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

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Table of Contents

List of Figures

List of Tables

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Conservancy for the Prairieville Creek – Gull Lake Conservation Project. The contents of the document do not necessarily reflect the views and policies of the EPA, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

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.

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 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 present challenges for the protection of these water resources. 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 Watershed Management Plan, the Four Township Water Resources Council hopes to contribute to the goals of protection of water resources throughout the watershed and improvement of water quality in key water bodies.

Natural features and open space are our shared resources. The natural areas in the Four Townships support diverse plant and animal life. A recent inventory of natural features in the Four Townships found that some of the landscape is still dominated by native vegetation essentially similar to the vegetation that existed in the Four Townships a century ago. As we look to the future, our biggest challenge is how to accommodate development and land use changes while protecting our shared natural heritage.

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 FTWA Management Plan 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 Four Township Water Resources Council (FTWRC) has been researching, documenting, and promoting approaches to help address these issues locally, from a long range planning perspective. In large part, the natural resources of the Four Townships will be protected based on collective decisions made at the local level over the long term. 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 government 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 Four Township Water Resources Council was established in 1994 with the mission of retaining the rural character and natural features that make the Four Townships special. The Four Township Water Resources Council 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.

1.2 Purpose of Watershed Plan

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

1. Prioritize future land use improvement and resource protection 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 management plan was 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 Natural Resources and Environment (MDNRE), Nonpoint Source Program. The Southwest Michigan Land Conservancy (SWMLC) in collaboration with the Kalamazoo River Watershed Council was awarded the grant in 2008. Development of the FTWA Management Plan relied on stakeholder input, agency support, and existing planning information generated by the Four Townships Water Resources Council since 1994. 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 recent 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 Four Township Water Resources Council (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).

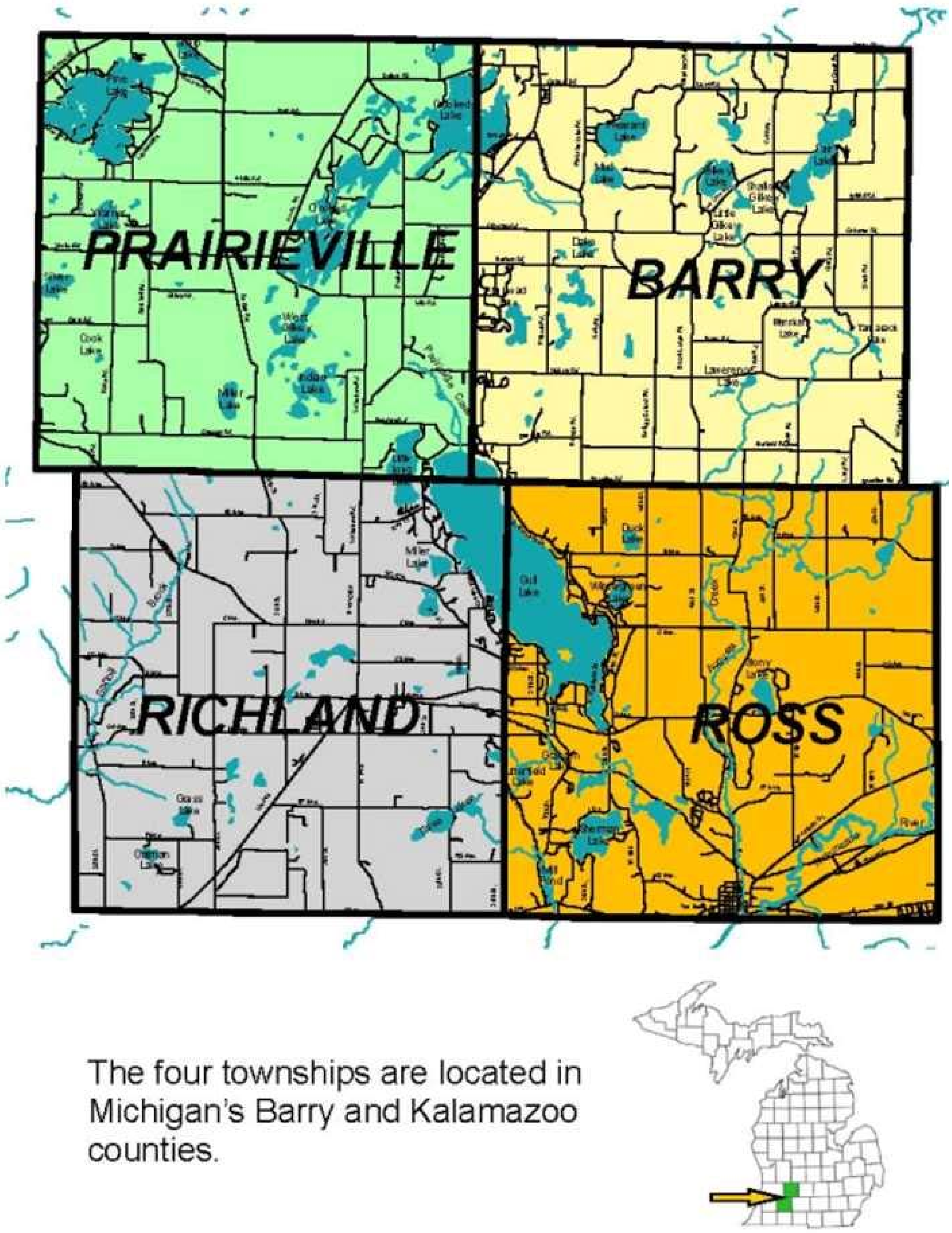

Figure 1. Original Four Township Area

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

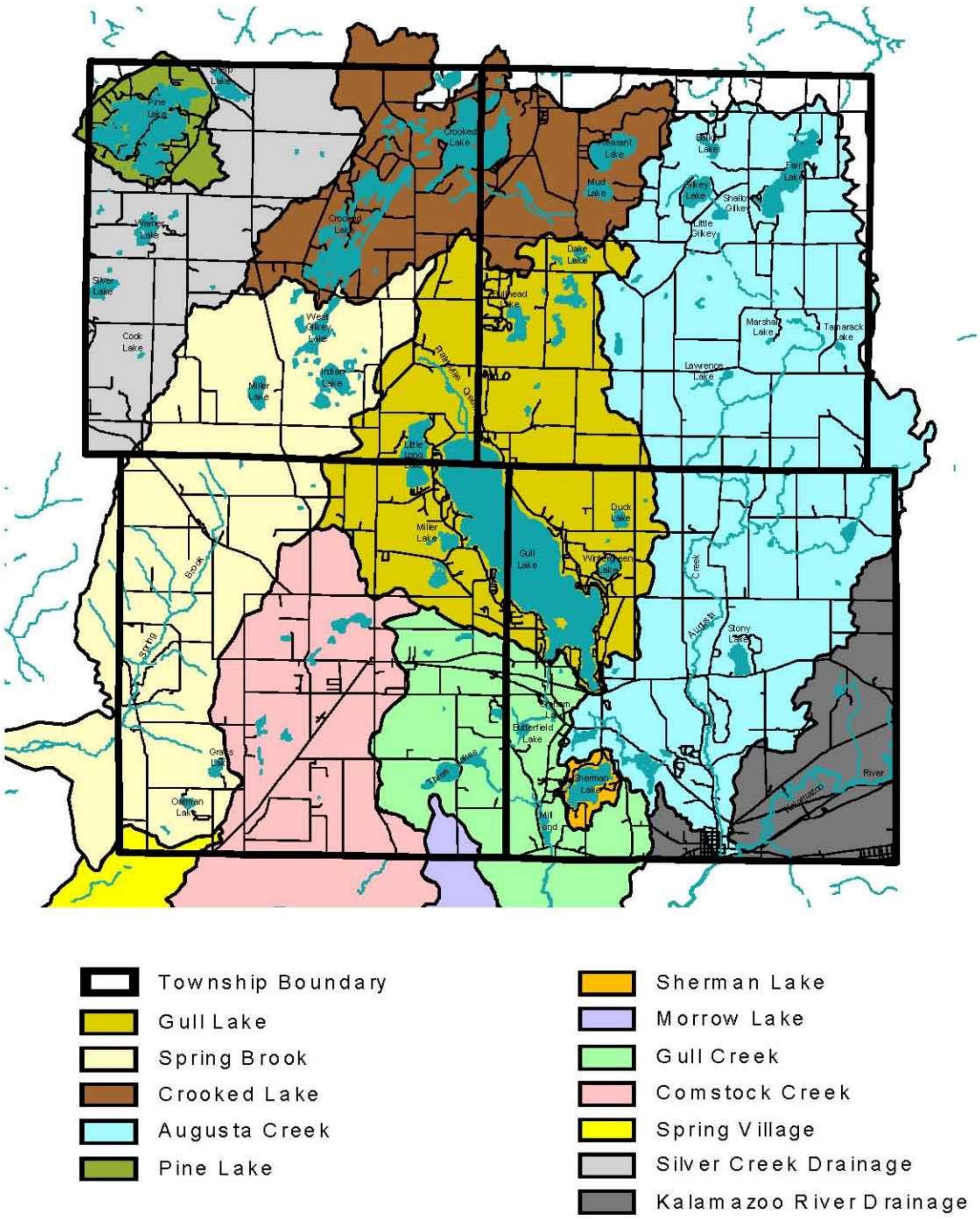

Figure 2. Subwatersheds of the Original Four Township Area

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).

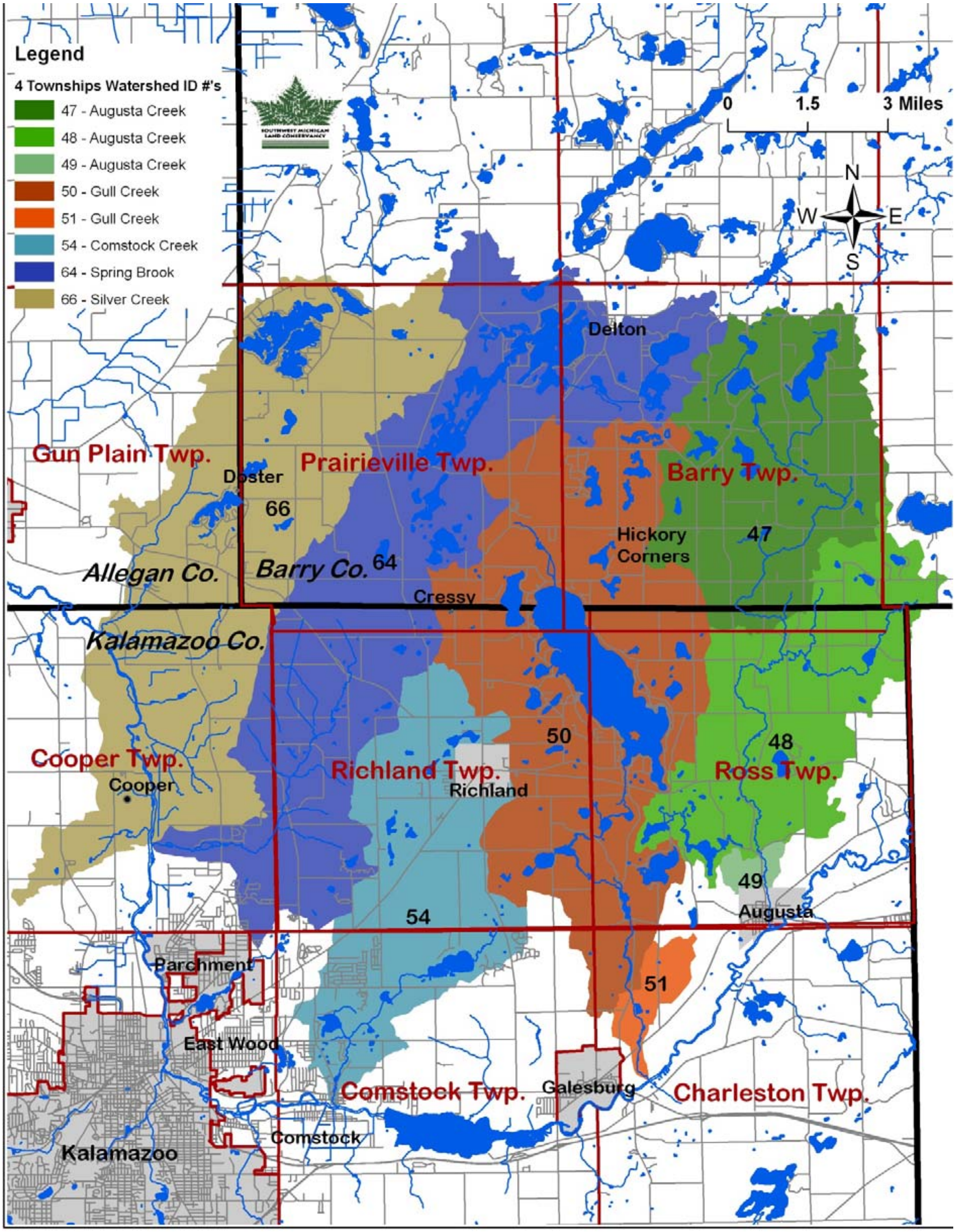

Figure 3. Watersheds included within the Four Township Watershed Area (FTWA) and the original four township boundaries. Major governmental jurisdictions are labeled. Subwatershed delineations are labeled as 47-51, 54, 64, and 66 per the Michigan Department of Natural Resources and Environment.

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).

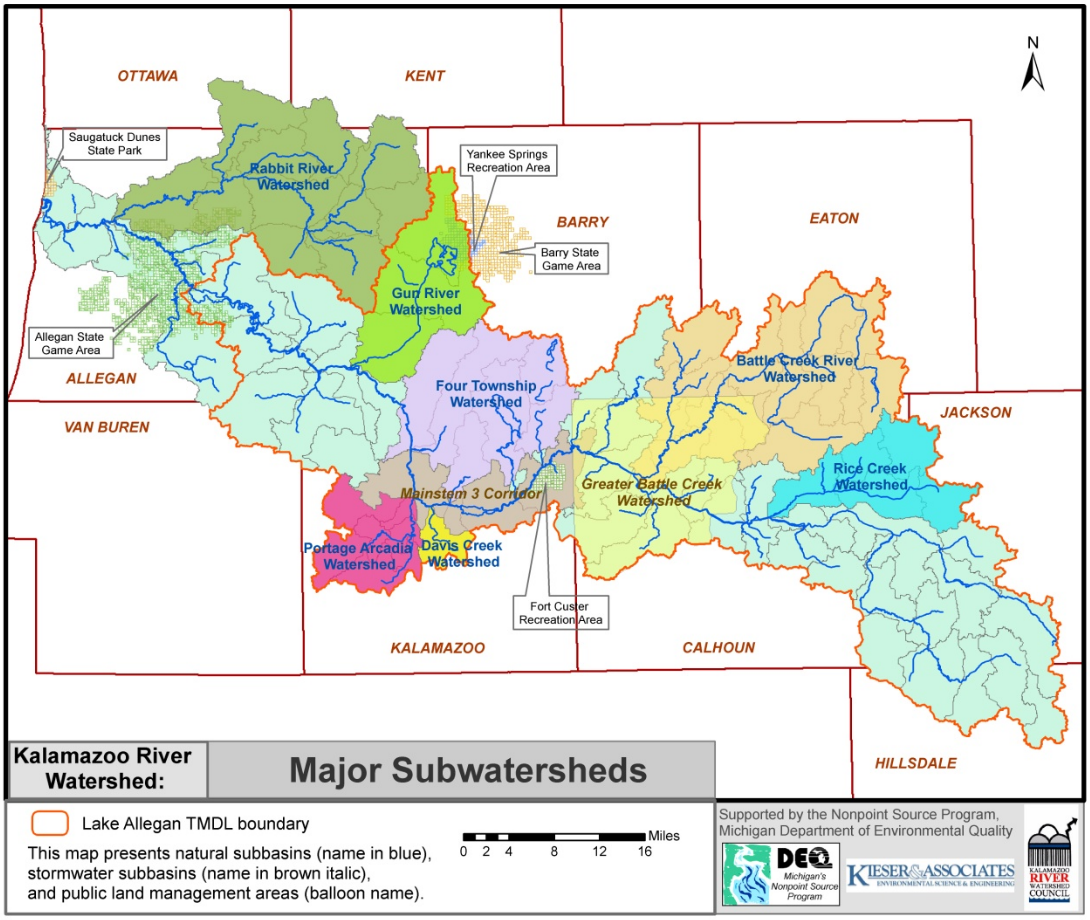

Figure 4. Kalamazoo River Watershed major subwatershed management units, programs, and features.

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 Michigan Department of Natural Resources and Environment (MDNRE). HUCs are not referenced except for in Table 1. Figure 3 also displays the MDNRE 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).

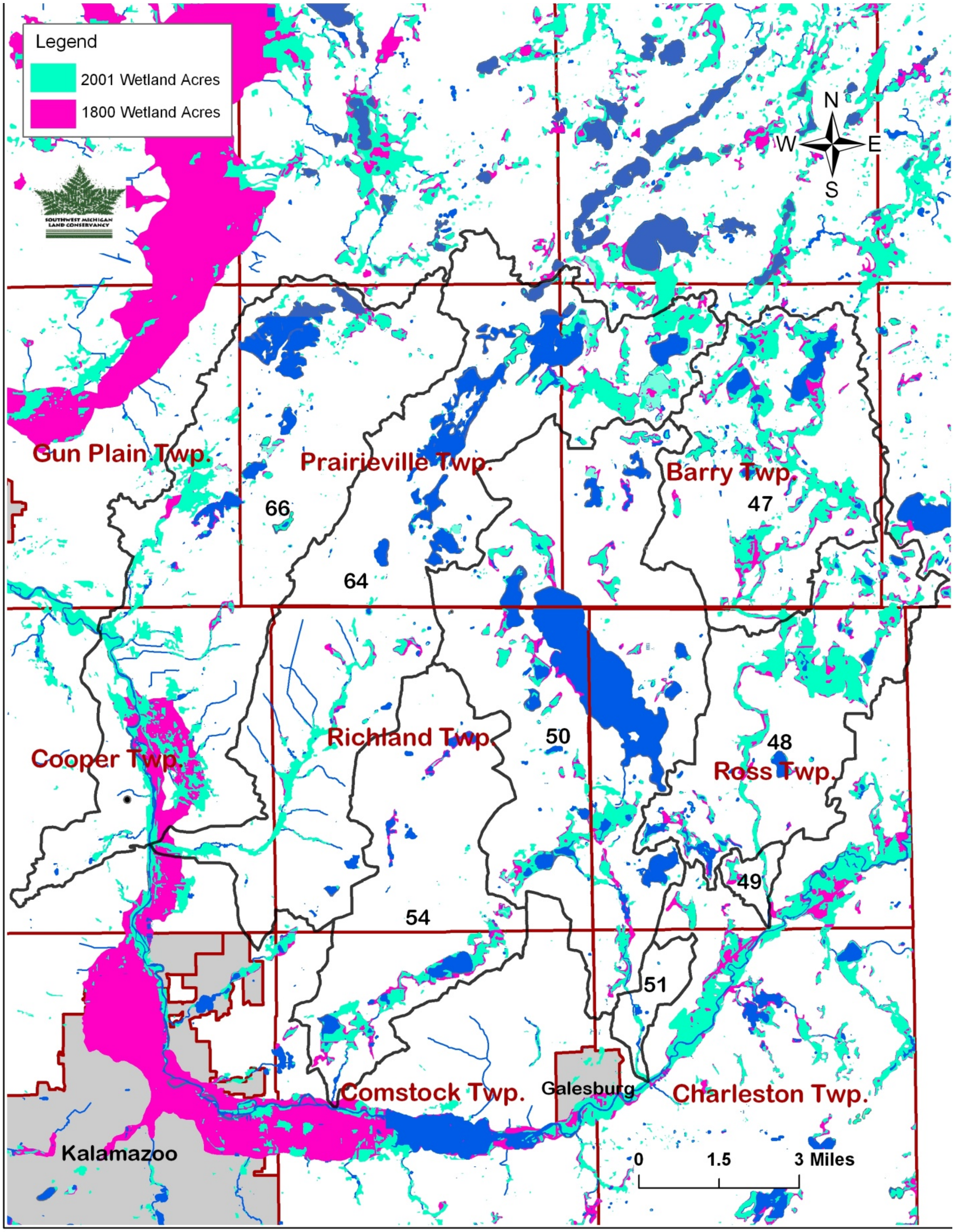

Figure 5. Four Township Watershed Area current and historic wetlands per the Michigan Department of Natural Resources and Environment.

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. (Chapter 6, MDEQ Integrated Report 2006).

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).

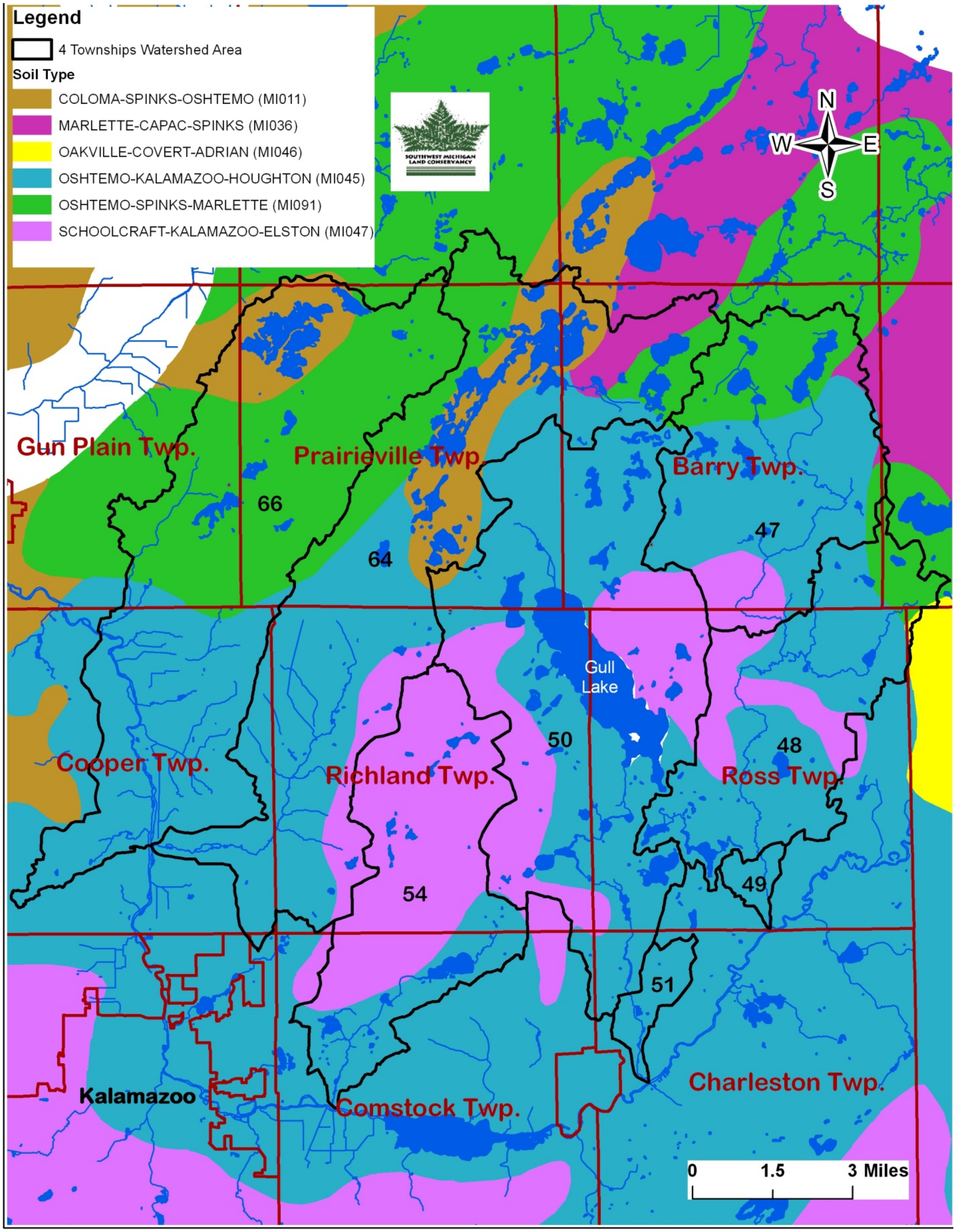

Figure 6. Soils within the Four Township Watershed Area (STATSGO).

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 Four Township Water Resources Council for further information 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.

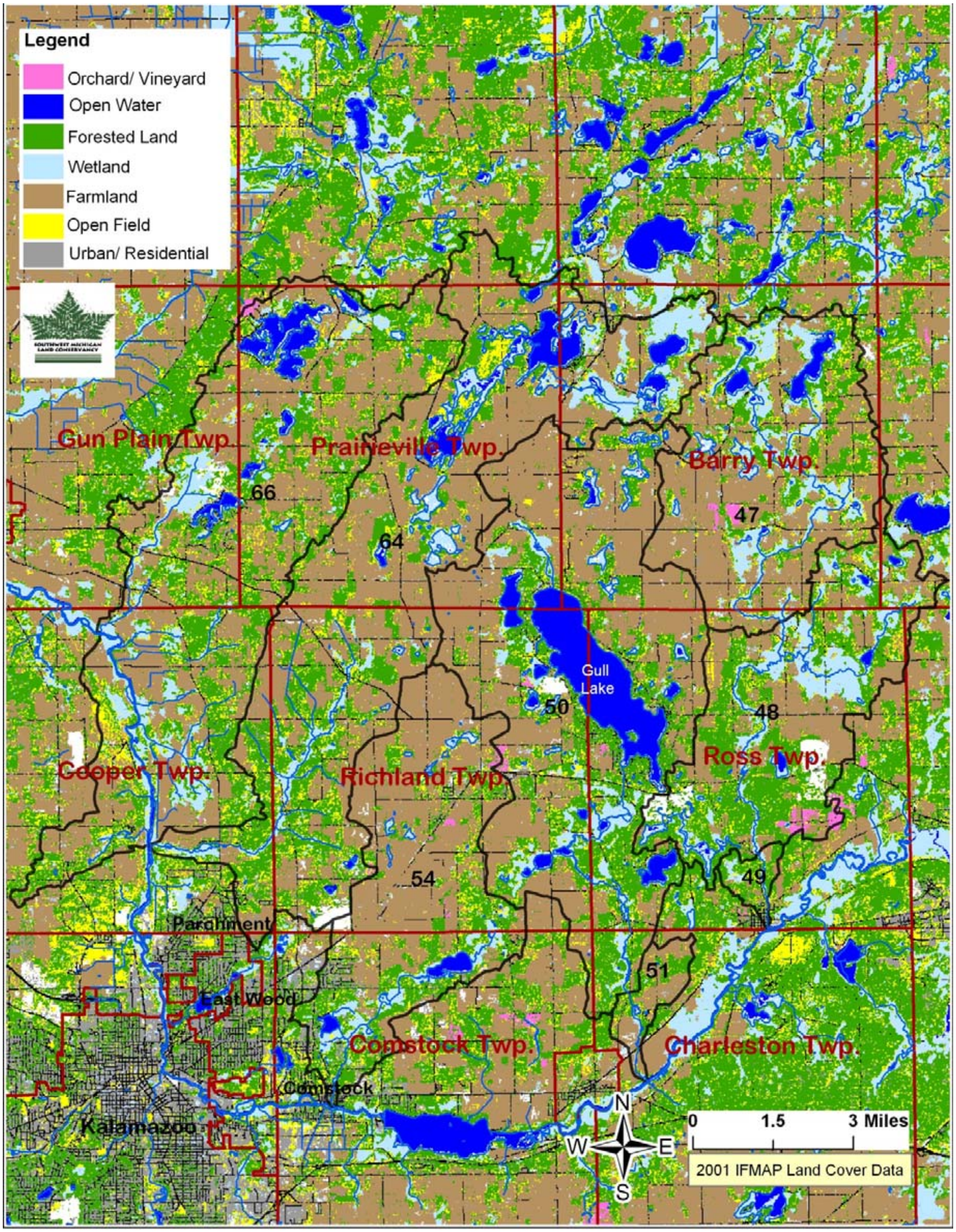

Figure 7. Four Townships Watershed Area land cover based on the 2001 Lower Peninsula land cover/use theme (MiGDL, 2007)

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 methodolgy. 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 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 Quality Organization 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.

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 Four Township Water Resources Council Issues Paper (1997) which can be found at the Council website www.ftwrc.org.

From 1982 to 1992, Michigan lost 854,000 acres of farmland, an average of 133 $mi.^2$ 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.

Between 1990 and 2020 urban development in Michigan will nearly double while the population will increase a mere 11.8%. However it is important to point out that growth in housing has been outpacing population growth because the median household size has been falling and, in places such as the FTWA, people are accepting longer commutes in order to be able to live in a rural setting.

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 strategies, 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 have the authority to enact ordinances that could affect the management of land. For example, several counties in Michigan have adopted phosphorus bans for lawn fertilizer use unless soil testing demonstrates a deficiency. As a result, city, village, township and tribal governments have a significant role to play in protecting water resources. This role helps to fulfill needs where federal and state statutes and county ordinances leave off.

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 (http://cfpub.epa.gov/npdes/home.cfm?program_id=298).

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 MDNRE maintains design and maintenance standards for road stream crossings through the Water Resources Division (http://www.michigan.gov/deq/0,1607,7-135-3313_3684_15299-11289--,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.

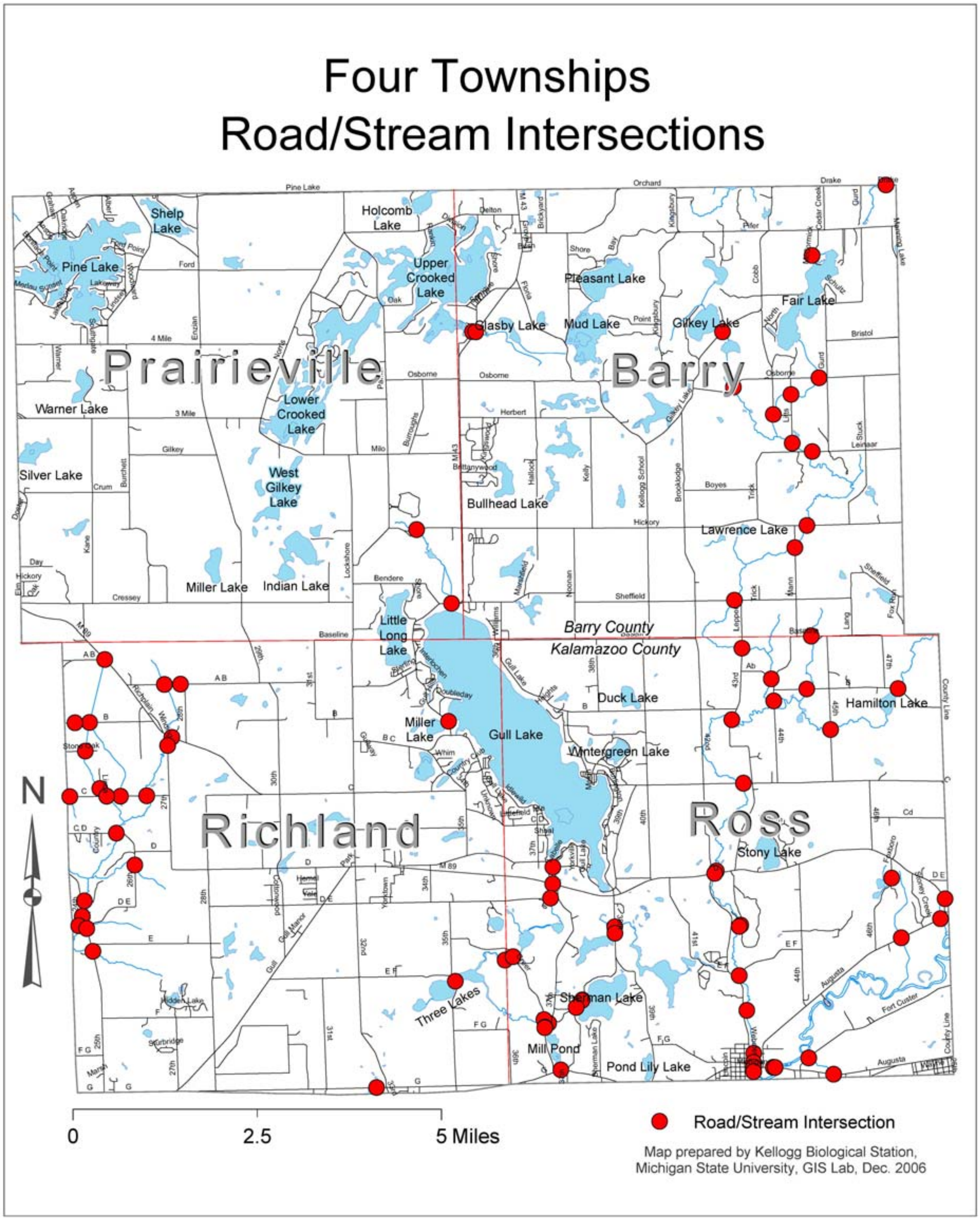

Figure 8. Road/Stream Crossing Signage

4.2 Regulatory Authority and Water Resources

The FTWA spans a number of government jurisdictions, with most area in 2 counties (Barry and Kalamazoo) and 6 townships. There are 2 villages (Augusta and Richland) but no cities or tribal lands.

Water Bodies (rivers, drains, streams, lakes)
The MDNRE 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 MDNRE has the authority to regulate the number of boats and size of engines at MDNRE access sites if human health or protected species are being impacted.

MDNRE 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 June 2010 see Appendix 1. Further the MDNRE 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, and Road Commission participate in the municipal stormwater permit program under a general watershed permit MIG610000 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 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 current, 2008 watershed permit to protect valued local water resources. A selection of key elements of the general pemit is included here for consideration:

> Post-Construction Storm Water Control for New Developments and Redevelopment Projects- The permittee shall develop, implement, and enforce a program through an ordinance or other regulatory mechanism to address post-construction storm water runoff from all new and redevelopment projects that disturb one (1) acre or more, including projects less than one (1) acre that are part of a larger common plan of development or sale that would disturb one (1) acre or more. The program shall include the following general requirements:
>
> - A minimum treatment volume standard to minimize water quality impacts

- Channel protection criteria to prevent resource impairment resulting from flow volumes and rates
- Operation and maintenance requirements
- Enforcement mechanisms with recordkeeping procedures
- A requirement for the project developer to write and implement site plans, which shall incorporate the requirements of this section of the permit

The permittee shall establish structural storm water BMP design standards by meeting any of the following:

- The permittee identified in its application a schedule to develop and place in effect an ordinance or other regulatory mechanism that incorporates the minimum treatment volume standard and the channel protection criteria listed in a) and b) below.
- The permittee identified in its application for coverage under this general permit its applicable local ordinance or regulatory mechanisms that implement a standard for storm water treatment and criteria for channel protection that existed before the permittee submitted its application.
- The permittee identified in its application for coverage under this general permit the applicable local procedures that implement a standard for storm water treatment and criteria for channel protection that existed before submittal of its application, and these local procedures will be converted into an ordinance or other regulatory mechanism by the date specified in the certificate of coverage (COC) for storm water pollution prevention Initiative (SWPPI) submittal.
- The permittee submits with the SWPPI an alternative approach, such as design criteria based on low-impact development (LID), that provides at least the same level of water quality treatment and channel protection as a) and b) below, and the alternative is approved by the Department.
- Elective Option: The permittee identified in the application for coverage under this general permit that it will develop an ordinance or other regulatory mechanism to meet the following outcomes:
    - A methodology and standard for treating water quality based on watershed priorities identified in the WMP
    - Criteria for channel protection based on scientifically accepted morphological concepts

Any combination of existing regulatory mechanism or procedure, approved alternative approach, elective option, or adoption of an ordinance or regulatory mechanism in accordance with the requirements of a) and b) below, may be used to establish the necessary minimum treatment volume standard and channel protection criteria, provided that they are applied to all new developments and redevelopment projects as described at the beginning of this section. Amendments made to ordinances or other regulatory mechanisms do not have to be submitted to the Department if the amendments do not reduce the level of channel protection or water quality treatment that were provided prior to the amendment.

a) The minimum treatment volume standard shall be either:

1. One inch of runoff from the entire site, or ½ inch of runoff from the entire site if the permittee demonstrates technical support for it in the WMP, or
2. The calculated site runoff is from the 90 percent annual non-exceedance storm for the region or locality, according to (a) or (b) below, respectively.
    a. The statewide analysis by region for the 90 Percent Annual Non-Exceedance Storms is summarized in a Department memo dated March 24, 2006, which is available on the Internet at: www.michigan.gov/deqstormwater; under Information, select “Municipal Program/MS4 Permit Guidance,” then go to the Storm Water Control Resources heading.
    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. This approach is subject to approval by the Department.

Treatment methods shall be designed on a site-specific basis to achieve the following:

- A minimum of 80 percent removal of total suspended solids (TSS), as compared with uncontrolled runoff, or
- discharge concentrations of TSS not to exceed 80 milligrams per liter (mg/l).

A minimum treatment volume standard is not required where site conditions are such that TSS concentrations in storm water discharges will not exceed 80 mg/l.

b) The channel protection criteria established in this permit is necessary to maintain post-development site runoff volume and peak flow rate at or below existing levels for all storms up to the 2-year, 24-hour event. "Existing levels" means the runoff flow volume and rate for the last land use prior to the planned new development or redevelopment. Where more restrictive channel protection criteria already exists or is needed to meet the goals of reducing runoff volume and peak flows to less than existing levels on lands being developed or redeveloped, permittees are encouraged to use the more restrictive criteria than the standard permit requirements.

More information on this program is available on the Michigan Department of Natural Resources and Environment stormwater website http://www.michigan.gov/deq/0,1607,7-135-3313_3682_3716---,00.html.

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 Planning 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.

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 MDNRE 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 DNRE 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 MDNRE 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 MDNRE 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 MDNRE 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 DNRE and the Department of Agriculture 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.

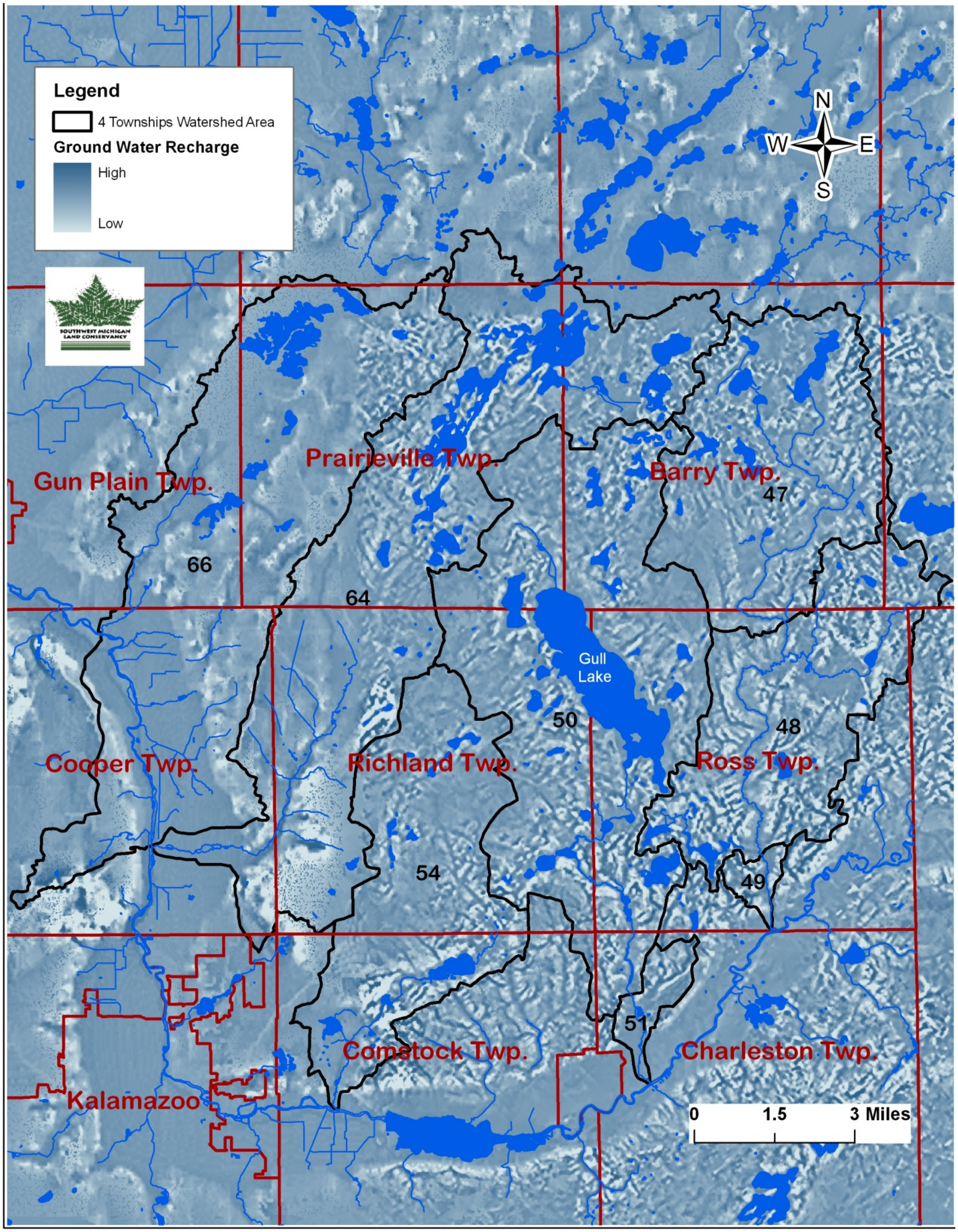

Figure 9. Groundwater recharge zones from Michigan Geospatial Data Library.

The following cities and villages near the FTWA participate in a local Wellhead Protection Program as of October 2008:

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

4.3 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			*	
	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		*		
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	*	*	*	*

		Ross Twp.	Richland Twp.	Barry Twp.	Prairieville Twp.
	Purchase of Development Rights			*	*
	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).

<u>Master Plans</u>
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.

<u>Zoning Ordinances</u>
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://www.ftwrc.org/publications.htm.

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.

4.4 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, Department of Natural Resources and Environment, 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**

Land Management Option	Description	Agreement	Landowner reimbursement
Wildlife Habitat Incentive Program (WHIP)	Provides technical and financial assistance to promote wildlife habitat including corridor, riparian buffer and rare species habitat development	Contracts run for a minimum of 5 years and a maximum of 10 years.	Up to 75% of cost of improvements.
Wetland Reserve Program (WRP)	Assists in restoring land to natural wetland condition.	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.

**These are just a few of many examples. For more information contact county Conservation District offices.

5 Natural Features

The natural features of the FTWA provide ecosystem services that benefit humans, such as recharging groundwater, cleansing air and filtering water. These natural features also 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.

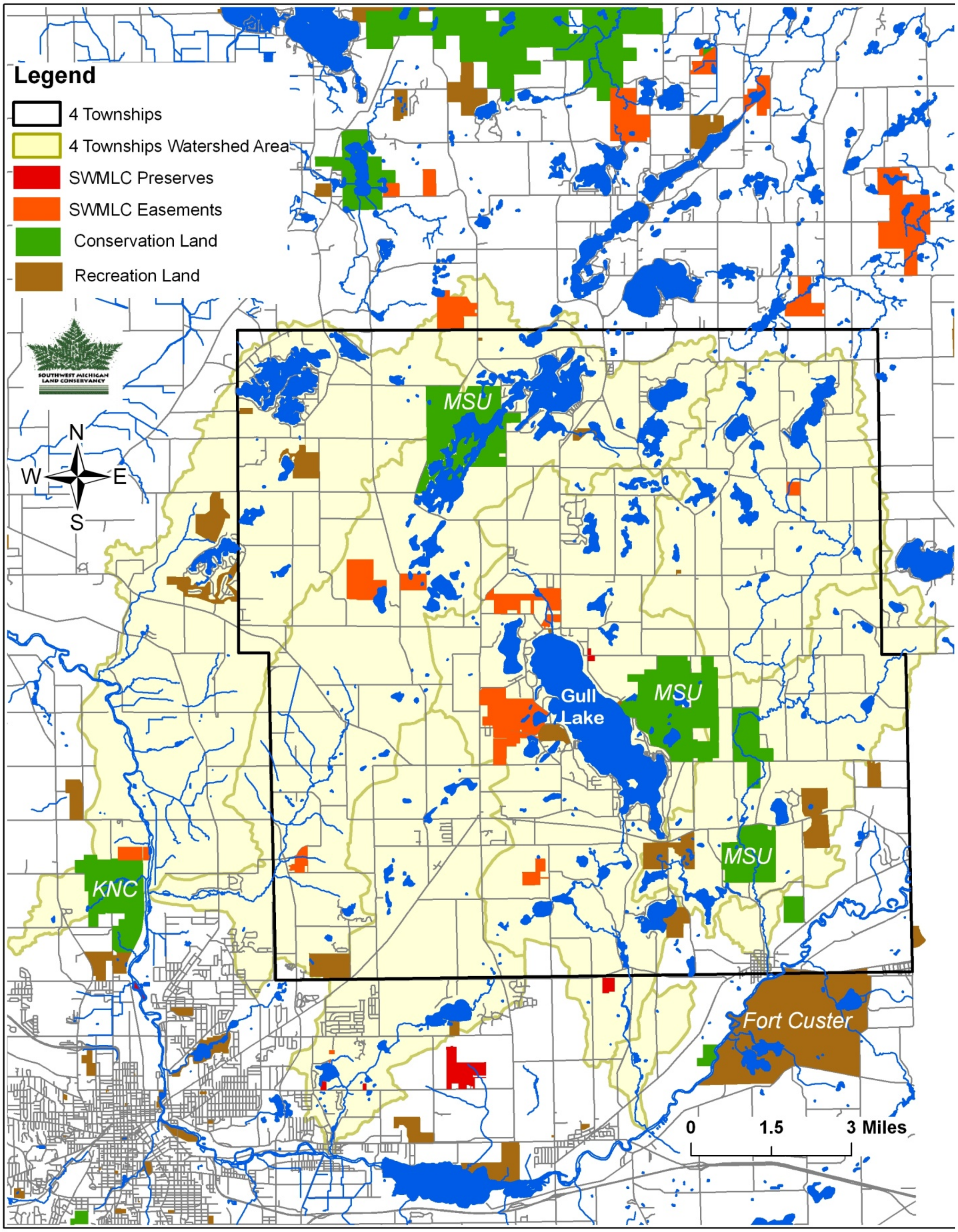

Figure 10. Conservation and recreation lands provided by the Southwest Michigan Land Conservancy.

Some of these lands are preserved either as conservation easements, or as holdings of the Kalamazoo Nature Center. The FTWRC in partnership with the SWMLC has facilitated the placement of 83 acres of land into conservation easements, and anticipate that more acreage will be conserved in late 2010. The Michigan State University land 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. An MDNRE fishing and hunting area 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.

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 Four-Township Water Resources Council has published a Natural Features Inventory reports for all four townships as a single unit, which is available under publications on FTWRC web page (www.ftwrc.org). The goal of the Natural Features Inventory is to promote more well-informed decisions when property of high ecological value is being considered for development.

In 2003, Michigan State University Extension identified 20 areas as high-priority Potential Conservation Areas (PCAs) within the four townships. The priority rating of each PCA was determined by many factors, including size, core area, association with streams, connection with nearby PCAs and natural areas, the restorability of adjacent properties, and the incidence of plants or animals of special concern. The identification of these 20 high priority PCAs concluded Phase I of the Natural Features Inventory.

Phase II of the inventory, based on field surveys of representative portions of each PCA, rated each of these 20 high priority PCAs 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).

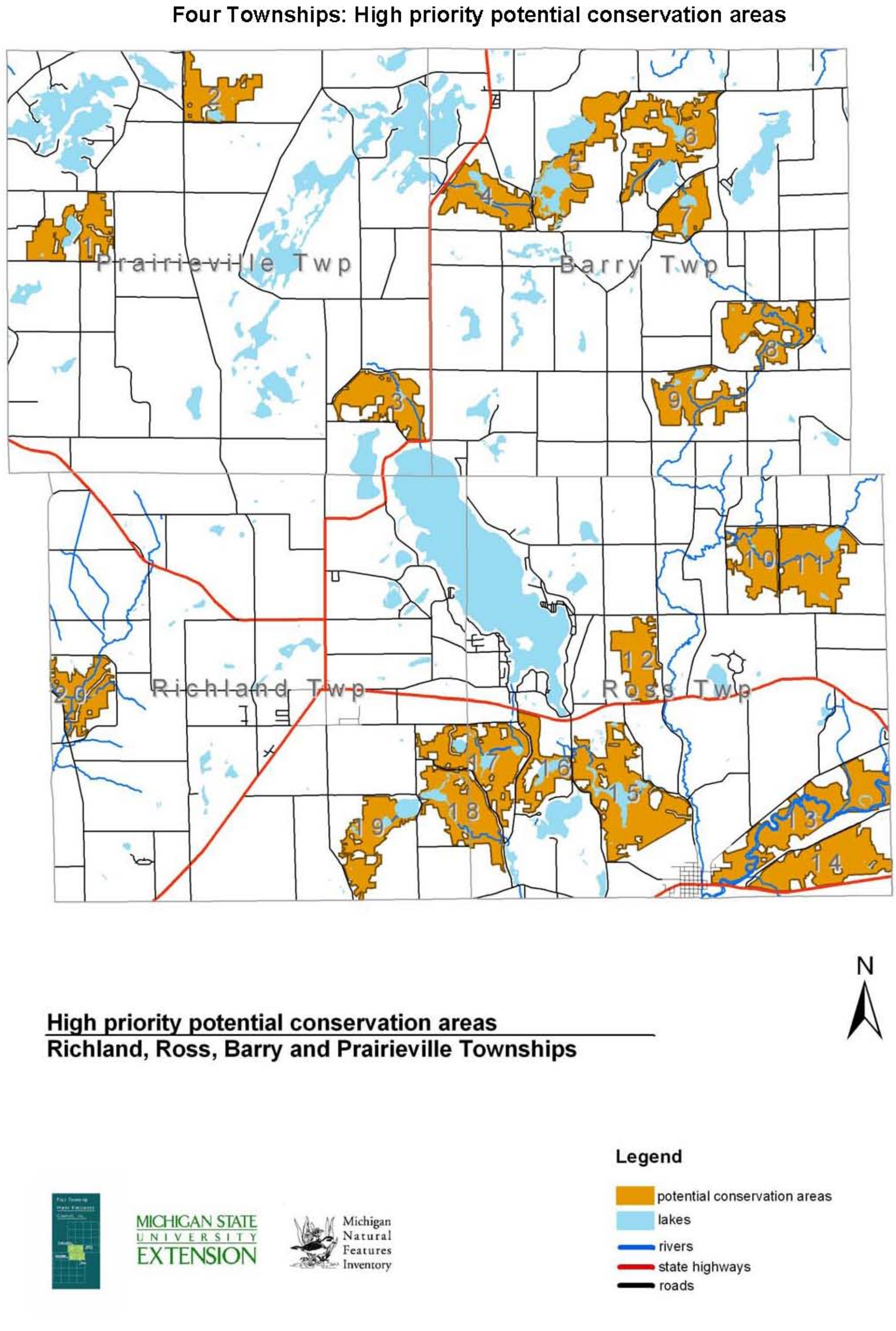

Figure 11. Priority Conservation Areas as Identified in the 2005 Four Townships Natural Features Inventory

All 20 PCAs are worthy of conservation priority, but the quality of natural features at some sites was higher than at others 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 development proposals in or near these PCAs.

Table 10. Priority Potential Conservation Areas (PCAs) as of 2005. See www.ftwrc.org for more information on the PCAs.

PCA	Name	Rank	Township
PCA1	Warner Lake and Camp Merrie Woode	very good	Prairieville
PCA2	Ford Road Pond	very good	Prairieville
PCA3	Prairieville Creek	very good	Prairieville
PCA4	Glasby Marsh	very good	Barry
PCA5	Blachman Swamp and Mud Lake	excellent	Barry
PCA6	Balker Lake Swamp	excellent	Barry
PCA7	Shallow Gilkey and Little Gilkey Lakes	very good	Barry
PCA8	Augusta Creek and Kidd Bog	excellent	Barry
PCA9	Lawrence Lake and Augusta Creek	very good	Barry
PCA10	Sherriff Marsh	excellent	Ross
PCA11	Stafford Swamp and Hamilton Lake	excellent	Ross
PCA12	Pine Meadows Farm and the Cheff Center	good	Ross
PCA13	Kalamazoo River Floodplain	excellent	Ross
PCA14	Fort Custer National Cemetery	excellent	Ross
PCA15	Brook Lodge	very good	Ross
PCA16	Crane's Lake	very good	Ross
PCA17	Butterfield Lake and Graham Lake	excellent	Ross
PCA18		very good	Richland

PCA	Name	Rank	Township
	Lower Three Lakes		
PCA19	Upper Three Lakes	excellent	Richland
PCA20	Spring Brook	excellent	Richland

Although PCAs are grouped by township, each township can be considered part of the larger FTWA. Cooperative conservation efforts across the broader FTWA are encouraged. Ecosystems are "open systems" and, to the extent possible, should be managed across jurisdictional boundaries. The PCAs along and south of the Kalamazoo River are in Ross Township but lie outside the FTWA that is the subject of the Watershed Management Plan. Three additional PCAs are proposed herein for future consideration and scrutiny (Table 11).

Table 11. Additional Proposed Priority Conservation Areas – post 2005

PCA	Name	Rank	Township
PCA21	Silver Creek	TBD	Gun Plain
PCA22	Pitchfork Valley (Augusta Creek above Leinaar Road)	TBD	Barry
PCA23	Trout Run/Cooper Creek	TBD	Cooper

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, and vice-versa.

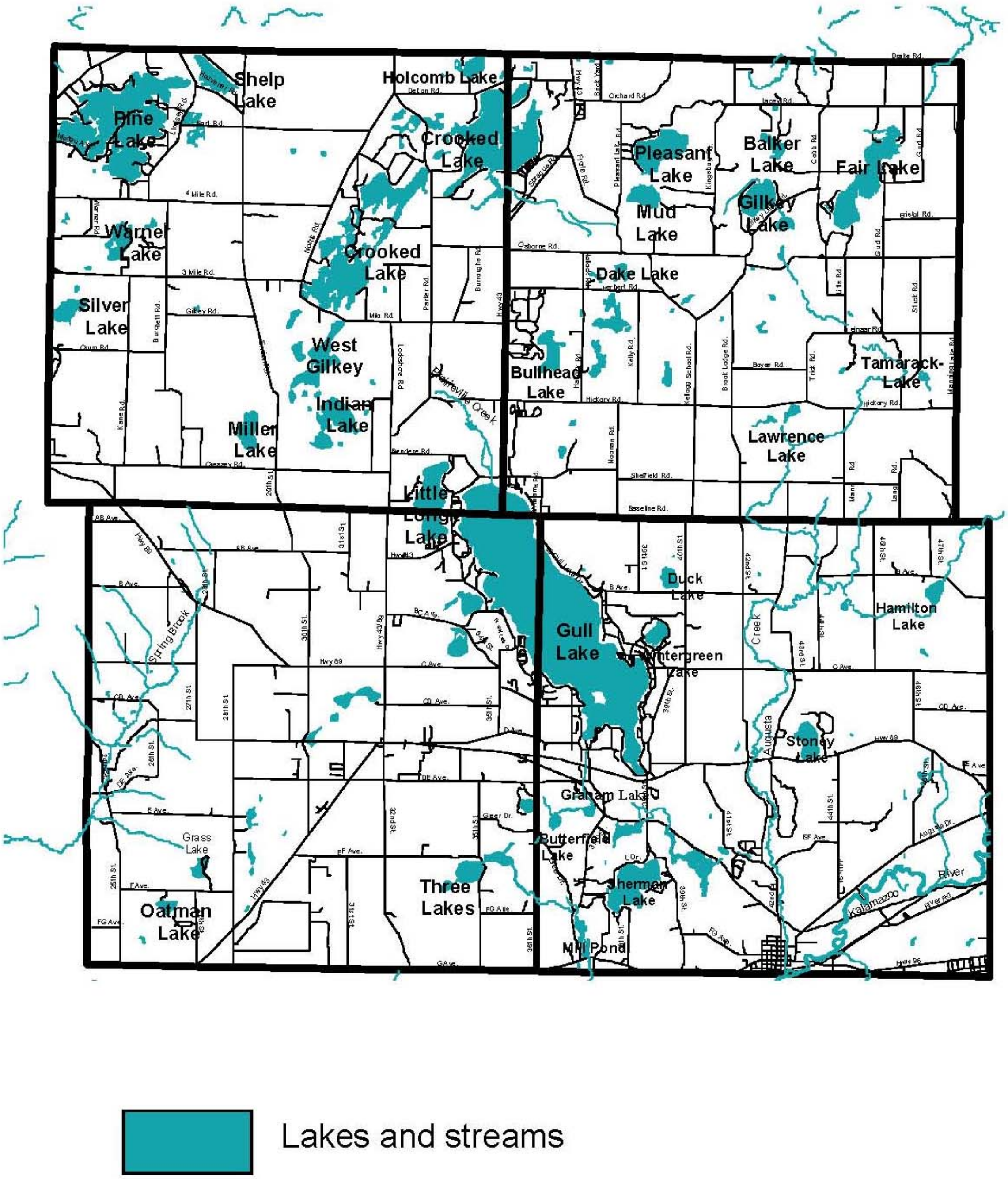

Figure 12. Water Bodies in the Original Four Townships

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 contribute to the hydrologic stability of the FTWA because they have large groundwater inputs (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.

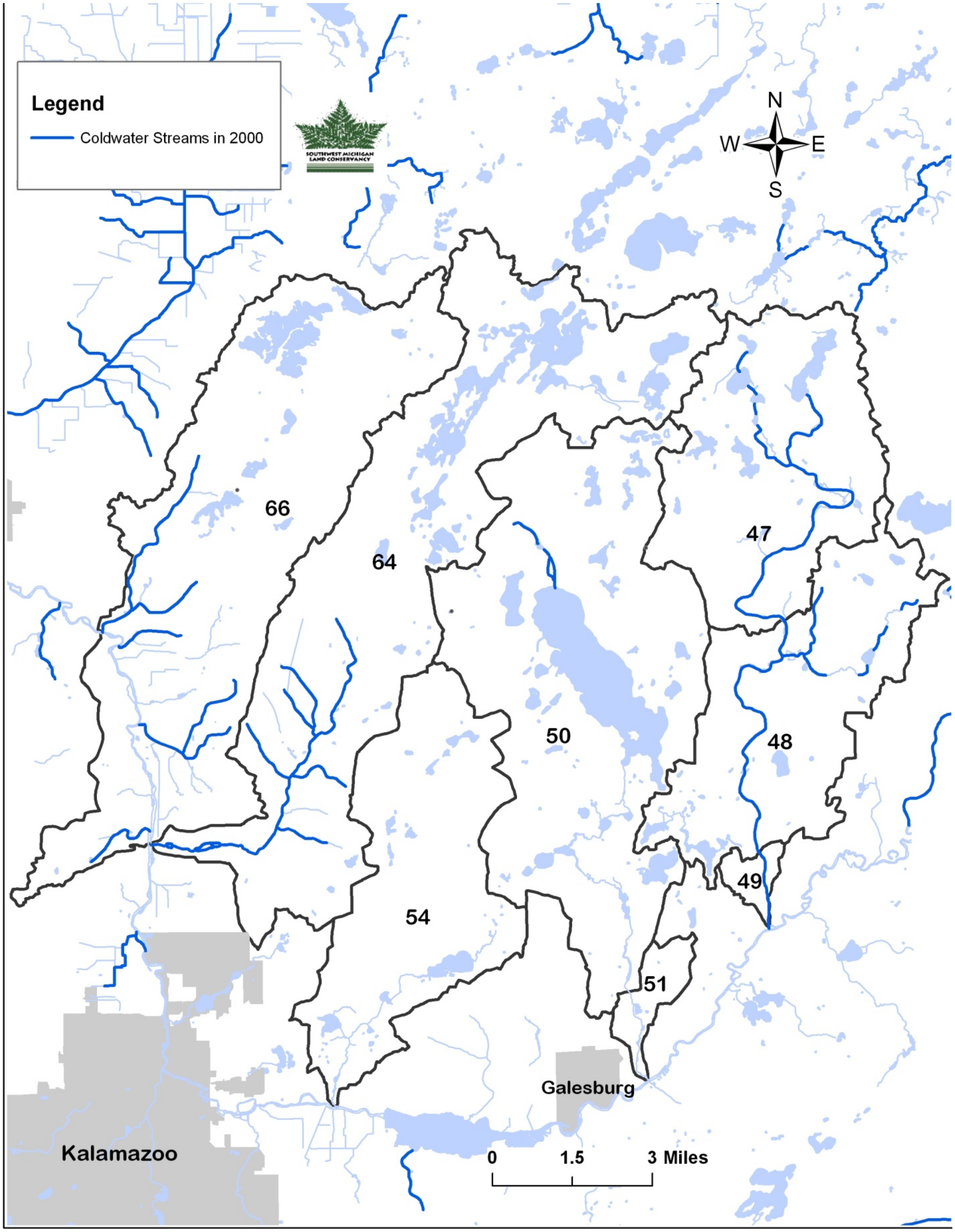

Figure 13. Coldwater streams in the Four Township Watershed Area from the Michigan Geospatial Data Library.

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 FTWRA 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. Water warmed in these ponds continues to move through the ground towards and into adjacent streams.

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

Table 12. 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 uses. Residential development around lakes with no connection to municipal wastewater treatment facilities can, but won't 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).

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.

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 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 MDNRE groundwater/drinking water programs.

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.

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 with permits has increased in recent years and the acreage on which manure is spread for disposal is increasing as well. Figure 14 shows acreage around the Gull Lake area where manure is spread. Improperly managed manure 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.

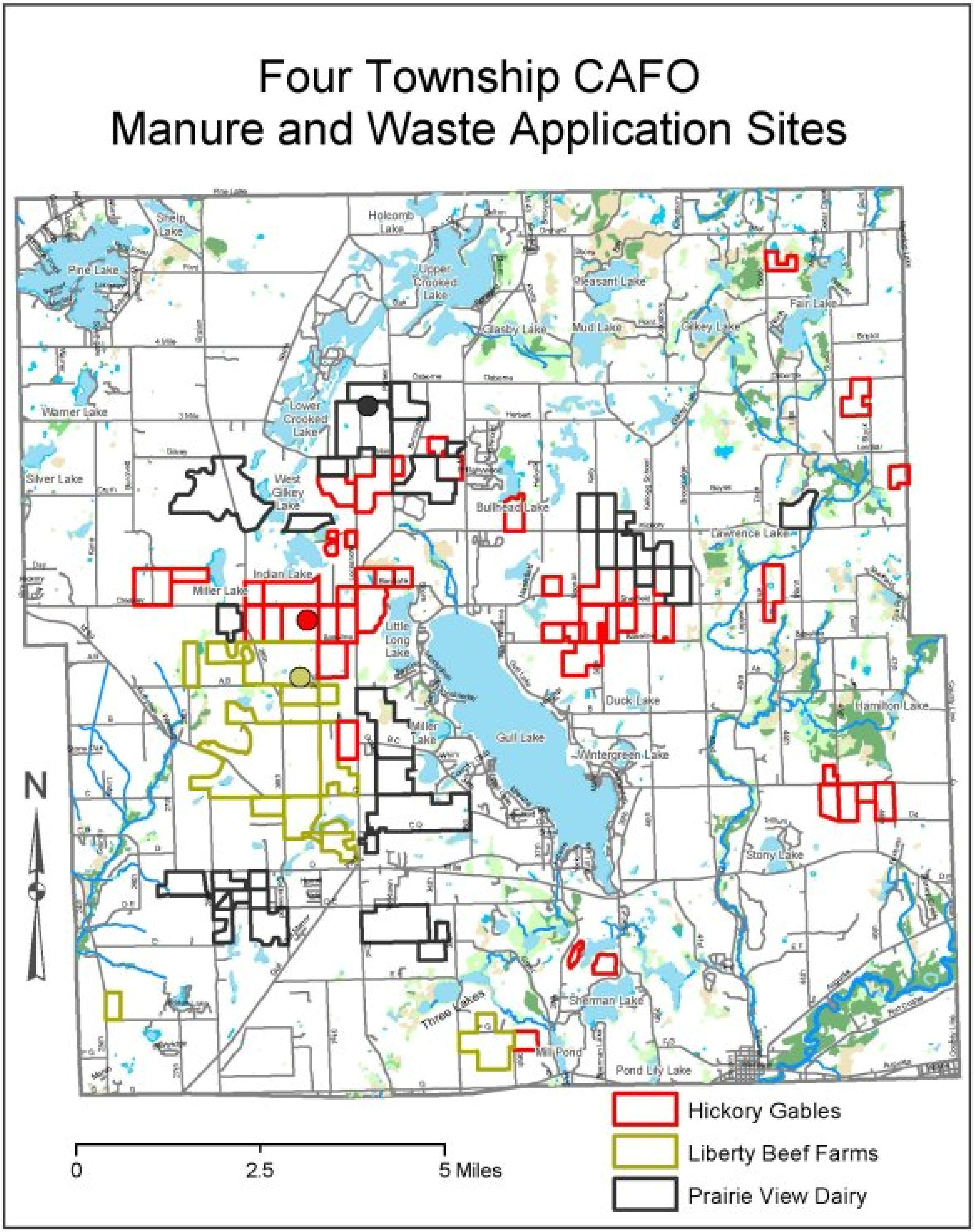

Figure 14. Animal waste application sites, based on DEQ (now DNRE) permit requests by three local Concentrated Animal Feeding Operations. Data compiled in 2008.

Table 13 lists common groundwater contaminant sources.

Table 13. 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. Early in the project period 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 newsletters and FTWRC newsletters indicated that a Watershed Management Plan update 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.

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 Four Townships Water Resources Council, MDNRE, Southwest Michigan Land Conservancy, 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.

The FTWRC maintains a website with a library of FTWA information (Appendix 5). An email communication list was used to keep stakeholders informed and to offer the opportunity to comment on the information being compiled and organized.

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)

6.2 Watershed Research and Model Review

Dr. Stephen Hamilton, Michigan State University, developed a GIS buffer layer to describe Riparian Areas around waterbodies (see section 8.2).

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 (Appendix 6).

7 Water Quality Summary

7.1 Designated Uses

According to the Michigan Department of Natural Resources and Environment, 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 14. (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 14. 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 15). See the Michigan Integrated Report (2010) for details on PCBs, Mercury, and Dioxin.

7.3 Individual Water Bodies

Other than for Fish Consumption, all lakes and streams included in the 2010 Integrated Report were fully supporting of assessed designated uses. Only one impairment based on nonpoint source pollution is listed that impacts the FTWA (Table 15).

Table 15. Impaired Water Bodies at a Glance.

Water Body	AUID	Impaired Use	Cause	TMDL Status
Kalamazoo River Watershed Rivers/Streams	All in FTWA	Fish Consumption	PCB in Fish Tissue	2013
Kalamazoo River Watershed Rivers/Streams	All	Fish Consumption	PCB in Water Column	2013
Gull Lake	0507-04	Fish Consumption	Mercury in Fish Tissue	2011
	0507-04	Fish Consumption	PCB in Fish Tissue	2013
Spring Brook	0605-01	Fish Consumption	Dioxin	2021
Unamed Tributary to Kalamazoo River	0607-02	Fish Consumption	Dioxin	2021
Unamed Tributary to Kalamazoo River	0607-03	Fish Consumption	Dioxin	2021
Silver Creek	0607-04	Fish Consumption	Dioxin	2021
Unamed Tributary to Kalamazoo River	0607-05	Fish Consumption	Dioxin	2021
Pine Lake W. of Prairieville	0607-06	Fish Consumption	Mercury in Fish Tissue	2011
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 Natural Resources and Environment (MDNRE, 2010).

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 MDNRE 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 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. MDNRE 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 subswatersheds. 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.

The 2010 Integrated MDNRE Report 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 MDNRE 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.

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.

Recent local expansion of Confined Animal Feeding Operations (CAFOs) has brought the total number of cattle in the vicinity of Gull Lake to ~5000, generating 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. 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 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.

Thermal changes are a concern primarily in the streams that currently support trout. Augusta Creek and Spring Brook are popular with anglers and their trout fisheries are managed by MDNRE. 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 16 contains the conceptual framework linking impaired and threatened designated uses, known and suspected pollutant, sources and causes.

Table 16. 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 - Whole FTWA under 2001 TMDL for excess algal growth, phosphorus (total); impairment in downstream Lake Allegan	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.	Approximately 9000 acres used for manure spreading
		Livestock facility runoff (S)	Improper manure storage and feedlot runoff.	Facility status to be determined
		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)
		Septic system failures and illicit connections (S)	Improperly designed, installed, and maintained septic systems. Unknown illicit connections.	Septic systems are widespread throughout 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.	4 sites of concern identified
		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	Temperature (S)	Lack of riparian habitat or habitat modification	Due to agriculture and urban land use and development	Extensive low density shoreline development widespread throughout the FTWA. Agriculture makes up 44% of the FTWA, and urban areas are developing
		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)

Designated Use	Pollutants and Impairments to Designated Uses	Source of Pollution	Causes for Release of Pollutants	Documented Presence in Watershed
	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)
		Road and bridge crossings (S)	Undersized culverts, poorly designed and maintained crossings.	4 sites of concern identified
	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 9000 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: 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 9000 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
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.

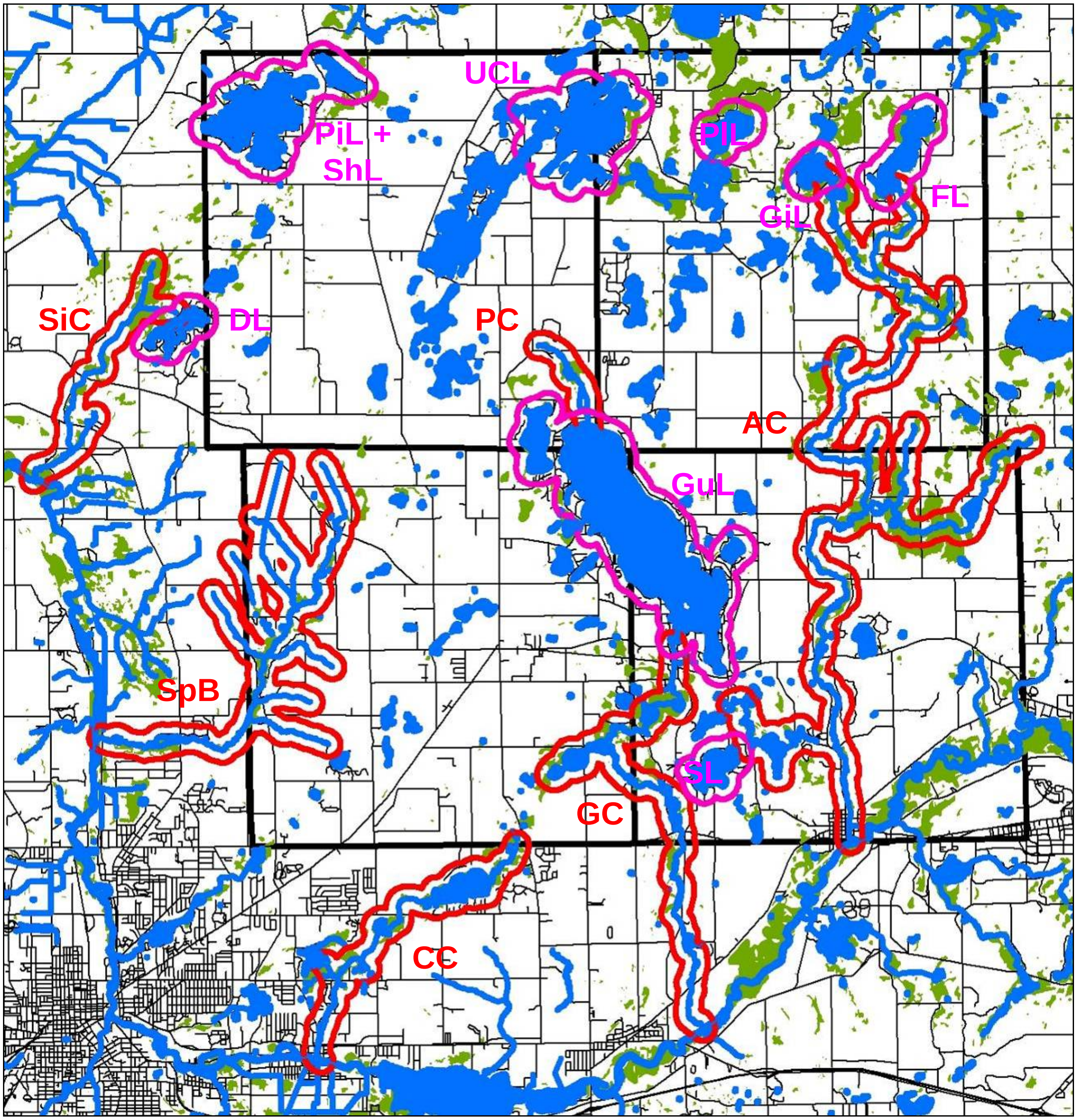

Figure 15. Riparian Areas along the main streams and most populated lakes in the FTWA. Riparian Area width = 1000 feet. Permanent waterbodies are blue, wetlands are green, and township boundaries are thick black lines. PiL = Pine Lake, ShL = Shelp Lake, DL = Doster Lake, UCL = Upper Crooked Lake, GiL = 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 1000 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.

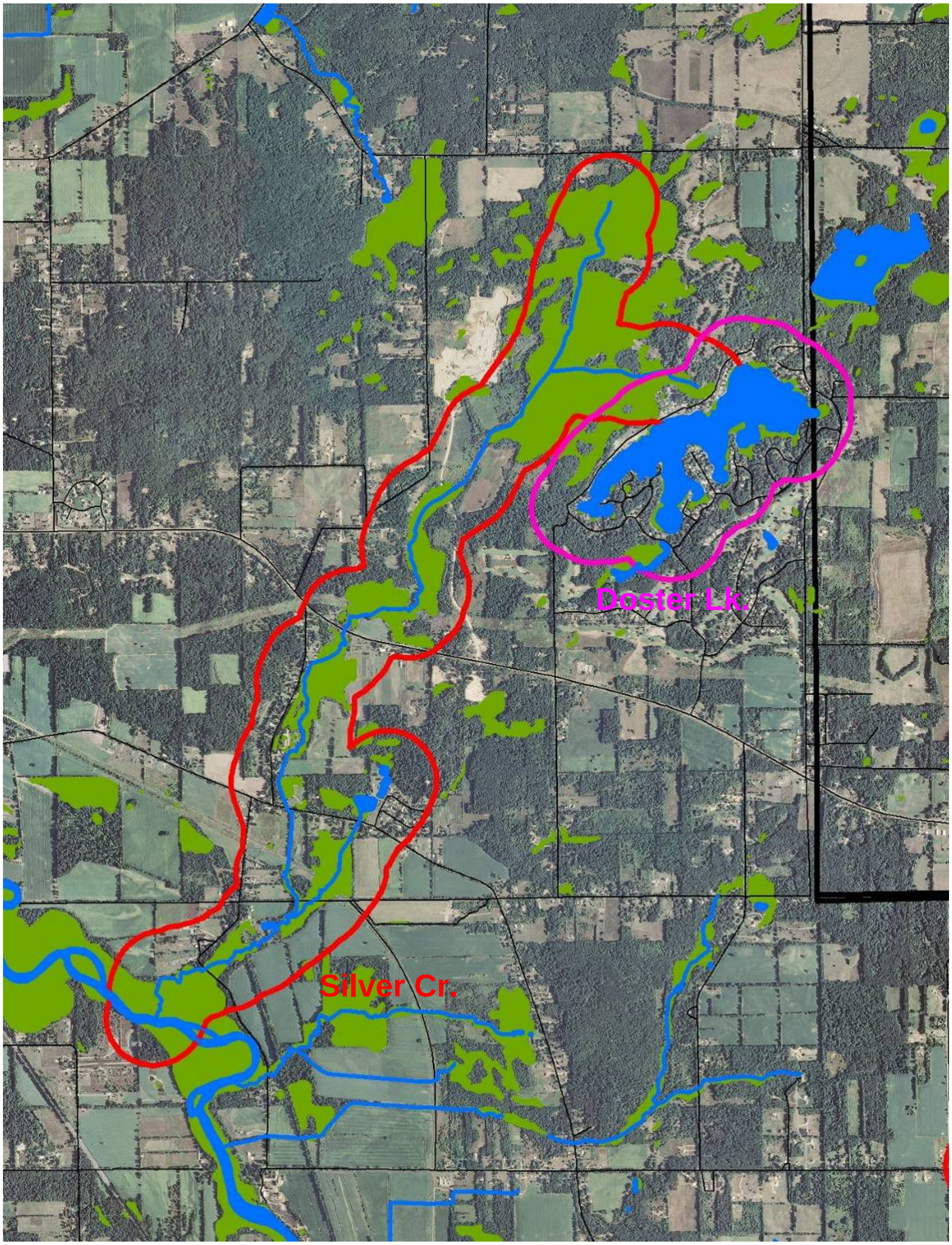

Figure 16. Riparian Areas for Doster Lake and Silver Creek. Permanent waterbodies are blue, wetlands are green, and township boundaries are thick black lines. Aerial photograph in this and subsequent figures is from 2009.

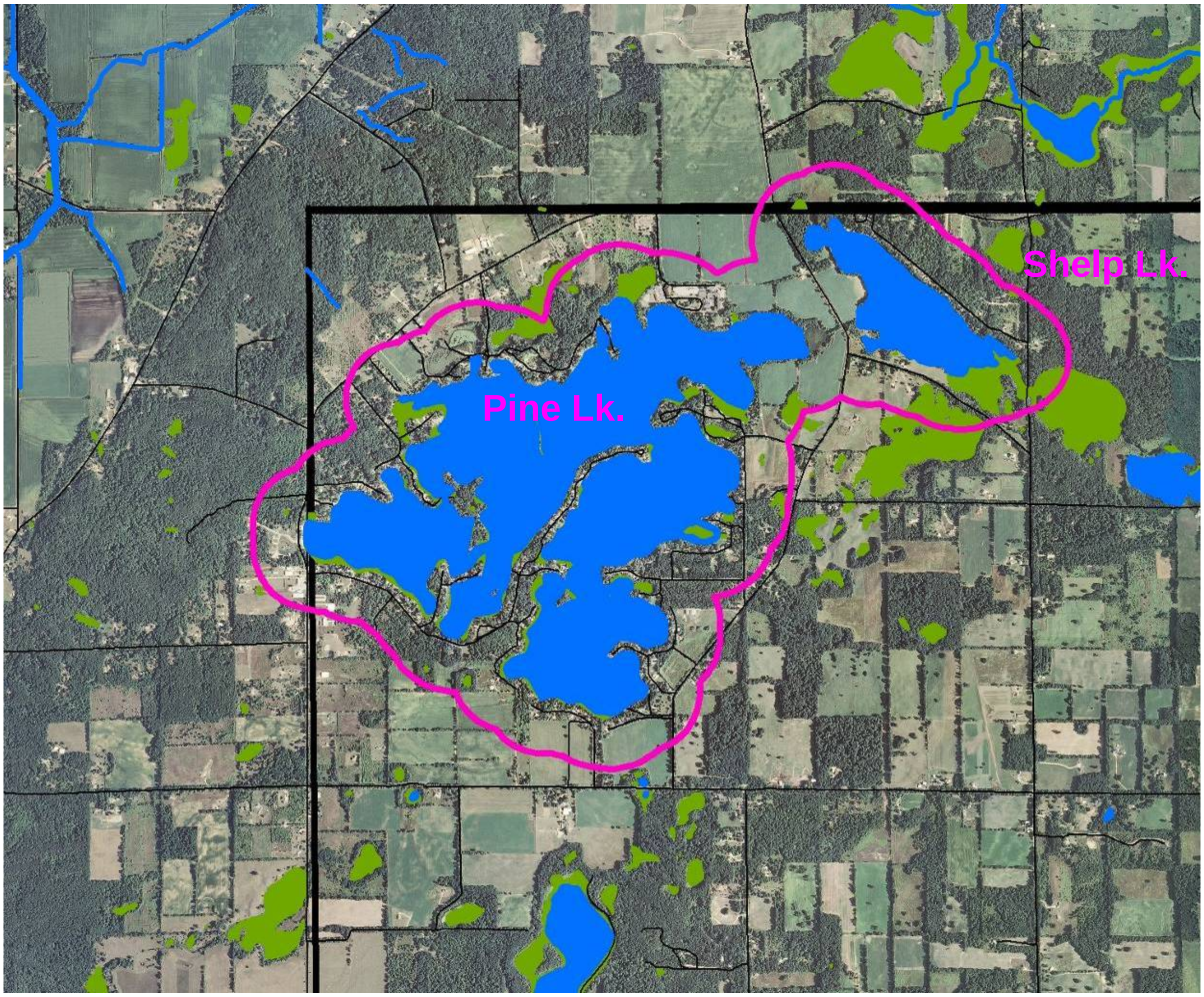

Figure 17. Riparian Areas for Pine and Shelp lakes. Shelp Lake is the smaller basin to the northeast of Pine Lake. Permanent waterbodies are blue, wetlands are green, and township boundaries are thick black lines.

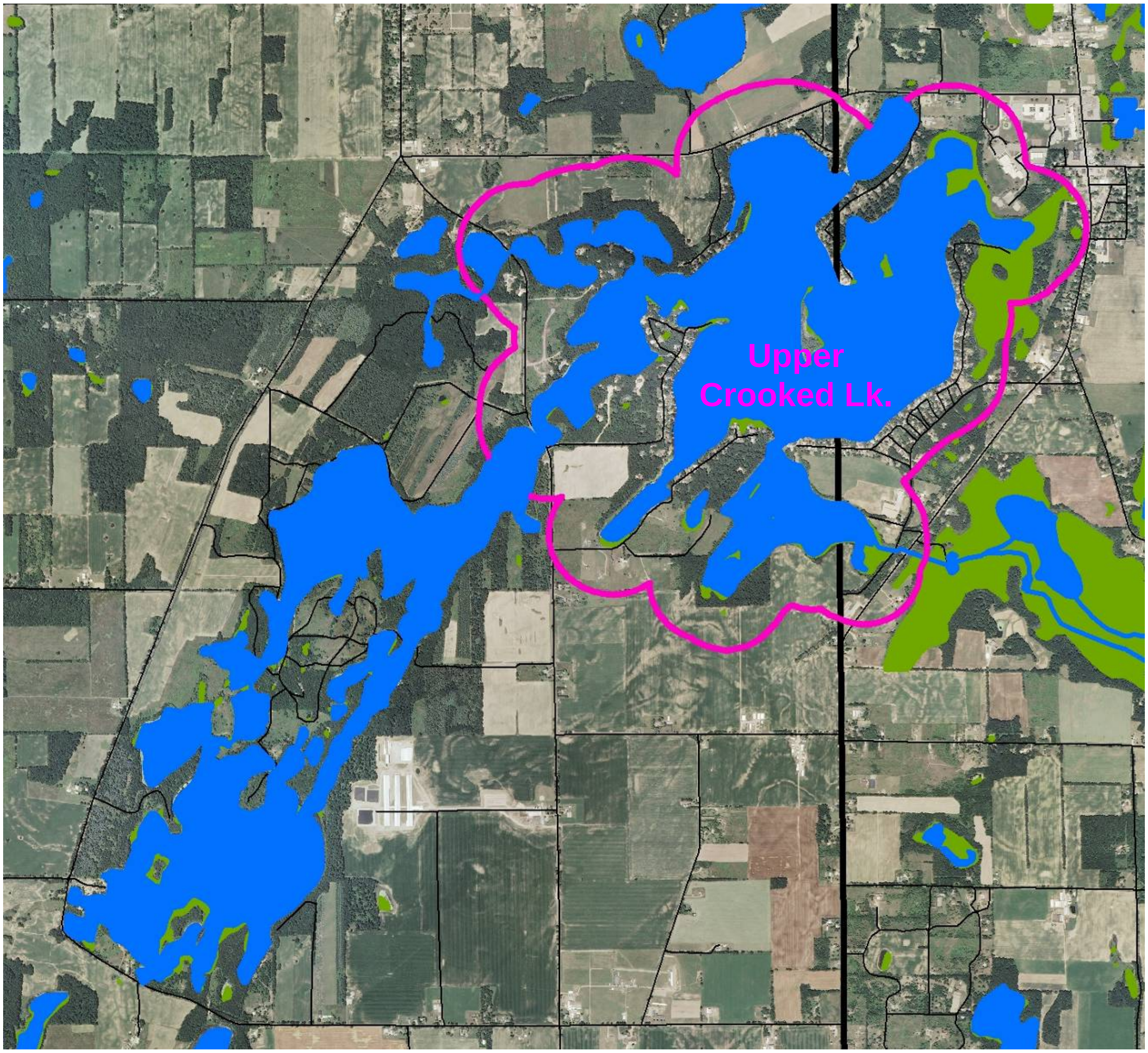

Figure 18. Riparian Areas for Upper Crooked Lake. The lower portion of the lake system (Lower Crooked Lake) is not included because it has few riparian residences and is relatively shallow. Permanent waterbodies are blue, wetlands are green, and township boundaries are thick black lines.

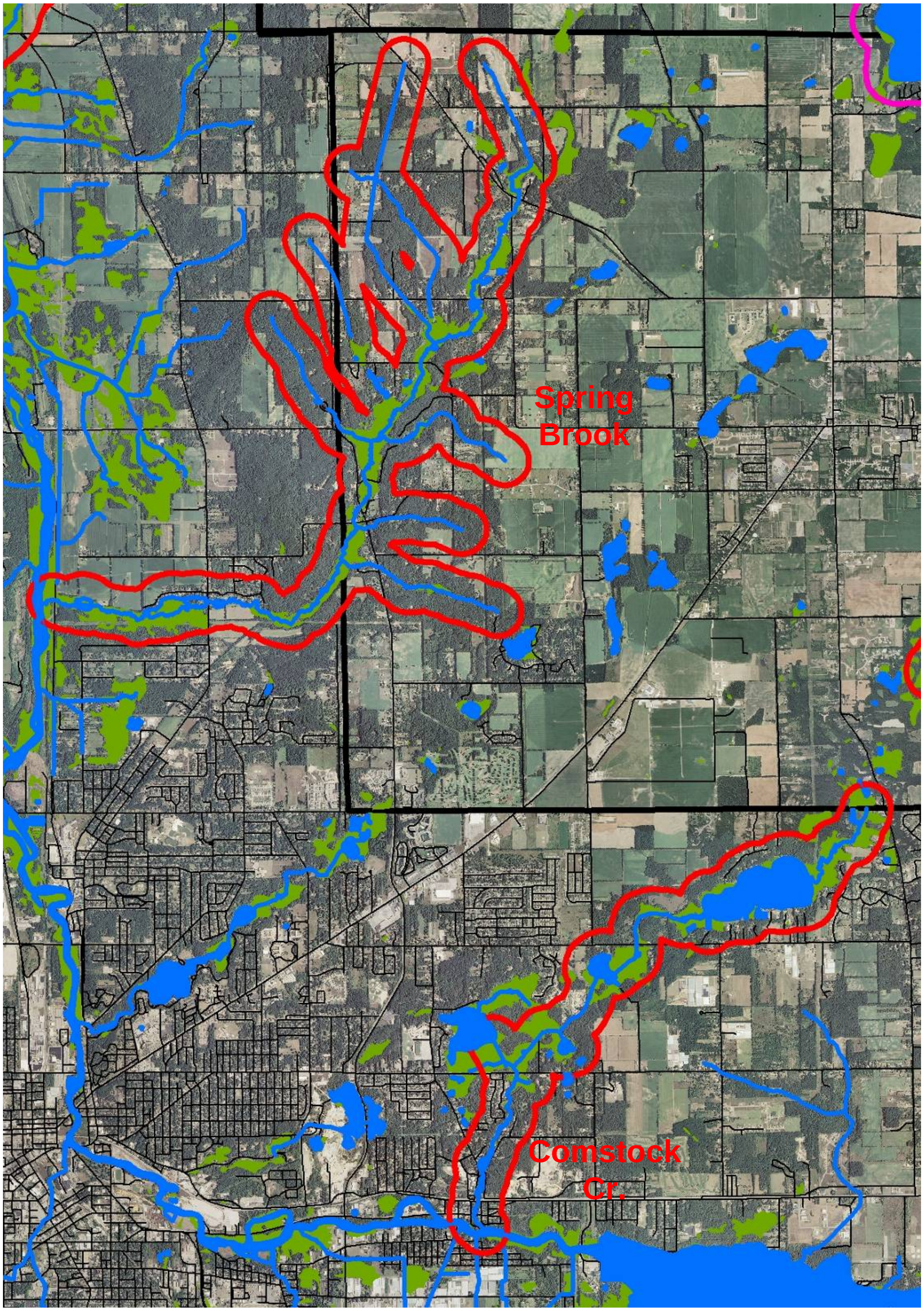

Figure 19. Riparian Areas for Spring Brook and Comstock Creek. Permanent waterbodies are blue, wetlands are green, and township boundaries are thick black lines.

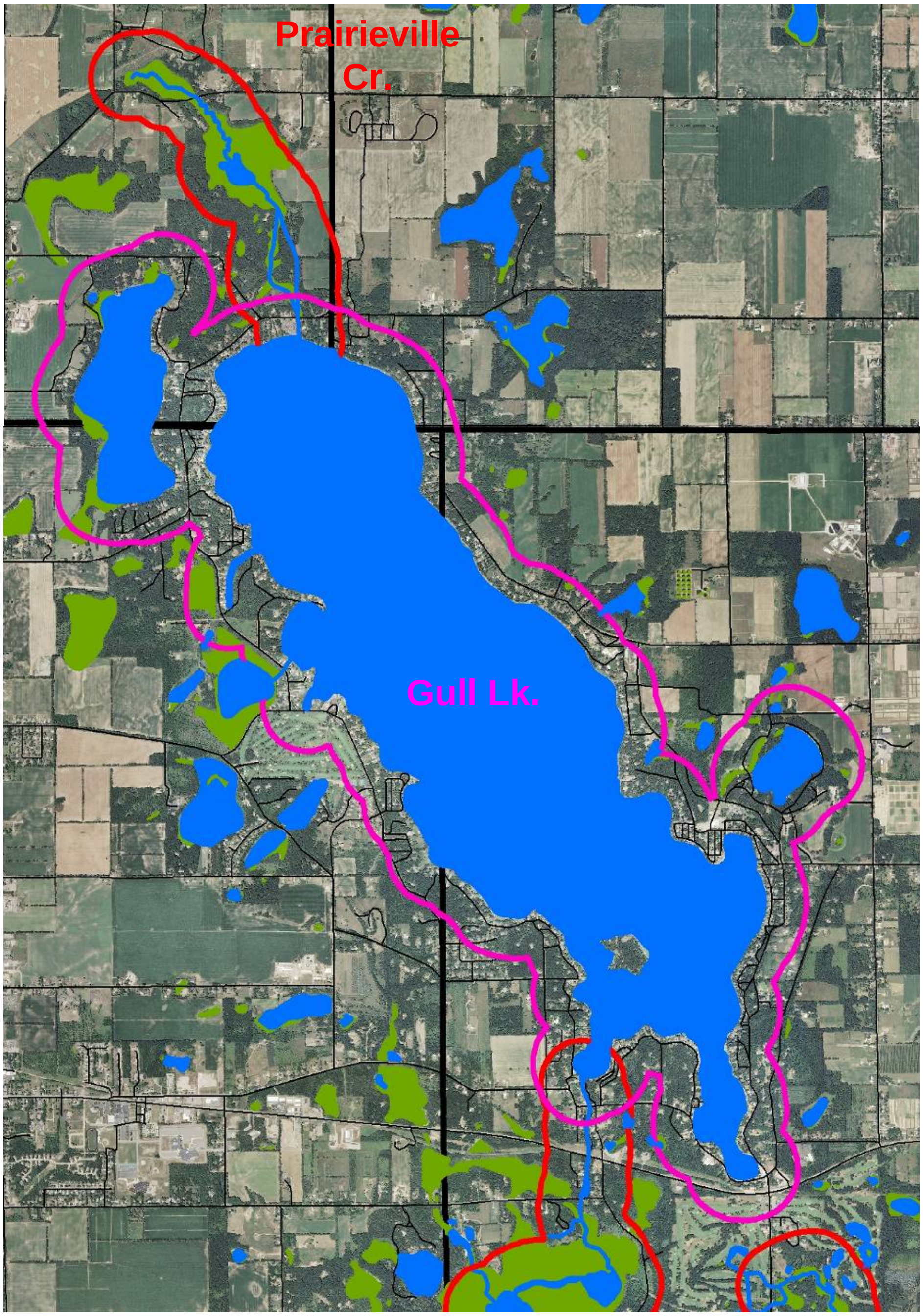

Figure 20. Riparian Areas for Prairieville Creek and for Gull Lake and two smaller lakes that drain into it (Little Long Lake on the northwest end and Wintergreen Lake on the east edge). Permanent waterbodies are blue, wetlands are green, and township boundaries are thick black lines.

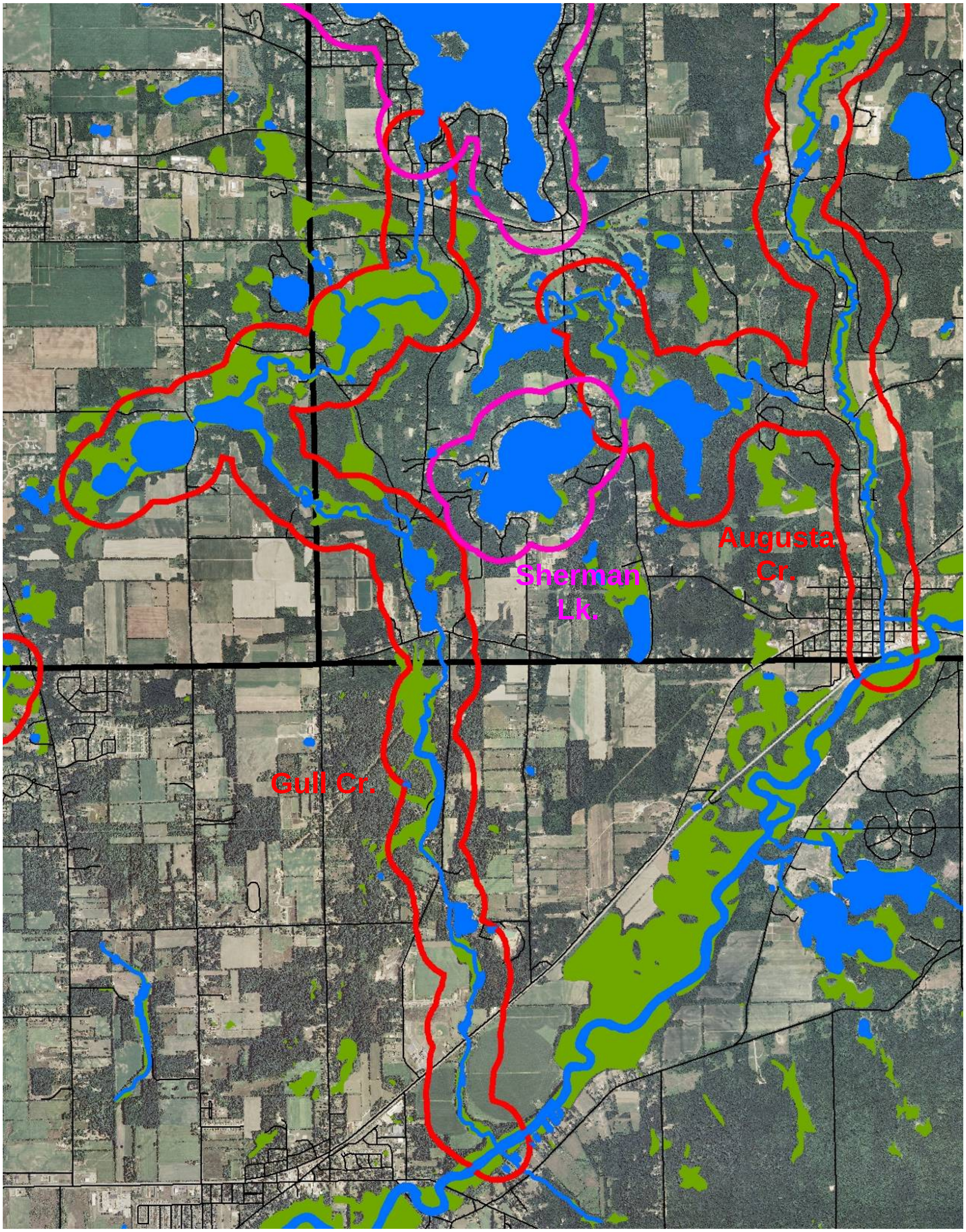

Figure 21. Riparian Areas for Gull Creek and lower Augusta Creek as well as Sherman Lake. Permanent waterbodies are blue, wetlands are green, and township boundaries are thick black lines.

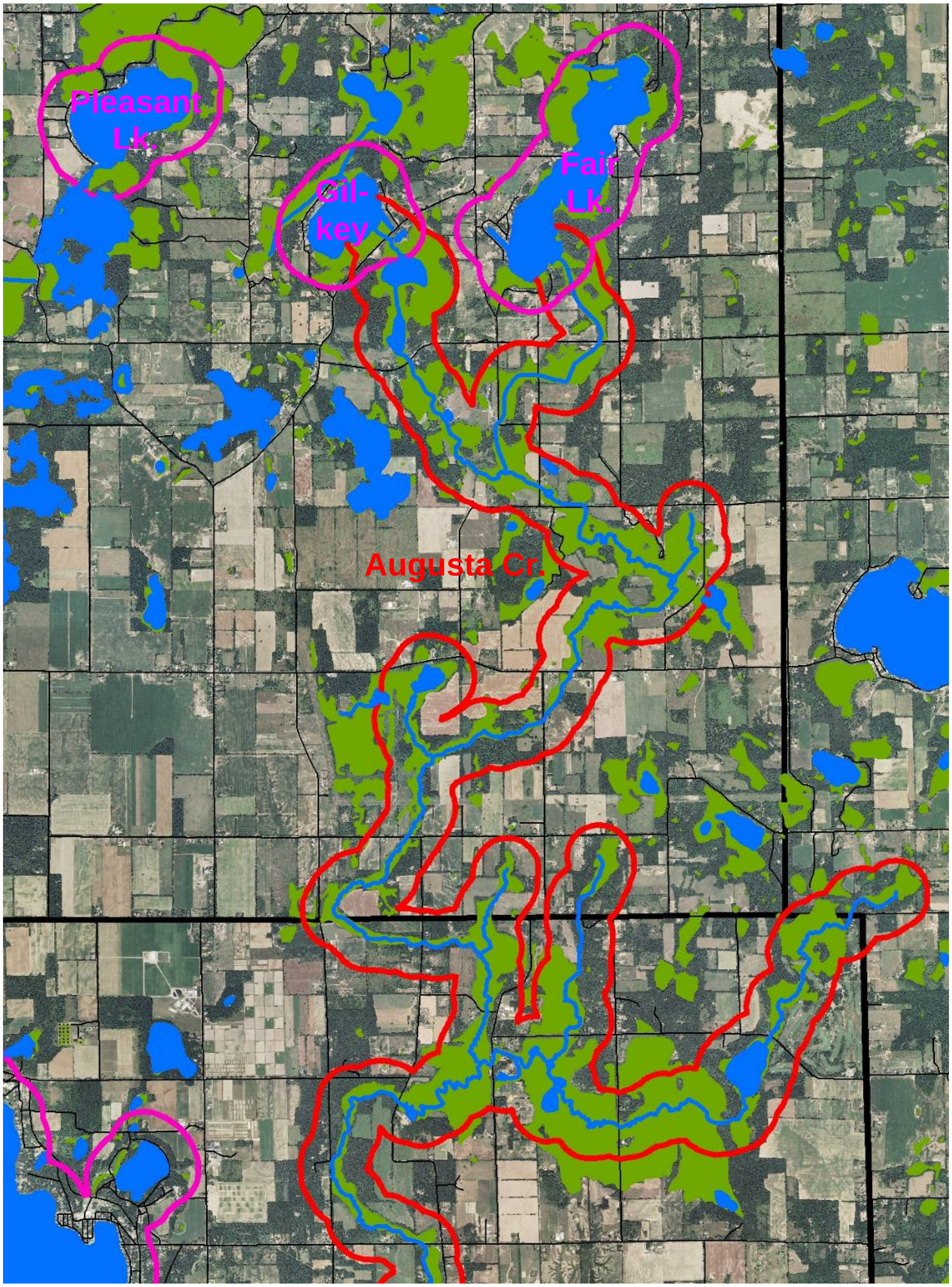

Figure 22. Riparian Areas for upper Augusta Creek and for Pleasant, Gilkey and Fair lakes. Permanent waterbodies are blue, wetlands are green, and township boundaries are thick black lines.

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, whereas the Riparian Areas described in this section were selected as the focus for efforts to stem non-point source pollution to 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, and if that land is also a PCA, then there is the further motivation to preserve it from the standpoint of biodiversity.

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 could include removal of dams, 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 (i.e., within the Riparian Areas), and reinstalling buffers of native vegetation at lakeside residences.

9 Goals, Objectives, and Implementation Strategies

Successful implementation of a watershed management plan is more likely to occur when the objectives are based on clearly defined goals. Goals can represent a long-term vision and also serve as guideposts established to keep everyone moving in the same direction and assess 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 Riparian Areas.

2. Mitigate non-point sources of pollution in storm-sewered areas and in Riparian Areas, particularly where there is current agriculture or residential/urban development.

3. Restore natural hydrological regimes in streams and natural ecosystems within Riparian Areas where opportunities exist.

Objectives for these goals are listed in Table 17 and linked to the reduction of pollutants.

Table 17. 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 1-20 within Riparian Areas				
Other Indigenous Aquatic Life and Wildlife: Impaired - Whole FTWA under 2001 TMDL for excess algal growth, phosphorus (total); impairment in downstream Lake Allegan	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 1-20 for a phosphorus load prevention of 4,208 lbs/yr (Appendix 8).
	3. Unstable flow (K)	Stormwater runoff (P)	Loss of floodplains and wetlands as retention. Discharge from impervious surfaces and developed areas.	Protect all PCAs 1-20 for a phosphorus load prevention of 4,208 lbs/yr (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 - Whole FTWA under 2001 TMDL for excess algal growth, phosphorus (total); impairment in downstream Lake Allegan	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 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).
		Septic system failures and illicit connections (S)	Improperly designed, installed, and maintained septic systems. Unknown illicit connections.	Identify and correct 100% of 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, 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.	Inventory shoreline sites 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 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)
		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 80 lbs/yr (Appendix 8).
		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.	Inventory shoreline sites 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 80 lbs/yr (Appendix 8).
	4. Temperature (S)	Lack of riparian habitat or habitat modification	Due to agriculture and urban land use and development	Protect all PCAs 1-20 for a phosphorus load prevention of 4,208 lbs/yr (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 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)
		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.

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.	Inventory shoreline sites 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 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 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 Augusta Creek Riparian Area				
Other Indigenous Aquatic Life and Wildlife: Impaired - Whole FTWA under 2001 TMDL for excess algal growth, phosphorus (total); impairment in downstream Lake Allegan	6. Habitat fragmentation (S)	Loss of habitat (K)	Filling and draining of wetlands. Development of open space for agriculture and urban development.	Identify potential restoration sites including additional PCAs in creeks outside of original four townships.

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

9.2 Implementation Strategies

Table 18 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 18, 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 area to work in first. Most rankings are self-explanatory but the following details clarify a few actions.

- Action 4 - subwatersheds with the higher densities of agricultural land use rank higher.
- Action 5 – subwatersheds with the more manure spreading rank higher.
- Action 6 – waterbodies with higher population densities rank higher; also those studied previously by the FTWRC rank higher than others.
- Action 10 – erosion sites with the higher potential load reductions rank higher.
- Action 12 – subwatersheds with higher known levels of concern rank higher.

Since resources will probably not be available to implement all of the tasks at once, Table 18 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 18 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 18. 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 within the Riparian Areas.										
1. Conservation Easements - Protect wetlands and adjacent natural lands	Protect all PCAs 1-20 for a phosphorus load prevention of 4,208 lbs/yr (Appendix 8) (habitat fragmentation, unstable flow, and temperature)	High - Prairieville Creek Riparian Area including PCA3	$1,000,000 for first 86 acres; 50% within PCA3 and 50% adjacent to PCA3 wetlands	High	in progress	Private landowners (unnamed); SWMLC, FTWRC	Nearly complete MDNRE 319 grant; $500,000 federal grant; $500,000 landowner match donation	Near completion of approximately 43 acres of PCA3 By 2020: 100 additional acres of PCA preserved	# Acres protected; Estimate pollutant loading increase prevented	PCA loading Table A8-2.
	Protect all PCAs 1-20 for a phosphorus load prevention of 4,208 lbs/yr (Appendix 8) (habitat fragmentation, unstable flow, and temperature)	High - Augusta Creek Riparian Area including PCAs 6, 7, 8, 9, 10, 11, 15	$2,000-$8,000 per acre for purchase;$1,000-$6,000 for conservation easement	High	0-3 years	Private landowners (unnamed); FTWRC	MDNRE 319, other grants; landowner donation	100 acres by 2015; 250 acres by 2020	# Acres protected; Estimate pollutant loading increase prevented	PCA loading Table A8-2.
	Protect all PCAs 1-20 for a phosphorus load prevention of 4,208 lbs/yr (Appendix 8) (habitat fragmentation, unstable flow, and temperature)	Medium - Spring Brook Riparian Area including PCA 20; Gull Creek Riparian Area including PCAs 17, 18; Silver Creek Riparian Areas Low - Comstock Creek Riparian Areas	$2,000-$8,000 per acre for purchase;$1,000-$6,000 for conservation easement	High	3-6 years	Private landowners (unnamed); FTWRC	MDNRE 319, other grants; landowner donation	100 acres by 2020	# Acres protected; Estimate pollutant loading increase prevented	PCA loading Table A8-2.
2. Enact or improve water quality protection related ordinances including 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 (nutrients, sediment, unstable flow); 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) (sediment)	Throughout FTWA	$10,000 per municipality	High	in progress	Municipalities	Municipalities, MDNRE	By 2015: 2 Municipalities By 2020: 4 Municipalities	Number of ordinances enacted; Number of municipalities with ordinances	NA

3. Enact ordinances protecting riparian buffers	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) (sediment); Encourage infiltration in urban/urbanizing areas, implement watershed focused land-use planning and stormwater management to achieve a 100% onsite stormwater use or infiltration (sediment, nutrients); Stabilize stream flows to moderate hydrology, reduce suspended solids, and maintain the floodplain (nutrients)	Throughout FTWA	$2,500 per municipality	High	3-6 years	Municipalities	Municipalities, MDNRE	By 2015: 2 Municipalities By 2020: 4 Municipalities	Number of municipalities with ordinances	NA
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.										
4. Install agricultural BMPs BMP type *-Filter Strips*	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);	High – Gull Creek Mouth; Upper Augusta Creek; Comstock Creek Medium – Gull Creek; Spring Brook; Silver Creek Low – Middle Augusta Creek	Depends on practice	High	0-3 years	Landowners (NRCS, Conservation Districts)	Farm Bill	By 2015: 4 landowners By 2020: 8 landowners	Number of acres; estimate load reduction; number of landowners; before and after photos	BMP loading Table A3-1
5. Develop and implement manure management plans	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).	High – Gull Creek Medium – Augusta Creek Middle, Spring Brook Low – All other areas	$4,000 - $10,000/plan (depends on the number of animals)	High	in progress	Landowners (NRCS, Conservation Districts)	Farm Bill Programs, Michigan Environmental Assurance Program (technical assistance)	By 2015: 4 new plans By 2020: all farms covered	Number of plans developed	NA
6. Assess stormwater management needs at built-out lakes	Inventory shoreline sites and implement BMPs to reduce total FTWA urban loading of phosphorus by 2,259 lbs/yr (Appendix 8) (nutrients, sediment, unstable flow)	High – Gull Lake Medium – Pine Lake, Upper Crooked Lake, Sherman Lake Low – Other developed/developing lakes	Inventory stormwater conveyances; estimate loads; sample; prioritize - $100,000 per large lakes, less for smaller	Medium	0-3 years	FTWRC/GLQO	MDNRE 319	By 2015: High ranked lake complete By 2020: Medium ranked lakes complete	Surveys of local community satisfaction	Depends on BMPs implemented following inventory; Table A3-1

7. Utilize stormwater BMPs BMP type *-Dry detention* *-Wet retention* *-Swales* *- Rain Garden* *-Constructed Wetlands*	Implement BMPs to reduce total FTWA urban loading of phosphorus by 2,259 lbs/yr (Appendix 8) (nutrients, sediment, unstable flow); Stabilize stream flows to moderate hydrology, reduce suspended solids, and maintain the floodplain (nutrients, sediment, unstable flow)	Throughout FTWA	Depends on practice	High	in progress	Municipalities, Drain and Road Commission	Municipalities, MDNRE 319	ongoing	Number of municipalities using practices; Estimate of pollutant loading reduction; before and after photos	BMP loading Table A3-1
8. Identify and correct illicit discharges to surface waters	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 (none known at present)	$500-$5,000 per site	Medium	in progress	Road and Drain Commissions per IDEP; County Health Deparment	Drain Commission, Municipalities, Road Commission	Ongoing	Number of connections or discharges identified and corrected	NA
9. Support municipal lawn fertilizer phosphorus restrictions	Encourage infiltration in urban/urbanizing areas, implement watershed focused land-use planning and stormwater management to achieve a 100% onsite stormwater use or infiltration (nutrients)	Throughout FTWA	$2,000/county	High	0-3 years	Municipalities, FTWRC, partners	In-Kind Donations	Allegan done; 1 county in 2 years; 2 in 3 years Statewide action pending	Number of counties with rules	NA
10. Identify and correct problem road/stream crossings	Repair identified problem sites for phosphorus load reduction of 80 lbs/yr (Appendix 8) (sediment)	High – Bendere Rd. at Little Long Lake; Hickory Rd. at Prairieville Cr. Medium – Silver Creek at Riverview Dr. (2010 culvert replacement pending); 45th St between C and B Ave. crossing Augusta Creek Low – other sites	$5,000-$15,000 per site	Medium	in progress	County road commissions, FTWRC, citizen referrals	Road Commission, municipalities	2 sites by 2015; all known problem sites by 2020	Number corrected; Estimate load reduction; before and after photos	Erosion site loading Table A8-4
11. Promote identification and correction of failing septic systems	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	$200-$6,000/system	Medium	in progress	County Health Department, citizen referrals	USDA Rural Development	By 2020: 4 systems	Number of systems; estimate load reduction	NA

12. Conduct additional pathogen genetic source tracking studies	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); 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).	High – Gull Creek, Augusta Creek Medium – Spring Brook Low – Comstock Creek, Silver Creek	$100 per sample	NA	in progress	FTWRC, GLQO, Kalamazoo County	Grants	By 2012 establish baseline	Statistically significant baseline of pathogen load established	NA
13. Promote use of household hazardous waste collection	Encourage infiltration in urban/urbanizing areas, implement watershed focused land-use planning and stormwater management to achieve a 100% onsite stormwater use or infiltration (nutrients, other); 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, other)	Throughout FTWA	$100 per public service message	Medium	0-3 years	County; FTWRC	Grants	Ongoing - annual reminders to stakeholders	Annual release	NA
14. Promote private drinking water well testing	Encourage infiltration in urban/urbanizing areas, implement watershed focused land-use planning and stormwater management to achieve a 100% onsite stormwater use or infiltration (nutrients); 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	Cost per kit	Low	0-3 years	County Health Department	General funds	Ongoing promotion	Number of kits utilized annually	NA
Goal No. 3 – Restore natural hydrological regimes in streams and natural ecosystems within Riparian Areas where opportunities exist.										
15. Prairie fen management	Identify potential restoration sites including additional PCAs in creeks outside of original four townships. (habitat fragmentation)	PCAs containing fens	$2,000-$8,000 per acre for purchase;$1,000-$6,000 for conservation easement	Low	0-3 years	FTWRC	Grants; landowner match	Add a management area by 2015	Added area	NA
16. Dam removals	Identify potential restoration sites including additional PCAs in creeks outside of original four townships. (habitat fragmentation)	Small dams along Augusta Creek	$50,000 – $250,000 per dam	Low	3-6 years	FTWRC	Grants; landowner match	2 dams by 2020	Dams removed; before and after photos	NA
17. Upland prairie restoration	Identify potential restoration sites including additional PCAs in creeks outside of original four townships. (habitat fragmentation)	Augusta Creek MDNRE land	$3,100 - $10,000 per acre (source Prairie Restoration Inc.)	Low	0-3 years	FTWRC	Grants; landowner match	Add a management area by 2015	Added area	NA

BMP Best Management Practice, PCA Priority Conservation Area, SWMLC Southwest Michigan Land Conservancy, FTRWC Four Township Water Resources Council, MDNRE Michigan Department of Natural Resources and Environment
FTWA Four Township Watershed Area, NRCS Natural Resource Conservation Service, GLQO Gull Lake Quality Organization, NA – not applicable/available

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 19 lists the Desired Uses identified through stakeholder input and research.

Table 19. 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 9)

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
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
2. Minimize modification of sensitive habitat areas such as stream corridors

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

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. 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 18. The I&E

plan provides goals and outlines the relationship between target audiences, watershed issues and outreach activities (Appendix 9).

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.

Wetland restoration and protection activities are clearly important in the FTWA. A targeted wetland restoration and protection project based on the Landscape Level Wetland Functional Assessment in conjunction with an educational campaign to landowners and municipal officials would be extremely helpful in advancing the wetland related tasks in the action plan. MDNRE performs landscape level analysis to better understand the functions of existing and lost wetlands. The results from such analysis can be utilized to locate wetlands with important functions such as protecting water quality, providing habitat and reducing flood impacts in the watershed. The results can help pinpoint potential restoration, enhancement, and protection activities to appropriate areas of the watershed that are most in need of a particular wetland function. These functions include 1) surface-water detention 2) streamflow maintenance 3) nutrient transformation 4) sediment and other particulate retention 5) shoreline stabilization 6) provision of fish and shellfish habitat 7) provision of waterfowl and waterbird habitat 8) provision of other wildlife habitat, and 9) conservation of biodiversity (rare or imperiled wetland habitats in the local region with regional significance for biodiversity).

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 9.

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 18 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 MDNRE Surface Water Assessment Section. The last basin rotation occurred during the 2009 field season and the report should be released in late 2010. 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 20 details monitoring components for prioritized pollutants and suggests evaluation criteria in light of current conditions. Table 21 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 6, Table 18, 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 20. 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	MDNRE, FTWRC, GLQO, MSU	Long term (Assess in 2014 and every 5 years after)	Degree of embeddedness	Not known, baseline needed	Maintain or reduce embeddedness
	Macro-invertebrate sampling	MDNRE, FTWRC, MSU	Long term (Assess in 2014 and every 5 years after)	Numerical score based on quantity and diversity	Excellent (Gull, Augusta Creeks), Acceptable (Springbrook, Comstock Creeks) – (MDEQ 2005); Acceptable (Silver Cr.) – MDEQ 2000)	Maintain "excellent" scores, increase scores for "acceptable" stream stretches
2. Nutrients	Water quality	MDNRE, 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, MDNRE, MSU	Short term (2011) 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	MDNRE, County Health Department, FTWRC, GLQO, MSU	Short term (2011) 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 have occured in surface water samples of Augusta and Prairieville Creeks (FTWRC 2010). Average *E. coli* 2001-2008: Spring Brook (233); Augusta Creek (223); Prairieville Creek (165); Little Long Lake Outlet (148); Gull Creek (94). Kalamazoo County (2009)	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 livestock 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	MDNRE, 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	Increase permanently protected lands
	MDNRE habitat survey	MDNRE	Long term (Assess in 2014 and every 5 years after)	Habitat evaluation score	Excellent – Non-impaired (Springbrook, 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
MDNRE Michigan Department of Natural Resources and Environment
FTWA Four Township Watershed Area
GLQO Gull Lake Quality Organization
MSU Michigan State University

Table 21.Environmental Monitoring Summary.

Organization	Monitoring Site	Type of Analysis	Protocol	Current Monitoring	Recommended Future Monitoring	Test Agent
MDNRE	Basin rotation stream sites change from year to year	Macroinvertebrate survey	MDNRE Protocol Procedure 51	Conducted in 2009	Once every 5 years (2014)	MDNRE
		Habitat survey	USEPA Rapid Bioassess-ment	Conducted in 2009	Once every 5 years (2014)	MDNRE
		Water Chemistry TP, TN, DO, Metals	MDNRE	No current routine monitoring in FTWA	As needed based on identified concerns	MDNRE
		E. coli	*E. coli* MPN/100ml	No current routine monitoring in FTWA	As needed based on identified concerns	MDNRE
MDNRE 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	MDNRE	Monthly grabs during growing season since 2001	Monthly	MDNRE and Wastewater Treatment Facility Labs
MDNRE 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 MDNRE assessment schedule	MDNRE
	Augusta Ck. (Wesley, 2005), Gull Lake (Dexter, 1991), Spring Brook (Dexter, 1992), Silver Creek (Dexter 1993)	Fishery survey	MDNRE	Last monitored early 1990's	Per MDNRE assessment schedule	MDNRE
County Health Department	Public beach – Ross Township Park, Robert Morris Park	*E. coli*	*E. coli* MPN/100ml	Weekly during annual use season since 2001	Weekly during annual use season	Kalamazoo County Health Department

Organization	Monitoring Site	Type of Analysis	Protocol	Current Monitoring	Recommended Future Monitoring	Test Agent
	Streams – Spring Brook, Augusta, Gull Creeks	*E. coli*	*E. coli* MPN/100ml	Weekly during annual use season	Weekly during annual use season	Kalamazoo County Health Department
	All listed above	Water quality parameters temperature, DO, pH, conductivity, turbidity	County	Weekly during annual use season	Weekly during annual use season	Kalamazoo County Health Department
FTWRC and GLQO	Streams – Prairieville Creek (2 sites), Augusta Creek (4 sites in Barry Co.) Lake – Little Long	*E. coli*	*E. coli* MPN/100ml	Current agreement and grant supplements Kalamazoo County monitoring, monthly since 2008	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 Community Foundation Grant provided resources for sampling program in July and October 2009	1-2 additional field seasons during use season during dry and wet weather conditions	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

Organization	Monitoring Site	Type of Analysis	Protocol	Current Monitoring	Recommended Future Monitoring	Test Agent
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
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 MDNRE Pollutants Controlled; targeted monitoring	NA	Targeted study over 1-2 seasons at high priority sites	All

TP – Total phosphorus, TN – Total nitrogen, DO – Dissolved oxygen, SRP – Soluble reactive phosphorus, TDP – Total dissolved phosphorus
FTRWC Four Township Water Resources Council
MDNRE Michigan Department of Natural Resources and Environment
FTWA Four Township Watershed Area
GLQO Gull Lake Quality Organization
MSU Michigan State University – researchers
USEPA United Stated Environmental Protection Agency

CLMP – Cooperative Lakes Monitoring Program
LTER – Long Term Ecological Research

Data sources online:

MDNRE 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/

Two additional monitoring efforts should be considered including: 1) Low flow monitoring for new water withdrawal permit process; and, 2) Continued E.coli monitoring in cooperation with research institutions and Kalamazoo County.

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 18, 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 18) 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.

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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Appendix 1. National Pollutant Discharge Elimination System Permits Regulated by the Michigan Department of Natural Resources and Environment in the Four Township Watershed Area as of June 2010.

Confined Animal Feeding Operations

Name/Designated Name	**Primary Species**	**Permit No.**	**County**	**Location Address 1**	**Total Animal Units**	**Source**
Liberty Beef Farms-CAFO	BEEF	MIG010139	Kalamazoo	29th Street, Richland 49083	1990	MNDRE CAFO List
Prairie View Dairy LLC-CAFO	DAIRY	MIG010123	Barry	12850 Parker Road, Delton 49046	2220	MDNRE CAFO List
Hickory Gables, Inc.	DAIRY	MI0058276	Barry	Cressy Rd., Hickory Corners 49060	2341	MDNRE CAFO List
Cary Dairy Farm	DAIRY	MIGO10087	Augusta Creek	6625 Poorman Rd. Battle Creek 49017		MDNRE - Hohm

Industrial Stormwater Permits

Waterbody Name	Facility Name	Location	Type
Pine Lake	Mar-Bil Marine	11261 Sunset Point, Plainwell 49080	Stormwater permit MIS110323
Pine Lake	Pine Lake Boat & Motor Co., Inc.	11730 Lindsey Road, Plainwell 49080	Stormwater permit MIS111556

Appendix 2. Analysis of Water Quality Planning and Zoning Techniques (LSL, 2007)

Analysis of Water Quality
Planning and Zoning Techniques

Ross Township
Richland Township
Prairieville Township
Barry Township

LSL Planning, Inc.
Community Planning Consultants

November 1, 2007

Table of Contents

Summary of Findings

This report reviews existing studies, plans and regulations relevant to the Gull Lake watershed and describes how Ross, Richland, Barry and Prairieville Townships currently address watershed planning and related regulations. These are primarily directed to water quality protection, and include: water resource and wetland protection; open space preservation; lake shoreland and stream corridor preservation; and lake access and overcrowding. A summary of how each community plans for and protects these resources is included in Tables 3 and 4.

Land use planning and zoning dictate, to a large extent, the density, type and location of future development. Prairieville, Ross and Richland Townships have local authority for planning and zoning, but Barry Township relies on the Barry County Master Plan and Zoning Ordinance. While Gull Lake and other nearby inland lakes are largely viewed as developed there still is potential for each community to do more to protect the long-term quality of their waterfronts by implementing regulations that require such things as vegetative buffers, reducing impervious surfaces and preserving natural features.

Master Plans

A master plan describes a community, outlines its goals and objectives, explains its land use policies and maps future land uses. Efforts to protect watersheds and their related resources are also important elements of a master plan. They provide the justification to regulate activities within them and to implement watershed protection measures that have the proper "governmental interest" in mind. Having a well documented master plan not only provides sufficient legal support to protect watersheds, but it can also express a community's commitment to do so.

Overall, each community's master plan discusses the importance of natural resources, such as surface water protection and supports progressive waterfront zoning regulations. However, while Richland Township has incorporated watershed language similar to the other three townships, its plan could be enhanced by additional natural resource maps and materials, such as natural feature inventories.

Zoning Ordinances

The Gull Lake watershed has been the focus of many previous planning efforts. An example is the work by the Four Township Water Resource Council that proposed several model zoning techniques to all four townships to help minimize the potential for overdevelopment and congestion along lakefronts. One of the recommendations dealt with funnel or keyhole provisions to address development that occurs when a waterfront lot provides lake access to non-waterfront properties. Of particular concern in these situations is lakefront congestion and decreased water quality due to increased surface water runoff caused by such things as compacted soils (due to increased pedestrian and vehicular traffic) and impervious surfaces. All four communities now protect Gull Lake, to varying degrees, from this type of development; a comparison is shown in Table 1 on pages four through six.

Another zoning technique promoted by the Council was "open space (cluster) development." With open space development a community can accommodate development and preserve important natural features (such as wetlands, steeply sloped lands, forested areas, stream corridors, or lake shorelands). All four communities have adopted model zoning regulations that permit open space cluster development, which is also required under Michigan's Zoning Enabling Act.

Future Recommendations

While the recommendations related to keyhole and cluster development proposed by the Four Township Water Resource Council are an excellent start, additional zoning tools are available to protect area-wide water quality. These include an extensive list that is available through the Council's website. An example is the comprehensive site plan review standards that emphasize environmental protection, setbacks from natural features, deferred parking and land clearing provisions. A complete list of these tools is included in Tables 5-8, which indicates for each township the level of commitment to protect water quality. The planning tools are categorized by their objective, for example, groundwater or surface water protection. The techniques are then ranked on a scale from 'minimal' to 'substantial' based on their effectiveness to provide environmental protection and they range from community based regulations to private property owner initiatives. Definitions for the various tools are listed at the back of this document.

Table I Comparison of Waterfront Regulations

	Ross Twp.	Richland Twp.	Barry Twp. (County Zoning Ordinance last updated in 2002)	Prairieville Twp.
Minimum Lot Width	Min. district requirement ranges from 75 ft. to 100 ft.	Min. district requirement 100 ft.	100 ft.	150 ft.
Wetland Exemption for Required Lot Width	Wetlands not included in width requirement	Wetlands not included in width requirement	50% of wetland shoreline can count toward width requirement	Wetlands not included in width requirement
Minimum Lot Depth	Min. district requirement	Min. district requirement	100 ft.	75 ft.
Minimum Lot Area by Zoning District	R-1 District: 20,000 sq. ft. R-2 District: 15,000 sq. ft.	A District: 20,000 sq. ft.	RL-1 District: 24,000 sq. ft. RL-2 District: 12,000 sq. ft.	R-1 District: water & sewer: 9,350 sq. ft.

Table I Comparison of Waterfront Regulations

	Ross Twp.	Richland Twp.	Barry Twp. (County Zoning Ordinance last updated in 2002)	Prairieville Twp.
				R-2 District: water & sewer: 8,000 sq. ft.
Building Setback from Water	50 ft. or average setback of nearest dwellings 25 ft. for accessory building	50 ft. or setback at a reasonable horizontal line of sight from adjacent buildings	RL-1 District – 35 ft. from ordinary high water mark RL-2 District – 30 ft. from ordinary high water mark	35 ft.
Building Height	35 ft. for dwelling 18 ft. for accessory buildings	35 ft. for dwelling 20 ft. for accessory buildings	No limit for single family 16 ft. for accessory buildings	No limit for single family 2 stories only for multi-family
Access Regulations	Minimum lot width: 75 ft. to 100 ft. (depends on district), plus 30 feet for each additional access lot Access lots cannot be used for boat launches	Minimum lot width per access : 100 ft.	2 access rights for 100 ft. Each additional access right requires 100 ft.; anything over requires special land use approval closely analyzing lake carrying capacity	150 ft. for one access right plus 20 feet per each additional access right
Site Plan Review	None required for additional access lots	Site plan review required for lots with more than one water access	None required for additional access lots	Site plan review required for lots serving more than two users
Natural Buffer Requirement	None along waterway	None along waterway	15 foot wide native vegetation strip along water	None along waterway
Docks	One dock per frontage, plus additional docks for each additional buildable lot area	Docks can't be closer than 50 ft. to a property line	One dock per access Docks can't be closer than 30 ft. to a property line	One dock for each 75 feet of frontage; docks can't be closer than 10 ft. to a property line

Table I Comparison of Waterfront Regulations

	Ross Twp.	Richland Twp.	Barry Twp. (County Zoning Ordinance last updated in 2002)	Prairieville Twp.
	Docks can't extend out in water more than 50 feet or within 10 feet to center of water Docks can't be closer than 10 ft. to a side lot line			
Channelization	Not addressed	Not allowed to create more frontage	Not addressed for lakefront. Allowed in Natural River area if approved by MDNR	Not addressed
Boathouses	Not allowed	Boathouses allowed as a special land use; subject to four conditions* Boat houses allowed for commercial uses as special land use	Not addressed One portable storage unit no greater than 64 sq. ft. allowed; setback at least 20 ft. from the native vegetation setback	Boathouses allowed as a special land use; subject to four conditions*
Lot Coverage Requirement	Maximum 25% to 30%	Maximum 25% to 30%; applies to buildings and structures not parking lots	Accessory buildings in RL-1 District can't exceed 1,024 sq. ft.	No requirement

* Four conditions include:
1. Be located adjacent to a navigable body of water, with no minimum setback
2. Be used to store one or more boats and boating accessories
3. Be established in compliance with applicable state and local laws
4. Complies with all size, height and location requirements for accessory buildings

Table 2 Comparison of Waterfront Building Regulations

	Ross Twp.	Richland Twp.	Barry Twp.	Prairieville Twp.
Maximum Building Coverage	R-1 – 15% R-2 – 20%	A-1 & A-2 - 30%	No maximum for single family; accessory buildings in RL-1 District can't exceed 1,024 sq. ft.	No maximum for single family
Minimum Floor Area	Single family- 1,040 sq. ft.	Single family-1,000 sq. ft.	RL-1- minimum core area of 24 ft. RL-2- 720 sq. ft.	Single family – 840 sq. ft.
Maximum Building Height	35 ft.	35 ft.	No maximum for single family; accessory buildings can't exceed 16 ft. or 1 story	No maximum for single family; multi-family - 2 story maximum
Nonconforming Lot Development Requirements	50 ft. waterway setback; other yard dimensions can be reduced based on a formula	Must meet district requirements	Formula for reduced front and side yards	Zoning Administrator determines waterfront setback based on surrounding setbacks

Table 3 Comparison of Water Protection Tools in Zoning Ordinances *

		Ross Twp.	Richland Twp.	Barry Twp.	Prairieville Twp.
Objective	Tool				
WATER QUALITY PROTECTION	Wetlands Ordinance				
	Soil Erosion/Sedimentation Control			✓	
	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		✓		
LAKE ACCSESS	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		✓		

Table 3 Comparison of Water Protection Tools in Zoning Ordinances *

		Ross Twp.	Richland Twp.	Barry Twp.	Prairieville Twp.
Objective	Tool				
SENSITIVE AREAS PROTECTION	Conservation Easements				
	Open Space/Cluster Development	✓	✓	✓	✓
	Purchase of Development Rights			✓	✓
	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 at the end of this document.

Table 4 Comparison of Water Protection Tools in Master Plans*

	Ross Twp.	Richland Twp.	Barry Twp.	Prairieville Twp.
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		✓	✓	

*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.

ROSS TOWNSHIP (*excerpts from the current Master Plan related to water quality*)

Goal: Protect the Quality of the Township's Ground and Surface Waters.

Supporting Statement: The highest intensity of land uses within the Township occurs around its major bodies of water. At the same time, individual wells provide the source of water for residents and business. The quality of both of these resources must be protected to sustain the viability of the Township for living, working, and recreation.

Objectives:

a. Identify environmentally sensitive areas along the Kalamazoo River, Augusta Creek and Township lakes, ponds, tributaries and wetlands to preserve for plant, wildlife and fish habitat.
b. Preserve surface water quality by establishing buffer regulations along rivers, streams, lakes and wetlands. Work with private watershed groups and community organizations to establish a comprehensive approach to water resource protection.
c. Continue to be active in the Four Township Water Resources Council, and support its mission of Farmland, Open Space and Water Quality Protection.
d. Promote storm water management practices throughout the Township.
e. Prevent potential groundwater contamination from individual septic systems, agricultural activities and industrial/commercial processes.
f. When demand requires, consider wellhead protection program for potential municipal wells. Establish measures that will preclude over-utilization of the Township's lakes.

ROSS TOWNSHIP ZONING REGULATIONS – *bold text indicates current regulations*

Table 5 SUMMARY OF REGULATORY TECHNIQUES FOR WATERSHEDS

	Degree of Effectiveness		
Objective	Substantial	Modest	Minimal

Table 5 SUMMARY OF REGULATORY TECHNIQUES FOR WATERSHEDS

	Degree of Effectiveness		
Objective	Substantial	Modest	Minimal
Water Quality Protection	NREPA * Wetland Protection Ordinance	Shoreline Vegetation Cover Restrictions	**Site Plan Review** *Lacks sufficient site plan review requirements; could be stronger. Site Plan Review standards only mention natural features that provide screening but not resource protection.*
	Soil Erosion/Sedimentation Ordinance	**Building/Septic Field Setbacks** *Building, but not septic fields.*	Fertilizer Restriction Ordinances
Water Quality Protection (cont.)	Natural Rivers Act	Impervious Surface Restrictions	Fertilizer Restriction Ordinances
	Stormwater Control Ordinance	**Floodplain Regulations** *Floodplain, Floodway and Flood fringe Reg.*	
Lake Access	Anti-Funneling Ordinance	Dock/Marina Regulations	Site Plan Review
	Carrying Capacity Restrictions	Lot Width/Density Provisions	Motor Restrictions/No Wake Restrictions
Sensitive Areas Protection	Conservation Easements	Planned Unit Development	**Master Plan** *Good discussion; but zoning ordinance could be strengthened.*
	Open Space/Cluster Development *Adopted model language from 4 Township Water Resource Council*	Overlay Zoning	Tree Preservation Ordinances
	Purchase of Development Rights		Large Lot Zoning
	Transfer of Development Rights (Non-Contiguous PUD)	Site Plan Review Requirements	Zoning Setbacks

Table 5 SUMMARY OF REGULATORY TECHNIQUES FOR WATERSHEDS

Degree of Effectiveness			
Objective	Substantial	Modest	Minimal

Notes: A complete set of natural resource definitions is included at the end of this document.
*NREPA: Natural Resource Environmental Protection Act, known as Act 451 of 1994. State act that combined numerous state environmental laws into one code, encompassing:

- Shorelands Protection and Management (Part 323)
- Wetlands Protection (Part 303)
- Surface Water and Floodplain Protection (Part 31)
- Soil and Sedimentation Control (Part 91)

RICHLAND TOWNSHIP (*excerpts from current Master Plan related to water quality*)

Goal: Retain the natural beauty and resources that have attracted people to settle in the Township while at the same time advancing the Township's opportunities for desirable growth consistent with the wishes of the residents to remain a "rural" residential community.

Water Resource Objective

Maintain the quantity and quality of the Township's surface and ground water supply.

Policy:

1. Prevent water pollution problems by guiding residential development into clustered patterns where it becomes more economical to sewer than if they were spread out indiscriminately.
2. Protect ground water sources by relating land use activities to selected areas containing soils and drainage suitable for septic tank development.
3. Filling or dredging lake shore frontage to increase its usefulness for building should be controlled so that no detrimental effect is created.
4. Minimize the pollution of surface waters by enforcing appropriate density controls and building setback standards.

RICHLAND TOWNSHIP ZONING ORDINANCE – *bold text indicates current regulations*

Table 6 SUMMARY OF REGULATORY TECHNIQUES FOR WATERSHEDS

	Degree of Effectiveness		
Objective	Substantial	Modest	Minimal
Surface Water Quality Protection	NREPA * Wetland Protection Ordinance	Shoreline Vegetation Cover Restrictions	**Site Plan Review** *Basic environmental standards for identification; lacks review standard.*
	Soil Erosion/Sedimentation Ordinance	**Building/Septic Field Setbacks** *50 ft. waterfront setback in Recreation/Open Space District*	**Fertilizer Restriction Ordinances** *Unique phosphorus detergent ordinance adopted in 1971 that bans any detergent over 8.7% phosphorus content.*
	Natural Rivers Act	Impervious Surface Restrictions	
	Stormwater Control Ordinance	Floodplain Regulations	
Lake Access	Anti-Funneling Ordinance Provisions	Dock/Marina Regulations	Site Plan Review
	Carrying Capacity Restrictions	Lot Width/Density Provisions	Motor Restrictions/ No Wake Restrictions
Sensitive Areas Protection	Conservation Easements	Planned Unit Development	Master Plan
	Open Space/Cluster Development	Overlay Zoning	Tree Preservation Ordinances
	Purchase of Development Rights		Large Lot Zoning
	Transfer of Development Rights (Non-Contiguous PUD)	**Site Plan Review Requirements**	**Zoning Setbacks** *50 ft. setback*

Degree of Effectiveness			
Objective	Substantial	Modest	Minimal

Notes: A complete set of natural resource definitions is included at the end of this document.
*NREPA: Natural Resource Environmental Protection Act, known as Act 451 of 1994. State act that combined numerous state environmental laws into one code, encompassing:

- Shorelands Protection and Management (Part 323)
- Wetlands Protection (Part 303)
- Surface Water and Floodplain Protection (Part 31)
- Soil and Sedimentation Control (Part 91)

PRAIRIEVILLE TOWNSHIP - Master Plan Evaluation for Water Resource Protection

PRAIRIEVILLE TOWNSHIP (*excerpts from current Master Plan related to water quality***)**

Goals

- Strive to protect environmental resources, such as rivers, lakes, wetlands and woodlands from the negative effects of new development.
- Create contiguous areas of open land to protect and promote the preservation of wildlife habitats, woodlands and water quality for the long-term health of the community and public enjoyment of the natural environment.

Policies

1) The Township, through review of development plans, will ensure that development takes place in an environmentally consistent and sound manner by minimizing potential soil erosion, disturbances to the natural drainage network, and protecting the quality of surface and groundwater resources, open space areas, wetlands, and woodlands.
2) Promote the preservation and restoration of sensitive natural resources, such as wetlands and water bodies, by implementing natural feature setbacks to filter sediments and contaminants that lead to environmental degradation.
3) Through zoning, site plan review and education, encourage approaches to land development that effectively integrate the preservation of natural features such as soils, topography, steep slopes, hydrology, air quality, unique views and vistas, and natural vegetation into the process of site design.

4) Utilize the resources of the Four Township Water Resource Council for environmental regulation models, such as site plan review and natural feature overlay language.
5) Adopt residential development measures that prevent the fragmentation of the natural resource base, such as scattered roadside development.
6) Require that site plans show locations of trees and other significant vegetation; topography, with steep slopes highlighted; patterns of surface water drainage; location of groundwater recharge areas and prime farmland soils.
7) To prevent water degradation, the density of lakefront residential development shall be based upon the availability of utilities. Existing developments with aging on-site septic systems should consider construction of new community sanitary sewer systems.
8) Provide density bonus incentives in open space/cluster developments and Planned Unit Developments to preserve natural features.
9) Educate landowners on environmental awareness and utilize the services of the Conservation District, MSU Extension, Four Township Water Resource Council and other agencies for curricula and materials.

Adopted a Waterfront Preservation Overlay within the Future Land Use Section of the Land Use Plan

Implementation: An overlay zone can be applied to multiple zoning districts to ensure the consistent regulation of land uses. Examples include requiring a greenbelt along a natural feature such as a lake, stream or wetland, a consistent development setback from the water's edge and the protection of natural vegetative buffers that act to absorb excess stormwater runoff from adjacent residential uses. The model zoning regulations developed by the Four Township Water Resource Council that incorporate many of these waterfront planning techniques should be used when updating local zoning ordinances.

PRAIRIEVILLE TOWNSHIP ZONING ORDINANCE - *bold text indicates current regulations*

Table 7 SUMMARY OF REGULATORY TECHNIQUES FOR WATERSHEDS

	Degree of Effectiveness		
Objective	Substantial	Modest	Minimal
Surface Water Quality Protection	NREPA * Wetland Protection Ordinance	Shoreline Vegetation Cover Restrictions	**Site Plan Review** *Very thorough site plan review standards and requirements.*
	Soil Erosion/Sedimentation Ordinance	**Building/Septic Field Setbacks** *35 feet setback along water.*	Fertilizer Restriction Ordinances

Table 7 SUMMARY OF REGULATORY TECHNIQUES FOR WATERSHEDS

	Degree of Effectiveness		
Objective	Substantial	Modest	Minimal
	Natural Rivers Act	Impervious Surface Restrictions *Have a lot coverage definition; but no requirement for total lot coverage*	
	Stormwater Control Ordinance	Floodplain Regulations	
Lake Access	Anti-Funneling Ordinance Provisions	Dock/Marina Regulations	Site Plan Review
	Carrying Capacity Restrictions	Lot Width/Density Reductions	Motor Restrictions/ No Wake Restrictions
Sensitive Areas Protection	Conservation Easements	Planned Unit Development	Master Plan
	Open Space/Cluster Development *Very adequate development provisions*	Overlay Zoning	Tree Preservation Ordinances
	Purchase of Development Rights		Large Lot Zoning
	Transfer of Development Rights (Non-Contiguous PUD)	Site Plan Review Requirements	Zoning Setbacks

Notes: A complete set of natural resource definitions is included at the end of this document.
*NREPA: Natural Resource Environmental Protection Act, known as Act 451 of 1994. State act that combined numerous state environmental laws into one code, encompassing:

- Shorelands Protection and Management (Part 323)
- Wetlands Protection (Part 303)
- Surface Water and Floodplain Protection (Part 31)
- Soil and Sedimentation Control (Part 91)

BARRY TOWNSHIP (*Excerpts from current Barry County Master Plan related to water quality*)

Goal

The surface water features of Barry County, including its lakes, wetlands, streams and rivers, will be clean and healthy, supporting a balance of native and natural plant and wildlife communities and a sustainable level of human use.

Objectives:

a. Maintain the existing coverage of filter/buffer requirements of 100' to protect most streams and wetlands in the County and develop techniques for ensuring these buffer areas continue to act as filters for natural areas.
b. Expand and strengthen storm water management standards to reduce the quantity and velocity of runoff, and increase the quality runoff.
c. Implement a program of surface water quality monitoring to develop trend line data for analysis and to serve as a basis for intelligent surface water regulation.
d. Define the environmental carrying capacity of the lakes in the County and employ the resulting analysis to guide land use decisions.

Goal

Groundwater in Barry County will be clean and plentiful with recharge areas protected and development techniques that are attentive to the preservation of this key resource.

Objectives:

a. Inventory wetlands and identify groundwater recharge areas, and evaluate and implement appropriate standards to protect wetland areas of less than five acres and recharge areas.
b. Complete a hydro-geological analysis of groundwater movements in developing areas served by private wells to identify key threats to ground water.

Goal

Storm water management, low impact development and water resources protection will be fundamental decision-making criteria in land use decisions.

Objectives

a. Evaluate and implement a program of time-of-sale inspections for septic tank drainfields.
b. Expand and strengthen storm water management standards to reduce the quantity and velocity of runoff, and increase the quality runoff.

BARRY TOWNSHIP ZONING ORDINANCE - *bold text indicates current regulations*

Table 8 SUMMARY OF REGULATORY TECHNIQUES FOR WATERSHEDS

	Degree of Effectiveness		
Objective	Substantial	Modest	Minimal
Surface Water Quality Protection	NREPA * Local Wetland Protection Ordinance	**Shoreline Vegetation Cover Restrictions** *Waterfront regulations require a 15 foot native vegetation strip.*	**Site Plan Review** *Natural feature identification*
Surface Water Quality Protection (cont.)	**Soil Erosion/Sedimentation Ordinance** *Site Plan Review requires compliance with County*	**Building/Septic Field Setbacks** *At least a 30 feet setback from water bodies.*	Fertilizer Restriction Ordinances
	Natural Rivers Act *Has a Natural River District*	**Impervious Surface Restrictions** *Lot Coverage only includes buildings and not parking lots.*	
	Stormwater Control Ordinance *Rigorous site plan review requirements with PIPP (Pollution Incident Prevention Plan).*	**Floodplain Regulations**	
Lake Access	Anti-Funneling Ordinance Provisions	Dock/Marina Regulations	Site Plan Review
	Carrying Capacity Regulations	Lot Width/Density Provisions	Motor Restrictions/ No Wake Restrictions
Sensitive Areas Protection	Conservation Easements	**Planned Unit Development**	**Master Plan**
	Open Space/Cluster Development *Minimum of 2 houses, maximum of 12 houses per cluster*	Overlay Zoning	Tree Preservation Ordinances

Table 8 SUMMARY OF REGULATORY TECHNIQUES FOR WATERSHEDS

Degree of Effectiveness			
Objective	Substantial	Modest	Minimal
	Purchase of Development Rights *County has ordinance*		**Large Lot Zoning** *Conservation Reserve District has 20 acre minimum lot size*
Sensitive Areas Protection (cont.)	Transfer of Development Rights (Non-Contiguous PUD)	**Site Plan Review Requirements**	**Zoning Setbacks** *Natural River District has a 100 ft. setback from river and 50 ft. setback from tributaries and Conservation Reserve District has a 50 ft. setback from streams and a 25 ft. setback from tributaries.*

Notes: A complete set of natural resource definitions is included at the end of this document.
*NREPA: Natural Resource Environmental Protection Act, known as Act 451 of 1994. State act that combined numerous state environmental laws into one code, encompassing:

- Shorelands Protection and Management (Part 323)
- Wetlands Protection (Part 303)
- Surface Water and Floodplain Protection (Part 31)
- Soil and Sedimentation Control (Part 91)

GLOSSARY OF WATERSHED PLANNING AND ZONING TECHNIQUES	
Density Reductions	Water quality can be protected by lowering development densities, thereby reducing the amount of impervious surfaces such as roads, parking lots, homes, and buildings.
Keyhole Regulations	Keyhole development or funneling occurs when a waterfront lot provides lake access to a development located away from the water. Funneling can allow a large number of homes to gain waterfront access through a small corridor. Unregulated, funneling has the potential to create a number of problems including land use conflicts; unsafe and inadequate access; noise; congestion; degradation of the environment; and decreased property values.
Lot Coverage Limits	Limits on lot coverage are addressed in a zoning ordinance and are defined as the amount of land covered by structures and buildings. Such requirements can be expanded to include all impervious surfaces such as paving, drives, patios, and decks.
Marina Approvals	Waterfront communities should adopt special land use regulations and review standards for marinas to ensure that they do not create adverse affects, such as traffic congestion, on the community and its resources.
Natural Resource Evaluation	A site assessment can be part of a development review process that includes identifying and describing significant natural features, such as wetlands, wildlife habitats, and tree stands. Such an assessment can determine the impacts of a proposed development on existing site features and natural resources.
On-Site/Community Treatment Systems	The expense of some waste water treatment techniques may be financially difficult, but one possible solution intended for very limited use is a package wastewater treatment system. This option can serve a small geographic area but it may not be affordable for a single development project. It may, however, prove feasible if several smaller projects are combined. Such a solution should not be used to promote development in areas without public services as this only acts to perpetuate unsustainable sprawl development.
Open Space Development	Using this technique, development density is based on a “parallel plan” that establishes the permissible density under existing zoning. The resulting density, however, must be sited on a smaller area of the site leaving the remainder as open space. While net density is higher for the smaller developed area the overall density still meets that which is required under existing zoning.

GLOSSARY OF WATERSHED PLANNING AND ZONING TECHNIQUES	
Overlay Zoning	Overlay zoning is the application of an additional set of regulations to an established zoning district. Areas commonly targeted by overlay zones include: floodplains, watersheds, lake shore lands, river corridors, environmentally sensitive areas, high risk erosion areas, historic districts or economic revitalization areas. Overlay zoning can be used to help ensure uniform regulations are in place across several zoning districts or political jurisdictions.
Purchase/Transfer of Development Rights (PDR/TDR)	PDR and TDR programs are voluntary preservation programs that allow individual property owners to sell the development rights to their land. Both programs involve conservation easements. The difference between the two is the opportunity under a TDR program to transfer development rights to another area.
Recreation Planning	A recreation plan identifies and prioritizes recreational improvements desired by a community over a specified time period. However, in order to qualify for state grants for recreational facilities and programs Michigan requires communities to have a current (no more than five years old) recreation plan.
Reduced Parking Requirements	Most parking requirements establish a minimum number of spaces, but allow much larger parking lots to be built. Some communities are now applying maximum parking requirements to ensure that parking lots are not over-sized, thereby, reducing impervious surfaces and runoff. Maximum requirements can not be exceeded without specific justification by the developer.
Road End Regulations	Public streets and rights-of-way that end at the water's edge can be used for reasonable use of and access to the water for boating, swimming, and fishing. Other activities, such as sunbathing, lounging, or picnicking may be restricted.
Scenic Resource Protection	Preserving scenic resources can be challenging particularly since opinions can vary from person to person making it difficult to decide which view is worth saving. In addition, views and vistas can include broad areas such as an entire valley or river basin. These challenges can limit the effectiveness of scenic resource preservation. Among the best methods is to establish key vantage points, and then protect views from those. These vantage points can also be reflected in the Master Plan.

GLOSSARY OF WATERSHED PLANNING AND ZONING TECHNIQUES	
Secondary Containment	A common method to protect groundwater from contamination (such as above ground fuel storage tanks) is secondary containment. A variety of methods can be used but the most common is the construction of "traps" to contain runoff and spills. These can include double walled tanks or the use of some other structure.
Septic System Maintenance	An effective way to reduce the risk of failing septic systems is to establish a septic system maintenance district where property owners are required to submit evidence that their system has been inspected or maintained at some periodic interval. Another option would be to require an inspection at the time a property is sold.
Site Plan Review Requirements	During the site plan review process, a planning commission may require a more detailed site evaluation to include natural resources, and the effects that a development may have on the environment and surrounding area.
Special Land Use - Access Points	Public access to many inland lakes is accommodated through sites that are maintained and operated by the Michigan Department of Natural Resources (DNR). Until recently, it was assumed DNR had exclusive jurisdiction over these, without regard to local zoning, even though it was clear that zoning could affect **private access**. However, a June, 1999 decision by the Michigan Supreme Court (Burt Township v Department of Natural Resources) indicated that townships may also regulate public access on inland lakes. Generally, this could be regulated by a special land use process. However, this may change with proposed legislation addressing access regulations.
Stormwater Management	A stormwater management ordinance can control site development so that natural drainage patterns are not disturbed. A developer may be allowed a variety of methods to accomplish this including retention (infiltration) basins, extended detention basins, constructed wetlands, and vegetative buffer strips. Many communities incorporate soil erosion and sedimentation control requirements into their storm water management regulations.

GLOSSARY OF WATERSHED PLANNING AND ZONING TECHNIQUES	
Tree Preservation Requirements	Trees have been shown to significantly reduce runoff because they not only reduce the amount of impervious surface, but they can slow surface runoff and provide a location where water can be absorbed. A tree preservation ordinance can establish a threshold number of trees that can be removed during development. A natural features inventory and site design that incorporates natural features are typical requirements
Vegetative Buffers	A greenbelt or vegetative buffer is an area of natural or established vegetation. By reducing runoff, greenbelts help reduce pollution transport to lakes and streams and provide numerous other benefits. An overlay zone could be used to preserve natural vegetative buffers along a stream that meanders through several zoning districts or political jurisdictions.
Wellhead Protection	A wellhead protection area is defined as the surface and subsurface area surrounding a water well or well field through which contaminants may move and reach the water table. In Michigan, the area for any potential threat is based upon a ground water time-of-travel of 10 years.
Wetland Regulations	There are three categories of wetlands that are subject to MDEQ regulations: those wetlands, regardless of size, that are contiguous to, or within 500 feet of the ordinary high water mark of a lake, stream, or pond; wetlands that are larger than five acres; and those wetlands deemed to be essential to the preservation of natural resources. Local jurisdictions may also adopt regulations to protect wetlands that do not fall under state control. However, certain requirements must be followed that include using the state's definition of a wetland and a community must complete a wetland inventory and make it available to the public at a reasonable cost. If a local jurisdiction denies a permit to disturb wetlands the affected landowner can request a revaluation of the property for tax assessment purposes to determine its fair market value under the restrictions imposed by the denial. Finally, if a community desires to regulate wetlands less than two acres in size it must find that the wetland is essential to the preservation of the community's natural resources.

Appendix 3. BMP descriptions, costs, and load reductions per area treated.

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. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice, and have more recently evolved into an urban practice.

Extended Dry Detention: Dry detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, and extended detention ponds) are basins whose outlets have been designed to detain stormwater runoff for some minimum time (e.g., 24 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool of water. However, they are often designed with small pools at the inlet and outlet of the basin. They can also be used to provide flood control by including additional flood detention storage.

Wet Detention: Wet ponds (a.k.a. stormwater 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). Ponds treat incoming stormwater runoff by allowing particles to settle and algae to take up nutrients. The primary removal mechanism is settling as stormwater runoff resides in this pool. Pollutant uptake, particularly of nutrients, also occurs through biological activity in the pond. Traditionally, wet ponds have been widely used as stormwater best management practices.

Infiltration Basin: An infiltration basin is a shallow impoundment that is designed to infiltrate stormwater into the soil. Infiltration basins typically have a high pollutant removal efficiency, and can also help recharge the groundwater, thus restoring low flows to stream systems. Infiltration basins need to be applied very carefully, as their use is often sharply restricted by concerns over groundwater contamination, site feasibility, soils, and clogging at the site. In particular, designers need to ensure that the soils on the site are appropriate for infiltration. Infiltration basins have been used as regional facilities, providing both water quality and flood control in some communities.

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. As stormwater runoff flows along these channels, it is treated through vegetation slowing the water to allow sediment to settle and water to filter through a subsoil matrix (mulch mix), and/or infiltration into the underlying soils. Variations of the grassed swale include the grassed channel, dry swale, and wet swale. The specific design features and methods of treatment differ in each of these designs, but all are improvements on the traditional drainage ditch. These designs incorporate modified geometry and other features for use of the swale as a treatment and conveyance practice.

Rain garden: Bioretention areas, or rain gardens, are landscaping features adapted to provide on-site treatment of stormwater runoff. They are commonly located in parking lot islands or within small pockets of residential land uses. Surface runoff is directed into shallow, landscaped depressions. These depressions are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, runoff ponds above the mulch and soil in the system. Runoff from larger storms is generally diverted past the facility to the storm drain system. The remaining runoff filters through the mulch and prepared soil mix. The filtered runoff can be collected in a perforated underdrain and returned to the storm drain system (depending on soil permeability or level of contamination).

Constructed wetlands: Stormwater wetlands (a.k.a. constructed wetlands) are structural practices similar to wet ponds that incorporate wetland plants into the design. As stormwater runoff flows through the wetland, pollutant removal is achieved through settling and biological uptake. Wetlands are among the most effective stormwater practices in terms of pollutant removal and they also offer aesthetic and habitat value. Although natural wetlands can sometimes be used to treat stormwater runoff that has been properly pretreated, stormwater wetlands are fundamentally different from natural wetland systems. Stormwater wetlands are designed specifically for the purpose of treating stormwater runoff, and typically have less biodiversity than natural wetlands in terms of both plant and animal life. Several design variations of the stormwater wetland exist, each design differing in the relative amounts of shallow and deep water, and dry storage above the wetland.

All definitions above were taken from the EPA "National Menu of Stormwater Best Management Practices" website (http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm).

Table A3-1 contains BMP average overall cost, engineering cost, 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 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.

Table A3-1. BMP costs and loads reductions.

	BMP Base Cost	BMP Engineering Costs	Annual O&M***	Load Reduction per Acre Treated (Low Density Residential)			Load Reduction per Acre Treated (High Density Residential)			Load Reduction per Acre Treated (Roads/Parking Lots)		
	($/acre treated)	*($/acre treated)*	*(percent of base costs)*	*TP (lbs/yr)*	*TSS (lbs/yr)*	*Runoff (ac-ft/yr)*	*TP (lbs/yr)*	*TSS (lbs/yr)*	*Runoff (ac-ft/yr)*	*TP (lbs/yr)*	*TSS (lbs/yr)*	*Runoff (ac-ft/yr)*
Filter Strips*	$13,800	$3,450	2% ($320)	0.5	164	0	0.7	693	0	1.3	1052	0
Grass Swale	$7,800	$1,950	5%-7% ($390-546)	0.5	131	0.1	0.7	554	0.4	1.3	842	0.4
Extended Dry Detention	$6,270	$1,568	1% ($63)	0.4	148	0.1	0.5	623	0.4	1	947	0.4
Wet Detention	$6,270	$1,568	3%-6% ($118-376)	1.1	148	0	1.5	623	0	2.9	947	0
Constructed Wetland	$42,254	$10,564	2% ($845)	0.6	125	0	0.8	527	0	1.6	800	0
	BMP Base Cost	**BMP Engineering Costs**	**Annual O&M***	**Load Reduction per Rooftop Treated (Low Density Residential)**								
	($/rooftop treated)	*($/rooftop treated)*	*(percent of base costs)*	*TP (lbs/yr)*	*TSS (lbs/yr)*	*Runoff (ac-ft/yr)*						
Rain Garden**	$3,496	$105	($175-$343)	0.06	8.2	0.02						
	BMP Base Cost	**BMP Engineering Costs**	**Annual O&M**	**Removal Efficiencies**								
Infiltration Basin****	$2 per cubic foot of storage for a 0.25 acre basin	NA	5%-10% of construction costs	TSS 75%	TP 60-70%	Bacteria 90%		Runoff 100% assumed				

*Data Sources: costs from EPA, 1999, Preliminary Data Summary of Urban Stormwater BMPs, EPA-821-R-99-D12; load reduction estimates from NREPA of 1994, PA 451, Part 30 - Water Quality Trading
**The average size residential roof is about 2,000 sq. ft. which equates to about 0.05 acres
***Annual O&M costs from: EPA, 1999, Preliminary Data Summary of Urban Stormwater BMPs, EPA-821-R-99-D12
(All remaining calculations were done using the Kalamazoo River Urban Stormater BMP Screening Tool); citations are included under the READ ME tab (Loading=NREPA of 1994, PA 451, Part 30; costs=WERF tool)
****Infiltration basins are a good option and common BMP in southwestern Lower Michigan. Design requirements are highly variable and do not lend themselves to standardization for comparison to other listed BMPs. Estimates are taken from www.stormwatercenter.net.

1. Michigan Department of Environmental Quality. 2002. Part 30 Water Quality Trading. Available at: http://www.state.mi.us/orr/emi/arcrules.asp?type=Numeric&id=1999&subId=1999-036+EQ&subCat=Admincode
2. Schueler T. 2008. Technical Support for the Bay-wide Runoff Reduction Method Version 2.0. Chesapeake Stormwater Network.
3. US Environmental Protection Agency. 2005. National Management Measures to Control Nonpoint Source Pollution from Urban Areas.
4. Water Environment Research Foundation. 2009a. User's Guide to the BMP and LID Whole Life Cost Models version 2.0. Available at: http://www.werf.org/AM/Template.cfm?Section=Research_Profile&Template=/CustomSource/Research/PublicationProfile.cfm&id=SW2R08
5. Water Environment Research Foundation. 2009b. BMP and LID Whole Life Cost Models Excel Worksheets for Extended Detention Ponds, Retention Ponds, Swales. Available for download at: http://www.werf.org/AM/Template.cfm?Section=Research_Profile&Template=/CustomSource/Research/PublicationProfile.cfm&id=SW2R08

Appendix 4. Water Quality Statement by Water Body

Here we provide additional information on the key lakes and streams identified as priority water bodies for protection, mitigation and restoration efforts. This information is unbalanced because some have received more study than others, in part because of the activity of researchers at Michigan State University's Kellogg Biological Station (KBS), located on Gull Lake. The water resources of the FTWA are further described in Allen et al. (1973), Rheaume (1990), and the *Four Township Water Atlas* (1998).

Gull Lake

Gull Lake is one of the largest inland lakes in Michigan, with an area of 2044 acres (822 ha) and a maximum depth of over 110 feet. This lake is unusual in southern Michigan because it supports a diverse fishery, including both warm- and cold-water species. Gull Lake serves as an important public recreational site for the region. Residential development lines the lakeshore.

The realization by the 1970's that the waters of Gull Lake were becoming more turbid with algae prompted public concern. Studies by researchers at KBS showed the link between nutrient supply and algal blooms and established that phosphorus was the principal nutrient limiting algal growth in the lake (reviewed by Tessier and Lauff 1992).

Gull Lake has been extensively studied since the early 1960s, including much limnological research conducted at the Kellogg Biological Station. Early studies documented that phosphorus is the limiting nutrient in Gull Lake (Moss, 1972a, 1972b). A water budget for Gull Lake in 1974 revealed that the lake received 40% of its water from groundwater inflow, 25% from direct precipitation onto the lake surface, and 35% from stream inflows (Tague 1977). The water budget was combined with information on the phosphorus concentrations of these inputs to formulate a phosphorus budget for the lake (Tague 1977). The phosphorus budget demonstrated that septic systems and lawn fertilization comprised 76% of the annual phosphorus inputs at that time.

Citizen action, supported by state and federal grants, resulted in construction of a sanitary sewer around the perimeter of Gull Lake in 1984. The diversion of a significant source of phosphorus from Gull Lake resulted in a rapid reversal in eutrophication trends and marked improvement in water quality characteristics (Tessier and Lauff 1992). Dr. Alan Tessier of KBS revised the phosphorus budget for Gull Lake based on water sampling during 1994-95. Another water quality concern involved the flow of phosphorus (P) -rich water from Wintergreen Lake at the KBS Bird Sanctuary to Gull Lake. In response to citizen concerns about algae along the shore where the water entered Gull Lake, in 1995 KBS installed a pipe to direct the outflow well offshore.

Dr. Stephen Hamilton of Michigan State University has sampled Gull Lake and its inflow streams for water quality since 1998, with support in recent years from the Gull Lake Quality Organization. Water quality in Gull Lake is considered good now, although late-summer blooms of the blue-green alga *Microcystis aeruginosa* cause some concern; based on considerable research at KBS, these blooms are believed to be caused by the invasive zebra mussels through a complex ecological interaction (Raikow et al. 2001).

Augusta Creek

Augusta Creek provides an example typical of most of the streams in the four-township area. This stream is particularly important for recreational opportunities because there is public access at the W.K. Kellogg Experimental Forest (owned by Michigan State University) and at the Augusta Creek Hunting and Fishing Area (owned by the Michigan Department of Natural Resources and Environment). Fly fishing is popular in the stream, which is annually stocked with trout.

A great deal of ecological research has been performed at Augusta Creek by professors and students from Michigan State University's Kellogg Biological Station (KBS), and the results of this research are found in numerous scientific publications (a complete list is maintained by the KBS library). Mahan and Cummins (1974) wrote an overview of the stream system and its plant and animal life. Dr. Stephen Hamilton of Michigan State University has sampled this stream for water quality since 1998.

Extensive riparian wetlands all along the stream courses in Augusta Creek and its tributaries help to stabilize the flow of water in the creek by absorbing excess water during high flow and slowly returning this excess water over ensuing periods of lower flow.

A study by the U.S. Geological Survey determined a water budget for the Augusta Creek watershed, estimating all of the significant inputs of water that support the discharge of the creek (Rheaume 1990). Over the long term, 38% of the precipitation falling within the watershed ultimately reaches the stream (the remainder is returned to the atmosphere by evapotranspiration). Most of the stream discharge is supported by groundwater inputs. Since groundwater flow through the watershed is very slow, the groundwater entering the creek in a particular year may have originated as precipitation years (or possibly even decades) earlier.

The large contribution of groundwater inputs to the discharge of Augusta Creek makes the stream flow relatively stable compared to creeks that receive more surface runoff. The U.S. Geological Survey has maintained records of discharge at EF Avenue since October 1964. The creek maintains much of its flow even in relatively dry periods because the groundwater inputs are less affected by short-term reductions in precipitation. For the same reason, the stream does not respond as strongly to wetter years, and even large rainfalls produce only a moderate increase in stream discharge and water level. Floods tend to occur more in the winter and spring during snowmelt or rainfall when the soils are frozen or saturated, and the floodplains along the stream are usually inundated only for brief periods. Additional hydrologic characteristics for Augusta Creek and other local streams are presented in Allen et al. (1972), and updated statistics on discharge for Augusta Creek are published in annual reports by the U.S. Geological Survey.

The groundwater gets into the stream by seepage through its bed and through the beds of lakes in its headwaters. In addition, groundwater on its way to the stream often appears near the soil surface in floodplain environments, maintaining riparian wetlands with distinct plant communities, many of which can be characterized as either prairie fens or forested floodplains.

The temperature of groundwater is around 50º F and varies little throughout the year. For streams like Augusta Creek that receive most of their flow from groundwater inputs, this stable temperature has several implications. Water temperatures are moderated by the groundwater inputs, staying cooler in the summer and warmer in the winter. The lower summer water temperatures resulting from groundwater inputs make Augusta Creek a suitable habitat for trout. Shading of the stream channel by forest also helps to keep the water cooler, and thus streamside vegetation should be protected whenever possible. In the winter, many reaches of Augusta Creek resist freezing because of the relatively warm groundwater inputs.

Prairieville Creek

Prairieville Creek is a small first order trout stream that is classified as second quality coldwater stream. Located at the southern end of Barry County, the creek originates through a series of large springs. Flowing south through a small natural impoundment (Mud Lake), Prairieville Creek empties into the north end of Gull Lake and is the major source of tributary inflow to Gull Lake, as evidenced in a 1974 study of the lake's hydrologic budget (Tague, 1977). The annual volume represents 60% of the total tributary inflow into Gull Lake supplying about 21% of the lake's annual water budget. The groundwater inflow directly into Gull Lake from the Prairieville Creek watershed and the other immediately adjacent drainage areas is also of disproportionate importance to the Gull Lake hydrologic budget. It was estimated that these drainage areas at the north end of Gull Lake contribute 35% of the total groundwater inflow volume. Prairieville Creek is the primary tributary and significant contributor of water into Gull Lake.

The creek is approximately 2 miles in length with an average width of 15 feet and a depth of 4 inches and the land along the creek is characterized by fen, marsh and wooded wetland with gently rolling hills. The watershed appears to have two different sections: an upper creek segment above Mud Lake containing the springs with numerous small inflows, subsoils made up of poorly drained Houghton muck and ecologically notable prairie fen and marsh; and the lower section containing a more defined stream course, a largely wooded riparian zone, and underlain by well-drained Oshtemo sandy loams. The headwaters are characterized more by overhanging vegetation and watercress with a more incised channel compared to the broader, shallow channel below Mud Lake. Below Mud Lake the creek is 80-100% shaded.

Dr. Stephen Hamilton of Michigan State University (MSU) has sampled this stream for water quality since 1998.The water quality is excellent due to the buffering effect of streamside wetlands, although nitrate concentrations are high because of the groundwater contribution. Fertilizer used in agriculture is thought to be the most likely source of nitrogen in groundwater. The water is clear year-round. The bottom types are rock and gravel (50-70%) and sand with marl (30-50%). Pools and riffles are common. Cover types include logs, undercut banks, and overhanging brush with an extensive forested canopy. An excellent mosaic of these cover types is available throughout the system.

Prairieville Creek is the only cold-water fish spawning area for Gull Lake and thus potentially supports spawning by Atlantic salmon, rainbow trout, northern pike, smelt and several species of suckers. Smelt, which were first introduced into Gull Lake in 1950 and have been introduced again in recent years, use this creek exclusively for spawning purposes. The MDNRE Fisheries Division has also documented natural reproduction by land-locked Atlantic salmon (all the way up to Mud Lake), and natural reproduction by rainbow trout and brown trout. However the Atlantic Salmon proved not to be able to sustain a population in Gull Lake and are no longer present there. Twelve other species of fish have also been documented in this small creek.

This area, with its high rate of groundwater discharge, virtually never freezes for more than a few days. As a result, it serves to feed and shelter large numbers of both game and non-game animals. Each winter thousands of waterfowl and shore birds, as well as hundreds of deer and upland species, winter and reproduce in this valley. Many of these species could not survive in this area without this protection, at least not at their current population levels.

Spring Brook

Spring Brook is similar to Augusta Creek in appearance but lacks the lakes in the headwaters. This as well as high lateral groundwater inputs make it colder than Augusta Creek, and it is the best trout stream in the FTWA. Unlike Augusta Creek, there is little public access and no public land along Spring Brook, and low-density residential development is more complete in its watershed and along its course. Water quality is good. Dr. Stephen Hamilton of Michigan State University (MSU) has sampled this stream for water quality since 1999.

A fen wetland site along Spring Brook formerly supported a population of the endangered Mitchell's Satyr butterfly, but monitoring has failed to find individuals there in recent years.

Gull Creek

Gull Creek drains from Gull Lake through a water control structure, then passes through extensive fen wetlands where it gains groundwater. A tributary brings water from the "Three Lakes" system. Downstream along G Avenue a dam forms a mill pond with residences on the west edge. Water quality appears to be good throughout the system. Dr. Stephen Hamilton of Michigan State University has sampled this stream for water quality since 1998.

The hydrology of Gull Creek and associated wetlands was studied in some detail by researchers from Western Michigan University in the late 1990s, after citizens expressed concern about a new well field installed there by the City of Kalamazoo. The information resides in unpublished reports (contact the Four Township Water Resources Council for more information).

Comstock Creek

Little information was found on Comstock Creek. The stream passes through Campbell Lake, the site of a public beach at a township park and an apparently natural water body. The City of Kalamazoo operates a well field downstream of Campbell Lake. Downstream there are a couple of small impoundments before the stream enters the Kalamazoo River. Water quality appears to be good.

Silver Creek

Silver Creek is a small second tributary to the Kalamazoo River located in the southeastern corner of Allegan County. The creek flows through two distinct land use areas. The upper half is a combination of fallow farm land and scrub shrub wetland; the lower half is dominated by active farm land (crops and cattle) and the Kalamazoo River Floodplain, and is interspersed with scrub shrub wetland. The underlying soils in this drainage are mostly composed of poorly drained loamy sands. The creek runs parallel to the Kalamazoo Moraine. It is a high quality designated trout stream and has a top-quality coldwater designation (Dexter, 1993).

Silver Creek begins in section 24 in Gun Plain Township, Allegan County and flows south 5.5 miles to its confluence with the Kalamazoo River in section 4 of Cooper Township in Kalamazoo County. The creek has an average gradient of 22 feet/mile with a flow volume of 6.1 cfs on the date sampled (August 31, 1999). Macroinvertebrate scores were at the high end of “acceptable” while habitat was “good” (slightly impaired). Water chemistry indicated that instream nutrient concentrations were comparable to reference conditions on the date sampled (MDEQ MI/DEQ/SWQ-00/090, 2000).

Upper Crooked Lake

The Crooked Lake system includes three interconnected basins known as Upper, Middle and Lower Crooked Lake, of which the upper lake has by far the most residential development. Upper Crooked Lake is separated from the Middle and Lower basins by a manmade causeway at Parker Road. That causeway has a culvert to allow flow at higher water levels, and flow is almost always from the upper to the lower lake. There are also a number of ponds and wetlands that occur in close proximity to the middle and lower lake basins, and their water levels tend to fluctuate in concert with the lake because the soils are highly permeable (allowing easy groundwater exchange between lake basins and nearby wetlands). Most of these lie on the MSU Lux Arbor Reserve.

Upper Crooked Lake has experienced particularly large variation in water levels over recent years, causing consternation among lakeside residents and potential developers of remaining lakeside land, who would prefer a stable water level. Water levels in the upper lake system are affected by the Parker Road culvert, which was originally set to maintain the level of the upper lake at 922.75 ft above sea level, a legal lake level established in 1942. That culvert has subsided from its intended level and is tilted upward on its downstream (western) end. The Delton Crooked Lake Association and the Barry County Drain Commissioner organized a successful effort to install a weir above the culvert in 2006 that prevents the upper lake from discharging water when it falls below its legal lake level. However a water level management plan was designed to allow for emergency water releases in case the water level in the middle and lower lake basins falls too low relative to the upper basin.

Like most local lakes with residential development, aquatic plant control through herbicide treatment has been conducted at Upper Crooked Lake, targeted particularly at Eurasian Water Milfoil.

Pine and Shelp lakes

Pine Lake is a large lake with much residential development. Water quality appears to be good. Like most local lakes with residential development, aquatic plant control through herbicide treatment has been conducted at Pine Lake, targeted particularly at Eurasian Water Milfoil.

Shelp Lake is a smaller lake just to the northeast of Pine Lake. This lake has dense residential development and residents have expressed general concerns about water quality in the recent past.

Gilkey and Fair lakes

Gilkey and Fair lakes are situated at the headwaters of the Augusta Creek system, and both lakes are surrounded by a mix of developed upland shoreline and fen wetlands. Outflow streams from both lakes pass under roads through culverts that may dictate their water levels. Fair Lake is the location of a long-term water level record extending back to the 1950s (data are maintained by Dr. Stephen Hamilton of Michigan State University).

Sherman Lake

Sherman Lake has dense residential development on its shores except the southern edge where the Sherman Lake YMCA is located. This lake is isolated from other surface waters. Like most local lakes with residential development, aquatic plant control through herbicide treatment has been conducted at Upper Crooked Lake, targeted particularly at Eurasian Water Milfoil. As a longer term solution, a voluntary-hookup sewer system has recently been installed for residents along the lake.

Pleasant Lake

Pleasant Lake has a narrow spit of land with homes and cottages on the west edge and is otherwise surrounded by wetlands. This lake is distinct among lakes in FTWA in its relatively low concentrations of dissolved substances, indicating that the major source of water to the lake is precipitation rather than groundwater. The water quality of this lake is consistent with the presence of *Sphagnum* mosses and other bog vegetation in the wetlands along its shores, which typically develop in precipitation-fed wetlands. Algal blooms have been a concern in Pleasant Lake in the past, and extension of the sewer system that serves Upper Crooked Lake to homes on this lake is currently under discussion.

Appendix 5. Existing Efforts, Studies, and Literature

Description	Catchment/Area	Date	Product Category	Target Audience
Four Townships Working Group Establishment*	FT		People	All
Water Atlas*	FT	1998	Attributes	Technical
Water Table Elevation Map*	FT	2001	Attributes	Technical
Four Townships Geographic Information System*	FT	2001	Data Management	Technical
Watershed Resource Papers*	FT	2001	Planning	Planner/Decision Maker
Farmland protection	FT			
Open space protections	FT			
Surface and groundwater protection	FT			
Environmentally sensitive area protection	FT			
Lake access and overcrowding				
Environmental Carrying Capacity (6 Lakes) *	6 Lakes	2002	Use Capacity	Planner/Decision Maker
Watershed Resource Regulation Guide*	FT	2002	Planning	Planner/Decision Maker
Citizens Guide to Conservation*	FT		Planning and Education	Public
Principles of open space development; 4 versions by township*	FT	2003	Targeted Planning	Public
A Guide to Stormwater Management*	FT	2005	Planning	Planner/Decision Maker
Open Space Development: Market and Design Challenges*	FT	2005	Planning	Planner/Decision Maker
Impervious Surface Analysis*	FT	2005	Planning	Technical
Low Impact Development*	FT	2005	Planning	Planner/Decision Maker
Ten ways, promote LID*	FT	2005	Planning and Education	Public

Natural Features Inventory*	FT	2005	Biotic Attributes	Planner/Decision Maker
Product dissemination compact disc*	FT		Planning and Education	All
Site Plan Review for Water Quality*	FT	2005	Planning	Planner/Decision Maker
Recreational Carrying Capacity (6 lakes) *	FT		Use Capacity	Planner/Decision Maker
Potential and Priority Conservation Areas*	FT		Planning	Technical
Sponsored Low Impact Development Workshop**	Regional		Planning and Education	All
Planning and zoning for water quality presentations***	FT	various	Planning and Education	All
Water quality and land-use issues presentations***	FT	various	Planning and Education	All
Shoreline landscaping and lake level control**	Crooked Lake	2006		
Junior Citizen planner**	Regional; Ross and Prairieville	2005-2006	Planning and Education	Public
Natural features presentations***	Ross and Prairieville	2005-2006	Planning and Education	
Tours - conservation easements***	Prairieville Creek Watershed	2006	Planning and Education	Public
Signage- watershed**	Pine Lake and Gun River Watershed	2006	Education	Public
Signage- road stream crossings**	Augusta and Prairieville Creeks and Spring Brook	2007	Education	Public
Road crossings and outfall maps	Stormwater permit coverage areas	Updated regularly, contact Kalamazoo County Road Commission	Data Management	Technical
Kanoe the Kazoo Tours***	Various	various	Planning and Education	Public
Annual Meetings**	Various	various	Planning and Education	Public

* literature – contact Four Township Water Resources Council or see publications on www.ftwrc.org
** efforts - contact Four Township Water Resources Council
*** presentations/tours - contact Four Township Water Resources Council

Appendix 6. Buildout Analysis and Urban Cost Scenarios for the Kalamazoo River Watershed Management Plan.

An empirical model to estimate nonpoint source pollution to surface waters based on existing land cover was run as part of the Kalamazoo River Watershed Management Plan (2010). Runoff volumes and pollutant loads were calculated using average runoff depth values produced by the Long-term Hydrologic Impact Assessment model (L-THIA) and available pollutant event mean concentration (EMC) values. Loads and volumes were calculated for “current” conditions (2001 land use; the most recent and comprehensive set of land cover data) and for future conditions in 2030 using a future land use layer predicted by the Land Transformation Model (LTM). The LTM data layer was used at three different scales: watershed, subwatershed and municipal/township levels. These modeling results were used to assess the impact of future potential urban development on water quality and to estimate the costs necessary to achieve water quality goals.

BUILD-OUT ANALYSIS AND URBAN COST SCENARIOS

FOR THE KALAMAZOO RIVER WATERSHED MANAGEMENT PLAN

Prepared for:
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September 30, 2010

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 Introduction

The Kalamazoo River watershed drains approximately 2,000 square miles of land that discharges into Lake Michigan at Saugatuck, Michigan. This 8-digit HUC watershed (#04050003) has numerous water quality issues resulting from historic and current land use decisions. One of the major problems in the watershed is nutrient enrichment of Lake Allegan, a reservoir on the Kalamazoo River mainstem west of the City of Allegan. Lake problems associated with the over-enrichment of phosphorus include nuisance algal blooms, low oxygen levels, poor water clarity, and a fish community heavily unbalanced and dominated by exotic carp.

Agriculture and forested land cover approximately 70% of the Kalamazoo River watershed, while developed urban lands represent only 8%. A 2001 watershed pollutant loading study found that urban land covers (transportation, industrial, and residential) may represent up to 50% of the overall nonpoint source phosphorus load to the Kalamazoo River (K&A, 2001). Where new development pressures exist, pollutant loads will increase unless policies are in place to mitigate impacts of new development. In Kalamazoo County, for example, land is being developed at 2.5 times the population growth, resulting in loss of farmland and forested areas (MSU, 2007). Despite a phosphorus TMDL that addresses existing nonpoint source loads as of 1998, these new development pressures and potentially negative impacts on hydrology, water quality, TMDL or watershed management goals in the Kalamazoo River watershed are not explicitly being addressed[1]. A statistical analysis of the last ten years of monitoring data since 1998 shows no progress had been made towards these load reduction goals (K&A, 2007)[2].

In the last ten years, several nonpoint source modeling studies have been conducted in major subwatersheds of the Kalamazoo River watershed and for the Lake Allegan/Kalamazoo River TMDL (K&A, 2001). However, no study has yet modeled the Kalamazoo River watershed in its entirety, and pollutant loading information is lacking for several areas including the mouth and headwaters of the Kalamazoo River. The development of a Kalamazoo River Watershed Management Plan (WMP) requires the quantification of current pollutant loads. It also needs an assessment of potential load changes resulting from future land development and land use change in the watershed.

To address these two WMP needs, a watershed-wide, nonpoint source empirical model was run by K&A as part of the WMP to estimate runoff volumes and pollutant loads from existing land cover. Runoff volumes and pollutant loads were calculated using average runoff depth values produced by the Long-term Hydrologic Impact Assessment model (L-THIA) and available pollutant event mean concentration (EMC) values. Loads and volumes were calculated for "current" conditions (2001 land use; the most recent and comprehensive set of land cover data) and for future conditions in 2030 using a land use layer produced by the Land Transformation Model[3] (LTM). The LTM data layer was used at three different scales: watershed, subwatershed and municipal/township levels. These modeling results were used to assess the impact of

[1] *The phosphorus Total Maximum Daily Load (TMDL) developed for Lake Allegan, which includes the entire watershed area upstream of Lake Allegan, requires a 43% reduction for nonpoint source phosphorus load for the April-June season, and a 50% reduction for the July-September season (Heaton, 2001). These reductions can only be achieved through the implementation of not only agricultural best management practices, but urban best management practices and policies, as well.*

[2] *A copy of this presentation can be downloaded at: http://kalamazooriver.net/tmdl/docs/M-89%20NPS%20Loading%201998-2007.pdf*

[3] *LTM developed by Bryan Pijanowski, et al. and currently hosted by Purdue University (Pijanowski, et al., 2000, 2002).*

future potential urban development on water quality and to estimate the costs necessary to achieve water quality goals. This report presents the methodology and results of this watershed-wide modeling effort.

2.0 Methods

The methods used in this analysis provide WMP stakeholders with information on current and predicted future runoff from the landscape within the watershed, nutrient loading from specific land cover, and potential costs to offset phosphorus loads now and in the future. Explanations of these models, input values, and assumptions are outlined below.

2.1 Model Descriptions

The build-out analysis for the Kalamazoo River WMP was developed by coupling a GIS-based runoff model with regionally recognized event mean concentration (EMC) values from the Michigan Trading Rules (Part 30), future land use data, and runoff data. L-THIA GIS, a simple rainfall-runoff model, was used to generate runoff values for both current and future build-out conditions. The future land use layers used in the build-out analysis were produced by the LTM, a GIS-based land use change model developed by researchers from Michigan State University and currently hosted by Purdue University (Pijanowski, *et al.,* 2000, 2002)[4]. The first step in this modeling effort coupled values from the L-THIA model with EMC values for Michigan to establish baseline pollutant loads and runoff volume in the Kalamazoo River watershed. The second modeling step incorporated predicted land use in 2030 from the LTM to calculate pollutant load and runoff volume changes that may result from projected changes in land cover in the future.

LONG-TERM HYDROLOGIC IMPACT ASSESSMENT

L-THIA WAS DEVELOPED AS A SIMPLE-TO-USE, ONLINE ANALYSIS TOOL PROVIDING AN ASSESSMENT OF THE IMPACT OF LAND USES ON RUNOFF. L-THIA CALCULATES AVERAGE ANNUAL RUNOFF FOR EACH UNIQUE LAND USE/SOIL CONFIGURATION USING LONG-TERM CLIMATE DATA FOR A SPECIFIED AREA. L-THIA USES THE SCS CURVE NUMBER METHOD TO ESTIMATE RUNOFF, A WIDELY APPLIED METHOD ORIGINALLY DEVELOPED BY THE UNITED STATES DEPARTMENT OF AGRICULTURE (USDA, 1986). THE ARCVIEW EXTENSION L-THIA GIS[1] WAS USED IN THIS ANALYSIS.

LAND TRANSFORMATION MODEL

THE LAND TRANSFORMATION MODEL IS A GIS-BASED MODEL THAT PREDICTS LAND USE CHANGES BY COMBINING SPATIAL RULES WITH ARTIFICIAL NEURAL NETWORK ROUTINES. SPATIAL RULES TAKE INTO ACCOUNT A VARIETY OF GEOGRAPHICAL, POLITICAL, AND DEMOGRAPHIC PARAMETERS SUCH AS POPULATION DENSITY, POPULATION GROWTH PROJECTIONS, LOCATION OF RIVERS AND PUBLIC LANDS, DISTANCE FROM ROADS, AND TOPOGRAPHY (PIJANOWSKI *ET AL*., 2002). THE MODEL AND ADDITIONAL INFORMATION ARE AVAILABLE FROM PURDUE UNIVERSITY'S WEBSITE. LTM WAS RUN FOR WISCONSIN, ILLINOIS, AND MICHIGAN AS PART OF THE EPA STAR ILWIMI PROJECT AND THE 2000-2030 TIME SERIES LAYERS ARE AVAILABLE ON THE LTM WEBSITE. THE LTM MICHIGAN LAND USE LAYERS FOR 2000 AND 2030 WERE SELECTED FOR USE IN THIS ANALYSIS.

[4] *Information on the land transformation model and data for download is available at: http://ltm.agriculture.purdue.edu/ltm.htm.*

The LTM layer for the year 2000 actually used the 2001 Integrated Forest Monitoring Assessment Prescription (IFMAP) land use/land cover dataset[5] as a base layer. For consistency purposes, this project references all analyses done using the LTM 2000 layer as 2001. The LTM land use categories are based on a reclassification of IFMAP categories using the USGS Gap Analysis Program (GAP) land use coding system (see Purdue University's LTM website). The build-out analysis was conducted using the LTM land use categories. Due to variation in land use category descriptions between the datasets, categories equivalent to the LTM descriptions were matched. The category equivalents for IFMAP, L-THIA and LTM are provided in Table 1. It should be noted that LTM layers have a 100-m resolution.

Table 1. Equivalence of land use categories between L-THIA, LTM and IFMAP datasets.

LTM Land Use Code	LTM Land Use Category	L-THIA Land Use Category	Equivalent 2001 IFMAP Land Use Category
11	Urban -commercial	Commercial	High Intensity Urban Runways
12	Urban-Residential	LD Residential	Low Intensity Urban
13	Other Urban	Open Spaces	Parks/Golf Courses
14	Urban - Roads and Parking Lots	Parking & Paved Spaces	Roads, Parking Lots
21	Agriculture - Non-row Crops	Agricultural	Forage Crops Non-tilled Herbaceous Orchards
22	Agriculture - Row Crops	Agricultural	Non-vegetated Farmland (plowed) Row Crops
30	Open - non-forested	Grass/pasture	Herbaceous Openland
41	Forest - Deciduous (upland)	Forest	Northern Hardwoods Aspen Forest Oak forest Other Upland Deciduous Mixed Upland Forest
42	Forest - Coniferous (upland)	Forest	Pines Other Upland Conifers Mixed Upland Conifers
43	Forest - Mixed Deciduous / Coniferous (upland)	Forest	Upland Mixed Forest Shrub/Low Density Forest
50	Open Water	Water/Wetlands	Open Water
610	Wetland - Wooded - shrubland	Water/Wetlands	Lowland Shrub
611	Wetland - Wooded - Lowland deciduous forest	Water/Wetlands	Lowland Deciduous
612	Wetland - Wooded - Lowland coniferous forest	Water/Wetlands	Lowland Coniferous
613	Wetland - Wooded - lowland mixed forest	Water/Wetlands	Lowland Mixed
62	Wetland - Nonwooded	Water/Wetlands	Emergent Wetland Floating Aquatic Mixed non-forested
70	Barren	Grass/Pasture	Sand/soil/rock/mud flats

[5] *2001 IFMAP land use map available at the Michigan Geographic Data Library:* http://www.mcgi.state.mi.us/mgdl/?rel=ext&action=sext

2.2 L-THIA Load Prediction Methodology

L-THIA calculates average annual runoff using a number of datasets, including long-term precipitation records, soil data, curve number values, and land use of the area modeled. To customize the analysis for the Kalamazoo River watershed, the following data layers were used as model inputs for L-THIA:

- Soil Survey Geographic (SSURGO) database[6]
- Layers from the LTM land use model results for 2001 and 2030
- Long-term precipitation data available for two National Oceanic and Atmospheric Administration co-op stations: Allegan (#200128) and Battle Creek (#200552)[7]

The default curve number values for a given land use/soil combination listed in the L-THIA manual were used for this analysis (Table 2). Average runoff depth was calculated using L-THIA for both the 2001 and 2030 land use layers.

The model was designed as a simple runoff estimation tool and as such, it contains a number of limitations. It is important to note the following:

- L-THIA only models surface water runoff
- It assumes that the entire area modeled contributes to runoff
- Factors such as contributions of snowfall to precipitation, the effect of frozen ground that increases stormwater runoff during cold months, and variations in antecedent moisture conditions are not modeled (L-THIA manual, 2005)

L-THIA is not designed to assess the requirements of a stormwater drainage system and other such urban planning practices, nor to model complex groundwater or fate and transport processes. However, the model clearly answered the needs of a simple loading analysis required in this project. A graphic description of the model process is presented in Figure 1.

Regionally recognized EMC values were used in the analysis to determine pollutant loading. These EMC values were calculated through the Rouge River National Wet Weather Demonstration Project. The project conducted an extensive assessment of stormwater pollutant loading factors per land use class (Cave *et al*., 1994) and recommended EMC values for 10 broad land use classes. These EMC values have since been incorporated into the Michigan Trading Rules (Part 30) to calculate pollutant loads from urban stormwater nonpoint sources. EMC values used in this analysis are presented in Table 2.

These EMCs, along with runoff depth grids produced through L-THIA, were used to calculate current and future pollutant loads using GIS spatial analysis functions. Pollutant loads and runoff volumes were calculated using the following equations (Michigan Trading Rules, 2002):

a) $R_L \times A_L \times 0.0833 = R_{Vol}$

b) $EMC_L \times R_L \times A_L \times 0.2266 = L_L$

[6] SSURGO soil data for each county within the Kalamazoo River Watershed were downloaded from NRCS Soil Mart: http://soils.usda.gov/survey/geography/ssurgo/

[7] NOAA data for each station downloaded from: http://lwf.ncdc.noaa.gov/oa/climate/stationlocator.html

Where:

EMC_L =	Event mean concentration for land use L in mg/l
R_{vol} =	Runoff volume in acre-feet/year
R_L =	Runoff per land use L from L-THIA in inches/year
A_L =	Area of land use L in acres
0.2266 =	Unit conversion factor (to convert mg-in-ac/yr to lbs/ac-yr)
L_L =	Annual load per land use L, in pounds

Using this equation, annual loads (with values presented in the form of GIS grids) were calculated for total phosphorus (TP), total nitrogen (TN), and total suspended solids (TSS) for both the 2001 and 2030 land use layers at the watershed, subwatershed, and municipality level.

Table 2. Curve numbers and event mean concentrations used in L-THIA and the build-out analysis.

LTM Land Use Categories	Curve Numbers for Soil Group				Event Mean Concentration (mg/L)			MI Trading Rules Land Use Category
	A	B	C	D	TSS	TN	TP	
Urban -Commercial	89	92	94	95	77	2.97	0.33	Commercial
Urban-Residential	54	70	80	85	70	5.15	0.52	Low Density Residential
Other Urban	49	69	79	84	51	1.74	0.11	Urban Open
Urban - Roads and Parking Lots	98	98	98	98	141	2.65	0.43	Highways
Agriculture - Non-Row Crops	64	75	82	85	145	5.98	0.37	Agricultural
Agriculture - Row Crops	64	75	82	85	145	5.98	0.37	Agricultural
Open - Non-Forested	39	61	74	80	51	1.74	0.11	Forest/Rural Open
Forest - Deciduous (upland)	30	55	70	77	51	1.74	0.11	Forest/Rural Open
Forest - Coniferous (upland)	30	55	70	77	51	1.74	0.11	Forest/Rural Open
Forest - Mixed Deciduous / Coniferous (upland)	30	55	70	77	51	1.74	0.11	Forest/Rural Open
Open Water	0	0	0	0	6	1.38	0.08	Water/Wetlands
Wetland - Wooded - Shrubland	0	0	0	0	6	1.38	0.08	Water/Wetlands
Wetland - Wooded - Lowland Deciduous Forest	0	0	0	0	6	1.38	0.08	Water/Wetlands
Wetland - Wooded - Lowland Coniferous Forest	0	0	0	0	6	1.38	0.08	Water/Wetlands
Wetland - Wooded - Lowland Mixed Forest	0	0	0	0	6	1.38	0.08	Water/Wetlands
Wetland - Non-Wooded	0	0	0	0	6	1.38	0.08	Water/Wetlands
Barren	39	61	74	80	51	1.74	0.11	Forest/Rural Open

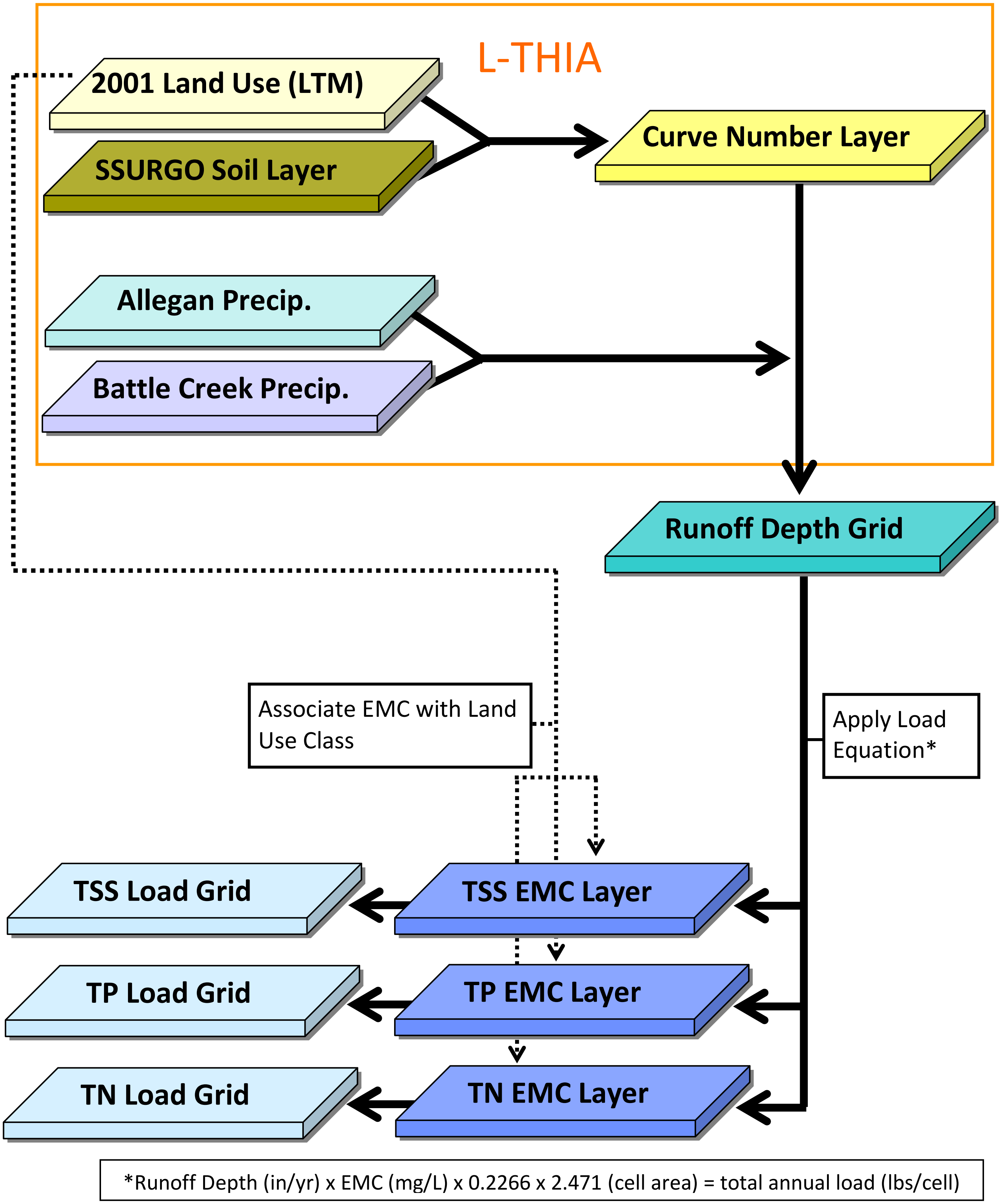

Figure 1. Conceptual flow chart of L-THIA nonpoint source modeling used to calculate runoff depth grids and additional datasets used to calculate annual nutrient and sediment loads in the watershed (where TP is total phosphorus, TN is total nitrogen and TSS is total suspended solids).

3.0 Results

Modeling results for the 2001 LTM layer were defined as the baseline for loading and runoff volume conditions. These may be considered generally comparable to the 1998 TMDL nonpoint source baseline load from which 50% reduction in TP loads are required. Predicted phosphorus loading results were within an acceptable range when compared to other available loading data for the Kalamazoo River watershed. As such, results obtained from the L-THIA/EMC model were deemed reasonable for the purposes of this evaluation. Modeling results for the 2030 LTM layer represented the build-out condition. The build-out analysis was conducted at three different scales, the entire Kalamazoo River watershed, 12-digit HUC subwatersheds, and municipalities/townships to support decision-making in the watershed management planning process. Land use throughout the watershed generally predicts an increase in urban land use and a decrease in forested, agricultural and wetland land cover.

3.1 Land Use Change Analysis

In order to compare current watershed loading to the predicted future loading scenario, land use layers from the LTM for the baseline year 2001 and predicted 2030 were analyzed. A comparison of land cover distribution in 2001 and 2030 for the entire Kalamazoo River watershed is presented in Figure 2. From 2001 to 2030, the most substantial change in land use is an increase in both urban land covers (commercial/high intensity and residential). From the model results, urban areas in the Kalamazoo River watershed could increase by more than 172,000 acres, corresponding to a 3.5 fold increase in urban areas compared to 2001. This growth of urban areas by 2030, as modeled would correspond to a loss of over 86,000 acres of farmland, 60,000 acres of forest and open land, and 20,000 acres of wetlands throughout the watershed.

It is important to note that the LTM layers used in this analysis modeled both urban and forest growth, although forest growth in the watershed is minor compared to forest lost to development. While the LTM model is programmed to exclude existing urban areas, water and designated public lands from future development, a small number of cells classified as water actually changed to urban categories (one-tenth of one percent). However, this error is minor and does not affect loading results in the build-out analysis.

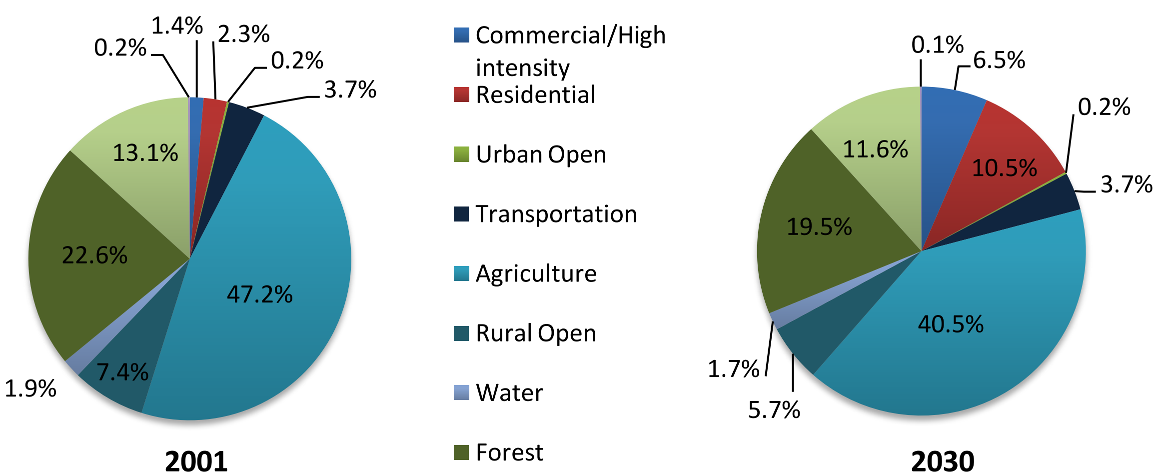

Figure 2. Comparison of land use breakdowns for the Kalamazoo River watershed in 2001 and 2030 (as predicted by the Land Transformation Model).

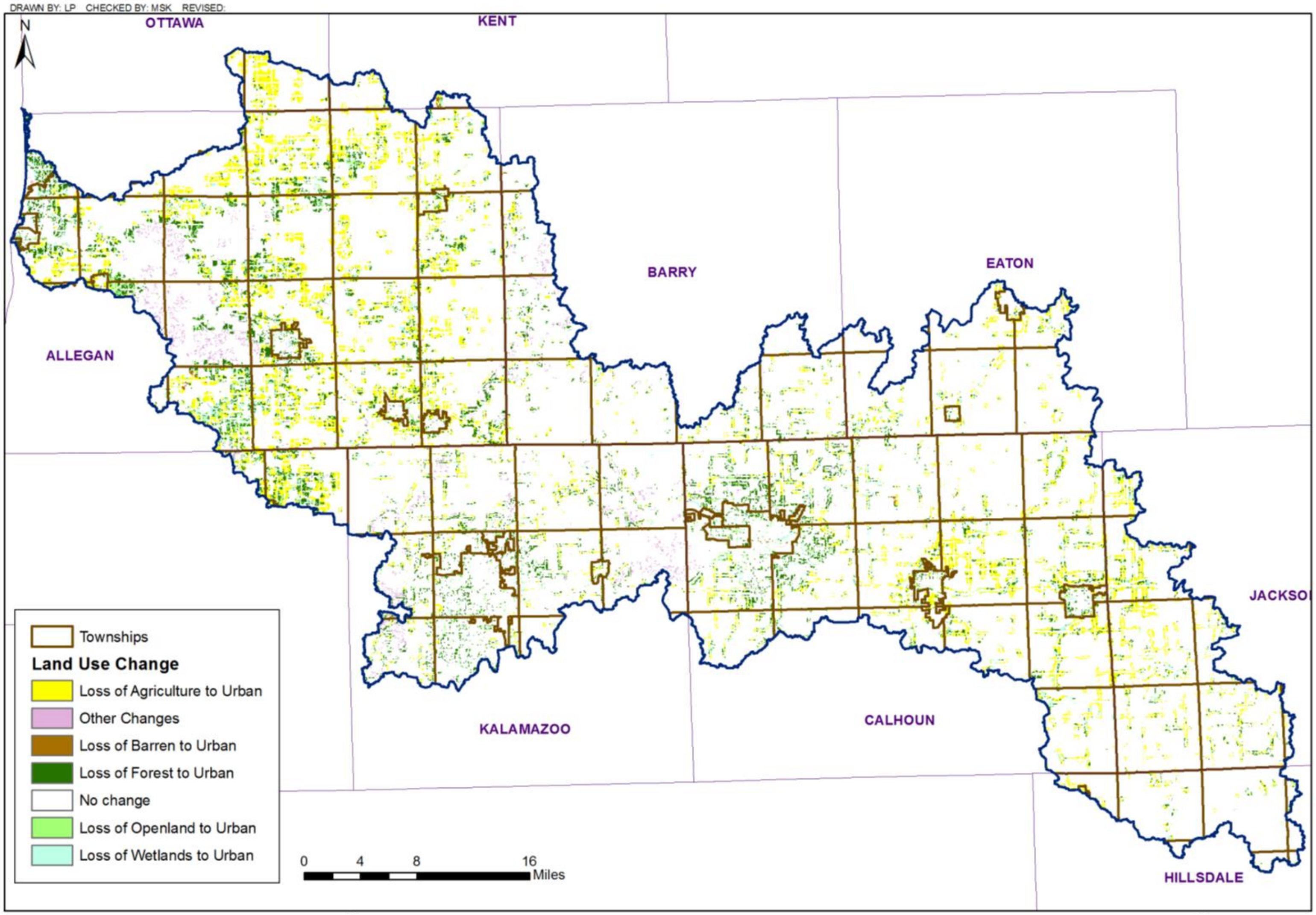

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Figure 3. Land use change from 2001 to 2030 in the Kalamazoo River watershed as predicted by the Land Transformation Model.

Note: In the map above, the category "Other Changes" refer to non-urban changes, such as open land to forest, or wetland to forest.

THE TOWNSHIPS PREDICTED TO HAVE THE GREATEST URBAN GROWTH IN THE NEXT 20 YEARS ARE SCATTERED ACROSS THE WATERSHED, BUT A LARGE MAJORITY ARE CONCENTRATED IN THE WEST IN ALLEGAN COUNTY WHERE THE LANDSCAPE IS MORE RURAL WITH PLENTY OF OPEN SPACE AND AGRICULTURE. THESE TOWNSHIPS SHOW GROWTH BECAUSE OF THEIR PROXIMITY TO RECREATION, OPEN LAND, AND MAJOR TRANSPORTATION ROUTES. A SUBSTANTIAL AMOUNT OF ACREAGE IS PREDICTED TO BE CONVERTED TO URBAN LAND USE BY 2030 IN THE TOWNSHIPS LISTED IN TABLE 3. ALL OF THE TOWNSHIPS CURRENTLY HAVE LESS THAN 1,000 URBAN ACRES, AND SOME HAVE FEWER THAN 500 ACRES. THE PREDICTED CHANGE RESULTS IN AN 8 FOLD TO OVER 35 FOLD INCREASE IN URBAN LAND COVER IN THESE AREAS.

A detailed breakdown of land use changes by township is presented in Appendix A. Table 3 below presents the ten townships with the highest potential for future urban development (i.e., greater than 2.5% increase). As modeled by LTM, the western portion of the watershed and the east side of the City of Marshall could experience the strongest urban expansion. Urban development in the west could be explained by the proximity of recreational and natural areas (such as the Allegan State Game Area) and the availability of land for development (Figure 4). The urbanization of such a large, contiguous area could likely have a strong negative impact on water quality, increase runoff and stream bank erosion, and generally degrade natural habitat in this currently rural part of the watershed. Urban development by the City of Marshall could be explained as suburban development and/or expansion and the high availability of agricultural land for development. Again, an increase in urban land cover without proper stormwater controls or regulation would result in higher nutrient loading, increased erosion, and an overall degradation of habitat and water quality.

Table 3. Townships in the Kalamazoo River watershed with the highest modeled increase in urban development by the year 2030.

Township	Total increase in urban areas (in acres)	% of total urban increase for the Kalamazoo River watershed
Cheshire	6,934	4.01
Salem	5,911	3.42
Trowbridge	5,911	3.42
Pine Grove	5,478	3.17
Allegan	5,253	3.04
Dorr	5,140	2.97
Marengo	4,930	2.85
Otsego	4,603	2.66
Monterey	4,470	2.58
Watson	4,351	2.52

Note: All township locations are shown in Figure 4, except for Marengo Township which is located east of the City of Marshall.

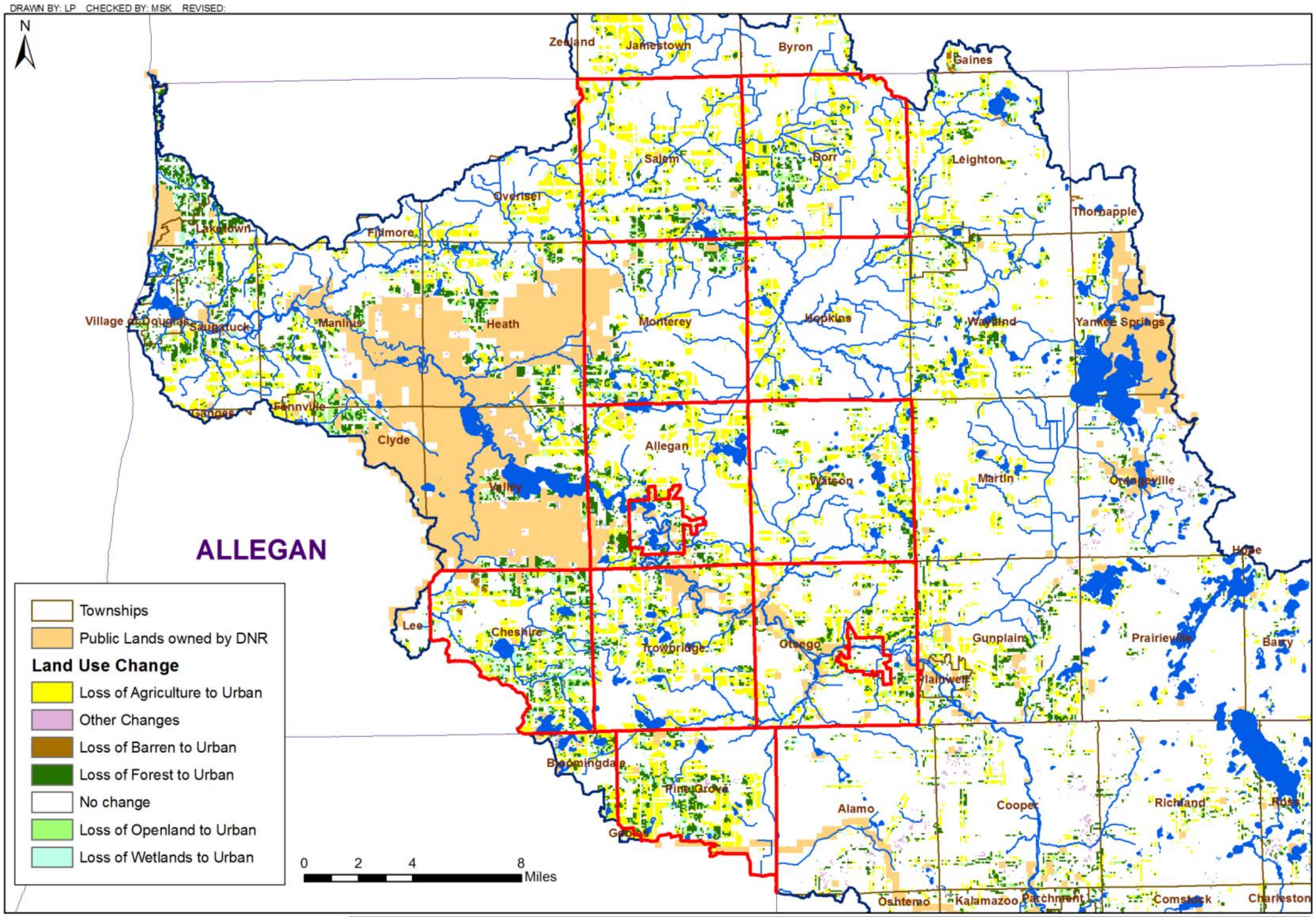

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Figure 4. Townships outlined in red located in the western section of the Kalamazoo River watershed have the largest predicted increase in urban area from the Land Transformation Model.

3.2 Pollutant Load and Runoff Volume Analysis at the Watershed Scale

Total runoff volume and pollutant loads for the Kalamazoo River watershed were calculated both for the baseline year 2001 and for the build-out year 2030 (Figure 5). It should be noted that loading and runoff calculations do not take into account the fact that municipalities may already have ordinances controlling stormwater runoff and/or phosphorus fertilizers or other regulations reducing runoff and phosphorus loading. Results show that the growing urbanization of the watershed by 2030 would lead to a 25% increase in runoff volume and TP load, 12% for TSS and 18% for TN load. These increases are related to the increase in impervious areas and land conversion from agricultural to urban uses.

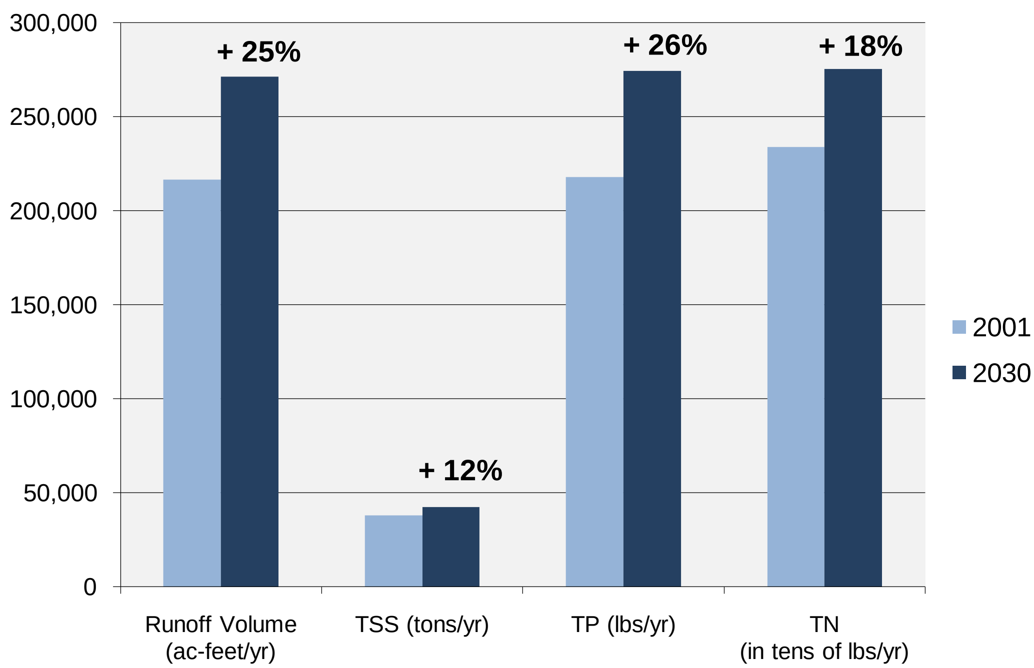

Figure 5. Nutrient load, sediment load and runoff volume comparisons between 2001 and 2030 for the Kalamazoo River watershed.

The 1999 Lake Allegan/Kalamazoo River Phosphorus TMDL requires a 43% reduction in TP load from nonpoint sources for the period April-June and a 50% reduction for July-September (Heaton, 2001). Figure 6 shows 2001 and 2030 loading compared to these TMDL goals. Nonpoint sources in the watershed include agricultural runoff (not regulated under the NPDES program) and urban sources, such as lawn fertilizers and stormwater runoff. Several counties in the watershed have recently passed ordinances limiting or banning the use of phosphorus fertilizers. However, it is difficult to quantify the impact of such regulations on future phosphorus loads. Agricultural nonpoint source remains a relatively high source of phosphorus to the entire watershed (40% of the total load to the watershed in 2001), yet the agricultural TP load is currently 30% lower than the total TP load from urban areas. In 2030, the model predicts that the phosphorus load from agriculture will represent only 27% of the total load and will be 60% lower than the total urban load (Figure 7). (These estimates reflect no changes in the level of best management practice [BMP] applications in either source category). Therefore, achieving the goals set in the Lake Allegan TMDL will not be possible unless measures are taken to mitigate the impact of urban development on water quality and quantity, both current and future. The implementation of stormwater BMPs and ordinances will become an important tool in reaching the TMDL nonpoint source load allocation.

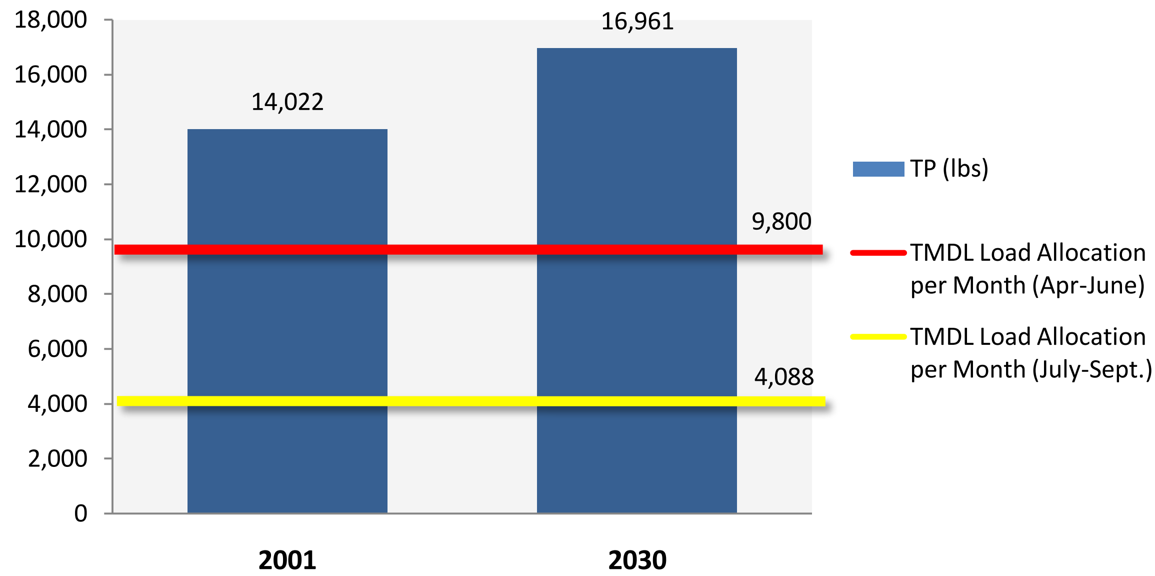

Figure 6. Comparison of NPS TP load (per month) in 2001 and 2030 with TMDL load allocation for the Lake Allegan/ Kalamazoo River TMDL area.

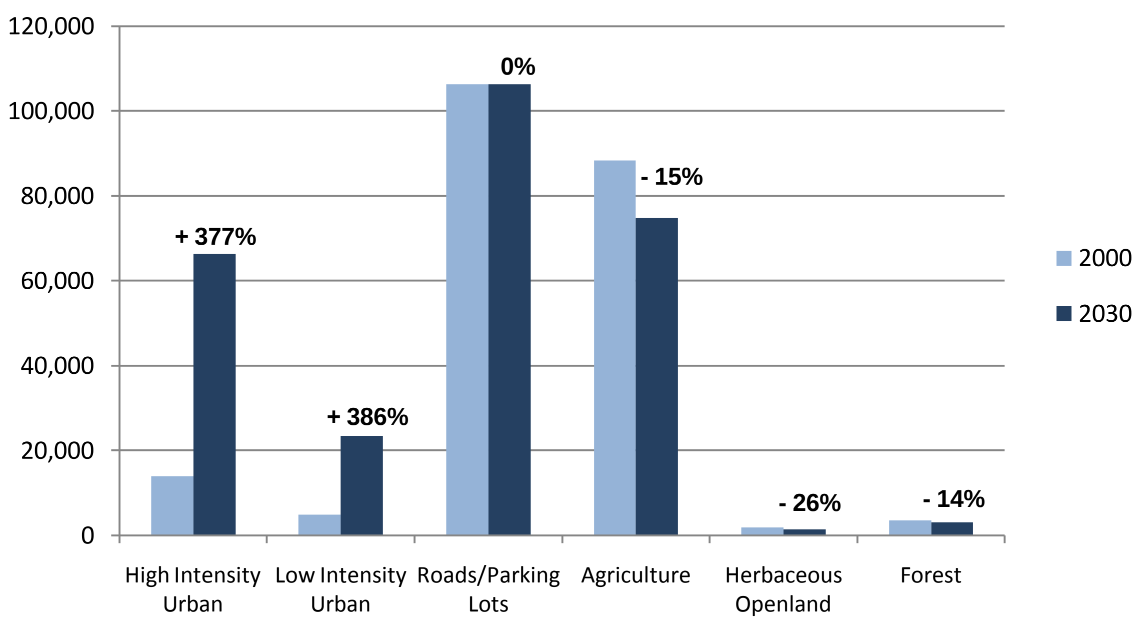

Figure 7. Total phosphorus load (in lbs/year) per land use in the Kalamazoo River watershed.

USING THE LAND TRANSFORMATION MODEL TO PREDICT FUTURE LAND USE IN THE WATERSHED, RESULTING LOAD INCREASES IN TOTAL PHOSPHORUS FROM HIGH INTENSITY AND LOW INTENSITY URBAN LAND USES ARE PREDICTED TO INCREASE BY OVER 375% AND 385%, RESPECTIVELY. WHEN PAIRED WITH PROACTIVE STORMWATER MANAGEMENT PRACTICES AND CONTROLS, GROWTH OF THESE URBAN AREAS DOES NOT HAVE TO RESULT IN EXTREME INCREASES IN TOTAL PHOSPHORUS LOADING TO THE RIVER. SECTION 4.0 DISCUSSES THE POTENTIAL STORMWATER COSTS ASSOCIATED WITH THE PREDICTED LOAD INCREASE.

3.3 Pollutant Load and Runoff Volume Analysis at the Subwatershed Scale

While all subwatersheds will experience an increase in runoff and loading to a varying extent, figures in Appendix B clearly show the trend by 2030 toward a larger increase in runoff and pollutant loading in the western part of the Kalamazoo River watershed, consistent with the land use change analysis in Section 3.1. The central area in the watershed between the Cities of Battle Creek and Kalamazoo and eastern parts of the watershed will be least impacted by urban development and the resulting environmental impacts. Annual average runoff and pollutant loads per subwatershed[8] are presented as maps in Appendix B and runoff volumes and pollutant loads for current baseline and future build-out are compared in Table B-1 in Appendix B.

In 2001, the subwatersheds with the highest runoff and pollutant loads are those located either in dense urban areas in the Cities of Kalamazoo, Portage and Battle Creek or in large agricultural areas, such as the Gun and Rabbit River subwatersheds (Table 4). Results are similar for 2030, in that the same urban and agricultural subwatersheds will continue to have the highest runoff and loading values. This is primarily due to predicted urban expansion in these areas of the watershed, as agricultural land is converted to residential and commercial uses (Table 5). In addition, two new subwatersheds (-0905, -0906) along the Kalamazoo River between Plainwell and Allegan are predicted to have some of the highest loadings in 2030, confirming the environmental impact of urbanization in this area (see Section 3.1 above).

These findings clearly highlight the difficulty of achieving TMDL goals in the long term when many high-loading subwatersheds are located upstream of Lake Allegan and directly along the Kalamazoo River. If land use changes occur as predicted without intervention, future loads will have to be offset in addition to the loads already in exceedence of the nonpoint source load allocation set by the TMDL. Areas outside of the TMDL area also have reason to be involved in watershed management planning as several rural subwatersheds around the City of Allegan (-0908, -0907, -0902) will experience the largest increases in pollutant loads as large acreages of agricultural and forested land are converted to urban land use (Table 6). In addition, the mouth of the watershed around the city of Saugatuck will also see large increases in loading as the attraction of the Lake Michigan shoreline leads to suburban sprawl. These areas do not currently fall under NPDES Phase II regulations, but future growth in the western portion of the watershed may result in regulation.

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[8] *The subwatershed analysis was done using the recent 12-digit HUC subwatershed layer available from the USDA Geospatial Data Gateway (http://datagateway.nrcs.usda.gov).*

In these high-growth subwatersheds, urban development will have to be managed in a sustainable manner if water quality is to be protected from further degradation. Permitted municipalities in high-loading, urban subwatersheds will need to consider all possible stormwater management options to limit increases in runoff from future development. Efforts to reduce stormwater impacts include retrofitting current residential and commercial impervious surfaces for stormwater retention or infiltration, as well as developing construction rules or ordinances promoting on-site retention for new developments.

Table 4. Subwatersheds contributing the largest nutrient and sediment loads to the watershed in 2001.

Subwatershed	HUC	Mean Runoff Depth (in/yr)	TSS (lbs/ac/yr)	TP (lbs/ac/yr)	TN (lbs/ac/yr)	% urban/ agriculture
Portage Creek	040500030603	4.21	112.12	0.37	2.93	40 / 15
Davis Creek-Kalamazoo River	040500030604	3.72	98.27	0.33	2.68	32 / 30
Harts Lake-Kalamazoo River	040500030503	3.56	97.18	0.32	2.30	27 / 8
Battle Creek	040500030312	3.49	97.69	0.32	2.33	27 / 13
Averill Lake-Kalamazoo River	040500030606	4.06	96.18	0.31	2.33	32 / 18
Kalamazoo River	040500030912	3.15	81.76	0.26	2.16	20 / 15
Fales Drain-Rabbit River	040500030802	2.90	85.19	0.24	2.87	7 / 53
Gun River	040500030703	2.79	83.40	0.23	2.87	5 / 58
Headwaters Little Rabbit River	040500030806	2.58	77.64	0.22	2.65	8 / 72
Black Creek	040500030809	2.54	80.06	0.22	2.67	5 / 80
Pigeon Creek-Rabbit River	040500030808	2.64	77.15	0.22	2.68	6 / 59
Little Rabbit River	040500030807	2.64	77.13	0.22	2.80	6 / 66
West Fork Portage Creek	040500030602	3.39	65.15	0.21	1.63	22 / 19

Table 5. Subwatersheds predicted to contribute the largest nutrient and sediment loads to the watershed in 2030.

Subwatershed	HUC	Mean Runoff Depth (in/yr)	TSS (lbs/ac/yr)	TP (lbs/ac/yr)	TN (lbs/ac/yr)	% urban/ agriculture
Portage Creek	040500030603	4.64	118.83	0.41	3.25	51 / 14
Kalamazoo River	040500030912	4.83	109.76	0.41	3.43	48 / 10
Harts Lake-Kalamazoo River	040500030503	4.17	107.34	0.37	2.75	43 / 6
Battle Creek	040500030312	4.04	106.59	0.36	2.75	43 / 11
Davis Creek-Kalamazoo River	040500030604	3.98	102.34	0.35	2.86	39 / 28
Averill Lake-Kalamazoo River	040500030606	4.55	102.50	0.35	2.62	46 / 15
Tannery Creek-Kalamazoo River	040500030906	3.94	90.67	0.33	3.04	40 / 24
Little Rabbit River	040500030807	3.86	91.17	0.32	3.50	32 / 49
Fales Drain-Rabbit River	040500030802	3.65	95.08	0.31	3.35	22 / 46
Trowbridge Dam-Kalamazoo River	040500030905	3.49	83.95	0.29	2.88	31 / 34
Gun River	040500030703	3.52	92.60	0.29	3.31	22 / 50
Pigeon Creek-Rabbit River	040500030808	3.50	88.46	0.29	3.23	24 / 50
Black Creek	040500030809	3.40	89.38	0.29	3.09	27 / 62

Table 6. Subwatersheds predicted to experience the largest changes in runoff volume, nutrient load and sediment load from 2001 to 2030.

		Runoff		TSS		TP		TN	
Subwatershed	HUC	Change in volume (acre-feet/yr)	% of total change	Change in load (tons/yr)	% of total change	Change in load (lbs/yr)	% of total change	Change in load (lbs/yr)	% of total change
Swan Creek	030908	3,207	5.9	288	6.5	3,373	6.0	26,866	6.4
Lake Allegan-Kalamazoo R.	030907	2,702	4.9	238	5.4	2,803	5.0	21,868	5.2
Base Line Creek	030902	1,582	2.9	124	2.8	2,119	3.8	14,353	3.4
Pigeon Creek-Rabbit River	030808	1,463	2.7	116	2.6	1,566	2.8	11,327	2.7
Rabbit River	030811	1,461	2.7	108	2.4	1,588	2.8	11,085	2.7
Black Creek	030809	1,586	2.9	104	2.3	1,543	2.8	9,513	2.3
Little Rabbit River	030807	1,524	2.8	105	2.4	1,590	2.8	10,424	2.5
Kalamazoo R.	030912	1,869	3.4	142	3.2	1,505	2.7	12,945	3.1
Tannery Creek-Kalamazoo R.	030906	1,460	2.7	128	2.9	1,504	2.7	11,683	2.8

3.4 Pollutant Load and Runoff Volume Analysis at the Township Scale

The results of runoff volume and pollutant load changes by township or city (municipality level) were very similar to results at the subwatershed level presented in Section 3.3 (i.e. the same areas were highlighted as high loading areas). Therefore, another statistic was calculated for each township/city and presented in Figures C-1 to C-4 in Appendix C. These tables present the change in each township/city's runoff volume and pollutant load as a percentage of the total watershed's change in runoff or loading in 2030. Total runoff volume and pollutant load values for the current baseline and future build-out years per township/city are presented in Table C-1 in Appendix C.

Changes in pollutant loads and runoff volume are consistent with land use changes discussed in Section 3.1. The townships or cities experiencing the largest increase in runoff volume and loads are the same municipalities forecasted to experience the largest urban development (refer to Table 3). They are located in the western section of the Kalamazoo River watershed, between the Cities of Allegan and Otsego (Table 7). Saugatuck Township, at the mouth of the watershed, and townships around the city of Battle Creek will also experience significant increases in runoff and pollutant loads according to the results of this modeling analysis. The municipal management level was chosen as part of this analysis because of the jurisdictional relevance of townships and cities. Townships and cities have the ability to pass ordinances and laws and use tax revenues to implement stormwater retrofits. Modeling future runoff and pollutant loading may be most useful in approaching municipalities and promoting early implementation of stormwater policies and BMPs. As runoff volume and pollutant loading changes over time, so do the resulting costs associated with reducing the loads and their resulting impacts. An example of this is provided in Section 4.0.

Table 7. Townships with greatest changes in runoff volume and pollutant loads as a percentage of the total watershed change in runoff volume and pollutant loads from 2001 to 2030.

	Runoff		TSS		TP		TN	
Name	Change in volume (acre-feet/yr)	% of total change	Change in load (tons/yr)	% of total change	Change in load (lbs/yr)	% of total change	Change in load (lbs/yr)	% of total change
Cheshire Twp	2,782	5.1	249	5.7	2,900	5.2	23,080	5.5
Salem Twp	2,217	4.0	151	3.4	2,330	4.2	15,238	3.7
Trowbridge Twp	1,920	3.5	154	3.5	1,916	3.4	13,932	3.3
Dorr Twp	1,844	3.4	133	3.0	1,894	3.4	12,748	3.1
Allegan Twp	1,848	3.3	155	3.5	1,884	3.4	14,089	3.4
Heath Twp	1,697	3.1	150	3.4	1,856	3.3	14,601	3.5
Monterey Twp	1,772	3.2	155	3.5	1,861	3.3	14,500	3.5

4.0 Stormwater Controls Cost Analysis

A simple cost analysis was conducted as an additional illustration for decision-makers to emphasize the importance of implementing stormwater runoff controls and policies as early as possible to meet TMDL load allocation requirements and protect overall water quality. Townships outside the TMDL area were also included in this analysis because they may eventually face similar requirements as the US EPA looks to expand the NPDES Phase II program or as more TMDLs are developed for impaired waters. Urban growth is predicted to increase to varying degrees throughout the entire watershed; therefore, costs for reducing the increased loading associated with this urban growth will increase, as well. The trend is for less developed townships and smaller municipalities to experience more rapid growth compared to larger cities that have already experienced full build-out in many areas. A simple cost analysis of stormwater controls was performed as part of analysis. The purpose of the analysis was to capture: 1) the current cost to reduce phosphorus loading in half to satisfy the TMDL baseline load level, and 2) the future predicted costs to reduce the future phosphorus loading, if urban growth continues without stormwater controls.

The cost analysis used several assumptions in order to calculate a conservative, generalized cost for loading reductions in each municipality. These assumptions were limited by the lack of site-specific data available for the watershed, the large scale of the watershed and large number of individual municipalities, and the general project scope. Therefore, assumptions used in the cost analysis are as follows:

- Only TP load from Commercial/High Density land use was considered in the cost calculation as this land use is most likely subject to current and future regulation.
- A value of $10,000 per pound of phosphorus reduced was used as a coarse, conservative estimate.
- No adjustments were made to account for cost inflation by 2030, land value, or operation and maintenance (which to a certain degree are implicitly covered in the $10,000/lb assumption).
- Retrofitting of existing commercial developments was not taken into account. A certain percentage of commercial properties are retrofitted each year to meet new standards and provide increased retention/infiltration. These retrofits would reduce the total load for 2030.
- The TP load from the 2001 loading analysis in this report is used in place of the 1998 TMDL baseline level for simplification purposes (again, any existing controls or treatment systems are not taken into account in this analysis).

Three scenarios were defined in order to compare the current load and future load as it relates to the TMDL, with the associated costs for each. The scenarios used in the analysis are:

Scenario 1: Stormwater ordinance passed in 2001 - A stormwater ordinance requiring all new commercial developments to infiltrate or retain 100% of stormwater runoff on-site is passed by the municipality at the start of TMDL implementation (i.e., there is no increase in load from commercial development between 2001 and 2030). Therefore, the cost to the municipality is only for stormwater retrofit BMPs to reduce the 2001 load by 50% (to meet TMDL requirements).

Scenario 2: Reducing new 2030 loading by 50% - The municipality is required to reduce the new 2030 load resulting from increased development by 50% (representative of a theoretical Phase II regulation that may apply in the future and require municipalities to implement retrofits).

Scenario 3: Retrofitting in 2030 to meet TMDL - The municipality waits until 2030 to address the Kalamazoo River phosphorus TMDL and is now required to reduce the new 2030 load to 50% below the loading level in 2001 (which represents the existing TMDL load allocation).

The cost analysis was conducted both at the township and subwatershed level to be consistent with other analyses presented in this report. The cost analysis results for all townships and municipalities are presented in Appendix D. While stormwater management can be implemented within both township and watershed boundaries, only townships have the authority to pass ordinances controlling stormwater BMP requirements. To provide a comparison with other municipalities, the City of Portage and Oshtemo Township are highlighted in the table in the appendix. They have substantially lower future loads and associated costs because both have already passed stormwater ordinances requiring on-site stormwater management[9] (Table D-1). Information was not available at the time of this analysis regarding other townships that may have passed similar ordinances. In the City of Portage, for example, it was assumed that the baseline urban-commercial phosphorus load would not increase over time, as the ordinance requires on-site stormwater infiltration for new development. The cost to reduce half of their baseline load is just over $5 million. The costs for scenarios 2 and 3 remain at the $5 million level since it can be assumed that the city's loading will not likely increase.

In contrast, Table 8 shows that municipalities and townships without current ordinances have a rising trend in stormwater control costs over time and under increasingly stringent regulatory scenarios. The table shows an excerpt from Table D-1 (Appendix D) of six major municipalities in the watershed within the TMDL area. Due to the built-out condition of these cities currently, somewhat limited urban growth is predicted for 2030 when compared to more rural areas with greater open areas for potential development. Nevertheless, costs for stormwater controls are not insignificant. The City of Battle Creek, for example, could expect stormwater control costs to more than double between 2001 and 2030 if action is postponed. Costs for the City of Marshall could be almost seven times greater in 2030 when compared to the Scenario 1 cost (early action) at only $500,000.

In addition, Table 8 includes six townships located from the eastern and western portions of the watershed as an example of how costs are impacted by large increases in urban-commercial loading. Since these townships have ample area for development and relatively low baseline loads, the substantial increase in future loading greatly increases stormwater control costs by 2030. In the case of Albion and Allegan Townships, which are located within the TMDL area, costs increase nearly 10 times between Scenario 1 and Scenario 3. Differences between Scenario 1 and 3 costs for the other four townships listed in Table 8 are much greater. For example, Cheshire Township's stormwater costs are expected to be over 100 times greater in 2030 when compared to Scenario 1 costs at only $200,000.

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[9] *Oshtemo Township's final stormwater ordinance (78.520) requires all owners or developers of property to construct and maintain on-site stormwater management facilities designed for a 100-year storm. The full text of the ordinance is available at: http://www.oshtemo.org/*
The City of Portage has adopted 9 stormwater BMP performance standards for development and redevelopment sites, including stormwater infiltration/retention on-site (FTCH, 2003).

Table 8. Stormwater control scenarios in cities and townships with high stormwater treatment costs related to increases in urban loading.

	TP Load (lbs/yr)		Cost of Stormwater Controls ($)		
Name	**2001 TP from urban-commercial**	**2030 TP from urban-commercial**	**Scenario 1 (in millions)**	**Scenario 2 (in millions)**	**Scenario 3 (in millions)**
City of Allegan	506	789	$2.5	$3.9	$5.4
City of Battle Creek	1,642	2,589	$8.2	$12.9	$17.7
City of Kalamazoo	1,822	2,231	$9.1	$11.2	$13.2
City of Marshall	106	382	$0.5	$1.9	$3.3
City of Otsego	199	334	$1.0	$1.7	$2.3
City of Plainwell	174	279	$0.9	$1.4	$1.9
Albion Twp	15	739	$0.75	$3.7	$7.3
Allegan Twp	417	2,225	$2.0	$11.1	$20.1
Cheshire Twp	37	2,574	$0.2	$12.9	$25.6
Dorr Twp	330	2,253	$1.6	$11.3	$20.9
Salem Twp	331	2,648	$1.7	$13.2	$24.8
Trowbridge Twp	93	2,007	$0.5	$10.0	$19.6

The scenarios used for this stormwater control cost analysis were based largely on the current requirements under the phosphorus TMDL, which applies to the area upstream of Lake Allegan in the western part of the watershed. Under the most stringent TMDL requirement, nonpoint source phosphorus loading is required to be reduced by half during certain months of the year (July-September) and by 43% from April-June. Over the past 10 years since the TMDL was developed, overall watershed phosphorus loading goals have not been met. Since point source loading contributions have stayed within their allocation, it has been determined that nonpoint sources are still discharging above the set load allocation. Results from this limited cost analysis suggest that the costs associated with reducing just the urban-commercial baseline loading to half within the TMDL area may total as much as $55 million (Figure 8). If the urban-commercial build-out and, therefore, phosphorus load are allowed to increase without implementing stormwater policies now, the costs to retrofit are predicted to soar above $380 million[10] by 2030 within the TMDL area[11]. For the entire TMDL watershed, waiting to implement stormwater controls on new and expanding development will equate to an almost 700% increase in the cost to meet the TMDL load allocation.

It is important to note that lower cost BMPs may be available for implementation in certain areas. For example, stormwater retention basins in areas where existing build-out is not prohibitive may generate a pound of phosphorus reduction at a price lower than the $10,000 assumption used in this analysis. For this reason, costs for Scenario 1 may be slightly lower than what is predicted here, although urban-residential loading is not taken into account in this analysis and would likely add additional costs. Conversely, urban areas that already have substantial build-out may find that stormwater retrofit projects may come at a

[10] *Future phosphorus load reduction costs have not been adjusted for inflation and are presented in 2009 dollars.*
[11] *When calculating stormwater control costs for retrofits in 2030, the build-out loading values that were used did not compensate for areas within the watershed that already have stormwater ordinances in place. Data for existing stormwater ordinances were not available at the time of this analysis and assumed to be limited in scope.*

greater cost than $10,000/pound of phosphorus reduced. The values presented as part of this analysis are meant for illustrative purposes and should not be considered an accurate cost for the scenarios presented herein.

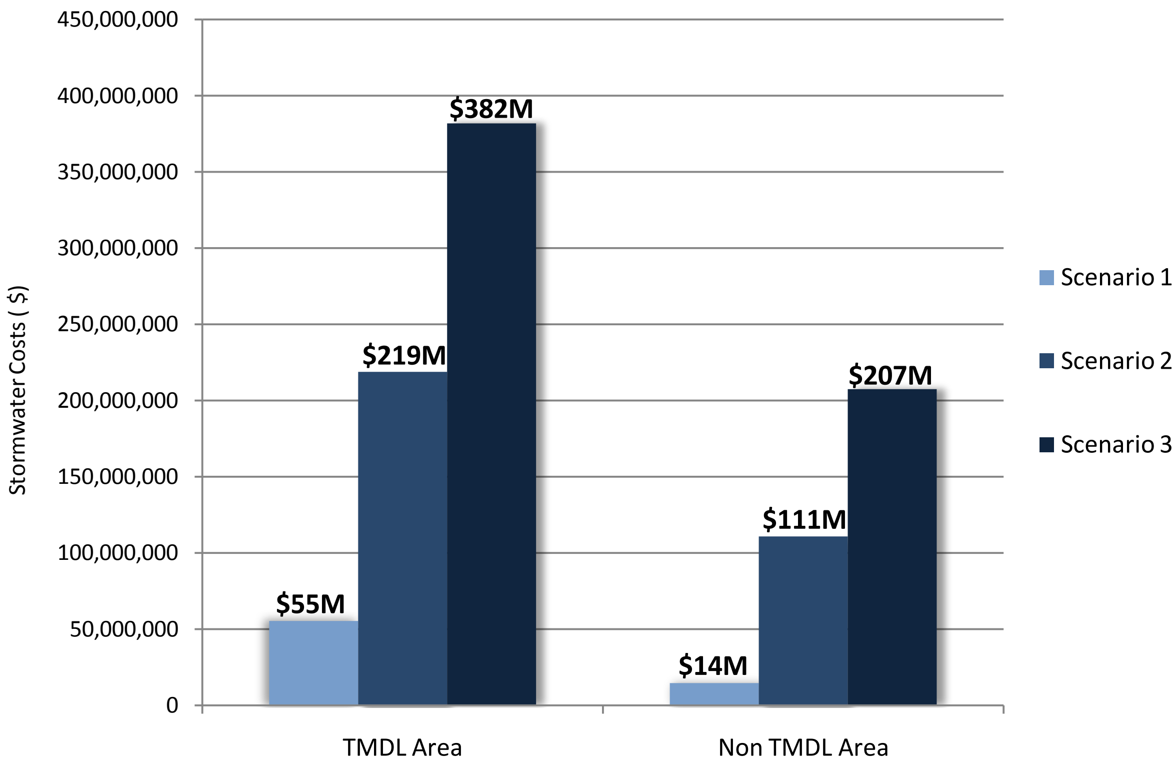

Figure 8. Increasing costs for stormwater controls to treat increasing urban phosphorus loads from 2001 to 2030 in both the TMDL area and the non TMDL area of the watershed.

In general, results show that stormwater retrofits in 2030 would be extremely expensive for municipalities, costing on average almost seven times the cost of controlling stormwater at 2001 loading values. In comparison, municipalities such as the City of Portage and Oshtemo Township have already passed stormwater ordinances that require new development to control TP loading, most often in the form of stormwater retention BMPs. The ordinance will work to limit TP loading from future build out, and therefore decrease the cost to retrofit developed areas with no stormwater controls. These townships will see substantial costs savings by 2030 in terms of stormwater controls. Their future costs are considerably lower when compared to townships with similar TP loads that will likely face the prospect of stormwater retrofits in 2030. In terms of the existing phosphorus TMDL, it is important to note that this limited analysis only calculates costs associated with urban-commercial loading and not other sources of nonpoint source runoff and pollutant loading. While urban-commercial loading is the largest contributing nonpoint source load in many areas within the watershed, municipalities must consider all nonpoint sources when implementing stormwater ordinances and regulations. For instance, many of the townships (e.g., Allegan Township) in the watershed are expected to have large increases in urban-residential land use, which may result in increased storm sewer infrastructure and, therefore, exponential increases in loading and retrofitting costs.

A SEPARATE URBAN BMP SCREENING TOOL AND SUPPORTING DOCUMENTATION DEVELOPED FOR THE KALAMAZOO RIVER WATERSHED AS PART OF THIS PROJECT IS AVAILABLE FROM THE KALAMAZOO RIVER WATERSHED COUNCIL. THE TOOL WAS DESIGNED TO ASSIST MUNICIPALITIES, TOWNSHIPS, AND WATERSHED MANAGERS IN ESTIMATING THE COST-EFFICIENCY AND REDUCTION POTENTIAL OF SEVERAL COMMONLY USED STORMWATER BMPS. THIS TOOL PROVIDES MUNICIPALITIES AND TOWNSHIPS WITH INFORMATION MORE SPECIFIC TO THEIR NEEDS TO SATISFY WMP REQUIREMENTS FOR COST AND REDUCTION POTENTIAL OF BMPS RECOMMENDED IN THE PLAN. THE PURPOSE OF THIS TOOL AND THE ANALYSIS PROVIDED IN THIS REPORT IS TO SUPPORT IMPLEMENTATION OF STORMWATER BMPS AT THE MOST COST-EFFECTIVE RATE.

5.0 Conclusions

This report presented the first comprehensive effort to estimate runoff and pollutant loads within the entire Kalamazoo River watershed. A simple runoff/loading model was developed using commonly accepted methods and equations, such as the Long-Term Hydrologic Impact Assessment model for estimating runoff and pollutant event mean concentrations referenced in the Michigan Trading Rules. Runoff volumes and pollutant loads were calculated for both current (baseline) conditions, using the most recent land use available from 2001, and future (build-out) conditions, using the 2030 land use map, produced by the Land Transformation Model. Modeling results for baseline and build-out conditions were analyzed at three geographic scales: entire watershed, 12-digit HUC subwatershed, and municipality.

Results from this analysis highlight a few areas within the watershed that are predicted to experience increasing urban development, and consequently large increases in stormwater runoff and pollutant loads. These critical areas include the western section of the Kalamazoo River watershed around the cities of Allegan, Otsego and Saugatuck; the area surrounding the City of Battle Creek; and the eastern side of the City of Marshall. It must be noted that the western part of the watershed contains the Allegan State Game Area. This currently rural area is expected to experience the largest change within the entire watershed. Urbanization could seriously impact the hydrology and water quality of this natural area. In addition, results clearly emphasize the increasing importance of stormwater as a non-point source of pollution while the proportion of TP load from agricultural activities is predicted to decrease from 40% to 27% by 2030. Implementation of stormwater runoff control practices will be required throughout the watershed to preserve water quality, prevent stream channel erosion and flashiness, and in particular to achieve the goals set in the Lake Allegan/Kalamazoo River TMDL. In fact, municipalities could face very high costs to control stormwater and achieve the reductions required in the TMDL as time progresses. Results from the stormwater cost analysis indicate that limiting the increase in stormwater runoff through ordinance may be an easy and less expensive option.

In conclusion, the loss of agricultural land and open space to urban areas within the next 30 years, as modeled in this report, predicts a 25% increase in runoff volume and phosphorus load, a 12% increase in total suspended solids load and an 18% increase in total nitrogen. These predicted increases conflict with the 40-50% TP load reduction goals set in the Lake Allegan/Kalamazoo River TMDL. Preserving water quality and implementing the current TMDL will not only require a concerted effort among all partners within the watershed, but also the extensive implementation of multiple practices and regulations. Such practices include stormwater BMPs and ordinances promoting infiltration, retention, and reduction in impervious surfaces; zoning regulations promoting mixed land uses and smart growth, including adoption of low impact development practices; preservation of open space and critical areas; and broad adoption of agricultural BMPs. The costs associated with these BMPs vary from project to project, although overall costs throughout the watershed likely range in the hundreds of millions of dollars. Early adoption of stormwater policies and implementation of stormwater controls can greatly reduce the price of load reductions required by the TMDL and other regulatory programs.

RESULTS PRESENTED IN THIS REPORT ARE NOT INTENDED TO PRESENT AN ACCURATE PREDICTION OF THE CURRENT OR FUTURE CONDITIONS IN THE KALAMAZOO RIVER WATERSHED. THEY ARE INSTEAD MEANT TO BE USED AS ESTIMATES TO GUIDE THE DEVELOPMENT AND IMPLEMENTATION OF THE WATERSHED MANAGEMENT PLAN, SUPPORT THE SELECTION OF CRITICAL AREAS WITHIN THE WATERSHED, AND PROVIDE A BASIS FOR EDUCATIONAL AND PROMOTIONAL EFFORTS. THESE RESULTS COULD BE USED TO INFORM DISCUSSIONS AND DECISIONS FROM LOCAL UNITS OF MANAGEMENT AND WATERSHED MANAGERS REGARDING ZONING AND LAND USE MANAGEMENT.

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Appendix A

Land Use Change Analysis per Township

APPENDIX A - Land Use Change Analysis per Township

Table A-1: Land Use Breakdown per Township for 2001 and 2030 (in acres).

	High Intensity Urban/ Commercial		Low Intensity Residential		Roads		Agriculture		Herbaceous Openland - Barren		Forest		Open water		Wetlands		Total increase in urban areas	% of urban increase	% of total watershed area
Name	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030			
Adams Twp	0	7	5	30	47	47	1,159	1,142	99	91	158	151	0	0	109	109	32	0.02	0.12
Alamo Twp	86	489	309	1,164	788	788	10,139	9,501	1,722	1,473	5,859	5,649	183	178	4,045	3,897	1,258	0.73	1.79
Albion, City	198	539	410	902	566	566	583	371	477	304	820	497	10	7	240	121	833	0.48	0.25
Albion Twp	25	1,119	215	2,347	477	477	13,744	11,703	1,245	1,048	3,588	2,992	20	15	1,727	1,339	3,227	1.87	1.62
Allegan, City	549	887	146	593	339	339	279	163	274	136	625	339	279	195	314	163	786	0.45	0.22
Allegan Twp	450	2,666	289	3,326	680	680	10,712	7,798	1,258	788	4,178	2,871	872	773	1,814	1,374	5,253	3.04	1.56
Assyria Twp	109	983	109	1,124	514	514	9,671	8,856	1,539	1,381	5,837	5,256	188	173	5,187	4,865	1,890	1.09	1.78
Barry Twp	136	576	170	568	494	494	10,339	9,953	1,253	1,176	3,820	3,622	776	724	4,008	3,884	838	0.48	1.61
Battle Creek, City	2,219	3,598	2,965	5,402	3,165	3,165	4,156	3,378	3,343	2,580	7,892	6,417	507	484	3,304	2,661	3,815	2.21	2.15
Bedford Twp	143	1,278	618	2,555	773	773	3,472	3,032	2,320	1,668	7,971	6,405	220	208	3,314	2,916	3,071	1.78	1.46
Bellevue Twp	131	820	170	860	677	677	10,193	9,555	1,166	1,028	3,573	3,259	77	64	3,662	3,417	1,379	0.80	1.51
Bloomingdale Twp	5	304	86	998	119	119	1,278	724	334	205	731	437	215	138	539	383	1,211	0.70	0.25
Brookfield Twp	27	255	54	309	465	465	12,068	11,693	660	657	1,920	1,880	156	156	2,429	2,392	482	0.28	1.37
Byron Twp	77	297	111	361	121	121	4,082	3,739	252	252	759	687	10	10	230	208	469	0.27	0.44
Carmel Twp	52	393	69	442	321	321	7,561	7,035	405	353	1,245	1,164	25	7	1,035	1,001	714	0.41	0.82
Charleston Twp	126	361	163	638	539	539	4,448	4,216	1,668	1,218	8,710	9,027	378	371	2,380	2,046	709	0.41	1.42
Charlotte, City	264	388	190	314	284	284	351	235	213	198	267	198	7	5	109	82	247	0.14	0.13
Cheshire Twp	40	2,963	299	4,309	442	442	6,474	3,926	2,056	1,161	4,075	2,256	588	504	3,459	2,051	6,934	4.01	1.35
Clarence Twp	42	712	84	1,381	442	442	11,169	9,886	974	882	2,864	2,523	810	796	4,050	3,818	1,967	1.14	1.57
Climax Twp	0	0	0	0	10	10	195	195	5	5	17	17	0	0	7	7	0	0.00	0.02
Clyde Twp	42	390	89	623	240	240	200	82	1,142	482	3,062	3,071	5	5	279	166	882	0.51	0.39

	High Intensity Urban/ Commercial		Low Intensity Residential		Roads		Agriculture		Herbaceous Openland - Barren		Forest		Open water		Wetlands		Total increase in urban areas	% of urban increase	% of total watershed area
Name	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030			
Comstock Twp	677	1,317	1,147	2,444	1,134	1,134	7,848	7,272	1,715	1,401	5,733	4,863	1,201	1,166	1,717	1,586	1,937	1.12	1.63
Concord Twp	72	1,248	178	2,343	638	638	13,801	11,288	1,668	1,475	3,714	3,333	42	42	3,057	2,807	3,341	1.93	1.78
Convis Twp	138	687	163	1,161	726	726	8,354	7,752	1,616	1,769	5,525	5,066	331	329	6,170	5,861	1,547	0.89	1.80
Cooper Twp	72	759	556	2,006	628	628	9,237	8,350	2,498	2,024	7,816	7,257	170	170	2,286	2,123	2,137	1.24	1.80
Dorr Twp	383	2,572	717	3,667	635	635	15,590	12,054	1,137	739	2,916	2,044	7	5	1,268	956	5,140	2.97	1.74
Eaton Twp	32	571	32	618	294	294	4,119	3,299	341	373	1,122	974	5	5	988	904	1,124	0.65	0.54
Eckford Twp	10	534	79	961	371	371	11,223	10,319	652	568	1,900	1,653	91	89	1,957	1,789	1,406	0.81	1.25
Emmett Twp	462	1,700	754	2,856	1,208	1,208	8,305	7,361	1,564	1,151	5,599	4,099	272	222	2,646	2,231	3,341	1.93	1.60
Fayette Twp	15	22	15	42	20	20	339	321	67	59	178	170	5	5	158	156	35	0.02	0.06
Fennville, City	84	198	89	235	96	96	259	96	59	40	89	47	22	2	27	15	259	0.15	0.06
Fillmore Twp	49	104	42	136	74	74	1,700	1,576	35	32	106	99	0	0	37	35	148	0.09	0.16
Fredonia Twp	12	264	37	529	235	235	3,314	2,901	467	390	1,144	1,025	208	195	1,994	1,871	744	0.43	0.57
Gaines Twp	5	119	2	106	79	79	870	806	67	89	205	178	7	7	195	153	217	0.13	0.12
Galesburg	25	86	89	255	49	49	259	166	94	67	269	198	17	15	126	94	227	0.13	0.07
Ganges Twp	7	49	32	84	5	5	217	143	27	15	25	17	0	0	0	0	94	0.05	0.02
Gobles, City	0	22	5	106	5	5	89	17	22	5	42	7	0	0	0	0	124	0.07	0.01
Gunplain Twp	198	2,031	269	2,726	880	880	11,248	9,111	1,369	934	5,500	4,072	195	158	2,147	1,942	4,290	2.48	1.69
Hanover Twp	30	726	257	1,433	519	519	10,257	9,167	2,444	2,246	5,369	4,942	255	252	3,084	2,928	1,873	1.08	1.71
Heath Twp	230	1,917	368	2,800	576	576	4,183	2,735	3,380	2,389	10,509	9,461	156	143	3,632	3,037	4,119	2.38	1.77
Homer Twp	37	773	131	1,478	516	516	13,455	12,073	1,077	961	1,777	1,554	15	2	2,644	2,293	2,083	1.20	1.51
Hope Twp	2	5	0	2	0	0	0	0	7	7	35	32	0	0	2	0	5	0.00	0.00
Hopkins Twp	158	1,112	203	1,579	672	672	17,435	15,646	588	521	2,113	1,858	114	99	1,777	1,581	2,330	1.35	1.77
Jamestown Twp	74	1,404	133	1,651	546	546	10,450	7,855	183	156	862	736	22	15	395	311	2,847	1.65	0.97
Johnstown Twp	30	576	82	692	329	329	4,831	4,282	684	598	2,691	2,352	67	59	2,123	1,947	1,156	0.67	0.83
Kalamazoo, City	2,451	3,029	3,576	4,883	2,538	2,538	596	427	1,520	1,114	3,907	2,918	292	190	845	672	1,885	1.09	1.23
Kalamazoo	726	1,070	1,436	2,113	892	892	949	744	899	756	2,029	1,537	44	32	492	393	1,021	0.59	0.58

	High Intensity Urban/ Commercial		Low Intensity Residential		Roads		Agriculture		Herbaceous Openland - Barren		Forest		Open water		Wetlands		Total increase in urban areas	% of urban increase	% of total watershed area
Name	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030			
Twp																			
Kalamo Twp	7	30	12	30	49	49	2,422	2,394	170	166	309	304	5	5	571	571	40	0.02	0.27
Laketown Twp	116	1,030	329	1,490	250	250	410	250	514	227	2,800	1,589	47	17	872	489	2,076	1.20	0.41
Lee Twp-Allegan	2	20	12	126	5	5	358	334	163	151	529	487	0	0	363	311	131	0.08	0.11
Lee Twp-Calhoun	74	381	69	635	526	526	14,856	14,312	1,085	1,025	3,217	3,062	203	203	3,237	3,126	872	0.50	1.79
Leighton Twp	304	1,502	284	1,824	578	578	12,313	10,573	951	937	2,550	2,090	403	383	2,016	1,725	2,738	1.58	1.51
Leroy Twp	10	334	124	857	319	319	5,434	4,917	833	704	2,041	1,782	292	279	2,639	2,498	1,058	0.61	0.90
Liberty Twp	7	69	20	131	44	44	610	487	77	74	119	94	136	136	180	158	173	0.10	0.09
Litchfield, City	2	15	2	62	20	20	138	72	2	0	5	2	0	0	0	0	72	0.04	0.01
Litchfield Twp	17	133	12	277	190	190	3,803	3,459	104	91	252	245	0	0	306	289	381	0.22	0.36
Manlius Twp	153	1,507	316	2,192	373	373	6,699	5,377	2,419	1,658	7,191	6,430	425	420	5,088	4,791	3,230	1.87	1.75
Maple Grove Twp	10	52	27	77	119	119	3,546	3,501	264	250	717	709	12	12	712	689	91	0.05	0.42
Marengo Twp	15	1,772	126	3,299	746	746	14,376	10,875	1,114	855	3,195	2,530	57	57	3,242	2,738	4,930	2.85	1.76
Marshall, City	151	539	376	1,129	398	398	1,161	633	356	220	932	605	64	52	573	457	1,142	0.66	0.31
Marshall Twp	84	974	175	1,984	1,117	1,117	11,619	9,889	1,112	959	3,138	2,669	119	99	2,874	2,548	2,698	1.56	1.56
Martin Twp	190	1,085	141	1,505	591	591	18,130	16,422	828	680	1,754	1,525	116	114	1,265	1,124	2,258	1.31	1.77
Monterey Twp	185	2,034	336	2,958	591	591	12,785	10,803	1,616	1,171	5,538	4,099	116	101	1,853	1,287	4,470	2.58	1.77
Moscow Twp	44	128	74	301	487	487	12,093	11,925	1,374	1,322	3,420	3,366	10	10	2,123	2,088	311	0.18	1.51
Newton Twp	15	116	37	232	114	114	2,031	1,955	425	408	1,107	1,006	5	2	1,282	1,218	297	0.17	0.40
Olivet, City	42	104	57	138	57	57	84	47	69	47	225	170	0	0	106	77	143	0.08	0.05
Orangeville Twp	215	736	373	1,006	262	262	4,161	3,818	1,547	1,238	7,057	6,852	1,021	956	2,718	2,488	1,154	0.67	1.33
Oshtemo Twp	432	944	638	1,700	806	806	4,047	3,516	1,465	1,003	4,754	4,309	52	49	373	252	1,574	0.91	0.98
Otsego, City	203	353	183	363	220	220	245	131	131	79	230	141	44	27	82	27	331	0.19	0.10
Otsego Twp	215	2,088	331	3,062	675	675	11,545	8,836	1,470	1,097	4,524	3,430	390	343	2,520	2,170	4,603	2.66	1.67
Overisel Twp	57	848	190	1,275	403	403	8,604	7,047	242	185	687	529	2	2	1,028	929	1,875	1.08	0.86

	High Intensity Urban/ Commercial		Low Intensity Residential		Roads		Agriculture		Herbaceous Openland - Barren		Forest		Open water		Wetlands		Total increase in urban areas	% of urban increase	% of total watershed area
Name	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030			
Parchment, City	69	94	180	269	89	89	12	5	79	30	124	84	2	2	27	15	114	0.07	0.05
Parma Twp	40	1,245	156	2,197	561	561	9,407	7,230	1,144	937	2,258	1,742	0	0	2,422	2,076	3,247	1.88	1.23
Pavilion Twp	10	40	35	96	96	96	2,343	2,278	161	163	507	497	52	52	588	573	91	0.05	0.29
Pennfield Twp	188	1,441	546	2,936	823	823	6,244	5,110	2,199	1,754	8,841	7,267	198	161	3,267	2,871	3,642	2.11	1.73
Pine Grove Twp	27	1,349	119	4,275	442	442	7,794	4,930	1,396	865	4,171	2,639	67	59	2,305	1,762	5,478	3.17	1.26
Plainwell, City	173	282	188	363	190	190	301	185	138	99	245	163	42	25	47	27	284	0.16	0.10
Portage, City	1,282	1,814	3,235	4,359	1,460	1,460	1,090	887	1,273	857	3,746	2,918	12	12	1,391	1,206	1,656	0.96	1.05
Prairieville Twp	131	697	208	744	623	623	12,016	11,540	1,396	1,285	5,402	5,167	1,547	1,391	1,922	1,811	1,102	0.64	1.79
Pulaski Twp	15	566	116	1,137	544	544	13,445	12,432	1,950	1,833	3,956	3,667	109	109	3,262	3,109	1,572	0.91	1.81
Richland Twp	96	554	339	1,332	667	667	12,214	11,483	1,574	1,423	5,570	5,108	1,035	1,021	1,468	1,396	1,450	0.84	1.79
Ross Twp	126	516	366	1,327	541	541	5,925	5,523	1,715	1,386	8,814	8,569	1,431	1,332	3,689	3,412	1,352	0.78	1.77
Salem Twp	358	2,832	341	3,778	650	650	14,265	10,351	1,238	828	3,526	2,417	168	163	2,355	1,920	5,911	3.42	1.77
Sandstone Twp	0	5	0	0	2	2	72	67	10	10	27	27	0	0	2	2	5	0.00	0.01
Saugatuck, City	59	111	96	163	91	91	0	0	52	49	282	193	151	146	69	49	119	0.07	0.06
Saugatuck Twp	195	1,824	472	2,728	551	551	4,374	2,970	1,206	793	3,788	2,271	642	603	2,239	1,740	3,884	2.25	1.05
Scipio Twp	40	279	86	596	566	566	10,143	9,738	1,295	1,216	2,718	2,587	74	62	2,503	2,387	749	0.43	1.34
Sheridan Twp	52	1,129	180	2,286	546	546	9,536	7,887	1,401	1,102	4,015	3,274	64	59	4,015	3,526	3,183	1.84	1.53
Somerset Twp	27	62	15	126	49	49	1,292	1,213	163	141	427	410	0	0	213	185	146	0.08	0.17
Spring Arbor Twp	35	341	166	603	220	220	4,122	3,660	764	689	1,362	1,253	15	15	1,095	996	744	0.43	0.60
Springfield, City	321	489	277	526	534	534	25	15	425	294	581	390	15	15	205	121	418	0.24	0.18
Springport Twp	22	381	32	712	114	114	3,968	3,180	269	235	467	371	2	0	472	363	1,038	0.60	0.41
Texas Twp	188	709	526	1,616	474	474	4,028	3,403	1,320	845	4,984	4,631	514	477	773	660	1,611	0.93	0.99
Thornapple Twp	27	54	32	84	69	69	2,204	2,189	136	334	371	346	35	35	138	131	79	0.05	0.25
Trowbridge	114	2,597	193	3,620	635	635	12,634	8,962	1,441	1,006	4,119	2,992	578	519	3,183	2,567	5,911	3.42	1.76

	High Intensity Urban/ Commercial		Low Intensity Residential		Roads		Agriculture		Herbaceous Openland - Barren		Forest		Open water		Wetlands		Total increase in urban areas	% of urban increase	% of total watershed area
Name	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030	2001	2030			
Twp																			
Valley Twp	96	1,025	257	1,576	339	339	1,386	766	3,395	1,871	12,491	12,913	1,651	1,576	2,978	2,535	2,249	1.30	1.74
Village of Douglas	84	188	163	314	158	158	15	15	210	84	282	163	119	116	72	64	255	0.15	0.09
Walton Twp	82	573	101	672	927	927	13,961	13,282	996	932	2,898	2,750	131	128	3,598	3,437	1,063	0.61	1.75
Watson Twp	153	1,960	175	2,721	773	773	12,847	10,274	1,273	1,030	4,428	3,526	343	324	3,000	2,431	4,351	2.52	1.77
Wayland, City	272	474	173	494	156	156	588	383	208	116	316	151	30	25	153	111	524	0.30	0.15
Wayland Twp	178	1,544	210	2,263	749	749	11,633	9,714	1,132	941	4,127	3,281	346	319	3,012	2,592	3,420	1.98	1.65
Wheatland Twp	0	5	0	10	2	2	220	210	40	40	67	64	0	0	104	101	15	0.01	0.03
Yankee Springs Twp	156	610	168	628	348	348	1,772	1,478	801	655	4,094	4,038	2,523	2,392	1,841	1,574	914	0.53	0.90
Zeeland Twp	12	148	5	156	30	30	1,584	1,302	5	5	27	25	0	0	10	7	287	0.17	0.13
Total	19,881	86,682	32,345	138,538	50,126	50,155	616,131	529,208	97,720	77,393	296,468	255,162	26,279	24,454	172,451	152,427	172,935	100	100

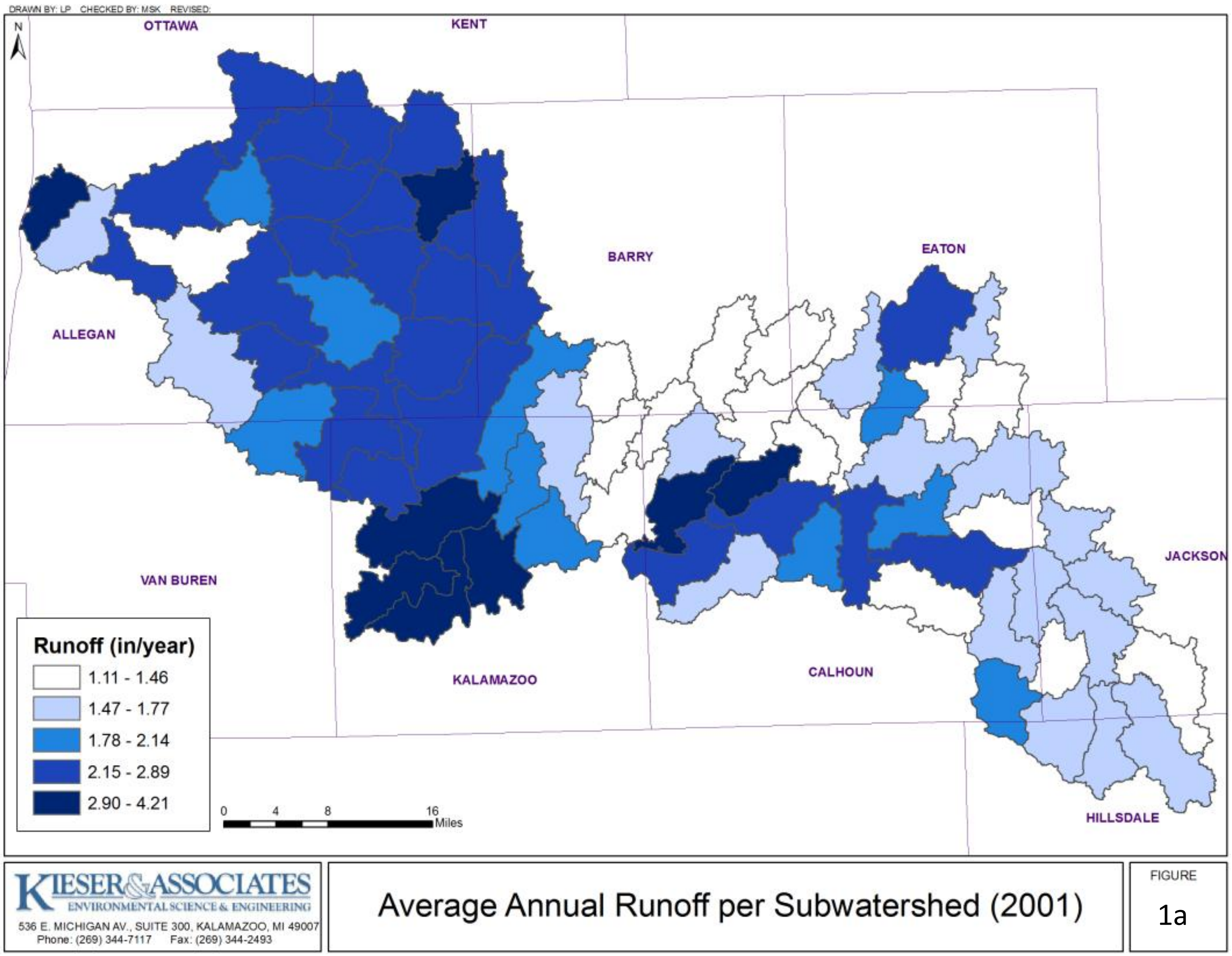
Note: The category “Urban Open” was removed for the table for practical reasons. It represents a small portion of the watershed and does not change during build-out.

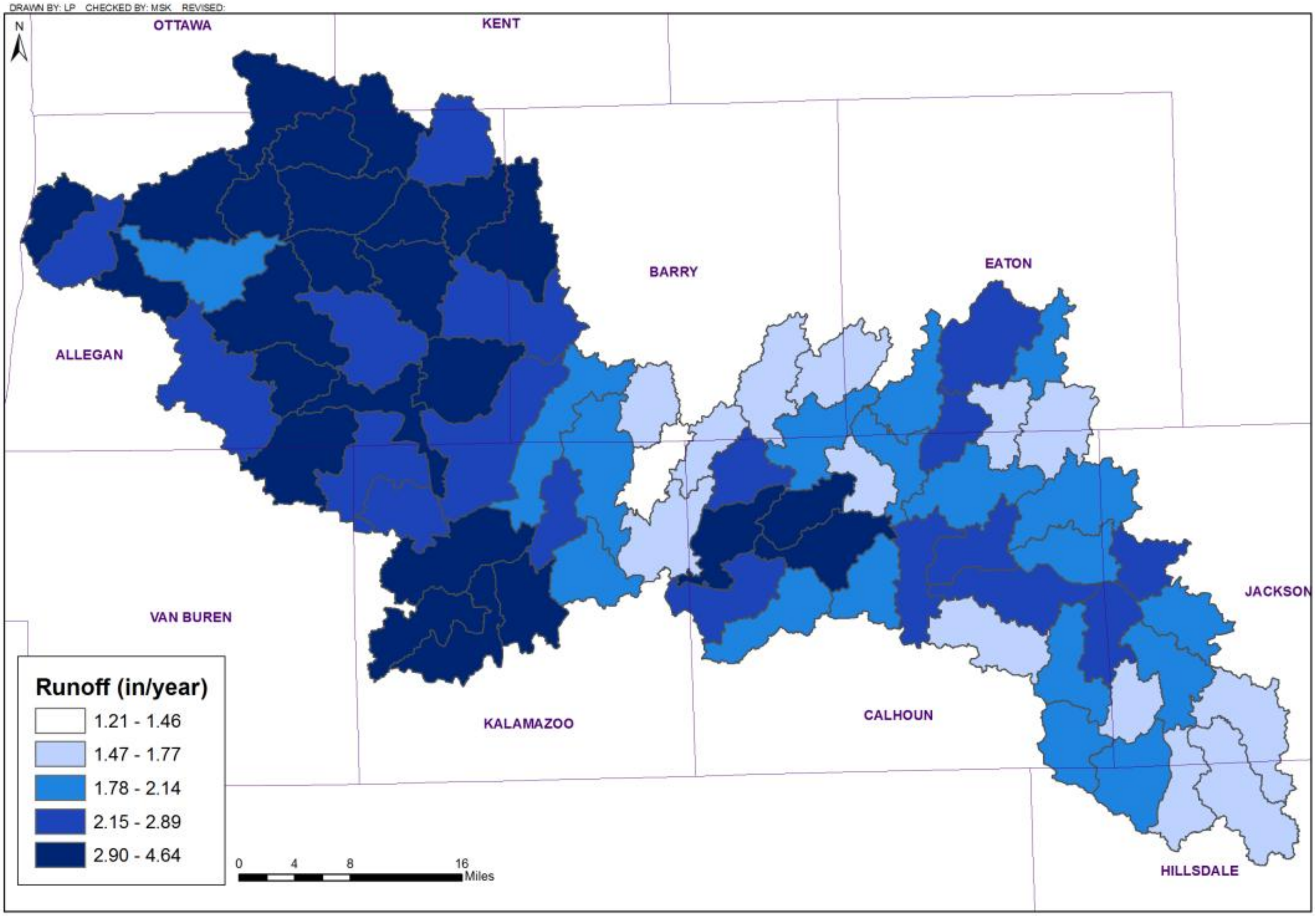
Appendix B

Runoff and Loading Comparison per 12-Digit HUC Subwatershed

APPENDIX B - Runoff and Loading Comparisons per 12-digit HUC Subwatershed

Figure B-1a and 1b: Average Annual Runoff (in/yr) per Subwatershed.





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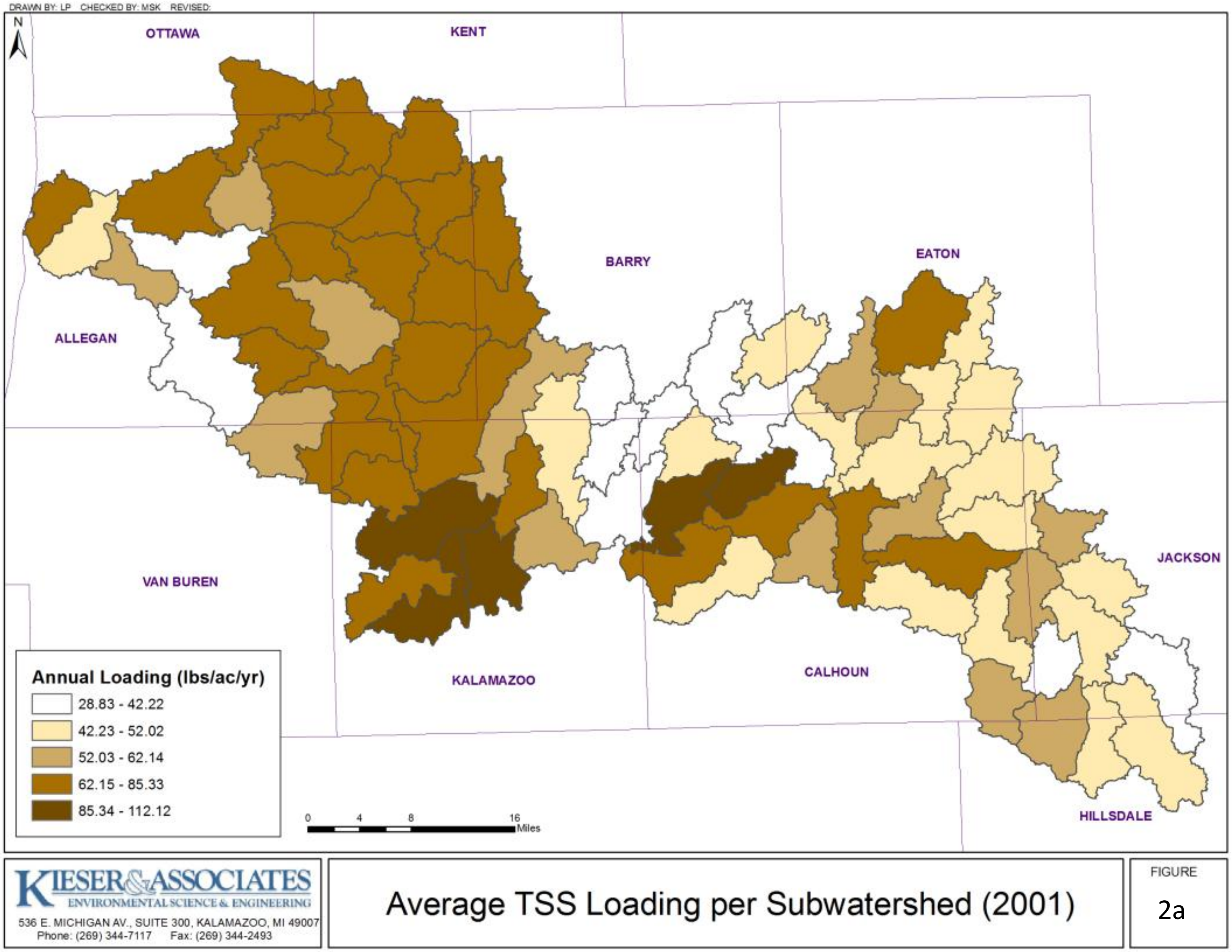
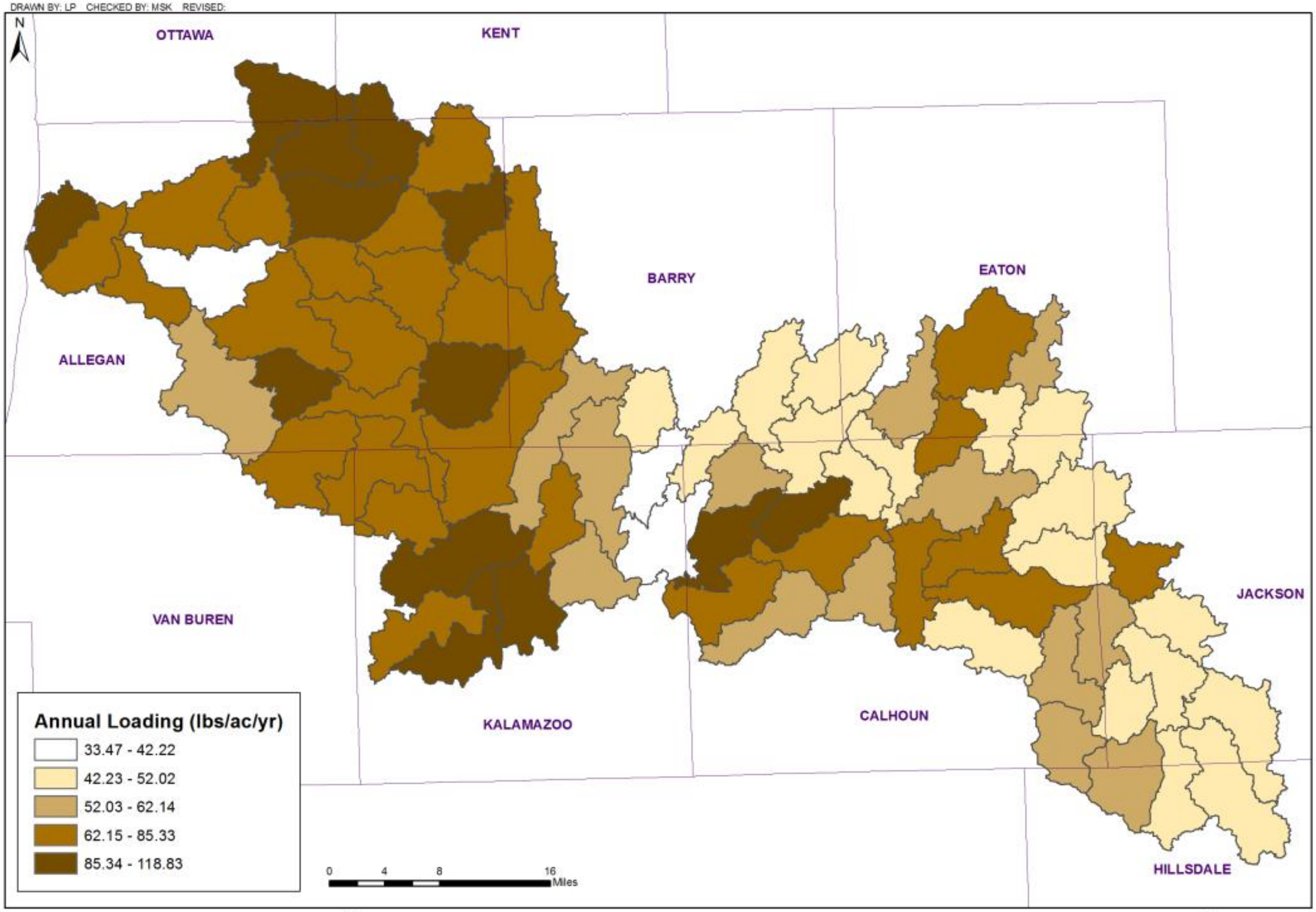
Average Annual Runoff per Subwatershed (2030)

FIGURE 1b

Figure B-2a and 2b: Average TSS Loading (lbs/ac/yr) per Subwatershed.



DRAWN BY: LP CHECKED BY: MSK REVISED:



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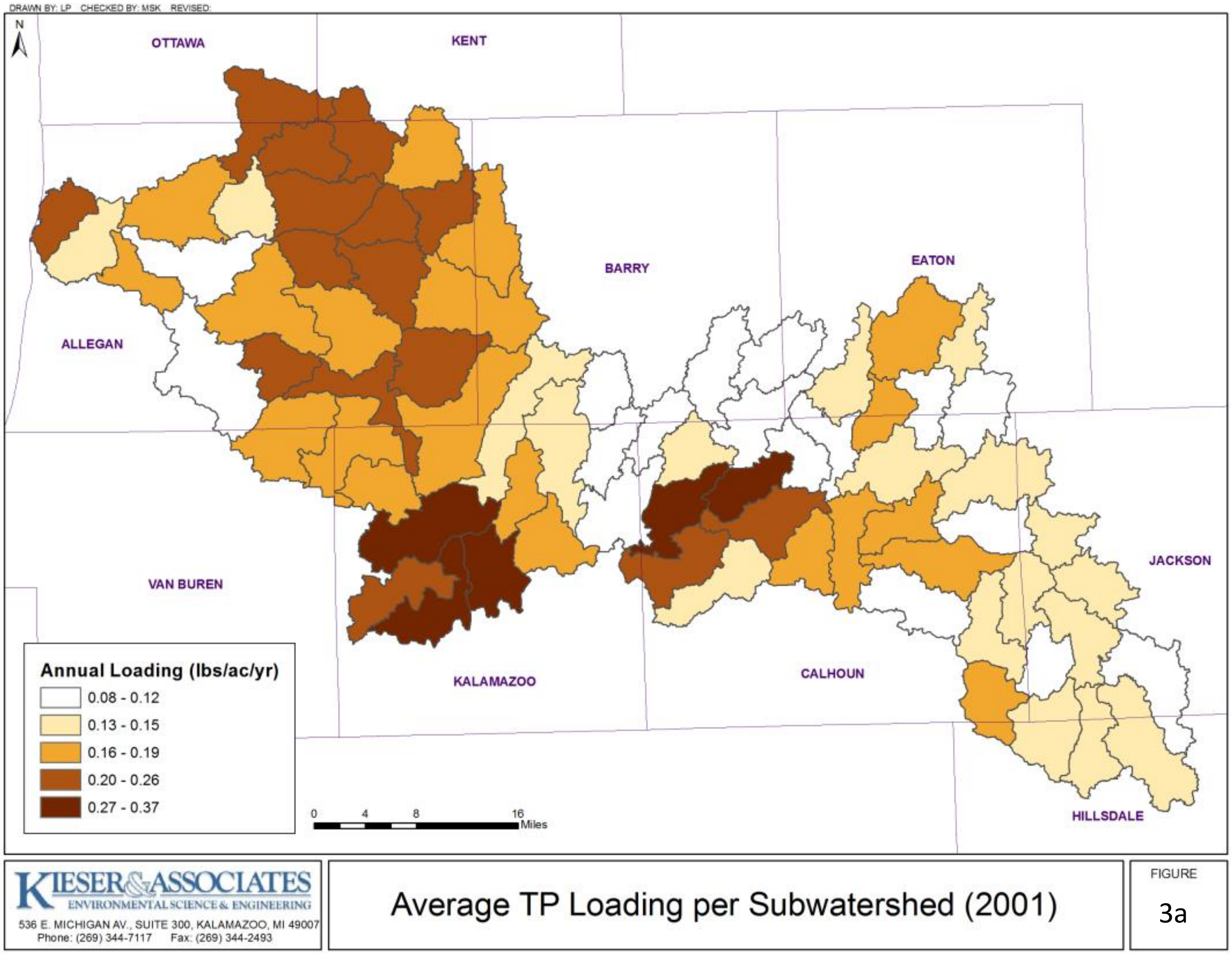
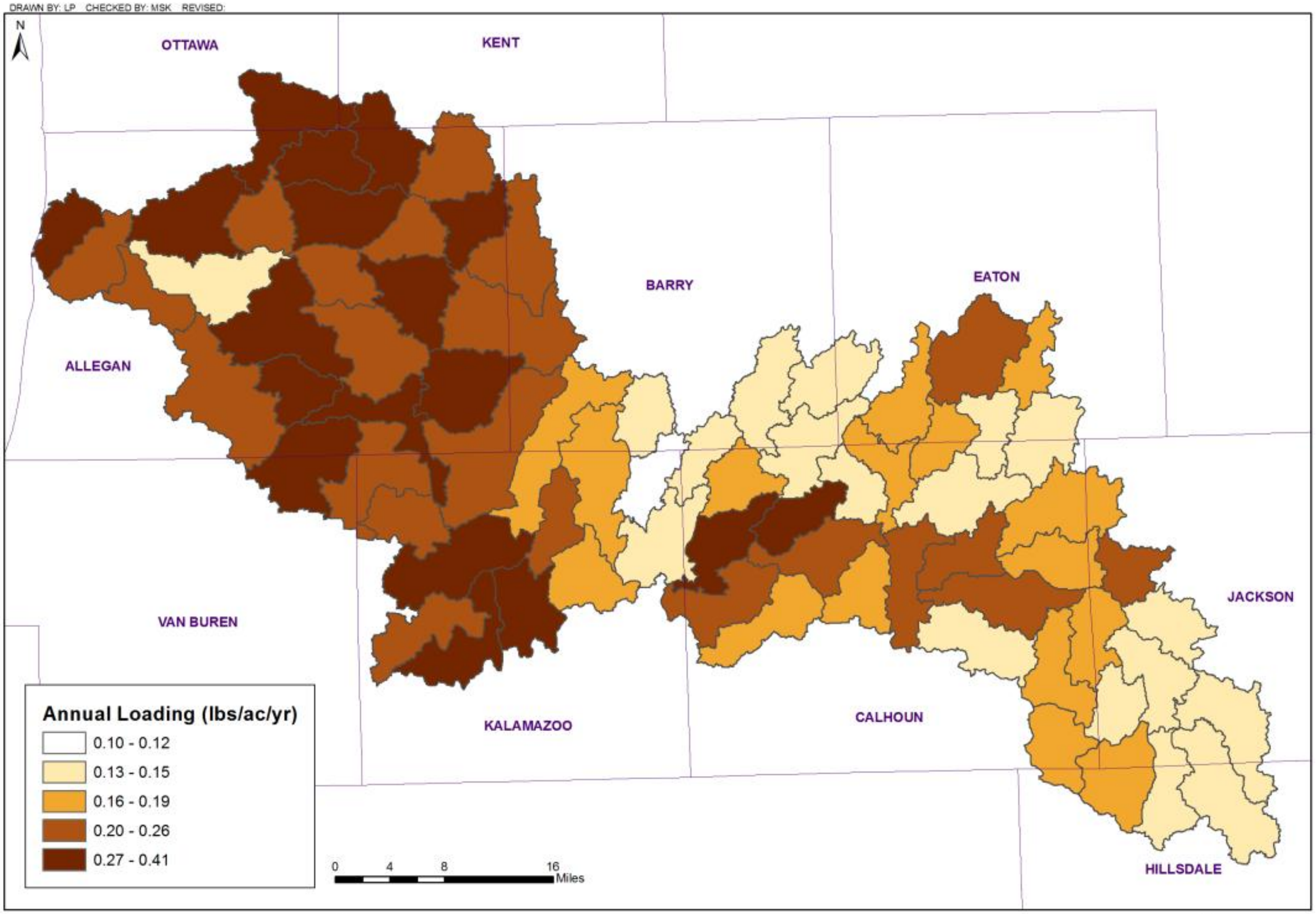
Average TSS Loading per Subwatershed (2030)

FIGURE 2b

Figure B-3a and 3b: Average TP Loading (lbs/ac/yr) per Subwatershed.





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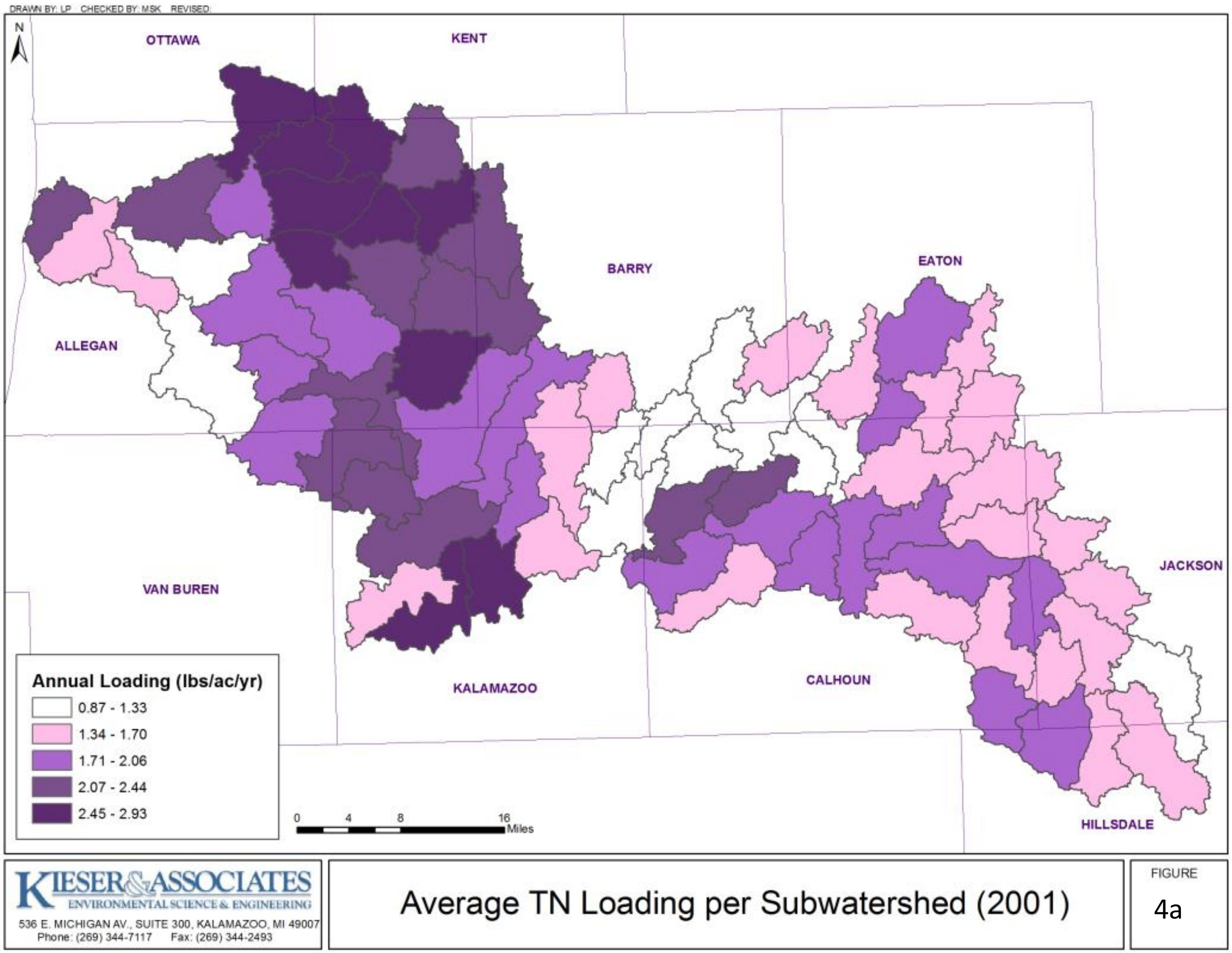
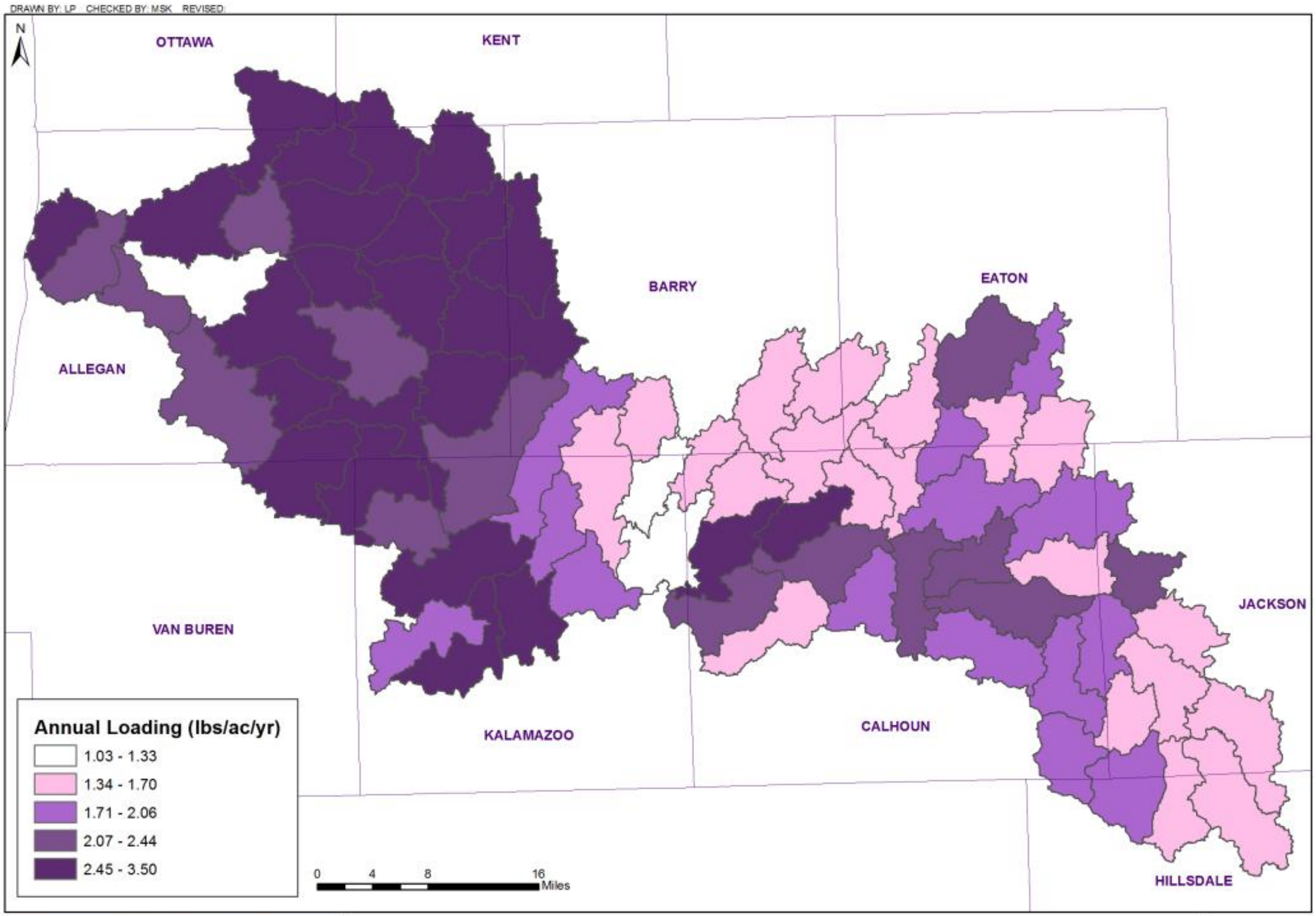
Average TP Loading per Subwatershed (2030)

FIGURE 3b

Figure B-4a and 4b: Average TN Loading (lbs/ac/yr) per Subwatershed.





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Average TN Loading per Subwatershed (2030)

FIGURE 4b

Table B-1: Load and Volume Comparisons per 12-Digit HUC Subwatershed.

		Runoff Volume (acre-feet/yr)				TSS (tons/yr)				TP (lbs/yr)				TN (lbs/yr)			
Stream	HUC	2001	2030	Change	% of total change	2001	2030	Change	% of total change	2001	2030	Change	% of total change	2001	2030	Change	% of total change
Upper North Branch Kalamazoo River	030101	2,179	2,608	430	0.8	403	437	34	0.8	2,228	2,656	428	0.8	26,524	29,655	3,131	0.8
Spring Arbor and Concord Drain	030102	1,674	1,953	279	0.5	314	333	20	0.4	1,739	2,006	267	0.5	20,595	22,315	1,719	0.4
Middle North Branch Kalamazoo River	030103	1,929	2,331	402	0.7	360	390	29	0.7	2,010	2,404	393	0.7	22,900	25,548	2,648	0.6
Lower North Branch Kalamazoo River	030104	1,981	2,574	593	1.1	378	419	41	0.9	2,116	2,696	580	1.0	23,670	27,413	3,744	0.9
Horseshoe Lake-South Branch Kalamazoo River	030201	3,041	3,221	180	0.3	573	587	14	0.3	3,161	3,342	181	0.3	36,875	38,162	1,286	0.3
Cobb Lake-South Branch Kalamazoo River	030202	1,827	1,952	125	0.2	341	350	9	0.2	1,887	2,017	131	0.2	22,039	22,988	949	0.2
Beaver Creek-South Branch Kalamazoo River	030203	2,640	2,796	156	0.3	504	514	10	0.2	2,780	2,936	156	0.3	32,736	33,691	955	0.2
Swains Lake Drain-South Branch Kalamazoo River	030204	1,199	1,439	240	0.4	225	243	18	0.4	1,235	1,475	240	0.4	14,761	16,458	1,697	0.4
Lampson Run Drain	030205	2,038	2,348	310	0.6	394	414	19	0.4	2,158	2,462	303	0.5	26,052	27,884	1,832	0.4
South Branch Kalamazoo River	030206	1,966	2,643	677	1.2	372	427	55	1.2	2,084	2,755	671	1.2	23,576	28,546	4,970	1.2
Narrow Lake-Battle Creek	030301	1,941	2,250	309	0.6	364	389	25	0.6	2,010	2,318	308	0.5	23,466	25,746	2,280	0.5
Relaid Mills Drain-Battle Creek	030302	1,315	1,577	262	0.5	250	270	21	0.5	1,369	1,623	254	0.5	16,305	18,149	1,845	0.4
Big Creek	030303	1,325	1,404	79	0.1	250	257	7	0.2	1,356	1,430	74	0.1	17,247	17,798	551	0.1
Headwaters Indian Creek	030304	2,827	3,122	295	0.5	527	552	25	0.6	2,896	3,193	297	0.5	34,840	37,134	2,295	0.5
Indian Creek	030305	1,697	1,948	251	0.5	312	333	21	0.5	1,798	2,050	252	0.4	17,772	19,698	1,925	0.5
Dillon Relaid Drain-Battle Creek	030306	4,389	4,927	538	1.0	811	854	43	1.0	4,680	5,193	513	0.9	47,071	50,743	3,672	0.9
Townline Brook Drain-Battle Creek	030307	2,096	2,369	273	0.5	386	410	24	0.5	2,189	2,457	268	0.5	22,900	24,979	2,079	0.5
Ackley Creek-Battle Creek	030308	1,347	1,773	426	0.8	238	278	40	0.9	1,369	1,797	428	0.8	13,603	17,165	3,562	0.9
Clear Lake-Battle Creek	030309	1,075	1,423	348	0.6	191	223	32	0.7	1,065	1,436	371	0.7	12,215	15,295	3,080	0.7
Headwaters	030310	1,868	2,045	177	0.3	351	366	15	0.3	1,936	2,101	166	0.3	22,855	24,118	1,263	0.3

Stream	HUC	Runoff Volume (acre-feet/yr)				TSS (tons/yr)				TP (lbs/yr)				TN (lbs/yr)			
		2001	2030	Change	% of total change	2001	2030	Change	% of total change	2001	2030	Change	% of total change	2001	2030	Change	% of total change
Wanadoga Creek																	
Wanadoga Creek	030311	1,989	2,632	643	1.2	350	408	57	1.3	1,963	2,624	660	1.2	21,985	27,236	5,251	1.3
Battle Creek	030312	3,441	3,984	542	1.0	581	634	53	1.2	3,748	4,323	575	1.0	27,690	32,679	4,988	1.2
Headwaters South Branch Rice Creek	030401	1,536	2,161	625	1.1	291	338	47	1.1	1,618	2,231	614	1.1	18,176	22,462	4,285	1.0
South Branch Rice Creek	030402	1,658	2,310	653	1.2	307	359	52	1.2	1,699	2,355	656	1.2	19,337	24,156	4,820	1.2
North Branch Rice Creek	030403	2,840	3,515	675	1.2	529	578	50	1.1	2,877	3,567	690	1.2	35,901	40,725	4,824	1.2
Wilder Creek	030404	2,241	2,687	446	0.8	427	461	34	0.8	2,319	2,764	445	0.8	29,196	32,344	3,148	0.8
Rice Creek	030405	2,065	2,717	652	1.2	388	432	44	1.0	2,195	2,837	641	1.1	23,558	27,668	4,110	1.0
Montcalm Lake-Kalamazoo River	030406	3,422	4,314	892	1.6	639	711	73	1.6	3,688	4,565	877	1.6	37,186	43,660	6,473	1.6
Buckhorn Lake-Kalamazoo River	030407	2,849	3,618	769	1.4	522	582	60	1.3	3,043	3,828	785	1.4	29,228	34,907	5,680	1.4
Pigeon Creek-Kalamazoo River	030408	2,077	2,290	213	0.4	396	411	14	0.3	2,208	2,421	213	0.4	24,670	26,028	1,358	0.3
Harper Creek	030409	2,106	2,659	553	1.0	384	434	50	1.1	2,202	2,767	565	1.0	22,006	26,608	4,602	1.1
Minges Brook	030410	3,390	3,983	593	1.1	610	664	54	1.2	3,662	4,257	595	1.1	33,063	37,874	4,811	1.2
Willow Creek-Kalamazoo River	030411	3,321	4,065	744	1.4	577	648	72	1.6	3,531	4,296	766	1.4	31,097	37,616	6,520	1.6
Headwaters Wabascon Creek	030501	1,895	2,364	469	0.9	335	379	44	1.0	1,843	2,318	476	0.9	21,869	25,777	3,908	0.9
Wabascon Creek	030502	1,524	2,263	738	1.3	261	333	73	1.6	1,554	2,310	755	1.3	13,732	20,229	6,497	1.6
Harts Lake-Kalamazoo River	030503	4,560	5,333	773	1.4	749	827	78	1.8	4,871	5,666	795	1.4	35,396	42,365	6,968	1.7
Sevenmile Creek	030504	1,127	1,413	286	0.5	200	225	25	0.6	1,116	1,400	283	0.5	12,662	14,848	2,186	0.5
Headwaters Augusta Creek	030505	1,337	1,438	101	0.2	245	254	9	0.2	1,349	1,447	98	0.2	16,193	16,965	773	0.2
Augusta Creek	030506	1,073	1,168	94	0.2	186	194	8	0.2	1,042	1,137	95	0.2	11,216	11,963	748	0.2
Gull Creek	030507	2,827	3,195	368	0.7	521	554	33	0.7	2,943	3,313	370	0.7	32,551	35,490	2,938	0.7
Eagle Lake-Kalamazoo River	030508	2,028	2,367	339	0.6	324	357	33	0.7	1,980	2,324	344	0.6	16,311	19,263	2,952	0.7
Morrow Lake-Kalamazoo River	030509	2,179	2,506	327	0.6	400	428	29	0.6	2,320	2,653	332	0.6	22,698	25,313	2,615	0.6
Comstock Creek	030601	1,899	2,135	236	0.4	354	374	19	0.4	2,039	2,275	236	0.4	20,935	22,690	1,755	0.4
West Fork Portage Creek	030602	4,262	4,970	708	1.3	494	529	35	0.8	3,167	3,576	409	0.7	24,775	28,093	3,318	0.8
Portage Creek	030603	5,801	6,386	585	1.1	929	985	56	1.3	6,199	6,820	621	1.1	48,515	53,827	5,312	1.3

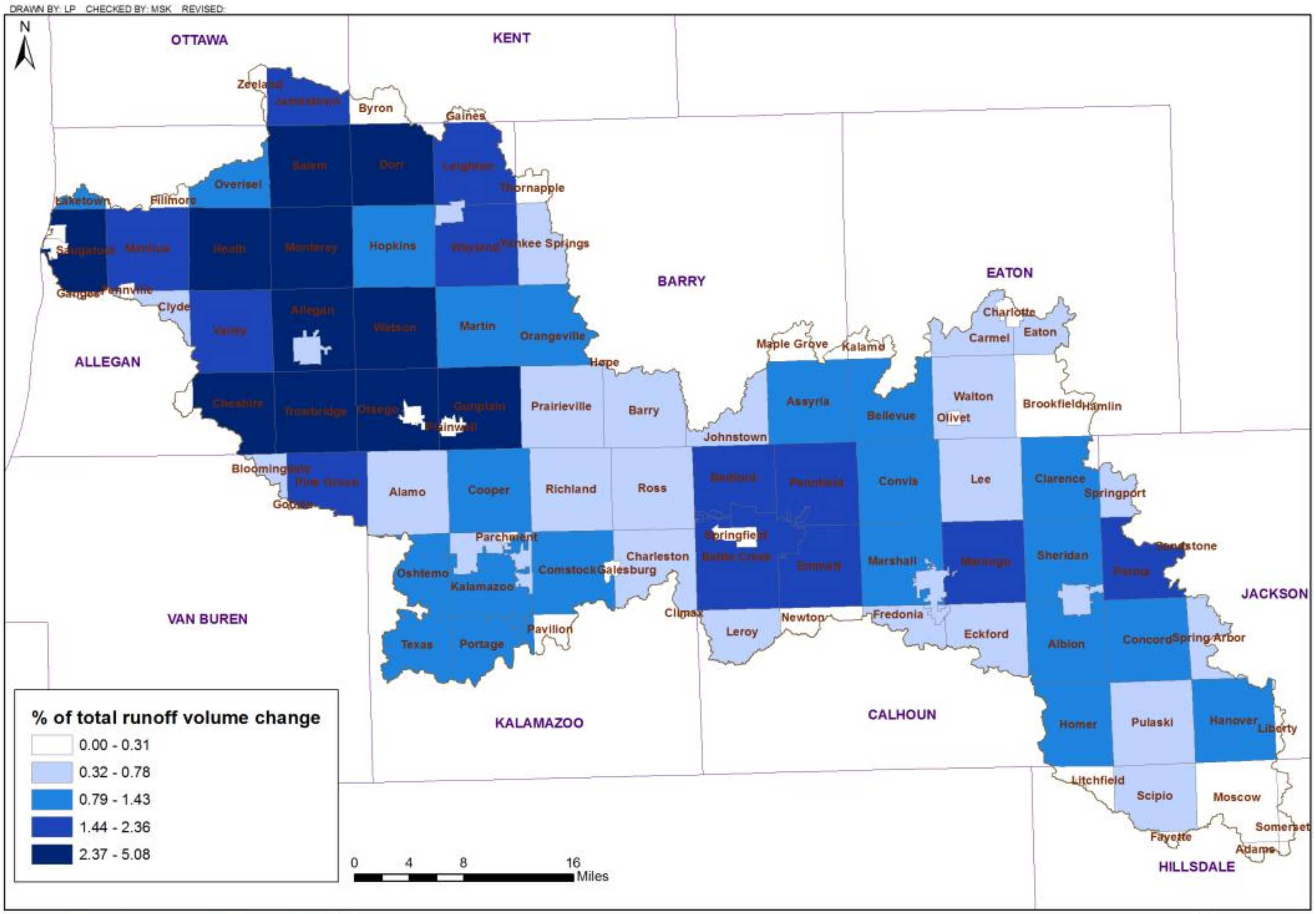
		Runoff Volume (acre-feet/yr)				TSS (tons/yr)				TP (lbs/yr)				TN (lbs/yr)			
Stream	HUC	2001	2030	Change	% of total change	2001	2030	Change	% of total change	2001	2030	Change	% of total change	2001	2030	Change	% of total change
Davis Creek-Kalamazoo River	030604	4,783	5,114	331	0.6	760	791	31	0.7	5,039	5,382	343	0.6	41,393	44,272	2,879	0.7
Spring Brook	030605	3,457	3,939	482	0.9	613	655	42	0.9	3,391	3,874	483	0.9	40,822	44,546	3,724	0.9
Averill Lake-Kalamazoo River	030606	8,516	9,550	1,034	1.9	1,216	1,296	80	1.8	7,933	8,790	857	1.5	58,941	66,248	7,307	1.8
Silver Creek-Kalamazoo River	030607	6,087	7,385	1,299	2.4	1,074	1,183	109	2.5	6,146	7,475	1,329	2.4	66,054	76,092	10,038	2.4
Gun Lake-Gun River	030701	3,712	4,349	638	1.2	616	672	55	1.2	3,485	4,153	667	1.2	39,662	44,901	5,239	1.3
Fenner Creek-Gun River	030702	5,524	6,359	835	1.5	963	1,027	63	1.4	5,278	6,160	881	1.6	69,295	75,475	6,181	1.5
Gun River	030703	5,025	6,347	1,322	2.4	905	1,005	100	2.2	4,992	6,371	1,380	2.5	62,303	71,938	9,635	2.3
Green Lake Creek	030801	3,220	4,137	916	1.7	585	661	76	1.7	3,302	4,204	902	1.6	37,698	44,399	6,701	1.6
Fales Drain-Rabbit River	030802	3,199	4,022	823	1.5	566	632	66	1.5	3,192	4,073	881	1.6	38,092	44,567	6,476	1.6
Miller Creek	030803	3,715	4,828	1,113	2.0	687	771	84	1.9	3,880	5,001	1,122	2.0	42,692	50,569	7,877	1.9
Bear Creek	030804	2,554	3,170	617	1.1	490	525	36	0.8	2,671	3,281	611	1.1	33,885	37,394	3,509	0.8
Buskirk Creek-Rabbit River	030805	2,485	2,904	419	0.8	441	471	30	0.7	2,562	2,994	432	0.8	28,460	31,396	2,937	0.7
Headwaters Little Rabbit River	030806	3,484	4,512	1,027	1.9	631	700	69	1.5	3,611	4,632	1,021	1.8	43,159	49,604	6,445	1.5
Little Rabbit River	030807	3,279	4,802	1,524	2.8	577	683	105	2.4	3,224	4,814	1,590	2.8	41,957	52,391	10,434	2.5
Pigeon Creek-Rabbit River	030808	4,488	5,951	1,463	2.7	790	906	116	2.6	4,418	5,983	1,566	2.8	54,829	66,156	11,327	2.7
Black Creek	030809	4,708	6,293	1,586	2.9	892	996	104	2.3	4,917	6,460	1,543	2.8	59,423	68,936	9,513	2.3
Silver Creek-Rabbit River	030810	2,244	3,202	957	1.7	358	435	77	1.7	1,979	3,013	1,034	1.8	23,989	31,632	7,643	1.8
Rabbit River	030811	4,777	6,239	1,461	2.7	826	934	108	2.4	4,617	6,205	1,588	2.8	55,293	66,378	11,085	2.7
Sand Creek	030901	2,613	2,939	326	0.6	456	480	24	0.5	2,566	2,917	351	0.6	28,666	31,166	2,499	0.6
Base Line Creek	030902	3,818	5,687	1,869	3.4	698	822	124	2.8	3,851	5,970	2,119	3.8	45,073	59,426	14,353	3.4
Pine Creek	030903	3,917	4,564	646	1.2	709	744	35	0.8	3,892	4,612	720	1.3	47,414	51,702	4,289	1.0
Schnable Brook	030904	3,639	5,020	1,381	2.5	677	785	108	2.4	3,819	5,180	1,361	2.4	41,449	51,153	9,704	2.3
Trowbridge Dam-Kalamazoo River	030905	3,249	4,515	1,266	2.3	556	655	99	2.2	3,268	4,582	1,314	2.3	35,563	44,984	9,421	2.3
Tannery Creek-Kalamazoo River	030906	2,446	3,906	1,460	2.7	414	542	128	2.9	2,444	3,948	1,504	2.7	24,635	36,318	11,683	2.8
Lake Allegan-Kalamazoo River	030907	5,159	7,861	2,702	4.9	829	1,067	238	5.4	4,960	7,763	2,803	5.0	50,582	72,450	21,868	5.2
Swan Creek	030908	3,968	7,175	3,207	5.9	620	908	288	6.5	3,444	6,817	3,373	6.0	39,656	66,522	26,866	6.4

		Runoff Volume (acre-feet/yr)				TSS (tons/yr)				TP (lbs/yr)				TN (lbs/yr)			
Stream	**HUC**	**2001**	**2030**	**Change**	**% of total change**	**2001**	**2030**	**Change**	**% of total change**	**2001**	**2030**	**Change**	**% of total change**	**2001**	**2030**	**Change**	**% of total change**
Bear Creek-Kalamazoo River	030909	2,383	3,482	1,099	2.0	316	418	102	2.3	1,758	2,968	1,210	2.2	19,148	28,936	9,788	2.3
Mann Creek	030910	2,153	3,032	879	1.6	299	383	85	1.9	1,794	2,782	988	1.8	16,288	24,397	8,110	1.9
Peach Orchid Creek-Kalamazoo River	030911	2,010	3,294	1,283	2.3	349	464	115	2.6	1,995	3,314	1,318	2.4	21,619	32,015	10,397	2.5
Kalamazoo River	030912	2,650	4,061	1,411	2.6	414	556	142	3.2	2,642	4,147	1,505	2.7	21,843	34,788	12,945	3.1
Total		216,737	271,399	54,751	100	37,866	42,306	4,440	100	218,313	274,285	55,973	100	2,337,823	2,755,016	417,193	100

Appendix C

Changes in Volume and Load per Township for Build-out Scenario

APPENDIX C - Changes in Volume and Load per Township for Build-out Scenario



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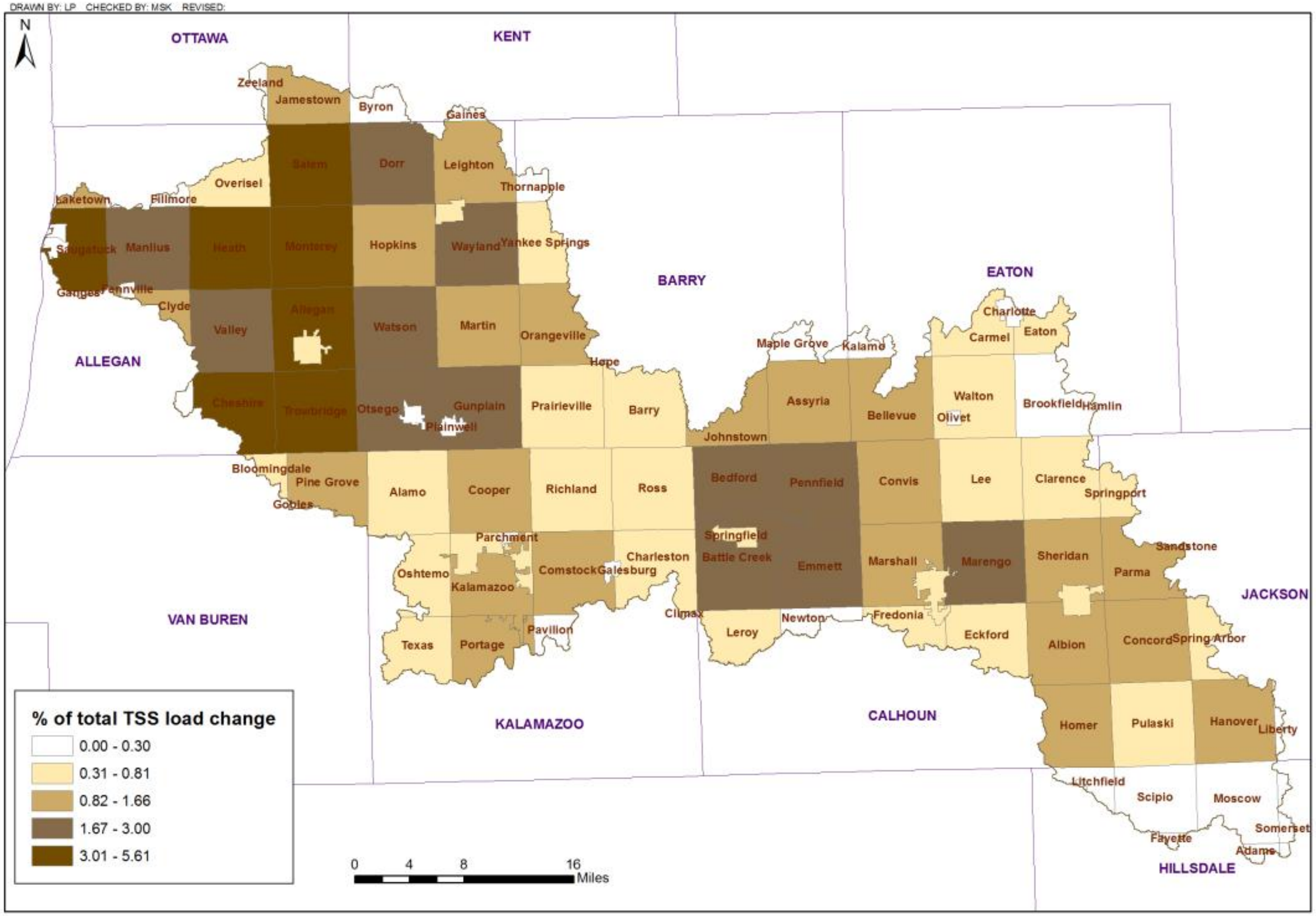
Proportion of Total Runoff Change in 2030

FIGURE
5a

DRAWN BY: LP CHECKED BY: MSK REVISED:



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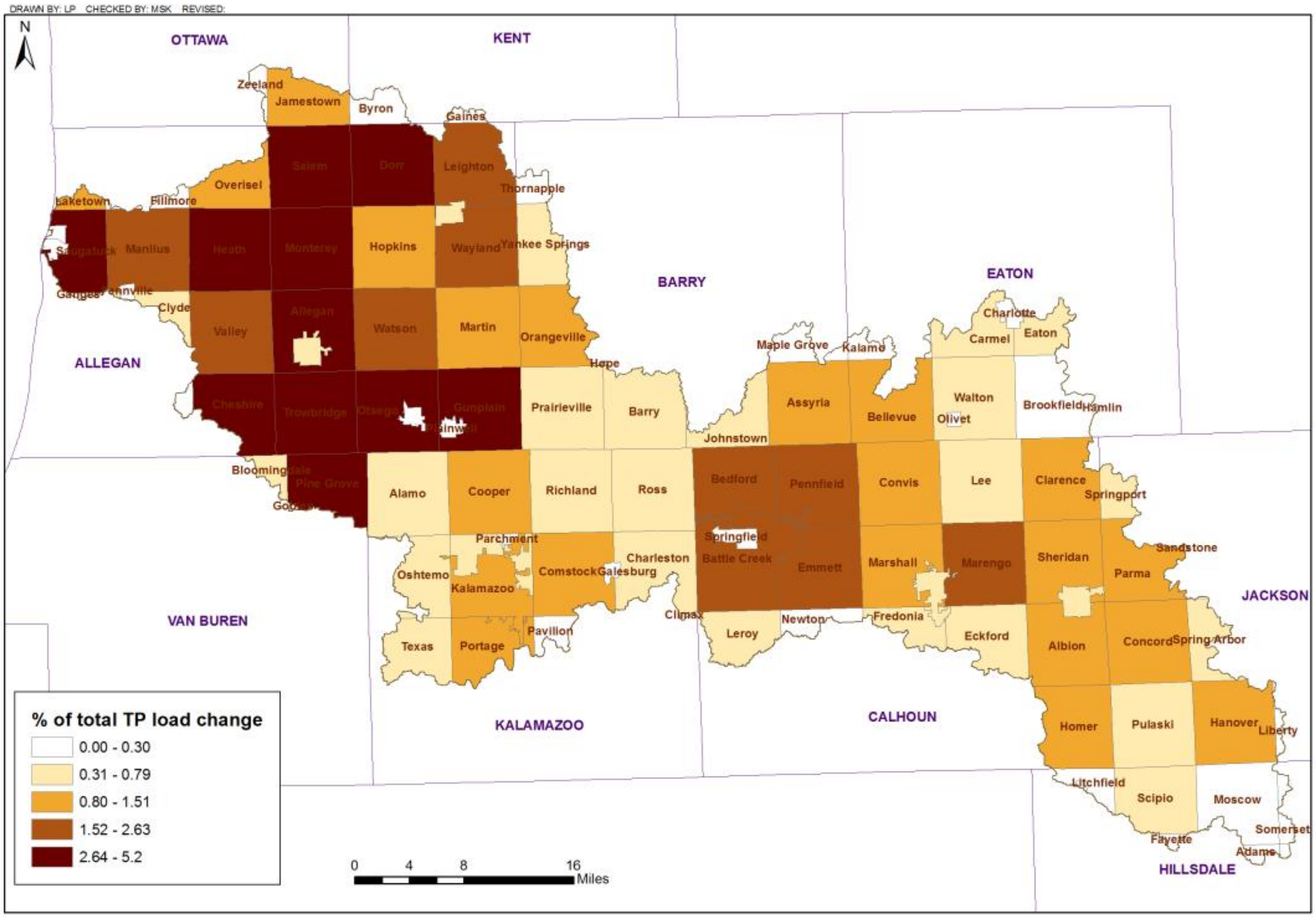
Proportion of Total TSS Change in 2030

FIGURE 5b



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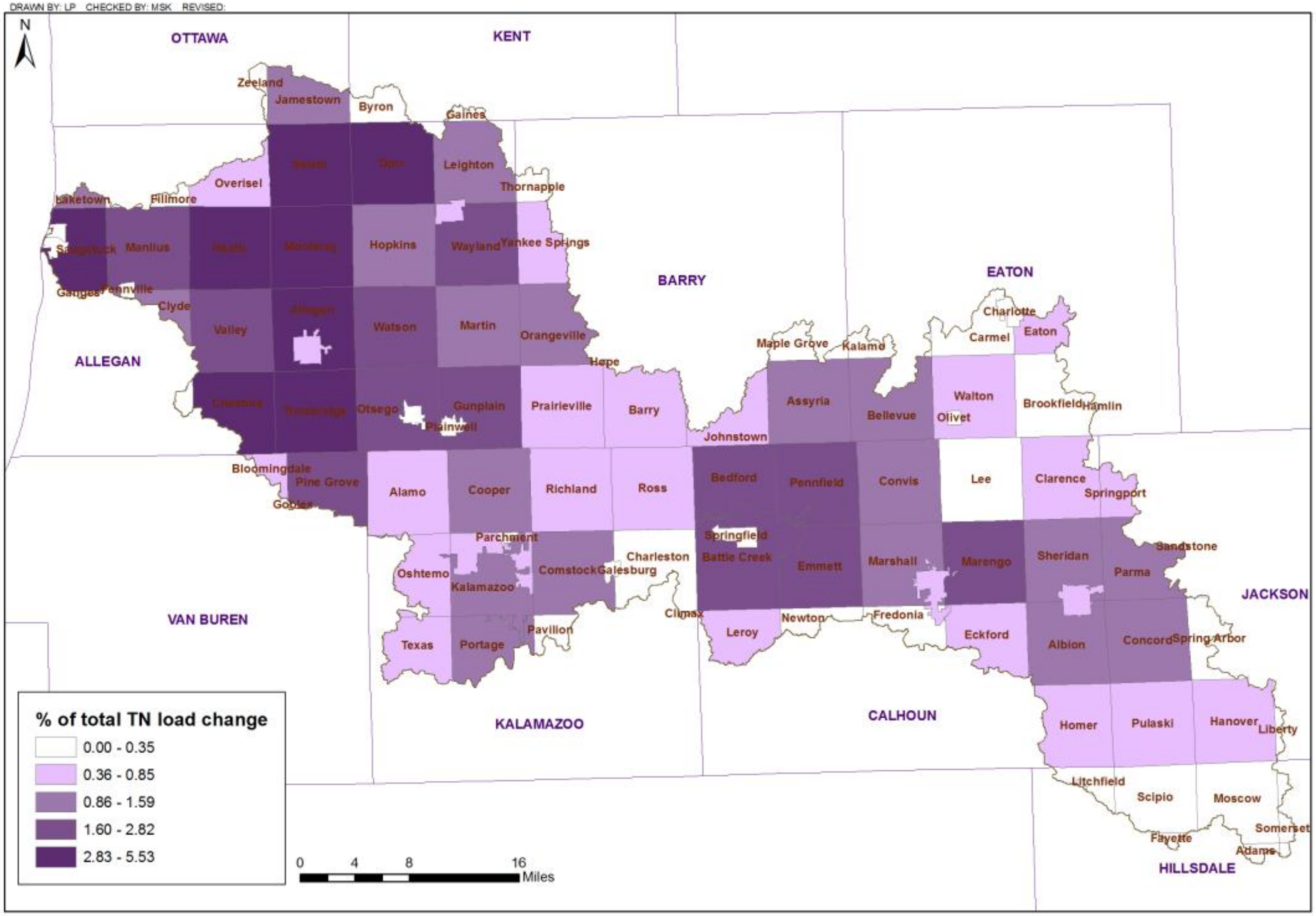
Proportion of Total TP Change in 2030

FIGURE 5c

DRAWN BY: LP CHECKED BY: MSK REVISED:



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Proportion of Total TN Change in 2030

FIGURE
5d

Table C-1: Total Loads and Runoff Volume per Township for Years 2001 and 2030.

		RUNOFF VOLUME (ACRE-FEET/YR)				TSS LOAD (TONS/YR)				TP LOAD (LBS/YR)				TN LOAD (LBS/YEAR)			
NAME	% of total watershed area	2001	2030	Change in Volume	% of total change	2001	2030	Change in Load	% of total change	2001	2030	Change in Load	% of total change	2001	2030	Change in Load	% of total change
Adams Twp	0.12	222	228	6	0.0	43	43	0	0.0	235	241	6	0.0	2,809	2,853	43	0.0
Alamo Twp	1.82	4,446	4,830	384	0.7	785	812	27	0.6	4,371	4,803	432	0.8	50,549	53,529	2,980	0.7
Albion	0.26	1,264	1,533	269	0.5	225	251	26	0.6	1,418	1,682	265	0.5	10,002	12,239	2,237	0.5
Albion Twp	1.64	2,516	3,239	723	1.3	481	534	54	1.2	2,630	3,346	716	1.3	32,325	37,302	4,977	1.2
Allegan	0.20	1,382	1,708	326	0.6	206	239	33	0.7	1,413	1,756	343	0.6	11,020	13,983	2,962	0.7
Allegan Twp	1.53	3,516	5,364	1,848	3.4	605	759	155	3.5	3,542	5,426	1,884	3.4	37,461	51,550	14,089	3.4
Assyria Twp	1.79	2,626	3,327	701	1.3	463	526	64	1.4	2,560	3,273	714	1.3	29,950	35,691	5,741	1.4
Barry Twp	1.57	2,524	2,852	328	0.6	458	488	29	0.7	2,561	2,878	317	0.6	29,764	32,261	2,497	0.6
Battle Creek	2.15	8,397	9,548	1,151	2.1	1,397	1,510	113	2.5	9,064	10,250	1,186	2.1	67,729	77,921	10,192	2.4
Bedford Twp	1.47	2,274	3,249	975	1.8	387	485	98	2.2	2,316	3,315	999	1.8	19,999	28,722	8,723	2.1
Bellevue Twp	1.53	2,524	3,035	511	0.9	464	511	47	1.0	2,626	3,128	502	0.9	28,013	32,041	4,027	1.0
Bloomingdale Twp	0.24	488	725	237	0.4	89	106	17	0.4	509	770	261	0.5	5,226	7,066	1,840	0.4
Brookfield Twp	1.40	2,299	2,439	141	0.3	437	448	11	0.2	2,395	2,528	132	0.2	28,801	29,721	920	0.2
Byron Twp	0.45	1,189	1,362	173	0.3	219	231	12	0.3	1,204	1,373	169	0.3	15,864	16,961	1,097	0.3
Carmel Twp	0.84	1,506	1,711	205	0.4	285	301	16	0.4	1,573	1,768	194	0.3	18,472	19,823	1,351	0.3
Charleston Twp	1.39	1,836	2,018	182	0.3	312	328	16	0.4	1,802	1,981	179	0.3	17,403	18,855	1,452	0.3
Charlotte	0.13	760	846	85	0.2	127	135	8	0.2	827	910	83	0.1	6,037	6,708	671	0.2
Cheshire Twp	1.33	2,577	5,359	2,782	5.1	445	694	249	5.6	2,476	5,376	2,900	5.2	28,657	51,736	23,079	5.5
Clarence Twp	1.55	2,290	2,752	462	0.8	427	462	35	0.8	2,334	2,802	468	0.8	28,324	31,663	3,338	0.8
Climax Twp	0.02	41	41	0	0.0	8	8	0	0.0	44	44	0	0.0	504	504	0	0.0
Clyde Twp	0.40	987	1,372	385	0.7	137	177	40	0.9	811	1,254	443	0.8	6,761	10,546	3,785	0.9
Comstock Twp	1.57	3,796	4,309	513	0.9	658	705	47	1.1	4,032	4,552	520	0.9	36,437	40,696	4,259	1.0
Concord Twp	1.80	2,851	3,577	726	1.3	538	588	50	1.1	2,987	3,693	706	1.3	34,673	39,200	4,527	1.1
Convis Twp	1.78	2,728	3,185	457	0.8	489	530	41	0.9	2,785	3,265	480	0.9	28,967	32,837	3,870	0.9
Cooper Twp	1.79	3,493	4,101	609	1.1	610	660	49	1.1	3,405	4,055	650	1.2	39,321	44,170	4,849	1.2
Dorr Twp	1.79	4,640	6,485	1,844	3.4	826	959	133	3.0	4,708	6,602	1,894	3.4	57,070	69,819	12,748	3.1
Eaton Twp	0.54	1,025	1,372	346	0.6	191	219	28	0.6	1,081	1,412	331	0.6	11,250	13,645	2,395	0.6
Eckford Twp	1.28	2,053	2,419	366	0.7	393	420	27	0.6	2,139	2,504	365	0.7	26,722	29,261	2,539	0.6
Emmett Twp	1.61	3,741	4,746	1,005	1.8	662	757	95	2.1	3,983	5,011	1,027	1.8	36,158	44,784	8,626	2.1

NAME	% of total watershed area	RUNOFF VOLUME (ACRE-FEET/YR) 2001	2030	Change in Volume	% of total change	TSS LOAD (TONS/YR) 2001	2030	Change in Load	% of total change	TP LOAD (LBS/YR) 2001	2030	Change in Load	% of total change	TN LOAD (LBS/YEAR) 2001	2030	Change in Load	% of total change
Fayette Twp	0.06	92	98	6	0.0	16	16	0	0.0	93	98	5	0.0	1,010	1,045	35	0.0
Fennville	0.06	369	452	83	0.2	60	66	6	0.1	396	481	85	0.2	3,316	3,870	553	0.1
Fillmore Twp	0.16	316	350	34	0.1	57	60	3	0.1	339	372	33	0.1	3,398	3,616	218	0.1
Fredonia Twp	0.57	912	1,108	196	0.4	169	184	16	0.4	944	1,146	202	0.4	10,292	11,787	1,495	0.4
Gaines Twp	0.11	321	380	60	0.1	56	62	6	0.1	316	375	59	0.1	3,398	3,889	490	0.1
Galesburg	0.07	154	202	48	0.1	26	30	4	0.1	164	217	52	0.1	1,431	1,833	401	0.1
Ganges Twp	0.02	37	65	27	0.1	7	9	2	0.0	39	64	25	0.0	469	643	174	0.0
Gobles	0.01	41	63	22	0.0	7	8	0	0.0	40	70	30	0.1	517	664	147	0.0
Gunplain Twp	1.72	4,838	6,424	1,586	2.9	875	1,002	127	2.9	4,908	6,533	1,624	2.9	56,310	68,092	11,782	2.8
Hamlin Twp	0.00	0	0	0	0.0	0	0	0	0.0	0	0	0	0.0	2	2	0	0.0
Hanover Twp	1.73	2,319	2,808	489	0.9	430	469	39	0.9	2,385	2,866	482	0.9	27,528	31,036	3,508	0.8
Heath Twp	1.80	3,578	5,275	1,697	3.1	525	675	150	3.4	2,998	4,854	1,856	3.3	32,159	46,759	14,601	3.5
Homer Twp	1.55	2,591	3,101	510	0.9	497	535	38	0.9	2,726	3,230	504	0.9	33,048	36,544	3,496	0.8
Hope Twp	0.00	3	6	2	0.0	0	1	0	0.0	2	5	2	0.0	23	43	20	0.0
Hopkins Twp	1.82	4,357	5,101	743	1.4	820	865	44	1.0	4,521	5,269	748	1.3	55,613	60,043	4,430	1.1
Jamestown Twp	1.00	2,780	3,672	892	1.6	530	589	59	1.3	2,953	3,799	847	1.5	33,947	39,116	5,168	1.2
Johnstown Twp	0.85	1,437	1,867	430	0.8	259	297	38	0.9	1,446	1,871	424	0.8	16,324	19,643	3,319	0.8
Kalamazoo	1.24	7,785	8,316	531	1.0	1,227	1,275	48	1.1	8,218	8,711	493	0.9	58,527	62,854	4,328	1.0
Kalamazoo Twp	0.58	2,775	3,090	316	0.6	459	490	31	0.7	3,023	3,353	330	0.6	22,551	25,351	2,800	0.7
Kalamo Twp	0.28	432	447	16	0.0	81	82	1	0.0	431	445	14	0.0	5,894	5,990	96	0.0
Laketown Twp	0.19	584	1,067	483	0.9	89	137	48	1.1	571	1,077	506	0.9	5,029	9,381	4,351	1.0
Lee Twp-Allegan	0.11	113	143	30	0.1	17	19	3	0.1	88	126	39	0.1	1,255	1,594	339	0.1
Lee Twp-Calhoun	1.84	2,864	3,063	198	0.4	535	551	16	0.4	2,929	3,124	194	0.3	35,860	37,265	1,405	0.3
Leighton Twp	1.51	3,620	4,552	932	1.7	659	732	74	1.7	3,697	4,623	926	1.7	43,867	50,523	6,656	1.6
Leroy Twp	0.91	1,312	1,569	256	0.5	244	265	21	0.5	1,361	1,629	267	0.5	15,177	17,226	2,049	0.5
Liberty Twp	0.08	153	192	39	0.1	28	31	3	0.1	159	198	39	0.1	1,800	2,062	262	0.1
Litchfield	0.01	53	59	5	0.0	10	10	0	0.0	59	65	6	0.0	533	539	6	0.0
Litchfield Twp	0.37	811	878	67	0.1	157	160	3	0.1	869	935	66	0.1	9,971	10,289	318	0.1
Manlius Twp	1.78	2,840	4,116	1,275	2.3	431	548	117	2.6	2,414	3,798	1,384	2.5	28,360	39,403	11,043	2.6
Maple Grove Twp	0.43	567	599	32	0.1	107	110	3	0.1	591	622	31	0.1	6,986	7,247	261	0.1

		RUNOFF VOLUME (ACRE-FEET/YR)				TSS LOAD (TONS/YR)				TP LOAD (LBS/YR)				TN LOAD (LBS/YEAR)			
NAME	% of total watershed area	2001	2030	Change in Volume	% of total change	2001	2030	Change in Load	% of total change	2001	2030	Change in Load	% of total change	2001	2030	Change in Load	% of total change
Marengo Twp	1.78	3,182	4,356	1,173	2.1	604	688	84	1.9	3,343	4,504	1,161	2.1	38,465	46,256	7,791	1.9
Marshall	0.31	1,043	1,338	294	0.5	185	209	25	0.6	1,147	1,449	302	0.5	9,167	11,466	2,299	0.6
Marshall Twp	1.59	3,614	4,235	621	1.1	681	725	44	1.0	3,889	4,516	627	1.1	38,942	43,208	4,266	1.0
Martin Twp	1.82	5,299	5,993	694	1.3	997	1,041	44	1.0	5,394	6,098	704	1.3	71,582	75,917	4,334	1.0
Monterey Twp	1.81	4,051	5,823	1,772	3.2	707	862	155	3.5	3,932	5,792	1,861	3.3	47,498	61,998	14,500	3.5
Moscow Twp	1.54	2,422	2,477	55	0.1	458	462	4	0.1	2,514	2,572	58	0.1	30,167	30,573	406	0.1
Newton Twp	0.41	511	597	86	0.2	92	100	8	0.2	512	603	91	0.2	5,778	6,541	763	0.2
Olivet	0.05	162	218	56	0.1	27	32	5	0.1	172	229	57	0.1	1,323	1,813	490	0.1
Orangeville Twp	1.28	2,408	2,950	542	1.0	361	411	50	1.1	2,068	2,652	584	1.0	25,004	29,719	4,715	1.1
Oshtemo Twp	1.00	3,136	3,608	472	0.9	316	337	21	0.5	1,958	2,201	242	0.4	16,578	18,539	1,961	0.5
Otsego	0.10	814	962	148	0.3	130	143	13	0.3	868	1,025	157	0.3	6,894	8,112	1,217	0.3
Otsego Twp	1.69	3,690	5,271	1,581	2.9	660	780	120	2.7	3,748	5,378	1,630	2.9	42,421	53,879	11,458	2.7
Overisel Twp	0.89	2,766	3,419	654	1.2	522	555	32	0.7	2,866	3,541	674	1.2	35,898	39,482	3,584	0.9
Parchment	0.05	264	290	26	0.0	44	46	3	0.1	293	322	28	0.1	2,067	2,318	251	0.1
Parma Twp	1.26	2,306	3,149	843	1.5	435	499	64	1.4	2,427	3,258	831	1.5	27,191	33,031	5,840	1.4
Pavilion Twp	0.29	438	461	23	0.0	83	84	2	0.0	459	484	25	0.0	5,335	5,509	173	0.0
Pennfield Twp	1.73	2,605	3,600	995	1.8	460	551	91	2.1	2,703	3,722	1,019	1.8	25,405	33,793	8,389	2.0
Pine Grove Twp	1.27	3,122	4,419	1,297	2.4	564	635	71	1.6	3,061	4,636	1,575	2.8	38,335	48,334	9,998	2.4
Plainwell	0.10	738	850	111	0.2	117	126	9	0.2	779	904	125	0.2	6,447	7,356	910	0.2
Portage	1.07	4,804	5,322	518	0.9	761	814	53	1.2	5,190	5,744	554	1.0	38,883	43,755	4,872	1.2
Prairieville Twp	1.68	3,455	3,865	410	0.7	633	669	36	0.8	3,516	3,913	397	0.7	41,112	44,168	3,057	0.7
Pulaski Twp	1.84	2,648	3,015	367	0.7	501	528	27	0.6	2,744	3,105	361	0.6	32,903	35,387	2,484	0.6
Richland Twp	1.75	3,361	3,720	359	0.7	611	640	28	0.6	3,408	3,779	372	0.7	39,124	41,843	2,719	0.7
Ross Twp	1.67	2,026	2,307	281	0.5	350	375	25	0.6	2,014	2,309	294	0.5	20,385	22,776	2,391	0.6
Salem Twp	1.81	5,279	7,496	2,217	4.0	938	1,089	151	3.4	5,223	7,553	2,330	4.2	65,527	80,765	15,238	3.7
Sandstone Twp	0.01	14	17	3	0.0	2	3	0	0.0	13	16	3	0.0	166	187	21	0.0
Saugatuck	0.05	256	313	56	0.1	39	45	6	0.1	267	329	62	0.1	1,972	2,539	566	0.1
Saugatuck Twp	1.02	2,336	3,865	1,529	2.8	383	529	146	3.3	2,294	3,899	1,605	2.9	21,707	35,036	13,330	3.2
Scipio Twp	1.37	2,525	2,709	183	0.3	476	489	14	0.3	2,634	2,824	191	0.3	30,421	31,769	1,348	0.3
Sheridan Twp	1.55	2,301	3,089	788	1.4	424	488	64	1.4	2,368	3,171	802	1.4	26,499	32,528	6,029	1.4

NAME	% of total watershed area	RUNOFF VOLUME (ACRE-FEET/YR) 2001	2030	Change in Volume	% of total change	TSS LOAD (TONS/YR) 2001	2030	Change in Load	% of total change	TP LOAD (LBS/YR) 2001	2030	Change in Load	% of total change	TN LOAD (LBS/YEAR) 2001	2030	Change in Load	% of total change
Somerset Twp	0.16	236	250	15	0.0	43	44	1	0.0	239	256	17	0.0	2,794	2,913	119	0.0
Spring Arbor Twp	0.61	987	1,197	209	0.4	183	200	17	0.4	1,025	1,226	202	0.4	11,695	13,145	1,450	0.3
Springfield	0.18	1,207	1,350	143	0.3	206	221	15	0.3	1,335	1,480	144	0.3	9,063	10,368	1,304	0.3
Springport Twp	0.42	744	990	246	0.4	140	157	17	0.4	757	1,004	246	0.4	9,771	11,394	1,623	0.4
Texas Twp	0.95	2,469	2,967	497	0.9	239	257	19	0.4	1,420	1,687	267	0.5	14,569	16,524	1,955	0.5
Thornapple Twp	0.25	662	691	29	0.1	121	124	3	0.1	657	689	32	0.1	8,702	8,978	276	0.1
Trowbridge Twp	1.76	3,292	5,212	1,920	3.5	602	756	154	3.5	3,363	5,279	1,916	3.4	38,269	52,200	13,932	3.3
Valley Twp	1.67	2,514	3,434	921	1.7	301	389	89	2.0	1,683	2,704	1,020	1.8	17,657	26,027	8,370	2.0
Village of Douglas	0.08	469	566	97	0.2	76	87	10	0.2	501	608	107	0.2	3,569	4,532	963	0.2
Walton Twp	1.78	3,588	3,940	353	0.6	674	703	29	0.7	3,779	4,126	347	0.6	41,286	43,867	2,581	0.6
Watson Twp	1.79	3,722	5,197	1,475	2.7	686	805	119	2.7	3,857	5,329	1,472	2.6	42,665	53,531	10,866	2.6
Wayland	0.15	845	1,049	204	0.4	126	144	18	0.4	849	1,082	232	0.4	7,621	9,423	1,801	0.4
Wayland Twp	1.66	4,661	5,897	1,236	2.3	844	937	93	2.1	4,678	5,978	1,300	2.3	55,990	65,164	9,174	2.2
Wheatland Twp	0.03	26	29	2	0.0	5	5	0	0.0	27	29	2	0.0	378	396	17	0.0
Yankee Springs Twp	0.71	1,731	2,141	410	0.7	263	299	36	0.8	1,532	1,950	418	0.7	15,791	19,101	3,309	0.8
Zeeland Twp	0.13	283	375	92	0.2	54	59	5	0.1	293	381	88	0.2	3,945	4,428	483	0.1
Total	100	217,061	271,812	54,751	100	37,866	42,306	4,440	100	218,313	274,285	55,972	100	2,337,823	2,755,016	417,193	100

Appendix D

Stormwater Controls Cost Analysis

APPENDIX D – Stormwater Controls Cost Analysis

Table D-1: Cost scenarios for implementation of stormwater controls per township.

	TP LOAD (LBS/YR)				COSTS OF STORMWATER CONTROLS (S)		
NAME	2001	2001 Load from Urban-Commercial	2030	2030 Load from Urban-Commercial	Ordinance passed in 2001	50% reduction in 2030	Retrofitting in 2030
Adams Twp	235	0	241	5	0	27,495	54,990
Alamo Twp	4,371	70	4,803	442	352,221	2,208,820	4,065,419
Albion	1,418	139	1,682	375	693,585	1,872,500	3,051,415
Albion Twp	2,630	15	3,346	739	75,168	3,697,475	7,319,782
Allegan	1,413	506	1,756	789	2,528,005	3,947,070	5,366,135
Allegan Twp	3,542	417	5,426	2,225	2,086,150	11,124,450	20,162,750
Assyria Twp	2,560	81	3,273	716	405,734	3,580,795	6,755,857
Barry Twp	2,561	97	2,878	415	486,259	2,076,455	3,666,651
Battle Creek	9,064	1,642	10,250	2,589	8,211,300	12,943,400	17,675,500
Bedford Twp	2,316	108	3,315	923	541,955	4,613,815	8,685,675
Bellevue Twp	2,626	73	3,128	552	364,199	2,761,925	5,159,651
Bloomingdale Twp	509	3	770	220	13,748	1,100,165	2,186,582
Brookfield Twp	2,395	16	2,528	165	80,000	826,475	1,572,950
Byron Twp	1,204	65	1,373	256	322,786	1,280,220	2,237,655
Carmel Twp	1,573	28	1,768	243	140,210	1,213,950	2,287,690
Charleston Twp	1,802	82	1,981	230	409,794	1,147,965	1,886,137
Charlotte	827	177	910	256	883,540	1,280,650	1,677,760
Cheshire Twp	2,476	37	5,376	2,574	183,400	12,869,850	25,556,300
Clarence Twp	2,334	24	2,802	472	121,252	2,362,110	4,602,969
Climax Twp	44	0	44	0	0	0	0
Clyde Twp	811	47	1,254	382	236,275	1,909,430	3,582,586
Comstock Twp	4,032	490	4,552	951	2,450,890	4,753,210	7,055,530
Concord Twp	2,987	45	3,693	827	222,575	4,135,625	8,048,675
Convis Twp	2,785	94	3,265	490	469,281	2,449,680	4,430,080
Cooper Twp	3,405	47	4,055	620	234,590	3,101,095	5,967,600
Dorr Twp	4,708	330	6,602	2,253	1,648,505	11,263,700	20,878,895
Eaton Twp	1,081	19	1,412	372	92,611	1,859,025	3,625,439
Eckford Twp	2,139	8	2,504	377	39,866	1,886,450	3,733,034
Emmett Twp	3,983	329	5,011	1,201	1,645,540	6,007,300	10,369,060
Fayette Twp	93	11	98	14	52,551	69,255	85,959
Fennville	396	79	481	167	393,335	834,915	1,276,495
Fillmore Twp	339	36	372	73	180,712	365,397	550,082
Fredonia Twp	944	8	1,146	192	39,866	958,985	1,878,104
Gaines Twp	316	0	375	55	0	276,250	552,499
Galesburg	164	17	217	60	85,959	300,108	514,256
Ganges Twp	39	6	64	34	30,396	168,120	305,844
Gobles	40	0	70	22	0	110,441	220,882
Gunplain Twp	4,908	200	6,533	1,765	1,001,185	8,823,950	16,646,715
Hanover Twp	2,385	24	2,866	508	118,332	2,537,550	4,956,769
Heath Twp	2,998	208	4,854	1,771	1,039,830	8,853,650	16,667,470
Homer Twp	2,726	21	3,230	534	106,064	2,672,100	5,238,137

	TP LOAD (LBS/YR)				COSTS OF STORMWATER CONTROLS (S)		
NAME	2001	2001 Load from Urban-Commercial	2030	2030 Load from Urban-Commercial	Ordinance passed in 2001	50% reduction in 2030	Retrofitting in 2030
Hope Twp	2	2	5	4	9,775	19,549	29,324
Hopkins Twp	4,521	134	5,269	944	668,800	4,720,745	8,772,690
Jamestown Twp	2,953	57	3,799	1,055	282,903	5,274,050	10,265,198
Johnstown Twp	1,446	22	1,871	427	107,541	2,136,480	4,165,419
Kalamazoo	8,218	1,822	8,711	2,231	9,110,650	11,154,400	13,198,150
Kalamazoo Twp	3,023	538	3,353	811	2,689,935	4,053,430	5,416,925
Kalamo Twp	431	5	445	19	22,543	97,397	172,251
Laketown Twp	571	111	1,077	981	553,555	4,905,675	9,257,795
Lee Twp-Allegan	88	2	126	18	9,775	89,432	169,088
Lee Twp-Calhoun	2,929	55	3,124	252	275,449	1,261,295	2,247,142
Leighton Twp	3,697	222	4,623	1,158	1,107,760	5,788,550	10,469,340
Leroy Twp	1,361	8	1,629	238	41,760	1,188,790	2,335,820
Liberty Twp	159	3	198	45	16,704	225,505	434,305
Litchfield	59	2	65	10	8,352	50,112	91,872
Litchfield Twp	869	12	935	93	58,464	465,568	872,672
Manlius Twp	2,414	129	3,798	1,308	644,070	6,541,400	12,438,730
Maple Grove Twp	591	7	622	36	34,914	180,546	326,178
Marengo Twp	3,343	10	4,504	1,221	50,112	6,106,450	12,162,788
Marshall	1,147	106	1,449	382	529,530	1,908,355	3,287,180
Marshall Twp	3,889	64	4,516	684	319,148	3,420,815	6,522,482
Martin Twp	5,394	154	6,098	915	767,560	4,576,010	8,384,460
Monterey Twp	3,932	165	5,792	1,819	826,540	9,093,850	17,361,160
Moscow Twp	2,514	30	2,572	83	150,262	417,139	684,015
Newton Twp	512	11	603	84	57,429	419,917	782,405
Olivet	172	29	229	77	144,423	386,704	628,985
Orangeville Twp	2,068	207	2,652	696	1,034,325	3,479,400	5,924,475
Oshtemo Twp	1,958	256	2,201	256	1,280,580	1,280,580	1,280,580
Otsego	868	199	1,025	334	994,915	1,671,495	2,348,075
Otsego Twp	3,748	190	5,378	1,780	949,245	8,899,100	16,848,955
Overisel Twp	2,866	48	3,541	802	241,688	4,011,775	7,781,862
Parchment	293	53	322	72	263,914	361,660	459,406
Parma Twp	2,427	23	3,258	871	116,929	4,355,695	8,594,462
Pavilion Twp	459	6	484	27	30,895	135,138	239,381
Pennfield Twp	2,703	126	3,722	986	629,755	4,930,365	9,230,975
Pine Grove Twp	3,061	22	4,636	1,236	111,698	6,177,950	12,244,203
Plainwell	779	174	904	279	868,250	1,396,750	1,925,250
Portage	5,190	1,026	5,744	1,026	5,131,850	5,131,850	5,131,850
Prairieville Twp	3,516	90	3,913	497	451,924	2,487,135	4,522,346
Pulaski Twp	2,744	8	3,105	384	41,760	1,918,810	3,795,860
Richland Twp	3,408	70	3,779	415	349,600	2,077,020	3,804,441
Ross Twp	2,014	80	2,309	320	400,897	1,602,385	2,803,873
Salem Twp	5,223	331	7,553	2,648	1,656,100	13,240,650	24,825,200
Sandstone Twp	13	0	16	3	0	16,704	33,408
Saugatuck	267	49	329	93	244,544	464,345	684,147
Saugatuck Twp	2,294	163	3,899	1,534	813,205	7,669,250	14,525,295

	TP LOAD (LBS/YR)				COSTS OF STORMWATER CONTROLS (S)		
NAME	2001	2001 Load from Urban-Commercial	2030	2030 Load from Urban-Commercial	Ordinance passed in 2001	50% reduction in 2030	Retrofitting in 2030
Scipio Twp	2,634	27	2,824	204	136,071	1,022,190	1,908,309
Sheridan Twp	2,368	28	3,171	764	141,985	3,818,395	7,494,806
Somerset Twp	239	12	256	24	58,464	121,806	185,148
Spring Arbor Twp	1,025	22	1,226	235	108,577	1,173,765	2,238,954
Springfield	1,335	196	1,480	332	978,960	1,661,630	2,344,300
Springport Twp	757	16	1,004	270	77,607	1,348,210	2,618,813
Texas Twp	1,420	132	1,687	350	661,320	1,751,490	2,841,660
Thornapple Twp	657	25	689	49	124,373	243,128	361,883
Trowbridge Twp	3,363	93	5,279	2,007	465,563	10,037,150	19,608,737
Valley Twp	1,683	104	2,704	940	520,075	4,701,365	8,882,655
Village of Douglas	501	77	608	149	383,541	744,845	1,106,150
Walton Twp	3,779	60	4,126	403	301,735	2,017,285	3,732,836
Watson Twp	3,857	107	5,329	1,537	537,300	7,686,550	14,835,800
Wayland	849	277	1,082	463	1,383,225	2,317,170	3,251,115
Wayland Twp	4,678	166	5,978	1,365	827,605	6,824,300	12,820,995
Wheatland Twp	27	0	29	2	0	11,678	23,356
Yankee Springs Twp	1,532	119	1,950	505	593,595	2,524,710	4,455,825
Zeeland Twp	293	9	381	116	45,972	580,490	1,115,008

Table D-2: Cost scenarios for implementation of stormwater controls per subwatershed.

		TP LOAD (LBS/YR)				COSTS OF STORMWATER CONTROLS (S)		
Watershed Name	**HUC**	**2001**	**2001 Load from Urban-Commercial**	**2030**	**2030 Load from Urban-Commercial**	**Ordinance passed in 2001**	**2030**	**Retrofitting in 2030**
Upper North Branch Kalamazoo River	030101	2,228	43	2,656	462	216,043	2,312,465	4,408,887
Spring Arbor and Concord Drain	030102	1,739	36	2,006	339	177,832	1,692,760	3,207,689
Middle North Branch Kalamazoo River	030103	2,010	34	2,404	454	170,024	2,269,280	4,368,536
Lower North Branch Kalamazoo River	030104	2,116	20	2,696	652	100,225	3,261,695	6,423,166
Horseshoe Lake-South Branch Kalamazoo River	030201	3,161	21	3,342	202	102,663	1,008,215	1,913,767
Cobb Lake-South Branch Kalamazoo River	030202	1,887	26	2,017	140	130,158	700,600	1,271,042
Beaver Creek-South Branch Kalamazoo River	030203	2,780	33	2,936	203	167,041	1,016,135	1,865,230
Swains Lake Drain-South Branch Kalamazoo River	030204	1,235	3	1,475	239	16,704	1,196,305	2,375,906
Lampson Run Drain	030205	2,158	8	2,462	349	39,247	1,746,390	3,453,533
South Branch Kalamazoo River	030206	2,084	25	2,755	673	125,281	3,364,195	6,603,110
Narrow Lake-Battle Creek	030301	2,010	28	2,318	325	139,083	1,626,710	3,114,337
Relaid Mills Drain-Battle Creek	030302	1,369	6	1,623	267	29,001	1,336,685	2,644,369
Big Creek	030303	1,356	18	1,430	99	89,664	496,048	902,432
Headwaters Indian Creek	030304	2,896	55	3,193	327	276,142	1,635,430	2,994,719
Indian Creek	030305	1,798	74	2,050	310	371,756	1,552,385	2,733,015
Dillon Relaid Drain-Battle Creek	030306	4,680	240	5,193	795	1,200,140	3,974,925	6,749,710
Townline Brook Drain-Battle Creek	030307	2,189	59	2,457	320	293,438	1,600,690	2,907,942
Ackley Creek-Battle Creek	030308	1,369	63	1,797	438	315,565	2,192,100	4,068,636
Clear Lake-Battle Creek	030309	1,065	26	1,436	308	131,350	1,540,130	2,948,911
Headwaters Wanadoga Creek	030310	1,936	36	2,101	209	179,041	1,047,000	1,914,960
Wanadoga Creek	030311	1,963	70	2,624	654	350,662	3,267,935	6,185,209
Battle Creek	030312	3,748	530	4,323	958	2,649,200	4,791,020	6,932,840
Headwaters South Branch Rice Creek	030401	1,618	13	2,231	649	66,816	3,244,005	6,421,194
South Branch Rice Creek	030402	1,699	12	2,355	635	58,464	3,176,455	6,294,446
North Branch Rice Creek	030403	2,877	25	3,567	684	127,405	3,418,620	6,709,835
Wilder Creek	030404	2,319	6	2,764	450	31,514	2,251,010	4,470,506
Rice Creek	030405	2,195	43	2,837	740	217,153	3,698,040	7,178,928
Montcalm Lake-Kalamazoo River	030406	3,688	150	4,565	1,021	752,050	5,106,400	9,460,750
Buckhorn Lake-Kalamazoo River	030407	3,043	130	3,828	868	652,245	4,338,095	8,023,945
Pigeon Creek-Kalamazoo River	030408	2,208	12	2,421	236	58,464	1,180,590	2,302,716
Harper Creek	030409	2,202	55	2,767	541	273,546	2,702,850	5,132,155
Minges Brook	030410	3,662	267	4,257	797	1,334,620	3,985,310	6,636,000
Willow Creek-Kalamazoo River	030411	3,531	399	4,296	1,024	1,994,250	5,119,800	8,245,350

		TP LOAD (LBS/YR)				COSTS OF STORMWATER CONTROLS (S)		
Watershed Name	**HUC**	**2001**	**2001 Load from Urban-Commercial**	**2030**	**2030 Load from Urban-Commercial**	**Ordinance passed in 2001**	**2030**	**Retrofitting in 2030**
Headwaters Wabascon Creek	030501	1,843	29	2,318	448	147,093	2,241,790	4,336,488
Wabascon Creek	030502	1,554	76	2,310	705	377,843	3,524,540	6,671,238
Harts Lake-Kalamazoo River	030503	4,871	926	5,666	1,574	4,628,095	7,871,550	11,115,005
Sevenmile Creek	030504	1,116	23	1,400	293	115,034	1,465,490	2,815,946
Headwaters Augusta Creek	030505	1,349	26	1,447	120	128,985	601,180	1,073,375
Augusta Creek	030506	1,042	16	1,137	96	77,607	480,629	883,650
Gull Creek	030507	2,943	74	3,313	409	370,905	2,045,875	3,720,845
Eagle Lake-Kalamazoo River	030508	1,980	246	2,324	528	1,227,745	2,641,385	4,055,025
Morrow Lake-Kalamazoo River	030509	2,320	64	2,653	362	317,745	1,810,155	3,302,566
Comstock Creek	030601	2,039	53	2,275	280	263,364	1,400,275	2,537,187
West Fork Portage Creek	030602	3,167	459	3,576	802	2,292,690	4,008,365	5,724,040
Portage Creek	030603	6,199	1,125	6,820	1,592	5,623,000	7,961,950	10,300,900
Davis Creek-Kalamazoo River	030604	5,039	1,412	5,382	1,694	7,057,950	8,469,250	9,880,550
Spring Brook	030605	3,391	104	3,874	568	519,505	2,839,325	5,159,145
Averill Lake-Kalamazoo River	030606	7,933	1,286	8,790	1,982	6,432,400	9,908,600	13,384,800
Silver Creek-Kalamazoo River	030607	6,146	302	7,475	1,554	1,511,370	7,768,750	14,026,130
Gun Lake-Gun River	030701	3,485	208	4,153	783	1,039,000	3,913,955	6,788,910
Fenner Creek-Gun River	030702	5,278	248	6,160	1,085	1,241,210	5,427,400	9,613,590
Gun River	030703	4,992	216	6,371	1,555	1,079,965	7,774,100	14,468,235
Green Lake Creek	030801	3,302	189	4,204	1,092	944,500	5,460,750	9,977,000
Fales Drain-Rabbit River	030802	3,192	192	4,073	981	961,900	4,905,625	8,849,350
Miller Creek	030803	3,880	157	5,001	1,272	785,935	6,358,750	11,931,565
Bear Creek	030804	2,671	47	3,281	735	236,698	3,676,450	7,116,202
Buskirk Creek-Rabbit River	030805	2,562	283	2,994	707	1,413,610	3,536,645	5,659,680
Headwaters Little Rabbit River	030806	3,611	241	4,632	1,358	1,207,295	6,792,000	12,376,705
Little Rabbit River	030807	3,224	257	4,814	1,854	1,282,600	9,271,650	17,260,700
Pigeon Creek-Rabbit River	030808	4,418	273	5,983	1,717	1,365,110	8,582,750	15,800,390
Black Creek	030809	4,917	103	6,460	1,854	513,625	9,268,950	18,024,275
Silver Creek-Rabbit River	030810	1,979	81	3,013	998	406,824	4,989,185	9,571,547
Rabbit River	030811	4,617	242	6,205	1,684	1,209,485	8,420,800	15,632,115
Sand Creek	030901	2,566	60	2,917	373	301,888	1,864,130	3,426,373
Base Line Creek	030902	3,851	14	5,970	1,774	68,146	8,870,250	17,672,354
Pine Creek	030903	3,892	72	4,612	741	361,007	3,706,320	7,051,633
Schnable Brook	030904	3,819	96	5,180	1,480	478,055	7,398,750	14,319,446
Trowbridge Dam-Kalamazoo River	030905	3,268	307	4,582	1,565	1,534,445	7,825,100	14,115,755
Tannery Creek-Kalamazoo River	030906	2,444	264	3,948	1,648	1,317,550	8,239,550	15,161,550
Lake Allegan-Kalamazoo River	030907	4,960	788	7,763	3,338	3,938,040	16,691,800	29,445,560
Swan Creek	030908	3,444	83	6,817	3,009	413,577	15,046,600	29,679,623
Bear Creek-Kalamazoo River	030909	1,758	74	2,968	1,069	370,422	5,345,500	10,320,578
Mann Creek	030910	1,794	175	2,782	975	875,565	4,876,335	8,877,105

		TP LOAD (LBS/YR)				COSTS OF STORMWATER CONTROLS (S)		
Watershed Name	**HUC**	**2001**	**2001 Load from Urban-Commercial**	**2030**	**2030 Load from Urban-Commercial**	**Ordinance passed in 2001**	**2030**	**Retrofitting in 2030**
Peach Orchid Creek-Kalamazoo River	030911	1,995	82	3,314	1,284	412,258	6,420,400	12,428,543
Kalamazoo River	030912	2,642	353	4,147	1,570	1,763,425	7,849,000	13,934,575

Appendix 7. Common Pollutants, Sources and Water Quality Standards

Sources of water pollution are broken down into two categories: point source pollution and nonpoint source pollution. Point source pollution is the release of a discharge from a pipe, outfall or other direct input into a body of water. Common examples of point source pollution are factories and wastewater treatment facilities. Facilities with point source pollution discharges are required to obtain a National Pollutant Discharge Elimination System (NPDES) permit to ensure compliance with water quality standards under the Clean Water Act. They are also required to report to the Michigan Department of Natural Resources and Environment on a regular basis. This process assists in the restoration of degraded water bodies and drinking water supplies.

Presently, most surface water pollution comes from wet weather, non-point source pollution. Polluted runoff is caused when rain, snowmelt, or wind carries pollutants off the land and into water bodies. Roads, parking lots, driveways, farms, home lawns, golf courses, storm sewers, and businesses collectively contribute to nonpoint source pollution.

Nonpoint source pollution, also known as polluted runoff, is not as easily identified. It is often overlooked because it can be a less visible form of pollution.

The State of Michigan's Part 4 Rules (of Part 31, Water Resources Protection, of Act 451 of 1994) specify water quality standards, which shall be met in all waters of the state. Common water pollutants and related water quality standards are described below. Note that not all water quality pollutants have water quality standards established.

Sediment
Sediment is soil, sand, and minerals that can take the form of bedload (particles transported in flowing water along the bottom), suspended or dissolved material. Sediment harms aquatic wildlife by altering the natural streambed and increasing the turbidity of the water, making it "cloudy". Sedimentation may result in gill damage and suffocation of fish, as well as having a negative impact on spawning habitat. Increased turbidity from sediment affects light penetration resulting in changes in oxygen concentrations and water temperature that could affect aquatic wildlife. Sediment can also affect water levels by filling in the stream bottom, causing water levels to rise. Lakes, ponds and wetland areas can be greatly altered by sedimentation. Other pollutants, such as phosphorus and metals, can bind themselves to the finer sediment particles. Sedimentation provides a path for these pollutants to enter the waterway or water body. Finally, sediment can affect navigation and may require expensive dredging.

Related water quality standards
Total Suspended Solids (TSS) - Rule 50 of the Michigan Water Quality Standards (Part 4 of Act 451) states that waters of the state shall not have any of the following unnatural physical properties in quantities which are or may become injurious to any designated

use: turbidity, color, oil films, floating solids, foam, settleable solids, suspended solids, and deposits. This kind of rule, which does not establish a numeric level, is known as a "narrative standard." Most people consider water with a TSS concentration less than 20 mg/l to be clear. Water with TSS levels between 40 and 80 mg/l tends to appear cloudy, while water with concentrations over 150 mg/l usually appears dirty. The nature of the particles that comprise the suspended solids may cause these numbers to vary.

Nutrients

Although certain nutrients are required by aquatic plants in order to survive, an overabundance can be detrimental to the aquatic ecosystem. Nitrogen and phosphorus are generally available in limited supply in an unaltered watershed but can quickly become abundant in a watershed with agricultural and urban development. In abundance, nitrogen and phosphorus accelerate the natural aging process of a water body and allow exotic species to better compete with native plants. Wastewater treatment plants and combined sewer overflows are the most common point sources of nutrients. Nonpoint sources of nutrients include fertilizers and organic waste carried within water runoff. Excessive nutrients increase weed and algae growth impacting recreational use on the water body. Decomposition of the increased weeds and algae lowers dissolved oxygen levels resulting in a negative impact on aquatic wildlife and fish populations.

Related water quality standards

Phosphorus - Rule 60 of the Michigan Water Quality Standards (Part 4 of Act 451) limits phosphorus concentrations in point source discharges to 1 mg/l of total phosphorus as a monthly average. The rule states that other limits may be placed in permits when deemed necessary. The rule also requires that nutrients be limited as necessary to prevent excessive growth of aquatic plants, fungi or bacteria, which could impair designated uses of the surface water.

Dissolved Oxygen - Rule 64 of the Michigan Water Quality Standards (Part 4 of Act 451) includes minimum concentrations of dissolved oxygen, which must be met in surface waters of the state. This rule states that surface waters designated as coldwater fisheries must meet a minimum dissolved oxygen standard of 7 mg/l, while surface waters protected for warmwater fish and aquatic life must meet a minimum dissolved oxygen standard of 5 mg/l.

Temperature/Flow

Removal of streambank vegetation decreases the shading of a water body, which can lead to an increase in temperature. Impounded areas can also have a higher water temperature relative to a free-flowing stream. Heated runoff from impervious surfaces and cooling water from industrial processes can alter the normal temperature range of a waterway. Surges of heated water during rainstorms can shock and stress aquatic wildlife, which are adapted to "normal" temperature conditions. Increased areas of impervious surfaces, such as parking lots and driveways, and reduced infiltration from other land use types, such as lawns and bare ground, leads to an increase in runoff. Increased runoff reduces groundwater recharge and leads to highly variable flow patterns. These flow patterns can alter stream morphology and increase the possibility of flooding downstream.

Related water quality standards

Temperature - Rules 69 through 75 of the Michigan Water Quality Standards (Part 4 of Act 451) specify temperature standards which must be met in the Great Lakes and connecting waters, inland lakes, and rivers, streams and impoundments. The rules state that the Great Lakes and connecting waters and inland lakes shall not receive a heat load which increases the temperature of the receiving water more than 3 degrees Fahrenheit above the existing natural water temperature (after mixing with the receiving water). Rivers, streams and impoundments shall not receive a heat load which increases the temperature of the receiving water more than 2 degrees Fahrenheit for coldwater fisheries, and 5 degrees Fahrenheit for warmwater fisheries.

These waters shall not receive a heat load which increases the temperature of the receiving water above monthly maximum temperatures (after mixing). Monthly maximum temperatures for each water body or grouping of water bodies are listed in the rules.

The rules state that inland lakes shall not receive a heat load which would increase the temperature of the hypolimnion (the dense, cooler layer of water at the bottom of a lake) or decrease its volume. Further provisions protect migrating salmon populations, stating that warmwater rivers and inland lakes serving as principal migratory routes shall not receive a heat load which may adversely affect salmonid migration.

Bacteria/Pathogens

Bacteria are among the simplest, smallest, and most abundant organisms on earth. While the vast majority of bacteria are not harmful, certain types of bacteria cause disease in humans and animals. Concerns about bacterial contamination of surface waters led to the development of analytical methods to measure the presence of waterborne bacteria. Since 1880, coliform bacteria have been used to assess the quality of water and the likelihood of pathogens being present. Combined sewer overflows in urban areas and failing septic systems in residential or rural areas can contribute large numbers of coliforms and other bacteria to surface water and groundwater. Agricultural sources of bacteria include livestock excrement from barnyards, pastures, rangelands, feedlots, and uncontrolled manure storage areas. Stormwater runoff from residential, rural and urban areas can transport waste material from domestic pets and wildlife into surface waters. Land application of manure and sewage sludge can also result in water contamination. Bacteria from both human and animal sources can cause disease in humans.

Related water quality standards

Bacteria - Rule 62 of the Michigan Water Quality Standards (Part 4 of Act 451) limits the concentration of microorganisms in surface waters of the state and surface water discharges. Waters of the state which are protected for total body contact recreation must meet limits of 130 Escherichia coli (E. coli) per 100 milliliters (ml) water as a

30-day average and 300 E. coli per 100 ml water at any time. The total body contact recreation standard only applies from May 1 to October 1. The limit for waters of the state which are protected for partial body contact recreation is 1000 E. coli per 100 ml water. Discharges containing treated or untreated human sewage shall not contain more than 200 fecal coliform bacteria per 100 ml water as a monthly average and 400 fecal coliform bacteria per 100 ml water as a 7-day average. For infectious organisms which are not addressed by Rule 62 The Department of Natural Resources and Environment has the authority to set limits on a case-by-case basis to assure that designated uses are protected.

Chemical Pollutants

Chemical pollutants such as gasoline, oil, and heavy metals can enter surface water through runoff from roads and parking lots, or from boating. Sources of chemical pollution may include permitted applications of herbicides to inland lakes to prevent the growth of aquatic nuisance plants. Other chemical pollutants consist of pesticide and herbicide runoff from commercial, agricultural, municipal or residential uses. Impacts of chemical pollutants vary widely with the chemical.

Related water quality standards

pH - Rule 53 of the Michigan Water Quality Standards (Part 4 of Act 451) states that the hydrogen ion concentration expressed as pH shall be maintained within the range of 6.5 to 9.0 in all waters of the state.

Appendix 8: Loading Calculations

Subwatershed Phosphorus Loading

To determine phosphorus reduction objectives, outputs from the Non-Point Source Modeling of Phosphorus Loads in the Kalamazoo River/Lake Allegan Watershed Total Maximum Daily Load (2001) were reviewed. Subwatershed phosphorus loads were calculated using information listed in Table 1 of the TMDL Model (2001). A fifty percent reduction in phosphorus loading from nonpoint sources is called for by the TMDL. Subwatershed loads and the 50% reduction are included in Table A8-1.

Table A8-1. Annual phosphorus loading contribution in pounds by subwatershed.

	Forest	Agriculture	Residential	Commercial Industrial	Transportation	Water/Wetland
Augusta Creek	393	1,079	154	32	414	597
Gull Creek	310	1,138	221	83	558	1,048
Comstock Creek	143	655	388	86	479	159
Spring Brook	349	1,185	309	60	671	782
Silver Creek	381	1,042	289	52	722	587
Total	1,577	5,098	1,360	314	2,845	3,172
50% reduction	788	2,549	680*	157*	1,422*	1,586

*total of urban components is 2,259 lbs

Priority Conservation Areas (PCAs)

The Natural Features Inventory: Prairieville, Barry, Ross and Richland Townships (2005) was reviewed and the following data were generated:

1) Acreage of each PCA.
2) Aerial photos with wetland overlays in the Inventory were used to visually estimate percent land cover for Water/Wetlands and Open/Forest in each PCA.

The BMP Tool, a spreadsheet product of the Kalamazoo River Watershed Management Plan (2010) was used to calculate loads:

1) Current PCA loading was determined by converting percent land cover categories to acres then entering those acreages into the spreadsheet tool. Load estimates were recorded.
2) The most common build out pattern in the FTWA is that uplands adjacent to waterbodies and wetlands develop fastest. Therefore future loading was calculated assuming that only Open/Forest land cover in PCAs was converted to 100% low density residential. Open/Forest acreages were grouped by township and the BMP Tool again was used to calculate loads. The difference in loading was calculated.

Table A8-2 contains the summary of results for PCAs 1-20.

Table A8-2. Estimates of total phosphorus and total suspended solids loading in Priority Conservation Areas.

		Estimate of Land Cover		Current Load Forest/Open plus Wetland/Water		Forest Open	Current Load Forest/Open		Load with 100% Low Density Residential Cover on Current Forest/Open Land		Load Difference Forest/Open Land Built Out Minus Current	
PCA	**Acres**	**Wetland Water**	**Forest Open**	**TP (lbs/yr)**	**TSS (lbs/yr)**	**Acres**	**TP (lbs/yr)**	**TSS (lbs/yr)**	**TP (lbs/yr)**	**TSS (lbs/yr)**	**TP (lbs/yr)**	**TSS (lbs/yr)**
PCA1	376	25%	75%	124	33,694	282	63	29,126	344	46,289	281	17,163
PCA2	347	25%	75%	114	31,082	260	58	26,854	317	42,677	259	15,824
PCA3	421	50%	50%	184	32,048	211	47	21,793	257	34,634	210	12,842
PCA4	417	90%	10%	252	22,564	42	9	4,338	51	6,894	42	2,556
PCA5	561	75%	25%	304	34,922	140	31	14,460	171	22,980	140	8,521
PCA6	589	75%	25%	319	36,665	147	33	15,183	179	24,129	146	8,947
PCA7	272	75%	25%	147	16,938	68	15	7,023	83	11,162	68	4,139
PCA8	445	90%	10%	270	24,138	45	10	4,648	55	7,386	45	2,739
PCA9	385	90%	10%	234	20,893	39	9	4,028	48	6,402	39	2,374
PCA10	316	90%	10%	191	17,108	32	7	3,305	39	5,253	32	1,948
PCA11	595	75%	25%	322	37,066	149	33	15,389	182	24,457	148	9,068
PCA12	325	90%	10%	197	17,649	33	7	3,408	40	5,417	33	2,008
PCA13	831	10%	90%	220	81,290	748	167	77,256	912	122,780	745	45,524
PCA14	583	25%	75%	192	52,231	437	97	45,135	533	71,731	436	26,596
PCA15	890	25%	75%	293	79,832	668	149	68,993	815	109,648	666	40,655
PCA16	278	25%	75%	92	24,988	209	47	21,586	255	34,306	208	12,720
PCA17	590	75%	25%	320	36,817	148	33	15,286	180	24,293	147	9,007
PCA18	532	33%	67%	194	45,268	355	79	36,665	433	58,271	354	21,606
PCA19	392	75%	25%	212	24,411	98	22	10,122	119	16,086	98	5,964
PCA20	332	67%	33%	168	22,206	111	25	11,464	135	18,220	111	6,756
Sum	**9477**			**4,351**	**691,812**	**4,218**	**941**	**436,060**	**5,148**	**693,016**	**4,208**	**256,956**

TP = Total Phosphorus; TSS = Total Suspended Solids

Erosion Sites

The Four Township Water Resources Council suggested several erosion sites thought to be contributing to surface water bodies. Sites were visited in late September 2010. Sites were all road and stream crossings with differing degrees of visible gully erosion. Gully dimensions were estimated for use in the State of Michigan Pollutants Controlled Spreadsheet (Table A8-3). All site were associated with gravel roads or asphalt road side gravel, therefore model inputs for sand were used. Default parameters automatically provided in the spreadsheet were used to estimate particle born nutrient loads associated with sediment loading. The age of the erosion sites was estimated after visual inspection unless otherwise noted. Loading estimates are summarized in the Table A8-4.

Table A8-3. Erosion site measurements

Site	Top Width (feet)	Bottom Width (feet)	Depth (feet)	Length (feet)	Soil Weight	Years of Erosion	Description
Silver Creek crossing at Riverview Drive	4	1	3	3	0.055	3	Erosion between pipe ends (double culvert) on north side of road stream crossing.
Benedere gravel road washout at north end of Little Long Lake	3	1.5	1.5	30	0.055	1	Road washout observed and estimated by SWMLC during summer 2010. Washout has since been re-graded.
Benedere gravel roadside gully at north end of Little Long Lake	4	2	1	400	0.055	1	Road edge gully.
Prairieville Creek crossing at Hickory Road	3	1	1	200	0.055	1	Road edge gully.
Wetland crossing on 45th St. between B and C Ave.	3	1	2	4	0.055	3	Erosion at pipe end (double culvert) on east side of road.

Table A8-4. Erosion site load estimate

Site	Sediment Load (tons/year)	Phosphorus Load (lb/year)
Silver Creek crossing at Riverview Drive	0.14	0.12
Benedere gravel road washout at north end of Little Long Lake	5.57	4.73
Benedere gravel roadside gully at north end of Little Long Lake	66.00	56.10
Prairieville Creek crossing at Hickory Road	22.00	18.70
Wetland crossing on 45th St. between B and C Ave.	0.29	0.25
Totals	94.00	79.90

Appendix 9. Education Plan

Introduction

The Four Townships Watershed Area Information & Education (I&E) Plan was formulated through the efforts of the FTWRC watershed planning subcommittee. The purpose of the plan is to provide a framework to inform and motivate the various stakeholders, residents and other decision makers within the FTWA to take actions that can protect water quality. This working document will also provide a starting point for organizations within the watershed looking to provide educational opportunities or outreach efforts.

Information & Education Goal

The I&E plan will help to achieve the watershed management goals by increasing the involvement of the community in watershed protection efforts through awareness, education and action. The watershed management plan goals are: 1) Prevent an increase in pollutants threatening water quality by sufficiently preserving or managing natural and working lands within the Riparian Areas; 2) Mitigate non-point sources of pollution in storm-sewered areas and in Riparian Areas, particularly where there is current agriculture or residential/urban development; and, 3) Restore natural hydrological regimes in streams and natural ecosystems within Riparian Areas where opportunities exist. The watershed community can become involved only if they are informed of the issues and are provided information and opportunities to participate. The I&E plan lists specific tasks to be completed.

Watershed Issues

The priority issues for the FTWA are described below. Each of these issues relate back to the goals and actions in the Watershed Management Plan.

For each major issue, priority target audiences have been identified (Table A9-1).

Table A9-1. Target Audiences

Target Audiences	**Description of Audience**	**General Message Ideas**
Businesses	This audience includes businesses engaging in activities that can impact water quality such as lawn care companies, landscapers, car washes, carpet cleaners, property management companies, etc.	Clean water helps to ensure a high quality of life that attracts workers and other businesses.
Developers/Builders/ Engineers	This audience includes developers, builders and engineers.	Water quality impacts property values.
Farmers	This audience includes both agricultural landowners and those renting agricultural lands and farming them.	Protecting water quality is a long-term investment; additional benefits include saving money by decreasing inputs (fuel, fertilizer)
Government Officials and Employees	This audience includes elected (board and council members) and appointed (planning commissions and zoning board of appeals) officials of cities, townships, villages and the county. This audience also includes the drain commission and road commission staff. It also includes state and federal elected officials.	Water quality impacts economic growth potential. Water quality impacts property values and the tax revenue generated in my community to support essential services. Clean drinking water protects public health.

Target Audiences	Description of Audience	General Message Ideas
Kids/Students	This audience includes any child living or going to school in the watershed.	Clean water is important for humans and wildlife. We all depend on water.
Property Owners	This audience includes any property owner in the watershed.	Water quality impacts my property value and my health.
Riparian Property Owners	This audience includes those property owners that own land along a river, stream, drain or lake.	Water quality impacts my property value and my health.

The priority audiences were selected because of their influence or ability to take actions, which would improve or protect water quality.

- Watershed Awareness - Watershed residents need to understand that their every day activities affect the quality of FTWA resources. All watershed audiences need to be made aware of the priority pollutants and their sources and causes in each of the watersheds. Lastly, education efforts should, whenever possible, offer audiences solutions to improve and protect water quality.
- Land Use Change - Audiences need to understand that land use change can disrupt the natural hydrologic cycle in a watershed, but that low impact building practices can offer protection.
- Stormwater Runoff - Stormwater runoff education efforts should increase awareness of stormwater pollutants, sources and causes, especially the impacts of impervious (paved or built) surfaces and their role in delivering water and pollutants to water bodies.
- Natural Resources Management and Preservation - Audiences need to understand that preservation and management of open space, wetlands, farmland and other natural features helps to reduce the amount of stormwater runoff entering water bodies, preserves natural ecosystems, and protects endangered species and ecosystem services.
- Agricultural Runoff - Education efforts should seek to help audiences understand the impacts of agricultural runoff to natural waterbodies and constructed drains. A key concept is the need to reduce soil erosion from agricultural lands. Soil loss, and its associated impacts, is of great concern to farmers.
- Septage Waste - Education activities should seek to educate audiences about the impacts of septic systems on water quality and the need for regular inspections and maintenance.

Distribution Formats

Because of the differences between target audiences, it will sometimes be necessary to utilize multiple formats to successfully get the intended message across. Distribution methods include the media, newsletters and direct mailings, email lists and websites, and passive distribution of printed materials. Below is a brief description of each format with some suggestions on specific outlets or methods.

1. Media

Local media is a key tool for outreach to several audience groups. The more often an audience sees or hears information about watershed topics, the more familiar they will become and the more likely they will be to use the information in their daily lives. Keeping the message out in front through press releases and public service announcements is essential to the success of education and outreach efforts.

Newspapers include: the Kalamazoo Gazette (including the Hometown Gazette), the Battle Creek Enquirer, Michigan Farm News, the Farmer's Exchange, Hastings Banner, and the Hastings Reminder.

Radio outlets include WMUK, WKZO, Michigan Farm Radio Network , WKMI – Kalamazoo
Television outlets include WWMT Channel 3, WOOD Channel 8, WZZM Channel 13, WGVU Channel 35 and WXMI FOX Channel 17.

2. Newsletters and other direct mailings
Several municipalities, governmental agencies, utilities, County offices and non-profit organizations send out newsletters or other mailings which may be coordinated with various outreach efforts such as fact sheets or "Did you Know" messages.

3. E-Mail lists and Websites:
The FTWRC maintains an active website and membership list which can be used to reach residents of the watersheds as well as elected officials and businesses. As part of the Information and Education plan, other organizations should be encouraged to supply watershed related educational materials through their websites where appropriate. Enviro-mich provides an opportunity to advertise events and workshops to a large audience. Enviro-mich is a list serve for those in Michigan interested in environmental issues.

4. Passive Distribution:
This method relies on the target audience picking up a brochure, fact sheet, or other information. This can occur by placing materials at businesses, libraries, township/city/village halls and community festivals and events.

Plan Administration and Implementation
An information and education implementation strategy (Table 9-2) is laid out for the Four Township Watershed Area. This table lists specific tasks or activities, a potential lead agency and partners, timeframe, milestones and costs to educate target audiences for each watershed issue.

Roles and Responsibilities
The FTWRC will continue to oversee the implementation of the I&E as well as make adjustments to the plan when necessary. An I&E committee will meet as needed to advise on educational efforts.

Existing Efforts
It is important to understand current education efforts being offered or resources that are available for use or adaptation in the FTWA. In some cases, existing efforts may need

additional advertisement or updating to more effectively transmit their intended message. A few existing efforts that could be supplemented or utilized in the FTWA are described below.

- MSU Extension periodically sponsors a Citizen Planner Course in Southwest Michigan. The target audiences for this course are municipal and planning officials as well as citizens. Topics presented during each course include various land use planning topics and techniques.
- Several regional watershed partners periodically host educational workshops related to watershed and water quality topics.
- Stormwater work groups in Kalamazoo and Battle Creek conduct Stormwater outreach specific to permitted municipal separate storm sewer system communities.
- The Lake Allegan/Kalamazoo River Phosphorus TMDL Implementation Committee conducts outreach specific to the Lake Allegan basin which includes all lands in the FTWA.

Priorities

Project priorities will be established to direct resources to the areas that will gain the most benefit from the designated outreach activity. These priorities should be re-evaluated over time.

Highest priority activities include:

- Activities that promote or build on existing efforts and expand partnerships with neighboring watershed projects, municipalities, conservation organizations and other entities.
- Activities that promote general awareness and understanding of watershed concepts and project goals.
- Activities that leverage external funding from local, state or federal sources.
- Activities that lead to actions (especially those in the watershed management plan), which help to improve and/or protect water quality.

Evaluation

Ultimately, evaluation should show if water quality is being improved or protected in the watershed due to education efforts being implemented. Since watersheds are dynamic systems, this can be difficult to accomplish. For the education efforts, one level of evaluation is documenting a change in knowledge or increase in awareness and participation. Measures and data collection for this level can take place in three specific ways:

- A large-scale social survey effort to understand individual watershed awareness and behaviors impacting water quality.
- A pre- and post-test of individuals at workshops focused on specific water quality issues in the FTWA.
- The tracking of involvement in a local watershed group or increases in attendance at water quality workshops or other events.

Specific evaluation measures are included in Table A9-2. Additional levels of evaluation, which estimate pollutant loading reductions and measure water quality improvements through monitoring, are explained in the FTWA Management Plan in Chapter 10.

Table A9-2. Information and Education Strategy for the Four Townships Watershed Areas

Issue	Priority Target Audience	Activity	Potential lead agency	Potential partners	Timeline** (milestone)	Evaluation	Costs
Watershed Awareness	All	Produce and distribute 3- 4 public service announcements/press releases per year[1,2,3]	FTWRC	GLQO, MSUE	current (3-4 PSAs/year)	number of news articles	5 hours staff time/press release
		Maintain website that makes watershed information easily available to the public[1,2,3]	FTWRC	GLQO, LA	current	website traffic - number of hits monthly	$20 per month hosting fees + 10 hours staff time/month
		Create a display and participate in 2-3 community festivals/year[1,2,3]	FTWRC	SWMLC, GLQO, LA	current (2-3 festivals/ year)	number of participants	$200 per event + 30 hours staff time to develop awareness
		Maintain signs identifying waterbodies at road crossings[1,2,3]	RC	FTWRC	current	number of installed signs	$200 per sign for printing and installation
		Install educational signage at BMP installations[2]	FTWRC	GLQO, MDNRE	medium-term	number of sign views	$300 per sign; 10 hours staff time/sign
	Kids/ Students	Develop a student stream monitoring program[1,2,3]	MSUE	FTWRC	long-term (1 school/ year)	number of schools participating in program	$1500 for program materials (nets, waders, etc) + 20 hours/month staff time
		Plan and offer 1 teacher training workshop/year[1,2,3]	FTWRC	MSUE, Battle Creek Clean Water Partners annual teacher training	long-term (1 training/ year)	attendance at workshop and incorporation of watershed topics into curriculum	$200/workshop + 40 hours staff time/year
		Distribute FTWRC curriculum materials on watersheds and water quality to teachers[1,2,3]	FTWRC	School Districts	medium-term (1 schools/ year)	number of schools incorporating curriculum materials	$200/school + 60 hours staff time
Land Use Change	Drain Commission	Meet one-on-one with drain commissioners to discuss alternative drain maintenance methods and ditch naturalization techniques and stormwater standards/ordinance[2]	DC, FTWRC	GLQO	medium-term (1 commissioner/year)	miles of county drains converted and improvements in stormwater standards	20 hours staff time

Agricultural runoff and Land Use Change	Farmers	Produce and distribute brochures/flyers/fact sheets to farmers about best management practices, cost share programs, wetland protection/restoration opportunities[1,2,3]	MSUE	NRCS	short-term (2 printed pieces/year)	number of practices installed, amount of Farm Bill $ spent in the watershed, reduction in pollutants	$1500 per direct mailing + 30 hours staff time/distribution
		Plan and host at least 1 workshop per year and host a tour/field site visit at least every 2-3 years addressing agricultural runoff, best management practices, wetland protection and restoration[1,2,3]	MSUE	NRCS	(1 workshop/ year and 1 tour/2-3 years)	number of attendees and evaluations completed	$200-$600/workshop + 80 hours/year
Land use change, stormwater runoff and natural resource management and preservation	Government units-officials	Promote trainings being offered on water quality, land use planning and LID[2]	FTWRC		current (2 trainings/ year)	increase in use of LID techniques	5 hours staff time/training
		Promote the adoption of a county-wide phosphorus ban in Kalamazoo and Barry Counties and assist with educational efforts[2]	FTWRC, LA, DC	KRWC	current (1 adoption/ year)	adoption of ordinance	$1000 (printing materials) + 120 hours staff time
		Plan and host at least 1 workshop or summit per year on land use and water quality related issues and to share successes in watershed protection efforts and host a watershed tour every 2-3 years focusing on low impact development[1,2,3]	FTWRC	KRWC	long-term (1 workshop/ year and 1 tour/2-3 years)	incorporation of watershed topics into land use planning	$600/year + 80 hours staff time
		Produce and distribute updated brochures/flyers/fact sheets on land use and water quality, low impact development, smart growth, green infrastructure etc[2]	FTWRC	GLQO	current (2 printed pieces/year)	increased use of practices	$800/printing & postage 80 staff hours/item
		Work one-on-one with planning commissions to improve plans and zoning ordinances for water quality protection ordinances, smart growth and low impact development and green infrastructure[1,2,3]	FTWRC	GLQO	current (3 municipalities/year)	number of improvements to plans and ordinances	200 hours staff time/municipality

Land use change, stormwater runoff and natural resource management and preservation	Developers/ builders/ engineers	Develop and distribute newsletter articles and brochures, flyers and fact sheets on low impact development to SW Michigan realtor and builders associations[2]	FTWRC	GLQO	medium-term (1 printed piece/year)	increased use of LID practices	30 hours staff time/item
		Plan and host a watershed tour to showcase LID every 2-3 years[1,2,3]	FTWRC	GLQO	medium-term (1 tour/2-3 years)	tour attendance and evaluations	100 hours/event + $50/person
		Promote use of statewide LID manual and trainings offered[2]	FTWRC	KRWC	short-term (1 training/ year)	attendance at trainings	80 hours staff time
Land use change, stormwater runoff and natural resource management and preservation	Property owners	Install storm drain markers and place door knob hangers to educate residents about stormwater runoff[2]	LA		current (2 municipalities/year)	number installed	40 hours staff time to coordinate volunteers
		Produce a direct mailing on land protection options - focus on property owners in high priority protection areas and high priority wetland protection/restoration areas[1,3]	SWMLC	Land Preservation Board	short-term (1mailing/ 2-3 years)	increased landowner interest in land preservation options	$1000/printing and postage + 100 hours staff time
		Host workshops/tours for property owners in high priority protection areas[1,3]	SWMLC	FTWRC	short-term (1 tour/ 2-3 years)	attendance and evaluations completed	$100-$500/workshop + 80 staff hours
		Distribute printed materials on what can be done to protect water quality and on land protection options for private landowners in tax or utility bills[1,3]	County and Townships	SWMLC	long-term (1 mailing/ year)	number of mailings	$300 printing/postage 40 hours staff time
Stormwater runoff	Government units- employees	Promote trainings on municipal operations (including road maintenance and construction) and best management practices to protect water quality[2]	DC	Municipalities, RC	medium-term (1 training/ year)	number of governmental employees attending trainings	20 hours/training opportunity
		Distribute brochures/flyers/fact sheets about municipal operations and road construction and maintenance best practices for water quality[2]	RC, Municipal-ities		medium-term (1 printed piece/year)	number adopting watershed friendly practices	$150/item printing and postage + 20 hours staff time/item

Stormwater runoff	Businesses	Give presentations at local business gatherings about what businesses can do to protect water quality[2]	MSUE, DC	FTWRC	medium-term (1 presentation/ year)	number of business adopting watershed friendly practices	40 hours staff time/presentation
		Distribute brochures/flyers/fact sheets about business operations best practices for water quality - focus on lawn care companies[2]	MSUE	FTWRC	medium-term (1 distribution/ year	number of business adopting watershed friendly practices	$200-$500 printing/postage 30 hours staff time/item
Septage waste	Riparian property owners	Develop 1 newsletter article per year for lake associations to utilize in their newsletters[2]	Health Dept, MSUE	FTWRC	medium-term (1 article/ year)	number of readers (circulation of publication)	10 hours staff time/article
		Develop and work with lake associations to distribute door knob hangers about septic system maintenance[2]	LA	FTWRC	medium-term (2 lakes/year)	number of households in distribution area	$0.50each printing + 100 hours staff time/lake association
		Encourage lake association members to meet with lake owners on a one-on-one basis to discuss septic system maintenance[2]	LA	MSUE	medium-term (2 lakes/year)	improved septic maintenance and reduced pollutants	3 hours/household
	Government unit-employees	Develop and distribute brochures/flyers/fact sheets about the impacts of failing septic systems and what local governments can do[2]	MSUE, Health Dept	LA	medium-term (1distribution/ 4 years)	increased number of septic related ordinances	$400 printing/postage 80 hours staff time
		Work one-on-one with planning commissions to improve plans and zoning ordinances relating to septic systems[2]	FTWRC	LA	current (3 municipalities/year)	increased number of improved septic related ordinances	80 hours/municipality

[1] = Goal #1) Prevent an increase in pollutants threatening water quality by sufficiently preserving or managing natural and working lands within the Riparian Areas.
[2] = Goal #2) Mitigate non-point sources of pollution in storm-sewered areas and in Riparian Areas, particularly where there is current agriculture or residential/urban development.
[3] = Goal #3) Restore natural hydrological regimes in streams and natural ecosystems within Riparian Areas where opportunities exist.
FTWRC = Four Township Water Resources Council; SWMLC = Southwest Michigan Land Conservancy; KRWC = Kalamazoo River Watershed Council; MSUE = Michigan State University Extension; LA = Lake Associations; GLQO = Gull Lake Quality Organization; DC = Drain Commissioner; RC = Road Commissioner
** short-term - within one year; medium-term - within 2-3 years; long-term - within 4-6 years