream.
4. Located within 500 feet of an inland lake, pond, river or stream.

5. Not connected to one of the Great Lakes or an inland lake, pond, stream, or river, but are more than 5 acres in size.
6. Not connected to one of the Great Lakes, or an inland lake, pond, stream, or river, and less than 5 acres in size, but the MDEQ has determined that these wetlands are essential to the preservation of the state's natural resources and has notified the property owner.

Since there are gaps in state protection of wetlands, a local unit of government (city, township, village, county) has the authority to create wetland regulations. A local wetland ordinance must be at least as restrictive as state regulations and the MDEQ must be notified if there is a local wetland ordinance in effect.

Some jurisdictions within the watershed require building setbacks and a no-disturb zone around wetlands, which can be just as effective as a wetland ordinance.

Floodplains

The MDEQ requires that a permit be obtained prior to any alteration or occupation of the 100-year floodplain of a river, stream or drain to ensure that development is reasonably safe from flooding and does not increase flood damage potential. Local ordinances restricting development in floodplains can be more restrictive than MDEQ regulations.

Several communities in the FTWA participate in FEMA's National Flood Insurance Program (NFIP). The NFIP is a federal program enabling property owners in participating communities to purchase insurance protection against losses from flooding. The program is designed to provide an insurance alternative to disaster assistance to meet the escalating costs of repairing damage to buildings and their contents caused by floods. The overall intent of NFIP is to reduce future flood damage through community floodplain management ordinances, and to provide protection for property owners against potential losses through an insurance mechanism that requires a premium to be paid for the protection.

Groundwater

Locally, the health department plays a role in groundwater protection with the regulation of the installation and design of septic systems. Local units of government have the authority to require the maintenance of septic systems through a septic system maintenance district ordinance. Another local groundwater protection option is a point of sale inspection ordinance for septic systems. With this ordinance, when property is sold there is a requirement to inspect the septic system. Barry County has a time of sale septic ordinance. In Van Buren County, Columbia Township also has adopted a time of sale septic inspection ordinance.

At the state level, the MDEQ and the Michigan Department of Agriculture and Rural Development monitor groundwater use. All large quantity withdrawals, defined as having the capacity to withdraw more than 100,000 gallons of water per day (as an average over any 30-day period, equivalent to 70 gallons per minute pumping), must be registered and water use must be reported annually. The State of Michigan recently

implemented the groundwater withdrawal assessment tool and new rules related to the Great Lakes Compact. The Water Withdrawal Assessment Tool (WWAT) is designed to estimate the likely impact of a water withdrawal on nearby streams and rivers. Use of the WWAT is required of anyone proposing to make a new or increased large quantity withdrawal (over 70 gallons per minute) from the waters of the state, including all groundwater and surface water sources, prior to beginning the withdrawal. A potential user must use the WWAT to determine if a proposed withdrawal is likely to cause an Adverse Resource Impact, and to register the withdrawal. Opportunities exist for the development and implementation of planning tools that use the new online WWAT to prevent overuse of local GW resources, rather than entering into contentious negotiations and reallocation with other users in the event of overuse.

The Michigan Wellhead Protection Program is intended to protect municipal drinking water supplies. The program minimizes the potential for contamination by identifying and protecting the area that contributes water to municipal water supply wells. This also works to avoid costly groundwater clean-ups. Figure 9 shows groundwater recharge zones in the FTWA.

The following cities and villages near the FTWA participate in a local Wellhead Protection Program:

- Augusta
- Charleston Township
- Gun Plain Township-Lake Doster
- Kalamazoo
- Parchment

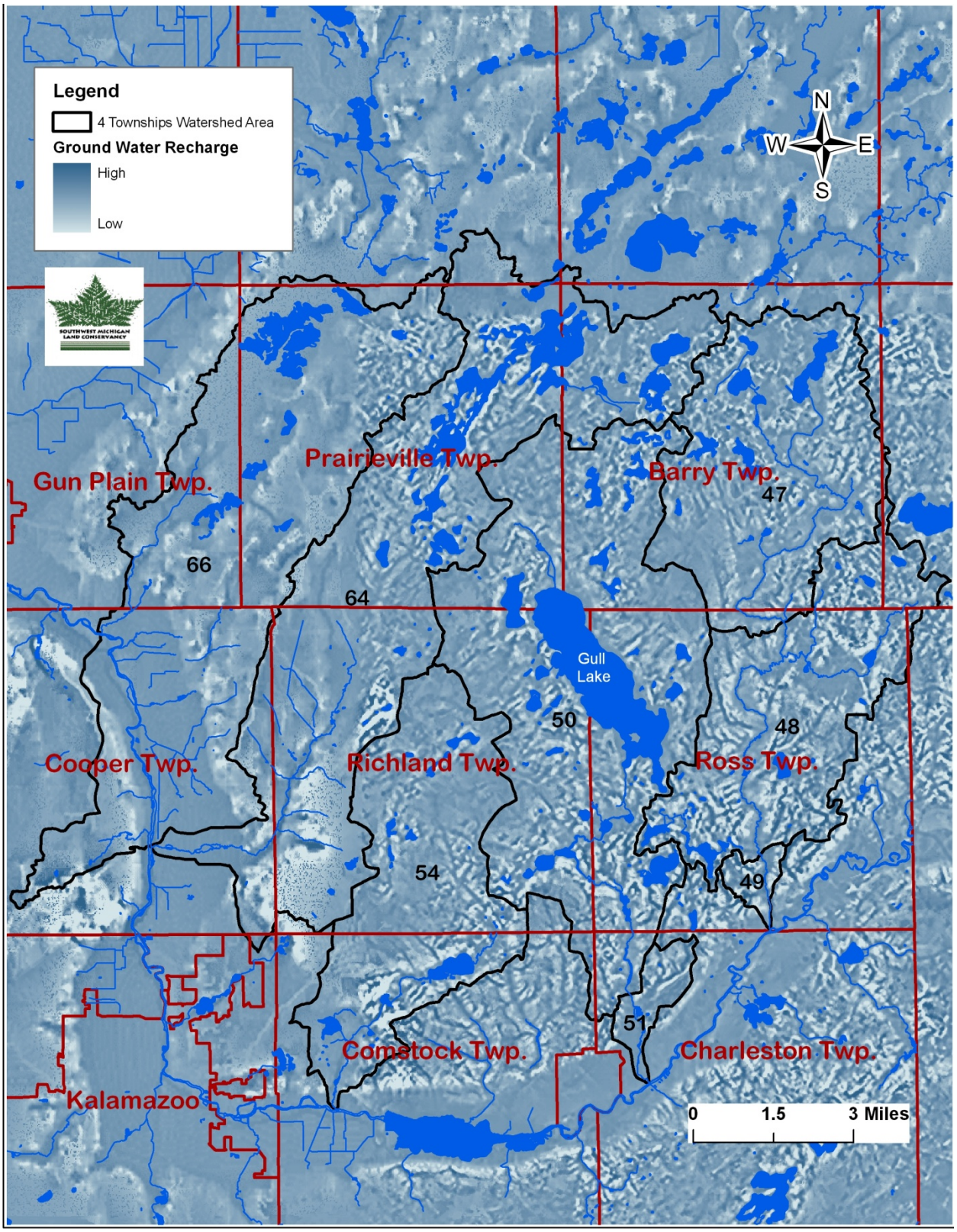

Figure 9. Groundwater recharge zones from Michigan Geospatial Data Library.

4.4 Local Water Quality Protection Policies

Local governments regulate land use mostly through master plans and zoning ordinances. Table 5 presents a list of governmental units that participate in the Federal Emergency Management Agency (FEMA) National Floodplain Insurance Program (NFIP).

Community participation in the NFIP is voluntary and based on an agreement between local governmental units and the Federal Government that states if a governmental unit will adopt and enforce a floodplain management ordinance to reduce future flood risks to new construction in Special Flood Hazard Areas, the Federal Government will make flood insurance available within the community as a financial protection against flood losses (http://www.fema.gov/cis/MI.html).

Table 5. NFIP Participation by Governmental Unit

Governmental Unit	County	FEMA NFIP Participation
Prairieville Twp.	Barry	yes
Barry Twp.	Barry	yes
Richland Twp.	Kalamazoo	yes
Ross Twp.	Kalamazoo	yes
Cooper Twp.	Kalamazoo	yes
Gunplain Twp.	Allegan	yes
Charleston Twp.	Kalamazoo	yes
Village of Augusta	Kalamazoo	yes
Comstock Township	Kalamazoo	yes

Planning and Zoning Status and Recommendations – Gull Lake Communities

Since 1984, water quality protection through local planning and zoning has been a key focus in the area of the original four townships. Early educational products created by the FTWRC led to periodic reviews and updates of several planning and zoning elements in many local jurisdictions. Table 6 and 7 are modified from an analysis conducted in the four townships in 2007 (LSL, 2007; Appendix 2). LSL (2007) documents the outcome of the most recent planning and zoning review for the original four townships bordering Gull Lake. Though this review does not include areas outside these four townships, ongoing planning and zoning improvements within the original four townships are a model for other townships striving to protect and improve water resources.

Table 6. Summary Comparison of Water Protection Tools in Zoning Ordinances for Townships Bordering Gull Lake (modified from LSL, 2007).

		Ross Twp.	Richland Twp.	Barry Twp.	Prairieville Twp.
Objective	Tool				
WATER QUALITY PROTECTION	Wetlands Ordinance				
	Soil Erosion/Sedimentation - Control (county-level in some cases)	*	*	*	*
	Natural Rivers District			*	
	Stormwater Control Ordinance			*	
	Shoreline Vegetation Restrictions			*	
	Building/Septic Field Setbacks	*			*
	Impervious Surface Restrictions (Lot Coverage)	*	*	*	
	Floodplain Regulations				
	Site Plan Review Standards for Water Quality	*	*	*	*
	Fertilizer/Phosphorus Restrictions (*statewide reg. in effect since 2012*)	*	*	*	*
	Time of Transfer Septic System Ordinance			*	*
LAKE ACCESS	Anti-Funneling or Keyhole Ordinance	*	*	*	*
	Carrying Capacity Restrictions for Lake Access			*	
	Dock/Marina Regulations	*	*	*	*
	Lot Width/Density Provisions	*	*	*	*
	Site Plan Review Standards for Lake Access		*		*
	Motor Restrictions/ No Wake Restrictions		*		
SENSITIVE AREAS PROTECTION	Conservation Easements				
	Open Space/Cluster Development	*	*	*	*
	Purchase of Development Rights			*	*

		Ross Twp.	Richland Twp.	Barry Twp.	Prairieville Twp.
	Transfer of Development Rights				
	Planned Unit Development			*	*
	Sensitive Area Overlay Zoning				
	Site Plan Review Requirements for Sensitive Areas			*	
	Tree Preservation Standards				
	Large Lot Zoning			*	
	Zoning Setbacks from Sensitive Areas		*	*	

Notes: A complete set of natural resource definitions is included in LSL (2007).

Table 7. Summary Comparison of Water Protection Tools in Master Plans for Townships Around Gull Lake (LSL, 2007).

	Ross	Richland	Barry	Prairieville
Watershed Concepts				
Protect Quality of Groundwater & Surface Water	*	*	*	*
Sensitive Environmental Area Documentation	*			*
Building Setbacks		*		*
Natural Buffers/Natural Feature Setbacks	*		*	*
Storm Water Management	*		*	
Wellhead Protection	*			
Keyhole Protection	*	*	*	*
Open Space Protection	*			*
Preservation of Onsite Natural Features			*	*
Coordinate with Four Township Water Resource Council and other organizations	*			*
Cluster Development		*		*
Prevent Filling and Dredging of Lake Shore		*		
Control Density Near Sensitive Features	*	*		*
Minimize Soil Erosion				*
Natural Feature Overlay				*
Site Plan Review Standards				*
Septic System Maintenance Program			*	
Implement Surface Water Quality Program			*	
Carrying Capacity Analysis for Lake Access Review			*	
Wetlands Protection			*	*
Groundwater Studies		*	*	

Notes: Master Plan elements have been generalized to identify similarities and differences between townships; many of these topics are found in the Goals and Objectives sections of the Master Plans.

Previous work by the FTWRC and partners, as well as work documented in LSL 2007 reveals:

- Plans generally do relate water quality and natural resource protection to the safety and welfare of the residents and community.
- Plans do address the connection between land use and water quality.
- Plans inadequately discuss the negative impacts of increased impervious surfaces and options for runoff prevention.
- Plans do include language on natural resource values and community responsibilities for protecting those resources.

The information summarized above in Tables 6 and 7 for communities around Gull Lake was followed by the following recommendations for master plans and zoning

ordinances, in this case tailored to Gull Lake but equally applicable to other water bodies (Memo, Moore to GLQO, 2009).

Master Plans

Strengthen community master plans to more clearly contemplate water quality protection at the watershed level, for example:

- Provide a joint vision statement addressing Gull Lake and its tributaries in each community's plan.
- Provide a clear and simple outline in each plan addressing such things as density of development in the immediate vicinity of Gull Lake and expectations for minimum open space and setbacks from wetlands and tributaries for new developments.
- Consider the development of a joint greenways plan.
- Consider a joint planning commission among the communities to address mutual topics of concern with respect to Gull Lake.
- Use more non-regulatory techniques for sensitive area preservation (e.g., conservation easements or purchase of development rights).
- Look for opportunities to retrofit low impact storm water management techniques.

Zoning Ordinances

LSL (2007) reviewed each of the four township's zoning ordinances for water quality protection techniques and found all ordinances above average in that regard, but there may still be room for improvement in ordinance administration, as examples:

- Require a certain percentage of open space for all developments, not just cluster developments.
- Pre-zone sensitive properties "planned unit development" (PUD) to ensure more oversight of site design during the development process.
- Prohibit construction of canals.
- Predetermine density allowances for sensitive lands with an overlay district.
- Devise low impact development design standards for the ordinance.
- Consider a subcommittee of the planners from each community that jointly review site plans for larger developments within ¼ mile of Gull Lake.
- Consider the requirement that any development of over 10 dwelling units shall develop as a planned unit development.
- Use non-contiguous PUDs to administer transfer of development rights.
- Provide criteria for the quality of open space, in addition to the quantity of open space
- As part of changes to the Planning Act, with respect to subdivisions now needing public hearing, include subdivisions in a site plan review process.
- Require that more than three (3) total land splits from a parcel come under site plan review, promoting a more thoughtful land division pattern that considers natural resources and existing development patterns.

Site plan review is the single most powerful tool of local government. Numerous communities have ample tools in the zoning ordinance for thorough site plan review, but

often they do not fully flex their local authority to protect natural resources during a development review process. Organizations in the four townships around Gull Lake continue to work to explore opportunities to harmonize planning and zoning around the lake to ensure that water resources continue to improve. The Gull Lake Water Quality Organization is specifically working on a harmonization plan (contact the organization for details www.glqo.net).

Planning and Zoning – general review considerations
Any jurisdiction interested in water resource protection through local planning and zoning should consider the following generalized review suggestions.

1. Waterbody Protection
   - require adequate building setbacks along rivers/drains and wetlands
   - encourage naturally vegetated buffers along streams, rivers, lakes and wetlands
   - floodplain protection regulations

2. Site Plan Review Process
   - show the location of natural features, such as lakes, ponds, streams, floodplains, floodways, wetlands, woodlands, steep slopes, and natural drainage patterns on site plans
   - show and label all stormwater best management practices on the site plan (rain gardens, swales, etc)
   - site plan review criteria - require the preservation of natural features, such as lakes, ponds, streams, floodplains, floodways, wetlands, woodlands, steep slopes, and natural drainage patterns to the fullest extent possible and minimize site disturbance as much as possible
   - require drain commissioner review of stormwater management during the site plan review process
   - require the use of native plants in all landscaping plans and vegetative stormwater best management practices (to help reduce storm water velocities, filter runoff and provide additional opportunities for wildlife habitat)
   - require the use of Low Impact Development techniques whenever feasible (see Low Impact Development for Michigan: A Design Guide for Implementers and Reviewers)
   - alternative stormwater requirement where Low Impact Development is not feasible – see section 4.2

3. Open Space and Agricultural Land Preservation
   - use bonus densities or other incentives to encourage open space developments
   - require all Planned Unit Developments to provide 25-50% open space
   - require open space areas to be contiguous and restrict uses of open space area to low impact uses
   - in agricultural zoning districts, utilize methods to limit fragmentation of farmland and to lessen conflicts between farming and residential uses
   - require buffers between agricultural operations and residential uses

- allow for clustering/open space developments in agricultural districts to protect natural features

4. Parking Lots and Roads – Reducing Impervious Surfaces
- allow for more flexibility in parking standards and encourage shared parking
- require a portion of large paved parking lots to be planted with trees/vegetation
- require treatment of stormwater parking lot runoff in landscaped areas
- require 30% of the parking area to have compact car spaces (9 x18 ft or less)
- allow driveways and overflow parking to be pervious or porous pavement
- use maximum spaces instead of minimums for parking space numbers
- require landscaped areas in cul-de-sacs and allow flexible spatial designs
- allow swales instead of curb and gutter (if curbs are used require perforated or invisible curbs, which allow for water to flow into swales

5. Stormwater best management practices (BMPs) (refer to Low Impact Development for Michigan: A Design Guide for Implementers and Reviewers see model stormwater ordinance at www.swmpc.org/ordinances.asp)

- allow the location of bioretention areas (rain gardens, filter strips, swales, natural shorelines) in required setback areas and common areas
- encourage the use of best management practices (BMPs) that improve a site's infiltration. Label BMPs and show on site plans
- require use of native plants for landscaping plans and for runoff/stormwater controls (prohibit invasive and exotic species)
- encourage use of above ground BMPs instead of below ground stormwater conveyance systems
- prohibit direct discharge of stormwater into wetlands, streams, or other surface waters without pre-treatment
- require periodic monitoring of BMPs to ensure they are working properly and require that all stormwater BMPs be maintained
- channel protection criteria – see section 4.2

Key documents available from the FTWRC contain background information, planning and zoning strategies, example language, and related public information and education documents. FTWRC products are available at http://ftwrc.org/publications_new/.

Appendix 3 contains descriptions of common BMPs, details implementation costs, and estimates typical pollutant load reductions. Common BMPs in brief include:

- Vegetated Filter Strips: Vegetated filter strips (grassed filter strips, filter strips, and grassed filters) are vegetated surfaces that are designed to treat sheet flow from adjacent surfaces.
- Extended Dry Detention: Dry detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, and extended detention ponds) are basins

with outlets designed to detain stormwater runoff for some minimum time (e.g., 24 hours) to allow particles and associated pollutants to settle.

- Wet Detention: Wet ponds (a.k.a. stormwater ponds, wet retention ponds, wet extended detention ponds) are constructed basins that have a permanent pool of water throughout the year (or at least throughout the wet season).
- Infiltration Basins: An infiltration basin is a shallow impoundment that is designed to infiltrate stormwater into the soil. Infiltration basins are believed to have a high pollutant removal efficiency, and can also help recharge the groundwater, thus restoring low flows to stream systems.
- Swales: The term swale (a.k.a. grassed channel, dry swale, wet swale, biofilter, or bioswale) refers to vegetated, open-channel management practices designed specifically to treat and attenuate stormwater runoff for a specified water quality volume.
- Rain garden: Bioretention areas, or rain gardens, are landscaping features adapted to provide on-site treatment of stormwater runoff.
- Constructed wetlands: Stormwater wetlands (a.k.a. constructed wetlands) are structural practices similar to wet ponds that incorporate wetland plants into the design.

Appendix 3 Table A3-1 contains BMP average overall costs, engineering costs, and annual operations and maintenance costs (O&M) based on the area (land acreage or rooftop) treated by the practice. Load reductions are estimated for total phosphorus, total suspended solids and runoff using the Kalamazoo River Watershed BMP Tool (2010) for areas treated by BMPs under three different, typical land uses in the FTWA. It should be noted that these costs are averages for construction of BMPs by professional engineers and developers in new build and retrofit development situations. It is likely that a homeowner could construct a stormwater treatment BMP (e.g., rain garden) at lower cost than estimated in Appendix 3 Table A3-1, but it should be noted that proper BMP performance is more likely when technical considerations are made such as elevations, soil infiltration rates, soil organic content, proximity to utilities, appropriate plant species, soil compaction during construction, etc.

4.5 Private Land Management

Beyond, federal, state and local laws protecting water quality, the greatest opportunity to protect and preserve water quality and natural resources rests with the landowner in how they manage their lands. Most of the land in the watershed is in private ownership. Many organizations are willing to provide technical assistance to landowners on how to better manage their lands to protect natural resources and water quality. These organizations include MSU County Extension Offices and the Kellogg Biological Station, Conservation Districts, Natural Resources Conservation Service, Southwest Michigan Land Conservancy, The Nature Conservancy, MDNR, MDEQ, and the United States Fish and Wildlife Service (Partners for Wildlife Program). Table 8 describes common land protection options and Table 9 describes common land management programs.

Table 8. Private Land Protection Options

Land Protection Option	Description	Results	Income Tax Deduction ?*	Estate Tax Reduction ?*
Conservation easement	Legal agreement between a landowner and a land conservancy or government agency permanently limiting a property's uses	Important features of the property protected by organization. Owner continues to own, use, live on land	Yes	Yes
Outright land donation	Land is donated to the land conservancy	Organization owns, manages, and protects land	Yes	Yes
Donation of land by will	Land is specifically designated for donation to the land conservancy	Organization owns, manages, and protects land	No	Yes
Donation of remainder interest in land with reserved life estate	Personal residence or farm is donated to the land conservancy, but owner (or others designated) continues to live there, usually until death	Organization owns remainder interest in the land, but owners (others) continue to live on and manage land during their lifetime subject to a conservation restriction	Yes	Yes
Bargain sale of land	Land is sold to the land conservancy below fair market value. It provides cash, but may also reduce capital gains tax, and entitle you to an income tax deduction	Organization owns, manages, and protects land	Yes	Yes

*The amount of income/estate tax reduction depends on a number of factors. Please consult a professional tax and/or legal advisor. (Adapted from Conservation Options: A Landowner's Guide, Land Trust Alliance.)

Table 9. Private Land Management Programs**

Management Option	Description	Agreement	Cost Share
Conservation Reserve Program (CRP)	Annual land rental program through FSA to re-establish native vegetation, improve water quality, habitat	Contracts from 10-15 years in length	Variable
ACEP Wetland Reserve Easements (WRE)	Restoring, protecting, and enhancing wetlands through easement purchase	Agreements can be 10-year, 30-year or perpetual	Up to 75% of cost of improvements or 100% for permanent agreements
Environmental Quality Incentives Program (EQIP)	Assists in restoring agricultural land to wildlife habitat	Agreements can last 2-10 years	Up to 75% of cost of improvements

**A few of many examples; for more information contact county conservation district offices

Several other habitat protection options are available to landowners with smaller parcels, especially focused on waterfront properties. Managing and protecting riparian habitat, and in particular shoreline habitat along inland lakes increasingly falls upon landowners. Several lake associations around the FTWA participate in programs of the Michigan Clean Water Corps (MiCorps), including Upper Crooked Lake and Little Long Lake in Barry County and Gull Lake and Sherman Lake in Kalamazoo County. Gull Lake also participates in the Michigan Shoreland Stewards (a program of the Michigan Natural Shoreline Partnership), which encourages landowners to improve habitat along shorelines by offering a certification system. Michigan Natural Shoreline Partnership offers in-depth landscape and ecological training to educators and contractors to install more naturalized shorelines. The MiCorps program offers lake associations training and technical assistance in evaluating the shoreline habitat of the entire lake.

5 Natural Features

The natural features of the FTWA support a healthy ecosystem and provide important wildlife habitat. Natural features also provide ecosystem services that benefit humans, such as recharging groundwater, cleansing air, and filtering water. They provide recreational opportunities including fishing, hunting, hiking, bicycling, bird watching, and boating.

5.1 Protected Lands

Figure 10 shows areas in the watershed that are under some form of protection. These parcels are protected from future development through various legal mechanisms and managed for different purposes. The parcels depicted as “SWMLC Conserved” are protected under conservation easements held by the Southwest Michigan Land Conservancy and most are under private ownership. The “Conservation Lands” are generally protected from future development through various mechanisms and owned by institutions, organizations, and agencies, such as Michigan State University, Kalamazoo Nature Center, and MDNR. Parcels protected and managed for recreation are also depicted on the Figure 10 and are under both private and public ownership.

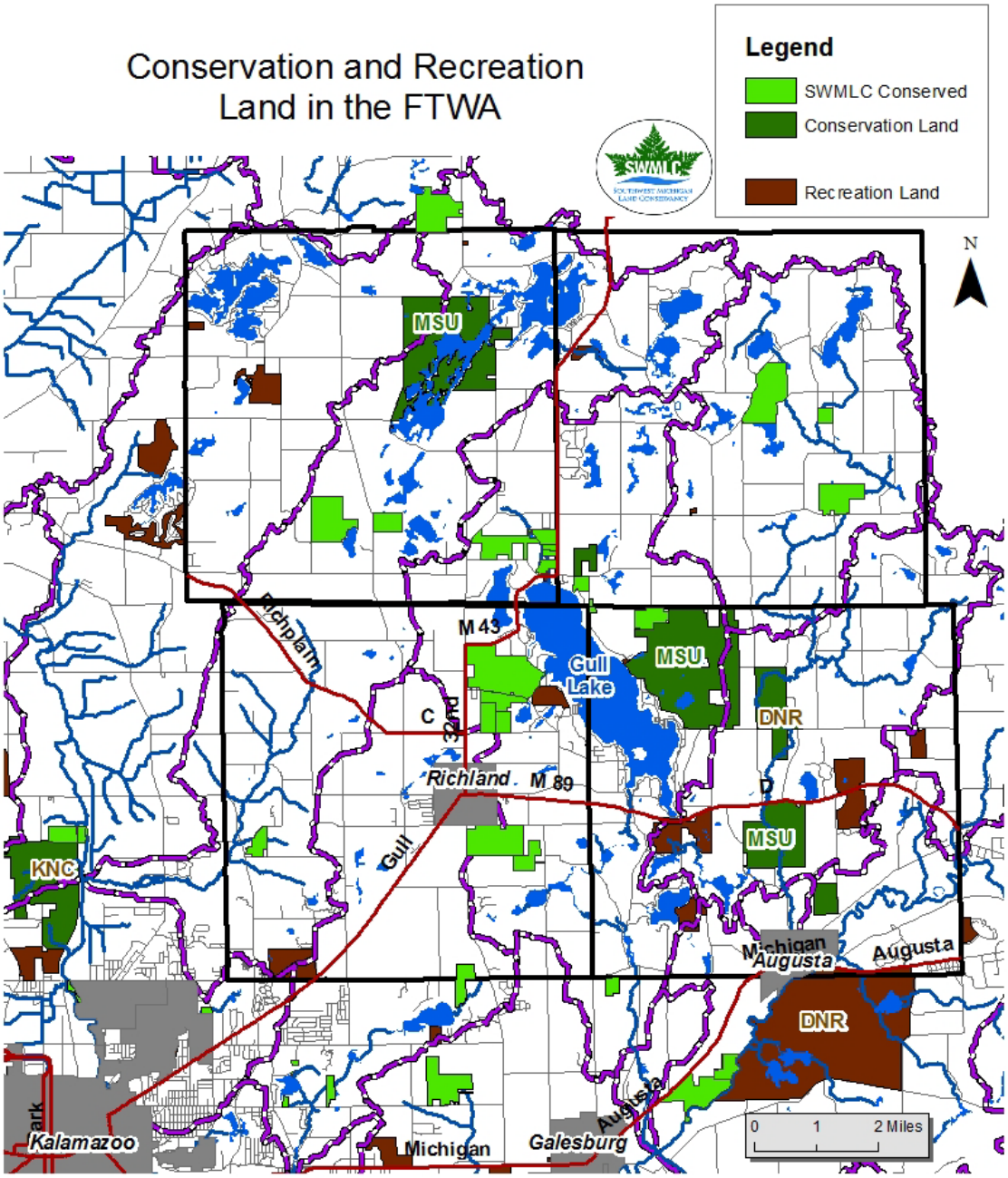

Figure 10. Conservation and recreation lands within the Four Township Watershed Area provided by the Southwest Michigan Land Conservancy as of 2016.

The FTWRC in partnership with the SWMLC has facilitated the placement of over 800 acres of land into conservation easements since this watershed management plan was first developed in 2011. These land conservation projects were implemented after being prioritized as a part of this plan, funded in part by two Clean Water Act Section 319 grants administered by MDEQ Nonpoint Source Program:

- Augusta Creek Conservation Project (2015): conserved 499 acres, with 158 acres of wetlands, 341 acres of adjacent uplands, and over 14,500 feet of frontage along surface water in three parcels located in the Augusta Creek watershed (http://www.michigan.gov/documents/deq/wrd-nps-augusta-creek_487936_7.pdf)

- Prairieville Creek-Gull Lake Conservation Project (2011): conserved 310 acres through six conservation easements that protect over 6,000 feet of frontage along Prairieville Creek (http://www.michigan.gov/documents/deq/deq-wrd-nps-prairieville_350127_7.pdf)

In total, the SWMLC holds conservation easements over 2,650 acres of land in the four townships. Michigan State University holds over 2,000 acres of land in the four townships that is open space by virtue of its present purpose (research and education on agriculture and the environment) but includes intensive agriculture and has no long-term guarantee of protection. Fort Custer is by nature a protected area of 990 acres. A MDNR fishing and hunting area approximately 350 acres in size lies along Augusta Creek east of Gull Lake, and this tract has been the site of prairie restoration efforts on the uplands that were formerly farmed. The USDA holds conservation easement over approximately 80 acres of agricultural land in the watershed.

As properties are developed, natural areas are impacted. The FTWA is rich in natural features, and many local citizens value the open space and diversity of ecosystems that make this area unique and ecologically noteworthy. The large natural areas are also important for local plants and animals. Wildlife corridors and areas with less disturbed, core wildlife habitat help maintain biodiversity and sources of genetic diversity. Through managed community growth, the natural character of the four-township area may be better conserved by directing development away from land in excellent ecological condition. The FTWRC has published a Natural Features Inventory (NFI) report for all four townships as a single unit, which is available under publications on FTWRC web page (www.ftwrc.org). The goal of the NFI is to promote more well-informed decisions when property of high ecological value is being considered for development.

In 2003 as part of the NFI, Michigan State University Extension identified 20 areas of land that were considered “Potential Conservation Areas” within the four townships. The priority rating was determined by many factors, including size, core area, association with streams, connection with nearby protected and natural areas, the restorability of adjacent properties, and the incidence of plants or animals of special concern. The identification of these 20 potential conservation areas concluded Phase I of the NFI.

Phase II of the inventory, based on field surveys of representative portions of each potential conservation area, rated each of these 20 areas in terms of conservation

priority. Sites were rated as excellent, very good, or good in terms of their floristic quality, wildlife habitat, and degree of human encroachment (Figure 11). One aspect lacking from the NFI was a water quality factor when selecting areas of high conservation value. Since the NFI was completed in 2005, two new land protection tools have been developed for the Kalamazoo River Watershed. The first tool is the Kalamazoo River Watershed Land Conservation Plan (LCP), and it identifies high quality wetlands and uplands where permanent protection will provide lasting water quality benefits. The second tool is the Landscape Level Wetlands Functional Assessment (LLWFA), and it identifies the specific functions (or ecosystem services) that specific wetlands provide, for example sediment retention, nutrient transformation, or shorebird habitat. High priority areas identified in the LCP and the LLWFA were compared to the 2005 NFI Potential Conservation Areas. In general, the priorities from all three tools overlapped substantially.

The LCP in particular was developed to allow us to prioritize high quality natural lands based on the water quality benefits these lands provide. The result of the LCP is a single numeric land protection score for each undeveloped parcel in the Kalamazoo River Watershed. These scores were developed through a Geographic Information Systems (GIS) model that weighted several factors for each parcel: land cover, presence of wetlands, proximity to surface water, proximity to existing conserved lands, presence of cold water streams, and presence of habitat for threatened and endangered species. The model only includes undeveloped land and parcels 20 acres or greater in size. The parcels were then ranked from highest to lowest conservation score and the top 90^{th} percentile received the designation of Tier 1 parcels (i.e., highest potential for water quality benefit if conserved, meaning the parcel is not developed into residential or commercial land use). A Tier 2 designation was given to parcels that fell within the 80^{th} – 90^{th} percentile and Tier 3 designation was given to parcels that fell within the 70^{th} – 80^{th} percentile.

In an effort to build upon the success of the conservation projects completed in 2011 and 2015 in the FTWA, the potential conservation areas identified in the original FTWA management plan have been expanded and refined to factor in water quality protection potential. These new areas are called Priority Conservation Areas (PCAs) and have been expanded from 20 discrete areas to 27 individual PCAs shown in Figure 11. The PCAs were developed using parcels originally identified as potential conservation areas in the 2005 NFI, then additional parcels were added using the top three tiers of priority areas from the LCP. Priority parcels from the LCP that were adjacent to or in close proximity (≤1 mile) to the original potential conservation areas were grouped to form the 27 new PCAs. One potential conservation area listed in the original watershed management plan was not included as a PCA because it included only state and federally owned land which are already provided some level of protection.

The Landscape Level Wetlands Functional Assessment identifies both existing and historic wetlands (i.e., former wetlands lost to filling or draining of the land). Only wetlands existing on the landscape and ranked as high in functional value were used to expand the PCAs. All of the parcels within the original potential conservation areas are

included in the new PCAs in order to protect the valuable and unique natural features identified on the sites.

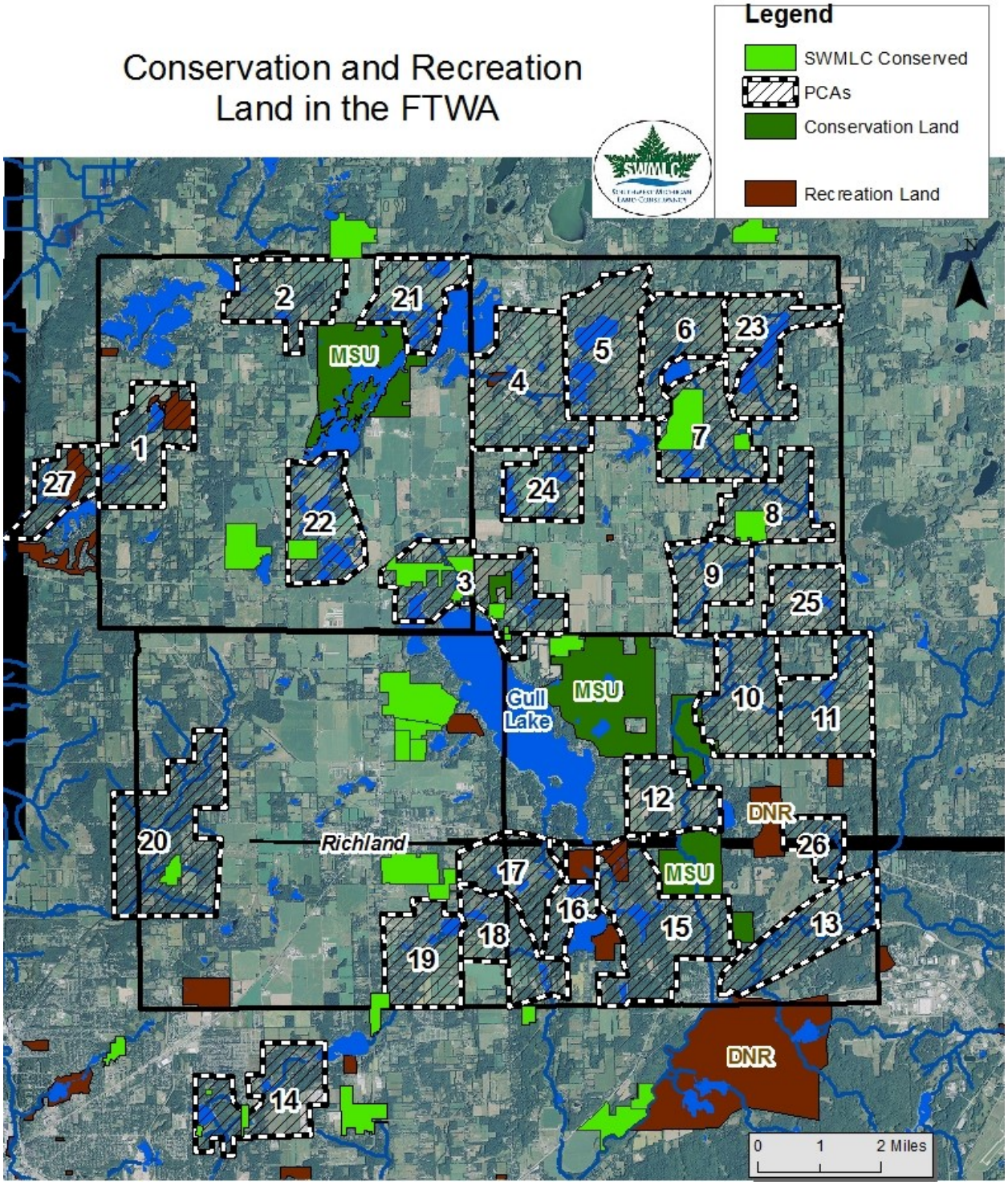

Figure 11. Priority Conservation Areas (PCAs) developed from the Natural Features Inventory (2005), Kalamazoo River Watershed Land Conservation Plan (2014), and the Landscape Level Wetland Functional Assessment (2015). The PCAs in this figure are shown in relationship to parcels that are currently conserved.

All 27 PCAs are worthy of conservation priority, but the quality of natural features at some sites was higher than at others as described in the NFI and noted in Table 10. These ratings should be used as a general guide in conjunction with the species lists and habitat descriptions for each PCA when evaluating conservation potential in or near these PCAs. Water quality is another major conservation value for each of these PCAs, and as such water quality significance is described for each PCA in Table 10.

Table 10. Priority Potential Conservation Areas (PCAs) as of 2016. More information available at www.ftwrc.org.

PCA	Name	Water Quality Significance	Natural Features	Township
PCA1	Warner Lake and Camp Merrie Woode	Werner and Star Lake in the Sliver Creek system	very good	Prairieville
PCA2	Ford Road Pond	Large wetlands south of Shelp Lake	very good	Prairieville
PCA3	Prairieville Creek	2 miles of creek frontage supplying 75% of surface water into Gull Lake	very good	Prairieville
PCA4	Glasby Marsh	30% wetland cover with Glasby Lake and surrounding wetlands	very good	Barry
PCA5	Blachman Swamp and Mud Lake	>50% wetlands and open water with Mud and Pleasant Lakes	excellent	Barry
PCA6	Balker Lake Swamp	Over 30% wetland cover with very high functioning wetlands on the LLWFA	excellent	Barry
PCA7	Shallow Gilkey and Little Gilkey Lakes	2 miles of Augusta Creek and 50% wetlands and open water, large area conserved	very good	Barry
PCA8	Augusta Creek and Kidd Bog	2 miles of Augusta Creek, large area conserved, 40% wetland cover	excellent	Barry
PCA9	Lawrence Lake and Augusta Creek	2 miles of Augusta Creek, large area conserved, 30% wetland cover	very good	Barry
PCA10	Sherriff Marsh	3 miles of Augusta Creek, 50% wetland cover	excellent	Ross
PCA11	Stafford Swamp and Hamilton Lake	Part of Sherriff Marsh complex, 2 miles of Augusta Creek, 30% wetland cover	excellent	Ross
PCA12	Pine Meadows Farm and the Cheff Center	1 mile of Augusta Creek and 10% wetland cover	good	Ross
PCA13	Kalamazoo River Floodplain	4.5 miles of the Kalamazoo River, 75% wetland cover, highly functioning on the LLWFA	excellent	Ross
PCA14	Comstock Creek Corridor	3 miles of Comstock Creek, Lyons Lake to Campbell Lake, 30% wetland cover	very good	Comstock

Table 10. Continued

PCA	Name	Water Quality Significance	Natural Features	Township
PCA15	Brook Lodge	1 mile of August Creek, 20% wetland cover	very good	Ross
PCA16	Crane's Lake	Crane Lake and 20% wetland cover	very good	Ross
PCA17	Butterfield Lake and Graham Lake	3 lakes and highly functioning wetlands on the LLWFA, 30% wetland cover, 1.5 miles of Gull Creek	excellent	Ross
PCA18	Lower Three Lakes	3 miles of Gull Creek, 20% wetland cover	very good	Richland
PCA19	Upper Three Lakes	Three Lakes and 25% wetland cover	excellent	Richland
PCA20	Spring Brook	8 miles of frontage on Spring Brook and mostly forested, 20% wetland cover	excellent	Richland
PCA21	Upper Crooked Lake	Adjacent to MSU Lux Arbor preserve and Upper Crooked Lake, wetlands	N/A*	Richland
PCA22	Indian Lake	Adjacent to Lower Crooked Lake, multiple inland lakes, and other conserved properties	N/A*	Richland
PCA23	Fair Lake	Riparian zone around Fair Lake, nearly 50% wetland land cover	N/A*	Barry
PCA24	Bullhead Lake	Riparian zone around Bullhead Lake and 2 other small lakes	N/A*	Barry
PCA25	Strewins Lake	Portions of Augusta Creek and Strewins Lake, 33% forested and 33% wetlands	N/A*	Barry
PCA26	Goff Drain	Upper watershed Goff Drain, heavily forested (>75%)	N/A*	Ross
PCA27	Silver Creek	Riparian zone around Lake Doster and upper Silver Creek, 50% wetlands and 30% forested	N/A*	Gunplain

**N/A denotes PCA was created after 2005 Natural Features Inventory, therefore natural features were not assessed in detail according to NFI protocols*

5.2 Generalized Hydrologic Cycle

The earth's water is one large, continuous feature that exists within a complex and dynamic cycle, and is commonly categorized as distinct features such as surface water, groundwater and wetlands. Although the cycle has no beginning or end, it is convenient to describe the generalized cycle with a starting point of surface water. Water evaporates from oceans, lakes and other surface waters to the atmosphere and is carried over land surfaces, where it condenses and is precipitated onto the land surfaces as rain, snow, etc. Some water will drain across the land as runoff into a water body. The land cover will affect how this water moves across the land. If the surface

soil is permeable, some water will infiltrate to the subsurface under the influence of gravity and will saturate the soil and/or rock. This zone of saturation is recognized as groundwater. Due to gravity, groundwater generally moves from areas of higher elevations to lower elevations to locations where it discharges to wetlands and/or surface water like lakes, streams, rivers (Figure 12). Wetlands may be viewed as a transition of groundwater to surface water.

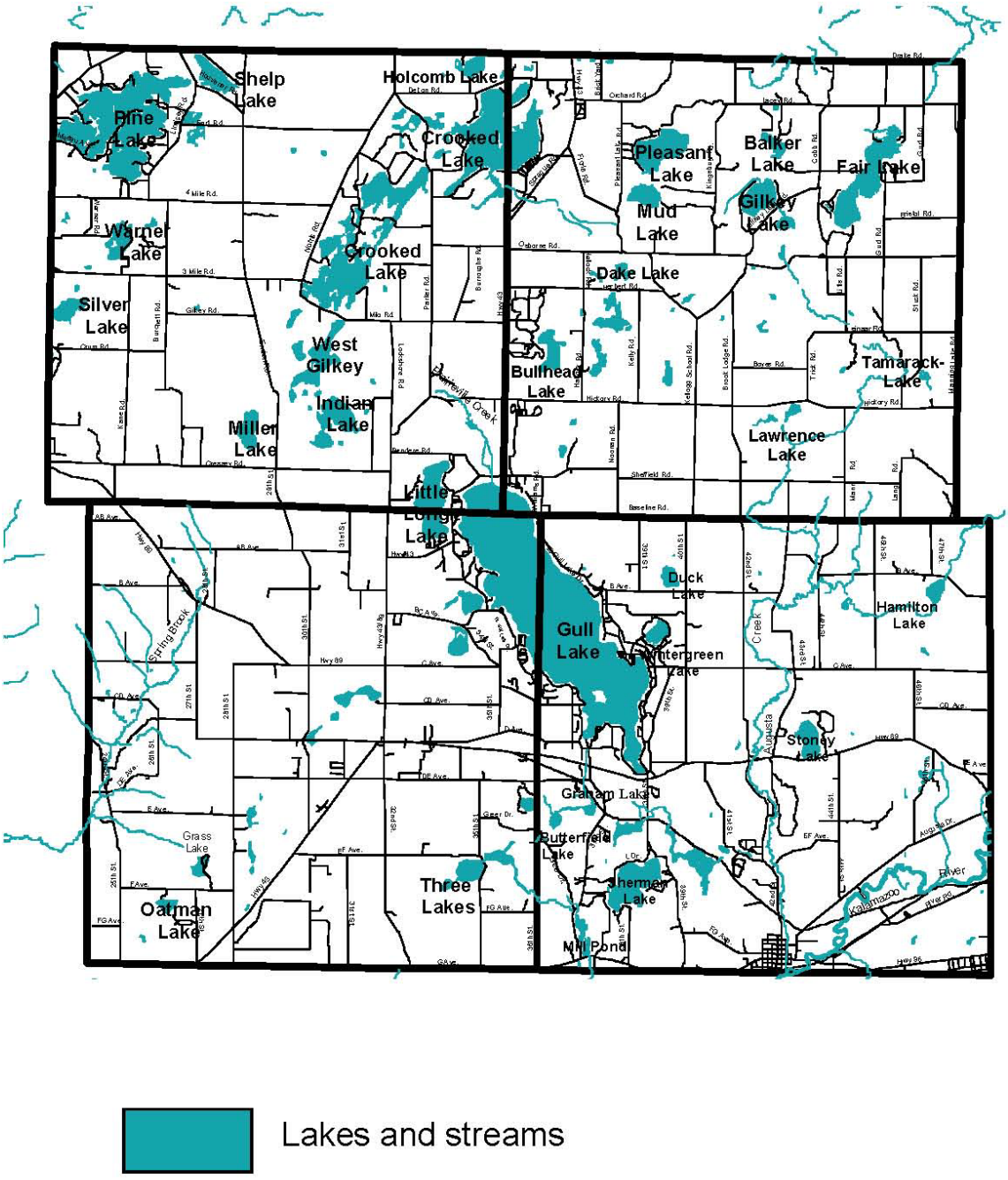

Figure 12. Water Bodies in the Original Four Townships

A properly functioning hydrologic cycle is greatly dependent upon the land cover and natural features in the watershed. Natural vegetation, such as forested land cover, usually has high infiltration capacity and low runoff rates. In contrast, urbanized land cover has impervious areas (buildings, parking lots and roads) and networks of ditches, pipes and storm sewers, which augment natural stream channels. Impervious surfaces in urban areas reduce infiltration and the recharge of groundwater while increasing the amount of runoff. Whereas the fate of water falling as rain in an area with natural ground cover might be:

- 40% evapotranspiration
- 10% runoff
- 25% shallow infiltration
- 25% deep infiltration

The fate of the same water falling in an area with a high level of impervious surfaces (75%-100%) is more like:

- 30% evapotranspiration
- 55% runoff
- 10% shallow infiltration
- 5% deep infiltration

This extra runoff carries pollutants in faster, higher volume flashy flows and contributes to poor water quality by delivering pollutants and causing excessive erosion of stream channels.

Agricultural lands, including row crops, orchards, vineyards, rangelands and animal farms can also have a significant impact on runoff and groundwater resources. Agricultural lands are often heavily compacted by farm equipment, which lessens their ability to infiltrate water. In addition, many agricultural lands are extensively ditched to move water off of the land as quickly as possible. Further, irrigation can alter the groundwater resources. These activities disrupt the natural hydrologic cycle and may negatively impact the functioning of the remaining natural features in the watershed.

Following is a discussion of the different natural communities found in the FTWA and the major threats to their existence and quality.

5.3 Rivers/Streams

Streams are important for their aesthetic, recreational, and ecological values in addition to being conduits of water and, potentially, of pollutants. Anecdotal evidence indicates that streams and rivers in the four-township area are probably in better ecological condition today than at many times during the historical past. For streams, this is largely explained by changes in land use; most low lying areas close to the stream channels were once used for agricultural purposes but have been left alone in recent decades as local agriculture has become more focused on row crops in the upland areas. The natural floodplains along the streams are becoming reforested, providing a buffer

against surface runoff and soil erosion and stabilizing the stream channels. The maintenance of these riparian buffer areas in the face of future pressures for residential development will be important to protect stream water quality. In the case of the Kalamazoo River, municipal sewage treatment and reductions in industrial point-source pollution in the Battle Creek area have led to considerable improvement in water quality during the past few decades, although nonpoint source pollution continues to be a problem.

Coldwater streams are a unique natural feature providing important spawning habitat and thermal refuge for coldwater aquatic species such as trout. Coldwater streams have large groundwater inputs, which helps to maintain stream temperature and good baseflow to the stream throughout the year (Figure 13). Coldwater streams are relatively rare in the southern lower peninsula of Michigan and those in the FTWA are some of the highest quality coldwater streams located this far south.

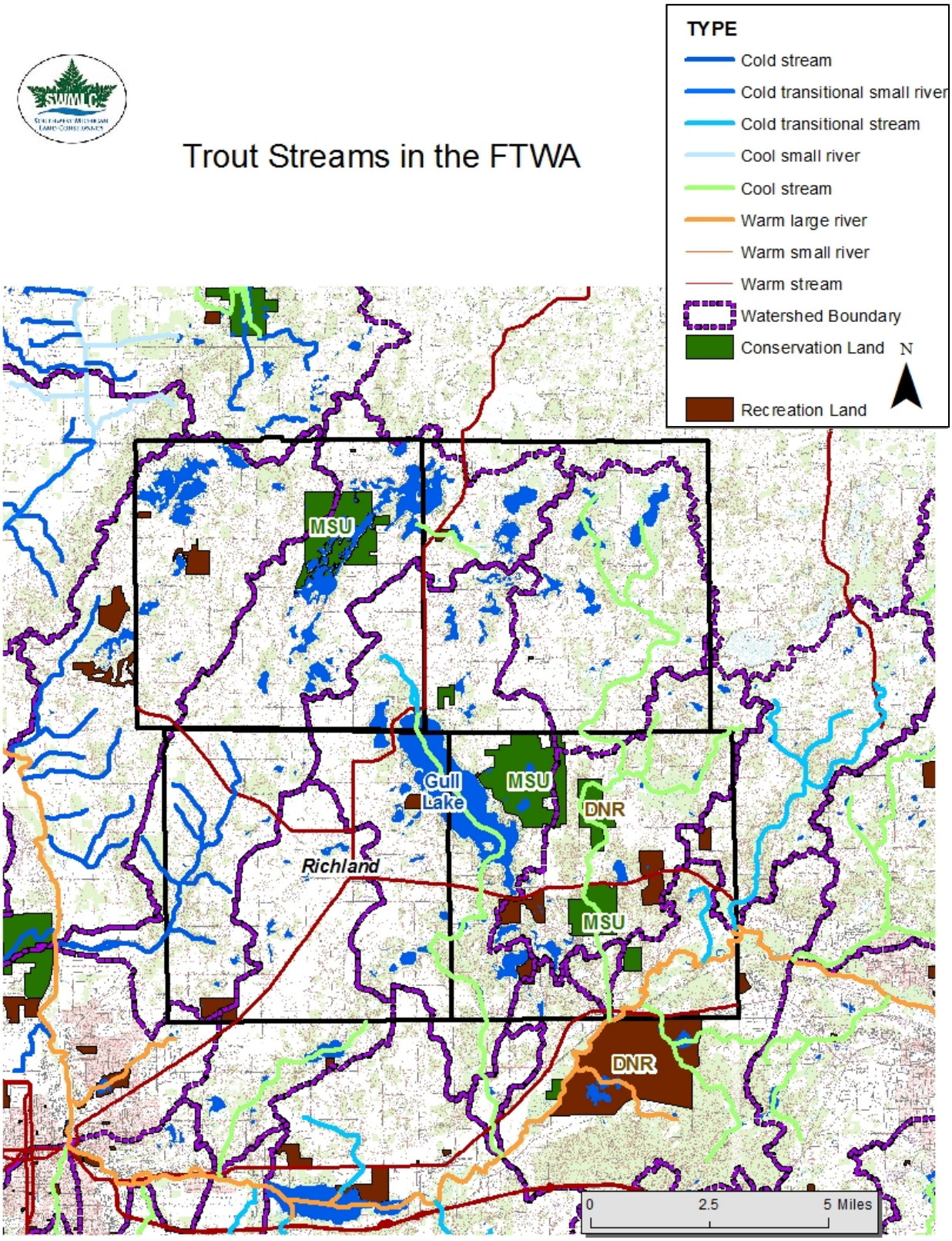

Figure 13. Stream classifications based on temperature regime from Michigan Department of Natural Resources (downloaded January 2017).

Warmwater streams are more common in the southern Lower Peninsula of Michigan and typically have higher surface water inputs than groundwater inputs. As a result, these streams have higher flow variability.

Threats

Water pollution and hydrologic alterations from changes in land use are a major threat to rivers and streams. This management plan is intended to address the major threats to surface water.

Invasive species such as zebra mussels also threaten aquatic communities in the FTWA and have already colonized Gull and Little Long Lakes; most of the other lakes are considered susceptible based on their chemistry (calcium availability for shells). Zebra mussels attach to any hard surface and can clog water intake pipes. They can become a nuisance on docks and piers and they may compete with resident aquatic species that filter algae and zooplankton for food. Zebra mussels present a nuisance for bathers who get cut by their sharp shells. Zebra mussels can improve water clarity, but they also kill native mussel species through suffocation and starvation. Although zebra mussels need lakes or impoundments to persist long-term, they can colonize river and stream segments downstream from these water bodies indefinitely via larval transport. In low-nutrient waters including Gull Lake, they promote a harmful "blue-green" alga known as *Microcystis aeruginosa*, which can produce toxins of concern for bathers and pets.

Riparian land owner activities can negatively impact streams. The removal of native vegetation from stream banks and floodplains reduces the contribution of woody debris, weakens stream banks leading to erosion, and leads to stream warming due to loss of shading. Riparian land owners are often compelled to dig "trout ponds" near streams, intercepting and exposing shallow groundwater aquifers. These ponds can also have negative effects on adjacent streams by causing cold groundwater to warm up when exposed to direct sunlight. The ponds often have direct surface water connections to streams as well, which can cause an increase in surface water temperature of adjoining streams and rivers. The presence of "trout ponds" and warming stream temperatures has been documented in Spring Brook and Silver Creek (Dexter 1992 and Dexter 1993).

5.4 Lakes

The aesthetic and recreational values of lakes are widely recognized by residents in the FTWA. The larger lakes are popular sites for seasonal and year-round residences, and lakes with public access also draw visitors from outlying areas to use the lakes for recreational purposes. Protection of the water quality of these lakes is therefore of paramount interest. There are also many smaller, shallow lakes that become filled with plant growth during the summer. These shallower lakes may not be suitable for motorized boating, but they have significant ecological and aesthetic values. The diversity of lake types in the FTWA is associated with a diversity of aquatic plant and animal life as well.

Lakes and wetlands are abundant in the FTWA. Gull Lake, which is one of the largest inland lakes in Michigan, occupies 2% of the four-township area in which it lies. All lakes and wetlands combined cover 16% of the four-township area (5300 acres of lakes and 9000 acres of wetlands). The Four Township Water Atlas notes that the installation of regional sewer systems during the 1980s reduced nutrient inputs and improved water quality at several FTWA lakes including Gull Lake.

Previous work in the FTWA by the FTWRC also included the documentation of recreational and environmental carrying capacity estimates for Gull, Sherman, Pine, Upper Crooked, Little Long, and Fair lakes (environmental capacity only in the case of Fair Lake) [available at www.ftwrc.org/publications].

Table 11 contains information on lakes greater than 5 acres in the FTWA.

Table 11. Key Lakes in the Four Townships Watershed Area

Name	County	Area (acres)	Surface Water Connection	Max. Depth (feet)	Public Access	Sewer System?
Gull Lake	Kalamazoo + Barry	2040	Discharge to Gull Creek	110	Yes	Yes
Pine Lake	Barry	621	Connected to Shelp Lk	34	Yes	No
Shelp Lake	Barry	79	Connected to Pine Lk	52	No	No
Lake Doster	Barry	Not avail.	Discharge to Silver Creek	Not avail.	No	No
Upper Crooked Lake	Barry	735	Isolated (incl. Lower Crooked Lake)	48	Yes	Yes
Pleasant Lake	Barry	143	Isolated	27	No	Proposed
Gilkey Lake	Barry	83	Discharge to Augusta Creek	33	No	Proposed
Fair lake	Barry	229	Discharge to Augusta Creek	39	No	Proposed
Sherman Lake	Kalamazoo	120	Isolated	38	Yes	Voluntary hookup

*Additional water quality information is available in Appendix 4 and in the *Four Township Water Atlas*.

Threats

Threats to lake environments within the watershed are primarily related to shoreline development and land use. Residential development around lakes with no connection to municipal wastewater treatment facilities can, but will not necessarily always, increase nutrient levels and bacteria counts in the lake. Lakes within the FTWA that have municipal sewer systems include Gull, Upper Crooked Lake, and Sherman Lake. With residential development, coarse woody material abundance and shoreline habitat diversity often strongly declines while nutrient loading often increases (but not necessarily if buffers are preserved). Removal of shoreline vegetation along lakes directly impacts water quality and destroys important wildlife habitat. Gull Lake Quality Organization is the first within the FTWA to document shoreline vegetation using the MiCorp *Score the Shore* protocol.

Human activities negatively affect inland lake ecosystems through alterations in water quality and physical habitat. For example, eutrophication can occur when increased nutrient loadings increase algae and aquatic vegetation to nuisance levels, resulting in decreased concentrations of dissolved oxygen when the excess algae and vegetation decompose. In addition, the quantity and quality of physical habitat available to fishes in the area between high and low water marks is altered by removal of coarse woody debris, by an increase or decrease (via chemical or mechanical removal) of aquatic plants, and by homogenization of the shoreline through erosion control efforts (e.g., rip-rap and sheet piling). Such changes in water quality and habitat features have been shown to negatively impact fish growth, limit natural reproduction, and reduce fish species richness

Invasive species are also a major concern in lakes and are transported between lakes by movement of boats, use of live bait, and sometimes deliberate introductions. One particularly notorious nuisance aquatic invasive species is the zebra mussel (see Section 5.3 above). Eurasian milfoil and curly leaf pondweed are two widespread invasive plants that grow underwater in lakes. Local lakeside residents spend much money on herbicide treatments to control these and other aquatic plants. Boats and trailers can transfer invasive aquatic species to water bodies, so special care should be taken by boaters to limit the possibility. Area lake associations have very recently become active in reducing the spread of aquatic invasive species. In particular, Upper Crooked Lake and Gull Lake have new boat wash stations. Both have hosted the state's mobile boat wash station at public launches during busy summer weekends in an effort to educate boaters on the threats of aquatic invasive species and how to stop their transmission to other lakes.

5.5 Wetlands

Wetlands are increasingly appreciated for the functions, values, or ecosystem services that they provide to society. As a result, a variety of federal and state legislation has been enacted to protect these ecosystems. Michigan has lost more than half of its wetlands to land drainage and conversion to agricultural, suburban, and urban uses. Widespread wetland destruction has resulted in increased flood damages, increased

soil erosion, degraded fisheries, degraded water quality, and losses of wildlife and recreational opportunities. While legislative protection has now slowed the loss of wetlands to outright drainage and filling, many wetlands are still being degraded by more insidious threats, such as non-point-source pollution and the invasion of exotic plant species. Also, existing legislation does not provide protection to smaller isolated wetlands of less than 5 acres, which can be significant in many areas.

What are some of the functions and values of wetlands that pertain to the FTWA? Certainly the maintenance of good water quality is important, especially in the case of wetlands along lakes and streams. These riparian wetlands can intercept groundwater discharge and surface runoff flowing towards surface waters, retaining nutrients, sediments, and contaminants from the water. Wetlands are particularly effective in removing nitrate, which is increasingly found at undesirably high concentrations in some domestic water wells. Riparian wetlands help to attenuate floods thereby stabilizing stream channels and reducing property damage downstream.

The Four Township Water Atlas has extensive information on existing FTWA wetland resources.

Prairie fens are geologically and biologically unique wetlands found only in the glaciated Midwest. In Michigan, they occur in the southern three to four tiers of counties. The groundwater springs, which characterize prairie fens, are very rich in calcium and magnesium. Typical plants found in prairie fens are switchgrass, Indiangrass, big bluestem, sedges, rushes, Indian-plantain, and prairie dropseed. The wettest part of a prairie fen, which is usually found near the water source, is called a "sedge flat" because members of the sedge family dominate the vegetation. The "fen meadow" is the largest part and is more diverse with many lowland prairie grasses and wildflowers. Slightly elevated areas, especially around the upland edge, also support tamarack, dogwood, bog birch and poison sumac. In the FTWA, prairie fens are found along streams and groundwater-fed lakes, although many have suffered shrub encroachment because of a lack of disturbance (fire, grazing, and beaver dams) and the expansion of buckthorn.

Threats

Current threats to wetlands include filling or draining to accommodate industrial, residential, agricultural or recreational land uses. Altered hydrology is a significant threat to most wetland types, whether it is due to a change in groundwater contributions to a fen or diversion of the water that feeds a swamp or marsh due to new road construction. Exotic species invasion, altered fire regime and polluted runoff with sediment, nutrients and chemicals also threaten wetlands. Invasive plants in FTWA wetlands include *Phragmites australis* and *Phalaris arundinacea*, two particularly aggressive grasses, of which the latter is well established but the former appears on the cusp of expansion with numerous founder stands appearing in the past few years.

5.6 Floodplains

A river, stream, lake, or drain may on occasion overflow its banks and inundate adjacent land areas. The land that is inundated by water is defined as a floodplain. In Michigan, and nationally, the term floodplain has come to mean the land area that will be inundated by the overflow of water resulting from a 100-year flood (a flood which has a 1% chance of occurring any given year). Forested floodplain systems represent an interface between terrestrial and aquatic ecosystems and are extremely valuable for storing floodwaters, allowing areas for sediment to settle and providing wildlife habitat.

The forested floodplains in the FTWA are largely intact with natural flood regimes. They occur along the lower reaches of the largest streams (Augusta Creek, Spring Brook) but are most extensive along the Kalamazoo River (outside the FTWA but within Ross Township).

Threats

Current threats to floodplains include conversion to industrial, residential, or recreational uses, wetland or floodplain fill or drainage, exotic species invasion, chemical pollution, sedimentation, creation of man-made ponds, and nutrient loading from agriculture and other land uses. Almost all rivers and their floodplains are subject to multiple hydrologic alterations, such as changes in land use, human-made levees, impoundments, channelization, and dams.

5.7 Groundwater

Extensive and high-quality groundwater reservoirs (or aquifers) underlie the four township area (Four Township Water Atlas, 1998). All residents in the four-township area are dependent on this groundwater for domestic water supplies (including drinking water), and groundwater is used for agricultural irrigation (especially for corn during dryer years). Groundwater is also a critical resource for nearby urban populations and industrial activities. Community well water supplies residents of Augusta, Richland and Delton. The City of Kalamazoo owns a well field in the Gull Creek watershed to augment their water supply when needed. Richland and Delton were obliged to install community water supplies after contamination from former industrial activities was revealed (Joe Johnson, FTWRC personal communication 2010). According to a March 4, 2010 Detroit News article a plastics plating company on N. 34th Street in Richland leaked hexavalent chromium into groundwater during the 1970s. Drinking water issues of this type are managed by several divisions within MDEQ, including the Remediation and Redevelopment Division overseeing sites with historic contamination, Drinking Water and Municipal Assistance Division overseeing the public drinking water supply, and the groundwater program within the Water Resources Division overseeing current groundwater discharges.

Because groundwater is not visible, it is easy to forget about its importance. However, if we fail to protect the quality of our groundwater, a most important local resource could readily be degraded. Groundwater in the four-township area is a renewable resource and its exploitation for human uses can be sustainable if it is wisely managed. At present, local domestic water use is largely non-consumptive because most of the water is returned to the aquifer through septic systems. Water extracted for use in urban areas

or for irrigation of crops, golf courses, and lawns is not returned to the aquifer and thus can potentially reduce the volume of water stored in the system. Reduced groundwater volume can in turn lower the water table, affecting surface waters that are in equilibrium with the water table or that receive groundwater discharge.

Most of the FTWA is underlain with Coldwater Shale bedrock, which contains no aquifers. The only groundwater source is the water located in the coarse textured drift material left by the glaciers. These glacial sources typically yield high amounts of groundwater (20-1,400 gallons per minute) and are very vulnerable to groundwater pollution.

The soils in the FTWA area are very permeable to water, and as a result much of the precipitation infiltrates the soils and moves across the landscape via groundwater flow paths. This is the primary way in which local groundwater aquifers are recharged in the long term; some recharge also occurs by seepage out of lakes and wetlands to the groundwater. Discharge of groundwater back to the surface provides much of the water in our streams and lakes. Despite these exchanges, however, the residence time of water in the aquifers (i.e., the time it takes to completely flush the groundwater and replace it with new water) is long, reflecting the immense volume of water stored below ground.

Groundwater discharge to streams, lakes, and wetlands controls both the quantity and quality of many of our surface waters. Residents often refer to a particular lake or stream as being "spring-fed", which they view as a positive feature. Groundwater inputs tend to be stable over time and maintain water bodies even during relatively dry years. Local streams are kept cooler during the summer by groundwater inputs and thereby can support trout. As water infiltrates soils and travels through underground flow paths, filtration and absorption effectively remove many kinds of contaminants. This is one reason that the water that exits from underground to discharge into surface waters tends to be of better quality than if the water had flowed overland to reach those water bodies.

One consequence of the high rate of exchange of water between the land surface, groundwaters, and surface waters is that our groundwater aquifers are highly susceptible to contamination originating at the land surface (Rheaume 1990). The long residence time of water in the aquifers means that once they are contaminated, it will take many, many years for their water quality to be restored. A relatively small quantity of chemical pollutants, if stored or discarded improperly at or beneath the land surface, can degrade the utility of vast amounts of groundwater before the problem is even noticed. It is thus vital that all residents, farmers and businesses in our area understand the susceptibility of our groundwater resources. It is important to maintain septic systems and apply chemicals to crops, golf courses, yards, and water bodies wisely and only when needed. The Home-A-Syst booklets, available through the local MSU Extension office, are a useful resource for residents interested in reducing their impact on our groundwater and surface waters (MSU 1998). Chemical pollutants can also enter the groundwater from sources such as leaking underground storage tanks and

abandoned well heads, and a number of these have been discovered in the FTWA. The Four Township Water Atlas (1998) contains extensive documentation about groundwater, including known and suspected concerns further detailed in later WMP tables.

Threats

Increased groundwater withdrawal to meet the demands of a growing population is a threat. Despite a general abundance of groundwater in the FTWA, there is growing concern about the availability of good quality groundwater for municipal, industrial, agricultural and domestic use, and for adequate baseflow to our lakes, streams and wetlands. Increased withdrawal can cause groundwater overdraft, which occurs when water removal rates exceed recharge rates. This depletes water supplies and may even cause land subsidence (the gradual settling or sudden sinking of the land surface from changes that take place underground).

In addition to groundwater withdrawals, increases in impervious surface and soil compaction limit infiltration and reduce groundwater recharge. These land use changes along with improvements in drainage efficiency (adding drain tiles, storm drains and ditches) further reduce groundwater recharge. The reduction in infiltration alters the hydrology of surface water causing increased flooding and streambank erosion.

Groundwater contamination can often be linked to land use. What goes on the ground can seep through the soil and turn up in drinking water, lakes, rivers, streams and wetlands. Activities in urban areas that pose significant threats to groundwater quality include industrial and municipal waste disposal, road salting, and the storage of petroleum products and other hazardous materials.

In rural areas, different threats to groundwater quality exist such as animal waste, septic systems, fertilizers and pesticides. Table 12 lists common sources of contaminants to the groundwater that originate from many different land uses.

There is growing concern that increasing land applications of animal waste threatens groundwater resources, and to a lesser extent, surface water resources in the FTWA. The number of Confined Animal Feeding Operations (CAFOs) with permits has increased in recent years and the acreage on which manure is spread for disposal is increasing as well. Appendix 1 shows acreage around the Gull Lake area where manure from CAFOs was spread in 2008. According to the State's MiWaters Database accessed in December 2016, other CAFOs located outside of the watershed now apply manure on fields located in Barry County in the Augusta Creek watershed (see Appendix 1). Information about manure applied to fields by smaller, unpermitted agricultural operations is not readily available like that of CAFOs. Improperly managed manure at any size agricultural operation can result in infiltration or runoff of nutrients or harmful pathogens to groundwater or surface waters. The FTWA has a number of horse farms that can pose similar threats if direct access to surface water bodies is not restricted or if excess manure is not handled appropriately.

Table 12. Common Groundwater Contaminant Sources

Source	**Contaminant**
Salting practices & storage	Chlorides
Solid waste landfills	Hazardous materials, metals
Snow dumping	Chlorides
Industrial uses	Hazardous materials
Agricultural fertilizers	Nitrates, phosphorus
Households	Hazardous materials
Manure handling	Nitrates, pathogens
Gas stations	Hydrocarbons, solvents
Home fertilizer	Nitrates
Auto repair shops	Hydrocarbons, solvents
Septic systems	Nitrates, pathogens
Recycling facilities	Hydrocarbons, solvents
Urban landscapes	Hydrocarbons, pesticides, pathogens
Auto salvage yards/junk yards	Hydrocarbons, solvents
Agricultural dealers	Hydrocarbons, pesticides, nitrates
Underground storage tanks	Hydrocarbons
Agricultural feedlots	Nitrates, pathogens
Industrial floor drains	Hydrocarbons, solvents

5.8 Forests

Forest lands protect rivers and streams and provide habitat for many species. Tree canopies and the underlying organic humus layer intercept and help to infiltrate rainfall runoff contributing to the stability of the hydrologic cycle.

Threats

The largest threats to natural forest communities in the FTWA are continued fragmentation and invasive species (e.g., garlic mustard). Fragmentation often results in nest predation and nest parasitism (mainly by cowbirds), which accounts for population declines of forest birds, especially neotropical migrants. Fragmentation also increases the ability of invasive species to penetrate forested areas. Invasive species can disrupt the forest's role in managing water and the hydrologic cycle. The Emerald Ash Borer is currently expanding into the area and threatens to eliminate ash trees that are important components of riparian woodlands. Invasives may disrupt local hydrology by using more or less water or by having shallower roots structures than the native species they replace.

5.9 Savanna and Prairie Remnants

The FTWA has several oak savanna and prairie remnants. Southwest Michigan is part of the tallgrass prairie region, which was dominated by grasses such as big bluestem and Indian grass. The tallgrass prairie vegetation sometimes reached a height of 10 feet or more. Oak savannas, characterized by a grassy prairie-type ground cover

underneath an open tree canopy, are common in areas that border the prairies. Prairies and oak savannas are fire-dependent systems.

Prairie grasses have been replanted at restoration sites throughout the FTWA, although the total area amounts to under 500 acres so far, about equally divided between private and state lands.

Oak savanna and prairies support many species such as the Eastern box turtle and the Great Plains spittlebug. These systems in the FTWA also support plants that are rare in Michigan and indicative of high-quality savannas, including Rattlesnakemaster, prairie coreopsis, sand grass, and black haw. The savannas with their native plants play an integral part of the hydrologic cycle by providing areas where water can easily infiltrate the soil.

Threats

The largest threat to savanna areas is the conversion to developed uses. Developing these natural areas can disrupt the natural water infiltration capacity of these areas. In addition, invasive alien plants have become extensively established in oak savanna and prairie remnants. These aggressive species are encouraged by the conversion of open lands to homes. Development creates large amounts of disturbed open ground and roadways that are new invasion routes for invasive species. Increased human recreational and other activities connected to development also tend to spread invasive plants' seeds further into natural areas. Suppression of natural fire regimes in developed areas further encourages the dominance of invasive over native plants, which are often adapted to recurring fire. Invasive plant species can actually result in reduced groundwater recharge, which disrupts the hydrologic cycle.

5.10 Rare Features

A variety of rare species and communities have been documented in targeted conservation areas in the FTWA. Work conducted for a Four Township Natural Features Inventory (2005) documents threatened, endangered, and special concern species/communities.

Threats

The major threat to rare species and features is habitat loss and fragmentation. As natural habitats become more fragmented and disrupted, invasive species can be accidentally or deliberately introduced into high quality habitat areas. Invasive species can displace or eliminate native species, particularly rare species that have specific habitat requirements. Invasive species can substantially alter the structure and functioning of high quality natural communities including an alteration of the amount of water that is infiltrated. Further, new construction can affect groundwater infiltration rates and consequently reduce the amount of water discharging from a spring. An altered hydrologic cycle can change the conditions necessary for the continued health of rare species populations and some natural communities such as prairie fens.

The Four-Township Breeding Bird Study indicates that the four townships harbor some of the highest numbers of breeding bird species of any area in southern Michigan (available at www.ftwrc.org/publications). During the period from 1970 through 2004, 152 species of breeding birds were documented in the four townships: 112 species in Barry; 122 species in Prairieville; 125 species in Richland; and 150 species in Ross. The rich diversity of breeding birds is related to habitat diversity, the relatively large amount of open space in the four townships and the minimal fragmentation within some of the core areas of the larger land holdings.

Data from 1973-75 and 1983-88 suggest even greater avian diversity than at present, indicating that recent landscape changes, particularly urban sprawl, may be having a deleterious effect on the overall quality of avian diversity in the four townships. Fortunately, this area has a substantial number of natural areas under preservation by public and private entities, which will temper the impact of suburban sprawl. While bird population changes have been substantial in the study area, the protected areas should help stabilize populations overall. Among the more serious threats facing regional bird populations are the aforementioned suburban sprawl and an associated increase in fragmentation, thought to contribute to higher parasitism rates and an increase in predation. Changing agricultural practices, as well as development in and around wetlands, impact grassland and wetland species. Increases in feral and domestic cats, auto traffic, cell phone towers and windows contribute to higher mortality rates.

Over the years, many of Michigan's Threatened and Endangered species have used the Four-Township area for breeding. Endangered species which have been noted historically, but not during this study, include Barn Owl and Prairie Warbler. Threatened species include Common Loon, Least Bittern, Trumpeter Swan, Bald Eagle, Red-shouldered Hawk, Long-eared Owl and Henslow's Sparrow. Of the Threatened species, all except the Red-shouldered Hawk and Long-eared Owl were found during the present study. The keys to the future health of the Four-Township area avifauna are protection and wise management of existing habitat resources to preserve current breeding bird populations, reduction of fragmentation to preserve area-sensitive species, public education, protective zoning with environmentally sensitive development, and vigilance against inappropriate land use. The report lists areas in each township considered to be essential for conserving breeding birds.

6 Plan Development Process

This FTW Management Plan was developed utilizing the best available data from a library of existing publications along with input from stakeholders. The planning process included:

- soliciting stakeholder input;
- reviewing previous studies and reports;
- conducting research on topics of concern; and,
- reviewing existing models to determine priority areas.

6.1 Stakeholder Input

Stakeholder participation was relied upon during the planning process. When developing the original watershed management plan, the FTWRC invited the public to its 2008 annual meeting and featured a presentation by the KRWC detailing the planning process. The KRWC invited attendees to be a part of the planning process through the FTWRC. SWMLC and FTWRC newsletters indicated that a WMP was underway in conjunction with the implementation of conservation easements. FTWRC steering committee meetings and sub-committee meetings were used on a quarterly basis to engage stakeholders and solicit input.

For the original WMP, steering committee and sub-committee participants were instrumental in identifying and commenting on compiled designated uses, desired uses, pollutants, sources and causes of pollutants, priority or critical areas. These participants also developed goals, objectives, and an action plan. The key partners included the FTWRC, MDEQ, SWMLC, and the Kalamazoo River Watershed Council. The FTWRC strives to maintain representation from township officials and planners as well as representation from the Gull Lake Quality Organization.

Most planning work in the FTWA took place between 1998 and 2005, funded by watershed planning grants. Appendix 5 lists several of the public involvement and education efforts related to early planning and assembly of FTWRC watershed planning products. Key project partners listed in FTWRC reports (2005) include:

- Southwest Michigan Land Conservancy (conservation easement acquisition)
- Michigan Natural Features Inventory (identification of priority conservation areas in the four townships)
- Kalamazoo Nature Center (breeding bird survey, information and education)
- Kalamazoo Community Foundation (natural features inventory funding assistance)
- Potawatomi Resource Conservation and Development Council (technical support and financial support for printing of natural features publication)
- Kalamazoo County Road Commission (participated in Council-sponsored planning workshop and offered input on stormwater management issues)

- Gull Lake Quality Organization (information and education, preparation and distribution of resource management publications)
- Augusta Creek Watershed Association (information and education, preparation of resource management publications)
- Barry County Natural Resources Action Team (assisted the Council with information and education, and distribution of Council publications)
- Michigan State University Extension (technical assistance, GIS development, organizational support, information and education)
- Barry County Planning Department (planning and zoning assistance)
- Barry County Commissioners and Planning Commission (planning and zoning)
- Township Boards and Planning Commissions of Prairieville, Richland, and Ross Townships (planning and zoning)
- Prairieville Township Board and Richland Township Board (assistance with planning and coordinating the Council's wetland tours)

During the watershed management plan update that took place in 2016-2017, the FTWRC sought public input by inviting the public to attend a regular meeting of the council on November 7, 2016 where planning elements for the updated WMP were discussed. This meeting was advertised in the local newspapers of record covering the Four Townships Watershed Area and via FTWRC email list. In addition, letters were mailed to specific stakeholders, especially those with jurisdiction or interest in specific waterbodies or areas of the watershed. In the letter, the FTWRC asked for input on the planning process and project interests from agencies and organizations such as county conservation districts, local units of government, county road and drain commissioners, and non-governmental organizations involved in environmental and wildlife conservation (e.g., Kalamazoo Valley Chapter of Trout Unlimited). Stakeholder comments are included in the report in Appendix 9.

6.2 Watershed Models

In 2010 Kieser & Associates, LLC completed a build out model for the Kalamazoo River Watershed Management Planning Project. The purpose of this effort was to evaluate the impact of future land use changes on water quality, specifically runoff volume, total suspended solids, phosphorus and nitrogen. In the model, land use change was based on the modeled future land use taken from the Land Transformation Model developed by Purdue University (Appendix 6).

In 2014 the SWMLC and KRWC partnered with a team of graduate students lead by Dr. J. David Allan from the University of Michigan to create a strategic conservation plan for the Kalamazoo River Watershed entitled *Kalamazoo River Watershed Land Conservation Plan* (LCP). The partners convened a group of more than 40 local experts to develop a list of criteria that would help identify high quality land in the watershed that, if protected from development and degradation, would best protect water quality. The final criteria included: land use; wetlands; proximity to water bodies and conserved lands; presence of cold water streams; and threatened or endangered species.

Based on these criteria, the team undertook a geographic information systems (GIS) analysis to prioritize the lands in the Kalamazoo River watershed based on their conservation value. The analysis yielded a unique numeric conservation value for each parcel in the watershed. The results of the analysis were separated into three tiers of priorities. Tier 1 represents land parcels scoring in the 90th percentile and above, Tier 2 represents parcels scoring in the 80th – 89th percentile, and Tier 3 represents parcels scoring in the 70th – 79th percentile based on conservation value.

The partners then ranked individual subwatersheds based on the concentration of Tier 1 parcels. With input from local natural resource professionals, these subwatersheds were grouped into eight priority areas for land conservation. The landscapes in these areas are extremely diverse, with everything from forested floodplains to prairie fen wetlands to coldwater trout streams. Several watersheds within the FTWA were listed as priorities in the LCP, including Silver Creek, Spring Brook, and Augusta Creek.

Results from the LCP were used to re-prioritize the PCAs described in Section 5.1 of this plan.

In 2015, the MDEQ completed the Landscape Level Wetlands Functional Assessment (LLWFA) modeling project throughout the Kalamazoo River Watershed, including the FTWA, which classified existing and historic wetlands by the specific functions they perform within the landscape. These functions include services such as floodwater storage, maintaining stream flow in creeks, holding back sediments, taking up nutrients, shading streams, and stabilizing shorelines to abate erosion problems. The LLWFA also identifies wetland functions that support fish, waterfowl, and amphibian habitat. Data from this model can help communities identify priority areas in the watershed where important functions have been lost such as flood storage. The data can be useful when revising local zoning ordinances and master plans. The LLWFA information is available on the MDEQ wetlands map viewer (http://www.mcgi.state.mi.us/wetlands/).

The most useful application of the LLWFA is for conservation projects with specific goals of increasing wetland cover and specific services or habitat. For this application the LLWFA data can be used to compare and rank the wetland functionality of individual parcels on a small scale basis (e.g., township-level or HUC-14 watershed). This can only be done by viewing the data in the GIS geodatabase using ESRI ArcGIS or similar software. For more general status and trends, the KRWC has reports with LLWFA data broken down by municipality, watershed, and parcel. In the FTWA wetland loss has been relatively low when compared to the overall Kalamazoo River Watershed. Spring Brook lost 9% wetland cover since pre-settlement time (394 acres); Augusta Creek lost 7% wetland cover (325 acres); Gull Creek lost 2% (108 acres); Comstock Creek lost 9% (92 acres); and Silver Creek lost 26% (1,472 acres). In comparison Gun River watershed has some of highest wetland lost at around 50%. In terms of the water quality services lost with the elimination of these historic wetlands, Spring Brook lost 3% functionality; Augusta Creek lost 17%; Gull Creek lost 15%; Comstock Creek lost 26%; and Silver Creek lost 45%.

6.3 Watershed Inventory

A non-point source pollutant inventory was completed for subwatersheds within the FTWA including Augusta Creek, Gull Creek, Prairieville Creek, Comstock Creek, Spring Brook, and Silver Creek. The FTWA is comprised of five major subwatersheds covering Richland and Ross Townships in Kalamazoo County and Prairieville and Barry Townships in Barry County located in southwest Michigan. All of the major creeks of the FTWA drain to the Kalamazoo River. The inventory methodology used for this project is designed to identify pollutant sources and is not recommended to establish a general watershed characterization. Potential sources of pollution were identified and quantified as part of a WMP update for the FTWA in 2016.

Previous public education efforts by FTWRC involved placing signage at many road-stream crossing sites around the watershed (Figure 8). A road-stream inventory map included in the first WMP identified approximately 77 crossings. For this project we expanded the number of sites to 105, which includes all of major road-stream crossing in all five subwatersheds, including tributaries to the major creeks. An earlier watershed inventory for Spring Brook was conducted in 2014 by the KRWC, and information from this inventory is included in the report. Sites assessed in 2014 were not re-assessed for this project with the exception of one erosion site on N. 26th Street.

Upon MDEQ staff recommendations, the FTWRC used the MDEQ's Pollutant Source Identification Data Sheet for this inventory. The form was used in conjunction with a driving inventory of the watershed, as it was not practical or feasible to walk the entire length of all streams in the FTWA. The KRWC watershed coordinator and volunteers spent ten days in the field driving the watershed and taking inventories at each major road-stream crossing, which totaled 105 crossings across all subwatersheds.

This watershed inventory documented few major pollution concerns and continues to support objectives of the WMP which call for protecting water quality. The majority of the pollution problems identified during the inventory originate from road runoff and problems with the physical road crossing which tend to cause erosion and other associated problems. Summaries of the pollution problems documented at 21 sites are included in Appendix 9, including an estimate of pollutant loading associated with each site. Pollutant loads were estimated using the Michigan Pollutants Controlled Spreadsheet, measurements from the inventory data sheets, and conservative assumptions.

7 Water Quality Summary

7.1 Designated Uses

According to the Michigan Department of Environmental Quality, the primary criterion for water quality is whether the water body meets designated uses. Designated uses are recognized uses of water established by state and federal water quality programs. All surface waters of the state of Michigan are designated for and shall be protected for the uses listed in Table 13. (Citation: R323.1100 of Part 4, Part 31 of PA 451, 1994, revised 4/2/99). A watershed management plan provides direction for restoring and protecting designated uses.

Table 13. Definitions of Designated Uses.

Designated Use	**General Definition**
Agriculture	Water supply for cropland irrigation and livestock watering
Industrial Water Supply	Water utilized in industrial processes
Public Water Supply (at the point of intake)	Public drinking water source
Navigation	Waters capable of being used for shipping, travel, or other transport by private, military, or commercial vessels
Warmwater Fishery	Supports reproduction of warmwater fish
Coldwater Fishery (applies only to coldwater bodies)	Supports reproduction of coldwater fish
Other Indigenous Aquatic Life and Wildlife	Supports reproduction of indigenous animals, plants, and insects
Partial Body Contact	Water quality standards are maintained for water skiing, canoeing, and wading
Total Body Contact	Water quality standards are maintained for swimming

For designated use assessments, pollutant based impairments and threats are considered. Impairments also can be caused by channelization related to unstable flow regimes. For detailed information on the most common pollutants (sediment, nutrients, temperature, flow, bacteria and chemicals) their sources and Michigan's water quality standards see Appendix 7.

The Clean Water Act (CWA) requires Michigan to prepare a biennial Integrated Report on the quality of its water resources as the principal means of conveying water quality protection/monitoring information to the United States Environmental Protection Agency (USEPA) and the United States Congress. For each water body, the report classifies each designated use as: 1) fully supported, 2) not supported or 3) not assessed.

Designated uses not supported because of a specific pollutant often require the development of a Total Maximum Daily Load (TMDL). A Total Maximum Daily Load is a calculation of the maximum amount of a pollutant a water body can receive and still meet applicable water quality standards.

7.2 General Water Quality Statement

Where assessed, the designated uses of Agriculture, Industrial Water Supply and Navigation are being met throughout the FTWA. The Public Water Supply use is not applicable in the FTWA because no communities withdraw water directly from surface waters.

The State of Michigan also considers Fish Consumption a designated use for all water bodies. The Fish Consumption designated use is considered not-supported due to elevated levels of polychlorinated biphenyls (PCBs) found in fish tissue. PCB's are ubiquitous in most river environments typically sourced from primarily from atmospheric transport into the FTWA. The Kalamazoo River Mainstem, downstream and outside of the FTWA, has PCB contamination in sediment from historic industrial practices and is a federal Superfund cleanup site.

There is a generic, statewide, mercury-based fish consumption advisory that applies to all of Michigan's inland lakes as well. Mercury is primarily sourced from the burning of coal, transported through the atmosphere and deposited in the FTWA. The State of Michigan has prepared and is implementing a statewide mercury reduction strategy (http://www.michigan.gov/deq/0,1607,7-135-3307_29693_4175---,00.html).

Dioxin impairs fish consumption in some FTW Areas, again, typically sourced from distant industrial practices through air deposition (Table 14). See the Michigan Integrated Report (2010) for details on PCBs, Mercury, and Dioxin.

7.3 Individual Water Bodies

Other than for Fish Consumption, the majority of lakes and streams included in the 2016 Integrated Report within the FTWA were fully supporting of assessed designated uses. Fish Consumption is a state-wide problem for many contaminants, including those in the FTWA (mercury, dioxins, and PCBs). The majority of these impairments should be addressed by state-wide Total Maximum Daily Loads (TMDLs) for mercury and PCBs.

In 2016, Augusta Creek is listed as impaired for *E. coli* due to exceedances in public health and water quality standards.

One additional impairment for Other Aquatic Indigenous Life and Wildlife impacts the FTWA. The impairment is in Lake Allegan, an impoundment along the Kalamazoo River downstream of the FTWA. The impairment is caused by nonpoint source phosphorus contributions from all of the watershed above the lake, including that from the FTWA. All of the impairments relevant to the FTWA are listed in Table 14.

Table 14. Impaired Water Bodies at a Glance (taken from MDEQ Integrated Report, 2016).

Water Body	AUID	Impaired Use	Cause	TMDL Status
Kalamazoo River Watershed Rivers/Streams	All in FTWA	Fish Consumption	PCB in Fish Tissue	2022
Kalamazoo River Watershed Rivers/Streams	All in FTWA	Fish Consumption	PCB in Water Column	2022
Headwaters Augusta Creek	0505-01	Total Body Contact Recreation	*Escherichia coli*	2022
Augusta Creek	0506-01	Total Body Contact Recreation	*Escherichia coli*	2022
Gull Lake	0507-04	Fish Consumption	Mercury in Fish Tissue	2022
Spring Brook	0605-01	Fish Consumption	Dioxin	>2022
Unamed Tributary to Kalamazoo River	0607-02	Fish Consumption	Dioxin	>2022
		Other Indigenous Aquatic Life and Wildlife, Fish Consumption	Mercury in Water Column	2022
Unamed Tributary to Kalamazoo River	0607-03	Fish Consumption	Dioxin	>2022
		Other Indigenous Aquatic Life and Wildlife, Fish Consumption	Mercury in Water Column	2022
Silver Creek	0607-04	Fish Consumption	Dioxin	>2022
		Other Indigenous Aquatic Life and Wildlife, Fish Consumption, Cold Water Fishery	Mercury in Water Column	2022
Unamed Tributary to Kalamazoo River (Chart Creek)	0607-05	Fish Consumption	Dioxin	2022
		Other Indigenous Aquatic Life and Wildlife, Fish Consumption	Mercury in Water Column	2022
Pine Lake W. of Prairieville	0607-06	Fish Consumption	Mercury in Fish Tissue	2022
Lake Allegan	0907-06	Other Indigenous Aquatic Life and Wildlife	Excess Algal Growth, Phosphorus (Total)	2001

The FTWA drains to the Kalamazoo River upstream of Lake Allegan. Thus, it is within the Lake Allegan watershed and therefore is subject to a phosphorus TMDL for Lake Allegan that was completed in 2001. An expected use attainment date has not been estimated by the Michigan Department of Environmental Quality (MDEQ, 2016).

Lake Allegan is a reservoir on the Kalamazoo River created by Calkins hydropower dam located in the middle of Allegan County. Total phosphorus concentrations measured by MDEQ in Lake Allegan between 1998-2000 averaged 96 ug/l and ranged from 69 to125 ug/l. Both point source and nonpoint source load limits were set in order to achieve an average in-lake total phosphorus concentration of 60 micrograms per liter in Lake

Allegan for the growing season from April-September. The nonpoint source limit calls for a 50% reduction in nonpoint source phosphorus loads during the growing season (April – September) and a 43% reduction at other times of year from 1998-2000 levels. The point source limit calls for a 23% reduction of phosphorus loading during the growing season. To date, point sources have met target load reductions but nonpoint sources have not, based on the best available tracking and calculation methodology. MDEQ does perceive improvements in Lake Allegan conditions and the overall thought of TMDL participants is that efforts are resulting in desired, positive changes.

Appendix 8 details loading reductions necessary to achieve annual 50% load reductions in total phosphorus from different land uses in FTWA subwatersheds. Appendix 8 also details loading calculations used to estimate loading prevented by preserving PCAs and repairing known erosion sites.

The runoff and buildout information (Appendix 6) can be used by townships to target a nonpoint source phosphorus load reduction of 50%. Townships can use the information to educate on the need and value of handling stormwater runoff in a more distributed way near its source. In new development situations, local ordinances and stormwater guidance can prevent a great deal of new runoff problems. Many options also exist to retrofit practices into already developed areas. Handling stormwater is a key component of protecting high value water resources in the FTWA.

A past Integrated Report by the MDEQ (2010) states the following in describing State of Michigan High Quality Waters in the FTWA:

> The Augusta and Gull Creeks watershed within the Kalamazoo River watershed includes a number of high quality streams and lakes. Gull Lake is a large, mesotrophic lake. While phosphorus levels in the watershed remain at acceptable levels, development pressures are a concern. Agriculture is also a potential source of nutrients. There are three recently constructed CAFOs in the watershed, which include new and expanded operations. Therefore, preservation of the riparian land is critical to provide an adequate buffer between agricultural operations and the water bodies.
>
> Spring Brook is a coldwater tributary to the Kalamazoo River immediately downstream of the city of Kalamazoo. A 1991 MDEQ biological survey conducted on Spring Brook indicated that this stream had the highest habitat quality for fish and other aquatic life of any coldwater stream of similar size that was sampled in southwestern Michigan. Brown trout of varying sizes were observed as well as high numbers and diversity of aquatic insects. A more recent biosurvey, conducted in 2004, found that approximately one mile of the riparian zone had been completely removed and replaced by subdivisions and lawns near Riverview Drive. A survey conducted further upstream, at DE Avenue, found a largely unimpacted riparian zone and an excellent macroinvertebrate community. Pollutants associated with development including sediment, phosphorus, and thermal inputs are the primary threats to this watershed.

In 2016, the MDEQ issued a new Integrated Report which included new impairments in the FTWA. The entire length of Augusta Creek is now documented by MDEQ as being impaired for full body contact recreation because of elevated *E. coli* levels. While updating the watershed management plan, the state was working on a statewide TMDL for all waterbodies impaired by *E. coli*. The TMDL was on public notice in 2017, and we anticipated an *E. coli* TMDL for Augusta Creek will be in effect within the next 1-2 years. In the 2016 Integrated Report all impairments have estimated TMDL dates of 2022, except for Dioxin impairments which list the TMDL schedule as >2022.

Additional water body narratives are included in Appendix 4.

8 Prioritization - Areas, Pollutants, Sources

As noted in the Introduction, the Four Townships Watershed Area (FTWA) possesses a rich diversity of surface waters in good ecological condition. These surface waters - lakes, streams, and wetlands - are highly valued by local residents for recreational and aesthetic reasons, and many of the local residents live on or close to lakes. The local landscape is underlain by extensive groundwater aquifers, and groundwater and surface-water bodies are intimately connected because the permeable soils of the area promote exchanges of water between the land surface, groundwater, streams, lakes, and wetlands. Thus the entire hydrologic system is vulnerable to the degradation of water quality in the case of contaminants that are mobile in groundwater systems, as for example agrochemicals from row-crop production (e.g., nitrate, atrazine). Wetlands are abundant in the FTWA and they serve to improve water quality because they are often situated at the interface between groundwater, surface runoff, and lakes and streams, where they remove excess nutrients, sediments, and contaminants. Protection is a priority wherever they occur.

In contrast to many populated watersheds that are in need of extensive restoration and remediation to ameliorate longstanding problems, the focus of watershed management in the FTWA is oriented to protection and preservation, with some attention to localized stormwater issues and a general concern about row-crop and animal agriculture. Future residential and urban development, as well as intensification of agriculture, presents the most important challenges for the protection of water resources.

8.1 Nonpoint Source Pollutants

Phosphorus (P), sediments, and microbial pathogens are the pollutants of greatest concern in lakes and streams of the FTWA, while nitrate and potentially other agrochemicals are a concern in groundwater given the predominance of groundwater wells to supply local drinking water for individual homes as well as municipalities. Here we focus on the non-point source pollutants of concern for surface waters.

Surface waters including lakes as well as streams and rivers in the FTWA are particularly sensitive to increased loading of phosphorus (P). This reflects in part the tendency for most water to reach lakes and streams via groundwater flow, and the fact that nitrogen as nitrate is highly mobile in groundwater whereas P tends to stick to soils and sediments. Most P loading to surface waters occurs via overland flow (including storm drains) as well as from fertilizer use and septic/sewer leakage at sites that are close to the water's edge. Sediments carried by overland flow or storm drains are likely to carry P with them that is potentially available to algae and plants. In addition, excessive loading of sediments to shallow waters can degrade habitat for aquatic plants and animals. Concentrations of available P in most surface waters are very low and seemingly slight increases can stimulate undesirable blooms of algae and aquatic plants. Streams are somewhat less sensitive to P loading but they deliver water to sensitive downstream waters including, in the case of the FTWA, the reservoirs along

the Kalamazoo River. Lake Allegan, located on the Kalamazoo River downstream of the FTWA streams, has a phosphorus TMDL as discussed in Section 7.3.

Like P and sediments, microbial pathogens originating on land are likely to reach water bodies primarily via overland flow and septic/sewer leakage. In addition, wildlife, livestock or pets that deposit excrement in close proximity to the water's edge, near storm drains, or within the water can be important sources.

Local expansion of Confined Animal Feeding Operations (CAFOs) has brought the total number of cattle in the vicinity of Gull Lake to almost 6,500. A hog CAFO is also located in the same vicinity in Prairieville township that has almost 3,000 animals, although manure from this site is given to other farm operations. MDEQ staff note the other operations are likely in close vicinity to the hog CAFO. There are two additional CAFOs just outside of the FTWA with a total of just over 5,000 animal units that document manure applications in Barry Township. The expanded CAFO presence has generated citizen concerns about the application of manure on local farm fields. The FTWA also contains a relatively large collection of horse farms. The implications of intensified animal operations for ground- and surface-water quality remain uncertain; even if manure is only applied at considerable distances from water bodies, the potential for nitrate leaching to groundwater may be enhanced. Nitrate in drinking water has already emerged as a problem for residents throughout the FTWA, although high levels are found in a minority of the total wells that are tested.

A pilot study to examine microbial indicators of fecal pollution from humans and cattle was conducted in 2009 by Marc Verhougstraete and Dr. Joan Rose of MSU, and the results were provided as a technical report to the FTWRC (see Appendix 11). Sampling was conducted at two locations (Prairieville and Augusta creeks) over two time periods. The July sampling represented relatively dry conditions and stable summer flow whereas a later sampling in October represented a period of higher and variable flow. A suite of indicators was examined, each with its advantages and disadvantages. Culture-based assays provided estimates of the abundance of *E. coli*, Enterococci, *Clostridium perfringens,* and coliphage (viruses that grow on bacteria). Both creeks carried concentrations of fecal bacteria that are high by public health standards. Notably, concentrations were high even in July when there had been no recent rain and runoff, and the coliphage data suggested that this contamination had occurred in the recent past. Molecular analyses that provide highly sensitive markers for fecal bacteria originating from either humans or cattle showed no evidence for contamination from those sources.

Taken together, these preliminary results suggest that warm-blooded wildlife were the likely source of fecal bacteria in these streams. Deer, raccoons, geese, and other wildlife frequent the wetlands and riparian areas and are much more likely to be the source of contamination in times when there is no runoff from more distant upland areas. However these results must be considered preliminary given that the limited amount of microbial sampling did not cover late winter and early spring, the most likely

time for microbial contamination from upland sources to reach streams by surface runoff.

From 2010 - 2011 the Kalamazoo County Department of Health and Community Services performed additional *E. coli* monitoring in Prairieville and Augusta Creeks under an agreement with the Gull Lake Quality Organization (reports provided in Appendix 11). The monitoring took place between April – December 2010 and May – September 2011. No statistical analysis was performed, but in general data showed high bacterial loads in early summer and fall months at most sampling locations during both wet and dry events. Winter sampling in November – December and spring sampling in April showed typically low bacterial counts.

The source(s) of *E. coli* throughout the FTWA have yet to be fully understood or identified. As new technology or improved indicators are developed, additional sampling over time, space, and weather conditions should be pursued, especially in Augusta Creek where the water quality impairment is present and a TMDL is pending. During the watershed inventory in 2016, no new potential sources were identified. Horse farms and pastures in upper Augusta Creek were observed, and as such microbial source tracking for this specific species could provide insight into horse manure and pasture runoff as a potential source of *E. coli*.

Generally the observations made during the 2016 inventory suggest more investigation is needed on a parcel-by-parcel basis. An *E. coli* source investigation similar to the approach used by other watershed groups would provide good information for the eventual TMDL and future implementation projects. This investigation should include a delineation of 16- or 18-digit hydrologic unit code subwatersheds, which is not currently available for the Augusta Creek watershed. The data gathered by the county health department could then be further evaluated for trends based on the smallest subwatershed delineation. The investigation would then take place on a subwatershed level by reviewing individual on-site septic systems and smaller agricultural operations, horse stables, pastures, and other hobby farms (see Table 17 for implementation projects).

Thermal changes are a concern primarily in the streams that currently support trout. Augusta Creek, Spring Brook, and Silver Creek are popular with anglers and their trout fisheries are managed by MDNR. Increased area of impervious surfaces that conduct storm runoff directly into the streams could pose a threat to the trout by increasing summer temperatures, which already can approach stressful levels. Similarly, impoundments or artificial ponds as well as riparian deforestation can increase stream temperatures. Several studies have pointed out how this problem is expected to become increasingly challenging as the climate warms.

Table 15 contains the conceptual framework linking impaired and threatened designated uses, known and suspected pollutant, sources and causes. The table references studies by MDNR documenting connected farm and residential ponds threatening stream warming.

It is worth noting that the impairments in Table 15 for Other Indigenous Aquatic Life and Wildlife apply only to Lake Allegan where the impairment has been documented through long-term water quality sampling. The FTWA is described as part of the TMDL because it is located within the upstream watershed contributing to Lake Allegan. While this designated use is being met in the FTWA, it is still subject to the requirements of the Lake Allegan/Kalamazoo River Phosphorus TMDL whereby a 50% reduction in nonpoint sources of phoshorus is required to restore the designated uses in Lake Allegan. For this reason, best management practices and restoration or protection projects that reduce nonpoint source phosphorus to the watershed are important and should receive priority consideration.

Table 15. Impaired and Threatened Designated Uses, Known and Suspected Pollutants and Sources, and Causes in the Four Township Watershed Area

Designated Use	Pollutants and Impairments to Designated Uses	Source of Pollution	Causes for Release of Pollutants	Documented Presence in Watershed
Agriculture: Met				
Other Indigenous Aquatic Life and Wildlife: Impaired - FTWA is within the contributing watershed to Lake Allegan, which has been under a TMDL for excess algal growth, phosphorus (total) since 2001; OIALF impairment in downstream Lake Allegan only	Nutrients (K)	Land application of manure (S)	Lack of manure management plans. Manure management plans may not be enforced for small and medium sized animal feeding operations. Improper manure handling and spreading.	CAFO permit information from MiWaters; Visual observations during watershed inventory; Aerial imagery.
		Livestock facility runoff (S)	Improper manure storage and feedlot runoff.	Suspected source due to visual observation of small farms and pasture land.
		Stormwater runoff (P)	Loss of floodplains and wetlands as retention. Discharge from impervious surfaces and developed areas. Ineffective stormwater management.	Urban/residential growth doubled the population of the western half of the FTWA (since 1960); Visual observations during watershed inventory.
		Septic system failures and illicit connections (S)	Improperly designed, installed, and maintained septic systems. Unknown illicit connections.	Septic systems are widespread throughout rural areas of the FTWA.
		Streambank/shoreline modification (S)	Lack of riparian vegetation. Inadequate soil erosion and sedimentation control. Flashy flows from changes in land use and lack of stormwater controls.	Extensive low density shoreline development widespread throughout the FTWA.
	Sediment (K)	Stormwater runoff (P)	Loss of floodplains and wetlands as retention. Discharge from impervious surfaces and developed areas. Ineffective stormwater management.	Urban/residential growth doubled the population of the western half of the FTWA (since 1960).
		Cropland erosion (S)	Conventional tillage practices. Plowing adjacent to water bodies.	Agriculture makes up 44% of the FTWA.
		Road and bridge crossings (S)	Undersized culverts, poorly designed and maintained crossings.	21 sites of concern identified (Appendix 9 Tables 2-6).
		Streambank/shoreline modification (S)	Lack of riparian vegetation. Inadequate soil erosion and sedimentation control. Flashy flows from changes in land use and lack of stormwater controls.	Extensive low density shoreline development widespread throughout the FTWA.
	Habitat fragmentation (S)	Loss of habitat (K)	Filling and draining of wetlands. Development of open space for agriculture and urban development.	Agriculture makes up 44% of the FTWA, and urban areas are developing.
	Unstable flow (K)	Stormwater runoff (P)	Loss of floodplains and wetlands as retention. Discharge from impervious surfaces and developed areas. Ineffective stormwater management.	Urban/residential growth doubled the population of the western half of the FTWA (since 1960); Hydrologic study indicated increasing flashiness in Augusta Creek.
Public Water Supply: Not applicable – no intakes				
Warmwater Fishery: Met				
Coldwater Fishery: Threatened Silver Creek, Spring Brook, Augusta Creek, Travis Drain (seerosion)	Temperature (S)	Lack of riparian habitat or habitat modification (K)	Due to agriculture and urban land use and development. Construction of ponds in rural areas.	Extensive low density shoreline development widespread throughout the FTWA; Agriculture makes up 44% of the FTWA and urban areas are developing;

Designated Use	Pollutants and Impairments to Designated Uses	Source of Pollution	Causes for Release of Pollutants	Documented Presence in Watershed
				DNR Fisheries Report for Spring Brook (1992) and Silver Creek (1993).
		Stormwater runoff (P)	Loss of floodplains and wetlands as retention. Discharge from impervious surfaces and developed areas. Ineffective stormwater management.	Urban/residential growth doubled the population of the western half of the FTWA (since 1960).
	Sediment (K)	Stormwater runoff (K) Road and bridge crossings (K)	Loss of floodplains and wetlands as retention. Discharge from impervious surfaces and developed areas. Ineffective stormwater management. Undersized and improper culverts, poor design.	Urban/residential growth doubled the population of the western half of the FTWA (since 1960); 21 sites of concern, Appendix 9 Tables 2-6.
	High flow (K)	Stormwater runoff (P)	Loss of floodplains and wetlands as retention. Discharge from impervious surfaces and developed areas. Ineffective stormwater management.	Urban/residential growth doubled the population of the western half of the FTWA (since 1960); Hydrologic study indicated increasing flashiness in Augusta Creek.
		Streambank/shoreline modification (S)	Lack of riparian vegetation. Inadequate soil erosion and sedimentation control. Flashy flows from changes in land use and lack of stormwater controls.	Extensive low density shoreline development widespread throughout the FTWA.
Partial Body Contact Recreation: Threatened All FTWA	Pathogens/Bacteria (K)	Land application of manure (S)	Lack of manure management plans. Manure management plans may not be enforced for small and medium sized animal feeding operations. Improper manure handling and spreading.	Approximately 9,000 acres used for manure spreading.
		Septic system failures and illicit connections (S)	Improperly designed, installed, and maintained septic systems. Unknown illicit connections.	Septic systems are widespread throughout the FTWA.
Navigation: Met				
Total Body Contact Recreation: Impaired Impairment due to elevated *E. coli* levels in Augusta Creek only; threatened in Prairieville Creek	Pathogens/Bacteria (K)	Unknown (Microbial source tracking found no human or bovine indicators) Potentially wildlife sources, and/or animal manure (non-bovine)	Wildlife sources from large wetland complexes in Prairieville Creek are suspected source. Pasture animals may be source in upper Augusta Creek. Lower sections unknown. Manure management plans may not be enforced for small and medium sized animal operations. Improper manure handling and spreading.	Microbial source tracking study, 2009, limited scope found no indicators of bovine or human waste in Prairieville and Augusta Creeks.
Industrial: Met				

(K) Known
(S) Suspected
(P) Potential

8.2 Riparian Areas: Rationale for Prioritization

As discussed earlier, natural landscapes in the FTWA yield little overland flow to distant surface waters under most circumstances because of the high permeability of the soils and the gentle slopes of the glacial terrain. Thus movement of phosphorus (P), sediments, and microbes from land to water is expected to be greatest where land lies in close proximity to the water's edge. For this reason, we have used Riparian Areas to delineate land with the highest priority for attention to non-point source pollution reduction.

Figure 15 shows the Riparian Areas throughout the FTWA that are our highest priority for protection and restoration. These areas are included as priorities under this WMP in addition to the PCAs described in Section 5.1 because much of the land directly adjacent to streams and lakes are too small in size for conservation easements. With smaller parcels, other best management practices should be implemented to protect water quality and reduce sources of non-point pollution to the stream. For example, riparian buffers with native vegetation and other streambank stabilization practices reduce erosion and non-point source pollution. Land use planning policies requiring a development setback and limit on clearing of vegetation are also good measures that can protect water quality.

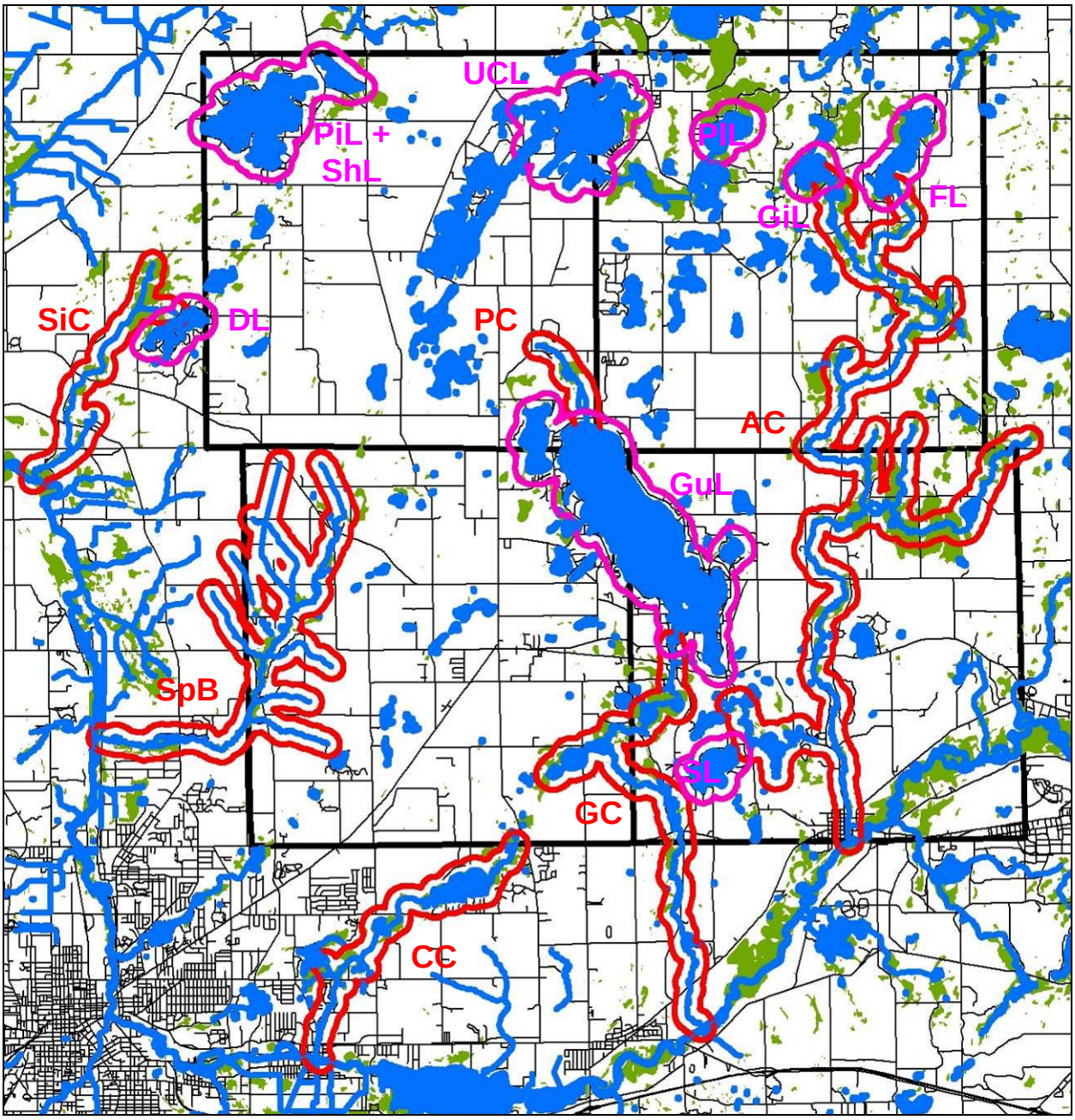

Figure 15. Riparian Areas along the main streams and most populated lakes in the FTWA. Riparian Area width = 1000 feet. Permanent waterbodies are blue, wetlands are green, and township boundaries are thick black lines. PiL = Pine Lake, ShL = Shelp Lake, DL = Doster Lake, UCL = Upper Crooked Lake, GiL = Gilkey Lake, PlL = Pleasant Lake, FL = Fair Lake, GuL = Gull Lake, SL = Sherman Lake, SiC = Silver Creek, SpB = Spring Brook, CC = Comstock Creek, GC = Gull Creek, PC = Prairieville Creek, AC = Augusta Creek.

Figures 16 - 22 show close-up views of each water body superimposed on 2009 aerial photographs from the USDA's National Agriculture Inventory Program. A Riparian Area of 1,000 feet from edge of selected waterbodies (e.g., lake or stream) was chosen to encompass most of the land that slopes down to the water's edge and, particularly with agricultural activity or residential/urban development, is likely to be capable of bypassing the soil filter via either overland flow or constructed drainage systems (e.g., storm drains). This Riparian Area width captures most of the residential development that has become concentrated along lakes and streams as well.

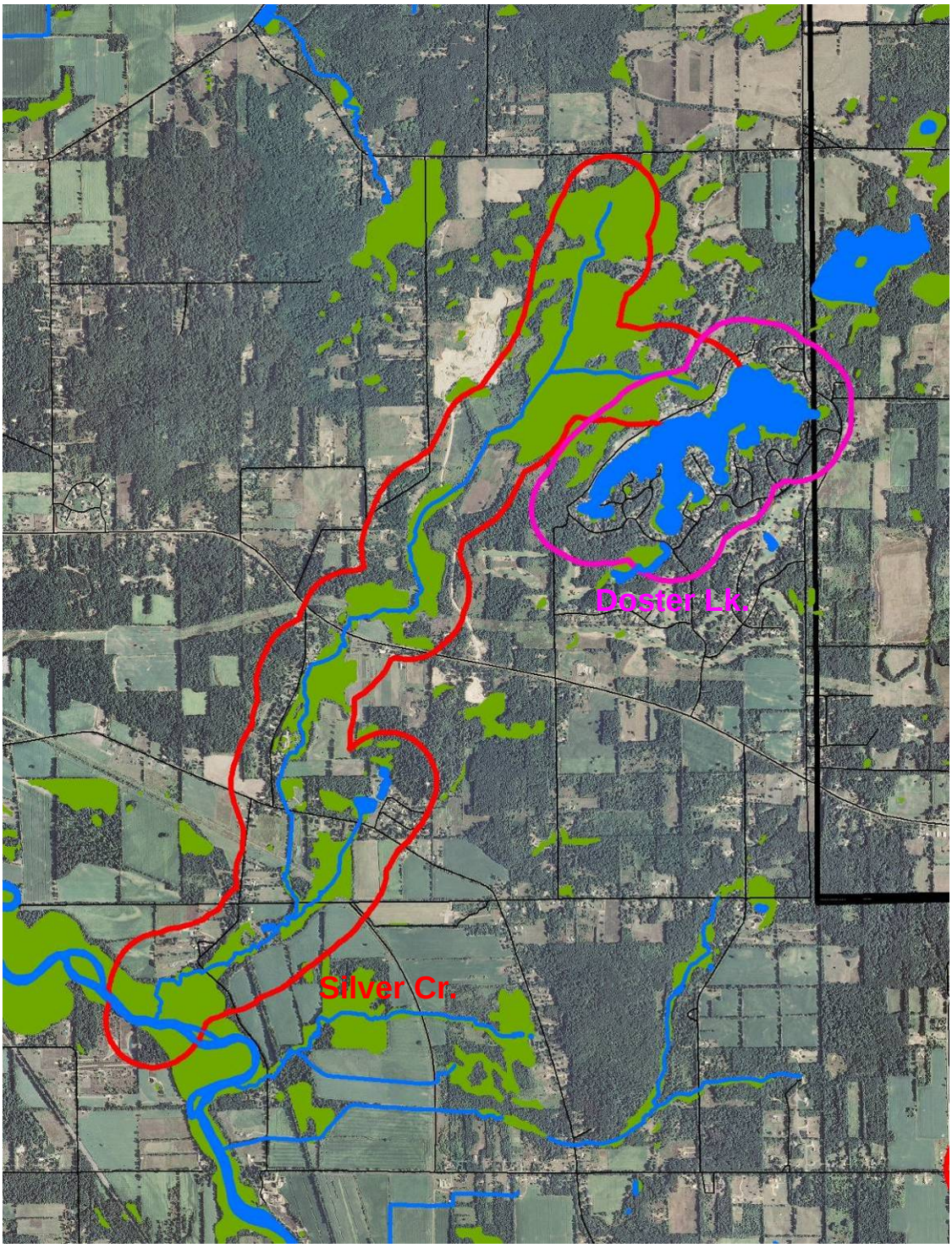

Figure 16. Riparian Areas for Doster Lake and Silver Creek. Permanent waterbodies are blue, wetlands are green, and township boundaries are thick black lines. Aerial photograph in this and subsequent figures is from 2009.

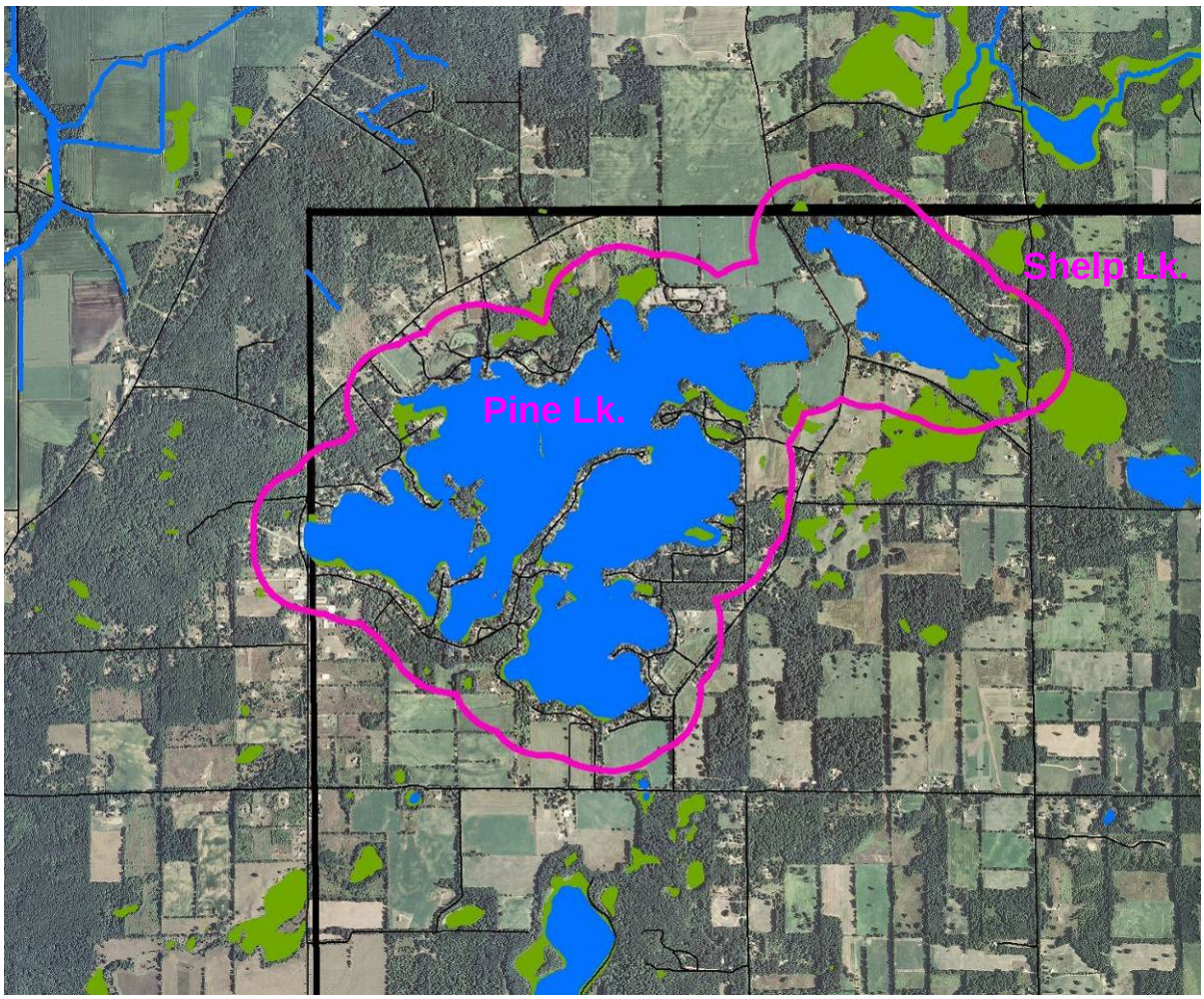

Figure 17. Riparian Areas for Pine and Shelp lakes. Shelp Lake is the smaller basin to the northeast of Pine Lake. Permanent waterbodies are blue, wetlands are green, and township boundaries are thick black lines.

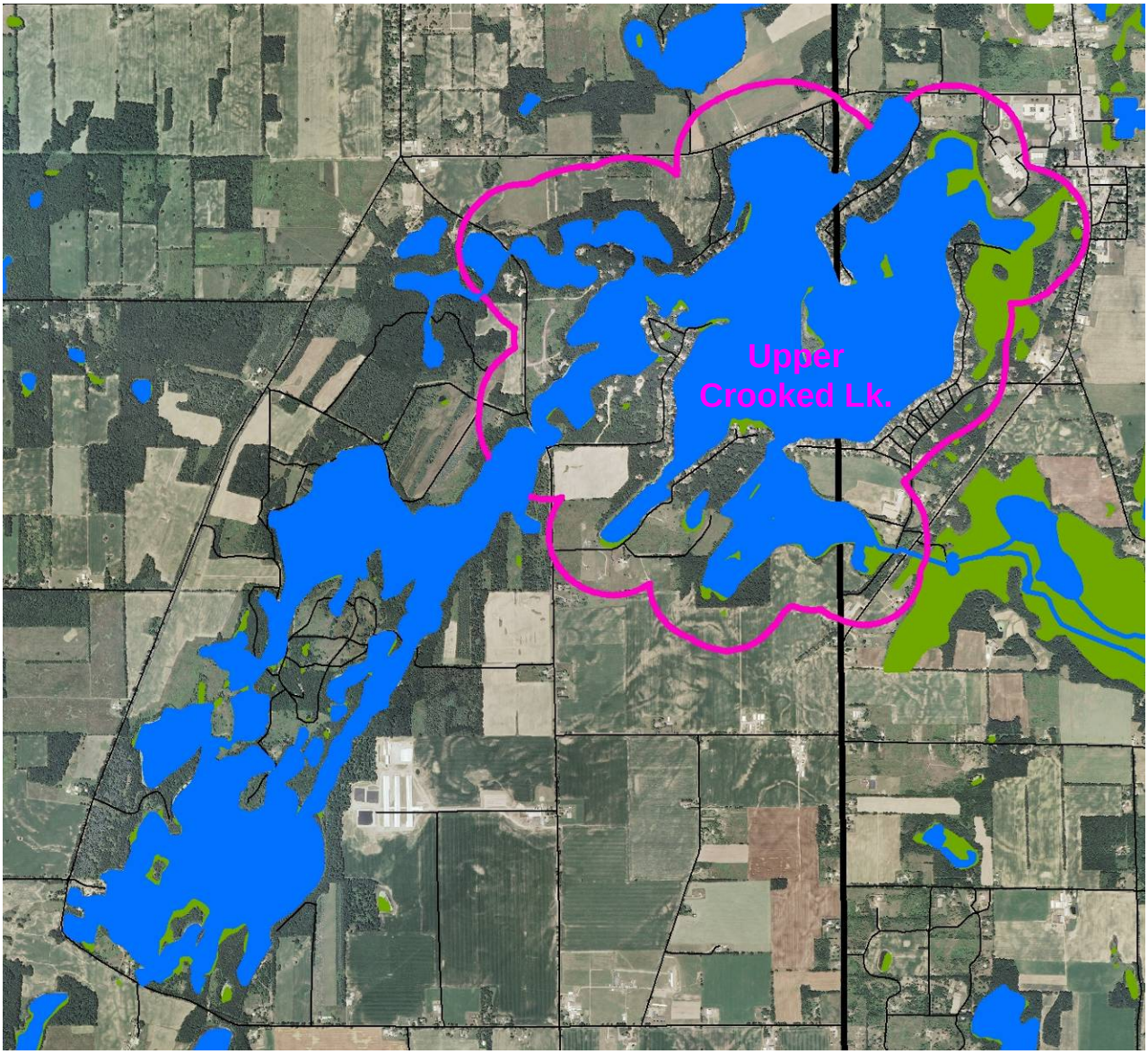

Figure 18. Riparian Areas for Upper Crooked Lake. The lower portion of the lake system (Lower Crooked Lake) is not included because it has few riparian residences and is relatively shallow. Permanent waterbodies are blue, wetlands are green, and township boundaries are thick black lines.

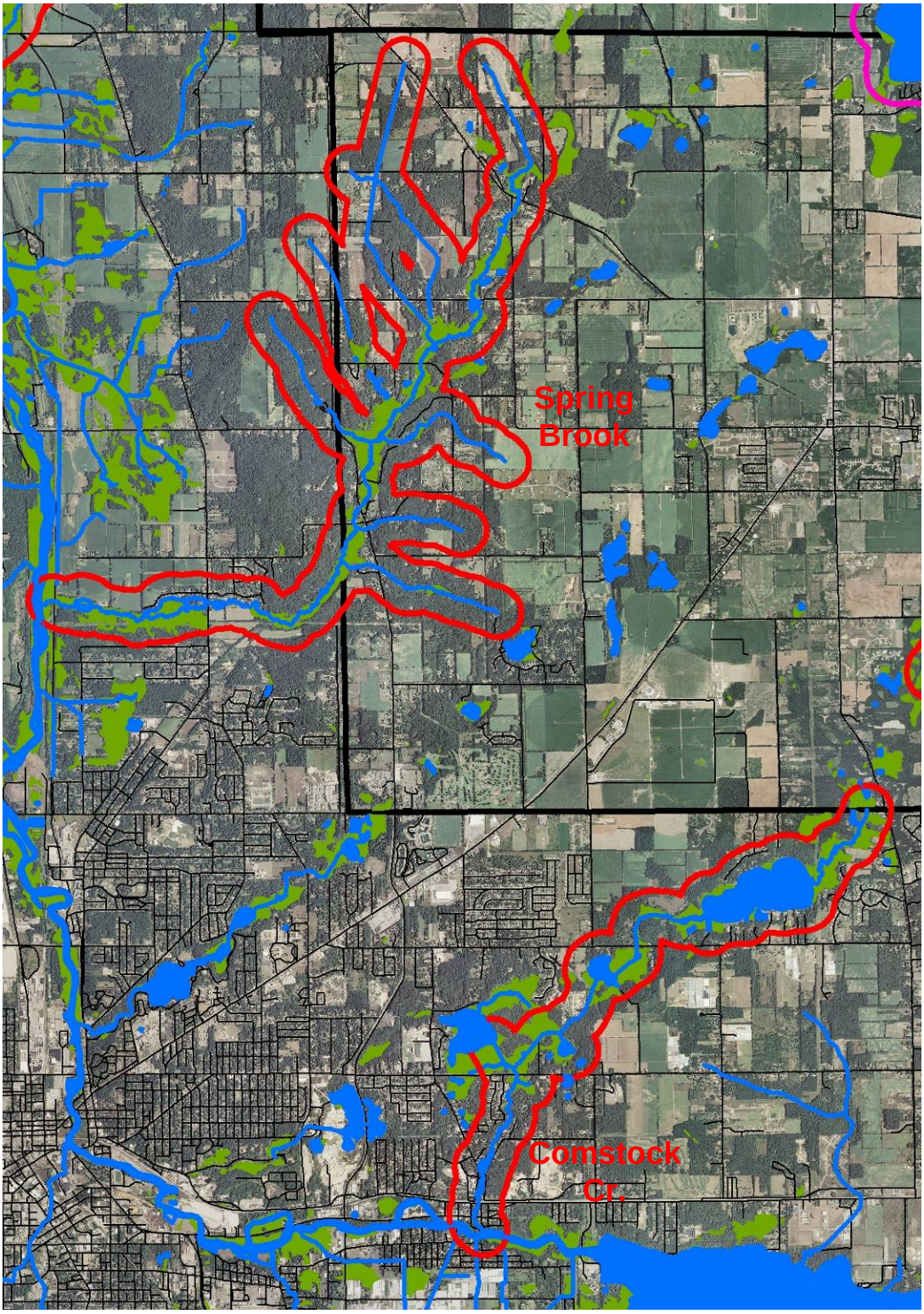

Figure 19. Riparian Areas for Spring Brook and Comstock Creek. Permanent waterbodies are blue, wetlands are green, and township boundaries are thick black lines.

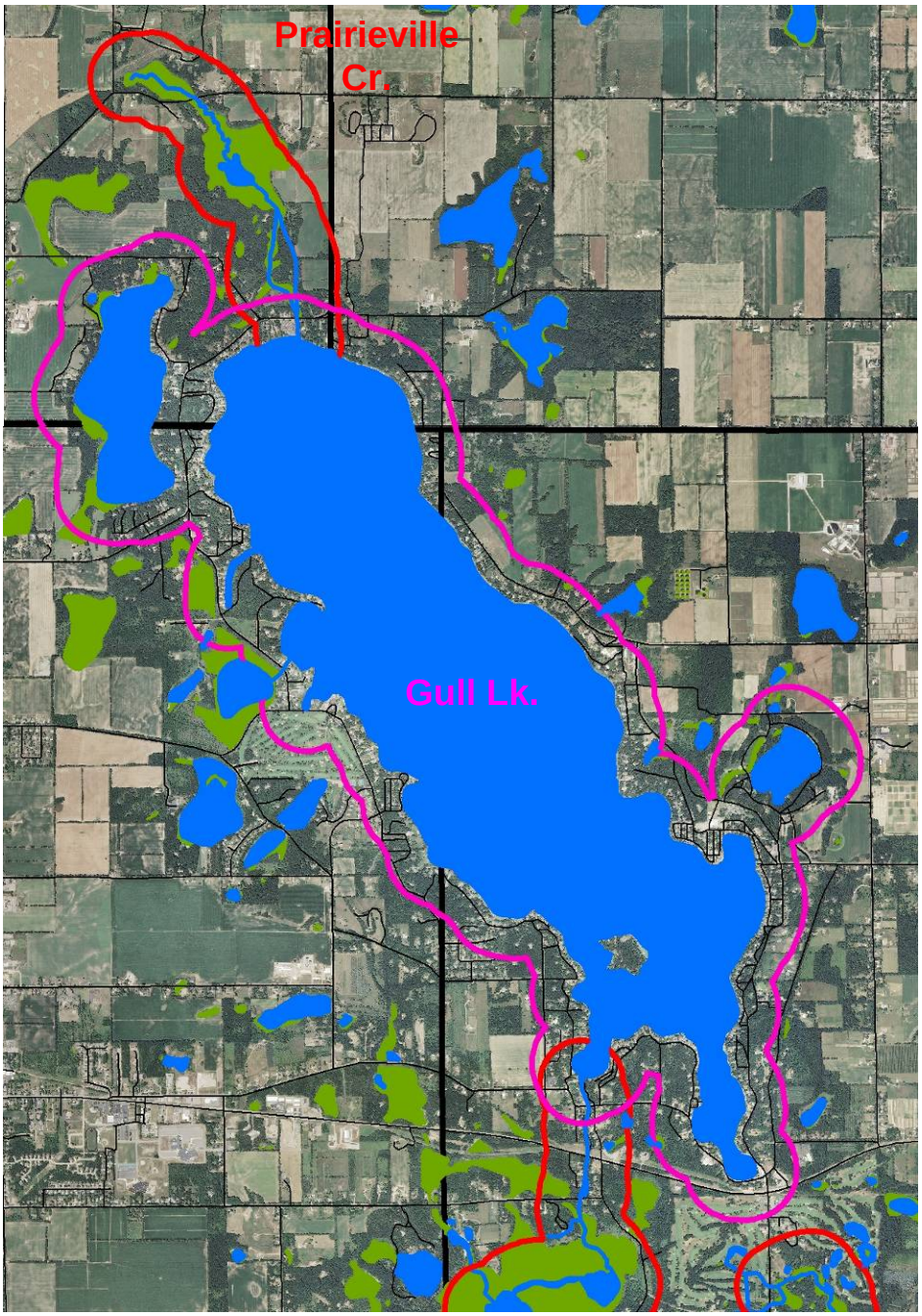

Figure 20. Riparian Areas for Prairieville Creek and for Gull Lake and two smaller lakes that drain into it (Little Long Lake on the northwest end and Wintergreen Lake on the east edge). Permanent waterbodies are blue, wetlands are green, and township boundaries are thick black lines.

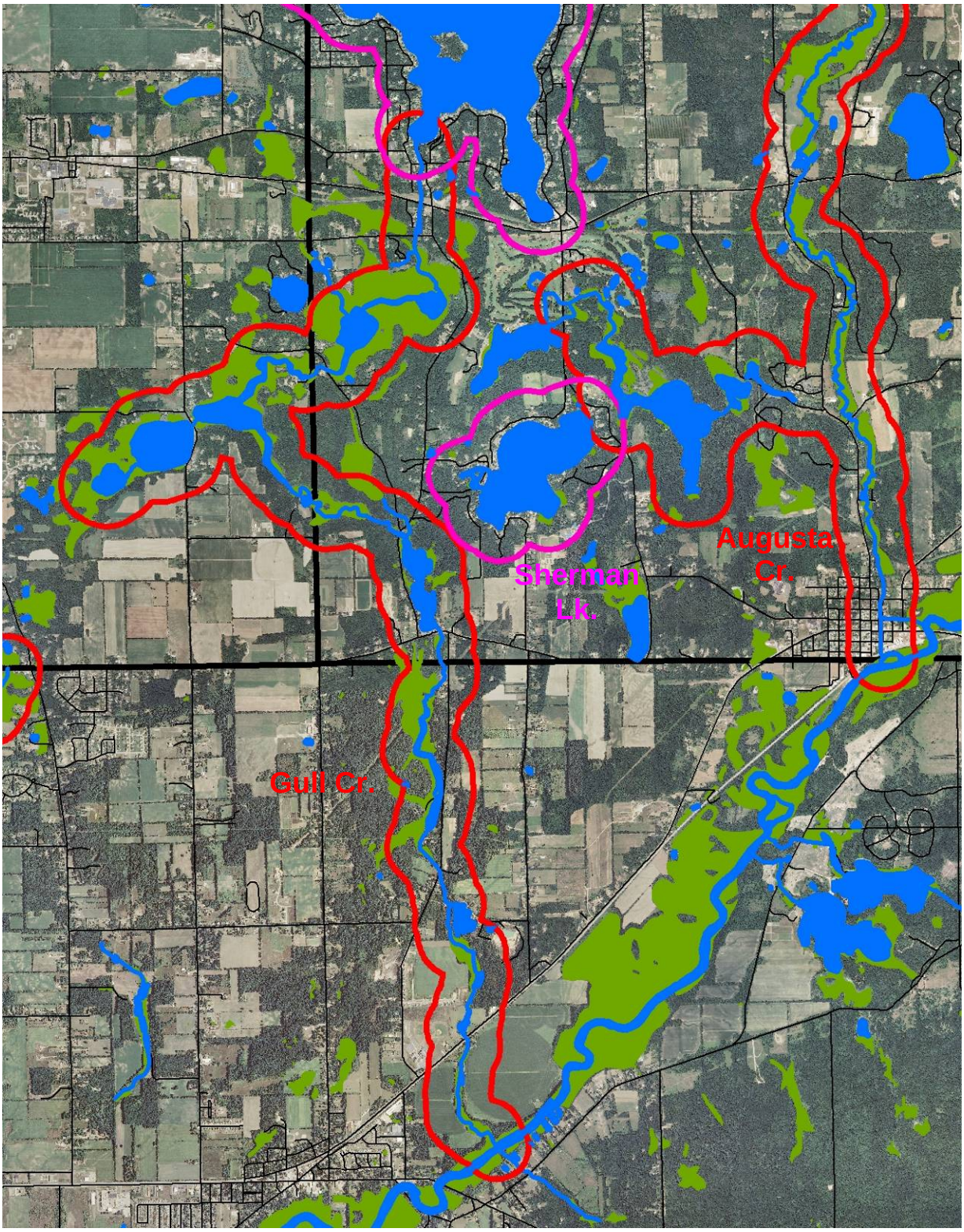

Figure 21. Riparian Areas for Gull Creek and lower Augusta Creek as well as Sherman Lake. Permanent waterbodies are blue, wetlands are green, and township boundaries are thick black lines.

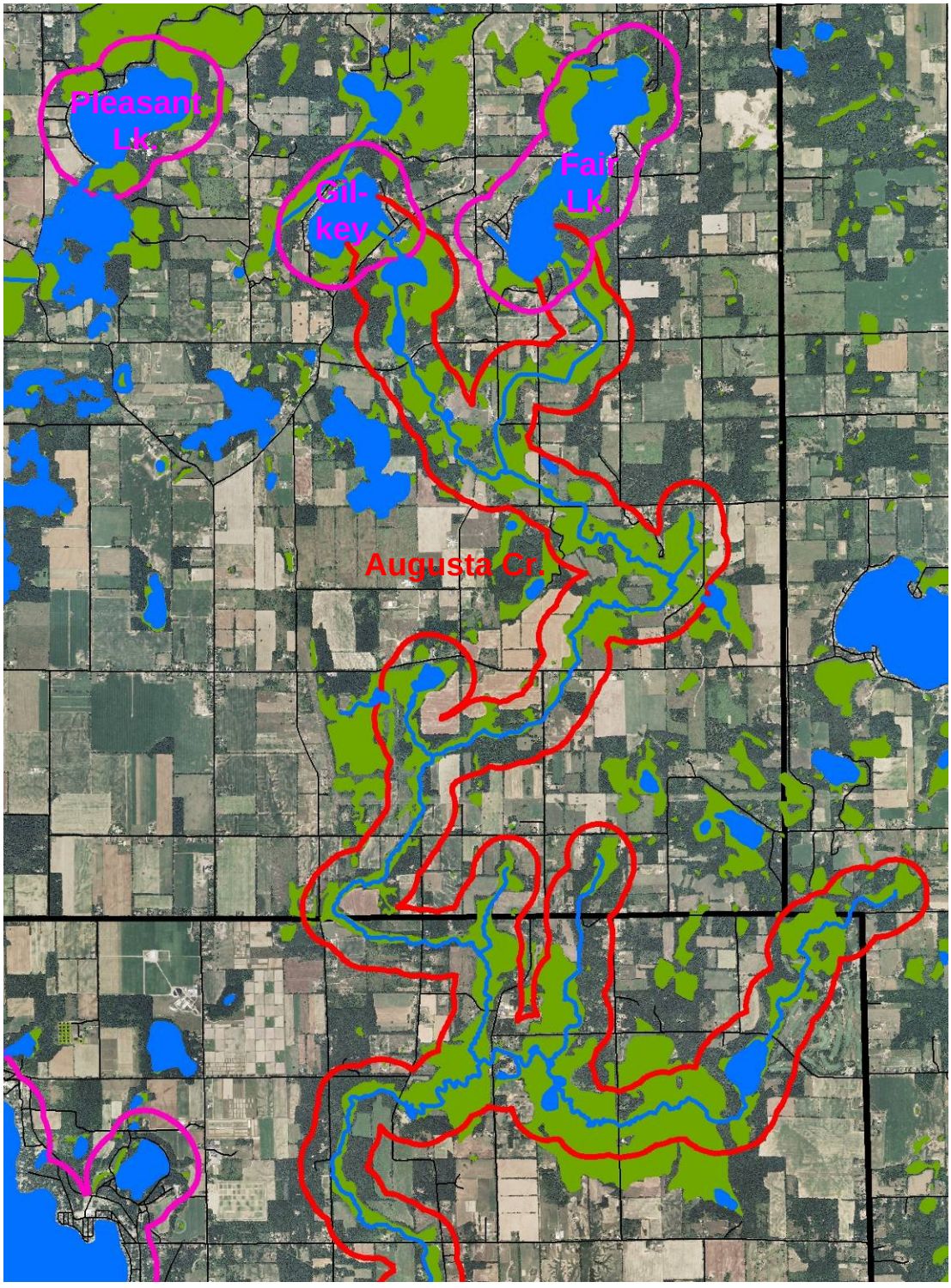

Figure 22. Riparian Areas for upper Augusta Creek and for Pleasant, Gilkey and Fair lakes. Permanent waterbodies are blue, wetlands are green, and township boundaries are thick black lines.

A general idea of the land cover is available from inspection of the buffers overlain in the aerial photographs. Land cover data are not presented for these buffers because we observed that the more recent land cover data, which were determined from satellite images, underestimate the residential development that prevails in the FTWA where homes tend to be embedded among trees. The 1978 MIRIS land cover data are better because they were derived from aerial photography, but much new residential development has occurred since 1978 in the FTWA. Wetlands are marked on the aerial photos based on the National Wetland Inventory conducted based on aerial photos from ca. 1981. Updating information on land cover based on aerial photo interpretation should be a priority for the Riparian Areas.

Lakes selected for Riparian Areas are those with the most residential properties and recreational use, and therefore the most important for local residents. Gull, Pine, Sherman, and Upper Crooked lakes have public access, whereas Doster, Pleasant, Gilkey, and Fair Lakes do not. Gull Lake is the most well known of these lakes and has long been a prime recreational and residential lake.

Streams selected for Riparian Areas are the major ones draining the FTWA as well as Prairieville Creek, the most important tributary water source for Gull Lake (see Appendix 4). All of these streams are lined by prairie fen wetlands and forested floodplains through much of their courses, and they are strongly groundwater-fed.

8.3 Relationship of Riparian Areas to Priority Conservation Areas

The Potential Conservation Areas (PCAs) described in Section 5.1 were identified as sites with outstanding biological resources and potential to protect water quality into the future, whereas the Riparian Areas described in this section were selected as the focus for efforts to stem non-point source pollution and contaminated runoff into lakes and streams. The PCAs are not all within the Riparian Areas. From the standpoint of non-point source pollution, we should seek to preserve as much of the natural (undeveloped) land within the Riparian Areas as possible (e.g., conservation easements and/or land use planning policies), and when necessary implement restoration best management practices to remove sources of non-point source pollution (e.g., repair erosion sites at road-stream crossings).

8.4 Riparian Area Protection, Restoration, and Mitigation

Riparian Areas deserve priority for preservation where they remain in good condition and for restoration or mitigation measures where they may be contributing disproportionately to non-point source pollutant loads. We suggest that in the FTWA available resources might best be split approximately equally between protection and restoration/mitigation. Augusta Creek, for example, has extensive riparian lands that are relatively natural, and the preservation of those natural riparian lands is key to maintaining the good water quality in that stream system as well as its biodiversity. Some of the lakes, including Gull and Upper Crooked, have little undeveloped riparian land left to protect, and the priority for those lakes should be mitigation of non-point source pollution. Information or links to information about mitigation measures such as stormwater management, planting bankside strips of natural vegetation, management of

runoff at road/stream crossings, and setbacks for new development are described elsewhere in this report.

The hydrology of the FTWA is relatively unmanaged with the exception of water levels on Gull and Upper Crooked lakes. Opportunities for ecological restoration in the FTWA includes removal of dams, correction of perched or blocked culverts, management of prairie fens and oak savanna (e.g., burning, removal of invasive plants, restoration of natural hydrology), ceasing to farm lands that are too close to the water's edge or installing agricultural best management practices to reduce soil erosion and runoff (i.e., within the Riparian Areas), reinstalling buffers of native vegetation at lakeside residences, and preventing the spread of aquatic invasive species (especially between inland lakes).

9 Goals, Objectives, and Implementation Strategies

Successful implementation of a WMP is more likely to occur when the objectives are based on clearly defined goals. Goals reflect the long-term vision and serve as guideposts established to keep everyone moving in the same direction and provide a way to measure progress. Objectives are more specific actions that need to occur to achieve the stated goal. This chapter provides a management strategy to protect and improve water quality in the FTWA. The management strategy prioritizes tasks to be implemented, identifies specific problem sites, and lays out a detailed action plan for implementation. The strategy also includes an information and education plan and describes current efforts.

9.1 Goals and Objectives for Designated Uses

The following goals are related to protecting the designated uses of key water bodies in the FTWA as identified in Section 8.

1. Prevent an increase in pollutants threatening water quality by sufficiently preserving or managing natural and working lands within the Priority Conservation Areas (PCAs), and where possible the greater Riparian Areas. This includes applying conservation and land protection tools in PCAs and Riparian Areas where landowner interests align.

2. Mitigate non-point sources of pollution in storm-sewered or tile drained areas and in Riparian Areas, particularly where there is current agriculture, transportation, and residential/urban development. This includes an emphasis on projects and public education that work at restoring riparian and shoreline vegetation.

3. Restore natural hydrological regimes in streams and natural ecosystems within Riparian Areas where opportunities exist. This includes repairing road-stream crossings where excessive runoff, stream alignment, and culvert problems exist that change hydrologic regimes and/or create other pollution problems. In areas with storm sewers and direct inputs to surface waters, stormwater volume must be addressed to prevent high flows during storms.

4. Work with non-governmental organizations, invasive species collaborations, local units of government, tribal governments, and state and federal agencies to protect and enhance fish and wildlife habitat and protect natural resources from the spread of invasive species (with special emphasis on aquatic invasive species).

Objectives for these goals are listed in Table 16 and are linked to the reduction of pollutants.

Table 16. Goals and Objectives as Related to Ranked Pollutants, Sources, and Causes in the Four Township Watershed Area.

Designated Use and Status	Ranked* Pollutants and Impairments to Designated Uses	Sources	Causes	Objectives (based on resource review and loadings)
Goal No. 1 – Prevent an increase in pollutants threatening water quality by sufficiently preserving or managing natural and working lands within the Riparian Areas.				
Priority Areas for Goal No. 1 – All designated uses – Priority Conservation Areas 1-27 and/or Riparian Areas				
Other Indigenous Aquatic Life and Wildlife: Impaired - FTWA is within the contributing watershed to Lake Alllegan, which has been under a TMDL for excess algal growth, phosphorus (total) since 2001; OIALF impairment in downstream Lake Allegan only	6. Habitat fragmentation (S)	Loss of habitat (K)	Filling and draining of wetlands. Development of open space for agriculture and urban development.	Protect all PCAs 1-27 for a phosphorus load prevention of 18,570 lbs/yr [edge-of-field] (Appendix 8).
	3. Unstable flow (K)	Stormwater runoff (P)	Loss of floodplains and wetlands as retention. Discharge from impervious surfaces, storm or tile inputs, and developed areas.	Protect all PCAs 1-27 for a phosphorus load prevention of 18,570 lbs/yr [edge-of-field] (Appendix 8).
Goal No. 2 – Mitigate nonpoint sources of pollution in storm sewered areas and in Riparian Areas, particularly where there is current agriculture or residential/urban development.				
Priority Areas for Goal No. 2 – All designated uses – Riparian Areas and storm-sewered areas				
Other Indigenous Aquatic Life and Wildlife: Impaired - FTWA is within the contributing watershed to Lake Allegan, which has been under a TMDL for excess algal growth, phosphorus (total) since 2001; OIALF impairment in downstream Lake Allegan only	2. Nutrients (K)	Land application of manure (S)	Lack of manure management plans. Manure management plans may not be enforced for small and medium sized animal feeding operations. Improper manure handling and spreading.	Establish filter strips, encourage manure management planning and compliance with the plan on 100% of the approximately 9,000 acres used for manure spreading.
		Stormwater runoff (P)	Discharge from impervious surfaces and developed areas. Ineffective stormwater management.	Encourage infiltration in urban/urbanizing areas, implement watershed focused land-use planning and stormwater management, and correct problematic road-stream crossings to achieve a 100% onsite stormwater use or infiltration.
		Stormwater runoff (P)	Loss of floodplains and wetlands as retention.	Implement BMPs to reduce FTWA urban loading of phosphorus by 2,259 lbs/yr (Appendix 8).
		Septic system failures and illicit connections (S)	Improperly designed, installed, and maintained septic systems. Unknown illicit connections.	Identify and correct 100% of known illicit connection in the FTWA, repair or replace aging septic systems and recommend regular maintenance of systems.
		Streambank/shoreline modification (S)	Lack of riparian vegetation. Inadequate soil erosion and sedimentation control. Flashy flows from changes in land use and lack of stormwater controls.	Stabilize stream flows to moderate hydrology, correct problematic road-stream crossings, reduce suspended solids, and maintain the floodplain.
		Streambank/shoreline modification (S)	Lack of riparian vegetation. Inadequate soil erosion and sedimentation control. Flashy flows from changes in land use and lack of stormwater controls.	Continue Score the Shore and other inventory protocols and implement BMPs to reduce total FTWA urban loading of phosphorus by 2,259 lbs/yr (Appendix 8).
	1. Sediment (K)	Stormwater runoff (P)	Discharge from impervious surfaces and developed areas. Ineffective stormwater management.	Encourage infiltration in urban/urbanizing areas, implement watershed focused land-use planning

Designated Use and Status	Ranked* Pollutants and Impairments to Designated Uses	Sources	Causes	Objectives (based on resource review and loadings)
				and stormwater management to achieve a 100% onsite stormwater use or infiltration.
		Stormwater runoff (P)	Loss of floodplains and wetlands as retention.	Implement BMPs to reduce FTWA urban loading of phosphorus by 2,259 lbs/yr (Appendix 8)
		Cropland erosion (S)	Conventional tillage practices. Plowing adjacent to water bodies.	Encourage filter strips, cover crops, reduced tillage; implement watershed focused land use planning. Reduce total FTWA agricultural phosphorus loading by 2,549 lbs/yr (Appendix 8).
		Road and bridge crossings (S)	Undersized culverts, poorly designed and maintained crossings.	Repair identified problem sites for phosphorus load reduction of 70 lbs/yr and sediment reduction of 60 tons/yr (Appendix 9)
		Streambank/shoreline modification (S)	Lack of riparian vegetation. Inadequate soil erosion and sedimentation control. Flashy flows from change in land use, lack of stormwater cntrls.	Stabilize stream flows to moderate hydrology, reduce suspended solids, and maintain the floodplain.
		Streambank/shoreline modification (S)	Lack of riparian vegetation. Inadequate soil erosion and sedimentation control. Flashy flows from changes in land use and lack of stormwater controls.	Continue Score the Shore and other inventory protocols and implement BMPs to reduce total FTWA urban loading of phosphorus by 2,259 lbs/yr (Appendix 8).
Coldwater Fishery: Threatened	1. Sediment (K)	Stormwater runoff (P)	Discharge from impervious surfaces and developed areas. Ineffective stormwater management.	Encourage infiltration in urban/urbanizing areas, implement watershed focused land-use planning and stormwater management to achieve a 100% onsite stormwater use or infiltration.
		Stormwater runoff (P)	Loss of floodplains and wetlands as retention.	Implement BMPs to reduce total FTWA urban loading of phosphorus by 2,259 lbs/yr (Appendix 8)
		Cropland erosion (S)	Conventional tillage practices. Plowing adjacent to water bodies.	Encourage filter strips, cover crops, reduced tillage; implement watershed focused land use planning. Reduce total FTWA agricultural phosphorus loading by 2,549 lbs/yr (Appendix 8).
		Road and bridge crossings (S)	Undersized culverts, poorly designed and maintained crossings.	Repair identified problem sites for phosphorus load reduction of 70 lbs/yr and sediment reduction of 60 tons/yr (Appendix 9)
	4. Temperature (S)	Lack of riparian habitat or habitat modification	Due to agriculture and urban land use and development	Protect all PCAs 1-27 for a phosphorus load prevention of 18,570 lbs/yr [edge-of-field] (Appendix 8).
	3. Unstable flow (K)	Stormwater runoff (P)	Discharge from impervious surfaces and developed areas. Ineffective stormwater management.	Encourage infiltration in urban/urbanizing areas, implement watershed focused landuse planning and stormwater management to achieve a 100% onsite stormwater use or infiltration.
		Stormwater runoff (P)	Loss of floodplains and wetlands as retention.	Implement BMPs to reduce total FTWA urban loading of phosphorus by 2,259 lbs/yr (Appendix 8)

Designated Use and Status	Ranked* Pollutants and Impairments to Designated Uses	Sources	Causes	Objectives (based on resource review and loadings)
		Streambank/shoreline modification (S)	Lack of riparian vegetation. Inadequate soil erosion and sedimentation control. Flashy flows from changes in land use and lack of stormwater controls.	Stabilize stream flows to moderate hydrology, reduce suspended solids, and maintain the floodplain.
		Streambank/shoreline modification (S)	Lack of riparian vegetation. Inadequate soil erosion and sedimentation control. Flashy flows from changes in land use and lack of stormwater controls.	Continue Score the Shore and other inventory protocols and implement BMPs to reduce total FTWA urban loading of phosphorus by 2,259 lbs/yr (Appendix 8).
Partial Body Contact Recreation: Threatened All FTWA	5. Pathogens/ Bacteria (K)	Land application of manure (S)	Lack of manure management plans. Manure management plans may not be enforced for small and medium sized animal feeding operations. Improper manure handling and spreading.	Establish filter strips, encourage manure management planning and compliance with the plan on 100% of the approximately 9,000 acres used for manure spreading.
		Septic system failures and illicit connections (S)	Improperly designed, installed, and maintained septic systems. Unknown illicit connections.	Identify and correct 100% of known illicit connection in the FTWA, repair or replace aging septic systems and recommend regular maintenance of systems.
Total Body Contact Recreation: Threatened All FTWA	5. Pathogens/ Bacteria (K)	Land application of manure (S)	Lack of manure management plans. Manure management plans may not be enforced for small and medium sized animal feeding operations. Improper manure handling and spreading.	Establish filter strips, encourage manure management planning and compliance with the plan on 100% of the approximately 9,000 acres used for manure spreading.
		Septic system failures and illicit connections (S)	Improperly designed, installed, and maintained septic systems. Unknown illicit connections.	Identify and correct 100% of known illicit connection in the FTWA, repair or replace aging septic systems and recommend regular maintenance of systems.
Goal No. 3 – Restore natural hydrological regimes in streams and natural ecosystems within Riparian Areas where opportunities exist.				
Priority Areas for Goal No. 3 – Priority conservation areas containing fens and coldwater streams/Riparian Areas				
Other Indigenous Aquatic Life and Wildlife: Threatened	6. Habitat fragmentation (S)	Loss of habitat (K)	Filling and draining of wetlands. Development of open space for agriculture and urban development. Fish passage barriers.	Pursue conservation easements in new PCAs outside of original four townships (TP load reduction 3,331 lbs/yr edge-of-field; TSS load reduction 114 tons/yr). Repair identified problem sites for phosphorus load reduction of 70 lbs/yr and sediment reduction of 60 tons/yr (Appendix 9)
Goal No. 4 – Protect habitat and stop spread of invasive species.				
Priority Areas for Goal No. 4 – Inland lakes and conserved lands throughout FTWA				
Other Indigenous Aquatic Life and Wildlife: Threatened	6. Habitat fragmentation (S)	Loss of habitat (K)	Filling and draining of wetlands. Development of open space for agriculture and urban development. Aquatic invasive species and terrestrial invasive species. Fish passage barriers.	Repair identified problem sites for phosphorus load reduction of 70 lbs/yr and sediment reduction of 60 tons/yr (Appendix 9); partner with CISMA and lake associations to stop spread of and treat AIS and terrestrial invasives.

(K) Known (S) Suspected (P) Potential * Qualitative ranking based on importance

9.2 Implementation Strategies

Table 17 is a detailed action plan with structural, vegetative and managerial tasks, which address priority pollutants and their sources. The Action Plan is based on designated use goals and objectives and is divided into priority areas and specific sites. This action plan should serve as a starting point for effective implementation. The items in the action plan should be reviewed periodically and updated as conditions change in the watershed.

Table 17, where applicable, assigns high, medium, and low rankings to individual waterbodies. These rankings can guide the implementation of any action and assist stakeholders in deciding which waterbody or areas to work in first. Most rankings are self-explanatory but the following details clarify a few actions.

- Actions 3-4 – subwatersheds with known water quality impairments rank higher, secondary focus on coldwater streams.
- Action 5 – waterbodies with higher population densities rank higher.
- Action 8 – erosion sites with the higher potential load reductions rank higher or projects where multiple sites can be corrected more efficiently also rank higher.
- Action 12 – subwatersheds with known water quality impairments and where exceedance of water quality standards has been observed.

Assuming resources will not be available to implement all of the tasks at once, Table 17 provides a suggested timeframe for beginning implementation of each task. Prioritizing the tasks will allow resources to be allocated to the tasks that address the most important pollutants and sources first. The timeframe may be changed if resources or opportunities become available for earlier implementation. Table 17 also provides a cost estimate for each task and identifies the potential lead agency or individuals that need to take action. Potential partners, funding sources and programs are listed, which could assist with task implementation. Lastly, milestones and proposed evaluation methods are listed for each task.

Table 17. Four Township Watershed Area Action Plan.

Recommended Prioritized BMPs	Objective and Pollutant	Ranked Critical and Priority Areas/Sites - Locations	Estimated Unit Cost	Water Quality Benefit	Begin	Lead	Funding	Milestones	Evaluation	Loading Quantification
Goal No. 1 – Prevent an increase in pollutants threatening water quality by sufficiently preserving or managing natural and working lands.										
1. Conservation Easements - Protect natural lands in PCAs identified by LCP as high impact on water quality	Protect all PCAs 1-27 for a phosphorus load prevention of 18,570 lbs/yr [edge-of-field] (Appendix 8) (habitat fragmentation, unstable flow, and temperature)	High – Augusta Creek, Spring Brook, Silver Creek (coldwater streams) Augusta PCAs 6-12, 15, 23, 25 Silver Creek PCAs 1, 2, 27 Spring Brook PCAs 20-22	$4,000-$10,000 per acre for purchase;$1,000-$4,000 for conservation easement	High	0-3 years	Private landowners (unnamed); SWMLC, FTWRC	MDEQ 319, other grants; landowner donation	Currently: 2,650 acres conserved (SWMLC); 990 (Ft. Custer); 380 (DNR); 80 (USDA); 2,000 (MSU) By 2022: 300 additional acres of PCA preserved	# Acres protected; Estimate pollutant loading increase prevented	PCA loading Table A8-2
		Medium - Comstock Creek PCAs Low – Prairieville Creek and any other watershed PCAs (low priority due to extensive conservation efforts already accomplished under past grant projects)	$4,000-$10,000 per acre for purchase; $1,000-$4,000 for conservation easement	Medium	3-10 years	Private landowners (unnamed); FTWRC	MDEQ 319, other grants; landowner donation	By 2027: 100 additional acres	# Acres protected; Estimate pollutant loading increase prevented	PCA loading Table A8-2

2. Enact ordinances and demonstration projects protecting riparian buffers and/or promoting use of green infrastructure	(1) Encourage infiltration in urban/urbanizing areas by educating municipalities about green infrastructure and stormwater ordinances to achieve a 100% onsite stormwater re-use or infiltration (sediment, nutrients) – e.g., encourage adoption of county drain office stormwater standards at township level; (2) Implement riparian buffers/BMPs/green infrastructure demonstration projects; (3) Host public education meetings, demonstrations, and other informational programs to encourage private land owners/businesses to plant native riparian buffers, rain gardens, and/or other green infrastructure	(1) Priority municipal units – Ross, Barry, Prairieville, Gun Plain Townships (riparian lake/stream and ordinances) and Richland Township secondary (2) Priority municipal units – Barry, Ross, Cooper, Comstock Townships (riparian/wetlands) (3) Priority riparian urban areas – Lower Spring Brook, Lower Prairieville Creek, Lower Augusta Creek	$10,000 per ordinance $7,500 for I&E/priority area $6,000 - $40,000 per demonstration site	High	in progress	Municipalities	Municipalities, MDEQ	Currently: Ross Township working on riparian overlay By 2022: 4 ordinances/ projects By 2027: 8 ordinances/ projects	Number of new ordinances and green infrastructure and stormwater BMPs	BMP loading Table A3-1
Goal No. 2 – Mitigate nonpoint sources of pollution in storm-sewered areas and in Riparian Areas, particularly where there is current agriculture or residential/urban development.										
3. Install agricultural BMPs BMP type: *-crop management (e.g., filter strips, no/low till, and cover crops)*	Establish filter strips, encourage manure management planning and compliance with the plan on 100% of the approximately 9,000 acres used for manure spreading (nutrients, pathogens/bacteria); Stabilize stream flows to moderate hydrology, reduce suspended solids, and maintain the floodplain (nutrients, sediment) for a total modeled estimated load reduction of 2,549 lbs/yr total phosphorus	High – Gull and Prairieville Creeks, Augusta Creek Medium – Spring Brook; Silver Creek Low – All other areas	Depends on practice	High	0-3 years	Landowners (NRCS, Conservation Districts)	Farm Bill	By 2022: 5 landowners By 2027: 10 landowners	Number of acres; estimate load reduction; number of landowners; before and after photos	BMP loading Table A3-1
4. Develop and implement comprehensive nutrient management plans; MAEAP verification	Encourage comprehensive nutrient management planning and manure handling; compliance with these plans on 100% of the approximately 9,000 acres used for manure spreading (nutrients, pathogens/bacteria). Encourage MAEAP verification and supporting BMPs	High – Gull and Prairieville Creeks, Augusta Creek Medium – Spring Brook, Silver Creek Low – All other areas	$4,000 - $10,000/plan (depends on the number of animal units)	High	in progress	Landowners (NRCS, Conservation Districts)	Farm Bill Programs, Michigan Agriculture Environmental Assurance Program (technical assistance)	By 2022: 5 new plans By 2027: 10 new plans	Number of plans developed	BMP loading Table A3-1
5a. Assess stormwater management needs at built-out lakes 5b. Promote natural shorelines and other BMPs to protect water quality	(1) Inventory shoreline sites through citizen surveys (e.g., Score-the-Shore) and professional surveys/GIS (e.g., university students/staff or engineering firm); (2) Host informational meetings and training program for natural shorelines and stormwater BMPs (e.g., master rain gardeners, shoreland stewards, natural shoreline partnership program(s)) (3) Implement BMPs to reduce total FTWA urban loading of phosphorus by 2,259 lbs/yr (Appendix 8 sites) (nutrients, sediment, unstable flow) and other	High – Gull and Little Long Lakes, adjoining waterbodies Medium – Pine Lake, Upper Crooked Lake, Sherman Lake, Lake Doster, Shelp Lake Low – Other developed/developing lakes, streams/impoundments	Inventory shoreline sites/SW contributions (volunteers or $30,000 per lake prof); $1,500/meeting; $2,500/I&E program; $2,000/buffer site; $5,000-$25,000 per	High	3-6 years	FTWRC/GLQO /KRWC/MSUE	Lake assessments, in-kind volunteers, habitat grants, MDEQ 319	By 2022: 25 shoreland stewards/equivalent, 2 new BMP sites, 2 programs implemented By 2027: 125 shoreland stewards/equivalent, 6	Surveys of local community satisfaction, number of sites improved	Depends on BMPs implemented following inventory; Table A3-1

	shoreline sites where surveys indicate deficiencies in natural vegetation/buffers/or necessary BMPs	along Comstock Creek and urbanized area of Augusta Village	App. 8 site implementation					new BMP sites, 10 programs implemented		
6. Utilize stormwater BMPs BMP type: -*Detention* *-Infiltration* *-Bioswale* *- Rain garden* *-Constructed wetlands*	Implement BMPs to reduce total FTWA urban loading of phosphorus by 2,259 lbs/yr (Appendix 8 sites; other sites in storm-sewered areas) (Appendix 8) (nutrients, sediment, unstable flow); Stabilize stream flows to moderate hydrology, reduce suspended solids, and maintain the floodplain (nutrients, sediment, unstable flow)	High – Riparian areas, especially with high residential use, and storm-sewered areas Medium – Watersheds with coldwater streams Low – Other watersheds	Depends on practice	High	in progress	Municipalities, Drain and Road Commission	Municipalities, MDEQ 319	Ongoing	Number of municipalities using practices; Estimate of pollutant loading reduction; before and after photos	BMP loading Table A3-1
7. Identify and correct illicit discharges to surface waters	Design and implement an in-depth *E. coli* investigation study on a smaller sub-watershed level and parcel-by-parcel surveying; identify and correct 100% of illicit connection in the FTWA, repair or replace aging septic systems, and recommend regular maintenance of systems (nutrients, pathogens/bacteria)	Throughout FTWA, with focus on Augusta Creek for *E. coli* investigation study	$500-$6,000 per site for septic repair/replacement; $15,000 for subshed delineation and investigation	High	1-3 years	County road and drain commissions per IDEP; Co Health Dept; FTWRC; conservation districts	Drain Commission, Municipalities, Road Commission; MDEQ 319	100% of known illicit connections fixed by 2027	Number of connections or discharges identified and corrected	NA
8. Identify and correct problem road/stream crossings	Repair identified problem sites for phosphorus load reduction of 70 lbs/yr and sediment reduction of 60 tons/yr (Appendix 9) (nutrients, sediment) Bank and road shoulder stabilization practices, culvert replacements, green infrastructure projects, and other best management practices	High – 21 actively eroding or NPS contributing sites (App. 9, Tables 2-6) Medium – sites in App. 9, Tables 2-6 denoted as “continue to monitor” Low – other sites described in App. 9 or additional sites with relatively high loading	>$15,000 per site	Medium	6-9 years	County road commissions, county drain commissioners municipalities, FTWRC, KVCTU, citizen referrals	Road Commission, drain commissioner municipalities, MDEQ 319, fisheries grants	3 sites by 2022, 4 additional sites by 2027	Number corrected; estimated load reduction; before and after photos	Loading Tables 2-6 in Appendix 9
9. Promote identification and correction of failing septic systems	Identify and correct 100% of illicit connections identified in the FTWA, repair or replace aging septic systems and recommend regular maintenance of systems (nutrients, pathogens/bacteria)	Throughout FTWA	$200-$6,000/system	Medium	in progress	County Health Department, citizen referrals	USDA Rural Development	By 2027: 100% of known problems	Number of systems; estimate load reduction	NA

10. Conduct additional pathogen source tracking studies	As new technology becomes available, continue testing for other source types of pathogens including non-bovine livestock especially equine and wildlife sources; establish filter strips, encourage comprehensive nutrient management planning and compliance on 100% of the approximately 9,000 acres used for manure spreading (nutrients, pathogens/bacteria)	High –Augusta Creek Medium – Prairieville Creek Low – all other creeks	$100 per sample	Low	6-9 years	FTWRC, GLQO, Kalamazoo County, Universities	Grants	Currently: baseline established By 2027: additional source types tested in Augusta Creek	TMDL implementation plan developed by 2027	*E. coli* colonies/counts within water quality standards
Goal No. 3 – Restore natural hydrological regimes in streams and natural ecosystems within Riparian Areas where opportunities exist.										
11. Wetlands and prairie fen restoration/ protection	Build partnerships with landowners for potential restoration/protection sites including additional PCAs in creeks outside of original four townships (habitat fragmentation)	PCAs containing wetlands and/or fens; wetlands with high water quality functionality from LLWFA	$2,000-$8,000 per acre for purchase; $1,000-$6,000 for conservation easement	Medium	0-3 years	FTWRC	Grants; landowner match	By 2022: host 2 landowner meetings By 2027: Host 4 meetings, 1 new project	Acres of wetlands/ functional units restored, protected	NA
12. Remove fish passage barriers	Identify dam owners and other partners interested in stream restoration, connectivity, and dam removal projects; repair road-stream crossings where barriers exist (habitat fragmentation)	High – Barriers along all coldwater streams (e.g., Augusta Creek, Spring Brook, Silver Creek, and Travis Drain) Medium – All other streams	$25,000 – $250,000 per dam; less for culvert replacements	Low	3-6 years	FTWRC	Grants; landowner match	2 barriers by 2022 4 barriers by 2027	Barrier removed; before and after photos	Miles of re-connected stream habitat
Goal No. 4 – Habitat protection; stop spread of invasive species, and treatment of invasives (especially aquatic invasive species) at inland lakes and lands with conservation easements, other protected lands.										
13. Invasive species	Identify and treat invasive species; stop the transmission of AIS to area lakes (habitat fragmentation)	High – targeted species, controllable infestations Medium – all other aquatic invasive species Low – terrestrial, other invasive species	$1,000 - $26,000/acre AIS treatment[1]	Low	0-3 years	Lake associations, BKC CISMA, FTWRC, municipalities	Grants, lake association fees, lake board assessments	Target spp. identified, 2 controlled by 2022 Emerge spp. identified, 6 controlled by 2027	Number of species controlled, number of acres treated	NA
14. Install boat wash stations	Install and train public on use of boat washing stations at public access points for inland lakes (habitat fragmentation)	High – lake with public access, high user rates Medium – lakes with public access, mod user rates and close proximity to other inland lakes Low – all others	$20,000 per boat wash station	Low	In progress	Lake associations, municipalities	Grants, lake association fees, lake board assessments	2 stations by 2022 4 stations by 2027	Number of boats washed/year; number of public access sites covered	NA

BMP Best Management Practice, PCA Priority Conservation Area, SWMLC Southwest Michigan Land Conservancy, FTRWC Four Township Water Resources Council, MDNR Michigan Department of Natural Resources, MDEQ Michigan Department of Environmental Quality, LCP Land Conservation Plan for Kalamazoo River Watershed
FTWA Four Township Watershed Area, NRCS Natural Resource Conservation Service, GLQO Gull Lake Quality Organization, NA – not applicable/available
[1] Anderson Economic Group, white paper 2012 (https://www.nature.org/ourinitiatives/regions/northamerica/areas/greatlakes/ais-economic-report.pdf)

Goals for Desired Uses

In addition to the Designated Uses established by state and federal water quality programs, stakeholders identified several Desired Uses for the FTWA. Desired uses are based on factors important to the watershed community. Desired uses may or may not have a direct impact on water quality. Table 18 lists the Desired Uses identified through stakeholder input, current initiatives, and other research.

Table 18. Four Township Watershed Area Desired Uses

FTWA Desired Use	**General Definition**
Coordinated development	Promote and achieve the environmental and economic benefits of planned communities through coordinated land use planning and low impact development/green infrastructure
Intact habitat for native aquatic and terrestrial wildlife	Protect and enhance the habitats on which indigenous, threatened, and endangered species depend
Open space and agricultural land	Develop a green infrastructure network consisting of natural, open and working lands to maintain a viable farming economy, maintain the rural character of communities, and maintain the natural ecosystem functions provided by woodlands, wetlands, and other natural areas
Groundwater resources protection	Protect groundwater recharge and wellhead areas from contamination and overdrafting
Appropriate recreational use and infrastructure	Ensure that recreational activities are protective of natural features and enhance pollution prevention
Watershed monitoring efforts	Continue and increase monitoring efforts to better understand issues in the FTWA and to create baselines for future reference
Watershed organization	Maintain and refine an organization to coordinate implementation of the watershed management plan especially educational tasks (Appendix 10)

The following objectives were developed to address the desired uses identified by stakeholders. Though the remainder of the watershed plan focuses on designated uses and objectives for their maintenance and restoration, the following desired use objectives are also highly related to ensuring a healthy watershed. Many of these objectives relate to education and outreach needs detailed later in this plan.

Coordinated land use planning in the FTWA.

1. Periodically review local plans, ordinances and regulations addressing stormwater management, non-point source pollution and related water quality and natural resource issues

2. Promote uniform set back requirements along lakes, streams, rivers and wetlands (Ross Township considering riparian buffer ordinance in 2017)
3. Apply model language for development standards and ordinances
4. Maintain resource maps for planning officials
5. Gain local commitments to consider the watershed context in planning efforts and to recognize stormwater planning early in site planning and evaluation
6. Conduct technical workshops and provide technical assistance throughout the watershed regarding the importance of coordinated watershed and land use planning

Protected habitat for native aquatic and terrestrial wildlife

1. Continue to implement PCA protection where landowner interest aligns
2. Minimize modification of sensitive habitat areas such as stream corridors
3. Coordinate with local CISMA to control the spread of invasive species, in particular aquatic invasive species
4. Collaboration of lake associations and other technical resources to better understand, identify, track, and treat aquatic invasive species; encourage information sharing between lake associations
5. Promote the use of natural shoreline practices and native vegetative buffers along lakeshores and riparian area
6. Work with local partners to remove fish passage barriers, reconnecting stream habitat for fish and other aquatic wildlife

Protected groundwater resources

1. Support community well head protection programs
2. Review water withdrawal applications using the Michigan Groundwater Withdrawal process
3. Develop strategies to prevent increased impervious surfaces in high recharge areas and to restore areas with high recharge potential, as appropriate

Improved recreation infrastructure along waterways while respecting natural features

1. Encourage coordinated recreation planning that promotes sustainable uses of natural resources and protects the unique natural features of FTWA communities
2. Educate boaters about limiting the movement of invasive species
3. Work to install boat wash stations at public access points

Continued/increased watershed monitoring efforts

1. Continue partnerships with agencies to refine and implement a monitoring strategy to examine the current quality of the river as well as to monitor changes over time
2. Continue monitoring of water quality impairments as technology and indicators advance to further understanding of pollutant sources
3. Encourage programs for testing of private drinking water wells

A sustainable organization to coordinate and implement the watershed management plan and to instill a sense of stewardship by carrying out actions in the FTWA education plan (Appendix 9).

1. Partner with other organizations to coordinate and implement watershed efforts
2. Maintain existing partnerships radiating from the FTWRC

9.3 Information and Education

The structural, vegetative and managerial tasks listed in the action plan are voluntary. Therefore, individuals, before they are motivated to action, will need to understand the watershed concerns and how their actions can play a role in protecting water quality. An Information and Education (I&E) plan was developed to offer a strategy for informing and motivating responsible parties to implement the tasks listed in Table 17. The I&E plan provides goals and outlines the relationship between target audiences, watershed issues and outreach activities (Appendix 10, Table A10-2).

9.4 Planning and Studies

In some areas, further study and investigation, as well as subwatershed planning may be needed before more specific recommendations can be made.

10 Evaluation

An evaluation process will determine if the plan implementation is effective and if improvements in water quality are being achieved. Measuring improvements and sharing results will increase community support for plan implementation. The level of evaluation and the methods utilized will largely be dependent on the existence of a sustainable watershed organization being able to carry out the proposed evaluation methods and on the amount of resources and funding available. Lastly, this Watershed Management Plan should be reviewed and updated periodically.

10.1 Knowledge and Awareness

The first level of evaluation is documenting a change in knowledge or increase in awareness. Measures and data collection for this level can take place in three specific ways:

1. A pre- and post-test of individuals at workshops focused on specific water quality issues in the FTWA. This should be an on-going activity.
2. The tracking of involvement in a local watershed group or increases in attendance at water quality workshops or other events. This should be an on-going activity.
3. A large-scale social survey effort of the FTWA population to understand individual watershed awareness and behaviors impacting water quality. Surveys are expensive, so this level of evaluation will not be able to happen until funding is secured. This type of action is often conducted by universities with this expertise (e.g., graduate program level or above).

Additional evaluation methods for measuring and tracking knowledge and awareness can be found in the Information and Education Plan in Appendix 10, Table A10-2.

10.2 Documenting Implementation

The second level of evaluation is BMP adoption or implementation. The measurement is mostly a documentation of successful implementation. The evaluation will involve identifying and tracking individuals, organizations and governmental units involved in implementing and adopting BMPs whether they be structural, vegetative or managerial. Data about the BMP implementation can be gathered simply through tracking the number of BMPs installed or adopted. This evaluation should be done annually.

Table 17 has milestones and specific evaluation methods proposed for measuring the progress of BMP implementation and improvements to water quality for each task in the FTWA action plan. The action plan should be reviewed at least annually to ensure progress is being made to meet the milestones. During the annual review, the action plan should be updated as tasks are completed and as new tasks are identified.

10.3 Monitoring Water Quality

Another level of evaluation is documenting changes in water quality through monitoring. The monitoring of water quality is a very complex task, which involves gathering data

from a number of sources. Periodic assessments of the water quality in the FTWA are conducted as part of the State of Michigan 5-year basin monitoring rotation conducted by the MDEQ Surface Water Assessment Section. The last basin rotation occurred during the 2014 field season and the report was released in 2016. Local efforts to monitor water quality include those of lake associations, drain commissioners, the Kalamazoo County Health Department, and the FTWRC. Combining data gathered under these programs, with other periodic water quality assessments will provide a picture of water quality in the watershed. Table 19 details monitoring components for prioritized pollutants and suggests evaluation criteria in light of current conditions. Table 20 catalogs current monitoring programs in the FTWA.

A targeted study of loading sources at built out lakes is of interest to several partners in the FTWA. Action item number 5, Table 17, captures this interest. Several partners have suggested the following model targeted for the highest priority lake, Gull Lake. A successful future study could serve as a model for similar targeted investigations of other built out priority lakes.

The team would like to: 1) conduct a detailed field inventory of stormwater conveyances into Gull Lake; 2) estimate specific and individual drainage stormwater footprint loads; 3) strategically sample the most potentially significant discharges to establish current loading conditions and pre-BMP installation loads (for later comparison to post-BMP loads); 4) prioritize installation needs and prepare BMP designs for priority sites for future installation when funding is available. Sampling sites (up to 8 total) are based on ongoing monitoring efforts of the Gull Lake Quality Organization and include:

- Bay area including Marina
- Gull Lake Country Club
- Gull Lake Ministries
- Prairieville Twp. Boat Launch
- Gull Island Parking Area

Table 19. Monitoring Components and Evaluation Criteria for Four Township Watershed Area.

Prioritized Impairment, Source, or Cause	Monitoring Components	Potential Parties to Implement Monitoring	Schedule for Implementation	Units of Measurement	Current Conditions	Evaluation Criteria
1. Sediment	Substrate embedded-ness	MDEQ, FTWRC, GLQO, MSU	Long term (Assessed in 2014 and every 5 years after)	Degree of embeddedness	Not known, baseline needed	Maintain or reduce embeddedness
	Macro-invertebrate sampling	MDEQ, FTWRC, MSU	Long term (Assessed in 2014 and every 5 years after)	Numerical score based on quantity and diversity	Excellent (Gull) and Acceptable (Spring Brook) – (MDEQ 2014); Excellent (Gull, Augusta Creeks), Acceptable (Springbrook, Comstock Creeks) – (MDEQ 2005); Acceptable (Silver Cr.) (2000)	Maintain "excellent" scores, increase scores for "acceptable" stream stretches
2. Nutrients	Water quality	MDEQ, FTWRC, GLQO, MSU	Long term (Assess in 2014 and every 5 years after)	Water quality rating	Local excess phosphorus not evident however the area is part of a phosphorus TMDL, requiring reductions	Monitor and track aquatic plant growth; monitor and track phosphorus levels in FTWA lakes; monitor and track conditions in Lake Allegan
3. Unstable Flow	USGS flow gauge data	USGS, MDEQ, MSU	Short term (2017) and annually thereafter	Cubic feet per second	Flow gauges record hydrographs during storm events, with peak flows and durations	Document reduction of peak flows and duration; track flashiness
4. Temperature	Water temperature	MDNR, County Health Department, FTWRC, GLQO, MSU	Short term (2017) and annually thereafter	Degrees	Coldwater designated streams present	Maintain average temperatures cold enough to support trout populations on 100% of designated coldwater streams
5. Pathogens, Bacteria	Water quality	County Health Department, FTWRC, GLQO, MSU	Ongoing	Bacteria counts per 100ml water	Exceedances were measured as recently as 2011, and occurred in surface water samples of Augusta and Prairieville Creeks.	Meet WQS for full and partial body contact 100% of the time
	Water quality	FTWRC, GLQO, MSU	Ongoing	Genetic Source Tracking	No current indication of human or bovine sources at tested sites	Meet WQS for full and partial body contact

						100% of the time
6. Habitat Fragment-ation	Wetland inventory and assessment and conservation easements	MDEQ, SWMLC, FTWRC	Long-term (2015)	Acres of and photos of wetlands protected; records of conservation easements	Wetland loss evident due to agricultural and urban development; LLWFA shows lower percentage of wetland loss in FTWA when compared to overall Kalamazoo River wetland loss	Increase permanently protected lands
	MDEQ habitat survey	MDEQ	Long term (Assessed in 2014 and every 5 years after)	Habitat evaluation score	Excellent (Gull), Marginal (Spring Brook) – (MDEQ 2014); Non-impaired (Gull, Augusta Creeks), Good – Slightly impaired (Augusta, Comstock Creeks) – (MDEQ 2005); Good – Slightly impaired (Silver Cr.) – MDEQ (2000)	Maintain or increase scores until 100% of locations score "excellent" or "good"

SWMLC Southwest Michigan Land Conservancy
FTRWC Four Township Water Resources Council
MDEQ Michigan Department of Environmental Quality
FTWA Four Township Watershed Area
GLQO Gull Lake Quality Organization
MSU Michigan State University

Table 20. Environmental Monitoring Summary.

Organization	Monitoring Site	Type of Analysis	Protocol	Current Monitoring	Recommended Future Monitoring	Test Agent
MDEQ	Basin rotation stream sites change from year to year	Macroinvertebrate survey	MDEQ Protocol Procedure 51	Conducted in 2014	Once every 5 years	MDEQ
		Habitat survey	USEPA Rapid Bioassess-ment	Conducted in 2014	Once every 5 years	MDEQ
		Water Chemistry TP, TN, DO, Metals	MDEQ	No current routine monitoring in FTWA	As needed based on identified concerns	MDEQ
		E. coli	*E. coli* MPN/100ml	No current routine monitoring in FTWA	As needed based on identified concerns	MDEQ
MDEQ and TMDLIC	Kalamazoo River mainstem sampling points between Galesburg and Lake Allegan (inflows and outflows of reservoirs and road crossings); also in reservoir sampling	TP	MDEQ	Twice monthly grabs in river and monthly grab samples from 5 sites in Lake Allegan during growing season since 2001	Monthly	MDEQ and Wastewater Treatment Facility Labs
MDEQ Fisheries	Augusta Creek and Gull Lake Outlet (2001), Silver Creek and Spring Brook (2000) per Wesley (2005)	Temperature	Handheld temperature probe	Last monitored 2000	Per MDEQ assessment schedule	MDEQ
	Augusta Ck. (Wesley, 2005), Gull Lake (Dexter, 1991), Spring Brook (Dexter, 1992), Silver Creek (Dexter 1993)	Fishery survey	MDEQ	Last monitored early 1990's	Per MDEQ assessment schedule	MDEQ
County Health Department	Public beach – Ross Township Park, Robert Morris Park	*E. coli*	*E. coli* MPN/100ml	Weekly during annual use season since 2001	Regular *E. coli* monitoring of est. sites in Augusta Creek and other creeks with suspected impairment	Kalamazoo County Health Department

Organization	Monitoring Site	Type of Analysis	Protocol	Current Monitoring	Recommended Future Monitoring	Test Agent
FTWRC and GLQO	Streams – Prairieville Creek (2 sites), Augusta Creek (4 sites in Barry Co.) Lake – Little Long	*E. coli*	*E. coli* MPN/100ml	Past monitoring; no new monitoring since 2011	Monthly sampling during use season	Kalamazoo County Health Department
	Augusta and Prairieville Creeks	Genetic source tracking of *E. coli*, Enterococci, *Clostridium perfringens* (bacteria) and Coliphage (a virus that grows on *E. coli*.	MSU Water Quality, Environmental and Molecular Microbiology Lab, Kalamazoo County Health Department	Past monitoring Health Department in 2010-2011; no new monitoring scheduled	Additional source tracking/new technologies needed to confirm sources (2009 source tracking found no human or bovine sources at limited sites)	FTWRC and GLQO
	None at this time	Low flow conditions	Flow meter, USGS protocol	Not monitored	Annual during historic low flow months in coldwater streams Prairieville Creek, Augusta Creek, Spring Brook, Silver Creek	FTWRC, volunteers
GLQO and MSU	Several inflows to Gull Lake: Gull Lake, Miller Lake outflow, Little Long Lake outflow, Prairieville Ck. at M-43, Wintergreen Lake outflow, Whites Lake north end, Country Club ditch	SRP, TP, TDP, Ammonia, Chloride, Nitrate, Sulfate, temperature, pH, DO, conductance	MSU	Growing season about every 2 months between 2005-2009	Continue same frequency	GLQO
MSU Litchman laboratory	Gull Lake, Wintergreen Lake	Light, temperature, DO, conductivity, pH, chlorophyll, blue green algae concentration, P, TN, *Microcystis*, zooplankton; secchi	MSU; CLMP	Since 2005 sampled weekly from ice out until November; Wintergreen Lake sampled every two weeks	Continue same frequency	MSU

Organization	Monitoring Site	Type of Analysis	Protocol	Current Monitoring	Recommended Future Monitoring	Test Agent
MSU Hamilton laboratory	Gull Lake inflow and outflow	Nutrients, dissolved ions, discharge, temperature	MSU	Sampled 4-5 times during summer since 2005	Continue same frequency	MSU
	Gull Lake	Zebra mussels and chlorophyll, P, N, *Microcystis*	MSU	Periodic sampling	Continue same frequency	MSU
MSU LTER	Prairieville Creek, Gull Creek at M-96, Spring Brook at DE Ave., Augusta Creek at Mann Rd., and groundwater at the Kellogg Bio Station	Nutrients and dissolved ions	MSU LTER	Periodic sampling since 1999	Continue same frequency	MSU
USGS	Augusta Creek	Discharge	USGS	Ongoing daily	Continue same frequency	USGS
All	Built out lakes	Stormwater pollutant loading	Modeling; runoff loading estimates using MDEQ Pollutants Controlled; targeted monitoring	NA	Targeted study over 1-2 seasons at high priority sites	All
	To be established	Groundwater and instream monitoring	TBD	NA	Low flow monitoring for new water withdrawal permits	All

TP – Total phosphorus, TN – Total nitrogen, DO – Dissolved oxygen, SRP – Soluble reactive phosphorus, TDP – Total dissolved phosphorus
FTRWC Four Township Water Resources Council
FTWA Four Township Watershed Area
MSU Michigan State University – researchers
CLMP – Cooperative Lakes Monitoring Program
MDEQ Michigan Department of Environmental Quality
GLQO Gull Lake Quality Organization
USEPA United Stated Environmental Protection Agency
LTER – Long Term Ecological Research
Data sources online: MDEQ surface water data: http://www.michigan.gov/deq/0,1607,7-135-3313_3686_3728---,00.html, Kalamazoo County data http://www.kalcounty.com/eh/lake-stream-monitoring.php, USGS data: http://waterwatch.usgs.gov/

10.4 Estimating Pollutant Load Reductions

The last level of evaluation is to estimate a reduction in pollutant loadings. A pollutant loading is a quantifiable amount of pollution that is being delivered to a water body. Pollutant load reductions can be calculated based on the ability of an installed BMP to reduce the targeted pollutant. Pollutant loading calculations are best used at specific sites where structural BMPs are installed and detailed data about the reduction of pollutants can be gathered. Specific pollutant load reduction calculations should be completed for structural BMPs when they are proposed and installed (Appendix 8).

In Table 17, under the last column (proposed evaluation methods), pollutant loading reduction calculations are suggested for evaluating several tasks in the action plan. These tasks typically include: protecting and restoring wetlands and sensitive lands, correcting failing septic systems, installing agricultural BMPs, utilizing urban stormwater BMPs, correcting livestock problem sites and correcting road/stream crossing problem sites. The other items in the action plan (Table 17) either deal with hydrological modifications or they are proactive and preventative measures (planning and rules). Estimating pollutant loads and load reductions for these types of practices often is not feasible. Appendix 8 includes estimates of pollutant loads prevented by preserving and protecting natural lands. Appendix 9 includes estimates of pollutant loads coming from road-stream crossing sites.

10.5 Evaluating the Watershed Management Plan

The watershed management plan should be reviewed and updated as needed. The FTWRC should take the lead in the management and action plan review process. As general guidance, the review should at a minimum include the following updates:

- Land Cover – at a minimum every 10 years
- Demographics – with every new US Census
- Future Growth and Development – every 5-10 years
- Local Water Quality Protection Policies – every 3 years
- Water Quality Summary – every two years with the release of MDEQ Integrated Reports
- Scheduled TMDLs – every two years with the release of MDEQ Integrated Reports or when a TMDL is completed
- Prioritization of areas, pollutants and sources – every 5-10 years
- Goals and Objectives – every 5-10 years
- Implementation (Action) Strategy – review annually and update as needed

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