Kalamazoo River Watershed Management Plan

Prepared by the Kalamazoo River Watershed Council

March 2011

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Acknowledgments

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President
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1. Introduction

The Kalamazoo River Watershed drains 2,020 square miles in southwestern lower Michigan and is one of the larger watersheds in Michigan, draining to Lake Michigan (Figure 1). The Kalamazoo River and its many connecting streams, lakes, and wetlands drain a landscape with diverse topography, soils, hydrology, natural habitats, development patterns, and economic interests (Figure 2).

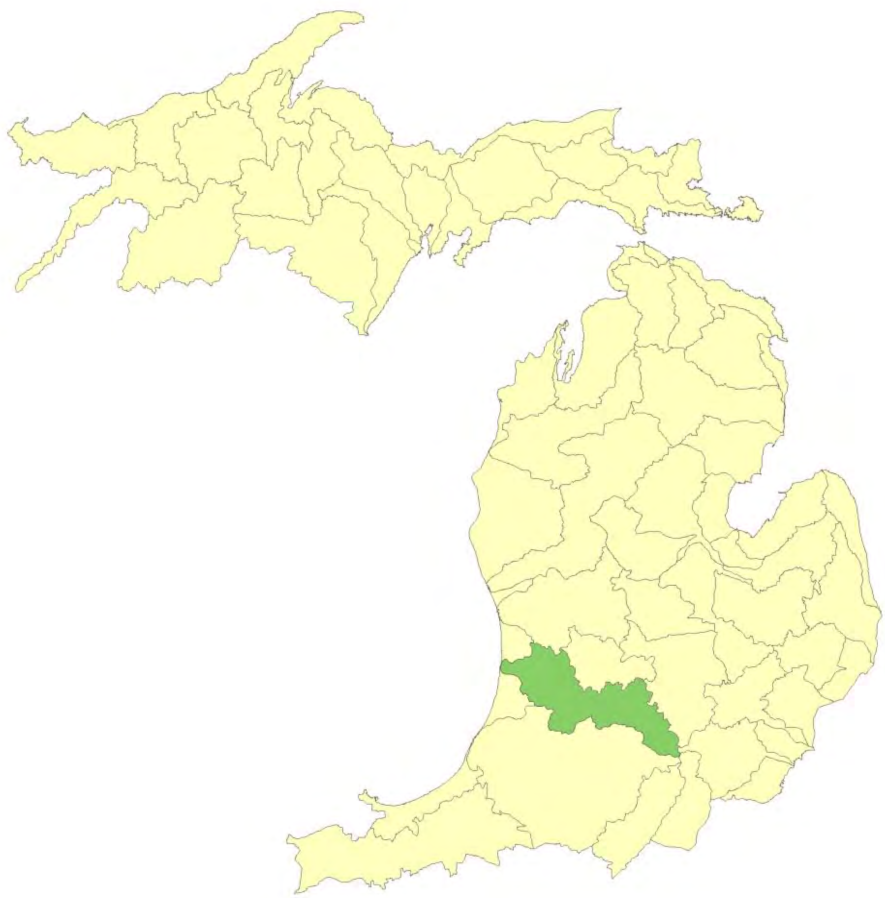


Figure 1. Kalamazoo River watershed highlighted in green within major Michigan watersheds, some of which extend into neighboring states.

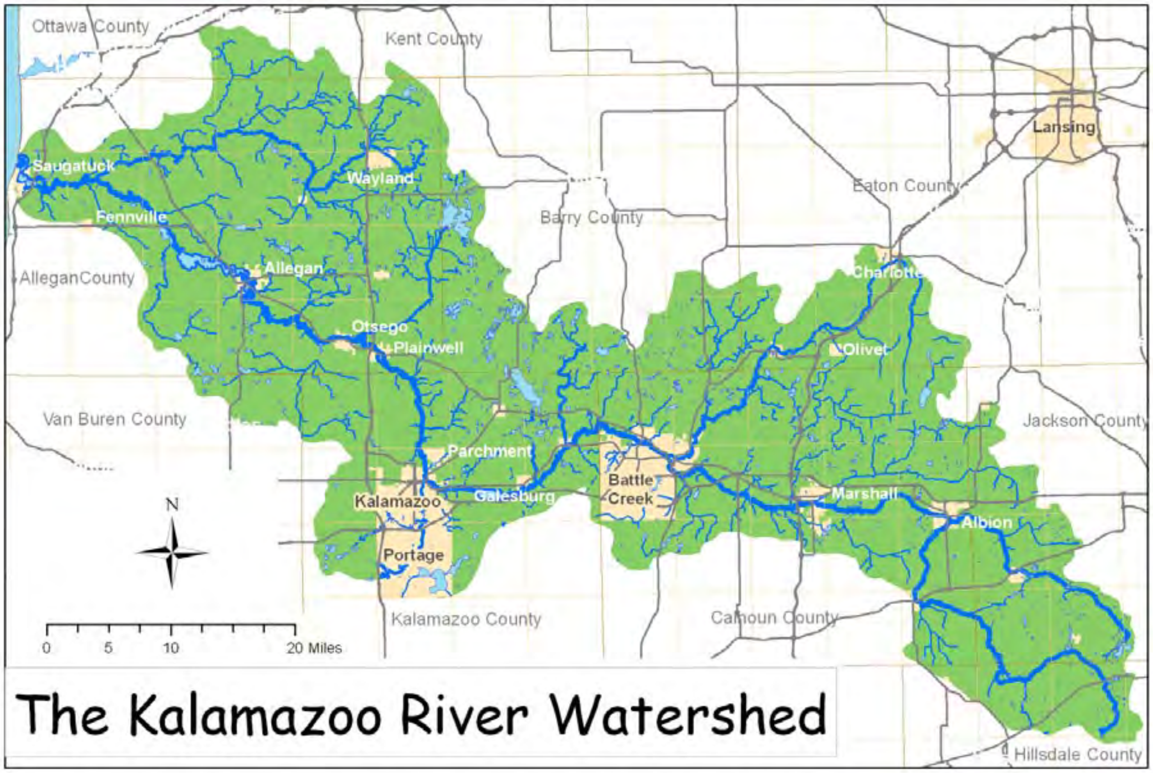


Figure 2. Map of the Kalamazoo River Watershed featuring major settlements, roads, and county and township boundaries.

The Kalamazoo River is notable for the great tragedy of historical industrial pollution in and along the river and its valley, with some of the most extensive contaminated sediments in the US. It is perhaps surprising, then, that this watershed also harbors some of the best preserved examples of Midwestern U.S. habitats including headwater streams, wetlands and floodplains, and has several large areas of contiguous forests and grasslands that are publicly accessible in state parks and game areas. The growing interest in local sustainability has engendered a sense of appreciation and shared ownership of the vital natural resources associated with the Kalamazoo River, its tributaries, lakes, and connected groundwater. In recent years there has been heightened interest among residents and governments in the region in pollution cleanup and prevention, smart growth, and habitat improvement and preservation, i.e., in watershed management in its broadest sense. This Plan seeks to channel this interest into an integrated vision, with specific steps for the near- and longer-term future to attain the goals and objectives we elucidate.

During the 1800s, people used the abundant water resources of the Kalamazoo River for waterpower, navigation and fisheries. Hydroelectric dams built along the river provided power as early as 1900, with 7 dams along the main river and over 100 in the overall watershed by the 1930s. Later the river became crucial for the development of manufacturing, including paper industries. Unfortunately the river was also used to dispose of wastes, resulting in dramatic degradation of water quality that probably reached its worst point in the 1950s and 1960s. The legacy of this past abuse of the river remains with us today in the form of contaminated sediments, particularly behind the dams where the reduced flow allowed sediment accumulation.

In 1953 a photo of a massive fish kill on Dumont Creek, a Kalamazoo River tributary, was featured on the cover of *Life Magazine.* That photo, entitled "Four acres of dead carp," caught the nation's attention, and public reaction contributed to the awakening of the U.S. environmental movement. The fish kill presumably resulted when the Kalamazoo River oxygen levels crashed due to an overload of municipal and industrial organic waste in the river. Later realization that there was widespread contamination of river fishes with synthetic industrial compounds known as PCBs (polychlorinated biphenyls) eventually led to the designation of the lower river and its adjacent floodplain as a federal Superfund Site in 1990. The history of industrial and sewage contamination as well as growing recognition of the PCB contamination problem resulted in the widespread impression of the river as unsanitary and worthless, a view which still persists today in some people's minds, but is highly undeserved.

In fact the ecological condition and aesthetic appearance of the river are greatly improved today. Gone are the days of unregulated industrial and municipal waste disposal, and the water clarity has improved dramatically. Diverse fishes and clams are returning, the riparian lands along the river are reforested with native floodplain forest, and the water is generally safe for recreation. Point sources of pollution from sewage and industrial activity are treated and their discharges are regulated under the Clean Water Act. Increasing attention is paid to more diffuse sources of pollution that threaten groundwater as well as runoff. Non-motorized land trails and water trails are being assembled on or along many water bodies including the Kalamazoo main stem. Waterfront property in urban areas is being redeveloped for other purposes, often emphasizing the aesthetic value of a view to the river.

While much progress has been made, significant challenges remain. Point sources of pollution have been brought under regulation, but now nonpoint source pollution contributes most of the total nutrient loading and remains an intransigent problem that demands fresh solutions. The insidious but largely invisible problem of PCB contamination in the river system presents a special challenge because these highly persistent contaminants are widely dispersed through the river and its reservoirs, resulting in the need for fish consumption advisories. Options to clean up PCB-contaminated sediments along the lower river course are still being deliberated. Overall, insufficient action has been taken so far to remove or isolate PCBs from the aquatic food chain, although the recent removal of the remnants of an old dam (Plainwell Dam) and the most contaminated sediments above it as well as contamination "hot spots" above the Plainwell diversion dam both represent encouraging steps toward a full cleanup.

The rupture of a major crude-oil pipeline near Marshall in late July 2010, which released ~20,000 barrels of oil, much of it entering the Kalamazoo River, will hopefully prove to be a unique event in the history of the region. Yet it serves as a reminder of the vulnerability of our water resources to accidental discharges and the need to be ever vigilant in safeguarding them. Had that oil reached the PCB-contaminated reaches of the lower river, or made it to Lake Michigan, or entered our groundwater aquifers, the impacts could have been even more severe – and protracted – than they were.

A challenge for the future is to advocate smart growth in place of traditional growth and development practices and policies, which continue to result in suburban sprawl and the consequent loss of open space, prime farm land, and important habitat such as wetlands. Unrestrained growth into rural areas results in stressed transportation networks and the weakening of agricultural- and tourism-dependent communities and support systems. Alternative development options are well documented and mechanisms to encourage them have been adopted in many other communities; we need to pursue the best and most appropriate of those ideas for the Kalamazoo River watershed.

1.1. The Challenge of Watershed Management

Regulatory, non-regulatory, and voluntary efforts and programs have yielded a diverse and active community of watershed stakeholders and managers, a growing number of watershed-based plans for tributaries within the Kalamazoo River watershed, and ongoing collaborative watershed management programs. However the capacity of the various organizations to partake in watershed planning and project implementation (a.k.a. Best Management Practices [BMPs]) is unstable from year-to-year, particularly because these activities are generally funded by short-term grants. A long-term and spatially broad approach to watershed management would bring advantages of continuity, optimal allocation of resources, and fostering synergistic interactions and efficiency among the many partners with interests in watershed issues.

Implementing watershed improvement actions comes down to one simple rule: people can make better land management choices that improve and protect shared water resources, and we can encourage such decisions with a combination of education, incentives, and policies. Much of watershed management is geared toward inspiring and incentivizing people to make choices that protect or enhance our shared water resources, choices that are underpinned by scientific and technical understanding.

Planning for the future always entails scenarios of population growth and economic development that are at best an educated guess, often relying heavily on extrapolation of past patterns of change. An additional and particularly daunting challenge for watershed planning is posed by the prospect of climate change and its uncertain implications for water resources. In southwest Michigan such changes are projected to include hotter summers, longer growing seasons, greater stress to plants including crops, and decreased water levels in lakes and flows in streams during the summer (http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts/regional-climate-change-impacts/midwest). At the same time, the general acceleration of the hydrological cycle may produce heavier precipitation events and thereby increase impacts of episodic storm runoff and river flooding. As the climate changes, we will have to adapt to new stresses on aquatic ecosystems and on our water supplies. Naturally, it behooves us as members of the global community to do all we can to help reduce our own contributions to climate change, for example by taking every opportunity to be more efficient and environmentally sustainable in our use of energy, and to reduce our consumption of material goods and food products that are produced at the cost of climate stability for future generations. Nonetheless, the balance of scientific evidence points to the inevitability of significant changes in climate, and while we can and should act now to reduce the severity of those changes, we will have no choice but to adapt to the changing climate of the future.

1.2. The Purpose of this Plan

A great deal of watershed management activity has taken place since the previous watershed-wide plan was prepared by the Kalamazoo River Watershed Council under its former name as a Public Advisory Council (KRPAC, 1998). The development and implementation of a number of watershed management plans for tributaries (sub-watersheds) within the Kalamazoo River watershed has been completed. However while we can point to many successes at local scales, the watershed planning efforts conducted over recent years have been largely disparate with little linkage and coordination. Hence the watershed community has expressed its desire to develop a unifying vision for water resources planning and management: a comprehensive Watershed Management Plan for the Kalamazoo River Watershed. This desire became evident at several meetings that brought together people from throughout the watershed who were interested in watershed management and planning (e.g., the 2005 Watershed Forum and 2007 Watershed Technical Summit, see www.kalamazooriver.org).

This Watershed Management Plan, prepared by the Kalamazoo River Watershed Council (KRWC) under an EPA Clean Water Act Section 319 grant administered through the Michigan Department of Environmental Quality (known as the Department of Natural Resources and Environment from 2008-2010), seeks to fulfill that desire. The purpose of the Plan is to provide a unified framework for dealing with water resource issues in the Kalamazoo River watershed. The Plan emphasizes an integrated approach, recognizing that water supply and water quality cannot be managed separately, and that ground water and surface water are interconnected resources, separated in time and space, but fundamentally interrelated (Winter et al. 1998: http://pubs.usgs.gov/circ/circ1139/pdf/front.pdf).

Watershed management is challenging because it entails a complex balance of multiple and sometimes conflicting issues and interests. This Kalamazoo River Watershed Management Plan (KRWMP) is an attempt to meet that challenge, to take into account the particular features of our local water resources and the many needs it must meet, and to weave them into a unifying vision for the Kalamazoo River watershed. Our hope is that this Plan will provide an enduring framework, yet one that is open to modification in response to new information and emerging issues.

This Plan is conceived following the "ecosystem management" paradigm that has been adopted by many resource management agencies in recent years (Christensen et al. 1996). The ecosystem management approach requires considering all aspects of water resources in decision-making, and recognizing that a wide range of decisions and actions — not just those traditionally associated with water management — can affect our water resources. Holistic watershed management must transcend traditional jurisdictional boundaries, recognizing that water resources are traditionally managed without explicit recognition of the overall interlinked hydrological system. A key consideration is the long-term sustainability (i.e., for future generations) of water resources for human uses, including water supply, irrigation, and recreational and aesthetic values, as well as for the maintenance of natural ecosystems and biodiversity. Given the complexity of this task, watershed management will be successful only if we can promote coordination and cooperation across institutions, governmental units, watershed organizations, and sub-watersheds; above all citizen education and involvement are fundamental.

The Plan sets a direction for policy and management decisions over at least the next decade and should be used as a guide for policy setting, decision-making and prioritizing actions originating from funding agencies, governmental units, private entities, organizations, and individuals. It forms a framework within which existing and new programs can be incorporated and coordinated for the most effective results. It also points to emerging issues and new areas in need of research and study.

The specific rationales for and purposes of this watershed-wide Plan include the following:

- To establish a unifying vision for water resources management
- To better coordinate ongoing efforts to preserve, protect, and enhance the water resources of the Watershed and the ecological, social and economic benefits they provide
- To identify and consider relationships between land use and water resources
- To explore the way forward towards more effective water resources management
- To identify a set of actions for achieving specific goals
- To invite all levels of stakeholders into the process of water resources management
- To serve as an approved 9-elements nonpoint-source plan under the EPA's Clean Water Act (Section 319).

1.3. Guiding Principles

Watershed management is a community driven process involving coalitions and partnerships of stakeholders developing multi-faceted solutions designed to meet specific water quality based goals. The general principles and sequential stages of watershed management are:

- Assess the nature and status of the watershed/ecosystem;
- Define short and long term goals;
- Determine objectives and actions needed to achieve selected goals;
- Consider benefits and costs of each action;
- Document plan and obtain commitment for actions;
- Implement actions; and
- Evaluate effects of actions and progress toward goals.

1.4. Structure and Use of this Plan

Implementing water resource protection and restoration requires a distributed network of watershed implementers, yet those implementers need to stay connected, learn from one another, and have the opportunity to speak with one voice when issues are best tackled at larger scales (e.g., watershed, regional, State, Great Lakes Basin, national, and global). Therefore we must take advantage of rapidly evolving electronic communication technologies and environmental assessment tools and models.

This Plan charts a course that will serve to guide watershed stakeholders new and old. Entities that are new to watershed thinking always have the option to become involved in the Kalamazoo River Watershed Partnership (http://www.kalamazooriver.org/content/view/59/49/). The Partnership may in time formalize the participation of Watershed Partners that have signed on to a Partnership Agreement (Attachment 1). Partners benefit now from regular communication through a Watershed Communication Center, maintenance of a Watershed Library by the Kalamazoo River Watershed Council, shared resources and outreach efforts, and cross promotion of related efforts to reach the general public to inspire and incentivize sustainable water resource behavior, choices, and land management.

Organization of the Plan

To a large extent this Plan builds on the successes of a variety of existing and ongoing efforts in sub-watersheds and additionally fills in some gaps not presently addressed in sufficient detail or spatial coverage by existing plans (Figure 3; Table 1).

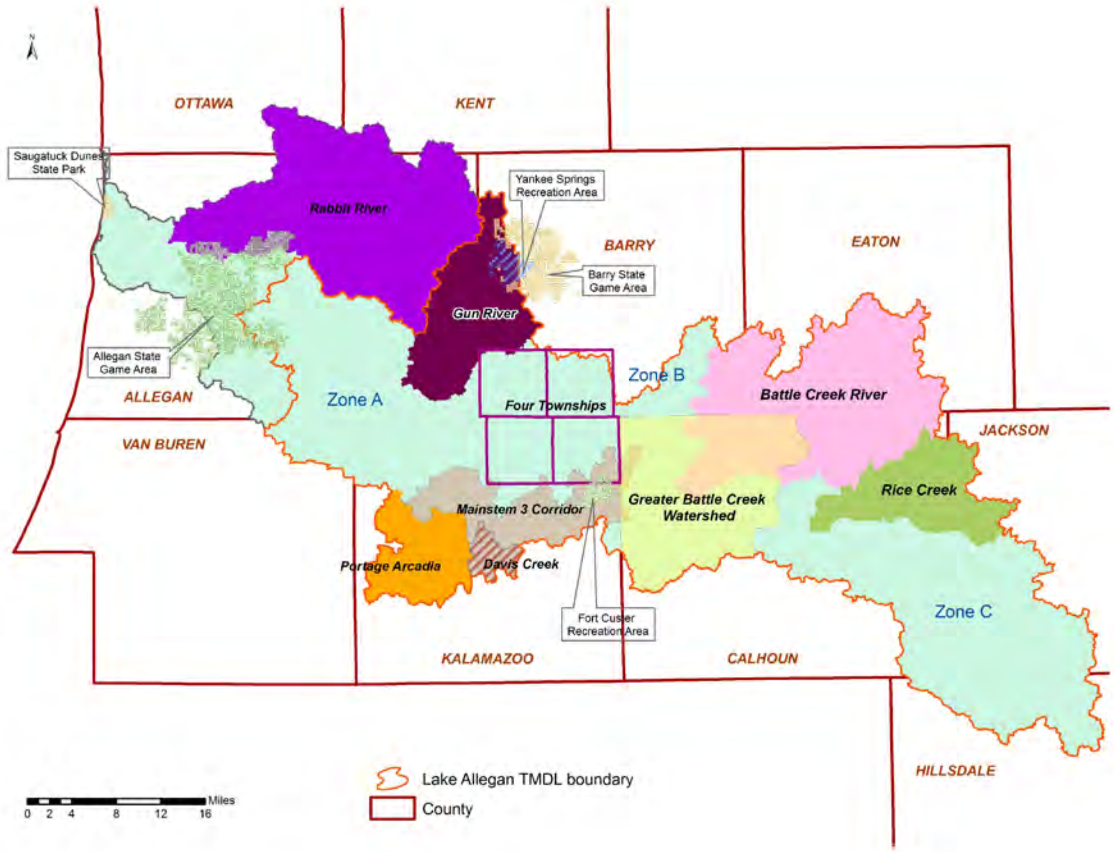


Figure 3. Subwatershed planning areas and zones without nonpoint source planning coverage as of 2007 in the Kalamazoo River Watershed (note a larger area in the Four Townships Watershed Area achieved coverage with an approved watershed plan in 2010).

Table 1. Kalamazoo River subwatershed plans.

Name of Watershed Plan	Submitted by	CMI Approved	9 Elements Approved*	Date
This Plan – The Kalamazoo River Watershed Management Plan (entire watershed)	Kalamazoo River Watershed Council	Pending	Pending	2010
Kalamazoo River Watershed Preventive & Remedial Action Plan	Kalamazoo River Watershed Council	Yes	No	1998
Michigan Department of Environmental Quality Biennial Remedial Action Plan Update for the Kalamazoo River Area of Concern	Michigan Department of Environmental Quality	NA	NA	2009
Kalamazoo River Area of Concern: Restoration Plan for the "Loss of Fish and Wildlife Habitat" and "Degradation of Fish and Wildlife Populations" Beneficial Use Impairments	Kalamazoo River Watershed Council	NA	NA	2009
Kalamazoo River – Ceresco Reach Watershed Management Plan	Calhoun Conservation District	Plan Under Development		
Lake Allegan/Kalamazoo River Phosphorus Total Maximum Daily Load (TMDL) Implementation Plan	The Forum of Greater Kalamazoo	NA	NA	2001
Lake Allegan/Kalamazoo River Phosphorus TMDL Strategic Action Plan	TMDL Implementation Committee	NA	NA	Updated regularly
Battle Creek River Watershed Management Plan	Calhoun Conservation District	Yes	Yes	2004
Greater Battle Creek Area Watershed Plan	City of Battle Creek, Calhoun Conservation District, City of Springfield	Yes	No	2001
Rice Creek Watershed Management Plan	Calhoun Conservation District	Yes	Yes	2004
Kalamazoo River Mainstem 3 Corridor Watershed Management Plan**	Kalamazoo County Road Commission	No	No	2007
Portage, Davis & Gourdneck Creeks Watershed Plan	City of Portage	Yes	No	2005
Portage Creek/Arcadia Creek Watershed Management Plan	The Forum of Greater Kalamazoo	Yes	Yes	2006
Four Township Area Watersheds	Four Township Water Resources Council	Yes	Yes	2010
Gun River Watershed Plan	Allegan Conservation District	Yes	Yes	2004
Rabbit River Watershed Plan (entire watershed)	Allegan County Drain Commissioner	Yes	Yes	2010
Allegan State Game Area	Management Plans	NA	NA	
Fort Custer	Management Plans	NA	NA	

* Plans that are only CMI approved need to be updated (through a planning grant or other funding) to meet 9 Elements criteria to be eligible for 319 implementation funding.
** Plan was developed as a Municipal Separate Storm Sewer System (MS4) permit requirement and has not been CMI or 9 Elements approved.
NA = Not Applicable

This Watershed Management Plan is designed to be accessible (web-friendly) and transferrable to a designated watershed lead/umbrella planning and implementation entity (e.g. Watershed Coordinator, Watershed Partnership Coordinator, Watershed Utility, or Watershed Commission). The Kalamazoo River Watershed Council (www.kalamazooriver.org) currently voluntarily fills this collaborative function on behalf of watershed partners, but actions identified in the Watershed Management Plan are intended for any organization to implement.

Many existing planning efforts have resulted in: 1) general management objectives; and/or, 2) site- or area-specific objectives (often called "actions"). When compiled for all existing plans, there are over one-hundred pages of listed actions across the sub-watershed management units (contact the Watershed Council for details). No attempt was made to re-prioritize existing sub-watershed management unit actions; rather, we synthesize and augment this information here. This Plan is intended to be available for periodic updates on actions that have been completed. We anticipate that regular sub-watershed planning and document updates by partners will be submitted for incorporation into this Plan.

2. Watershed Description

2.1. Geology and Groundwater

The Kalamazoo River drains a landscape lying on thick glacial deposits, and as a result there is generally a high degree of linkage between surface and ground waters, with a predominant influence of groundwater discharge on streams, rivers, most lakes, and many wetlands (Grannemann et al. 2008). Bedrock outcrops are absent and although the depth of unconsolidated glacial deposits lying on the underlying bedrock is variable, in most of the watershed it is quite thick. Glacial deposits range in depth from more than 400 feet in the western portions of the watershed to 50 feet or less east of Battle Creek.

The geomorphology of the landscape is largely a reflection of the most recent continental glaciation, when two large ice lobes converged in this area (Kincare and Larson 2009). As the glacial ice retreated from the area around 14,000 years ago, it left till plains and upland end moraines as well as relatively level outwash plains. The Kalamazoo River and its floodplain were originally formed from glacial meltwaters, and the morphology of the river valley reflects the much higher discharge at that time, as well as postglacial fluctuations in Lake Michigan water levels and the “rebound” of the underlying crust after the weight of glacial ice was removed. Because of this origin, the floodplain is quite wide in many reaches compared to modern-day discharge of the river (Figure 4).

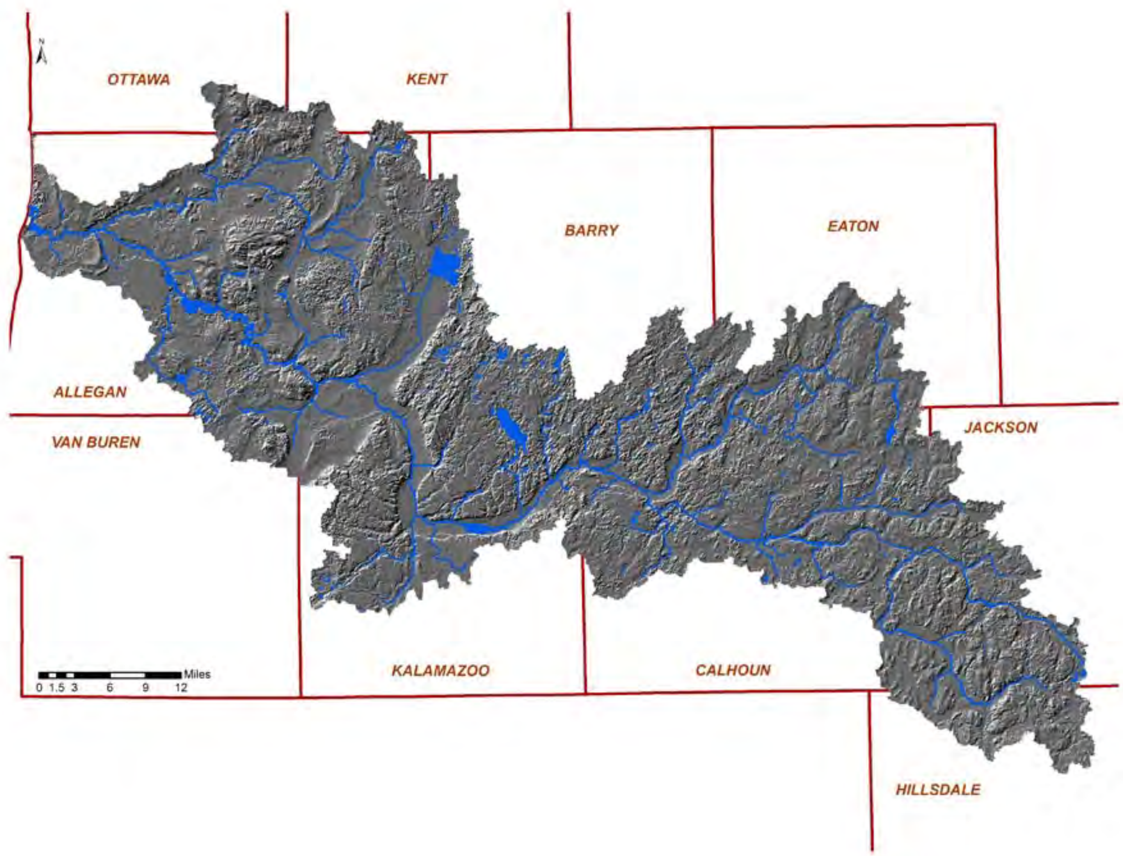


Figure 4. Shaded relief of the Kalamazoo River Watershed.

The geology and hydrogeology of the watershed are well described in previous publications, including Rheaume (1990) and Wesley (2005). A recent overview of Michigan geography also contains much useful information pertinent to this watershed and provides it in the context of the broader region (Schaetzl et al. 2009).

Tributary streams reach the river through valleys that dissect the glacial terrain, and often originate in or pass through lakes and wetlands. Many streams gain most of their water from diffuse groundwater inputs. A substantial fraction of the upland area is composed of undulating, hummocky terrain that can be difficult to assign to a particular stream watershed on the basis of surface topography. Most of the abundant lakes and wetlands of the area occupy depressions (glacial kettles) formed by the melting of residual glacial ice, and many lack surface connections to other water bodies. The lowermost reach of the main stem of the river traverses former lake sediments deposited during a period of high lake levels that followed the last glaciation.

Soils in the watershed are diverse and range from dominance by clay and silt to sand and organic materials (Table 2; Figure 5). 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 are intermediate with an infiltration rate of 0.5-1.0 inches/hour. Group C soils are sandy clay loams with a low infiltration rate when thoroughly wetted (i.e., 0.17-0.27 inches/hour). Group D soils have the lowest infiltration rate, ranging 0.02-0.10 inches/hour. Protection of areas with high infiltration capacity (Group A soils) is especially important for maintaining: 1) groundwater-surface water interactions; 2) ground- and stream-water quality; and, 3) temperature regimes within the watershed. Examples of measures to protect groundwater recharge include impervious cover restrictions and agricultural BMPs.

Table 2 . Soils within the Kalamazoo River Watershed (from the STATSGO data base).

MUID	Name	Group
MI006	MORLEY-BLOUNT-PEWAMO (MI006)	C
MI011	COLOMA-SPINKS-OSHTEMO (MI011)	A/B
MI014	SPINKS-HOUGHTON-BOYER (MI014)	B
MI017	MIAMI-CONOVER-BROOKSTON (MI017)	B
MI022	HOUGHTON-CARLISLE-ADRIAN (MI022)	A/D
MI023	MIAMI-HILLSDALE-EDWARDS (MI023)	B
MI024	BOYER-OAKVILLE-COHOCTAH (MI024)	B
MI034	RIDDLES-HILLSDALE-GILFORD (MI034)	B
MI035	MARLETTE-CAPAC-PARKHILL (MI035)	B
MI036	MARLETTE-CAPAC-SPINKS (MI036)	B
MI040	ITHACA-ZIEGENFUSS-PEWAMO (MI040)	C/D
MI041	BARRY-LOCKE-HATMAKER (MI041)	B
MI043	MATHERTON-SEBEWA-FOX (MI043)	B
MI045	OSHTEMO-KALAMAZOO-HOUGHTON (MI045)	B
MI046	OAKVILLE-COVERT-ADRIAN (MI046)	A
MI047	SCHOOLCRAFT-KALAMAZOO-ELSTON (MI047)	B
MI048	CAPAC-RIDDLES-SELFRIDGE (MI048)	B
MI050	GRATTAN-PIPESTONE-GRANBY (MI050)	A
MI058	PERRINTON-ITHACA-COLOMA (MI058)	A/D
MI061	PARKHILL-CAPAC-LONDO (MI061)	B
MI082	GILFORD-MAUMEE-SPARTA (MI082)	B
MI083	GRANBY-GILFORD-THETFORD (MI083)	A/B
MI084	URBANLAND-PARKHILL-CAPAC (MI084)	B/D
MI091	OSHTEMO-SPINKS-MARLETTE (MI091)	B

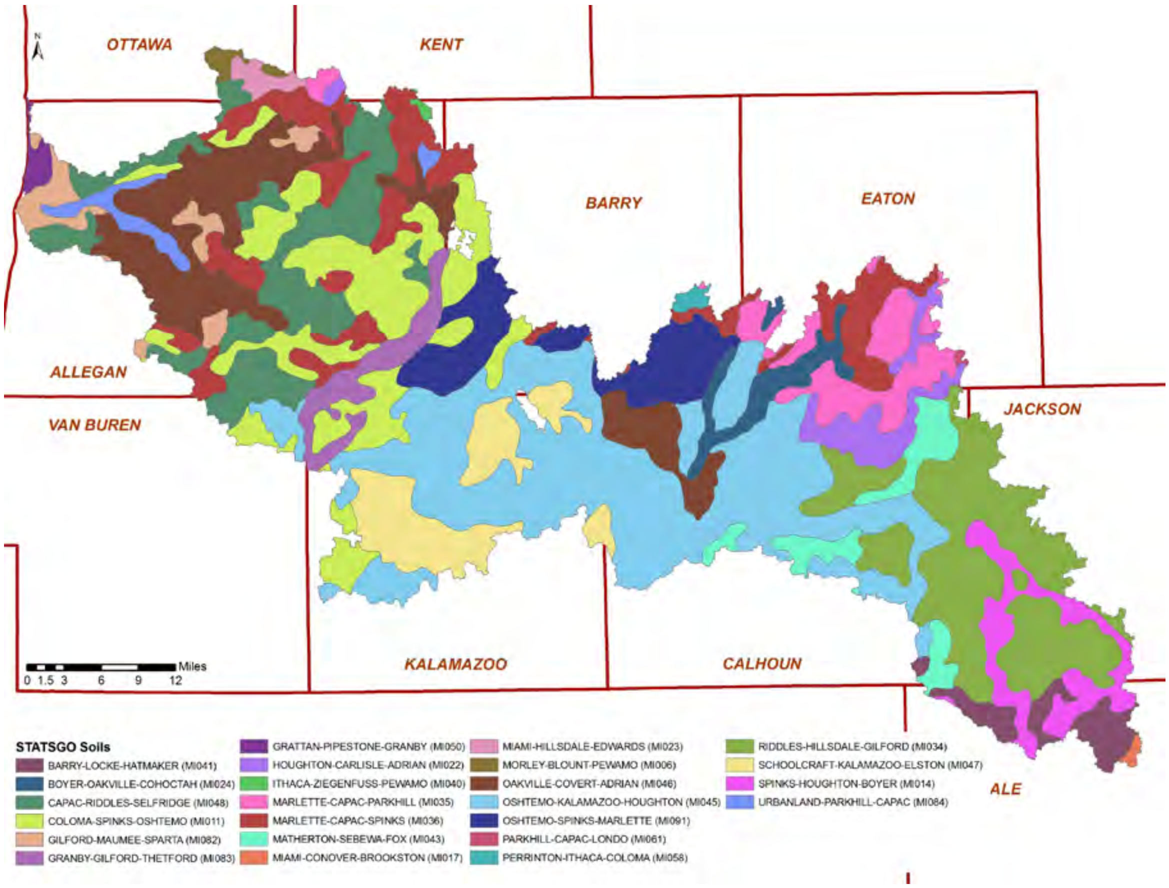


Figure 5. Soils within the Kalamazoo River Watershed (STATSGO data base).

The most common upland soil formations are alfisols, reflecting the predominance of deciduous forest during their formation (Schaetzl 2009). About 25% have clay loam or clay textures (found mostly in Eaton County and to a lesser extent in Allegan and Van Buren counties). About 70% of the watershed is covered with coarse-textured soils that are relatively permeable to infiltration of water. Forty percent are sandy loams and loams of intermediate texture (found primarily in Calhoun, Allegan, Barry, and Kalamazoo Counties). Soils with loamy sand and sandy textures make up approximately 30% of the land (found mostly in the western part of the basin). The remaining 5% are organic and are distributed through the basin, usually in wetlands and river bottoms. Prime agricultural soils cover a significant portion of the watershed (Figure 6).

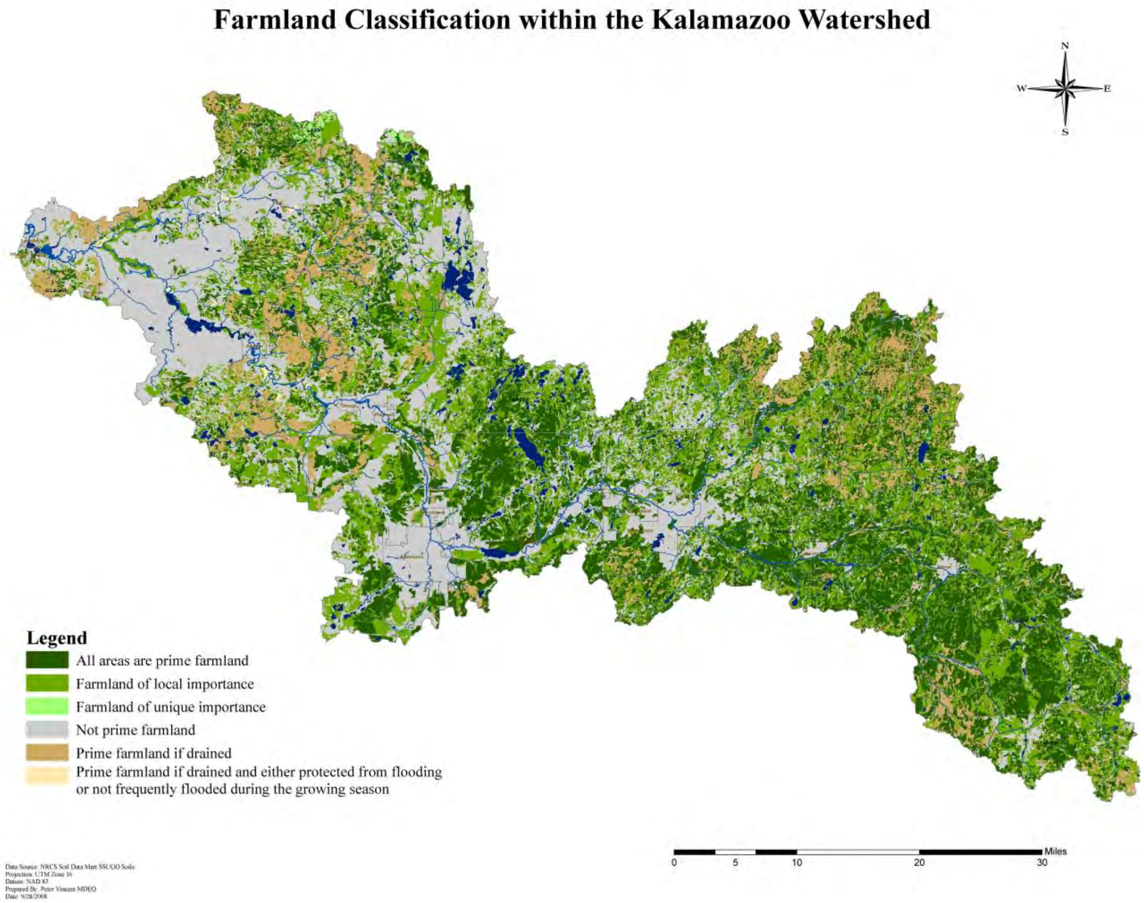


Figure 6. Agricultural land classifications in the Kalamazoo River Watershed.

Climate

Climate describes the general weather conditions over a long period of time in a given area. The climate of southwestern Michigan is humid with a significant influence of the Great Lakes. Mean temperatures range from 23°F (-5°C) in January to 72 °F (22°C) in July (1971-2000: Andresen and Winkler 2009). Average annual precipitation is about 32 inches (813 mm); about half falls as snowfall. Climate in areas near the Great Lakes, including western parts of the Kalamazoo River watershed, is influenced by the “lake effect” of Lake Michigan that includes elevated snowfall and milder temperatures. The climatic influence of Lake Michigan provides niches for a variety of native plant species as well as certain types of agriculture (e.g., fruit trees, blueberries) that would not grow further inland. Average growing season ranges from about 153 days at the eastern end of the watershed to about 184 days along Lake Michigan.

There is a growing body of scientific evidence suggesting that climate change is already impacting ecosystems and water resources in subtle but important ways. Climate change projections based on climate models are best interpreted on regional scales. A recent assessment for the Midwest US by the United States Global Change Research Program (2009) is excerpted here:

Average temperatures in the Midwest have risen in recent decades, with the largest increases in winter. The length of the frost-free or growing season has been extended by one week, mainly due to earlier dates for the last spring frost. Heavy downpours are now twice as frequent as they were a century ago. Both summer and winter precipitation have been above average for the last three decades, the wettest period in a century. The Midwest has experienced two record-breaking floods in the past 15 years. There has also been a decrease in lake ice, including on the Great Lakes. Since the 1980s, large heat waves have become more frequent than anytime in the last century, other than the Dust Bowl years of the 1930s. The observed patterns of temperature increases and precipitation changes are projected to continue, with larger changes expected under higher emissions scenarios.

Key issues:

- During the summer, public health and quality of life, especially in cities, will be negatively affected by increasing heat waves, reduced air quality, and increasing insect and waterborne diseases. In the winter, warming will have mixed impacts.
- The likely increase in precipitation in winter and spring, more heavy downpours, and greater evaporation in summer would lead to more periods of both floods and water deficits.
- While the longer growing season provides the potential for increased crop yields, increases in heat waves, floods, droughts, insects, and weeds will present increasing challenges to managing crops, livestock, and forests.
- Native species are very likely to face increasing threats from rapidly changing climate conditions, pests, diseases, and invasive species moving in from warmer regions.

Reference: http://www.globalchange.gov/publications/reports/scientific-assessments/us-impacts/regional-climate-change-impacts/midwest

Protection and management of our water resources will need to adapt to the changing climate, and projection of the future based on the past will become increasingly uncertain.

2.2. Hydrology: Ground and Surface Waters

The Kalamazoo River Watershed is richly endowed with surface and subsurface water, with most of it in good to excellent condition for supporting human uses and aquatic life. Yet protection of this valuable resource should be paramount because it is vulnerable to degradation.

Ground water provides the major water source for residences and communities, industries, and agriculture throughout the watershed. The sustainability of this resource depends on maintenance of both its quantity and quality. Infiltration of water from rain and snow replenishes (recharges) groundwater aquifers, but urban and suburban land use tends to reduce infiltration by diverting more water to drainage systems. Agricultural land use can also result in less groundwater recharge where tile drainage systems are installed and by producing seasonally bare and sometimes compacted soils. Groundwater quality is impacted by a myriad of human activities including fertilizer and waste applications, septic system discharges, road salts, and accidental leakage or spills of chemicals. Groundwater is particularly vulnerable in the Kalamazoo River watershed due to the prevalence of well drained soils.

Watershed-scale hydrological studies include Allen et al. (1972), Rheaume (1990), and Fongers (2008), with the former two focused on Kalamazoo County. For an extensive review of river hydrology see The Kalamazoo River Fisheries Assessment (Wesley, 2005).

Landscape-scale water budgets have been evaluated for the Kalamazoo River watershed (Allen et al. 1972). Analysis of a 34-year record (1933-66) of precipitation, evaporation, and river runoff for the Kalamazoo River watershed indicated that of the 35 inches (890 mm) of annual precipitation, about 65% was returned to the atmosphere by evapotranspiration and most of the remainder became river runoff. The annual rate of groundwater recharge by precipitation in the area averaged 9 inches (230 mm) and usually occurs mainly during the cooler months of November-May, when evapotranspiration rates are low. Stream hydrograph separation revealed that about two-thirds of the annual discharge of the Kalamazoo River above Kalamazoo is derived from groundwater discharge, providing a stable baseflow all year in the river and most of its tributaries. This constant inflow of groundwater all year attenuates seasonal extremes of water temperature.

Such water budgets illustrate the long-term average water balance but do not provide a picture of the seasonal and longer-term dynamics of water movement through the landscape (Webster et al. 2006). Given the importance of groundwater flow paths and large volume of the groundwater reservoirs, travel times of ground water through these watersheds are undoubtedly long compared to watersheds in which overland flow is a more dominant route of water movement. Based on studies of similar terrain in southern Wisconsin, the groundwater discharged into streams is likely to have originated as infiltration of precipitation over several decades (Saad 2008, Rupert 2008). This means that contaminants in ground water turn over slowly, and the water quality impacts of land use practices will be slow to manifest themselves – but equally slow to diminish. Groundwater flow models based on well log and surface elevation data reveal flow directions and approximate travel times and can be valuable tools for management of groundwater resources and associated groundwater-dependent surface waters (Bartholic et al. 2007).

The Kalamazoo River Watershed is divided into sub-watersheds based on a system known as the Hydrologic Unit Code (HUC) (Figure 7).

Figure 7. Kalamazoo River Watershed 14 digit Hydrologic Unit Codes.

HUCs were developed by the United States Geological Society to delineate boundaries for watersheds. The United States is divided hierarchically into successively smaller units. The units are classified into six levels starting with large areas such as the Great Lakes Region (2-digit) down to small areas (e.g., 14-digit). The overall Kalamazoo River has an 8-digit HUC (04050003).

HUCs are used as a basis of organization by several different management agencies and are used in this plan to organize data and model portions of the watershed. HUCs arranged at the 10-digit level provide another useful spatial grouping that can include the 14-digit level subwatersheds (Figure 8).

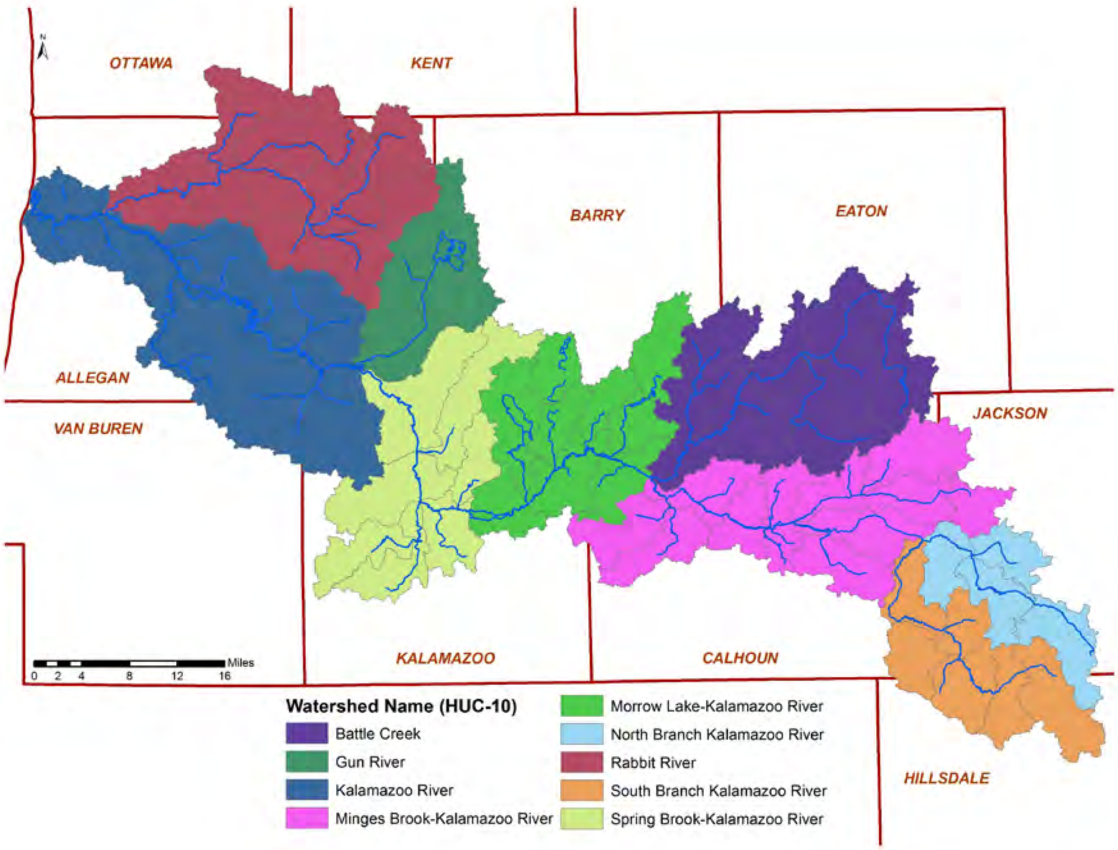


Figure 8. Kalamazoo River Watershed 10-digit Hydrologic Unit Code major subwatersheds (14-digit lines are also visible).

The crosswalk table (Attachment 2) contains HUC codes and additional information including how HUCs are grouped in different subwatershed management units (WMUs). Referencing Watershed Management Units (WMUs) are a convenient way to illustrate the interlinked nature of the many sub-watersheds — defined here as areas drained by a single waterway or watercourse (also see groupings in Figure 3 and Table 1). The WMU groupings are based on existing nonpoint-source watershed plans, stormwater plans, and phosphorus reduction plans that are maintained by and guide watershed partners in several sub-watershed areas or land management areas.

HUCs need to be interpreted with caution at the finest spatial scales. In glacial landscapes, watersheds delineated by topography alone may not accurately reflect groundwater flow directions, particularly at headwater stream locations and in relatively level terrain.

The concept of a stream flow regime embodies not only the annual range and average discharge but also the variation over a range of time scales. Stream flow regime is important to stream ecology, pollutant loading, and pollutant transport (Poff et al. 1997, Postel and Richter 2003). The most stable stream flow regimes are found in sub-watersheds where groundwater discharge is a high proportion of the flow, and these are most common in the middle of the watershed. Streams draining less permeable, fine-textured soils show less stable natural flow regimes. Stream flow regimes tend to be perturbed by several different human interferences. Agricultural tillage, urbanization, stream channelization, filling of wetlands, and installation of drainage systems for agriculture and urban development all contribute to stream flow instability. On the other hand, impoundments that create large reservoirs relative to stream discharge can attenuate flow variability.

Seasonal flooding occurs throughout the Kalamazoo River watershed, most often in late winter and spring, but most damage occurs to developments within the floodplain. Ice damming is often involved in floods that result in property damage. However, increasing urbanization, and the flashy runoff that accompanies impervious surfaces, can certainly aggravate flooding. In summer it may also cause undesirable inputs of warm runoff water to coldwater trout streams.

Analysis of hydrological time-series data detected increases in stream flashiness in several gauged watershed tributaries (Fongers, 2009, http://www.michigan.gov/documents/deq/lwm-nps-kalamazoo_229438_7.pdf). Changes in flashiness may be related to watershed land use conversion to agriculture and urban development. These research outcomes and management implications are further considered in later sections of the KRWMP and used to define watershed actions in critical areas.

2.3. Land Use and Cover

Land cover in the Kalamazoo River watershed is approximately 47% agriculture (dominated by corn and soybeans), 30% unmanaged terrestrial uplands (mostly secondary deciduous forest and successional old fields), 15% lakes and wetlands, and 8% urban. There is some tile drainage in the area but most agricultural land in the watershed is naturally well drained, and is neither tiled nor affected by artificial ditches (Schaetzl 2009).

The Integrated Forest Monitoring, Assessment, and Prescription (IFMAP) system is an inventory application being developed by the MDEQ to suitably inventory resource information in a GIS-based system that integrates with numerous other resource inventories used by the agency. The following analysis used the 2001 IFMAP map available from Michigan Geographic Data Library. This land cover data set was derived from analysis of Landsat satellite imagery and in the case of low density urban development it seems to provide a minimum estimate because homes among trees are often not detected. A map of land use and cover and summary tables shows the heterogeneous distribution throughout the Kalamazoo River watershed, and sub-watersheds vary considerably in land use and cover (Figure 9; Tables 3 and 4).

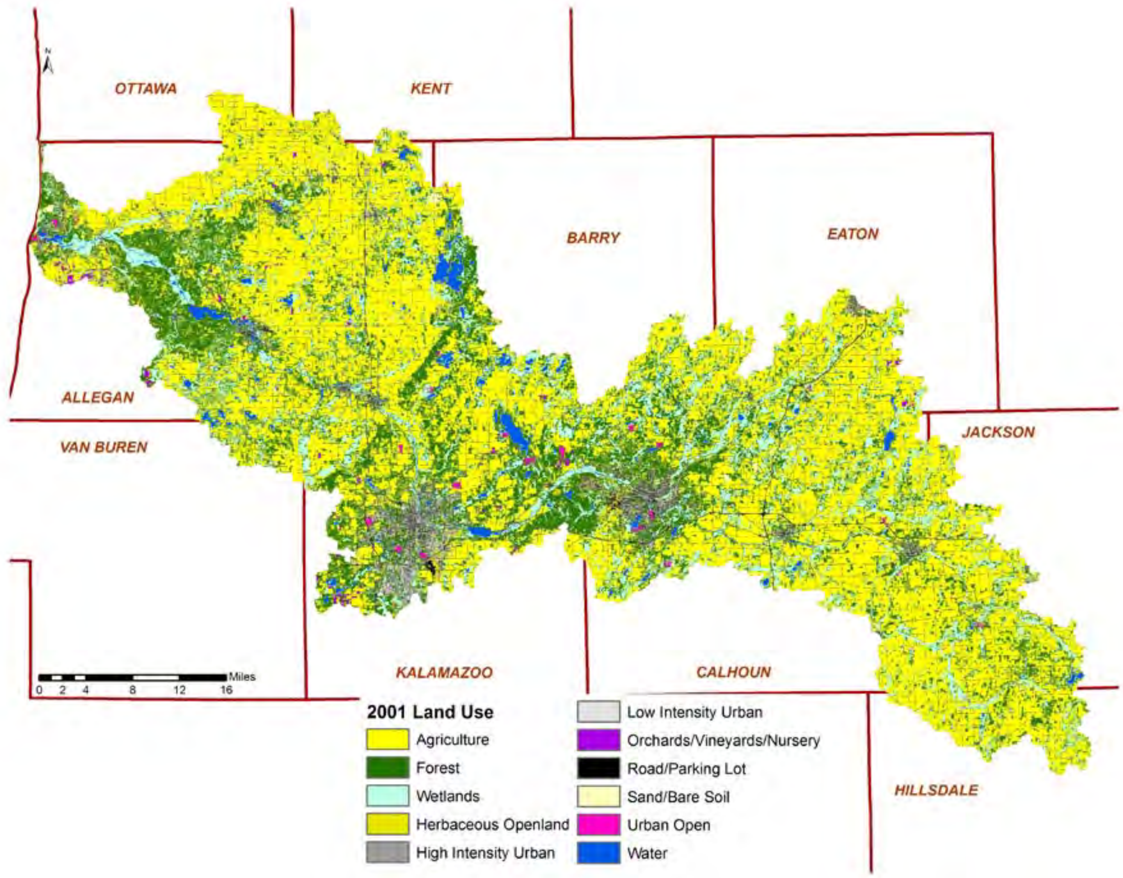


Figure 9. Land use and cover in the Kalamazoo River Watershed in 2001 based on data from the Integrated Forest Monitoring, Assessment, and Prescription (IFMAP) system.

Table 3. Land use breakdown for the entire Kalamazoo River Watershed based on the data in Figure 9.

Land use/land cover category	**Area (acres)**	**% of the watershed area**
Low intensity urban	29,786	2.29
High intensity urban	16,800	1.29
Transportation	49,803	3.82
Farmland	615,517	47.25
Open land/parks	117,511	9.02
Forest	275,574	21.15
Water	24,259	1.86
Forested wetlands	77,431	5.94
Non-forested wetlands	91,920	7.06
Sand/soil/bare	4,204	0.32
Total	1,302,804	100.00

Table 4. Land use breakdown for each major watershed management planning area (see Table 1) in the Kalamazoo River Watershed (percentage of subwatershed area).

Land use/land cover category	Battle Creek River	Rice Creek	Rabbit River	Portage-Arcadia	Mainstem 3 Corridor	Gun River	Greater Battle Creek	Four Townships Watersheds	Davis Creek
Low intensity urban	1.40	0.85	1.72	14.03	7.34	1.24	4.06	1.41	7.56
High intensity urban	1.07	0.32	1.31	5.92	5.04	0.99	2.22	0.43	9.14
Transportation	4.29	3.09	3.15	8.60	7.31	2.76	6.21	2.71	10.15
Farmland	51.60	55.81	61.61	18.08	24.24	47.53	29.14	44.46	38.90
Open land/parks	6.97	7.00	7.33	11.60	11.50	7.60	11.34	8.79	12.54
Forest	16.44	14.84	14.96	33.33	31.41	23.22	28.45	25.12	10.32
Water	1.10	0.42	0.59	1.73	2.67	5.23	1.32	4.82	0.53
Forested wetlands	8.22	7.42	3.85	3.04	5.41	4.39	8.34	4.46	5.84
Non-forested wetlands	8.48	10.19	5.02	3.36	4.53	6.62	8.31	7.70	4.01
Sand/soil/bare	0.43	0.05	0.46	0.31	0.55	0.42	0.60	0.09	1.03
Total	100	100	100	100	100	100	100	100	100

Note: Some WMP areas overlap. The land use breakdown was calculated for each defined WMP area regardless of overlapping areas.

Three areas remain without a WMP (Figure 3). Zones A, B and C are respectively located in the west, center and east of the Kalamazoo River Watershed. Land use and cover in these zones is detailed in Table 5; they are dominated by farmland and forest cover.

Table 5. Land use breakdown for areas without a WMP in the Kalamazoo River Watershed (percentage of subwatershed area) .

Land use/land cover category	Zone A	Zone B	Zone C
Low intensity urban	1.7	0.7	1.0
High intensity urban	1.1	0.3	0.4
Transportation	3.3	2.3	3.1
Farmland	41.3	41.2	59.5
Open land/parks	11.3	8.7	7.7
Forest	24.9	25.7	14.9
Water	2.5	0.7	0.6
Forested wetlands	6.5	7.1	5.7
Non-forested wetlands	6.9	13.2	7.2
Sand/soil/bare	0.5	0.1	0.1

Ninety-six percent of the land in the Kalamazoo River watershed is privately owned. The remaining 55,000 acres are publicly owned. Major public lands include Allegan State Game Area (48,000 acres), Fort Custer Recreation Area (3,000 acres), and about one-fifth of the Yankee Springs Recreation Area (1,000 acres; the remainder lies in the Grand River watershed) (Figure 10; See also Figure 9).

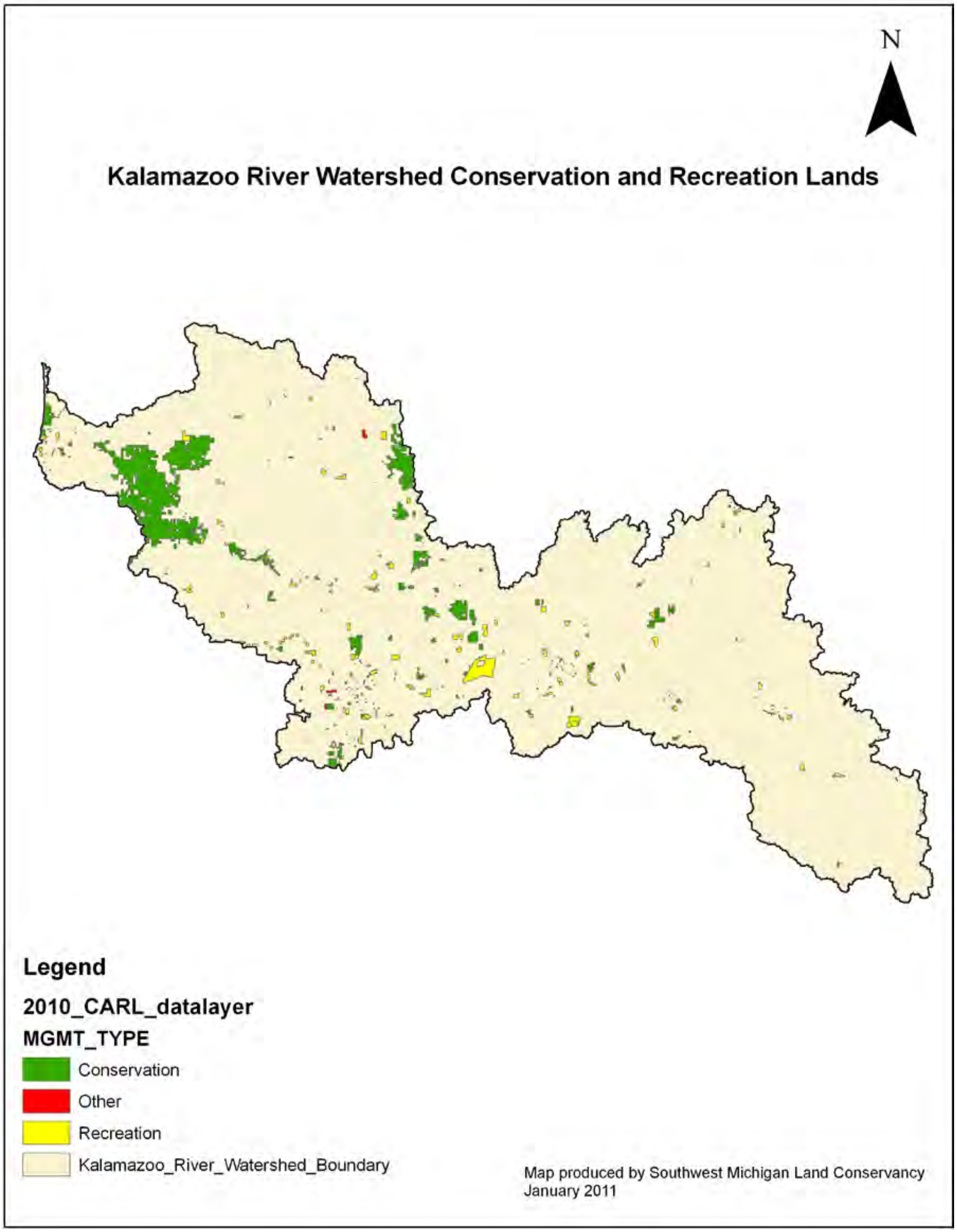


Figure 10. Conservation and recreation lands in the Kalamazoo River Watershed.

Most of the areas mapped in Figure 10 represent especially large tracts of contiguous unmanaged forests and fields with substantial wildlife and recreational values. Figure 10 includes smaller conserved land holdings and arrangements as well as compiled by the Southwest Michigan Land Conservancy, 2011. Land ownership along the mainstem of the lower Kalamazoo River is approximately half public (particularly the Allegan State Game Area and Fort Custer State Recreation Area) and half private.

The watershed was originally covered with deciduous forest, interspersed with smaller areas of oak openings, prairie, and savanna. Most of the watershed was converted to agriculture during European settlement in the mid 1800s (Chapman and Brewer 2008). In recent decades row crop agriculture has been practiced on the more productive soils, while secondary forest has developed on much of the relatively marginal land that proved to be too sloping, excessively well drained (i.e., sandy), or poorly drained, and was therefore abandoned from agriculture during the 1900s.

2.4. The Kalamazoo River Mainstem

The following description of the main stem of the Kalamazoo River is distilled from Wesley (2005), where more detail including information on fisheries resources can be found.

The Kalamazoo River has a low to moderate stream gradient, dropping 540 feet in elevation from its headwaters on the South Branch (1,120 ft. above sea level) to Lake Michigan (580 ft. above sea level). Elevation at the headwaters of the North Branch is 1,042 ft. above sea level. The average drop in elevation over the 166 miles of main stem and South Branch is just over 3 feet per mile.

The North and South branches of the Kalamazoo River originate within a few miles of each other: the North Branch originating in Farewell and Pine Hills lakes in southern Jackson County and the South Branch rising in marshy areas south of Moscow in northeastern Hillsdale County. The two branches join at Albion, forming the main stem which flows northwesterly for approximately 123 miles before entering Lake Michigan near Saugatuck. Along the way, the river flows through several municipalities: Marshall, Battle Creek, Augusta, Galesburg, Comstock, Kalamazoo, Parchment, Plainwell, Otsego, Allegan, and Saugatuck, among which Battle Creek and Kalamazoo are the largest.

More than half the length of the mainstem between Albion and Ceresco (east of Marshall) is impounded by dams or heavily developed in the cities of Albion and Marshall. The mainstem of the Kalamazoo River from Ceresco to the southwestern edge of Battle Creek flows through scenic natural areas and includes several islands. The river is about 80-100 feet wide and averages 1-2 feet deep. Through Battle Creek and adjacent suburbs, the river is almost entirely within developed areas and has been diverted into a concrete channel in downtown Battle Creek to reduce flood hazard. Recent discussions with the City of Battle Creek and other parties have contemplated removal or naturalization of that concrete channel.

From Augusta to Galesburg there is little development, except in the villages. The Fort Custer State Recreation Area includes a natural reach of river and floodplain below Augusta, and there is also a tract owned by The Nature Conservancy. The river is wide and deep, averaging 110 feet wide and four feet deep. Between Galesburg and Comstock, the river flows into Morrow Lake, formed by an impoundment (Kilowatt Dam) now fitted with a privately owned hydroelectric dam. From this point, the river flows through more urbanized areas of Comstock and Kalamazoo. From Kalamazoo, the river flows north through natural and agricultural areas to Plainwell.

The river gradient increases to 2.6 feet per mile between Plainwell and Allegan. However the steepest drops are sites of old hydroelectric dams whose remnants remain today. The most upriver dam (Plainwell Dam) was breached in 2008, restoring relatively high-gradient riffle habitat. Three other dam sills remain in place above the city of Allegan (i.e., Trowbridge, Otsego Township, and Otsego City), where another old dam has been maintained and forms the pool along the downtown area.

From Allegan the river flows into Lake Allegan, created by the Calkins Bridge hydroelectric dam (managed by Consumers Energy and recently relicensed by the Federal Energy Regulatory Commission). Below this dam it flows through the most natural section of the river, within the Allegan State Game Area. A major tributary, the Rabbit River, enters the Kalamazoo at New Richmond.

Near the mouth of the Kalamazoo River there are extensive marshlands and an open harbor in the vicinity of Saugatuck and Douglas denoted as Lake Kalamazoo on some maps. Like many rivers entering the eastern side of Lake Michigan, the Kalamazoo River flows through a backflooded zone in its lowermost reach that reflects earlier downcutting of the river channel during a time of lower lake levels. This lake-like water body has been deepened somewhat by historical dredging to facilitate boat access, but constant sediment deposition tends to fill in the dredged areas. Local residents and businesses are advocating new dredging at the upstream end of the “harbor” there. The Kalamazoo River enters Lake Michigan through a dredged channel that passes the beach and adjacent sand dunes between sheet-pile training walls.

2.5. Dams and Reservoirs

There are 110 dams in the Kalamazoo River basin registered under MDEQ with 15 on the Kalamazoo River mainstem (See tables in Wesley, 2005). Some dams are classified by MDEQ Dam Safety Section according to their purpose: 4 for hydroelectric power generation, 11 retired hydroelectric dams, 60 for recreation (including lake-level control structures), 4 flood-control dams, 2 for water supply, and 30 for other reasons (private ponds, county park ponds, hatchery ponds, etc.). It is not known how many small unregistered dams exist in the basin. The Kalamazoo River dams are essentially “run-of-river” dams that do not change much in stored water volume over the seasons.

The first dams were built across small creeks at high gradient locations to power grain and saw mills. Construction of mill dams began in the 1830s and continued until 1900. From 1890 to 1940, several large dams were constructed to generate electricity. All of the larger and now retired hydroelectric dams were built between 1856 and 1906. These dams were originally made to power grain, saw, and paper mills and were later converted to generate electrical power. Because of their age and inefficiencies, these dams are no longer being used for power generation. The last phase of dam building was between 1945 and 1980; these dams were built to control lake levels for recreation and waterfront development. The dam that forms Morrow Lake near Comstock (Kilowatt Dam) is an exception and was originally constructed to create a reservoir to provide cooling water for a coal burning power plant. It was later retrofitted to produce a modest level of electric power.

Dams 6 feet or more in height and/or with impounding capacity at design flood elevation of 5 surface acres or more are regulated under Michigan's Dam Safety, Part 315 of the Natural Resources and Environmental Protection Act, 1994 P.A. 451 as amended; or the Federal Energy Regulatory Commission (FERC) Regulation 18 of Part 12 of the Code of Federal Regulations.

Dams have many detrimental affects on aquatic communities in rivers. They impede fish movements, fragmenting fish populations and blocking spawning migrations. Dams interrupt river systems and typically were built at high quality river habitat, turning it into lentic, or ponded, habitat. Some fishes and aquatic insects migrate up or downstream to reach different feeding and temperature habitats throughout the year. Mortality or injury can result while passing through dams, especially those with hydroelectric turbines. Entrainment often causes mortality or injury as a result of fish being struck by turbine blades, pressure changes, sheer forces in turbulent flows, and water velocity accelerations.

Impoundments that discharge water from the surface typically increase downstream water temperatures by spilling warm surface waters. This is especially critical in the warm summer months. Increased water temperatures can lead to elimination of certain aquatic species including fish. Evaporation rates increase with the higher temperatures and much greater impoundment surface area. Dissolved oxygen levels in impoundments are often lower than those in moving streams during warmer seasons, and this change can alter fish populations in impounded portions of a river system. However, in impoundments with longer water residence times (> one week), prolific growth of phytoplanktonic algae can result in elevated oxygen concentrations compared to the river (Reid and Hamilton 2007).

Impoundments also act as sediment and debris traps, and often contain historical accumulations of contaminated sediments. By far most of the PCBs within the Kalamazoo River system reside in sediment accumulations behind artificial impoundments, with the largest proportion in Lake Allegan.

Sediment-free water released below the dam has high erosive power causing increased scour and bank erosion. Woody debris is caught in impoundments and eventually sinks, depriving downstream segments of important fish habitat. Sediment and biotic materials in impoundments change the nutrient dynamics of flowing river systems. Water that slows down in reservoirs has time to grow algae that can reach undesirably high abundance (Reid and Hamilton 2007). Historical loading of phosphorus to reservoirs can result in the release of phosphorus from the sediment up into the water column in a process known as internal loading (Baas 2009).

3. Community Profile

3.1. Synopsis of Regional History

Since 1975 Western Michigan University anthropologists have conducted field studies at many sites along the length of the Kalamazoo River to learn more about prehistoric human habitation. More than 400 separate sites were identified in Allegan County alone. Results of those studies show that humans have used the Kalamazoo River basin continuously for more than 11,000 years. Few permanent settlements, however, have been found along the river. Studies and historic written records indicate the area was used seasonally for hunting, fishing, and maple sugaring. It is thought that the basin did not have the kinds of soils necessary to encourage permanent settlements. However, from about 700 years ago, there was some farming by Native Americans.

Probably the earliest Europeans to glimpse the Kalamazoo River were Jesuit Priest Father Jacques Marquette and two companions as they were returning from visiting Indians in Illinois in 1675. Although other missionaries may subsequently have passed the mouth of the River, it wasn't until the late 1700s that the area was frequented by fur traders. By the early 1800s, there were several small communities along the River, including Kalamazoo. Farmers soon replaced fur traders and quickly populated much of the watershed. Many shipped their goods down the river on flat boats to Singapore, established at the mouth of the river in the 1830s. This "bustling port" was later buried by the shifting sand dunes and abandoned in the 1870s. With the introduction of the railroad in the 1840s, the importance of the river for transportation declined.

By the mid-1800s, several communities had grown up along the river as mill towns and commercial centers: Battle Creek, Kalamazoo, Parchment, Plainwell, Otsego, and Allegan. After the Civil War and into the 20th century, various industries, from cereal production to pharmaceuticals to automobile parts, flourished. Several communities became sites for paper production, locating plants along the river for water intake and waste discharge. De-inking practices (no longer in use) led to PCB contamination of the river. Sewage effluent, other industrial discharges, and trash also contributed to the pollution of the river. From the 1940s to the 1960s, the river was considered an "eyesore" and most people did their best to avoid it.

Beginning in the 1970s with the federal Clean Water Act, serious efforts were made to clean up the river. Although today the river is far cleaner, the persistent PCB contamination has led to Superfund designation of an 80-mile section from Kalamazoo to Saugatuck as well as a 3-mile section of Portage Creek, and the lower river has especially stringent advisories for fish consumption. More details on the PCB contamination and efforts to address it are provided in Section 5 of this Plan.

A massive oil spill was discovered in late July 2010, the result of a pipeline rupture in a small tributary of the Kalamazoo River known as Talmadge Creek, southwest of the City of Marshall. The pipeline is managed by Enbridge Energy Partners LLC. Up to a million gallons of tar-sands crude oil escaped, much of it entering the Kalamazoo River below Marshall, contaminating a 30-mile reach that was in excellent ecological condition. The magnitude of this oil spill makes it possibly the largest ever experienced in the Midwestern U.S.

The river level was unusually high at the time, resulting in the spread of oil onto river banks and into expansive floodplain wetlands. The most heavily oiled river banks and floodplains were upriver of Battle Creek, but oil also contaminated the river downstream to the upper end of Morrow Lake. The emergency response, coordinated mainly by Enbridge and EPA, successfully contained the oil above the remaining 80 miles of river (and Lake Michigan). The first response was to contain the oil as it moved downstream. Around 3,000 animals, mostly turtles but also geese and other water birds and some mammals and snakes, were collected, cleaned and released or maintained in captivity over the winter. Surprisingly, there were no significant fish kills.

Over the 3 months following the spill, hundreds of boats and thousands of workers deployed booms and removed oil-contaminated sediment and vegetation over the 30 miles of river and floodplain. The Talmadge Creek corridor was almost completely excavated, with clean fill returned to more or less re-create the original wetland surface and stream channel. Specific locations along the entire impact zone with the heaviest oil contamination have been excavated; mostly these have been low-lying islands but a few low spots on the floodplains also required excavation. In certain areas such as behind dams and in off-channel oxbows and coves, oil was found to rise to the surface when the sediment was disturbed, indicating that significant oil was in the sediment. Those areas were either aerated to float the oil and collect it (most places), or dredged (Ceresco Dam reservoir upstream of Battle Creek). Enbridge states that more than 90% of the oil in the river has been recovered, mostly by using booms and vacuum suction, although this remains to be verified.

The longer-term remediation and restoration of the oil-affected reaches is expected to take several years. Shoreline stabilization has been implemented, and planting of native species of plants will commence during 2011. Currently, the MDEQ is negotiating the remediation and restoration plan with Enbridge. Meanwhile, as of December 2010 there were still some emergency cleanup actions taking place. Unknown at this time are the chronic impacts of the oil spill, either from the short-term exposure of long-lived wildlife or from residual petroleum or heavy-metal contamination in the river and its floodplain. There is no doubt that the cleanup activities had substantial environmental impact in and of themselves, including the removal of vegetation and the destabilization of river banks and sediment deposits, and these impacts may persist for some time.

The Kalamazoo River Watershed Council was named as one of the “Assisting Agencies” under the “Unified Command” led by the EPA and Enbridge to respond to the spill, and as such we were represented at all public meetings and at stakeholder and agency briefings. We have closely tracked the spill response and contributed numerous technical suggestions based on the experience of our Board and our familiarity with the river and floodplain ecosystems. We have also been involved in outreach activities, including public talks and presentations to schools and community groups.

3.2. Governmental and Political Structure

The watershed is located in portions of 10 counties, 19 cities, 11 villages and 107 townships. This diversity of governmental jurisdictions presents a challenge for integrated water management (Table 6).

Table 6. Political boundaries within the Kalamazoo River Watershed.

POLITICAL BOUNDARY TYPE	**NAME**	Is entire jurisdiction in KZ watershed?	If not, area of watershed within the jurisdiction boundaries (acres)
COUNTIES	Allegan	N	399,699.16
	Barry	N	115,655.08
	Calhoun	N	311,010.29
	Eaton	N	83,145.81
	Hillsdale	N	46,741.43
	Jackson	N	100,224.41
	Kalamazoo	N	202,845.82
	Kent	N	8,689.11
	Ottawa	N	14,681.60
	Van Buren	N	20,224.66
TOWNSHIPS	*OTTAWA COUNTY*		
	Jamestown Twp	N	12584.23138
	Park Twp	N	too small
	Zeeland Twp	N	1797.74734
	ALLEGAN COUNTY		
	Leighton Twp	N	19,026.16
	Fillmore Twp	N	2,097.37
	Overisel Twp	N	11,086.11
	Dorr Twp	N	21,872.59
	Salem Twp	Y*	22,771.47
	Laketown Twp	N	4,943.81
	Wayland	Y	
	Wayland Twp	Y	
	Manlius Twp	Y*	23,820.15
	Heath Twp	Y	
	Hopkins Twp	Y	
	Monterey Twp	Y	
	Saugatuck	Y	
	Village of Douglas	Y	
	Saugatuck Twp	N	13,932.54
	Fennville	Y	

POLITICAL BOUNDARY TYPE	NAME	Is entire jurisdiction in KZ watershed?	If not, area of watershed within the jurisdiction boundaries (acres)
	Martin Twp	Y	
	Watson Twp	Y	
	Allegan Twp	Y	
	Allegan	Y	
	Clyde Twp	N	4,644.18
	Valley Twp	N	21,123.53
	Ganges Twp	N	149.81
	Gunplain Twp	Y	
	Otsego Twp	Y	
	Otsego	Y	
	Trowbridge Twp	Y	
	Lee Twp	N	24,719.03
	Cheshire Twp	N	17,677.85
	Plainwell	Y	
	BARRY COUNTY		
	Thornapple Twp	N	3,595.49
	Yankee Springs Twp	N	11,685.36
	Maple Grove Twp	N	5,842.68
	Hope Twp	N	149.81
	Orangeville Twp	N	16,629.16
	Assyria Twp	Y*	22,921.28
	Johnstown Twp	N	10,037.42
	Barry Twp	N	20,973.72
	Prairieville Twp	Y	
	CALHOUN COUNTY		
	Clarence Twp	N	20,524.28
	Lee Twp	Y	
	Convis Twp	Y	
	Pennfield Twp	Y	
	Bedford Twp	Y	
	Battle Creek	Y	
	Marengo Twp	Y	
	Springfield	Y	
	Emmett Twp	Y	
	Marshall	Y	
	Albion	Y	
	Sheridan Twp	Y	
	Marshall Twp	Y	
	Albion Twp	Y*	21,273.34
	Eckford Twp	N	15,131.04
	Fredonia Twp	N	7,640.43
	Newton Twp	N	4,943.81
	Leroy Twp	N	12,134.79
	Homer Twp	N	19,026.16

POLITICAL BOUNDARY TYPE	**NAME**	Is entire jurisdiction in KZ watershed?	If not, area of watershed within the jurisdiction boundaries (acres)
	EATON COUNTY		
	Carmel Twp	N	10,187.23
	Kalamo Twp	N	3,146.06
	Eaton Twp	N	7,940.05
	Charlotte	N	1,947.56
	Hamlin Twp	N	too small
	Brookfield Twp	N	17,977.47
	Walton Twp	Y	
	Bellevue Twp	N	20,374.47
	Olivet	Y	
	HILLSDALE COUNTY		
	Somerset Twp	N	2,097.37
	Moscow Twp	N	19,925.03
	Scipio Twp	N	17,078.60
	Litchfield Twp	N	5,393.24
	Litchfield	N	299.62
	Wheatland Twp	N	299.62
	Adams Twp	N	2,097.37
	Fayette Twp	N	1,048.69
	JACKSON COUNTY		
	Springport Twp	N	5,692.87
	Sandstone Twp	N	too small
	Parma Twp	N	15,880.10
	Spring Arbor Twp	N	7,490.61
	Concord Twp	Y	
	Liberty Twp	N	1,348.31
	Hanover Twp	N	22,621.65
	Pulaski Twp	Y	
	KALAMAZOO COUNTY		
	Richland Twp	Y	23,670.34
	Cooper Twp	Y	23,370.72
	Ross Twp	Y	25,018.65
	Alamo Twp	Y*	22,172.22
	Charleston Twp	N	17,827.66
	Comstock Twp	N	22,471.84
	Kalamazoo Twp	Y	6,891.36
	Kalamazoo	Y	16,928.79
	Parchment	Y	599.25
	Oshtemo Twp	N	13,932.54
	Galesburg	Y	1,048.69
	Climax Twp	N	299.62
	Pavilion Twp	N	3,745.31
	Portage	N	11,984.98
	Texas Twp	N	12,434.42

POLITICAL BOUNDARY TYPE	NAME	Is entire jurisdiction in KZ watershed?	If not, area of watershed within the jurisdiction boundaries (acres)
	KENT COUNTY		
	Byron Twp	N	5,992.49
	Gaines Twp	N	1,647.94
	VAN BUREN COUNTY		
	Pine Grove Twp	N	16,479.35
	Bloomingdale Twp	N	2,996.25
	Gobles	N	149.81
VILLAGES	Hopkins	Y	
	Martin	Y	
	Homer	N	149.81
	Bellevue	Y	
	North Adams	N	299.62
	Springport	Y	
	Parma	N	149.81
	Concord	Y	
	Hanover	Y	
	Richland	Y	
	Augusta	Y	
CITIES	Wayland	Y	
	Saugatuck	Y	
	Village of Douglas	Y	
	Fennville	Y	
	Allegan	Y	
	Otsego	Y	
	Plainwell	Y	
	Battle Creek	Y	
	Springfield	Y	
	Marshall	Y	
	Albion	Y	
	Charlotte	N	1,947.56
	Olivet	Y	
	Litchfield	N	299.62
	Kalamazoo	Y	
	Parchment	Y	
	Galesburg	Y	
	Portage	N	11,984.98
	Gobles	N	149.81

Note: Y* a very small area is not in the watershed

The political geography of the Kalamazoo River watershed is also complex. All or part of three U.S. Congressional districts (Figure 11), several State Senate districts (Figure 12), and several State Representative districts (Figure 13) are included in the watershed.

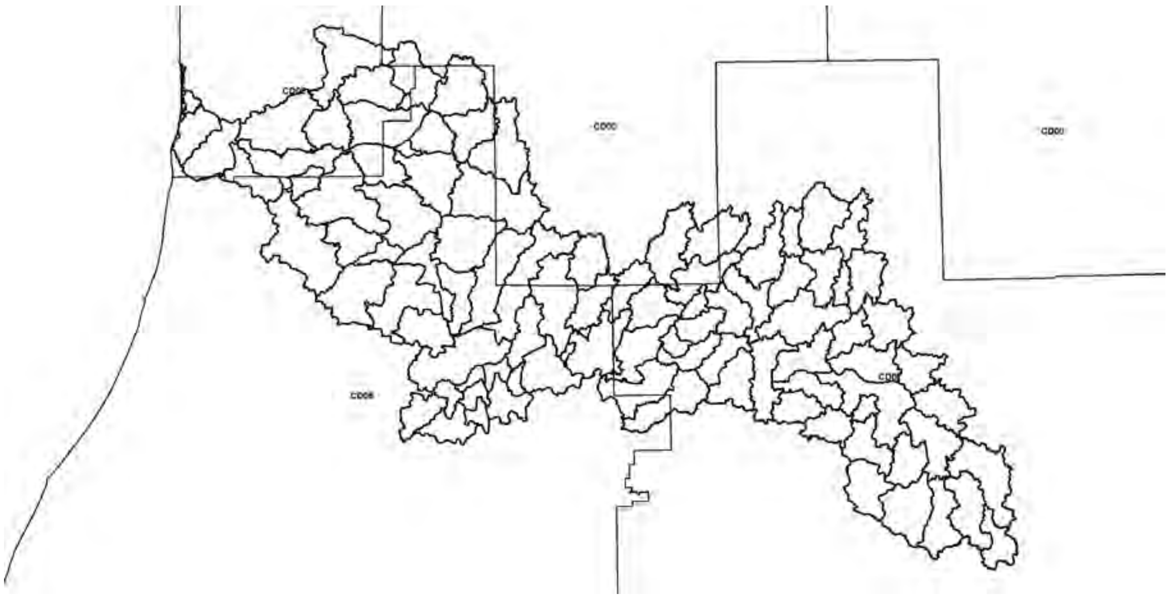


Figure 11. Congressional districts.

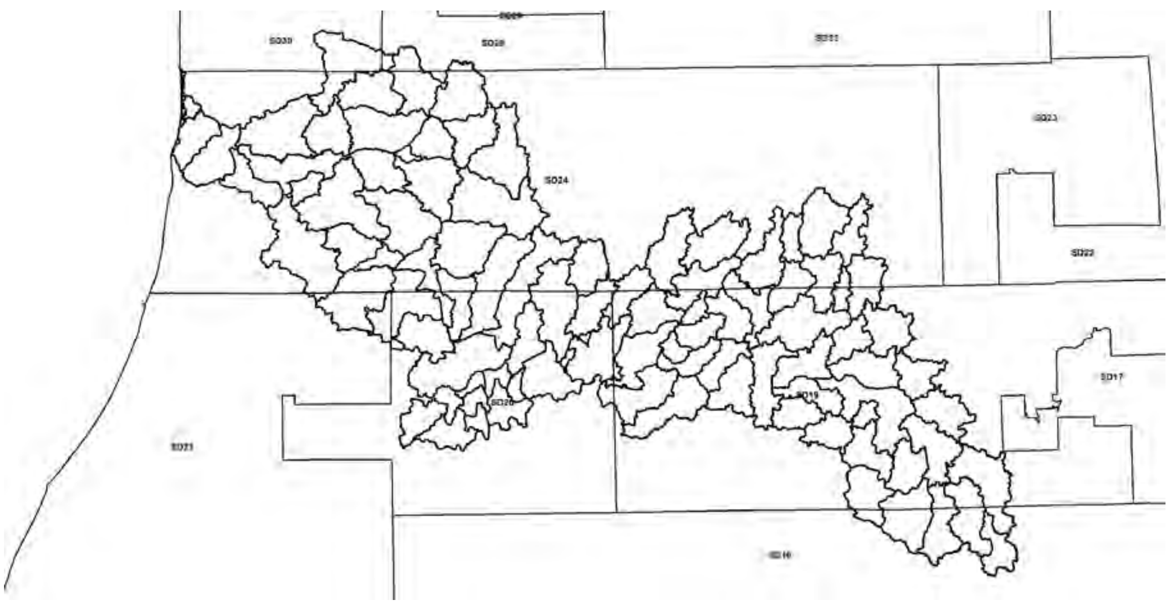


Figure 12. State Senate districts.

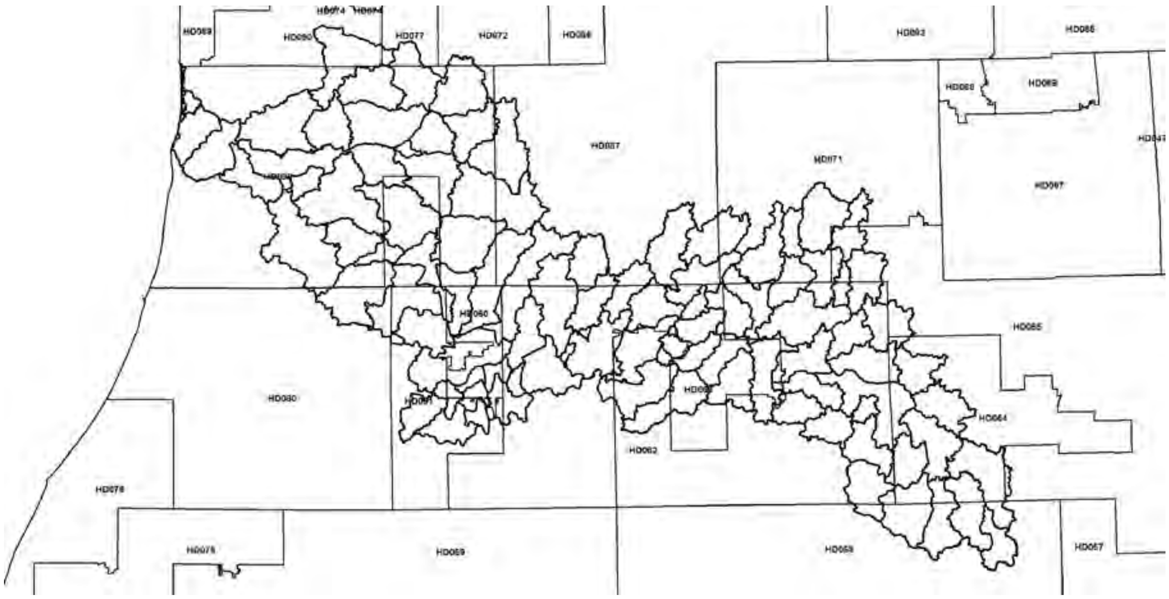


Figure 13. State House districts.

There are 18 circuit court judges, 20 district court judges, and nine probate court judges serving the area. Because parts of ten counties are in the watershed, there are 10 prosecuting attorneys, sheriffs, county clerks, registers of deeds, and treasurers serving the watershed. Each county, city, village, and township also has elected officials, as well as several regulatory and advisory agencies and boards, such as the drain commissioner, health department, planning divisions, and zoning commissions.

3.3. Urban and suburban centers and industrial activity

While land use is predominantly rural and agricultural, the largest urban areas are located along the river corridor and thereby have a disproportionate impact on water quality. However this also means that the river provides a natural resource in close proximity to people who can enjoy it, offering not only recreation and education but the potential for waterfront redevelopment and enhancements such as trailways.

There is a mix of light and heavy industry in the watershed with large and small firms providing diverse products and services, including pharmaceuticals (Pfizer and Perrigo being particularly notable), cereal and other food products, printing and packaging, automobile and aircraft parts, and office furniture. Most are centered in larger population areas, although some are located in small cities and villages. Major commercial areas (retail shopping centers, restaurants, and other consumer services) are centered in the three largest cities: Battle Creek, Kalamazoo, and Portage.

Heavy industrial activity has declined in the last two decades, including the closure of most of the paper plants along the river. This in turn has significantly reduced point-source inputs of wastewater to the river, but also has left local communities to struggle with a diminished local tax base and abandoned industrial properties and legacy pollutants along or near their riverfronts.

3.4. Agriculture

Row-crop production predominates in the watershed. Major grain crops include corn, soybeans, wheat, and oats. Considerable land is also used for pasture and growing alfalfa. Major fruit crops include apples, peaches, pears, blueberries, and strawberries, located mainly in the western part of the watershed. Specialty crops/products include maple syrup, honey, wines and fruit juices, bedding plants, nursery stock, and Christmas trees. Dairy and beef cattle, sheep, and pigs are also raised in the watershed. Poultry farms produce chickens, turkeys, and eggs. Animal agriculture is increasingly concentrated in large-scale operations.

3.5. Demographics, Future Growth and Development

Approximately 400,000 people live in the watershed, with most concentrated in the metropolitan areas of Kalamazoo and Battle Creek. Other population centers (year 2000 census figures in parentheses), in addition to Kalamazoo (72,161) and Battle Creek (52,777), include Portage (45,236), Albion (9,144), Marshall (7,459), Plainwell (9,933), Otsego (3,933), and Allegan (4,838). There are both urban and rural minority populations, including African Americans and Hispanics. Native American communities are located in Allegan and Calhoun Counties.

The watershed encompasses all or part of 31 public school districts, all or part of four community college districts (Jackson, Kellogg, Kalamazoo, and Grand Rapids), one public university (Western Michigan University), and four private colleges (Albion, Kalamazoo, Miller, and Davenport).

The watershed has abundant natural and water resources that attract businesses, residents and recreationists. Drastic economic contraction has occurred across the State of Michigan entailing significant manufacturing job losses. However, over the next few decades, the watershed is expected to see population growth and continued land use change, especially from expanding urban areas. By comparing the rate of land consumption to population growth, the Michigan Land Resource Project found that from 1980 to 1995, land was consumed at a rate eight times the rate of population increase in Michigan (MLULC, 2003). A significant economic shift has been underway toward a service economy, though opportunities to transition to a low carbon/new energy economy are poised to lead to manufacturing expansion in the alternative energy and advanced transportation sectors. Still, the region's strongest sectors in general have been agriculture and tourism, both of which ultimately rely heavily on the maintenance of sustainable soils, water, and other natural resources.

The KRWMP planning process involved modeling future growth in the watershed and relating that growth and land use change to future runoff conditions. See Attachment 3 and later sections of the Plan for more information and implications.

3.6. Outdoor Recreation

The Kalamazoo River watershed offers excellent opportunities for outdoor recreation that draw visitors from outside the watershed, particularly from neighboring states including the Chicago area. Yet the full potential value of outdoor tourism has yet to be tapped.

Campsites, ranging from rustic tent sites to modern trailer/recreation vehicle sites, are found in private and public campgrounds. Private recreational facilities provide a variety of services, including golf courses, archery ranges, horseback riding, boat and canoe rentals, marinas, Great Lakes charter boat services, fishing ponds, skiing, snowmobiling, and sledding. Several parks and launch sites allow direct access to the Kalamazoo River and its larger reservoirs.

Two state parks and a major state game area are located in the watershed. Fort Custer State Recreation Area, a 2,960 acre state park, is located on the Kalamazoo River between Kalamazoo and Battle Creek. Yankee Springs State Recreation Area, a 5,000 acre state park (of which about 1,000 acres are in the watershed in the Gun River sub-watershed), is located northeast of Plainwell. The Allegan State Game Area, with 48,000 acres, is the largest state-owned area in the watershed and is traversed by the lower Kalamazoo River. Other state-owned recreational properties in the watershed include a portion of the Kal-Haven Trail Sesquicentennial State Park and several game areas. Fort Custer, Yankee Springs, and Allegan provide day-use and overnight facilities.

There are several major city and county parks. Major parks include Markin Glen, River Oaks, Coldbrook, Milham, Verberg, and Kindleberger parks in Kalamazoo County and Littlejohn Lake, Dumont Lake, and Oval Beach in Allegan County. City/village parks and river walks providing access to the riverfront are found in Albion, Marshall, Battle Creek, Kalamazoo, Parchment, Plainwell, Otsego, Allegan, and Saugatuck.

Michigan Department of Natural Resources (MDNR) access sites on the river are located at Morrow Lake in Kalamazoo County and at Lake Allegan, Allegan Dam, Palmer Bayou, Ottawa Marsh, New Richmond, Indian Point, and Lake Kalamazoo in Allegan County. Also, there are numerous MDNR boat access sites at lakes in the watershed.

In addition to the state parks and game areas described above, several other nature areas/preserves are found in the watershed. Sites with major visitor facilities include the W.K. Kellogg Biological Station (Michigan State University), the Kalamazoo Nature Center, and Binder Park Zoo in Battle Creek.

Multi-use, non-motorized trailway mileage is increasing rapidly in several watershed areas with the expansion of trails like the Kalamazoo River Valley Trail. Often, land trails parallel river valley corridors, sometimes at the site of old rail lines, providing numerous opportunities for land and water intersections. Volunteers in the Kalamazoo River watershed are gradually implementing a Michigan Heritage Water Trail on the mainstem of the Kalamazoo River from Calhoun County to the Lake Michigan shore, with coordination by the KRWC. Volunteers expect that additional trail signage and mapping will follow in select tributary corridors.

Mainstem Kalamazoo River fishing continues to improve, particularly for smallmouth bass. Numerous headwater tributaries support trout and are some of Michigan's southernmost trout streams owing to the high degree of groundwater input that maintains cooler water temperatures in the summer.

4. Natural Features and their Protection

Relatively natural forest, wetlands, and grasslands abound in the Kalamazoo River watershed because of its overall rural nature, the abundance of isolated wetlands that could not be drained for agriculture, and the widespread abandonment of agricultural activity on more marginal lands that were too sloped, erosion prone, or sandy. In addition, the broad floodplains of the Kalamazoo River valley have returned to a more natural state in many reaches. These natural features, together with land that is still in agriculture, provide important ecosystem services that are often underappreciated, including recreational opportunities, maintenance of groundwater recharge, clean water, wildlife habitat, and biodiversity.

This chapter is not meant to be a comprehensive inventory of natural features in the watershed but rather a broad overview with emphasis on features of importance for watershed management and protection such as large land holdings important for the maintenance of biodiversity.

We are fortunate to have a wide array of protected areas in and near the Kalamazoo River watershed. Cumulatively, 71,205 acres in the watershed are categorized as conservation and recreation lands, of which 56,047 are protected conservation lands according to the 2010 CARL and National Conservation Easement databases maintained by Ducks Unlimited. These areas can be organized into two categories: State of Michigan conservation lands, such as, state game areas and state parks; and land that is protected by county and local governments and conservation organizations such as land trusts. Substantial State of Michigan owned land includes but is not limited to the Allegan State Game Area, Fort Custer State Recreation Area, Yankee Springs State Recreation Area, and the Barry State Game Area. The Fort Custer Training Center is a large area of largely forested military land adjacent to the Fort Custer State Recreation Area http://www.dnr.state.mi.us/parksandtrails/Details.aspx?id=448&type=SPRK and it is increasingly managed to protect and enhance natural features as well as for its training mission.

Areas under protection by municipalities and conservation organizations such as the Michigan Nature Association and the Southwest Michigan Land Conservancy account for 11,807 acres in the watershed. In many cases, these areas contain natural features of particular functional and hydrological importance to the Kalamazoo River. The Southwest Michigan Land Conservancy (SWMLC) serves the nine county region of southwest Michigan by acquiring and protecting natural areas and open space through gifts, purchases of land, and through conservation easements; providing programs and sites for outdoor recreation, nature study and the appreciation of history; and assisting individuals and organizations who want to protect ecologically significant land. The Michigan Nature Association also conserves land and manages several preserves in the watershed.

SWMLC and regional partners have created strategic conservation plans for several subwatersheds within the Kalamazoo River Watershed. These plans identify critical resource areas for protection that provide water quality and quantity benefits. In the Four Townships Water Resource Council (FTWRC) project area, SWMLC has worked with the FTWRC to protect Potential Conservation Areas (PCA's) identified through a 2005 Natural Resource Inventory. This plan identifies 20 PCA's in Four Townships Watershed Area. In 2010, the KRWC, SWMLC and the Four Townships Water Resources Council completed a three year land protection project in the Prairieville Creek PCA, to protect lands along a headwater stream of Gull Lake in Barry County.

In 2009 SWMLC initiated a collaborative Strategic Conservation Plan with the MDNR, Barry Conservation District, Michigan Audubon, Pierce Cedar Creek, MSU Extension, Barry County Planning and Land Information Services Department and Potawatomi RC&D to conserve wildlife habitat and water resources within and adjacent to the 22,000 acre Barry State Game Area and Yankee Springs Recreation Area. This state resource area is located within the Thornapple River and Gun River watersheds, with conservation plan priorities of protecting additional land adjacent to the Fish Lake section of the SGA which flows into the Gun River and land around Gun Lake.

In addition to significant riparian forest and lotic wetlands along the Kalamazoo River mainstem, conservation organizations have prioritized several critical natural areas throughout the Kalamazoo River Watershed. Management plans and/or natural features inventories have been created for a few of these priority areas including: Rice Creek (Calhoun County)- conserved land expansion; Crooked Creek (Calhoun), Cotton Lake (Calhoun)- conserved land expansion; and West Fork of Portage Creek (Kalamazoo) to protect additional open space to protect the wellhead protection area of the City of Kalamazoo wellfields and significant groundwater recharge on adjacent upland areas.

However, most of these areas have not been extensively surveyed and would benefit from strategic conservation planning, natural features inventories and/or wetland functionality assessments: Silver Creek in Prairieville Township (Barry)- significant wetlands, conserved land expansion; Ackley Creek/Big Marsh Lake (Calhoun) - highly diverse natural areas, headwater wetlands; Augusta Creek (Kalamazoo and Barry); Silver Creek in Gun Plain Township, Allegan County- significant groundwater recharge, natural areas; Comstock Creek (Kalamazoo)- conserved land expansion; Baseline Creek (Allegan and Van Buren)- conserved land expansion, headwater wetlands; Silver Creek in the City of Kalamazoo- conserved land expansion; Spring Creek (Kalamazoo)- conserved land expansion; Harper Creek (Calhoun)- conserved land expansion; Minges Creek (Calhoun)- restore degraded intact natural area along creek; South Branch of the Kalamazoo River near Albion; Waubascon Creek and Lake (Calhoun)- conserved land expansion.

These areas present significant opportunities to expand existing conserved lands and protect additional biologically and ecologically diverse resource areas that protect water quality and water quantity. The long-term sustainability of the river will be dependent upon the quality of its contributing waters. Protecting critical areas where the opportunity exists is a proactive strategy to fulfill the objectives of this watershed management plan, including non-point source pollution reduction. As has been demonstrated with other water management plans, the process of prioritizing natural land for conservation is a valuable first step to focusing efforts in the areas that have the greatest impact to water quality and quantity in the watershed.

The lower Kalamazoo River (below Lake Allegan) was designated a Michigan Natural River in 1981, and a management plan was prepared by the Department of Natural Resources in 1981 and revised in 2002 (http://www.michigan.gov/dnr/0,1607,7-153-30301_31431_31442-95805--,00.html). The designation also includes the lower 17 miles of the Rabbit River and several miles of lesser tributaries.

4.1. Terrestrial Ecosystems

There are four broad classes of terrestrial vegetation communities in the watershed. While each is a distinct plant community, there are many transitional zones (ecotones) that exist between these communities. Some of the dominant species are found in many different communities and may be prevalent in more than one area.

- Dry Southern Hardwood Forest - Forests of dry upland sites with burr oak, black oak, or white ash dominating
- Moist Southern Hardwood Forest - Forests that occur in richer and moister soils and are dominated by beech and sugar maple
- Wet Lowland Forest - Forests characterized by willow or cottonwood, or bottomland floodplain forest including sycamore, silver maple and ash
- Grassland-Savanna Complex - Includes the combination of prairies, sedge meadows and savannas, characterized as treeless or with scattered trees and dominated by grasses or sedges either wet or dry (Chapman and Brewer 2009).

In the Michigan Natural Features Inventory (March 1994) for Allegan and Kalamazoo counties, several distinctive plant communities of particular conservation interest are listed:

Allegan County - Dry Sand Prairie, Dry-Mesic Northern Forest, Dry-Mesic Southern Forest, Great Lakes Marsh, Interdunal Wetland, Lakeplain Wet-Mesic Prairie, Mesic Southern Forest, Oak Barrens, Open Dunes, Prairie Fen

Kalamazoo County - Coastal Plain Marsh, Mesic Prairie, Mesic Southern Forest, Prairie Fen, Southern Floodplain Forest, (note: mesic is a habitat with well-drained soils, but with an ample amount of moisture; a fen is a wetland with saturated muck soils, receiving groundwater inputs that are neutral to strongly alkaline).

The watershed has oak savanna and prairie remnants. Southwest Michigan is part of the tallgrass prairie region 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.

Oak savanna and prairies support many species such as the Eastern box turtle and the Great Plains spittlebug. These systems in the watershed also support plants that are rare in Michigan and indicative of high-quality savannas, including rattlesnakemaster, prairie coreopsis, sand grass, and black haw.

Wildlife is abundant throughout the watershed. An inventory of animals of the Allegan State Game Area, included in a 1992 master plan for the area, listed 235 bird species, 45 mammal species, 19 amphibian species, 76 fish species and 23 reptile species. Important resident game species include the white-tailed deer, cottontail rabbit, fox squirrel, gray squirrel, raccoon, ring-necked pheasant, ruffed grouse, bobwhite quail, and wild turkey. Beavers are common along most watercourses and in smaller streams and wetlands they often make their presence known by their constant hydraulic engineering.

Important species of waterfowl, commonly taking up summer residence, include the mallard duck, black duck, wood duck, Canada goose, blue-winged teal, and American coot. Others, found only during spring and fall migration, include the blue goose, whistling swan, redhead duck, canvasback, goldeneye, American merganser, bufflehead, lesser scaup, American gallinule, Wilson's snipe, baldpate, pintail, and green-winged teal. The American woodcock is a migratory forest species.

4.2. Streams and Rivers

Streams are important for their intrinsic aesthetic, recreational, and ecological values in addition to being conduits of water and, potentially, of pollutants (Table 7).

Table 7. Major streams in the Kalamazoo River Watershed.

Waterbody	**Miles**
North Branch Kalamazoo River	28.0
South Branch Kalamazoo River	43.0
Rice Creek (North and South Branches)	29.5
Wilder Creek	10.5
Seven Mile Creek	4.0
Wabascon Creek	16.0
Battle Creek River	46.0
Wanadoga Creek	12.0
Indian Creek	9.0
Big Creek	6.0
Augusta Creek	15.0
Gull Creek	8.0
Davis Creek	6.0
Arcadia Creek	2.5
Portage Creek (includes West Branch)	18.5
Pine Creek	6.0
Baseline Creek	4.0
Sand Creek	4.0
Spring Brook	6.0
Gun River	13.0
Miner Creek	7.0
School Section Creek	3.0
Schnable Brook	4.0
Swan Creek	16.5
Bear Creek	6.5
Sand Creek	3.5
Mann Creek	6.0
Rabbit River	46.5
Little Rabbit	14.0
Red Run Drain	7.0
Black Creek	15.0
Miller Creek	7.0
Miller Creek	3.5
Silver Creek	2.0
Green Lake Creek	7.0

Anecdotal evidence indicates that streams and rivers in the watershed are probably in better ecological condition today than during much of the past 150 years. In larger rivers, the control of point-source inputs of sewage and industrial waste has vastly improved water quality. In smaller streams improvements in recent decades are 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 and rivers 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.

Coldwater streams, which are tributaries with particularly high rates of groundwater input, are a unique natural feature providing important spawning habitat and thermal refuge for coldwater aquatic species including trout (Summarized in Wesley, 2005 Table 7 and Figure 30). The Kalamazoo River contains some of the southernmost trout streams in the Midwest U.S (Figure 14).

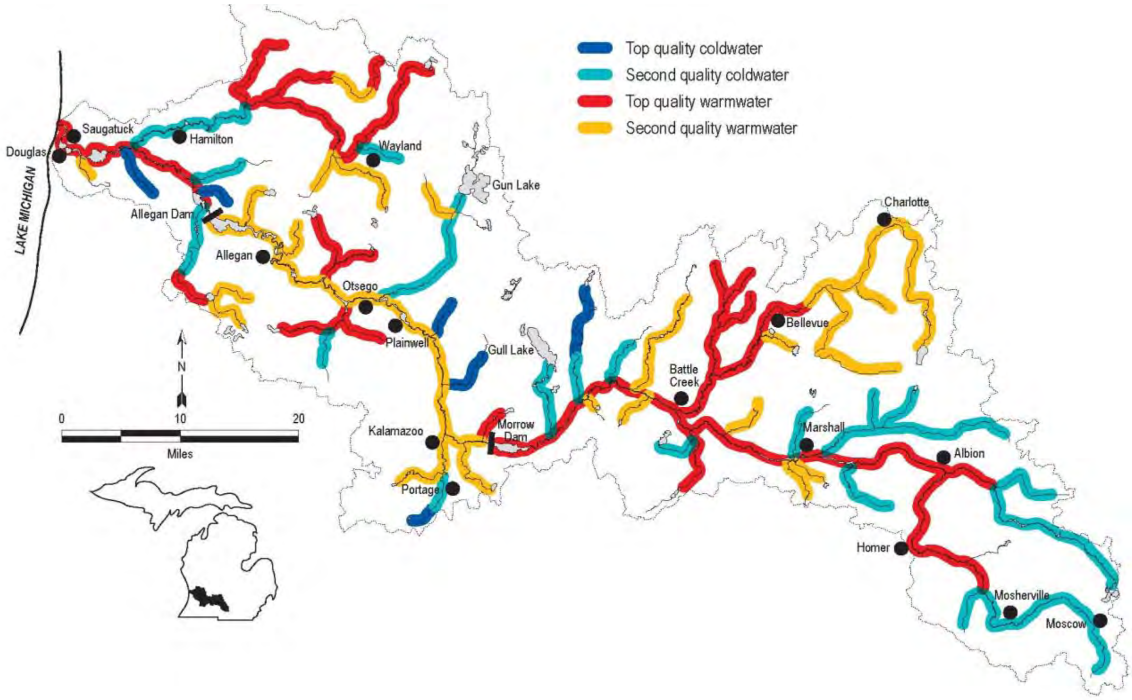


Figure 14. Michigan Department of Natural Resources, Fisheries Division, stream classification, 1964 (from Wesley, 2005).

4.3. Lakes

The aesthetic and recreational values of lakes are widely recognized by residents in the watershed. The larger lakes are popular sites for seasonal and year-round residences, and those 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 and can be excellent for angling. The diversity of lake types in the watershed is associated with a diversity of aquatic plant and animal life as well.

There are about 2,450 lakes and ponds totaling 37,500 acres scattered across the watershed, ranging in size from Gun Lake (Allegan/Barry Counties) at 2,611 acres and Gull Lake (Kalamazoo/Barry Counties) at 2,040 acres, to numerous smaller lakes and ponds. There are 52 lakes or impoundments of 100 acres or more in area. A summary by county is shown in Table 8.

Table 8. Major lakes in the Kalamazoo River Watershed.

County	Number of Lakes over 100 Acres	Total Surface Area (acres)
Allegan	17	5,510
Barry	11	5,560
Kent	0	0
Calhoun	12	2,360
Eaton	1	130
Hillsdale	0	0
Jackson	2	340
Kalamazoo	9	3,880
Ottawa	0	0
Van Buren	0	0

Threats to lake environments 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. Proper maintenance of home septic systems and care with the use of fertilizers are especially critical in the vicinity of water bodies. With residential development and associated roads and yards, coarse woody material abundance and shoreline habitat diversity strongly decline while nutrient loading often increases.

Human activities negatively affect inland lake ecosystems through alterations in water quality and physical habitat. For example, increased nutrient loadings from lawn fertilizers can increase algae and aquatic vegetation to nuisance levels and decrease concentrations of dissolved oxygen when 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 of certain fish species, and reduce fish species richness while shifting assemblage structure towards more tolerant species.

4.4. Wetlands and Floodplains

Wetlands

Wetlands are increasingly appreciated for the functions, values, and ecosystem services that they provide to society, and 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 due to outright drainage and filling, scientists are realizing that many wetlands are still being degraded by more insidious threats, such as non-point-source pollution and the invasion of exotic plants. Also, legislation does not provide protection to smaller isolated wetlands of less than 5 acres, which are common in many areas of the watershed.

Wetlands play an important role in the maintenance of good water quality, especially where they lie along lakes and streams because these 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 local groundwater aquifers. Riparian wetlands help to attenuate floods, as discussed earlier with regard to streams, thereby stabilizing stream channels and reducing property damage downstream.

Historically drained wetland areas offer possibilities for restoration. The most extensive areas of drained wetlands are apparent in a map created by MDEQ that highlights hydric soils (i.e., of wetland origin) that are not presently considered wetlands and are consider potential wetland restoration areas (Figure 15). Such areas were originally drained for agriculture and some are still farmed while others have been abandoned.

An analysis conducted for this watershed planning process by Kieser & Associates, LLC used the potential wetland restoration layers provided by MDEQ used to create Figure 14. Major subwatershed potential wetland restoration area ranks (Table 9) and counts and average sizes (Table 10) were summarized.

Table 9. Total area (in acres) of potential wetland restoration areas based on restoration rank for all major subwatersheds, where rank 1 is highest priority.

	Restoration rank				
	Highest 1	**2**	**3**	**Total area (acres)**	**% of total wetland restoration area classed as rank #1**
Rabbit River Watershed	3,936.5	7,812.4	2,964.2	14,713.1	10.0
Gun River Watershed	7,974.1	2,663.1	1,695.9	12,333.2	20.2
Battle Creek River Watershed	7,032.6	10,375.2	5,119.2	22,527.0	17.8
Rice Creek Watershed	2,375.0	2,406.7	1,381.1	6,162.9	6.0
Portage/Arcadia Watershed	443.8	636.5	265.8	1,346.2	1.1
Davis Creek Watershed	151.4	323.8	224.7	699.9	0.4
Four Township Watershed	761.5	1,919.1	1,084.1	3,764.7	1.9
non_WMP Zone A	4,388.0	11,641.5	5,944.1	21,973.7	11.1
non_WMP Zone B	312.1	568.2	762.4	1,642.7	0.8
non_WMP Zone C	5,978.0	6,032.1	4,112.8	16,122.9	15.2
Total for the Kalamazoo River Watershed	*39,438.5*	*52,416.3*	*28,345.8*	*120,200.6*	32.8

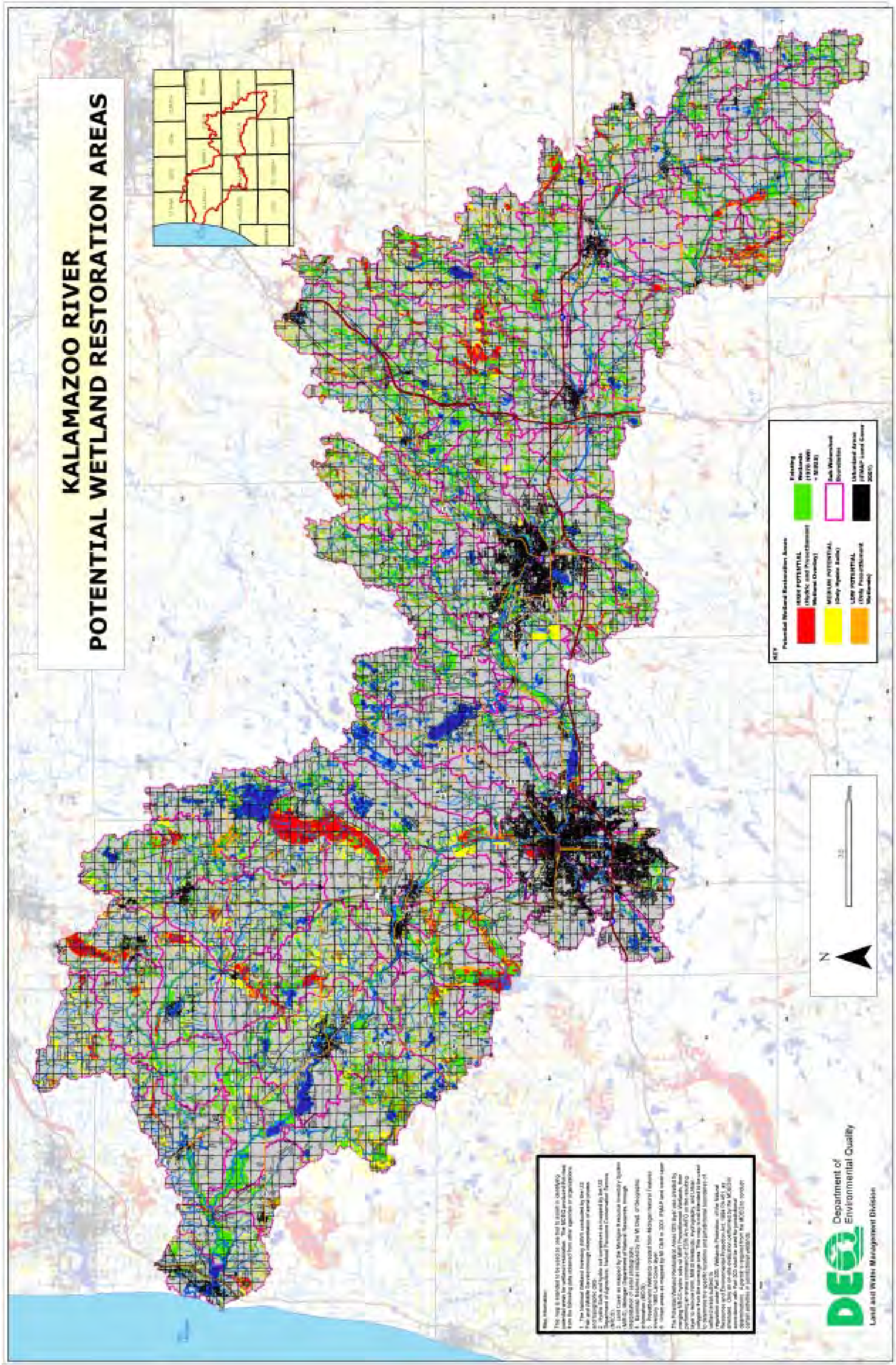

KALAMAZOO RIVER
POTENTIAL WETLAND RESTORATION AREAS
Department of
Environmental Quality
Land and Water Management Division

Figure 15 (previous page). Kalamazoo River potential wetland restoration areas (see http://www.mcgi.state.mi.us/wetlands/ for original maps).

The Gun River Watershed appears to be one of the most important watersheds for potential wetland restoration. It has the largest proportion (over 20%) of first priority wetland restoration areas and the largest average size of potential wetland restoration areas. Another important watershed for wetland restoration is the Battle Creek River Watershed, with over 17% of first priority restoration areas. However, potential wetland restoration areas in this watershed appear to be more fragmented.

Table 10. Number, and average size, of wetlands area per restoration rank.

	Restoration rank					
	Highest 1		**2**		**3**	
	Number	*Average area (ac)*	Number	*Average area (ac)*	Number	*Average area (ac)*
Rabbit River Watershed	1018	*3.87*	3034	*2.57*	1095	*2.71*
Gun River Watershed	671	*11.88*	1840	*1.45*	620	*2.74*
Battle Creek River Watershed	3208	*2.19*	5617	*1.85*	3171	*1.61*
Rice Creek Watershed	980	*2.42*	1703	*1.41*	936	*1.48*
Portage/Arcadia Watershed	358	*1.24*	747	*0.85*	332	*0.80*
Davis Creek Watershed	107	*1.41*	175	*1.85*	122	*1.84*
Four Township Watershed	1193	*0.64*	2367	*0.81*	1070	*1.01*
non_WMP Zone A	2384	*1.84*	5553	*2.10*	2251	*2.64*
non_WMP Zone B	902	*0.35*	1222	*0.47*	834	*0.91*
non_WMP Zone C	2754	*2.17*	4709	*1.28*	2825	*1.46*
Total for the Kalamazoo River Watershed	15766	*2.50*	30389	*1.72*	15759	*1.80*

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. Fens are wetlands characterized by high rates of groundwater through-flow, and in southern Michigan that groundwater is typically rich in dissolved ions including calcium, magnesium and bicarbonate. 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" often 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, poison sumac, and the invasive glossy buckthorn.

In the Watershed, prairie fens are commonly found along lakes and streams where groundwater discharges from adjacent uplands. They are particularly likely to exist where glacial outwash plains meet more elevated moraines or ice-contact ridges.

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.

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). Often, floodplains are forested. These dynamic forested 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.

Current threats to floodplains include conversion to industrial, residential, or recreational uses, wetland or floodplain fill or drainage, exotic species invasion, chemical pollution, sedimentation, 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.

4.5. Rare Features and Species

A variety of rare species and communities have been documented in the Watershed. The Michigan Natural Features Inventory (December 2009) for Allegan, Kalamazoo, and Calhoun Counties list plants and animals, occurring in these counties, considered endangered (in danger of extinction in the state), threatened (likely to become endangered in the foreseeable future), or of special concern (not threatened or endangered at present but could be in the future and should be monitored) under state statutes. Major watershed counties checked at http://web4.msue.msu.edu/mnfi/data/county.cfm include:

Allegan County –
State Endangered: 13
State Threatened: 48
State Special Concern: 47
State Extirpated (no longer found in the area): 2
Federal - Listed Endangered, 1; Listed Threatened, 1; Considered for Status, 1

Kalamazoo County –
- State Endangered: 19
- State Threatened: 61
- State Special Concern: 63
- State Extirpated (no longer found in the area): 8
- Federal - Listed Endangered, 2; Considered for Status, 1

Calhoun County
- State Endangered: 11
- State Threatened: 21
- State Special Concern: 29
- State Extirpated (no longer found in the area): 4
- Federal - Listed Endangered, 1; Listed Threatened, 2; Considered for Status, 1

Major threats to rare species and features include habitat loss and fragmentation and invasive species. 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.

4.6. Invasive species (aquatic and wetland)

Invasive species are a particular concern in lakes. An especially notorious aquatic invasive species is the zebra mussel. Through human activity such as boating, zebra mussels have the potential to spread. 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 can cause local extirpation of native mussel species through suffocation and starvation. Eurasian milfoil and curly leaf pondweed are two widespread nuisance plants in lakes. Boats and trailers can transfer these species to water bodies, so special care should be taken by boaters to limit the possibility.

5. The legacy of contaminated sediments

Discharges into the Kalamazoo River from some paper industry recycling processes created very serious contamination problems prior to the 1970's. The primary contaminant is a class of synthetic industrial compounds called polychlorinated biphenyls (PCBs) (http://www.atsdr.cdc.gov/toxprofiles/tp17.html), a hazardous substance and probable human carcinogen. PCBs were introduced to Portage Creek and the Kalamazoo River through disposal of PCB-contaminated paper residuals and associated drainage. The disposal areas (now often referred to as landfills) are situated on the river banks and contain millions of cubic yards of PCB-contaminated waste. The contaminated sediments were largely deposited in Kalamazoo River impoundment areas downstream of source areas (e.g., Plainwell Dam, Otesgo City and Township Dams, Trowbridge Dam, and Calkins [Lake Allegan Dam].

The contaminated area still includes three miles of Portage Creek from Cork Street just above Bryant Mill Pond in the city of Kalamazoo, to its mouth at the Kalamazoo River, and from Morrow Dam on the Kalamazoo River for 80 miles downstream to Lake Michigan.

PCB discharges have been essentially eliminated because of a ban on their production and other regulatory point source controls, but large amounts of uncontrolled contaminants are still present in and near portions of the river channel in the lower Kalamazoo River valley floodplain. It has been estimated that the river sediments contain more than 120,000 pounds of PCBs within millions of cubic yards of contaminated sediment, soils, and paper residuals. This site is being addressed through federal, state, and responsible parties' actions.

Relation to nonpoint source runoff
Contaminated sediment issues are exacerbated by unstable watershed hydrology that typically leads to flashiness, causes excess in-stream erosion, and stresses dams. Failing and partially demolished dams also resulted in eroding, contaminated streambanks in former impoundments. The river channel re-cut behind several dams after the sill levels had been lowered leading to additional contributions of contaminated sediment. Atmospheric transport of PCBs, as well as other persistent organic pollutants, is an ongoing source of pollution to all surface water bodies and complicates the understanding of background levels of PCB pollution. In addition, stormwater runoff can carry pollutants sourced from deteriorating infrastructure (e.g., leaking storage containers), from atmospheric deposition on to the land, and from contaminated surface soils.

5.1. PCBs in the river system and food webs

PCBs in the sediments accumulate and can "biomagnify" in the food web. Fish, being several links up the food chain, may have high concentrations of contaminants in their bodies. Older fish often have the highest concentrations. Humans are exposed to PCBs by eating contaminated fish and wildlife. Federal and state fish consumption guidelines establish an action level of 2 mg/kg total PCBs in edible portions of fish tissue. PCB concentrations in fillets of many species of fish from Portage Creek and the Kalamazoo River typically exceed this threshold. The Michigan Department of Community Health has issued fish consumption advisories for the Kalamazoo River and Portage Creek for many years and maintains a fish consumption guidebook (www.michigan.gov/fishandgameadvisory), although paper copies are no longer widely distributed due to funding limitations.

There are several ways (exposure pathways) humans can be exposed to PCBs in water and sediment. PCBs in the river are almost entirely bound to sediment and soil particles, and are not usually present at levels of concern in the water unless contaminated sediments have been disturbed and suspended in the water. Therefore, PCB concentrations in surface waters generally do not exceed levels at which increased health risks would be incurred. Skin contact with water in the Kalamazoo River is not expected to result in a notably increased health risk to humans. Even occasionally swallowing water from the Kalamazoo River, as when falling out of a boat, should not put anyone at increased risk from PCBs.

Since most contaminated sediment remains too wet to become airborne, inhalation of airborne particles would not result in a significant amount of exposure to PCBs. Health risks attributable to this pathway are highly unlikely. At this time there are no known sites in the Kalamazoo River (other than Superfund landfills which have been fenced off from the general public) where typical activities would provide sufficient skin contact with PCB-contaminated soil or sediments to result in increased health risks. The public has raised concerns, however, that sediment is very easily suspended in the water by swimmers, power boats, flooding, and windy weather, and young children frequently swallow water while swimming.

Among stations for which total PCB loading rates were estimated, the lower Kalamazoo River contributed 16 kg/year in 2005 (Aiello, 2006). Despite evidence that water column PCB concentrations in the lower Kalamazoo River are generally the highest in the State of Michigan, agencies have not recommended human contact restrictions and recent reviews conclude that normal recreational activity on the river is safe.

The Kalamazoo River Watershed Council (KRWC) asked the Michigan Department of Community Health (MDCH) to evaluate the health hazards from the PCBs present in the water and sediment of the Kalamazoo River. Following the KRWC's review of the then available public health assessment, the Council requested responses to specific questions regarding dermal contact with and incidental ingestion of water and sediments during recreational use of the river. In response, the MDCH, in consultation with the federal Agency for Toxic Substances and Disease Registry (ATSDR) investigated risks associated with ingestion of water and sediment associated with recreational activities. Their investigations found that there is no apparent health hazard regarding dermal contact with or incidental ingestion of water and sediments during recreational use of the river (Aiello, 2006).

The Kalamazoo River Human Health Risk Assessment (MDEQ, 2003) http://www.michigan.gov/deq/0,1607,7-135-3311_4109_4217-84646--,00.html was conducted to identify potential risks and hazards associated with exposures to PCBs released into the Kalamazoo River system. Section 3.2 of the Kalamazoo River Human Health Risk Assessment for the river, as it relates to contact with surface water, states:

> "During hunting or fishing activities, contact with river surface water and sediment may occur. Contact with surface water and sediment may also occur during other recreational activities such as swimming and boating. In general, contact with sediment and surface water does not result in significant risks or hazards. This assumption is consistent with the findings presented in Health Consultation for Allied Paper / Portage Creek / Kalamazoo River (MDCH 1997). In that document, it is stated that "moist sediments might adhere more strongly to skin than drier soil, but river water would tend to wash the sediments off before the soiled skin reaches the mouth or food." In addition, the quantity of water consumed during swimming has been estimated to be significantly less than that consumed when water is used for drinking water (50 milliliters/hour, which is a typical swimming event versus 2 liters/day) (EPA 1989, 1992). For this reason, the ingestion of surface water is not considered a significant pathway."

Finally, current and future Superfund remedial activities along the Kalamazoo River and Portage Creek are expected to disturb substantial sediment. Controls are required that minimize the risk of significant downstream transport of re-suspended contaminated sediments. Guidelines are in place to reduce the impact of downstream transport of contaminated sediments should site monitoring indicate that turbidity and PCB water column exceedances are occurring. Evidence from routine up- and downstream sampling during recent removal of contaminated river sediments near Plainwell indicates that engineering controls successfully prevented significant downstream transport of PCBs associated with disturbed sediments (contact the KRWC).

The Natural Resource Damage Assessment, written by the resource Trustees, concisely documents contaminant concentrations in surface water, sediment, soils, fish and wildlife and provides background on the history of the site (http://www.fws.gov/midwest/KalamazooNRDA/). The Trustee agencies for this NRDA are the U.S. Fish and Wildlife Service, the Michigan Department of Environmental Quality, the Michigan Department of Natural Resources (added by Governor Granholm on September 29, 2004), the Michigan Department of the Attorney General, and the National Oceanic and Atmospheric Administration. The Trustees will determine the amount of restoration needed both to return the Kalamazoo River environment to what it would have been like if the contaminants had not been released and to compensate the public for the loss of use and enjoyment of their natural resources resulting from the contaminants.

5.2. Superfund

The Comprehensive Environmental Response, Compensation, and Liability Act -- otherwise known as CERCLA or Superfund -- provides a Federal "Superfund" to clean up uncontrolled or abandoned hazardous-waste sites as well as accidents, spills, and other emergency releases of pollutants and contaminants into the environment. Through

CERCLA, EPA was given power to seek out those parties responsible for any release and assure their cooperation in the cleanup.

Through various enforcement tools, EPA obtains private party cleanup through orders, consent decrees, and other small party settlements. EPA also recovers costs from financially viable individuals and companies once a response action has been completed.

In June, 1990 the Michigan Department of Natural Resources notified three potentially responsible parties (PRPs), Allied Paper, Inc. (Millennium Holdings, LLC), the Georgia-Pacific Corporation, and Simpson Plainwell Paper Company (now Weyerhaeuser), of their intent to spend public funds to conduct a remedial investigation/feasibility study. In August 1990, the Allied Paper, Inc./Portage Creek/Kalamazoo River site was included on the National Priorities List, commonly known as Superfund. MDEQ was designated as the lead agency at that time.

The Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund site includes five disposal areas, five paper mill properties, an approximately 80-mile stretch of the Kalamazoo River from the Morrow Lake dam to Lake Michigan, and a three-mile stretch of Portage Creek (Figure 16).

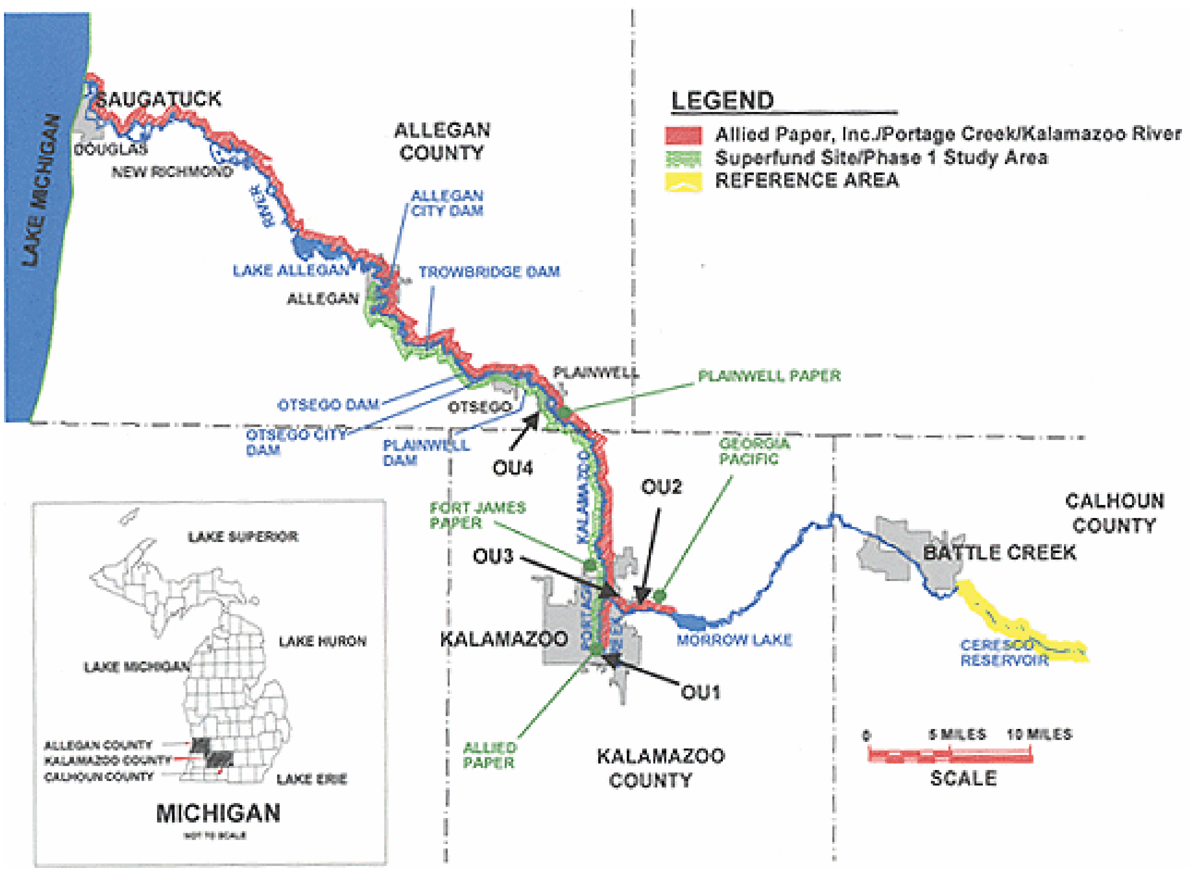
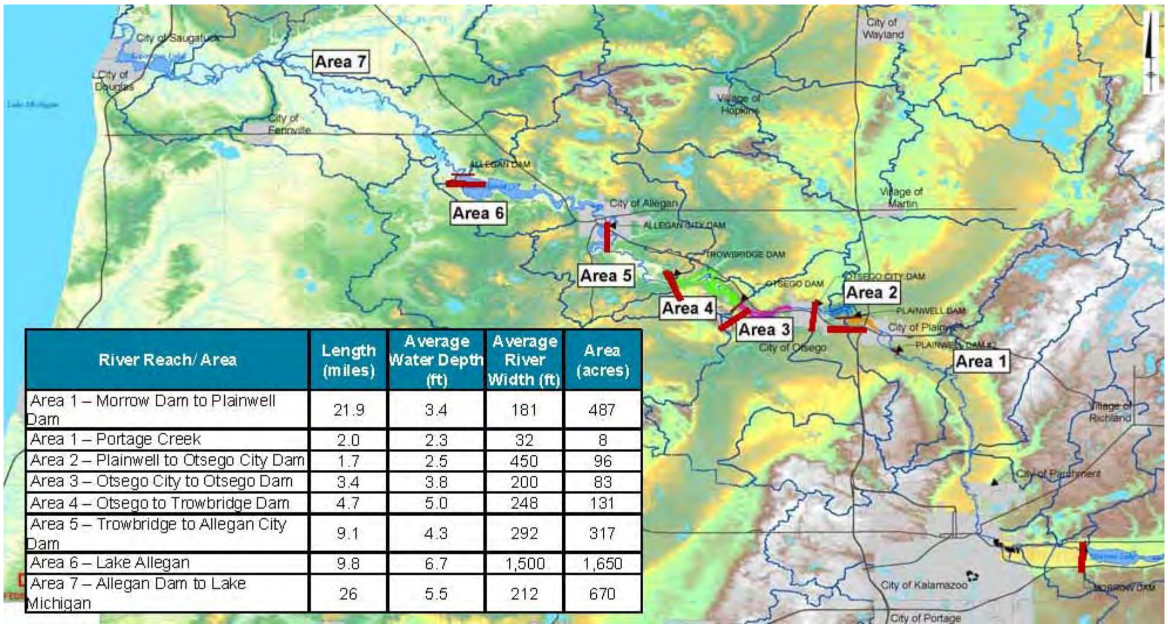


Figure 16. The Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund site. Red shaded areas indicate the extent of the entire site. Green shaded areas indicate an early management unit designation which has since been changed (see Figure 17).

At this time, the site is divided into five cleanup projects known as operable units (OUs):

- OU #1, Allied Paper Property/Bryant Mill Pond Area;
- OU #2, Willow Boulevard and A-Site Landfill;
- OU #3, Kings Highway Landfill;
- OU #4, 12th Street Landfill; and
- OU #5, the Portage Creek and Kalamazoo River sediments are further delineated into seven "areas" (Figure 17).



River Reach/ Area	Length (miles)	Average Water Depth (ft)	Average River Width (ft)	Area (acres)
Area 1 – Morrow Dam to Plainwell Dam	21.9	3.4	181	487
Area 1 – Portage Creek	2.0	2.3	32	8
Area 2 – Plainwell to Otsego City Dam	1.7	2.5	450	96
Area 3 – Otsego City to Otsego Dam	3.4	3.8	200	83
Area 4 – Otsego to Trowbridge Dam	4.7	5.0	248	131
Area 5 – Trowbridge to Allegan City Dam	9.1	4.3	292	317
Area 6 – Lake Allegan	9.8	6.7	1,500	1,650
Area 7 – Allegan Dam to Lake Michigan	26	5.5	212	670

Figure 17. The seven areas of operable unit #5 of the Allied Paper, Inc./Portage Creek/Kalamazoo River Superfund site.

EPA's cleanup approach for the Kalamazoo River is to first eliminate ongoing sources of PCBs to the river, which includes the exposed paper wastes along the river banks and flood plain soils (or impoundments), and then address in-stream sediments. The exposed paper wastes are particularly abundant behind State-owned and privately-owned dams along the river, where the formerly impounded areas allowed sediment to accumulate (these dams are taken down to their sills now). Before evaluating cleanup options for in-stream sediments, EPA will investigate upstream sources of PCBs and evaluate the existing landfill OUs and paper mill properties to ensure they are not a source of PCBs to the river. Generally, EPA's cleanup will begin upstream and work downstream on a reach-by-reach and dam-to-dam basis.

Several cleanup actions have occurred or are in process at source areas on or near the banks of Portage Creek and the Kalamazoo River.

EPA Cleanup status:
http://www.epa.gov/region5superfund/npl/michigan/MID006007306.htm

Cleanup, documentation, and public involvement details:
http://www.epa.gov/Region5/sites/kalproject/
Further "time critical" cleanup details:
http://www.epaosc.org/site/site_profile.aspx?site_id=5239

In a bankruptcy court settlement in 2010, the company that was holding the Allied Paper properties and liabilities, Millennium Holdings, Inc., was dissolved when its parent company, Lyondell/Basell went through Chapter 11 bankruptcy, ultimately emerging and continuing global operations. Financial liabilities were settled for the Allied Landfill property and cleanup obligations downstream of the Allied Site for approximately 10% of what Federal agencies estimated (according to court documents) was required for full river valley cleanup. Two viable responsible parties remain, Georgia Pacific and Weyerhaeuser.

Under the settlement the U.S. EPA has received about $103 million total for cleanup of the Allied Paper/Portage Creek/Kalamazoo River Superfund Site. A custodial trust was established to take ownership and possession of environmentally contaminated properties owned by Lyondell or its affiliates. One of these properties is the Allied Paper Mill. Approximately $50 million of the trust funds will be dedicated to the cleanup of the Allied Paper Mill. Additionally, the settlement requires Lyondell to pay approximately $49.5 million to resolve liabilities at the Allied Paper/ Portage Creek/Kalamazoo River Superfund Site. The U.S. will also receive approximately $3.2 million in payout on its allowed general unsecured claim against Lyondell/Millennium for the Allied Paper/ Portage Creek/ Kalamazoo River Superfund Site. The agreement relieves Lyondell/Millennium from any future financial responsibility at the Allied Superfund site. As of this writing and as far as the KRWC is aware, these funds have neither begun to be spent, nor has their use been more specifically allocated.

5.3. Area of Concern

In 1987, amendments to the Great Lakes Water Quality Agreement (GLWQA) were adopted by the federal governments of the U.S. and Canada. Annex 2 of the amendments listed 14 different beneficial use impairments (BUIs) which are caused by a detrimental change in the chemical, physical, or biological integrity of the Great Lakes system. The Annex directed the two countries to identify Areas of Concern (AOCs) that did not meet the objectives of the GLWQA. Remedial Action Plans (RAPs) addressing the BUIs were to be prepared for all 43 AOCs identified, including the Kalamazoo River. The BUIs provided a tool for describing effects of the contamination or other kinds of impairments, and a means for focusing remedial actions.

The KRWC, state, and federal agencies recognize the Area of Concern boundary as described below (Figure 18), although the KRWC feels that the "river" should include the 100-year floodplain and any former impoundment sediments that may lie above that level.

The Kalamazoo River AOC includes the lower portion of the river from Morrow Dam in Kalamazoo County near Galesburg to the mouth of the River in Allegan County at Saugatuck, as well as three miles of Portage Creek from its confluence with the Kalamazoo River (MDEQ, 2006a).

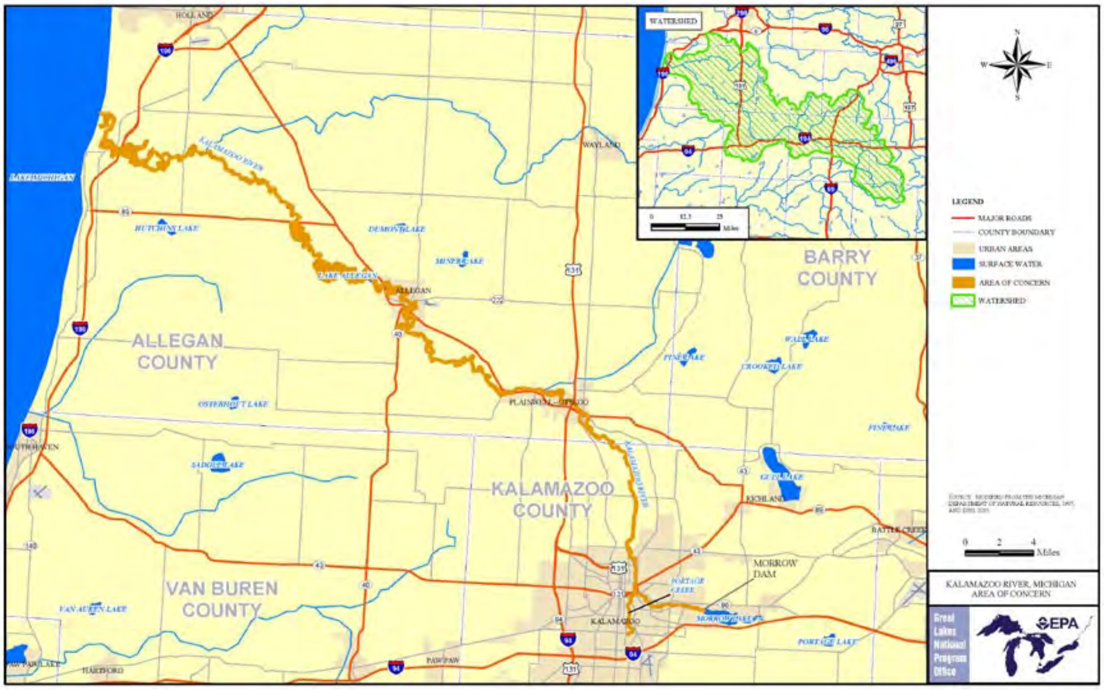


Figure 18. The Kalamazoo River Watershed Area of Concern extends along the river courses outlined in gold.

The Michigan Department of Environmental Quality (MDEQ) Remedial Action Plan (RAP) has recently been updated for the Area of Concern (AOC), and is the primary tool for documenting and communicating progress toward BUI removal and AOC delisting to the public and agencies. These processes and relevant restoration criteria are described in more detail in the MDEQ's Guidance for Delisting Michigan's Great Lakes Areas of Concern (Guidance) (MDEQ, 2008).

The purpose of this Kalamazoo River RAP update is to track progress in the AOC on remedial actions completed in recent years. This update discusses BUI assessment results that are based on the readiness of a BUI removal and subsequent technical committee review and recommendations. Comprehensive background information is provided in the 1987 and 1998 Kalamazoo River RAP documents (Michigan Department of Natural Resources [MDNR], 1987 and Kalamazoo River Watershed Public Advisory Council [Kalamazoo River PAC], 1998).

The future of the Kalamazoo River AOC is heavily dependent on ongoing PCB contamination assessment, risk-based PCB cleanup level establishment, legal settlements, and PCB cleanup activities associated with the Superfund and Natural Resource Damage Assessment (NRDA) processes. The Superfund and NRDA processes are regulatory programs with community involvement processes. These processes allow limited site specific input and influence by working groups of resource stakeholders involved in the non-regulatory programs (e.g., AOC program).

The AOC has eight BUIs determined under Annex 2 of the GLWQA, including: Restrictions on Dredging, Loss of Fish and Wildlife Habitat, Degradation of Fish and Wildlife Populations, Degradation of Aesthetics, Bird and Animal Deformities, Restrictions on Fish Consumption, Beach Closings, and Degradation of Benthos.

A Fish and Wildlife Advisory Team was created by the KRWC to use the process outlined in the Guidance to develop local restoration criteria for the Loss of Fish and Wildlife Habitat & Degradation of Fish and Wildlife Populations BUIs. The Kalamazoo River Area of Concern: Restoration Plan for the "Loss of Fish and Wildlife Habitat" and "Degradation of Fish and Wildlife Populations" Beneficial Use Impairments documents locally-established targets for the restoration of the Loss of Fish and Wildlife Habitat and Degradation of Fish and Wildlife Populations BUIs in the Kalamazoo River Watershed AOC. These BUIs relate to the physical degradation of fish and wildlife habitat and related fish and wildlife population reductions. The targets identified will be incorporated into the Kalamazoo River AOC Remedial Action Plan (RAP), maintained by the MDEQ Office of the Great Lakes. This is one step in a larger process, with the ultimate goal that all impairments (total of 8 for the Kalamazoo River AOC) will be restored, BUIs will be removed, and the AOC will be "delisted".

5.4. Overlapping Superfund and AOC Issues

The regulatory Superfund cleanup program and non-regulatory AOC programs have common issues. PCBs in sediments cause direct harm through the food chain and indirectly prevent the near term removal of failing mainstem river dams. Dam removal would lead to restoring high gradient river habitat currently buried in impoundments. In recent years, the KRWC has worked to maintain regular contact with Superfund, AOC, and NRDA parties with the expectation that these programs can complement one another and lead to faster, better cleanups, more habitat recovery, and more rapid progress toward removing BUIs and delisting the Kalamazoo River AOC.

5.5. Other trace contaminants

Dioxins and Mercury
At several sites throughout the watershed, dioxins have been documented in fish tissue at levels of potential concern for human consumption (MDNRE 2010). These locations show no obvious correspondence with current or former industrial activity. The causes and consequences of this apparent contamination of aquatic food webs remain to be discerned. Information on the health concerns of dioxins is available at http://www.michigan.gov/mdch/0,1607,7-132-2945_5105_51514-113198--,00.html. Fish consumption impairments due to dioxin are listed in Table 14. Mercury also impairs fish consumption in most inland waters in Michigan and is sourced mostly from coal fired power generation facilities.

Over the past several decades, the MDEQ has implemented a variety of activities that include monitoring, regulations and policies for identifying, preventing, or eliminating the use and release of mercury, a toxic pollutant. The Mercury Strategy Workgroup (MSWG), consisting of MDEQ staff representing Air, Water, Waste, Pollution Prevention , and Land Remediation, along with a representative from the Michigan Department of Community Health, has developed and released the Mercury Strategy Staff Report and its Appendices . Included in the report are 67 recommended action steps towards the goal of eliminating anthropogenic mercury use and releases in Michigan. Access the report at http://www.michigan.gov/deq/0,1607,7-135-3307-184041--,00.html.

Heavy metals

Heavy metals are a common contaminant of concern at former industrial sites, landfills, and in urban soil in general. Though PCBs are the contaminant of concern in the Superfund and AOC designated areas, heavy metals are often cited as a concern by local communities, especially those with a history of manufacturing and heavy industry.

Crude oil and its components from the 2010 Enbridge pipeline release

The 2010 oil release into the Kalamazoo River was described in Section 3.1 above. As of this writing it is too early to determine the longer-lasting impacts of the oil, but they may well include sediments and soils contaminated with petroleum hydrocarbons as well as associated metals such as vanadium. The likely sites of contamination lie in a reach of river that was relatively clean before the oil release. Naturally it will be critical to carefully survey and monitor all potentially contaminated sites, and to take remedial action where deemed necessary and feasible.

6. Water Resource Management

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

6.1. Watershed Management: Setting Boundaries

In addition to working within the jurisdictional structure of local governmental units, watershed management efforts have often been delineated along hydrological boundaries, which makes sense for water management. In most cases these watershed boundaries extend across townships, cities, and often counties, an unavoidable complexity but one that underscores the need to transcend traditional jurisdictional boundaries and instead take a landscape approach when dealing with our water resources. Figure 3 illustrates the spatial relationships of existing sub-watershed management areas, stormwater plans, and phosphorus reduction plans created and maintained by watershed partners.

6.2. Land Use and Water Quality

The quality of water and the ecology of lakes, rivers, streams and shorelines depend on the way land is managed, patterns of land use in relation to natural resources, and especially the way water is managed on a site. 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. County, city, village, township and tribal governments all have a significant role to play in protecting water resources. This role becomes important where federal and state statutes and county ordinances fall short of the needed measures.

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. “Downstream” often means a flow path from uplands to groundwater, streams, rivers and lakes.

Once the desired configuration of different future land uses (e.g., high density residential, low density residential, commercial, industrial, etc) is determined with respect to soils, natural features, water bodies and drainage patterns, appropriate planning can steer 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 to support land development – can be minimized through the use of smart growth and low impact development techniques http://www.semcog.org/LowImpactDevelopment.aspx.

Best management practices (BMPs) are methods that have been determined to be the most effective, efficient and practical means of preventing or reducing pollution. Often BMPs to address non-point source pollution entail changes in the way people carry out traditional activities, for example in agriculture, forestry, mining and construction. The US EPA, working with partners in industry and the academic community, has established and published best management practices for soil erosion, stormwater treatment, fuel storage, pesticide and fertilizer handling and the management of livestock yards. Much useful information on BMPs can be found on web pages of the EPA http://www.epa.gov/ebtpages/pollbestmanagementpractices.html and Michigan DEQ http://www.michigan.gov/deqnps choose "Information & Education". Reference for a variety of agricultural BMPs are available at http://water.epa.gov/polwaste/nps/bestnpsdocs.cfm.

6.3. Regulatory Authority for Water Resources

The Michigan Department of Natural Resources and Environment regulates surface waters in the watershed based on the Natural Resources and Environmental Protection Act, PA 451, part 301 Inland Lakes and Streams. This statute regulates the dredging, filling, construction and any structural interference with the natural flow of a lake or stream. This act also regulates marina operations. Permits are needed for activities such as construction of docks or placing fill or structures in lakes and streams. The MDNR has the authority to regulate the number of boats and size of engines at public access sites if human health or protected species are being impacted. Cities, villages and townships can enact ordinances that further protect the water quality of lakes and streams. Model ordinances to protect water quality can be found at http://www.michigan.gov/deq select "water", "surface water", and then "storm water".

The MDEQ 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 see http://www.michigan.gov/deqnps choose "Information & Education". Furthermore, the MDEQ administers the municipal stormwater program, which requires owners or operators of municipal separate storm sewer systems (MS4s) in urbanized areas to implement programs and practices to control polluted stormwater runoff. Several municipalities in the Kalamazoo and Battle Creek Urbanized Areas are covered by MS4 permits. More information on this program is available at http://www.michigan.gov/deq select “water”, “surface water”, “storm water”, and then “municipal program”.

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 are not stormwater permittees, their local ordinances, master planning, zoning, and development practices can use principals described in the 2008 watershed permit to protect valued local water resources (revoked in 2010). 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

- o 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 Environmental Quality stormwater website http://www.michigan.gov/deq select “water”, “surface water”, and then “storm water”.

Each county’s 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 they have been legally established and control structures exist. The soil erosion and sedimentation program is housed in different departments depending on the county. The County Enforcement Agent for the soil erosion program has the responsibility of ensuring earth change activities that are one or more acres in area and/or are within 500 feet of a watercourse or lake do not contribute soil to water bodies.

Each county's health department is involved in several areas of nonpoint source controls: onsite wastewater treatment systems, septage waste hauling, monitoring residential wells, and operating a household hazardous waste program.

The State of Michigan recently implemented the groundwater withdrawal assessment tool as part of new rules related to the Great Lakes, under the Great Lakes - St. Lawrence River Basin Water Resources Compact. The Water Withdrawal Assessment Tool (WWAT) is designed to estimate the likely impact of a water withdrawal on nearby streams and rivers. The MDEQ and the Michigan Department of Agriculture monitor large-quantity groundwater use. All large quantity withdrawals, defined as having the capacity to withdraw more than 100,000 gallons of water per day average over any 30-day period, equivalent to 70 gallons per minute pumping, must be registered and water use must be reported annually. The Comprehensive State Groundwater Protection Program is a statewide program that looks at groundwater uses, including drinking water, and its role in sustaining the health of surface water bodies (rivers, streams, wetlands, marshes). 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. One must use the WWAT to determine if a proposed withdrawal is likely to cause an Adverse Resource Impact, and to register the withdrawal.

Opportunities may exist for the development and implementation of planning tools that use the new online WWAT to prevent overuse of local GW resources and to avoid overuse of local aquifers, 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 the drinking water supply. The program minimizes the potential for contamination by identifying and protecting the area that contributes water to municipal water supply wells and avoids costly groundwater clean-ups. The following cities and villages in the Watershed participated in a local Wellhead Protection Program as of October 2008:

- Albion
- Allegan
- Augusta
- Battle Creek
- Bellevue
- Charleston Township
- Charlotte
- Concord
- Fennville

- Gobles
- Gun Plain Township-Lake Doster
- Kalamazoo
- Kalamazoo Lake Sewer and Water Authority
- Litchfield (Adams Field)
- Marshall
- Martin
- Pennfield Township - North Acres
- Otsego
- Otsego Township
- Parchment
- Plainwell
- Portage
- Saugatuck Township
- Springport
- Wayland
- Yankee Springs Township

Watershed Based Permits

Federal and state regulatory programs are often using watershed-based permitting to achieve watershed management goals, particularly those that relate to nonpoint source runoff. In the Kalamazoo River watershed, two groups of NPDES stormwater permittees have organized themselves to communicate and coordinate their water quality efforts. One group is based around the Kalamazoo urbanized area and is referred to as the Stormwater Work Group. The second is based around the Battle Creek urbanized area and is referred to as the Clean Water Partners. These groups follow regulatory guidelines to meet permit requirements including watershed based planning and education. Beyond just reducing the negative impacts of stormwater runoff, these groups are encouraged to prevent future stormwater problems by developing or adopting preventative measures. The permittees have additional responsibility to reduce stormwater problems on their property, eliminate illicit discharges to the storm sewer system, enact ordinances for water quality and channel protection, and encourage public participation and public education.

Total Maximum Daily Load (TMDL) Programs

Under section 303(d) of the Clean Water Act, states, territories, and authorized tribes are required to develop lists of impaired waters, defined as waters that are too polluted or otherwise degraded to meet all applicable water quality standards. The law requires that these jurisdictions establish priority rankings for waters on the lists and develop Total Maximum Daily Loads (TMDLs) for these waters. A TMDL is a calculation of the maximum amount (loading rate) of a pollutant that a waterbody can receive and still safely meet water quality standards http://www.epa.gov/owow/tmdl/.

The only TMDL that has so far been established in the Kalamazoo River watershed is the Kalamazoo River/Lake Allegan TMDL for phosphorus (Heaton 2001: http://www.deq.state.mi.us/documents/deq-swq-gleas-tmdlallegan.pdf; see also www.kalamazooriver.net). Lake Allegan, formed by an impoundment of the Kalamazoo River, is considered worthy of protection for its warmwater fishery, other indigenous aquatic life and wildlife, agriculture, navigation, industrial water supply, partial body contact recreation, and total body contact recreation. Prioritization of the Lake Allegan TMDL was driven by Michigan's five-year rotating watershed assessment approach. The United States Environmental Protection Agency (USEPA) conducted a National Eutrophication Survey of Lake Allegan in 1972, and at that time the lake was classified as hypereutrophic, with phosphorus implicated as the major pollutant contributing to the eutrophication. Additional monitoring data collected by the MDEQ in 1988, 1994, 1996, and 1997 and by Michigan State University (Reid and Hamilton 2007, Baas 2009) indicated that the lake had improved since the early 1970s but was still considered extremely nutrient-enriched and eutrophic, with high nutrient and chlorophyll a levels, excessive turbidity, periodic nuisance algal blooms, low dissolved oxygen levels, and an unbalanced fish community dominated by carp and channel catfish. Total phosphorus concentrations measured by MDEQ in Lake Allegan between 1998-2000 averaged 96 ppb and ranged from 69 to 125 ppb.

The phosphorus TMDL for Lake Allegan was determined based on similarities between Lake Allegan and an upstream reservoir of similar characteristics (Morrow Lake), where the total phosphorus concentrations are lower (~60 ppb) and water quality is evidently better as a result. Using Morrow Lake as a model, the desired total phosphorus goal for Lake Allegan was set at 60 ppb. This is a lakewide average and the inflow total phosphorus concentrations tend to be about 20% higher than those of the outflow. The average total phosphorus concentrations in Lake Allegan in 1998 and 1999 were 95 and 96 ppb, respectively. Reid and Hamilton (2007) discuss this case in some detail and point out some of the scientific uncertainties in the concept that a proportionate decrease in phosphorus loading of this magnitude will make Lake Allegan's water quality as good as that in Morrow Lake. Nonetheless, reductions in loading of phosphorus can only help to improve water quality, not only in Lake Allegan but also in the river above and below the reservoir and in the waters of Lake Michigan to which the river drains.

Since 2001, people responsible for point sources and nonpoint sources have been working in collaboration to decrease phosphorus and sediment loading to the Kalamazoo River. The KRWC has participated in meetings of this group of stakeholders for the past several years, which has included the several cities and villages wastewater treatment plants, local industry and consultants, the Kalamazoo Environmental Council (KEC), Michigan Farm Bureau (MFB), Michigan Agricultural Stewardship Association (MASA), Michigan Department of Agriculture (MDA), Natural Resources Conservation Service, MDEQ, and numerous others. This unique effort has required point source permittees to assist in the implementation of projects that achieve nonpoint source phosphorus reduction including changes to rules and regulations (e.g., ordinances), public education, and monitoring. Since all citizens, governments, businesses, and NGOs have a role to play in nonpoint source loading reductions TMDL efforts are open to any individual or organization with something to contribute. A TMDL Implementation Committee was formed in order to guide efforts to meet the TMDL goals. A comprehensive implementation plan was developed by this committee to address all of the known or suspected sources of anthropogenic phosphorus loads in the Kalamazoo River portion of the Lake Allegan drainage (The TMDL Implementation Plan can be downloaded at http://kalamazooriver.net/tmdl/implement/index.htm).

The committee has been engaged in many public education activities and non-point source phosphorus reduction efforts/projects as well as having provided in-kind services for this WMP project. Despite these active efforts, past phosphorus monitoring has indicated that the overall TMDL water quality goals for Lake Allegan have not been met. Though point sources have consistently met their waste load allocations with few exceptions, progress towards non-point source load allocations have not yet been identified in river monitoring. Past assessments of TMDL water quality monitoring data can be downloaded at http://kalamazooriver.net/tmdl/docs/M-89%20NPS%20Loading%201998-2007.pdf.

Besides tracking and addressing point-source inputs, participants have sought to address non-point source pollution as well. In addition, they have participated in the Kalamazoo River Water Quality Trading Demonstration Project, which has been conducted in the Kalamazoo River to improve water quality and provide information vital to the design of a statewide water quality trading program. The project, led by Kieser & Associates and the Forum for Kalamazoo County, demonstrated and evaluated the environmental and economic implications of watershed-based phosphorus trading between point- and non-point sources, with the goal of providing an incentive for implementing voluntary non-point source reductions and promoting collaborative, community-driven watershed management planning.

New TMDLs are targeted for development by specific future dates (see Table 14) and a several pollutants have been targeted as candidates for TMDLs. Most of these involve trace contaminants including PCBs, dioxins, and mercury, with concentrations in water and/or fish tissue proposed as the indicator. Davis Creek, a small tributary entering the river above the City of Kalamazoo, has known problems with oil of unknown origin leaking into the river, as well as with fecal-associated bacteria (*E. coli*) of uncertain origin. Axtell and Arcadia Creek are also impaired by *E. coli* likely caused by domestic animals and nuisance wild animals, including geese. Excess sediment loading has been identified as a problem in a few sites; fortunately the coarse soils of much of the watershed are not as prone to soil erosion and transport as some other watersheds in Michigan and elsewhere where finer clays and silts are more predominant.

6.4. Roads and Water Quality

Roads can have substantial impacts on water quality. 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 significant pollution concern. The Michigan Department of Transportation and county Road Commissions are responsible for the construction and maintenance of most roads in the watershed. 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; for more information see http://www.semcog.org/Environmental_Sensitivity.aspx.

Increases in the area of impervious surfaces (roofs, parking lots, and roads) change stream hydrology by directing an increasing proportion of precipitation into storm drains instead of infiltrating into soils. Impervious surface area in the Kalamazoo River watershed has been mapped as part of this Plan (Figure 19).

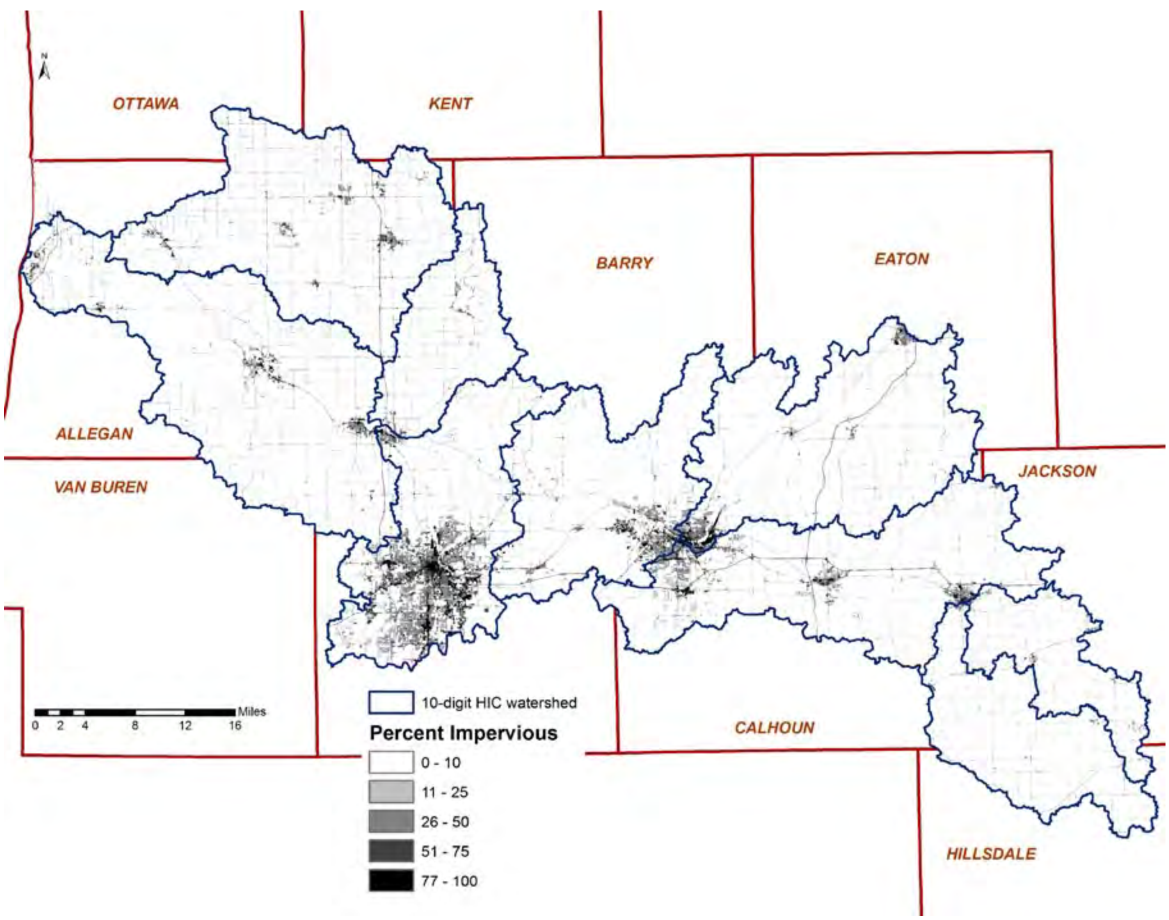


Figure 19. Impervious cover in the Kalamazoo River Watershed.

While the overall proportion of impervious surface area remains small, it is significant in the urbanized areas, which tend to lie along the rivers and historically have used streams as a means to quickly drain streets. Hence runoff from impervious surface areas can have a disproportionate impact of water quality in the Kalamazoo River and its tributaries, and undoubtedly contributes to pollutant loading including phosphorus (Baas 2009).

With increased development also comes more stream crossings. There are 2,755 road and utility stream crossings over the Kalamazoo River and tributaries. Improper crossing installations can lead to channel and fish habitat degradation, particularly because of sedimentation where large amounts of soil (and sand applied to roads in winter) wash into the stream (see tables in Wesley, 2005). Until recently MDEQ monitored road stream crossings periodically to identify problem areas in need of improvement. Approximately 500 road stream crossings were rated and mapped by MDEQ in 2000-2003 and Figure 20 displays available locations. About half of the crossings that were surveyed appeared to be in Good condition, but 44% were judged to be in Fair or Poor condition. More details are available in Attachment 4.

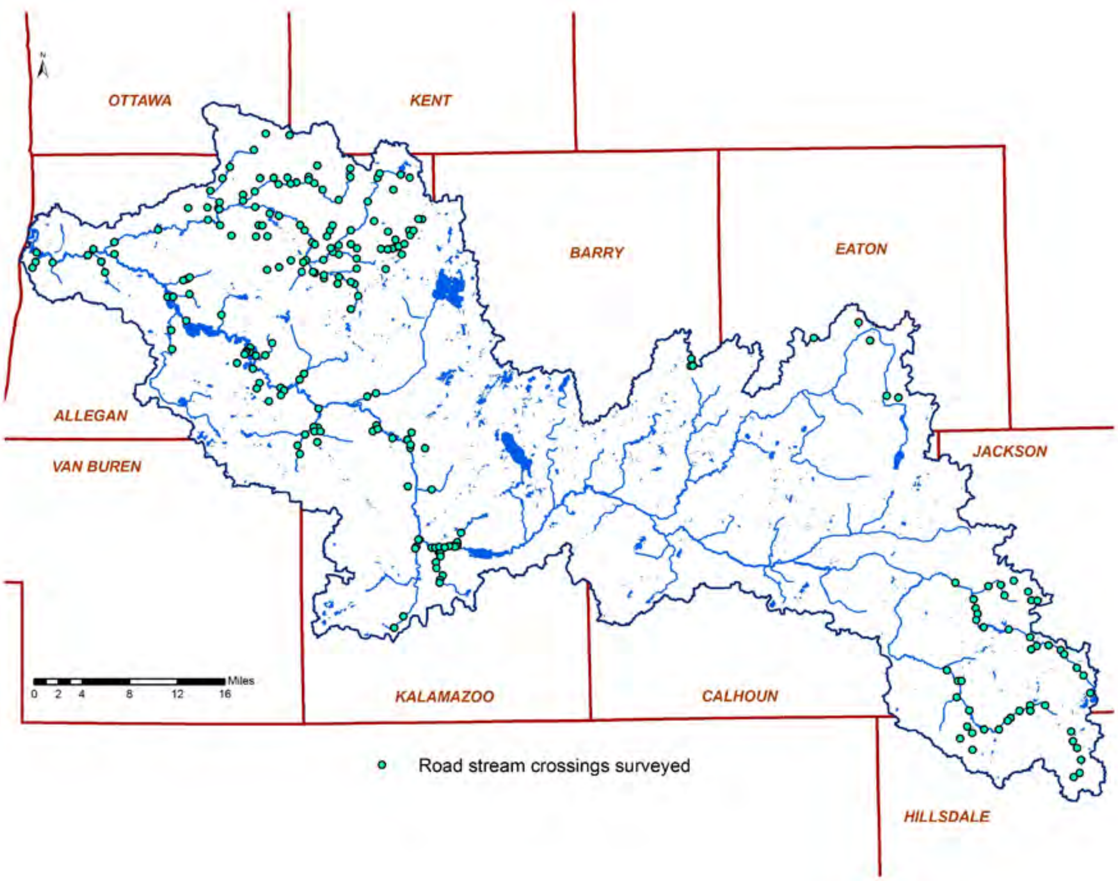


Figure 20. Road stream crossings surveyed by the MDEQ in 2000-2003.

6.5. Water Bodies (rivers, drains, streams, lakes)

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

- Connected to one of the Great Lakes.
- Located within 1,000 feet of one of the Great Lakes.
- Connected to an inland lake, pond, river, or stream.
- Located within 500 feet of an inland lake, pond, river or stream.
- Not connected to one of the Great Lakes or an inland lake, pond, stream, or river, but are more than 5 acres in size.
- 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 DEQ 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, or county) has the authority to create wetland regulations. A local wetland ordinance must be at least as restrictive as state regulations and state officials must be notified if there is a local wetland ordinance in effect. Approximately 50 communities in Michigan have adopted local wetland ordinances. As of April 2008, within the Kalamazoo River watershed only Clyde Township, in Allegan County, is listed as having a local wetland ordinance: http://www.michigan.gov/deq select “water”, “drinking water”, and then “water wellhead protection”. 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 Michigan DEQ requires that a permit be obtained prior to any alteration or occupation of the 100-year floodplain of a river, stream or drain to ensure that development is reasonably safe from flooding and does not increase flood damage potential. Local ordinances restricting development in floodplains can be more restrictive than MDEQ regulations.

Several communities in the watershed 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 provide protection for property owners against potential losses through an insurance mechanism that requires a premium to be paid for the protection. Review local community status at http://www.fema.gov/fema/csb.shtm.

Groundwater
Locally, county health departments play 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.

6.6. Local Water Quality Protection Policies

Local governments regulate land use mostly through master plans and zoning ordinances. Community participation in the NFIP is voluntary and based on an agreement between local governmental units and the Federal Government. The agreement 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.

Local government master plans have the option to include a number of elements related to water quality and aquatic ecosystem protection. Master plans may relate water quality and natural resource protection to the safety and welfare of the residents and community. Plans may address the connection between land use and water quality. Further, the plans may discuss the negative impacts of increased impervious surfaces and the need for stormwater management and low impact development techniques to protect water quality. Lastly, plans may include language on natural resources (lakes, wetlands, streams, riparian buffers, woodlands, open space etc.) and their value to the community and their role in protecting water quality.

The following provisions in zoning ordinances are suggested for consideration by local governmental units interested in water quality and water resource protection:

1. Waterbody Protection
   - require adequate building setbacks along rivers/drains and wetlands
   - require 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 BMPs (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 Manual for Michigan: A Design Guide for Implementers and Reviewers* available at http://www.semcog.org/lowimpactdevelopmentreference.aspx.

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, such as sliding-scale, to limit fragmentation of farmland (e.g., number of times it can be split based on original lot size) 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 hammerhead shaped cul-de-sacs to reduce paved surface area
   - 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 BMPs (refer to *Low Impact Development Manual 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) in required setback areas and common areas
- encourage the use of best management practices (BMPs) that improve a site's infiltration and have BMPs labeled and shown on site plans
- require use of native plants for landscaping plans and for runoff/stormwater controls (prohibit invasive and exotics 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 – require proper release rate to insure no increase in stormwater discharge rate or volume for the 2 year/24-hour storm post construction (see page 62 for more information)

6.7. 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 private landowners 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 Extension staff, Conservation Districts, Natural Resources Conservation Service, Southwest Michigan Land Conservancy, The Nature Conservancy, Kalamazoo Nature Center, Department of Environmental Quality, and United States Fish and Wildlife Service (Partners for Wildlife Program). Land trusts such as the Southwest Michigan Land Conservancy and The Nature Conservancy assist private landowners with permanent conservation options such as Conservation Easements, which leave the land in private ownership and preserve many practical land use rights. See Table 11 and 12 for more detailed information on protection and management options available for private lands.

Table 11. 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) continue 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 12. 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 active agricultural 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.

Special Limited Time Opportunities

Numerous state and federal programs and particularly Farm Bill programs annually support private lands management. Two unique opportunities expected to be available in the Kalamazoo River Watershed for several years beyond 2010 are the Great Lakes Restoration Initiative (GLRI, see www.epa.gov/glnpo/glri) and the Agricultural Watershed Enhancement (AWEP, see www.nrcs.usda.gov/programs/awep/) programs. The GLRI has the following focus areas: 1) Cleaning up toxics and areas of concern; 2) Combating invasive species; 3) Promoting nearshore health by protecting watersheds from polluted run-off; 4) Restoring wetlands and other habitats; and, 5) Working with partners on outreach. AWEP is a voluntary conservation initiative that provides financial and technical assistance to agricultural producers to implement agricultural water enhancement activities on agricultural land for the purposes of conserving surface and ground water and improving water quality.

Healthy Waters Rural Pride Initiative

The Healthy Waters Rural Pride Initiative (HWRP), being assembled in southwest Michigan by volunteers, creates a formula for ensuring a sustainable rural future by partnering local working farms preservation programs and water quality protection practices to permanently improve the riparian ecosystems and associated habitats. The Initiative has been developed to address the following issues:

Limitations of current working farm protection options and financial incentives.

- The working farm protection options provided by Public Act 116 are not permanent and the financial penalties for removing land are not enough of a deterrent and are frequently unpaid by the farmer.

- Buffer practices implemented through Farm Bill and Conservation Reserve Program cost share contracts are limited to 10-15 years and then can be removed. These buffers practices can also be removed prior to end of the contract with a penalty.

Current Farmland Preservation Models do not address natural resource protection.

- The standards of requiring a Conservation Plan to enroll in Farmland Preservation vary among counties throughout the State of Michigan.
- There are no requirements for implementing best management practices to keep sediment and nutrients on the land.
- Placing an easement on just the buffer area, as done in other conservation practice models, does not address the needs of the farmer, the whole farm or the community.

Shortcomings of local Agricultural Technical Assistance and Preservation Delivery Systems:

- Technical Staff are either non-existent or frequently change due to short term funding through grant programs.
- Knowledge, expertise and relationships are lost with staff turnover.
- Landowner commitment and interest are jeopardized when technical assistance is inconsistent.

HWRP is an innovative approach to locally manage natural and agricultural resources for economic, environmental and social sustainability. It acknowledges that agriculture maintains open space and has an intrinsic contribution to a county’s economy, environment, character, history, recreational opportunities, and quality of life.

7. Water Quality Summary

Within a watershed, water quality can vary greatly from one water body to the next. The federal 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 (US EPA) 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 may require the development of a Total Maximum Daily Load (TMDL; see discussion in Section 6.3 above).

7.1. Designated and Desired Uses

According to the Michigan DEQ, the primary criterion for attainment of water quality standards (see Attachment 4.5) is whether the water body meets designated uses. Designated uses are recognized uses of water established by state and federal water quality programs. All surface waters of the state of Michigan are designated for and shall be protected for the uses listed in Table 13 (Citation: R323.1100 of Part 4, Part 31 of PA 451, 1994, revised 4/2/99). This watershed management plan provides guidance for protecting and restoring designated uses.

Table 13. Designated use definitions (see Attachment 5 for numerical standards and further detail).

Designated Use	General Definition
Agriculture	Water supply for cropland irrigation and livestock watering
Industrial Water Supply at point of intake	Water utilized in industrial processes
Public Water Supply	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 (as applicable)	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 this Plan, a current list of impaired waters under section 303(d) was synthesized and is presented in Table 14.

Table 14. Impaired designated uses in the Kalamazoo River Watershed.

Water Body	AUID	Impaired Use	Cause	TMDL Status
Kalamazoo River Watershed Rivers/Streams	All except 0103-01, 0104-01, 0201-01, 0202-01, 0202-02, 0203-02, 0204-04, 0205-01, 0206-01, 0206-02, 0406-01, 0406-02, 0407-01, 0407-02	Fish Consumption	PCB in Fish Tissue	2013
Kalamazoo River Watershed Rivers/Streams	All	Fish Consumption	PCB in Water Column	2013
Misc. Waters-Swains Lake Drain	0204-03	Other Indigenous Aquatic Life and Wildlife	Other Anthropogenic Substrate Alterations, Other Flow Regime Alterations	
Ceresco Impoundment	0408-02	Fish Consumption	PCB in Fish Tissue	2013
Crooked Creek	0408-06	Other Indigenous Aquatic Life and Wildlife	Sedimentation/Siltation	2011
Gull Lake	0507-04	Fish Consumption	Mercury in Fish Tissue	2011
	0507-04	Fish Consumption	PCB in Fish Tissue	2013
Kalamazoo River	0508-01	Other Indigenous Aquatic Life and Wildlife	Mercury in Water Column	2011
	0508-01	Other Indigenous Aquatic Life and Wildlife	PCB in Water Column	2013
	0508-01	Fish Consumption	Mercury in Water Column	2011
Whiteford Lake Outlet	0508-04	Other Indigenous Aquatic Life and Wildlife	Mercury in Water Column	2011
	0508-04	Fish Consumption	Mercury in Water Column	2011
Unamed Tributary to Kalamazoo River	0508-05	Other Indigenous Aquatic Life and Wildlife	Mercury in Water Column	2011
	0508-05	Fish Consumption	Mercury in Water Column	2011
Kalamazoo River	0509-01	Other Indigenous Aquatic Life and Wildlife	Mercury in Water Column	2011
	0509-01	Other Indigenous Aquatic Life and Wildlife	PCB in Water Column	2013
Morrow Lake (Pond) Reservoir	0509-02	Fish Consumption	PCB in Fish Tissue	2013

Water Body	AUID	Impaired Use	Cause	TMDL Status
Portage Creek	0603-02	Fish Consumption	PCB in Fish Tissue, PCB in Water Column (attainment expected 2022 and 2026)	2013
Axtell Creek	0603-05	Total Body Contact Recreation	*E.Coli*	2022
Axtell Creek	0603-05	Partial Body Contact Recreation	*E.Coli*	2022
Kalamazoo River	0604-01	Other Indigenous Aquatic Life and Wildlife	Mercury in Water Column	2011
Kalamazoo River	0604-01	Other Indigenous Aquatic Life and Wildlife	PCB in Water Column	2013
Kalamazoo River	0604-01	Fish Consumption	Dioxin	2021
Davis Creek	0604-02	Total Body Contact Recreation	*E.Coli*	2016
Davis Creek	0604-02	Partial Body Contact Recreation	*E.Coli*	2016
Davis Creek	0604-02	Warm Water Fishery	Oil and Grease	2014
Davis Creek	0604-02	Warm Water Fishery	Petroleum Hydrocarbons	2014
Davis Creek	0604-02	Fish Consumption	Dioxin	2021
Davis Creek	0604-03	Total Body Contact Recreation	*E.Coli*	2016
Davis Creek	0604-03	Partial Body Contact Recreation	*E.Coli*	2016
Davis Creek	0604-03	Fish Consumption	Dioxin	2021
Spring Brook	0605-01	Fish Consumption	Dioxin	2021
Kalamazoo River	0606-01	Other Indigenous Aquatic Life and Wildlife	Mercury in Water Column	2011
Kalamazoo River	0606-01	Other Indigenous Aquatic Life and Wildlife	PCB in Water Column	2013
Kalamazoo River	0606-01	Fish Consumption	Dioxin	2021
Kalamazoo River	0606-01	Fish Consumption	Mercury in Water Column	2011
Kalamazoo River	0606-03	Other Indigenous Aquatic Life and Wildlife	Mercury in Water Column	2011
Kalamazoo River	0606-03	Other Indigenous Aquatic Life and Wildlife	PCB in Water Column	2013
Kalamazoo River	0606-03	Fish Consumption	Dioxin	2021
Arcadia Creek	0606-04	Total Body Contact Recreation	*E.Coli*	2022
Arcadia Creek	0606-04	Partial Body Contact Recreation	*E.Coli*	2022
Arcadia Creek	0606-04	Other Indigenous Aquatic Life and Wildlife	Mercury in Water Column	2011
Arcadia Creek	0606-04	Other Indigenous Aquatic Life and Wildlife	PCB in Water Column	2013
Arcadia Creek	0606-04	Fish Consumption	Dioxin	2021

Water Body	AUID	Impaired Use	Cause	TMDL Status
Kalamazoo River	0607-01	Other Indigenous Aquatic Life and Wildlife	Mercury in Water Column	2011
Kalamazoo River	0607-01	Other Indigenous Aquatic Life and Wildlife	PCB in Water Column	2013
Kalamazoo River	0607-01	Fish Consumption	Dioxin	2021
Kalamazoo River	0607-01	Fish Consumption	Mercury in Water Column	2011
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
Unamed Tributary to Kalamazoo River	0607-05	Other Indigenous Aquatic Life and Wildlife	Other Anthropogenic Substrate Alterations	
Unamed Tributary to Kalamazoo River	0607-05	Other Indigenous Aquatic Life and Wildlife	Other Flow Regime Alterations	
Pine Lake W. of Prairieville	0607-06	Fish Consumption	Mercury in Fish Tissue	2011
Gun Lake	0701-08	Fish Consumption	Mercury in Fish Tissue	2011
Fenner Lake	0702-01	Fish Consumption	Mercury in Fish Tissue	2011
Fenner Lake	0702-01	Fish Consumption	PCB in Fish Tissue	2013
Fenner Creek	0702-03	Other Indigenous Aquatic Life and Wildlife	Other Anthropogenic Substrate Alterations, Other Flow Regime Alterations, Sedimentation/Siltation	2014
Gun River	0702-05	Other Indigenous Aquatic Life and Wildlife	Other Anthropogenic Substrate Alteration, Other Flow Regime Alterations	
Fish Lake	0702-08	Fish Consumption	Mercury in Fish Tissue	2011
Selkirk Lake	0803-01	Fish Consumption	Mercury in Fish Tissue	2011
Red Run	0806-02	Other Indigenous Aquatic Life and Wildlife	Cause Unknown, Sedimentation/Siltation	2017
Red Run	0806-02	Other Indigenous Aquatic Life and Wildlife	Direct Habitat Alterations, Other Flow Regime Alterations	
Hamilton Impoundment, Rabbit River	0811-03	Fish Consumption	PCB in Fish Tissue	2011
Osgood Drain	0905-01	Other Indigenous Aquatic Life and Wildlife	Mercury in Water Column	2011
Osgood Drain	0905-01	Other Indigenous Aquatic Life and Wildlife	PCB in Water Column	2013
Osgood Drain	0905-01	Fish Consumption	Dioxin	2021
Osgood Drain	0905-01	Fish Consumption	Mercury in Water	2011

Water Body	AUID	Impaired Use	Cause	TMDL Status
			Column	
Kalamazo River and Pine Creek	0905-02	Other Indigenous Aquatic Life and Wildlife	Mercury in Water Column	2011
Kalamazo River and Pine Creek	0905-02	Other Indigenous Aquatic Life and Wildlife	PCB in Water Column	2013
Kalamazo River and Pine Creek	0905-02	Fish Consumption	Dioxin	2021
Kalamazoo River	0906-01	Other Indigenous Aquatic Life and Wildlife	Mercury in Water Column	2011
Kalamazoo River	0906-01	Other Indigenous Aquatic Life and Wildlife	PCB in Water Column	2013
Kalamazoo River	0906-01	Fish Consumption	Dioxin	2021
Kalamazoo River	0906-01	Fish Consumption	Mercury in Water Column	2011
Kalamazoo River	0907-01	Other Indigenous Aquatic Life and Wildlife	Mercury in Water Column	2011
Kalamazoo River	0907-01	Other Indigenous Aquatic Life and Wildlife	PCB in Water Column	2013
Kalamazoo River	0907-01	Fish Consumption	Dioxin	2021
Kalamazoo River	0907-01	Fish Consumption	Mercury in Water Column	2011
Dumont Creek and Kalamazoo River	0907-02	Fish Consumption	Dioxin	2021
Rossman Creek and unamed tribs	0907-03	Other Indigenous Aquatic Life and Wildlife	Mercury in Water Column	2011
Rossman Creek and unamed tribs	0907-03	Other Indigenous Aquatic Life and Wildlife	PCB in Water Column	2013
Rossman Creek and unamed tribs	0907-03	Fish Consumption	Dioxin	2021
Rossman Creek and unamed tribs	0907-03	Fish Consumption	Mercury in Water Column	2011
Dumont Creek	0907-05	Fish Consumption	Dioxin	2021
Lake Allegan	0907-06	Other Indigenous Aquatic Life and Wildlife; Fish Consumption	Excess Algal Growth, Phosphorus (Total)	2001*
Lake Allegan	0907-06	Fish Consumption	Dioxin	2021
Lake Allegan	0907-06	Fish Consumption	PCB in Fish Tissue	2013
Kalamazoo River	0909-01	Other Indigenous Aquatic Life and Wildlife	Mercury in Water Column	2011
Kalamazoo River	0909-01	Other Indigenous Aquatic Life and Wildlife	PCB in Water Column	2013
Kalamazoo River	0909-01	Fish Consumption	Mercury in Water Column	2011

Water Body	AUID	Impaired Use	Cause	TMDL Status
Kalamazoo River	0911-01	Other Indigenous Aquatic Life and Wildlife	Mercury in Water Column	2011
Kalamazoo River	0911-01	Other Indigenous Aquatic Life and Wildlife	PCB in Water Column	2013
Kalamazoo River	0911-01	Fish Consumption	Mercury in Water Column	2011
Peach Orchard Creek	0911-02	Other Indigenous Aquatic Life and Wildlife	Mercury in Water Column	2011
Peach Orchard Creek	0911-02	Fish Consumption	Mercury in Water Column	2011
Kalamazoo River	0911-03	Other Indigenous Aquatic Life and Wildlife	Mercury in Water Column	2011
Kalamazoo River	0911-03	Fish Consumption	Mercury in Water Column	2011
Kalamazoo Lake	0912-01	Fish Consumption	PCB in Fish Tissue	2013

Attachment 11 includes a map displaying nonpoint source related impaired waterbodies.

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

The State of Michigan also considers Fish Consumption a designated use for all water bodies. There is a generic, statewide, mercury-based fish consumption advisory that applies to all of Michigan's inland lakes.

Industrial. There are several industrial water intake sites along the Kalamazoo River. Industries and commercial businesses also use the river for surface water discharge either directly or via municipal sewage treatment facilities. Figure 21 shows current NPDES permits for discharging treated waste water, cooling water and other effluents.

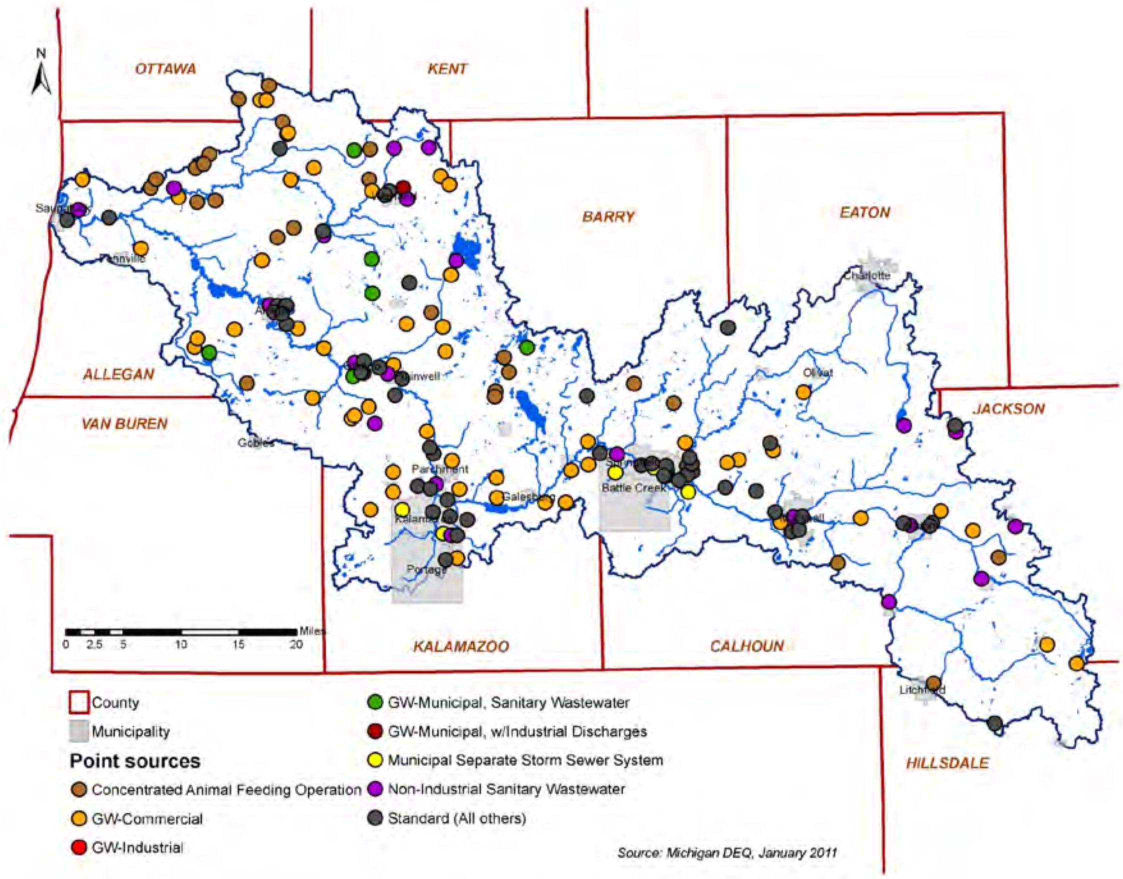


Figure 21. NPDES pollutant discharge permits in the Kalamazoo River Watershed.

Municipal. There are no municipal drinking water intakes on the river. The main source of drinking water is from groundwater wells, private and municipal. Residential wastes are discharged to groundwater via septic systems, or to the river via municipal sewage treatment facilities.

Agricultural. There is some intake of river water for irrigation of crops. The Kalamazoo River and its tributaries are also used extensively for watering livestock.

Navigational. About a one mile stretch of the Kalamazoo River mouth downstream of Kalamazoo Lake (Harbor Area) is designated as an Army Corps of Engineers recreational waterway and maintained through dredging. Sand periodically removed from the channel is clean enough that it does not trigger the need for special handling and is disposed of locally.

A 2007 review of existing subwatershed plans at that time revealed the following breakdowns for subwatershed impaired and threatened uses and prioritization of pollutants (Table 15) [These listings are not 303(d) listings but are impairments and threatened uses perceived by watershed stakeholders].

Table 15. Summary of subwatershed impaired and threatened use review and prioritization of pollutants in plans published before as 2007 perceived by stakeholders (not 303(d) listings).

Watershed Management Unit	Agriculture	Industrial Use	Navigation	Warmwater Fisheries	Coldwater Fisheries	Aquatic Life and Wildlife	Partial Body Contact	Full Body Contact
Rice Creek				k	k	k	k	k
Battle Creek River	t			k	k	k		t
Mainstem 3 Corridor				k	k			
Davis Creek				k	k	k		
Portage/Arcadia Creeks			t	k	k	k		t
Gun River	t		t	k	k	k		t
Upper Rabbit River				k	k	k		t

t = threatened
k = known

Table 15. continued

Watershed Management Unit	Sediments	Nutrients	Hydrological Flow	Pathogens	Oil, Grease, Heavy Metals, Hydrocarbons	Pesticides	Salts	Temperature	Solid Waste
Rice Creek	h	h	h	m	l-m	l-m	l-m	h	
Battle Creek River	h	h	h	m	m	m	l	l	l
Mainstem 3 Corridor	h	h		h	h				
Four Townships	h	m		l		l			
Davis Creek	h	h	h	l	h	l			l
Portage/Arcadia Creeks	h	h	h	h	h		h		
Gun River	h	h	h	h	l-m			h	
Upper Rabbit River	h	h	h	l-m		l-m			

h = high
m = medium
l = low

This Plan relies on current, known impairments to designated uses that have specific pollutants, sources, and causes (Table 16). Threats are also discussed in general in the narrative. An assessment of individual water bodies was completed for the watershed and can be found in Attachment 6. Detailed information is available in numerous subwatershed plans referenced in Table 1.

Table 16. Impaired and threatened designated uses, known and suspected pollutants and sources, and causes in the Kalamazoo River Watershed.

Designated Use	**Prioritized 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 **-** Lake Allegan watershed under 2001 TMDL for excess algal growth, phosphorus (total); Threatened – All	1. Nutrients (K)	Cropland erosion (K)	Conventional tillage practices. Plowing adjacent to water bodies.	Agriculture makes up over half of land use
		Stormwater runoff (K)	Loss of nutrient and sediment retention capacity of floodplains and wetlands. Discharge from impervious surfaces and developed areas. Ineffective stormwater management.	Urban/residential growth. Wetland drainage
		Land application of manure (S)	Lack of adherence to manure management plans. Manure management plans may not be enforced for small and medium sized animal feeding operations. Improper manure handling and spreading.	Land used for manure spreading
		Livestock facility runoff (S)	Improper manure storage and feedlot runoff.	Facility status to be determined
		Septic system failures and illicit connections (S)	Improperly designed, installed, and maintained septic systems. Unknown illicit connections.	Septic systems are widespread
		Streambank or 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 along many waterbodies

Table 16. Impaired and threatened designated uses, known and suspected pollutants and sources, and causes in the Kalamazoo River Watershed.

Designated Use	**Prioritized Pollutants and Impairments to Designated Uses**	**Source of Pollution**	**Causes for Release of Pollutants**	**Documented Presence in Watershed**
Impaired – Crooked Creek; Red Run Drain; Fenner Creek; Un-named Tributary to Kalamazoo River south of the City of Plainwell; Threatened – All	2. Sediment (K)	Stormwater runoff (K)	Loss of floodplains and wetlands as retention. Discharge from impervious surfaces and developed areas. Ineffective stormwater management.	Urban/residential growth. Wetland drainage
		Cropland erosion (K)	Conventional tillage practices. Plowing adjacent to water bodies.	Agriculture makes up over half of land use
		Road and bridge crossings (S)	Undersized culverts, poorly designed and maintained crossings.	Subwatershed plans document site specific concerns
		Streambank or 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 along many waterbodies
Impaired – Red Run Drain; Threatened – All	6. Habitat degradation or fragmentation (K)	Loss of habitat (K)	Agricultural land drainage (e.g., tiles). Development of open space for agriculture and urban development. Drain management.	Agriculture makes up over half of land use, and urban areas are developing
Impaired **-** Rabbit River Swains Lake Drain and Misc. Waters; Fenner Creek; Gun River; Red Run Drain; Threatened – All	3. Unstable flow (K)	Stormwater runoff (P)	Loss of floodplains and wetlands as retention. Discharge from impervious surfaces and developed areas. Ineffective stormwater management. Drain management.	Urban/residential growth; hydrologic study indicated increasing flashiness in some tributaries.
Public Water Supply: Not applicable – no intakes				

Table 16. Impaired and threatened designated uses, known and suspected pollutants and sources, and causes in the Kalamazoo River Watershed.

Designated Use	Prioritized Pollutants and Impairments to Designated Uses	Source of Pollution	Causes for Release of Pollutants	Documented Presence in Watershed
Warmwater Fishery: Impaired – Davis Creek	7. Oil and grease; Petroleum hydrocarbons (K)	Historic industrial discharge (K)	Uncontrolled historic source(s) and sediment contamination	Ongoing release from uncontrolled source(s)
Coldwater Fishery: Threatened – All applicable coldwater systems including particularly Portage Creek;	4. Temperature (S)	Lack of riparian habitat or habitat modification	Due to agriculture and urban land use and development; extensive impervious surfaces.	Extensive low density shoreline development and agriculture along many waterbodies
		Stormwater runoff (P)	Loss of floodplains and wetlands as retention. Discharge from impervious surfaces and developed areas. Ineffective stormwater management.	Urban/residential growth
Total and Partial Body Contact Recreation: Impaired – Axtell Creek, Davis Creek, Arcadia Creek; Threatened – urbanized watersheds	5. Pathogens-Bacteria (K)	Stormwater runoff (K)	Pets and urban nuisance wildlife (esp. Canada Geese)	Urbanized stormwater drainage systems
Navigation: Met				
Industrial: Met				

K = known, S = suspected

7.2. Water Quality: General Considerations

As noted in the Introduction, the Kalamazoo River watershed possesses a rich diversity of surface waters, most of which are in good ecological condition. These surface waters - lakes, streams, and wetlands - are highly valued by local residents for recreational and aesthetic reasons. The watershed is underlain by extensive groundwater aquifers, and groundwater and surface-water bodies are intimately connected where permeable glacial 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 watershed 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, and hence their protection is a priority wherever they occur.

The Kalamazoo River watershed is predominantly rural but also includes urban and suburban landscapes, and although urban land use is a small fraction of the watershed, the larger cities formerly supported a plethora of industrial activities. The legacy of industrial pollution, most notably PCBs, is a continuing problem that has already been discussed in Section 5. Another major legacy of earlier industrial activity persists in the form of aging dams, which in the case of the lower Kalamazoo River hold large quantities of contaminated sediments behind them. Other contaminants of industrial origin occur in specific sites, notably old landfills and other hot spots where groundwater has been contaminated by poor practices on the land surface.

Besides the legacy contaminants from industrial activity, phosphorus, sediments, and microbial pathogens are the pollutants of greatest concern in lakes and streams of the Watershed, 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 greatest concern for surface waters.

Surface waters including lakes as well as streams and rivers in the watershed are particularly sensitive to increased loading of phosphorus (P). Phosphorus is the most common limiting nutrient to biological productivity in freshwater systems. Most water reaches lakes and streams via groundwater flow. 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. In rivers including the Kalamazoo River main stem that receive municipal and industrial discharges of waste water, a substantial fraction of the P loading can come from point sources. Nonpoint sources of P include sediments carried by overland flow or storm drains. These sediments pose two issues: 1) sediments typically carry P in a form that is available to algae and plants; and, 2) 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 the reservoirs along the Kalamazoo River. Lake Allegan, located on the Kalamazoo River downstream of much of the watershed, has a phosphorus TMDL as discussed in Section 6.3.

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

Recent local expansion of Confined Animal Feeding Operations (CAFOs) in southwest Michigan has led to increasing citizen concerns about the application of manure on farm fields. 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 on wells in the agricultural portions of the watershed, although high levels are found in a minority of the total wells that are tested. Nitrate consumed in drinking water can block the ability of human blood to transport oxygen and has been associated with other health problems. High nitrate in drinking water is believed to be especially dangerous for pregnant mothers and the very young.

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

In a watershed that contains certain waters that have been markedly degraded by pollution, it is tempting to focus all of our resources and attention on remediation of the worst sites. Yet mitigation of the more widespread yet insidious non-point sources of water pollution is just as important, and a broad-scale, comprehensive approach to water quality protection and improvement would yield the greatest benefits to residents across the entire watershed. Also, the protection of our highest-quality water bodies should be a priority, and sometimes their ecological integrity can be inadvertently endangered by the residents who appreciate them and live along them. In this Plan we strive to balance the competing needs to remediation, restoration, mitigation, and pro-active protection of our diverse and abundant water resources.

7.3. Groundwater quantity and quality

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 bypass soil infiltration and rapidly direct runoff into streams and lakes. This hard conveyance system, sometimes called grey infrastructure, rapidly and efficiently delivers nutrients, sediments, and pathogens to receiving water bodies. Impervious surfaces in urban areas also alter the natural hydrology, reducing infiltration and the recharge of groundwater while increasing the amount of runoff.

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 and thereby enhances surface runoff. In addition, many agricultural lands are extensively tiled and/or ditched to move water off of the land as quickly as possible. Furthermore, irrigation can be a consumptive use of local groundwater resources. These activities disrupt the natural hydrologic cycle and negatively impact the functioning of the remaining natural features in the watershed.

Extensive and high-quality groundwater reservoirs (or aquifers) underlie much of the watershed. 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 watershed is a renewable resource and it can be sustainable if it is wisely managed. At present, some 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 watershed 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 watershed are generally 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 through 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 vulnerability of our groundwater resources. Users must 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 MSU Extension (http://www.msue.msu.edu/portal/), are a useful resource for residents interested in reducing their impact on our groundwater and surface waters. Chemical pollutants can also enter the groundwater from sources such as leaking underground storage tanks and abandoned well heads.

Threats

Increased groundwater withdrawal to meet the demands of a growing population or water-demanding industries is a threat. Despite a general abundance of groundwater in the watershed, there is growing concern about the availability of good quality groundwater for municipal, industrial, agricultural and domestic use, while maintaining natural flow regimes 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. Extensive drainage in parts of the watershed, for example in the Gun River plain, has lowered the groundwater level by several feet. The reduction in infiltration alters the hydrology of surface water causing increased flooding and streambank erosion.

Groundwater contamination can often be linked to land use. What goes on the ground can seep through the soil and turn up in drinking water, lakes, rivers, streams and wetlands. Activities in urban areas that pose significant threats to groundwater quality include industrial and municipal waste disposal, road salting, and the storage of petroleum products and other hazardous materials. In rural areas, different threats to groundwater quality exist such as animal waste, septic systems, fertilizers and pesticides. Table 17 lists common groundwater contaminant sources.

Table 17. 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	Nitrate, phosphorus
Households	Hazardous materials
Manure handling	Nitrate, pathogens
Gas stations	Hydrocarbons, solvents
Home fertilizer	Nitrate, phosphorus
Auto repair shops	Hydrocarbons, solvents
Septic systems	Nitrate, 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	Nitrate, pathogens
Industrial floor drains	Hydrocarbons, solvents

Contaminated sites come either under the jurisdiction of federal Superfund program, or under Part 201 of the Natural Resources and Environmental Protection Act, Public Act 451 of 1994, as amended. There are six federal Superfund sites in the watershed: 1) Allied Paper, Inc./Portage Creek/Kalamazoo River (see PCB Contamination Chapter); 2) Auto-Ion Chemicals, Inc.; 3) K and L Avenue Landfill; 4) Michigan Disposal (Cork Street Landfill); 5) Rockwell International Corp; and 6) Roto-Finish Co., Inc. As of 1994, there were 84 "Part 201" sites (State Superfund) in Kalamazoo County and 41 in Allegan County. As of 1995 there were also 143 and 49, respectively, identified leaking underground storage tanks in those counties. It is not known how many of these sites are introducing contaminants to surface waters; all certainly have the potential to pollute ground water.

7.4. Loading to Lake Michigan

In addition to water sampling in recent years, the USGS and MDEQ evaluated potential trends for 28 water quality constituents (physical properties, major ions, nutrients, bacteria, pH and alkalinity, and suspended sediments) for selected National Stream Quality Accounting Network stations in Michigan (Syed and Fogarty, 2005). Data were collected from 1973 to 1995 from the Kalamazoo River, among others. The Kalamazoo and Muskegon Rivers showed significant positive trends (increasing concentrations) in nitrogen compounds. Due to data and analysis method limitations, the Clinton River was the only river that could be analyzed for phosphorus trends; it showed a significant negative trend in total phosphorus concentration.

Lake Michigan phosphorus levels are not in excess of GLWQA in-lake goals despite loading from tributaries. Much attention is placed on nearshore filamentous algal blooms caused by altered nutrient dynamics, suspected to be the result of the invasive zebra mussel and now its relative the quagga mussel, which has replaced zebra mussels in Lake Michigan since 2005. Nearshore algal increases in recent years are likely caused by a combination of factors which may include changes in pollutant loading from the land as well as changes in the Great Lakes food web.

8. Development of the Kalamazoo River Watershed Management Plan

This Watershed Management Plan was developed utilizing 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;
- attending meetings of various watershed partners;
- supporting MDEQ modeling efforts:
- developing and interpreting models for the project; and,
- reviewing existing models and trends.

8.1. Public Input and Stakeholder Concerns

The results from previous public summary documents (1998 Remedial Action Plan and more recent Area of Concern documents, TMDL Implementation Plan), public forums (2005 Watershed Summit, 2007 Watershed Technical Summit), steering committee meetings (quarterly TMDL Steering Committee, infrequent TMDL Technical Committee, project Technical Committee, and TMDL Strategy Committee), and occasional attendance at subwatershed planning meetings (Gun, Rabbit, Four Townships, Portage & Arcadia Creeks, Davis Creek, Kalamazoo Stormwater Partners, and Battle Creek Areas Clean Water Partners) were utilized to identify current watershed issues and priorities. Further, during the planning process, several methods were used to engage stakeholders and invite input. These methods included a website with draft documents and feedback instructions, online videos describing the planning effort, repeated email communications to interested citizens and groups on watershed topics through the "watershed communications center", mentions of the watershed planning project during public speaking opportunities and public involvement projects (annual Kanoe the Kazoo, Carp Derby, Super Soils Saturday, trash cleanups, professional talks like 2007 State of Lake Michigan conference). Finally, subwatershed stakeholders and organizers have identified known or perceived issues within the subwatersheds documented in the plans and processes referenced in Table 1.

The KRWC maintains a website and library of watershed information often in both print and electronic formats (contact krwc@kalamazooriver.org for details or see www.kalamazooriver.org).

Public comment was invited on the draft final plan for one month in January of 2011using our e-mail list of over 350 watershed partners and a summary of feedback is included in Attachment 10.

8.2. Water Quality Evaluation: Linking Pollutant Loads to Water Quality

As is the case for most watersheds, water quality is impacted by many factors. The ways in which we use and alter land in the watershed can have a direct impact on the water that runs off into lakes, streams and wetlands. Associated with the project, the MDEQ analyzed the hydrology of the Kalamazoo River watershed as well as the Dickinson Creek subwatershed. The Project team also conducted extensive modeling to calculate watershed loading, buildout, and future loading scenarios and associated costs.

MDEQ Hydrologic Studies In Brief

Kalamazoo Hydrologic Study

The Kalamazoo River Watershed Hydrologic Study (MDNRE, 2008a) was conducted by the Hydrologic Studies Unit (HSU) of the Michigan Department of Environmental Quality (MDEQ) to better understand the watershed's hydrologic characteristics. Study link: http://www.michigan.gov/documents/deq/lwm-nps-kalamazoo_229438_7.pdf

Key finding - Hydrologic characteristics of the watershed were evaluated to provide a basis for stormwater management to protect streams from increased erosion and flooding and to help determine the watershed management plan’s critical areas. The 50 percent chance (2-year) 24-hour storm is used in the hydrologic modeling. Relatively modest, but frequent, storm events, such as the 50 percent chance storm, have more effect on channel form than extreme flood flows. Unless properly managed, increases in runoff from 1- to 2-year storms increase channel-forming flows, which increase streambank and bed erosion as the stream enlarges to accommodate the higher flows. Flashiness increases have been identified at seven USGS gages in the Kalamazoo River watershed.

Dickenson Hydrologic Study

This study (MDNRE 2008b) analyzed Dickenson Creek. Study link:
http://www.michigan.gov/documents/deq/lwm-nps-dickinson_265808_7.pdf
Key finding - The hydrologic analysis indicates channel-forming peak flows have been declining, but may increase in the future due to urbanization and the associated imperviousness. Morphologic analysis of the stream at Michigan Avenue indicates moderate to high bank erosion potential and that the stream’s power exceeds the resistance of most of the channel bed material, also indicating potential erosion.
The stream channel may be adapting to a higher flow regime, or the results may be distorted by excess sand load from construction in the area. Morphologic analysis of the stream near the mouth indicates low to high bank erosion potential and that stream power approximately equals the resistance of most of the channel bed material, indicating approximate equilibrium. The most actively eroding reach is apparently an isolated problem, but the meander cutoffs that occurred during 2008 illustrate the potential rate of the stream’s response to erosive flows.

If not properly managed, runoff from future development in the middle and lower watershed has the potential to increase channel-forming peak flows, the duration of channel-forming flows, and the frequency of those flows because the impervious areas may, by themselves, generate higher peak flows than the entire watershed would have previously. Protecting this stream from both higher flows and longer durations of channel-forming flows is important to prevent destabilizing the stream channel. Unless the increased runoff can be mitigated by infiltration or reuse, extended duration of higher flows is likely.

Watershed Runoff, Buildout, Phosphorus TMDL, and Cost Analysis

In order to characterize and evaluate the potential impacts from land use change in the Kalamazoo River Watershed, modeling efforts were conducted in conjunction with this watershed planning process, including:

- Land use summary
- Buildout Analysis and Urban Cost Scenarios (Kieser & Associates (K&A), LLC, Attachment 3)
- Buffer Analysis (K&A, Attachment 7)
- Stormwater BMP Tool and Guide (K&A, Attachment 8 printout of Microsoft Excel 2007 spreadsheet tool worksheets; available online for download from www.kalamazooriver.org)

Overall Land Use

The overall land use breakdown by category in the Kalamazoo River Watershed was generated for consideration and use in additional modeling exercises and is summarized in Table 3 (see Attachment 3 for full methodology). The land use distribution was calculated using the most recent land use data layer available from the Michigan Geographic Data Library (IFMAP 2001 (Integrated Forest Monitoring Assessment Prescription) land use/land cover dataset downloaded from: http://www.mcgi.state.mi.us/mgdl/?rel=ext&action=sext). Agriculture (including row crops, orchards and pasture) comprises nearly half of the land cover in the watershed with over 615,000 acres. Second to agriculture are forest covered lands. Over one fifth of the land area in the watershed is classified as forested. This unique make up of land uses in the watershed was used to determine sources of the highest runoff volumes and pollutant loads.

Subwatershed Management Unit Land Use

Land use was also broken down at the subwatershed level in order to prioritize runoff and loading from specific contributing streams. Table 4 shows the land use breakdown by category for selected subwatersheds of the Kalamazoo River Watershed. The distribution of land uses in these subwatersheds can be substantially different from the watershed-wide distribution. Subwatersheds such as Portage-Arcadia Creeks, Mainstem 3 Corridor (M3C), Greater Battle Creek, and Davis Creek have a much higher percentage of urban land uses. The Battle Creek River, Rice Creek, and Rabbit River subwatersheds have substantial land areas used for agriculture. These land use distinctions at the subwatershed level help inform this WMP when selecting appropriate types of management practices for restoration and protection.

Table 5 shows a similar land use breakdown for the areas designated as Zone A, B and C (see Figure 3). These zones are areas within the Kalamazoo River Watershed that are not currently covered under an approved watershed management plan. The land use distribution shows limited urban or suburban development within any of these zones. The main land use in these areas is agriculture, followed by forested land cover. Each of the zones has anywhere from 13% to over 20% wetland coverage as well.

Lake Allegan/Kalamazoo River Phosphorus Total Maximum Daily Load

One of the major water quality problems in the Kalamazoo River watershed is nutrient enrichment of Lake Allegan, a 1,650-acre impoundment on the Kalamazoo River mainstem west of the City of Allegan. The lake sits approximately 30 miles upstream of Lake Michigan. The problems in Lake Allegan 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 carp. Due to these impairments, in 2001 the MDEQ developed a Total Maximum Daily Load (TMDL) for total phosphorus for the entire watershed upstream of Lake Allegan. An average in-lake total phosphorus concentration of 60 micrograms per liter (*u*g/L, or ppb) was set for Lake Allegan for the period April to September (MDEQ, 2001). Due to settling of phosphorus in the lake, the concentration goal was recognized as 72 *u*g/L in the river where it flows under M-89 representing the inlet of the lake. In addition to the total phosphorus concentration goal in the lake, the TMDL established other water in-lake quality goals listed in Table 18.

Table 18. Additional in-lake water quality goals established as part of the Lake Allegan TMDL (source: DEQ 2001).

Parameter	Desired Attribute/Goal	2001 Condition (in Lake Allegan)
Chlorophyll a	30 *u*g/L (Apr-Sept average)	67 *u*g/L (average Apr-Sept, 1999)
Dissolved Oxygen	5 mg/L (daily minimum)	3.1 mg/L (daily minimum)
Secchi Depth (Transparency)	3.5 feet (Apr-Sept average)	2 feet (Apr-Sept average)
Carp/Catfish	30% (community average)	87% (community average)

The TMDL also stipulates the monthly loads for point sources and non-point sources measured at M-89 in order to meet the in-lake phosphorus goal for Lake Allegan. Point sources were given a collective, monthly waste load allocation of 8,700 pounds per month of total phosphorus from April-June each year and 6,700 pounds per month of total phosphorus from July-September. For the non-point sources, a load allocation was set which limits monthly total phosphorus to 9,800 pounds of total phosphorus from April-June and 4,088 pounds of total phosphorus from July-September (the load allocations include the following sources: all upstream non-point sources, Dumont Creek loads, immediate drainage to Lake Allegan, and precipitation). A breakdown of the allocations, including a margin of safety, is included in Table 19.

Table 19. Monthly TMDL total phosphorus loading goals under the load allocation for non-point sources and wasteload allocation for point sources to Lake Allegan (source: DEQ, 2001).

	Monthly Goal for April-June Period	**Monthly Goal for July-September Period**
Load Allocation (NPS):	(Pounds of Total Phosphorus)	
Dumont Creek	96	34
Immediate Drainage	62	62
Precipitation	42	42
Kalamazoo River (Inlet)	9,600	3,950
Load Allocation Total	9,800	4,088
Waste Load Allocation (PS)	8,700	6,700
Margin of Safety	100	50
Total Monthly Load Goal	**18,600**	**10,838**

Empirical Loading Model and Buildout Related to the Phosphorus TMDL

K&A conducted empirical runoff and loading modeling for the entire Kalamazoo River watershed in order to determine which areas contribute disproportionate nutrient and sediment loads. Modeling methodology and additional build-out results are presented in a technical report in Attachment 3. Generally, the Long Term Hydrologic Impact Assessment (LTHIA) tool was used to generate loading estimates.

Assuming that no new BMPs or low impact development practices are used in the future, K&A modeled the predicted phosphorus loading in 2030. The predicted increase was estimated using the Land Transformation Model land use layer for Michigan that predicts future land use change based partly on population growth (see Attachment 3 for full details on the Land Transformation Model). Results showed an increase in non-point source total phosphorus loading to Lake Allegan by almost 3,000 pounds per month. If this predicted growth occurs without new requirements for on-site stormwater controls, the necessary load reductions to meet the TMDL will greatly increase. By 2030, non-point source total phosphorus loads would have to be reduced by over 7,100 pounds per month from April-June and 12,800 pounds per month from July-September. Figure 22 shows both 2001 and 2030 non-point source total phosphorus loading as a monthly average and compares it to TMDL goals.

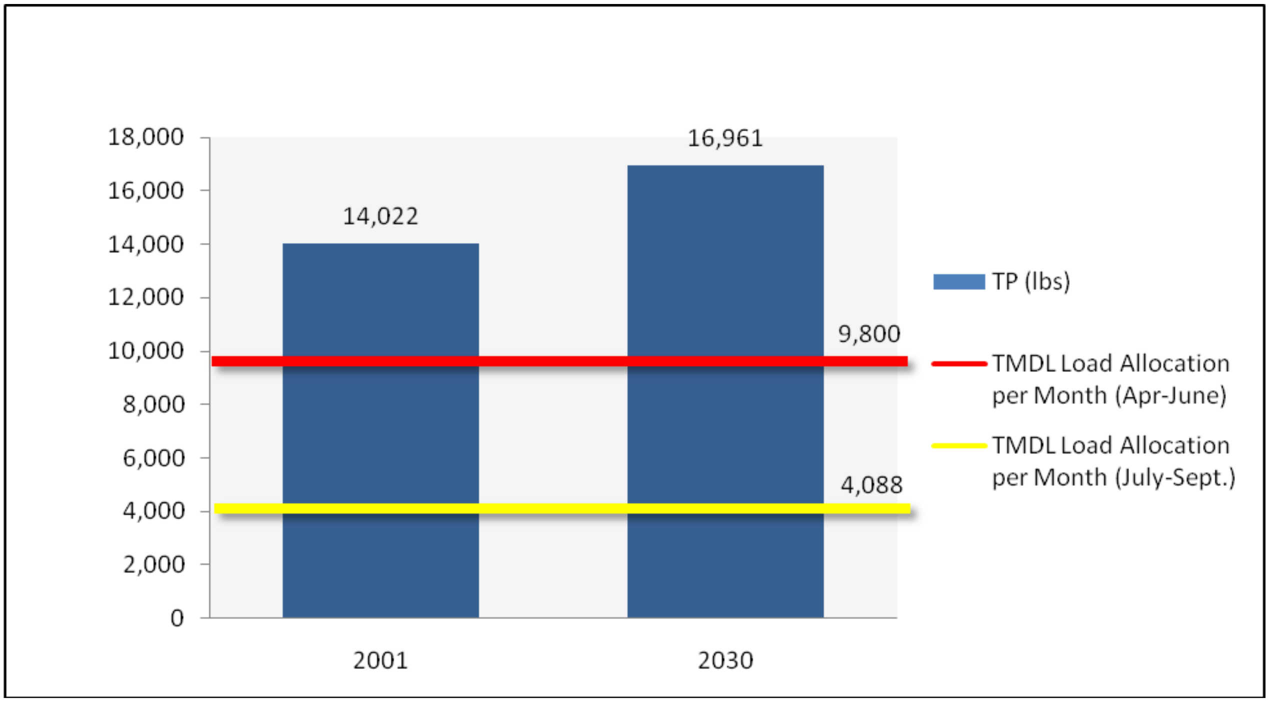


Figure 22. Comparison of non-point source total phosphorus loading from 2001 and 2030 land uses for the Lake Allegan TMDL Watershed (see Attachment 3).

The increase in pollutant loads is directly related to the predicted urbanization of the watershed by 2030. K&A compared the future land use breakdown with the 2001 land use breakdown. Figure 23 shows the percentages of each land use for 2001 and 2030 for the entire watershed.

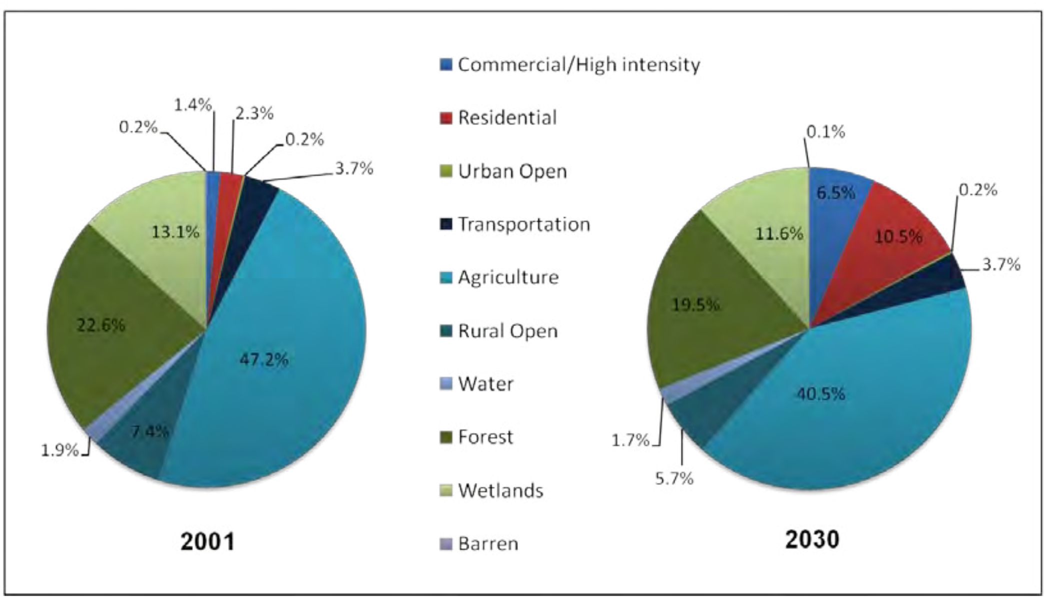


Figure 23. Comparison of land use distributions in 2001 and 2030 by percentage (see Attachment 3).

Figure 23 depicts notable increases in the following urban land uses:

- Commercial/high intensity urban (increase from 1.4% to 6.5% of the watershed)
- Residential/low intensity urban (increase from 2.3% to 10.5% of the watershed)

These predicted urban land uses will likely replace agriculture, forests and wetlands in 2030. These current land covers, which generally have a much lower pollutant loading on a per acre basis when compared to urban land uses, exhibit the following watershed-wide decreases by 2030:

- Agriculture is predicted to decrease by 6.7%
- Forests are predicted to decrease 3.1%
- Wetlands are predicted to decrease by 1.5%

A summary of the runoff and associated pollutant loading for 2001 and 2030 is shown in Figure 24. Runoff and total phosphorus show the greatest increase by percentage from 2001 to 2030. Modeling results show that overland runoff, often in the form of stormwater, will have a major impact on the watershed if left untreated. Current watershed pollutant loading is projected to increase by 12% for sediments and 26% for total phosphorus, resulting primarily from the increase in urban land use (see Figure 7 in Attachment 3). For this reason, urban and suburban areas remain critical for the implementation of retrofit and new Best Management Practices (BMPs). Stormwater runoff volumes are projected to increase by 25% which could have major impacts on small streams and tributaries to the river as a result of increased erosion and scour and decreased aquatic habitat. **It will be critical that undeveloped, rural areas enact ordinances and regulations for stormwater management.**

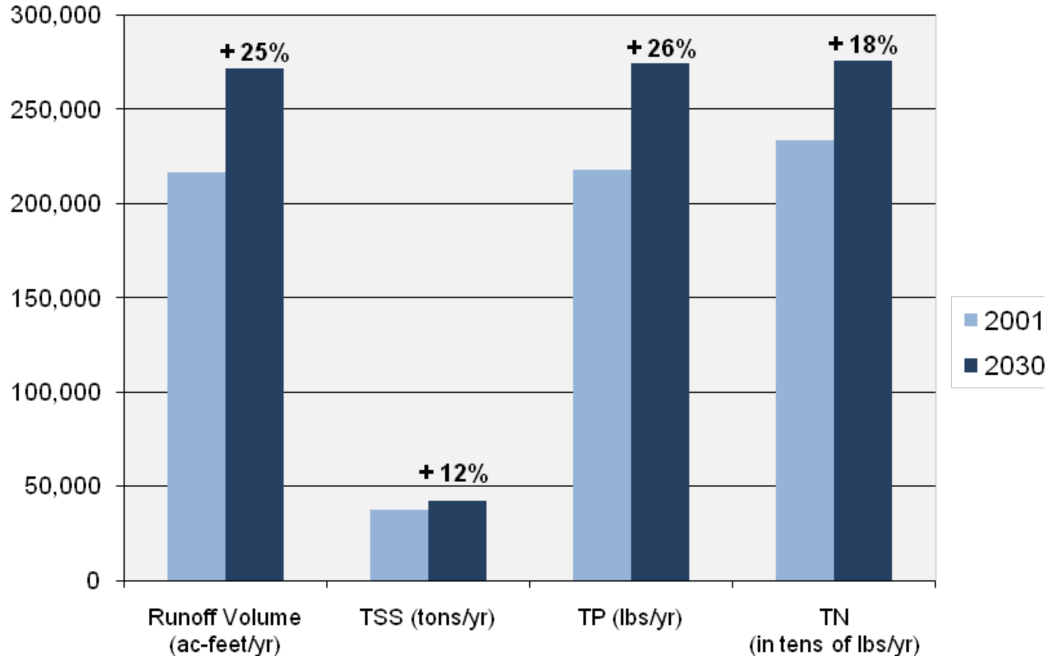


Figure 24. Current (2001) runoff, total suspended solids (TSS), total phosphorus (TP) and total nitrogen (TN) loading and predicted increases in 2030 (see Attachment 3).

Future Phosphorus Loads

The phosphorus loading associated with each land use category for both 2001 and 2030 is shown in Figure 25. These values are an indicator of potential sources and causes of excess phosphorus loading at the watershed scale. In 2001, the two major sources of phosphorus are linked primarily to urban land use and agriculture. Impervious surfaces like roads and parking lots are the highest single source of loading in both 2001 and 2030. By 2030, urban land use is predicted to increase exponentially, while loading from agriculture may decrease slightly. The build-out report has watershed maps that show sources of total suspended solids, total nitrogen and runoff volume in 2001 and 2030 (Attachment 3, Appendix B). Land use change by category for each township is also included in the report (Attachment 3, Appendix A).

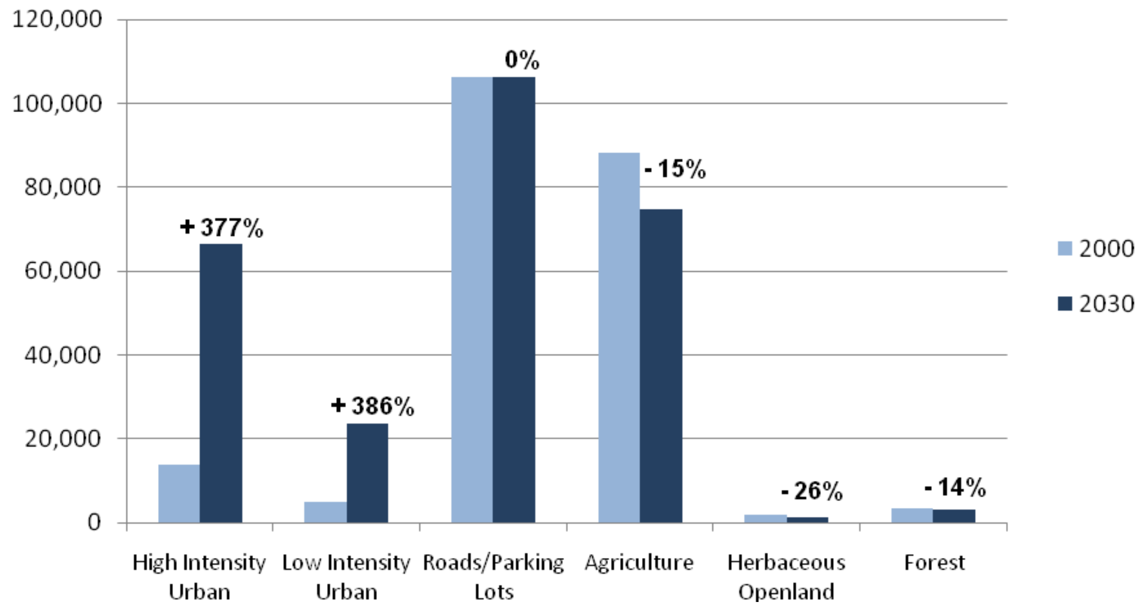


Figure 25. Sources of total phosphorus loading (in lbs/year) per land use in the Kalamazoo River Watershed in 2001 and 2030 (see Attachment 3).

Implications By Jurisdictional Boundary

The increase in urban land cover and pollutant loading is most relevant at the jurisdictional boundary level. Jurisdictions such as townships have authority to pass regulations and ordinances to manage stormwater runoff from future growth and the associated pollutant load. For this reason, the K&A build-out report provides a land use breakdown for 2001 and 2030 for each township and/or city in the watershed (see Attachment 3). In terms of the greatest overall impact at the entire watershed scale, the ten townships that are predicted to have the greatest increase in urban land use growth are presented in Table 20. Currently, these townships generally have a strong agricultural and rural character. They do not fall under federal stormwater regulations and therefore do not currently have a legal mandate to develop policies to require stormwater controls for new development.

Table 20. Sources of total phosphorus loading (in lbs/year) per land use in the Kalamazoo River Watershed in 2001 and 2030 (see Attachment 3). These townships have the highest predicted urban land use growth.

Township	Total predicted increase in urban areas (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 26, except for Marengo Township which is located east of the City of Marshall.

Townships in the western portion of the watershed, primarily Allegan County, are generally predicted to build out most significantly due to their proximity to key features like Lake Michigan, proximity to urban centers, road infrastructure, and proximity to natural areas (e.g., Allegan State Game Area) (Figure 26).

Townships listed in Table 21 show increases in runoff that account for between 3.2% and 5.1% of the total predicted increase in runoff watershed-wide indicating that the overall watershed is substantially impacted by these key townships. These townships also show substantial potential increases in other non-point source loading if no BMPs or stormwater controls are put in place with the predicted growth. Total suspended solids are predicted to increase by 155 to almost 250 tons per year per township. Total phosphorus is predicted to increase by 1,800 to 2,900 pounds per year per township. Total nitrogen is predicted to increase by 14,500 to over 23,000 pounds per year per township. For all of the components listed in Table 21, these townships collectively comprise over 25% of the increases expected on a watershed-wide basis for runoff, solids, phosphorus and nitrogen.

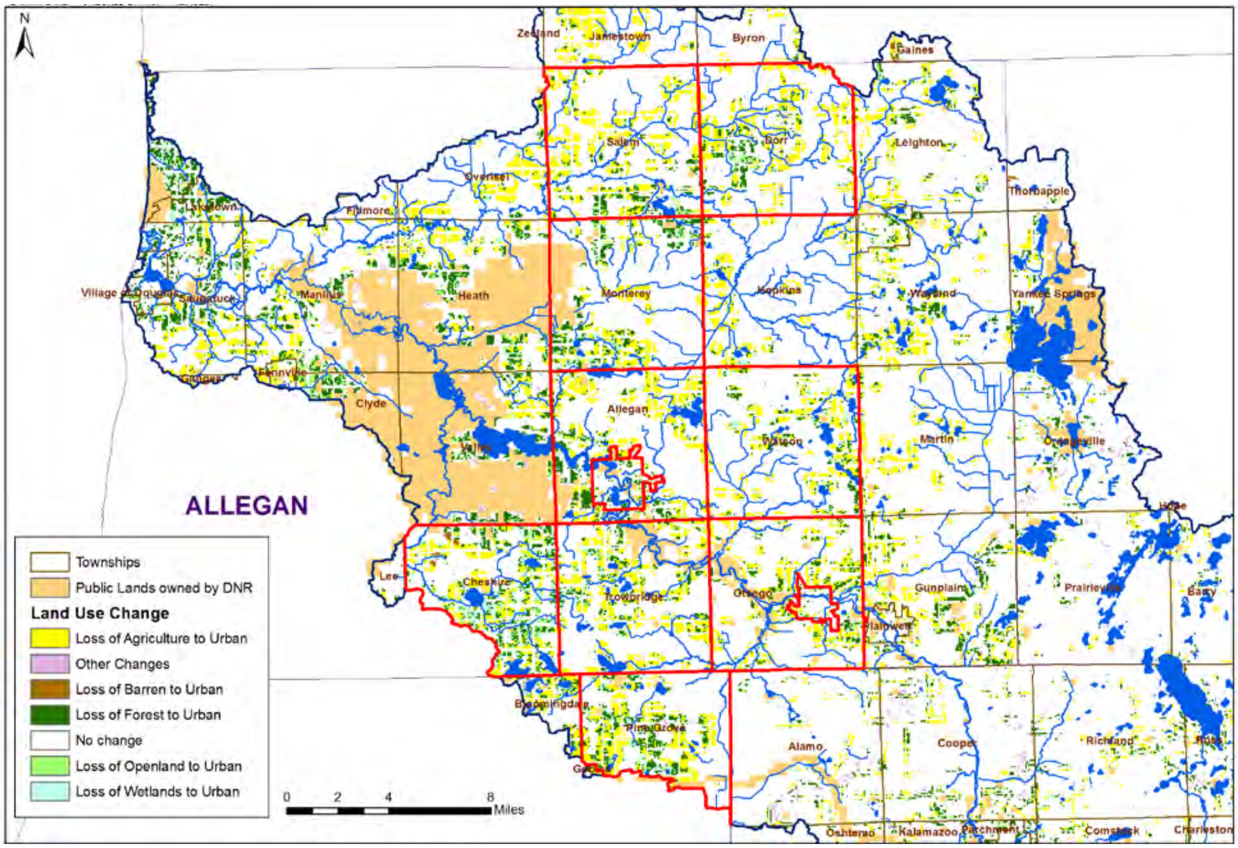


Figure 26. Townships with the greatest predicted increase in urban land cover by 2030 are outlined in red and include Cheshire, Salem, Trowbridge, Pine Grove, Allegan, Dorr, Otsego, Monterey, and Watson (see Attachment 3).

Table 21. Townships predicted to have the greatest increase in runoff and pollutant loads as a percentage of the increases predicted watershed-wide (see Attachment 3).

	Runoff		**TSS**		**TP**		**TN**	
Township 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	2,782	5.1	249	5.7	2,900	5.2	23,080	5.5
Salem	2,217	4.0	151	3.4	2,330	4.2	15,238	3.7
Trowbridge	1,920	3.5	154	3.5	1,916	3.4	13,932	3.3
Dorr	1,844	3.4	133	3.0	1,894	3.4	12,748	3.1
Allegan	1,848	3.3	155	3.5	1,884	3.4	14,089	3.4
Heath	1,697	3.1	150	3.4	1,856	3.3	14,601	3.5
Monterey	1,772	3.2	155	3.5	1,861	3.3	14,500	3.5

Note: “Percent of total change” categories represent the total change on a watershed-wide basis.

Costs of Overall Stormwater Treatment Scenarios

In order to characterize the necessary load reductions to meet TMDL water quality goals and the associated costs, two approaches were used for the watershed management plan. First, as part of K&A’s empirical modeling efforts, stormwater control costs were analyzed (see Attachment 3 for full details). The stormwater cost analysis provides a fixed estimation of the costs associated with a number of watershed scenarios, while the BMP tool allows users to enter in site-specific information so they can quickly calculate expected non-point source loading from: a) specific land uses; b) load reductions associated with user-selected BMPs; and, c) the approximate costs associated with the BMPs.

K&A completed a simple cost analysis as an additional illustration for decision-makers to emphasize the importance of implementing stormwater runoff controls and policies as early as possible to meet both TMDL load allocation goals and protect overall water quality. **Modeling results indicated that the trend in the Kalamazoo River watershed by 2030 will be that largely rural townships and smaller municipalities will experience more rapid growth than the larger cities that have already experienced substantial build-out.** The purpose of the cost analysis was therefore intended to capture: 1) current costs to reduce phosphorus loading by half to satisfy TMDL goals; and, 2) future predicted costs to reduce future phosphorus loading, if urban growth continues with no stormwater controls.

The assumptions used in the simple analysis are listed in Attachment 3. Three scenarios were developed to determine costs for phosphorus reductions in the Kalamazoo River watershed:

1) Stormwater ordinances are passed for the entire watershed now that require all new development to build on-site treatment. In this scenario costs to a municipality represent only those required to retrofit current stormwater sources with BMPs to reduce 2001 loading levels by 50% for TMDL requirements;
2) Municipalities must assume costs to reduce their 2030 loading by 50% (this represents a theoretical municipal stormwater regulation); and,
3) Municipalities in 2030 under the TMDL must assume costs to reduce their 2001 loading by 50% (like scenario 1), in addition to offsetting any new loading since 2001.

Scenario 1 was developed to show stakeholders the lowest possible stormwater treatment costs, which is treating 50% of the 2001 loading. This scenario assumes that a municipality currently has a stormwater ordinance in place which requires all new development to treat stormwater on-site (e.g., City of Portage or Oshtemo Township). Scenario 2 was developed to show potential future stormwater costs primarily for areas not under the phosphorus TMDL. This scenario assumes no stormwater ordinance is in place and that future stormwater regulations (in 2030) require the municipality to reduce 50% of their loading. It is important to note this scenario falls short of compliance with the Lake Allegan/Kalamazoo River TMDL. The third scenario was developed to show how the cost of stormwater treatment exponentially increases if no stormwater ordinances are enacted by 2030. The scenario assumes a municipality is required to reduce their loading to 50% of their 2001 loading level (which is compliant with the current requirements of the phosphorus TMDL). This would be in addition to offsetting any new loading since 2001.

The cost results from these three scenarios are shown in Figure 27.

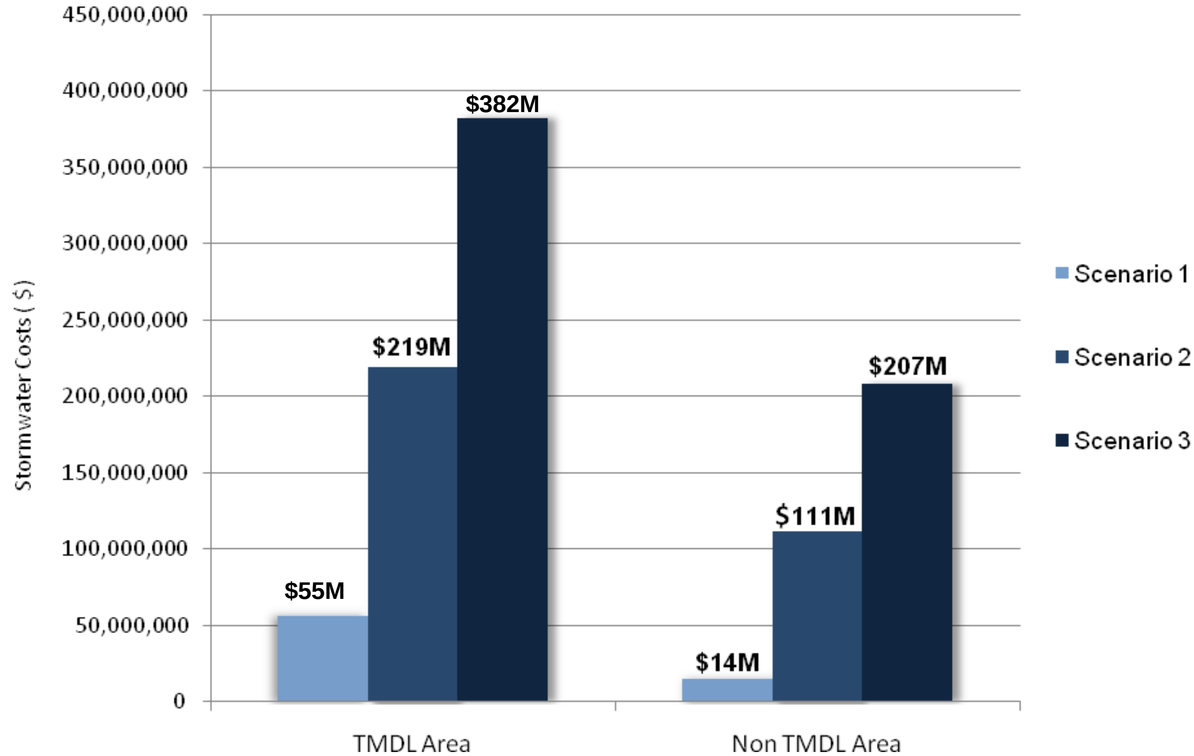


Figure 27. Increasing cost for all municipalities in each area (in millions of 2010 dollars) for stormwater controls to treat phosphorus to the levels specified in each scenario for both Lake Allegan TMDL area and non-TMDL areas (downstream of Lake Allegan) (see Attachment 3).

In general, cost analyses show that stormwater retrofits in 2030 would cost municipalities on average almost seven times the cost of controlling stormwater in such a way that would hold loading at the 2001 level. This difference represents the potential cost savings that would be realized if a stormwater ordinance were enacted that would require all new development to infiltrate or treat stormwater on-site. In contrast, municipalities such as the City of Portage and Oshtemo Township that have already passed stormwater ordinances will have limited to no new phosphorus loading from future build out and therefore no additional costs. **In terms of the existing phosphorus TMDL, it is important to note that this limited analysis only calculates costs associated with commercial/ high intensity urban loading and not other sources of nonpoint source runoff and pollutant loading (such as low intensity land use), while municipalities that are regulated under the municipal separate storm sewer system permit (MS4) 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 residential/low intensity land use, which may result in increased storm sewer infrastructure costs, substantial increases in future loading and thus, future retrofit costs that would otherwise have been borne by private developers if stormwater ordinances were in place now.**

Stormwater Treatment Costs By Jurisdiction

As an example of how stormwater treatment costs will affect specific jurisdictions, Table 22 shows the stormwater costs associated with each scenario for specific municipalities. For the smaller municipalities not subject to MS4 permit requirements (Allegan, Marshall, Otsego and Plainwell) listed in the table, stormwater costs from Scenario 1 to Scenario 3 more than double. This table can also be used to understand the potential cost savings for cities if they were to implement stormwater control regulations now rather than waiting until 2030 to meet TMDL loading goals. For townships listed in Table 22, the cost differentials between Scenario 1 and Scenario 3 are much greater than for the cities because major cities are effectively already built out. The median increase in cost is almost 14 times greater for the townships when compared to implementing an ordinance now. Trowbridge Township, which has a substantial portion of its land area draining to Lake Allegan and falls under the TMDL, shows an increase in costs by almost 40 times between Scenario 1 and 3.

Table 22. Stormwater control scenarios in cities and townships with high stormwater treatment costs related to increases in urban loading from new development projected for 2030 (see Attachment 3).

Name	TP Load (lbs/yr)		Cost of Stormwater Controls ($)		
	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

Note: None of the cost scenarios are adjusted for inflation or discounted in any way.

Kalamazoo River Urban Stormwater BMP Screening Tool

In addition to the fixed load reduction and stormwater cost analysis in the build-out report (Attachment 3), the Kalamazoo River Urban Stormwater BMP Screening Tool (K&A, 2010b) was designed to assess urban non-point source BMP applications for any critical area in the watershed. It provides preliminary pollutant loading and runoff reductions with the associated long-term costs. Attachment 8 includes printed copies of the spreadsheet tabs.

Under Tab A the user must select the township or city where the critical area is located. This loads the specific precipitation value for the selected jurisdiction. The tool provides the flexibility to enter the specific land use categories that make up the critical area or the user can select pre-defined land use breakdowns for specific cities and townships by using the look-up table. The tool also allows the user to enter a user-defined percentage imperviousness factor or use the default value for each land use. Once the land use is entered in acres, the pollutant loading for total phosphorus, total suspended soils and runoff volume is populated.

Under Tab B the user must enter the acreage of the critical area that is being treated by a particular BMP. Five urban stormwater BMPs have been loaded into this first version of the tool. These BMPs include:

- Grass Swales
- Extended Dry Detention Basin
- Wet Detention Basins
- Rain Gardens
- Constructed Wetlands

These BMPs were selected after researching available data for different urban stormwater BMPs. The efficiencies and associated costs for these BMPs were readily available and sufficient research was available to assure the data were reliably accurate. In addition, these BMPs are commonly used in the Kalamazoo River Watershed and generally recommended in this watershed management plan to reduce stormwater impacts.

Once the data are entered into Tab B, a future loading (or post-BMP implementation) breakdown is populated for total phosphorus, total suspended solids and runoff volume for the critical area. In addition, a detailed breakdown of costs is included for each BMP. The estimated cost breakdown includes the average cost per unit of load or volume reduction, the BMP base cost, engineering and planning/landscaping cost, and a total BMP costs.

While the BMP tool directly provides an estimate of the current loading from a particular critical area and the associated load reductions and costs for selected stormwater BMPs, the tool can be used in a number of different ways. Guidance on the different applications of this tool and instructions on how to apply them are included in

Attachment 8. The following applications have been identified for using the tool to assess the restoration or conservation of critical areas to:

- Calculate general stormwater treatment costs in a critical area
- Selectively calculate runoff, total phosphorus and sediment loading from specific portions of a township or city and estimate BMP implementation costs (for example, on a project-by-project basis)
- Compare and select the most cost-effective reductions by testing and screening different BMPs
- Track progress toward TMDL non-point source load allocation goals using installed BMPs in a critical area or throughout a jurisdiction
- Calculate BMP costs to reduce current total phosphorus load in order to comply with water quality standards or the TMDL
- Assess potential future loading (or "prevented" future loading) from a critical area (e.g., to determine potential future benefits of conservation easements on critical natural areas)

This tool was developed as a framework for calculating loading reduction and BMP costs for critical areas or other target areas. The tool has unlimited potential for adding additional urban stormwater BMPs if data are available. Individual stakeholders can apply this tool to their critical area to determine current and "future" loading (by simply changing the land use distribution). The tool allows stakeholders to explore the pollutant loading and runoff reductions from different recommended preventative and restorative BMPs.

Other Stormwater Loading Tools

Another loading/BMP tool that is available in the Kalamazoo River watershed, but was developed separately from this project, is NutrientNet. Technical service providers from the Calhoun and Allegan Conservation Districts have used this online tool in a past project to calculate load reductions from agricultural BMPs. The tool provides a long list of agricultural BMPs that are recommended by NRCS (http://kalamazoo.nutrientnet.org). A preliminary user's manual has been developed for NutrientNet and is available from the Gun Lake Tribe. This tool can also be used to calculate nutrient and sediment reductions from a limited number of common stormwater BMPs (extended dry detention, wet detention, retention and swales). The tool does not have the capability to estimate BMP costs like the Kalamazoo River Urban Stormwater BMP Screening Tool can.

One feature that NutrientNet offers that could be utilized by watershed stakeholders is the BMP tracking tool. This easy-to-use feature allows individuals to submit completed BMP projects to an administrator. The administrator can then upload all non-point source BMPs along with the associated pollutant reduction information. The tool tracks cumulative reductions on an annual basis at the subwatershed and watershed level. Because this tool has already been developed, it is the preferred tracking tool for load reductions in the Kalamazoo River Watershed at this time. A system that allows individual users to submit projects is ideal in such a large watershed. The administrator role allows for checking of data and a centralized entity to ensure quality control and disseminating data to the entire watershed. As of September 2010, the tool is administered by the Gun Lake Tribe. More information about the Targeted Watershed Grant Project is available at http://www.envtn.org/Kalamazoo_River_Wtrshed.html.

9. Prioritization - Areas, Pollutants, Sources

Priority areas were identified in the watershed based on the areas that are contributing, or have the potential to contribute, non-point source pollution at rates that are disproportionate to their area in a watershed. As discussed in Section 7.2 above, our focus is on nutrients, sediments, pathogens, and in coldwater streams, temperature. While both nitrogen and phosphorus are necessary ingredients for eutrophication (i.e., excessive algal and plant growth), phosphorus tends to be the key limiting factor in low-nutrient, high-quality waters of the region, so here we emphasize phosphorus. However, control of nitrogen is also worthwhile, as excess nitrogen can be involved in eutrophication of wetlands and presents a health hazard in drinking water supplies in the form of nitrate. Fortunately, many of the measures to mitigate phosphorus loading also help reduce nitrogen loading to surface waters, although nitrogen is capable of traveling much longer distances through groundwater flow paths.

There are many ways to approach the problem of non-point source pollution, and in fact a multi-faceted approach is imperative in a watershed as complex as that of the Kalamazoo River. Yet prioritization is necessary given limitations in funds and human resources to take on the problem. By identifying priority areas, implementation can be targeted to the places where the most benefit can be achieved. Naturally, best management practices are best practiced everywhere they can be, but a greater return on investment can be achieved in specific areas where problems are known to be most acute. The scientific literature contains many examples documenting how the majority of the non-point source pollution reaching rivers or lakes can originate from a small fraction of the watershed. Such critical areas are often in close proximity to water bodies, or where hydrological linkages are enhanced via constructed drainage systems (e.g., storm sewers, agricultural land drainage), or where soils and topography facilitate the overland movement of water, sediments and nutrients to water bodies.

In Table 23 we summarize our prioritization of subwatersheds in need of actions to mitigate non-point source pollution.

Table 23. Kalamazoo River Watershed critical areas and uses.

Designated Use		Zone C	Rice, Battle Creek, Dickinson Creeks	Greater Battle Creek	Zone B	Main-stem 3 Corridor	Four Township	Davis Creek	Portage & Arcadia Creeks	Gun River	Rabbit River	Zone A	Lake Allegan
	Predominant Land Cover	Rural-Agric.	Rural-Agric.	Urban-Suburban	Rural-Agric.	Mix	Rural-Agric.	Urban	Urban-Suburban	Rural-Agric.	Rural-Agric.	Rural-Agric.	Mix
	Notes on coverage	Includes Swain's Lake Drain		Includes Crooked Creek					Includes Axtell	Inc. Fenner Creek	Inc. Red Run Drain		
Agri-cultural, Industrial Water Supply, Public Water, Navigation	*Status*	*Met or NA*	*Met or NA*	*Met or NA*	*Met or NA*	*Met or NA*	*Met or NA*	*Met or NA*	*Met or NA*	*Met or NA*	*Met or NA*	*Met or NA*	*Met or NA*
Warm Water Fish	*Status*	*Imp*						*Imp-confluence to Cork St.*					
	Pollutant(s) Causing Impairment(s)	Anthro-pogenic Substrate Alterations, Flow Regime Alterations						Oil and Grease, Petroleum Hydro-carbons					
	Pollutant(s) Causing Impairment(s)												

Designated Use		Zone C	Rice, Battle Creek, Dickinson Creeks	Greater Battle Creek	Zone B	Main-stem 3 Corridor	Four Township	Davis Creek	Portage & Arcadia Creeks	Gun River	Rabbit River	Zone A	Lake Allegan
Other Aquatic Life	*Status*	*Imp – Swain's Lake Drain*		*Imp – Crooked Creek*						*Imp – Fenner Creek and Gun River near Gun Lake*	*Imp – Red Run Drain*	*Imp – unamted tributary*	*Imp – Lake Allegan Water-shed*
	Pollutant(s) Causing Impairment(s)	Anthro-pogenic Substrate Alterations, Flow Regime Alterations		Sediments & Siltation						Both - Anthro-pogenic Substrate Alterations, Flow Regime Alterations, Fenner - Sediments & Siltation	Cause Unknown, Direct Habitat Alteration, Flow Regime Alterations, Sediments & Siltation	Anthro-pogenic Substrate Alteration, Flow Regime Alteration	Excess Algal Growth, Phos-phorus (Total)
Partial Body Contact	*Status*							*Imp-confluence to Cork St.and from Cork St. upstream*	*Imp – Axtell Creek and Arcadia Creek*				
	Pollutant(s) Causing Impairment(s)							*E. coli*	*E. coli*				

Designated Use		**Zone C**	**Rice, Battle Creek, Dickinson Creeks**	**Greater Battle Creek**	**Zone B**	**Main-stem 3 Corridor**	**Four Township**	**Davis Creek**	**Portage & Arcadia Creeks**	**Gun River**	**Rabbit River**	**Zone A**	**Lake Allegan**
Full Body Contact	*Status*							*Imp- confluence to Cork St.and from Cork St. upstream*	*Imp – Axtell Creek and Arcadia Creek*				
	Pollutant(s) Causing Impairment(s)							*E. coli*	*E. coli*				

Inc. = includes
Imp = impaired
Purple color = Preservation
Green color = Mitigation
NA = not applicable

Table 23. con't

Overall Quality Scores (3 = best)	**Zone C - Head-waters**	**Rice Creek**	**Battle Creek River**	**Dickinson Creek**	**Greater Battle Creek**	**Zone B**	**Mainstem 3 Corridor**	**Four Townships**	**Davis Creek**	**Portage & Arcadia Creeks**	**Gun River**	**Rabbit River**	**Zone A - Lower river**	**Lake Allegan**
Quality Natural Areas	2	2	2	2	2	3	2	3	2	2	2	2	3	NA
Quality of Hydrology High=Stable	3	3	2	3	2	3	2	3	1	1	2	1	2	NA
Quality of Corridor	3	3	2	2	2	3	2	3	1	2	1	1	3	NA
Lack of Urban Pollutants	3	2	2	2	1	3	2	3	1	1	3	3	3	NA
Lack of Development Pressure	2	2	2	1	2	2	2	2	2	2	2	2	1	NA
Lack of Current Agricultural Threats	2	2	2	2	2	3	2	1	2	2	1	1	2	NA
Lack of Wetland Loss	2	2	2	2	2	3	2	3	2	2	1	2	3	NA
Total Quality Score	**17**	**16**	**14**	**14**	**13**	**20**	**14**	**18**	**11**	**12**	**12**	**12**	**17**	**NA**

Purple color = Preservation
Green color = Mitigation

Known impairments are listed, and a scoring system is employed to produce a rough ranking by environmental quality. The subwatersheds with the lowest overall quality scores (green highlight) include the three most urbanized areas (Greater Battle Creek, Davis Creek, Portage & Arcadia creeks) as well as the heavily agricultural Gun and Rabbit rivers. Intermediate quality scores (no highlight) indicate some problems in Rice Creek, the Battle Creek River, Dickinson Creek, and the Mainstem 3 Corridor. The remaining subwatersheds are ranked in the highest quality group (purple highlight). Lake Allegan, whose eutrophication issues are linked to a very large contributing watershed area (Baas 2009), was not ranked in this manner because problems originate upstream from multiple land uses included in agricultural, forest, urban, and other lands.

We elaborate on the rationale for this prioritization below. In all cases the land closest to the water's edge deserves the most attention because the priority pollutants we have identified – phosphorus, sediments, and pathogens – are more likely to reach the water from areas nearby. Thus riparian areas, perhaps as much as 1000 feet in width if specific detail on runoff is not available, define a zone where land use needs to be scrutinized more carefully. Importantly, where urban stormwater or agricultural drainage systems exist, the distance of influence would be longer because runoff can travel long distances with little alteration of its pollutant load.

Land use in riparian areas throughout the Watershed was analyzed for this Plan (See Buffer Analysis in Attachment 7). Using a relatively narrow riparian area width of 50 m (164 feet) on either side of streams and along lake shores, the 2001 land cover data showed that about 3% and 23% of these narrow riparian areas are presently in urban land use and in agriculture, respectively (as a percent of all riparian areas). Estimates of loading based on general models suggest that the 23% of riparian land in agriculture contributes about 40% of the total phosphorus loading to the water bodies from the riparian areas.

The Buffer Analysis also included a modeling scenario analysis in which future land use changes were predicted using an accepted pre-existing model (Land Transformation Model). By 2030 it is predicted that about 8% of the agriculture and unmanaged land will be converted to urban and suburban development in these riparian areas. The consequences of this land use conversion for non-point source pollution are estimated to be quite significant, entailing increases in water runoff and associated loads of sediments, nitrogen, and phosphorus. This analysis underscores the importance of planning for appropriate land uses in the most sensitive lands close to the water's edge.

Table 24 provides a full breakdown of how pollutant loading and runoff to the river system will change when land is converted from natural and agricultural lands to urban. It is important to note that the land use within this riparian area will have a direct impact on water quality as the delivery of runoff and pollutants is very high due to the proximity to surface water. The particular concern for the Kalamazoo River watershed is that by 2030 runoff is projected to increase by over 23% and total phosphorus concentrations by greater than 25%. Nitrogen and sediment loads are also expected to increase as land within the riparian area is developed for urban purposes. These increases can be mitigated by enacting surface water setback ordinances, stormwater retention ordinances, green spaces or corridors, and conservation planning (see section on goals and objectives).

Table 24. Pollutant load comparison between 2001 and 2030 land uses within 100 meter riparian area in the Kalamazoo River watershed (see Attachment 7).

Loading	2001	2030	Change in Value	Percent Change
Runoff (acre-feet/yr)	8,945	11,066	2,121	23.7
TSS (tons/yr)	1,508	1,705	197	13.1
TP (lbs/yr)	8,713	10,950	2,237	25.7
TN (lbs/yr)	96,813	115,717	18,904	19.5

In addition to mitigating future loading impacts through the use of set-backs, green spaces, ordinances and conservation planning, the current (2001) loading to the river from this riparian area can be addressed by incentivizing agriculture to install vegetative buffers along surface waters. This practice is explored further in Attachment 7. A simple cost analysis was conducted by K&A to determine the costs and potential loading benefits from installing vegetative buffers in riparian areas across the whole Kalamazoo River watershed. Three scenarios were tested to determine what the impacts would be from converting 25%, 50%, and 75% of the agricultural land in riparian areas to vegetative filter strips. The results from the analysis are summarized in Table 25.

Table 25. Buffer scenario and cost analysis for agricultural land conversion to grass filter strips (see Attachment 7).

Scenarios							Cost Analysis	
	Agricultural Area Converted to Perennial Grass (acres)	TP Load from Grass (lbs/year) (1)	Original TP Load(1) from Agriculture (lbs/year)	TP Load Reduction from Land Conversion (in 100-m buffer) (lbs/year)	TP Load Reduction from Area Adjacent to Buffer (lbs/year)	Total Load Reduction (lbs/ year)	Implement-ation Costs (in 2009 $) (NRCS) (2)	Estimated Cost per Pound of Load Reduction (in 2009 $)
25%	4,729	121	916	795	1,676	2,471	$2,137,508	$865
50%	9,458	241	1,832	1,591	3,352	4,943	$4,275,016	$865
75%	14,187	362	2,748	2,836	5,029	7,865	$6,412,524	$865

Note:
(1) TP loads in the table above were calculated using average annual loading values (see Attachment 7).

(2) Cost calculations were done using a value of $452/acre for buffer strip installation (2009 communication with Allegan Conservation District).

9.1. Urban/Suburban Mitigation Areas

Urban and suburban areas occupy a relatively small fraction of the Kalamazoo River watershed, but they are very important sources of non-point source pollution to surface waters. This is in part because the largest urban areas are located along the rivers (Battle Creek, Kalamazoo) and rural residential development is often concentrated along lakes and streams. Urban and suburban development brings impervious surfaces, constructed drainage systems, fertilized lawns, waste from pets and geese, leaking septage, etc., all contributing to the non-point source pollution described above. In addition, thermal pollution can occur when runoff from exposed impervious surfaces rapidly reaches streams with coldwater habitat.

Non-point source pollution in the most urbanized watersheds of the Kalamazoo River watershed has already received considerable attention in recent years. Watershed-wide analyses of pollutants can be found in the Build-Out Analysis of this report (Appendix A of that section has maps showing modeling results), as well as in the Fongers (2009) *Kalamazoo River Watershed Hydrologic Study*. These analyses point clearly to the disproportionate contributions of the most urbanized areas (particularly the "metropolitan areas" of Kalamazoo and Battle Creek), and the role of altered hydrology (i.e., the rapid drainage of stormwater into the nearest lake, stream or river). These analyses also show that smaller communities with extensive development (e.g., Wayland) can have important impacts on stream water quality, particularly where the streams are not large. Furthermore, Baas (2009) shows how urbanized areas contribute disproportionately to non-point source phosphorus loads, in addition to their point sources (i.e., permitted municipal wastewater and industrial discharges).

Specific subwatersheds with highly urbanized land cover have already developed their own Watershed Management Plans, and significant progress has been made toward mitigation of non-point source pollution in those areas. These subwatersheds include Portage/Arcadia creeks, Davis Creek, and the Battle Creek River (Table 1, Section 1.4). Nonetheless, non-point source pollution problems persist in these areas, and further attention will be required to follow through on plans and measures that have been charted out through the preparation of these subwatershed Watershed Management Plans. These plans also serve as a valuable guide to how to address problems in comparable urbanized areas that are not presently covered by a watershed management plan. Municipal Separate Storm Sewer System (MS4) permit processes also motivate discussions about how to improve stormwater management in the urbanized parts of the watershed.

Lower density residential development, referred to here as suburban development, also impacts water quality, but we have paid less attention to it in the overall Kalamazoo River watershed. Often such development occurs outside of cities and is variably regulated by township and county governments, with their relative roles varying from one county to another. The recently approved Watershed Management Plan for the Four Township Water Resources Council presents an example of how such development could be dealt with across multiple local governmental jurisdictions (FTWA WMP 2010); in that largely rural area, riparian areas of 1000 feet along lakes and streams were chosen to identify land with the highest priority for mitigation of non-point source pollution. The underlying premise is that most non-point source loading of pollutants originates close to water bodies, which is consistent with our understanding of phosphorus, sediment and pathogen movement in southwest Michigan landscapes. One could argue that the approach taken in that plan could be applied throughout the Kalamazoo River watershed to good effect.

In the urban/suburban mitigation areas, the pollutant sources are prioritized as follows:

1. Stormwater runoff – Hydrologic alterations that promote rapid drainage from urbanized areas result in flashy stream flow. Non-point source pollutants abound in stormwater runoff, largely as a result of abundant impervious surfaces, construction and road maintenance activities, over-fertilization of lawns, pet waste, leaf burning, and a multitude of other sources.

2. Streambanks – Flashy stream flow increases streambank erosion. Removal of natural vegetation also enhances erosion, and lessens the ability of the riparian zone to filter sediments and nutrients from runoff. Increased solar radiation reaching coldwater trout streams due to vegetation canopy removal can undesirably increase water temperatures.

3. Septage and animal waste – Septic systems are suspected to be a source of nutrients and pathogens in lake areas lacking municipal sewer services. In addition, though uncommon in this watershed, the failure of sewer system infrastructure in urban areas has also led to releases of untreated wastewater. Waste from pet dogs and wildlife frequenting urban parks (e.g., Canada Geese and ducks) is another source of nutrients and pathogens.

9.2. Rural/Agricultural Mitigation Areas

In general, the contribution of agricultural land to non-point source pollution of nutrients, sediments and pathogens is well understood, although loading rates vary by activity and environmental setting. Disturbance due to tillage and harvest of annual row crops, applications of fertilizers and animal manure, and concentrated livestock operations can all result in enhanced movement of sediments, nutrients, and pathogens to water bodies. Tile drainage and channelization of streams can convey water rapidly to bypass the soil and wetland filters that may once have existed, resulting in enhanced loading to water bodies.

Some subwatersheds with heavily agricultural land use and recognized problems with water quality have, with 319 grant support, already developed their own Watershed Management Plans, and significant progress has been made toward mitigation of non-point source pollution in those areas. These subwatersheds include the Rabbit River, Gun

River, Rice Creek, and the Battle Creek River (Table 1, Section 1.4). As in the case of the urban subwatersheds, these plans point the way for other subwatersheds with similar land use.

The modeling results from the Build-Out Analysis in this report (see Attachment 3) provide an indication of which rural/agricultural subwatersheds deserve the greatest priority for efforts to mitigate non-point source pollution. These results largely support the emphasis placed to date on the aforementioned watersheds: the lower portions of the Kalamazoo River Watershed including the Rabbit and Gun rivers are clearly more important sources of sediments and total phosphorus than subwatersheds with comparable % agricultural land cover in the uppermost parts of the watershed. The Rabbit and Gun rivers, as well as some adjacent subwatersheds in that area, lie on lake plain terrain and as a result more land drainage was necessary to allow agriculture there, and the soils are often less permeable to infiltration and finer in texture, making them more prone to erosive transport by overland flow. In the case of the Gun River plain where extensive wetlands once existed, the muck soils that were drained for agriculture have been subsiding/sinking due to organic matter breakdown over the decades of farming, making drainage increasingly difficult. The Gun River is above Lake Allegan, the site of a phosphorus TMDL (Section 6.3), whereas the Rabbit River is below Lake Allegan. Hence the Gun River has received more study in connection with the Kalamazoo River/Lake Allegan TMDL. It is important to remember, however, that the Rabbit River influences the loading of non-point source pollutants via the Kalamazoo River to Lake Michigan, and that the nearshore waters around the mouth of the Kalamazoo River are heavily used for recreation including bathing (Oval Beach, Saugatuck State Park).

Approaches for mitigation of agricultural non-point source pollution include setbacks from water bodies, buffer and filter strips, wetland restoration, and a large number of best management practices (BMPs) for soil and nutrient conservation. No-till cultivation has proven value for reducing soil erosion, although recent research suggests that dissolved phosphorus mobilization from the soil surface may be enhanced. Programs to encourage adoption of BMPs (e.g., Agricultural Water Enhancement Program) as well as setting aside sensitive farmland as conservation lands (e.g., Conservation Reserve Program) would best be applied preferentially to subwatersheds with the lowest environmental quality scores in Table 23, and within those subwatersheds the lands closest to water bodies (streams and lakes) should be highest priority from the standpoint of non-point source pollution reduction.

Agricultural areas with constructed water drainage systems deserve special attention because they can effectively deliver nutrients and pathogens directly to surface waters that would otherwise be attenuated or eliminated as water traveled via natural flow paths. In the Kalamazoo River watershed, such areas are especially concentrated in the Gun and Rabbit river watersheds but are also found elsewhere.

In the rural/agricultural mitigation areas, the pollutant sources are prioritized as follows:

1. Overland runoff and constructed drainage systems – The intensive row-crop agriculture typical of the region predisposes land to soil erosion and nutrient movement, and proximity to water bodies makes non-point source pollution much more likely. Tile drains and channelized streams enhance the transport of pollutants to downstream water bodies. The lands that are most susceptible to "off-farm" movement of sediments, nutrients and pathogens should be identified for mitigation and, where appropriate, conservation set-asides or restoration measures.

2. Sediments and nutrients in overland flow. A number of BMP methods are available to effectively slow or retain water and encourage infiltration or at least deposition of sediments before runoff reaches streams and lakes. These have proven value in reducing non-point source pollution loading.

3. Fertilizers, application of manure, tillage, etc. Much has already been done in this regard, but occasional problems still occur, sometimes involving inappropriate siting or timing of agricultural activities especially concentrated animal feeding operations (CAFOs) and small to mid-sized animal feeding operations (AFOs) spreading excess manure. The proliferation of concentrated animal feeding operations has also attracted attention because the manure applications to farm fields are conspicuous and sometimes create problems for water quality in nearby waters. Manure runoff may contain pathogens, as well as nutrients that can stimulate algal growth and lead to oxygen depletion if they reach surface waters.

9.3. Ecosystem Restoration Areas to Ameliorate Non-Point Source Pollution

Ecosystem restoration as used here refers to actions to encourage the return of a degraded or altered ecosystem to a more natural state, such that it better provides ecosystem services which, in the case of water quality, can include maintenance of natural hydrology and prevention or amelioration of pollutant loads. There are many opportunities for aquatic ecosystem restoration in the Kalamazoo River watershed; a few examples are discussed here.

Old dams that no longer serve useful purposes and often have become unsafe are obvious restoration opportunities. These include some dams along the Kalamazoo River mainstem as well as many smaller dams along streams throughout the river network.

The KRWC has long advocated for removal of several old dams on the lower Kalamazoo River between Plainwell and Allegan, and these projects are necessarily tied to the removal of PCB-contaminated sediments behind the dams. Their eventual removal should result in improved water quality, particularly with regard to suspended algae that grow and persist in backwaters behind impoundments (Reid and Hamilton 2007), and would benefit river habitat and recreational uses as well.

The possibility of removal of the dam that forms Morrow Lake deserves study. Morrow Lake is a large reservoir above the PCB-contaminated reaches of the Kalamazoo River mainstem that affects surface-water quality in a surprising way. Heaton (2001), Reid and Hamilton (2007), and Baas (2009) have all documented how the sediments of this reservoir release massive quantities of phosphorus to downstream waters during the summer, adding up to a contribution similar in magnitude to the largest point sources in the river system. Presumably this is a legacy of high phosphorus loading over a prolonged period in the past, and based on studies in lakes it could persist for several decades. The dam is used for hydropower at present, and there is public boating access to the reservoir. Operation of the dam has produced undesirably large fluctuations in stream flow downstream, and algal growth in the reservoir makes downstream waters more turbid than they would otherwise be. The pros and cons of removal of this dam are thus complex but should be considered.

Restoration of channelized and tile-drained stream reaches is another measure that could ameliorate non-point source pollution. In some cases channelization drained formerly isolated wetlands or replaced more diffuse sheet flow across the land, whereas in others it simplified a formerly meandering stream channel, and/or disconnected a stream from its floodplain. Often these hydrological alterations have enabled agricultural and residential development that precludes restoration at present, but in other cases the “reclaimed” land has proven to be marginal or unsuitable for such uses. In cases where restoration is possible, benefits for water quality could justify land acquisition in conservation easements. The Gun River plain is a subwatershed with a particularly large amount of land classed as potential wetland restoration area (Figure 15). A smaller area of agricultural land drainage located south of Battle Creek in the Minges Brook watershed is presently targeted for restoration of natural wetlands and stream channels (contact Kalamazoo County Drain Commissioner).

9.4. High-Quality Aquatic Ecosystems Preservation Areas

While the emphasis of much of this Plan has been on actions to mitigate current human impacts on surface waters, it is also important to guard against future changes that might threaten the quality of our best surface waters. Inventories of natural features are one way to identify the surface waters in best ecological condition, in which biodiversity is usually the metric. Aquatic ecosystems that support the greatest biodiversity, including particularly rare and threatened species, tend to also have high water quality. Natural flow and flood regimes tend to support physical and biological processes that improve water quality, or at least do not degrade it. Wetlands are particularly important for water quality because they often retain or remove nutrients before they reach lakes and streams. Ecosystems of particular ecological importance are good candidates for conservation easements, which in the case of wetlands and water bodies should include ample upland buffer wherever possible.

In addition to preservation of areas that are important to biodiversity, we should consider measures to protect high-quality waters even if they are heavily altered and utilized by people. Gull Lake in the Four Townships watershed is a good example (see Attachment 6). Its shoreline is entirely developed, its water level is regulated, its fishery has long been manipulated, and it is heavily used for recreation. Nonetheless, given its importance to people, Gull Lake deserves special considerations regarding land use change and the implications for water quality. Similar high-quality lakes with outstanding recreational and aesthetic values include Gun Lake, a number of lakes in the City of Portage and Texas Township, and Goguac Lake in Battle Creek.

10. Goals and Objectives

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. The goals and objectives for the Watershed address both water quality concerns and desired uses.

10.1. Goals and Objectives for Designated Uses

The following two goals are related to restoring and protecting the designated uses of water bodies in the KRW. Objectives for these goals are listed in Table 26.

1. Maintain designated uses by preventing or reducing pollutants threatening or impairing water quality and by preserving or managing Preservation and Ecosystem Restoration Areas.

2. Meet/restore designated uses by reducing pollutants threatening or impairing water quality in Urban/Suburban and Rural/Agricultural Mitigation Areas.

Regarding watershed loading reduction goals:

Phosphorus load reduction goals were calculated for agricultural and urban land uses and are included in some objectives in Table 26. The agricultural goal is based on Table 25. By implementing filter strips in 75% of agricultural lands within the suggested 100 meter riparian area, a whole watershed reduction of 7,865 pounds of phosphorus per year will result. By implementing at least the least efficient urban BMP (extended detention) from Table 34 on 30% of urban lands (including high density urban, low density urban, and transportation acreages listed in Table 3), a whole watershed reduction of 41,076 pounds of phosphorus per year will result. The Lake Allegan phosphorus TMDL drainage includes 76.4% of the whole watershed, thus a TMDL watershed area reduction of approximately 37,383 pounds of phosphorus per year is expected. The TMDL calls for a total reduction of 34,395 pounds of phosphorus. Therefore, by meeting these reduction goals across the whole watershed it is expected that the TMDL reduction goals will be met for nonpoint sources (see TMDL discussion in Section 8). Calculations are included in Attachment 12.

Table 26. Goals and objectives as related to ranked pollutants, sources, and causes in the Kalamazoo River Watershed.

Designated Use and Status	Ranked* Pollutants and Impairments to Designated Uses	Sources	Causes	Objectives (based on resource review and loadings)
Goal No. 1 – Maintain designated uses by preventing or reducing pollutants threatening or impairing water quality and by preserving or managing Preservation and Ecosystem Restoration Areas.				
Priority Areas for Goal No. 1 – Buffers				
Other Indigenous Aquatic Life and Wildlife: Threatened – All	6. Habitat degradation or fragmentation (S)	Loss of habitat (S)	Filling and draining of wetlands. Development of open space for agriculture and urban development. Drain management.	Preserve and restore wetlands and open space. Consider alternatives to traditional drain management.
	1. Nutrients (S)	Stormwater runoff (S)	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 100% onsite stormwater use or infiltration to prevent predicted load increases.
Coldwater Fishery: Threatened – All applicable coldwater systems	4. Temperature (S)	Lack of riparian habitat or habitat modification; constructed stormwater drainage systems.	Due to agriculture and urban land use and development	Achieve full vegetative cover in riparian zones. Divert warm stormwater from impervious surfaces into holding basins.
		Stormwater runoff (P)	Loss of floodplains and wetlands as retention. 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 100% onsite stormwater use or infiltration to prevent predicted load increases.

Designated Use and Status	**Ranked* Pollutants and Impairments to Designated Uses**	**Sources**	**Causes**	**Objectives (based on resource review and loadings)**
Goal No. 2 – Meet/restore designated uses by reducing pollutants threatening or impairing water quality in Urban/Suburban and Rural/Agricultural Mitigation Areas.				
Rural/Agricultural Mitigation Priority Area for Goal No. 2 – Impaired waters and buffers				
Other Indigenous Aquatic Life and Wildlife: Impaired - Lake Allegan watershed under 2001 TMDL for excess algal growth, phosphorus (total); Red Run Drain; Swains Lake Drain; Fenner Creek; Gun River Threatened – All	1. Nutrients (K)	Cropland erosion (K)	Conventional tillage practices. Plowing adjacent to water bodies.	Encourage BMPs such as filter strips, cover crops, reduced tillage; implement watershed focused land use planning. Reduce total watershed agricultural phosphorus loading by 7,865 lbs.**
		Land application of manure (S)	Lack of adherence to 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 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 connections, 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.
	2. Sediment (K)	Cropland erosion (K)	Conventional tillage practices. Plowing adjacent to water bodies.	Encourage BMPs such as filter strips, cover crops, reduced tillage; implement watershed focused land use planning. Reduce total watershed agricultural phosphorus loading by 7,865 lbs.**

Designated Use and Status	Ranked* Pollutants and Impairments to Designated Uses	Sources	Causes	Objectives (based on resource review and loadings)
	6. Habitat degradation or fragmentation (K)	Loss of habitat (K)	Filling and draining of wetlands. Development of open space for agriculture and urban development. Drain management.	Control known sources causing site specific habitat damages. Steer development toward appropriate lands.
	3. Unstable flow (K)	Stormwater runoff (P)	Loss of floodplains and wetlands as retention. Drain management.	Restore wetlands.
		Road and bridge crossings (S)	Undersized culverts, poorly designed and maintained crossings.	Repair identified problem sites.
Urban/Suburban Mitigation Priority Area for Goal No. 2 – Impaired waters and buffers				
Other Indigenous Aquatic Life and Wildlife: Impaired - Lake Allegan watershed under 2001 TMDL for excess algal growth, phosphorus (total); Crooked Creek; Red Run Drain; Fenner Creek; Unamed Tributary to Kalamazoo River south of the City of Plainwell; Swains Lake Drain; Gun River Threatened – All	1. Nutrients (K)	Stormwater runoff (K)	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 100% onsite stormwater use or infiltration to prevent predicted load increases.
		Stormwater runoff (K)	Loss of retention capacity of floodplains and wetlands.	Implement BMPs to reduce urban loading of phosphorus by 41,077 lbs.**
	2. Sediment (K)	Stormwater runoff (K)	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 100% onsite stormwater use or infiltration to prevent predicted load increases.
		Stormwater runoff (K)	Loss of floodplains and wetlands as retention.	Implement BMPs to reduce urban loading of phosphorus by 41,077 lbs.**
		Road and bridge crossings (S)	Undersized culverts, poorly designed and maintained crossings.	Repair identified problem sites.
		Streambank-shoreline modification (S)	Lack of riparian vegetation. Inadequate soil erosion and	Stabilize stream flows to moderate hydrology, reduce suspended solids, and

Designated Use and Status	Ranked* Pollutants and Impairments to Designated Uses	Sources	Causes	Objectives (based on resource review and loadings)
			sedimentation control. Flashy flows from changes in land use and lack of stormwater controls.	maintain the floodplain.
	3. Unstable flow (K)	Stormwater runoff (P)	Loss of retention capacity of floodplains and wetlands. Discharge from impervious surfaces and developed areas. Ineffective stormwater management. Drain management.	Encourage infiltration in urban/urbanizing areas, implement watershed focused land-use planning and stormwater management to achieve 100% onsite stormwater use or infiltration to prevent predicted load increases.
Total and Partial Body Contact Recreation: Impaired – Axtell Creek, Davis Creek, Arcadia Creek; Threatened – urbanized watersheds	5. Pathogens-Bacteria (K)	Stormwater runoff (K)	Pets and urban nuisance wildlife (esp. Canada Geese)	Encourage infiltration in urban/urbanizing areas, implement watershed focused land-use planning and stormwater management to achieve 100% onsite stormwater use or infiltration to prevent predicted load increases. Encourage pet waste pick up and nuisance wildlife discouragement measures.

* Pollutant ranked by order of importance at the watershed scale. #1 is most important.

** Generally, treating 30% of urbanized land uses in the entire watershed with typical BMPs will reduce phosphorus loading by 41,077 lbs. Treating 75% of agricultural land uses within a 100 meter riparian area with vegetated filter strips in the entire watershed will reduce phosphorus loadings by 7,865 lbs. The total load reduction combining agricultural and urban land uses then is 48,942 lbs. The Lake Allegan/Kalamazoo River phosphorus TMDL calls for a nonpoint source reduction of 50% from baseline 1998 watershed loadings from 76.4% of the watershed acreage (that which drains to Lake Allegan). Note stormwater is considered a nonpoint source pollutant in this TMDL program. It is assumed that achieving load reductions of 48,942 lbs using these BMPs across the whole watershed will result in reduction in the TMDL portion of the watershed by 37,383 lbs, which exceeds the 34,395 lbs reduction called for by the TMDL. Attachment 12 includes calculations.

10.2. Goals for Desired Uses

In addition to the designated uses established by state and federal water quality programs, stakeholders have identified several desired uses for the watershed. 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 27 lists the desired uses identified through ongoing ecosystem/watershed management efforts, public meetings, and discussions with watershed stakeholders. The desired uses listed all have a direct or indirect impact on water quality.

Table 27. Desired uses of the Kalamazoo River Watershed.

KRW 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
Information sharing	Promote continuing stakeholder involvement and communication across existing regulatory and non-regulatory land and water resource programs in the watershed
Fish and wildlife habitat	Protect and enhance the habitats on which indigenous, threatened, and endangered species depend
Open space and agriculture	Develop a green infrastructure network that supports viable agricultural and rural communities and promotes sustainable soils and water resources through permanent protection and management practices
Groundwater	Protect groundwater recharge and wellhead areas from contamination and overdrafting
Recreation	Promote a balance of undisturbed habitat and accessible water and non-motorized trails on or along appropriate sections of the Kalamazoo River and its tributaries
Human and ecosystem health	Promote accelerated efforts by the CERCLA and Great Lakes AOC programs removing PCBs from the food chain
Watershed monitoring	Increase efforts to better understand issues in the KRW and to create baselines for future reference
Climate change integration	Integrate implications of climate change into watershed planning and implementation
Watershed organization	Develop a sustainable organization to coordinate and implement the watershed management plan and strengthen the watershed implementation partner network.

The following goals were developed to address the desired uses identified by stakeholders. Objectives for these goals are listed below.

Goal 1. Promote and implement coordinated land use planning in the Kalamazoo River watershed, including:

- Regularly review, summarize, and update partners and the public on local plans, ordinances and regulations addressing polluted runoff and related water quality and natural resource issues
- Promote common set back requirements near surface waters
- Promote model language for development standards and ordinances
- Develop or promote resource tools for planning officials
- Gain local commitments to conduct planning at the watershed level and to recognize stormwater planning early in site planning and plan review
- Conduct technical workshops and provide technical assistance throughout the watershed regarding the importance of coordinated watershed and land use planning

Goal 2. Encourage continuing stakeholder involvement and information sharing across watershed scale regulatory and non-regulatory programs:

- Refine operations of the current voluntary "watershed communication center" targeting mayors, city managers, county administrators, governing bodies, planning commissioners, community development corporations, and neighborhoods about regional solutions to water resource problems through land use planning
- Refine operations of the "watershed communication center" targeting all state and federal agencies involved in pollution cleanup and prevention in the watershed (e.g., agricultural/rural support entities, stormwater, TMDL, NPS, NPDES, wellhead/groundwater, public health, Great Lakes Area of Concern, CERCLA, NRDA).
- Promote and grow the watershed partnership agreement
- Conduct semi-annual watershed technical meetings (technical focus)
- Conduct an annual watershed review meeting (all issues focus)

Goal 3. Protect open space and promote sustainable agricultural practices:

- Develop a green infrastructure network consisting of natural, open and working lands
- Promote the economic infrastructure necessary for a diverse and viable farming economy that is protective of water quality, groundwater, and healthy soil
- Promote the maintenance of rural character and viewsheds
- Define and enhance natural ecosystem functions

- Promote permanent water quality improvements through land protection using management practices
- Protect critical water resource areas through land protection tools

Goal 4. Protect habitat for native aquatic and terrestrial wildlife:

- Implement required, desirable, and preferred remedial projects identified in Area of Concern plans that result in Beneficial Use Impairment removal and lead to Area of Concern delisting
- Build support to include more sections of the Kalamazoo River and tributaries in the state's Natural Rivers Program
- Develop a community supported green infrastructure vision for the watershed that includes natural and working lands
- Develop a strategic conservation plan for the watershed that identifies natural and open lands that protect water quality and quantity
- Assist conservation organizations, local governments and landowners to preserve and manage wildlife habitat
- Minimize modification of sensitive habitat areas such as stream corridors
- Promote invasive species prevention programs
- Promote maximum riparian, and adjacent upland protections as well as ecological restoration objectives in designated coldwater subwatershed corridors

Goal 5. Protect groundwater resources:

- Promote existing and additional community well head protection programs
- Promote continued closure of abandoned wells
- Determine current and future amount of groundwater withdrawal and its potential impacts
- Develop strategies to prevent increased impervious surfaces in high recharge areas and to restore areas with high recharge potential, as appropriate
- Encourage stakeholder participation in State of Michigan groundwater conservation and dispute resolution associated with groundwater withdrawal regulation

Goal 6. Improve recreation infrastructure along river while respecting natural features:

- Encourage coordinated recreation planning that promotes sustainable uses of natural resources and protects the unique natural features of watershed communities
- Incorporate bank stabilization efforts and BMPs at access sites to minimize the impact of foot traffic and erosion
- Educate private and commercial river users on the proper management of woody debris to improve navigability without impacting fish habitat or hydrology
- Remove litter and trash along banks
- Educate boaters about limiting the movement of invasive species

Goal 7. Safeguard human and ecosystem health:

- Encourage safe use of contaminated sections of the lower Kalamazoo River Valley
- Promote public involvement in the CERCLA "Superfund" process
- Promote the use of AOC financial and technical resources to accelerate, enhance, or better cleanups primarily delivered by the CERCLA process
- Maintain regular communication with NRDA state and federal trustees and share ideas on natural resource remedial investment opportunities

Goal 8. Continue/increase watershed monitoring efforts:

- Partner with technical Watershed Partners to develop and implement a monitoring strategy to monitor water resource changes over time
- Coordinate volunteer road/stream crossing riparian surveys to assess current conditions and monitor changes over time as well identify problem sites
- Encourage monitoring and increased regulation of commercial groundwater withdrawals

Goal 9. Refine operations of an umbrella watershed organization to coordinate and implement the watershed management plan and to instill a sense of stewardship:

- Develop a funding strategy that includes membership, governmental unit, foundation and business support
- Identify potential future lead organizations if umbrella operations must be transferred from current voluntary leadership of the KRWC
- Secure sustainable funding to hire staff and implement the watershed management plan
- Create and grow a watershed management endowment
- Develop an annual work plan for the organization

Goal 10. Build the capacity to understand and adapt to climate change:

- Monitor and communicate the scientific consensus on local and regional implications of climate change and opportunities to take action
- Host periodic regional workshops to receive direct updates from global, national, and local experts, and to consider adaptation measures pertaining to water resource protection and management

11. Implementation Strategies

11.1. Action Plan by Priority Area

Table 28 contains recommended actions to achieve designated use and desired use goals.

Table 28. Kalamazoo River Watershed management action table.

Task - Recommended or Prioritized BMPs	Pollutant/Objective	Ranked Critical and Priority Areas/Sites - Locations	Begin	Lead	Cost	Funding	Milestones	Evaluation	Loading Quantification	Years**
Designated Use Goals										
Designated Use Goal 1. Maintain designated uses by preventing or reducing pollutants threatening or impairing water quality and by preserving or managing Preservation and Ecosystem Restoration Areas.										
Enact or improve water quality protection related ordinances	Prevent future stormwater problems. Preserve and restore wetlands and open space. Consider alternatives to traditional drain management.	High – communities predicted to experience rapid build-out; preservation areas Medium – all remaining drained lands	i	Munici-palities	$10,000 per municipality	Municipalities, MDEQ	By 2015: 10% Municipalities By 2020: 25% Municipalities	Number of ordinances enacted; Number of municipalities with ordinances	Table 33	5
Expand natural rivers or similar special designations	Preserve and restore wetlands and open space. Consider alternatives to traditional drain management.	High – Preservation areas Medium – expand along Kalamazoo River mainstem	l	KRWC	unknown	Voluntary, donations	Add area by 2020	Area added	NA	10
Protect sensitive lands	Preserve and restore wetlands and open space.	High – coldwater stream corridors; preservation areas Medium – all wetlands and lands adjacent to wetlands	s	Conser-vancies	$2,000-$8,000/acre for purchase, $3,000/ease ment	Trusts, MDEQ, foundations	By 2015: 250 acres By 2020: 500 acres	Number of acres protected; estimate loading prevented	Table 33	10
Conduct watershed wide Natural Features Inventory	Preserve and restore wetlands and open space.	Whole watershed	s	KRWC, partners	unknown	Grants	By 2012: funding secured	Project completed	NA	6
Convene local watershed stakeholders to develop a watershed-wide land conservation vision	Preserve and restore wetlands and open space	Whole watershed	s	Conser-vancies, partners	$6,000	Grants, in-kind	By 2012: funding secured	Project completed	NA	1.5

Task - Recommended or Prioritized BMPs	Pollutant/Objective	Ranked Critical and Priority Areas/Sites - Locations	Begin	Lead	Cost	Funding	Milestones	Evaluation	Loading Quantification	Years**
Designated Use Goal 2. Meet/restore designated uses by reducing pollutants threatening or impairing water quality in Urban/Suburban and Rural/Agricultural Mitigation Areas.										
Both Urban/Suburban and Rural/Agricultural										
Conduct wetland functional analysis	Restore wetlands.	Whole watershed	s	Local sub-watersheds, KRWC	$30,000	Grants	By 2014: half of watershed By 2016 all of watershed	Analysis completed	NA	6
Identify and correct illicit discharges to surface waters	Identify and correct 100% of illicit connections, repair or replace aging septic systems and recommend regular maintenance of systems.	High – Kalamazoo and Battle Creek Urbanized Areas Medium – All other cities and villages Low – remainder of watershed	i	Road and Drain commissions per IDEP, Cities, NRCS, Lake Associations	$500-$5,000 per site	Drain Commission, Municipalities, Road Commission	By 2015: 50% of known sites By 2020: all known sites	Number of connections or discharges identified and corrected. Number of systems.	NA	o
Identify and correct failing septic systems	Identify and correct 100% of illicit connections, repair or replace aging septic systems and recommend regular maintenance of systems.	High – all areas close to waterbodies	i	County health, citizen referrals	$500-$5,000 per site	USDA Rural Development, Local Governments	By 2020: 100% of known systems	Number of systems; estimate load reduction	Table 35	20
Dam removals	Control known sources causing site specific habitat damages.	High – high hazard dams Medium – dams preventing fish passage or damaging sensitive habitats	m	KRWC	Depends on sites - $10,000 - $1,000,000	Grants; landowner match	2 dams by 2020 on mainstem of river; 2 tributary dams	Dams removed	NA	10

Task - Recommended or Prioritized BMPs	Pollutant/Objective	Ranked Critical and Priority Areas/Sites - Locations	Begin	Lead	Cost	Funding	Milestones	Evaluation	Loading Quantification	Years**
Urban/Suburban										
Utilize stormwater BMPs - *Dry detention, wet retention, swales, rain garden, constructed wetlands*	Implement BMPs to reduce urban loading of phosphorus by 50% per Lake Allegan TMDL program*.	High – Impaired waterbodies in Kalamazoo and Battle Creek Urbanized Areas (retrofits); all areas of new development Medium – remaining Urbanized Areas Low – remainder of watershed in riparian areas	i	Munici-palities, Drain and Road Commission	Depends on practice	Municipalities, MDEQ 319	By 2015: 10% of urban acreage treated by BMPs By 2020: 25% treated	Number of municipalities using practices; Estimate of pollutant loading reduction	Table 34; Attachment 9	o
Enact/improve water quality protection related ordinances especially stormwater related	Encourage infiltration in urban/urbanizing areas, implement watershed focused land-use planning and stormwater management to achieve 100% onsite stormwater use or infiltration to prevent predicted load increases.	High – communities predicted to experience rapid build-out Medium – all remaining drained lands	s	Munici-palities	$2,500 per municipality	Municipalities, MDEQ 319	By 2015: 10% Municipalities By 2020: 25% Municipalities	Number of municipalities with ordinances	Attachment 3	5
Promote outreach, education, and I&E sharing by permitted stormwater communities to unpermitted communities	Encourage infiltration in urban/urbanizing areas, implement watershed focused land-use planning and stormwater management to achieve 100% onsite stormwater use or infiltration to prevent predicted load increases.	High – cities and villages without municipal stormwater permits Medium – townships predicted to build-out fastest Low – all other communities	s	Munici-palities, Drain and Road Commission	Staff time/in-kind	Municipalities, MDEQ 319	By 2012: materials created By 2015: materials distributed to all un-permitted communities	Media exposure	NA	5

Task - Recommended or Prioritized BMPs	Pollutant/Objective	Ranked Critical and Priority Areas/Sites - Locations	Begin	Lead	Cost	Funding	Milestones	Evaluation	Loading Quantification	Years**
Rural/Agricultural										
Utilize agricultural BMPs - *Filter strips*	Encourage BMPs such as filter strips, cover crops, reduced tillage; implement watershed focused land use planning. Reduce total watershed agricultural phosphorus loading by 50% per Lake Allegan TMDL*	High – Impaired waterbody subwatersheds, Gun River, Rabbit River Medium – Rice Creek, Battle Creek River	i	Landowners (NRCS, Conservation Districts)	Depends on practice	Farm Bill	By 2015: 50% of farms in riparian areas By 2020: 75% of farms in riparian areas	Number of acres; estimate load reduction; number of landowners	Table 34, Table 25	o
Restore wetlands by removing tiles in ag drains	Restore wetlands	High –Gun River Medium – Rabbit River Low – Rice Creek, Battle Creek River	m	Landowners, NRCS	$1,000 - $2,000/ acre	WRP, Wetland organizations, MDEQ 319	By 2016: 100 acres By 2020: 300 acres	Acres restored; loading reduced	Table 33	10
Develop and implement manure management plans	Establish filter strips, encourage manure management planning and compliance with the plan on 100% of acres used for manure spreading.	High – Four Townships Area Medium – Rabbit Rivers, Gun River Low – Rice, Battle Creek	i	Landowners (NRCS, Conservation Districts)	$4,000 - $10,000/plan (depends on the number of livestock)	Michigan Environmental Assurance Program, Farm Bill Programs	By 2015: 50% coverage By 2020: 75% coverage	Number of plans developed	NA	10
Utilize alternative drain maintenance/ construction techniques	Preserve and restore wetlands and open space. Consider alternatives to traditional drain management.	High – Gun River Medium – Rice, Battle Creek, and Rabbit Rivers	s	Drain Commissions, Ag Agencies	$20/ft revetments, $7/foot debris management, $20 ft. two stage ditch, over $100/ft for j-hooks and cross vanes	Drain Assessments, MDEQ 319	By 2015: 2 projects By 2020: 5 projects	Number of miles of drain maintained or constructed with alternative drain techniques	NA	10

Task - Recommended or Prioritized BMPs	Pollutant/Objective	Ranked Critical and Priority Areas/Sites - Locations	Begin	Lead	Cost	Funding	Milestones	Evaluation	Loading Quantification	Years**
Prevent/limit livestock access (fencing, crossings structures, alternative water sources)	Control known sources causing site specific habitat damages. Steer development toward appropriate lands.	High – Rabbit River Medium – mitigation areas	o	CD, NRCS	$2/ft fencing, $1,200 - $3,600/crossing structure, $500/water source	Farm Bill	By 2015: 10% of known sites By 2020: 50% of known sites	Number of sites corrected; Estimate sediment and nutrient loading reduction	See subwatershed plans documents (plans listed in Table 1)	10
Desired Use Goals										
Goal 1. Promote and implement coordinated land use planning in the Kalamazoo River watershed, including:										
Support watershed-based MS4 stormwater plan implementation	Gain local commitments to conduct planning at the watershed level and to recognize stormwater planning early in site planning and plan review	All	i	KRWC	unknown	Drain Commission, Municipalities, Road Commission		Outreach programs continue		o
Encourage initiatives that generate revenue for stormwater program implementation	Develop or promote resource tools for planning officials	All	l	KRWC	$2,000/county	Donations	By 2015: 1 municipality; By 2020: 2 municipalities	Number of counties with rules		10
Adopt recognized nonpoint source management practice quantification and tracking system	Develop or promote resource tools for planning officials	All	l	Phosphorus TMDL or watershed entity	unknown	Grants	By 2015: system adopted	Use of system by distributed watershed service providers		5
Improve zoning to locate high density or intensive uses in appropriate areas	Promote common set back requirements near surface waters	All	i	Private landowners (unnamed)	$5,000/municipality	Municipalities	By 2015: 1 municipality By 2020: 2 municipalities	Number of municipalities with improved zoning maps		3

Task - Recommended or Prioritized BMPs	Pollutant/Objective	Ranked Critical and Priority Areas/Sites - Locations	Begin	Lead	Cost	Funding	Milestones	Evaluation	Loading Quantification	Years**
Goal 2. Encourage continuing stakeholder involvement and information sharing across watershed scale regulatory and non-regulatory programs										
Support continued Lake Allegan/Kalamazoo River phosphorus TMDL strategic plan and subwatershed implementation actions	Refine operations of the current voluntary "watershed communication center"	Lake Allegan Watershed	i	KRWC	Depends on TMDL strategies implemented	Municipalities, MDEQ 319	Scheduled promotion of TMDL	Phosphorus concentrations and loads; resource improvements		o
Promote locally led implementation of management practices in 303(d) listed waterbodies to pre-empt new TMDLs	Promote and grow the watershed partnership agreement	All	o	Subwater-shed partners	Depends on practices selected	Grants, landowners	New 303(d) listings are followed by actions within 2 years	Listings are regularly removed from list		o
Goal 3. Protect open space and promote sustainable agricultural practices										
Utilize soil testing to determine appropriate application rates	Promote the economic infrastructure necessary for a diverse and viable farming economy that is protective of water quality, groundwater, and healthy soil	All	i	Landowners, MSU Extension	$3.85/acre/year crops $14/acre/year specialty crops	Unknown	Annual increase in testing	Number of test performed		o
Develop a watershed Green Infrastructure plan	Develop a green infrastructure network consisting of natural, open and working lands	All	l	Regional planner	unknown	Grant	By 2020 completed			10
Goal 4. Protect habitat for native aquatic and terrestrial wildlife										
Target NRDA projects with multiple corridor benefits (e.g., increased floodplain protection, wetland preservation, greenspace continuity	Assist conservation organizations, local governments and landowners to preserve and manage wildlife habitat	PCB contaminated area	o	KRWC	unknown	Donations	Depends on agency process and compensation settlement	Projects in lower river corridor		20

Task - Recommended or Prioritized BMPs	Pollutant/Objective	Ranked Critical and Priority Areas/Sites - Locations	Begin	Lead	Cost	Funding	Milestones	Evaluation	Loading Quantification	Years**
Restore concrete lined river/stream channels	Implement required, desirable, and preferred remedial projects identified in Area of Concern plans that result in Beneficial Use Impairment removal and lead to Area of Concern delisting	Where present	m	Munici-palities	unknown	Grant	By 2016: 2000 feet By 2020: 5000 feet	Length of channel restored		10
Goal 5. Protect groundwater resources										
Encourage wellhead protection program actions	Develop strategies to prevent increased impervious surfaces in high recharge areas and to restore areas with high recharge potential, as appropriate	All	o	Munici-palities, watershed partners	unknown	Municipalities				
Goal 6. Improve recreation infrastructure along river while respecting natural features										
Encourage and develop linear trail programs, land and water, that balance access and preservation	Encourage coordinated recreation planning	All	o	Subwater-shed partners	unknown	Donations, grants	Trail mileage increases annually	Miles of trail implemented		o
Goal 7. Safeguard human and ecosystem health										
Educate public about special fish consumption advisories through distributed materials, signage, and face to face interaction	Encourage safe use of contaminated sections of the lower Kalamazoo River Valley	All	s	State agencies, KRWC		Grants		Awareness		o
Promote State of Michigan mercury reduction plans	Encourage safe use of contaminated sections of the lower Kalamazoo River Valley	All	s	KRWC		Donations		Atmospheric concentration		o

Task - Recommended or Prioritized BMPs	Pollutant/Objective	Ranked Critical and Priority Areas/Sites - Locations	Begin	Lead	Cost	Funding	Milestones	Evaluation	Loading Quantification	Years**
Investigate source of dioxins in subwatersheds on 303(d) listing; encourage regulatory response, laymen's interpretation, and public education where actionable	Encourage safe use of contaminated sections of the lower Kalamazoo River Valley	All	m	KRWC		Grants		Awareness		2
Implement polychlorinated biphenyls contamination isolation and removal from the river environment	Promote public involvement in the CERCLA “Superfund” process	PCB contaminated area	o	Superfund parties		Superfund		Uncontrolled contamination, tissue concentrations		20
Maintain and implement Area of Concern Remedial Action Plans to achieve Beneficial Use Impairment removal and AOC delisting	Promote the use of AOC financial and technical resources to accelerate, enhance, or better cleanups primarily delivered by the CERCLA process	PCB contaminated area	o	AOC agencies; Superfund parties; Natural Resource Damage Trustees; KRWC		AOC program		Uncontrolled contamination, tissue concentrations; habitat/population recovery		20
Remove "Beach Closings" BUI	Encourage safe use of contaminated sections of the lower Kalamazoo River Valley	PCB contaminated area	o	AOC agencies, KRWC		AOC program		Removed		1
Support MDEQ exploration of Aesthetics and Dredging BUIs	Encourage safe use of contaminated sections of the lower Kalamazoo River Valley	PCB contaminated area	s	AOC agencies, KRWC		AOC program		Removal of BUIs where appropriate		3

Task - Recommended or Prioritized BMPs	Pollutant/Objective	Ranked Critical and Priority Areas/Sites - Locations	Begin	Lead	Cost	Funding	Milestones	Evaluation	Loading Quantification	Years**
Goal 8. Continue/increase watershed monitoring efforts										
Develop watershed monitoring program that coordinates long-term needs of phosphorus TMDL, NPDES, and MDEQ basin rotation	Partner with technical Watershed Partners to develop and implement a monitoring strategy to monitor water resource changes over time	All	l	Universities, TMDL, SW, KRWC	unknown	Grants, contributions from permittees	By 2014 statistical design completed By 2015 monitoring begins By 2020	Key water quality parameter trends can be detected		10
Goal 9. Refine operations of an umbrella watershed organization to coordinate and implement the watershed management plan and to instill a sense of stewardship										
Develop sustainable watershed management funding	Develop a funding strategy that includes membership, governmental unit, foundation and business support	NA	s	KRWC	unknown	Donations	By 2014: framework created	Buy in by watershed partners		5
Goal 10. Build the capacity to understand and adapt to climate change										
Create educational materials about current climate change implications and future predictions	Monitor and communicate the scientific consensus on local and regional implications of climate change and opportunities to take action	All	s	KRWC	unknown	Grants, foundations	By 2012 customize materials finalized By 2013 all watershed jurisdictions contacted	Materials distributed; meetings held		4

In progress = I; Ongoing = o; Short = s; Medium = m; Long = l

NRDA = Natural Resource Damage Assessment

* Lake Allegan/Kalamazoo River phosphorus TMDL calls for a nonpoint source reduction of 50% from baseline 1998 watershed loadings. Combined nonpoint monthly goals are 9,800 lbs from April to June and 4,088 lbs from July to September. Note stormwater is considered a nonpoint source pollutant in this TMDL program.

** Years to complete

11.2. Information and Education

Introduction

The KRWMP Information & Education (I&E) Plan was formulated through the efforts of the KRWC. The purpose of the plan is to provide a framework to inform and motivate the various stakeholders, residents and other decision makers within the watershed to take actions that can protect water quality (Table 29). 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 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

Table 29. 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, 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, carpet cleaners, property management companies, 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; money is saved 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.
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.

Watershed Issues

The priority issues for the watershed are described below. Each of these issues relate back to the goals and actions in the KRWMP.

For each major issue, priority target audiences have been identified. 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 everyday activities affect the quality of water resources. All watershed audiences need to be made aware of the priority pollutants. 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, email lists, blogs, online video, social networking, 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.

Key local newspapers include: the Kalamazoo Gazette (including the Hometown Gazette), the Battle Creek Enquirer, Michigan Farm News and the Farmer's Exchange.

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.

To reach more distant, rural watershed residents, watershed partners should be encouraged to assist in distributing information in local markets.

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 KRWC 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 30) is laid out for the KRW. 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 KRWC 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 watershed. 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 watershed 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 sewage system (MS4) communities.
- The Lake Allegan/Kalamazoo River Phosphorus TMDL Implementation Committee conducts outreach specific to the Lake Allegan basin, the majority of the watershed.

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. The word “watershed” should become more commonly used with the general public over time.
- 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.

Table 30 contains an education strategy relating activities to designated use goals.

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 (see evaluation measures in Table 30).

Table 30. Information and Education Strategy for the Kalamazoo River Watershed Related to Watershed Goals[1,2].

Issue	Priority Target Audience	Activity	Potential lead agency	Potential partners	Timeline* (milestone)	Evaluation	Costs
Watershed Awareness	All	Produce and distribute 4 public service announcements/press releases per year [1,2]	KRWC	PART, MSUE	current (4 PSAs/year)	number of announcements	5 hours staff time/press release
		Maintain website that makes watershed information easily available to the public [1,2]	TMDL, KRWC		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]	KRWC	PART	current (2-3 festivals/ year)	number of participants	$200 per event + 30 hours staff time to develop awareness
		Maintain watershed communication center [1,2]	KRWC	Other lead entity	current	number of messages	8 hours staff time per week
	Kids/ Students	Develop a student stream monitoring program [1,2]	MSUE	KRWC	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]	KRWC	MSUE	long-term (1 training/ year)	attendance at workshop and incorporation of watershed topics into curriculum	$200/workshop + 40 hours staff time/year
		Distribute KRWC curriculum materials on watersheds and water quality to teachers [1,2]	KRWC	School Districts	medium-term (1 schools/ year)	number of schools incorporating curriculum materials	$200/school + 60 hours staff time

Land Use Change	Drain Comm.	Meet one-on-one with drain commissioners to discuss alternative drain maintenance methods and ditch naturalization techniques and stormwater standards/ordinance [1]	DC, KRWC	PART	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 [2]	CD, 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]	CD, 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	Govern-ment units, officials	Promote trainings being offered on water quality and use planning, LID, and green infrastructure [1]	KRWC	SW, TMDL	current (2 trainings/ year)	increase in use of LID techniques	5 hours staff time/training
		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]	CD, Municipal ities, SW	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 [1]	SW	PART	current (2 printed pieces/year)	increased use of practices	$800/printing & postage 80 staff hours/item
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 [1]	SW, TMDL	PART	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]	SW, TMDL	PART	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 [1]	KRWC	SW, TMDL	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]	PART		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]	Land Conservancies	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]	Land Conservancies	KRWC	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 [1,2]	County and Townships	Land Conservancies	long-term (1 mailing/ year)	number of mailings	$300 printing/postage 40 hours staff time
Stormwater runoff	Govern-ment units, employees	Promote trainings on municipal operations (including road maintenance and construction) and best management practices to protect water quality [2]	SW, Municipalities	PART	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, Municipalities		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 [1,2]	DC, SW	KRWC	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]	SW, TMDL	KRWC	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 [1,2]	Health Dept, MSUE	KRWC	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]	Local gov.	KRWC	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]	MSUE	Local gov.	medium-term (2 lakes/year)	improved septic maintenance and reduced pollutants	3 hours/household
	Govern-ment unit,emplo yees	Develop and distribute brochures/flyers/fact sheets about the impacts of failing septic systems and what local governments can do [2]	MSUE, Health Dept	Local gov.	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]	CDs		current (3 municipalities/year)	increased number of improved septic related ordinances	80 hours/municipality

[1] Maintain designated uses by preventing or reducing pollutants threatening or impairing water quality and by preserving or managing Preservation and Ecosystem Restoration Areas.
[2] Meet/restore designated uses by reducing pollutants threatening or impairing water quality in Urban/Suburban and Rural/Agricultural Mitigation Areas.
KRWC = Kalamazoo River Watershed Council; MSUE = Michigan State University Extension; PART = All Partners; DC = Drain Commissioner; RC = Road Commissioner; SW = MS4 Stormwater permitees; TMDL = signatories and participants; CD = county conservation districts.
* short-term - within one year; medium-term - within 2-3 years; long-term - within 4-6 years

12. Moving from Plan to Action and Results

12.1. 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:

- 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.
- The tracking of involvement in a local watershed group or increases in attendance at water quality workshops or other events.

Additional evaluation methods for measuring and tracking knowledge and awareness can be found in the Information and Education Plan (Table 30).

The City of Battle Creek conducted a recent survey which gauged citizen awareness of watershed and stormwater issues. Large scale surveys reaching regional stakeholders will require partnership across watershed groups like stormwater permittees and the phosphorus TMDL implementation committee. These types of surveys require a specific Quality Assurance Plan and significant expertise in unbiased survey techniques.

12.2. 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 30 has milestones and specific evaluation methods proposed for measuring the progress of BMP implementation and improvements to water quality for each task in the 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.

12.3. 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 watershed are conducted as part of the State of Michigan 5-year basin monitoring rotation conducted by the MDEQ Surface Water Assessment Section. Local efforts to monitor water quality include those of lake associations, drain commissioners, the Kalamazoo County Health Department, and subwatershed planners and implementers. Combining data gathered under these programs, with other periodic water quality assessments will provide a picture of water quality in the watershed.

Expanding Current Monitoring Efforts:

- Research low flow monitoring for new water withdrawal permit process
- Review MDEQ monitoring results and data summaries (every 5 years) to assess future monitoring
- Review County Health Department annual monitoring reports in Kalamazoo County (and wherever available)

Over the years the number of available stream monitoring gauges has been reduced due to funding limitations. Watershed partners may need to combine resources to be sure that real-time monitoring stations continue to operate.

Table 31 includes monitoring components and Table 32 summarizes monitoring programs working at the sub- or full watershed scale. Coordinating long term monitoring across the watershed is a long term desire.

Table 31. Monitoring components and evaluation criteria for Kalamazoo River Watershed. See attachment 5 for a narrative including water quality standards.

Impairment, Source, or Cause	Monitoring Components	Potential Parties to Implement Monitoring	Schedule for Implementation	Units of Measurement	Current Conditions	Evaluation Criteria
Sediment	Substrate embedded-ness	MDEQ, 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	MDEQ, MSU	Long term (Assess in 2014 and every 5 years after)	Numerical score based on quantity and diversity	Most monitored sites rank acceptable to excellent	Maintain "excellent" scores, increase scores for "acceptable" stream stretches
Nutrients	Water quality	MDEQ, TMDL participants, MSU, Stormwater permittees	Long term (Assess in 2014 and every 5 years after)	Water quality rating	The watershed is part of a phosphorus TMDL, requiring reductions; Lake Allegan in-lake goals of 60 ppb phosphorus average and 72 ppb at the inlet.	Monitor and track aquatic plant growth; monitor and track phosphorus levels; monitor and track conditions in Lake Allegan including fishery; monitor stormwater outfalls per MDEQ requirements
Unstable Flow	USGS flow gauge data	USGS, MDEQ, TU	Short term (2011) and annually thereafter	Cubic feet per second	Flow gauges record hydrographs during storm events, with peak flows and durations. TU creating a citizen monitoring network for stream flow measurements related to groundwater withdrawal program.	Document reduction of peak flows and duration; track flashiness
	Bank pins scour chains (previous research studies)	MDEQ	Unknown	Bank loss (inches, or centimeters per unit time)	Un-gauged locations have undergone bank erosion studies. Some pins may still be in use or usable	Useable pins could be checked as a follow up to individual research efforts. Three stations remain on the Battle Creek River that may be useable, also near Elm St. Dam

Temperature	Water temperature	MDEQ, County Health Departments, MSU; trained volunteers; TU	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
Pathogens, Bacteria	Water quality	County Health Departments, MSU	Ongoing	Bacteria counts per 100ml water	Impairments exist in urban streams	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 in the Four Township Watershed Areas	Meet WQS for full and partial body contact 100% of the time
Habitat Fragment-ation	Wetland inventory and assessment and conservation easements	MDNR, TMDL participants	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
	MDEQ stream habitat survey	MDNR	Long term (Assess in 2014 and every 5 years after)	Habitat evaluation score	Most monitored sites rank as acceptable	Maintain or increase scores until 100% of locations score “excellent” or “good”

FTRWC Four Township Water Resources Council
MDEQ Michigan Department of Environmental Quality
MDNR Michigan Department of Natural Resources
FTWA Four Township Watershed Area
GLQO Gull Lake Quality Organization
MSU Michigan State University
TMDL Total Maximum Daily Load
TU Trout Unlimited

Table 32. Environmental monitoring summary.

Organization	Monitoring Site	Type of Analysis	Protocol	Current Monitoring	Recommended Future Monitoring	Test Agent; report contact
MDEQ	Kalamazoo River Basin monitored every 5 years (specific stream sites vary)	Macroinvertebrate survey	Protocol Procedure 51	Conducted in 2009	Once every 5 years (2014)	MDEQ; SWAS
		Habitat survey	USEPA Rapid Bioassess-ment	Conducted in 2009	Once every 5 years (2014)	MDEQ; SWAS
		Water Chemistry TP, TN, DO, Metals	MDEQ	No current routine monitoring in FTWA	As needed based on identified concerns	MDEQ; SWAS
		E. coli	*E. coli* MPN/100ml	No current routine monitoring in FTWA	As needed based on identified concerns	MDEQ; SWAS
MDEQ and TMDLIC	Kalamazoo River mainstem sampling points between Galesburg and Lake Allegan (inflows and outflows of reservoirs and road crossings); also in reservoir sampling	TP	MDEQ	Monthly grabs during growing season since 2001	Monthly	MDEQ and Wastewater Treatment Facility Labs; MDEQ Sylvia Heaton and City of Kalamazoo Sue Foune
Stormwater permittees	Outfalls	TP	MDEQ	Subset of known outfalls per year during dry and wet weather	Continue	Individual labs or private labs; Kalamazoo John Paquin, Battle Creek Christine Kosmowski
MDNR Fisheries	Several	Temperature	Handheld temperature probe	Last monitored 2000	Per MDNR assessment schedule	MDNR; Plainwell office
	Several	Fishery survey	MDNR	Last monitored early 1990’s	Per MDNR annual work plan, contact MDNR	MDNR; Plainwell office
Kalamazoo County Health Department	County public beaches	*E. coli*	*E. coli* MPN/100ml	Weekly during annual use season since 2001	Weekly during annual use season	Kalamazoo County Health Department; same

Organization	Monitoring Site	Type of Analysis	Protocol	Current Monitoring	Recommended Future Monitoring	Test Agent; report contact
	County streams in Kalamazoo, and St. Joseph River basins. Also select monitoring in Barry County	*E. coli*	*E. coli* MPN/100ml	Weekly during annual use season	Weekly during annual use season	Kalamazoo County Health Department; same
	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; same
FTWRC, GLQO, MSU	See Gull and Augusta Creeks Watershed Management Plan: the Four Township Watershed Area	*E. coli;* Genetic source tracking of *E. coli*, Enterococci, *Clostridium perfringens* (bacteria) and Coliphage (a virus that grows on *E. coli*.); numerous chemical parameters	*E. coli* MPN/100ml; MSU labs; MSU	Monthly	Monthly during use season; additional season and weather conditions desired; Genetic Source Tracking not as frequent only a few times per year	Kalamazoo County Health Department, FTWRC and GLQO; Health Department
Calhoun Conservation Districts grant projects	Kalamazoo River Ceresco Area Watershed Area; upper, mid, lower Crooked Cr; unnamed trib; Easterly/Dibble Drain; Pigeon Cr; also 3 stations on Rice Creek	Level 3 geomorphic assessment; elevation, cross section, pebble counts, lateral bank erosion with pins, aggredation-degradation with scour chains	BEHI	Unknown	Continue beyond short term grant funded projects	Calhoun Conservation District; same
USGS	Several in watershed	Discharge	USGS	Ongoing daily	Continue same frequency	USGS; www.usgs.gov "water", "real-time"

TP – Total phosphorus, TN – Total nitrogen, DO – Dissolved oxygen, SRP – Soluble reactive phosphorus, TDP – Total dissolved phosphorus
FTRWC Four Township Water Resources Council

MDEQ Michigan Department of Environmental Quality
MDNR Michigan Department of Natural Resources
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
TMDLIC Total Maximum Daily Load Implementation Committee
SWAS Surface Water Assessment Section

Data sources online:

MDEQ surface water data: http://www.michigan.gov/deq/0,1607,7-135-3313_3686_3728---,00.html.
Kalamazoo County data: http://www.kalcounty.com/eh/lake-stream-monitoring.php
USGS data: http://waterwatch.usgs.gov/

12.4. 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.

In Table 28, 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 and utilizing urban stormwater BMPs. The other items in the action plan either deal with hydrological modifications or habitat or they are proactive and preventative measures (planning and rules). Estimating pollutant loads and load reductions for these types of practices is not feasible.

Typical pollutant and runoff volume reductions from recommended protection measures can be calculated by stakeholders using the Kalamazoo River Urban Stormwater BMP Screening Tool (Attachment 8). Table 33 provides a general sense of expected loading reductions from land conservation. For example, if one forested acre of land were converted to low density residential, the new load reduction would increase by 1 pound of total phosphorus/acre/year, 61 pounds total suspended solids/acre/year, and 0.2 acre-feet of runoff volume/acre/year. The table below provides a sense of what future loadings are being mitigated by protecting natural areas and agriculture from being developed for low density and high density residential purposes. The same table can be used to get a sense of the average estimated load reductions from converting agricultural land to wetlands, forest, or herbaceous open land.

Table 33. Comparison of higher loading land uses to lower loading land uses.

		Reduction per Acre		
Land Use Type	**Converted to**	**Total Phosphorus Load Reduction (pounds/ac/yr)**	**Total Suspended Solids Load Reduction (pounds/ac/yr)**	**Runoff Volume Reduction (acre-feet/ac/yr)**
Low Density Residential	Wetlands	0.6	115	-2.1
	Forest	1.0	61	0.2
	Herbaceous Open	1.0	61	0.2
	Agriculture	0.5	61	0.2
High Density Residential	Wetlands	1.1	644	-0.4
	Forest	1.5	590	1.9
	Herbaceous Open	1.5	590	1.9
	Agriculture	1.0	590	1.9
Agriculture	Wetlands	0.1	54	-2.3
	Forest	0.5	0	0
	Herbaceous Open	0.5	0	0

Note: The values above were calculated using the Kalamazoo River Urban Stormwater BMP Screening Tool assuming an average annual precipitation of 37.63 inches/year.

Table 34 is a matrix of potential pollutant load and runoff volume reductions per acre for the recommended urban stormwater BMPs presented in the Kalamazoo River Urban Stormwater BMP Screening Tool. Stakeholders can use the tool to estimate the expected load reductions from specific stormwater BMPs at specific critical areas, as noted in Table 28.

Table 34. Estimated load reductions and volume reduction per acre of land treated from recommended urban stormwater BMPS (by land use type).

		Load/Volume Reductions (per Acre) by Land Use Type		
		Low Density Residential	**High Density Residential**	**Roads/ Parking Lots**
Grass Swale	TP (lbs/ac/yr)	0.5	1.0	2.5
	TSS (lbs/ac/yr)	131	660	1,019
	Runoff (ac-ft/ac/yr)	0.2	1.9	2.0
Extended Dry Detention	TP (lbs/ac/yr)	0.3	0.8	2.3
	TSS (lbs/ac/yr)	148	577	1,036
	Runoff (ac-ft/ac/yr)	0.2	1.7	1.8
Wet Detention	TP (lbs/ac/yr)	1.1	1.6	3.1
	TSS (lbs/ac/yr)	148	577	1,036
	Runoff (ac-ft/ac/yr)	0	1.7	1.8
Rain Garden	TP (lbs/ac/yr)	1.2	1.7	3.2
	TSS (lbs/ac/yr)	164	693	1,052
	Runoff (ac-ft/ac/yr)	0.4	2.1	2.2
Constructed Wetland	TP (lbs/ac/yr)	0.6	1.1	2.6
	TSS (lbs/ac/yr)	125	654	1,013
	Runoff (ac-ft/ac/yr)	0	1.7	1.8

Note: The values above where calculated using the Kalamazoo River Urban Stormwater BMP Screening Tool with rainfall of 37.63 inches/year. Efficiency values from Chesapeake Bay Stormwater Network (Schueler, 2008).

Attachment 9 contains additional information about BMPs including descriptions and operation/maintenance costs.

Table 35 provides a cursory estimate of loading from septic systems. It is important to note that several variables must be used to fully characterize the likely impacts septic systems have on surface water, for instance environmental variables, septic system variables, and physical variables all affect how pollutants move through groundwater. The age of the system, frequency of use, frequency of clean out, nutrient-containing products treated by the system, and distance to surface water can all change the exact loading from the system. Similarly, soil type, permeability, drainage factors, and phosphorus adsorption capacity must be considered when determining septic system impacts.

Table 35. Typical pollutant loading to groundwater from septic systems.

Pollutant	Units	Load (for every 1 gallon treated/year)	Load (per average septic system/year)*
Total suspended solids	lbs/yr	0.2	61.3
Total Phosphorus	lbs/yr	0.05	12.8
Total Nitrogen	lbs/yr	0.1	33.7
Biological oxygen demand	5-day	0.4	119.6
Ammonia nitrogen	lbs/yr	0.1	25.6

*Assuming the average septic system treats water from 4 people per day using approximately 70 gallons of water per person per day, or 280 gallons treated per day per septic system (source: Ohio Department of Natural Resource Loading Spreadsheet from Canter and Knox, 1985. *Septic Tank System Effects on Ground Water Quality*, Lewis Publishers).

12.5. Evaluating the Watershed Management Plan

The watershed management plan should be reviewed and updated as needed. The KRWC, or umbrella partnership leader, 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
- Action Strategy Comparisons – compare the overall watershed Action Plan with periodically updated subwatershed management unit action plans

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Attachment 1. Partnership agreement.

PARTNERSHIP AGREEMENT

Protection and Enhancement of the Kalamazoo River Watershed

This document is a non-regulatory Partnership Cooperation Agreement between various units of government, businesses and private sector organizations dedicated to long-term, sustainable protection and enhancement of the broad range of values found within the Kalamazoo River Watershed. The partnership is not a contract. It is a statement of intent, support and willingness to participate at a level appropriate to the respective interests of the individual partners.

The groups committed to this partnership jointly recognize the need for improving, maintaining and protecting the quality of the Kalamazoo River Watershed. They share a desire to protect and enhance the designated and desired uses of the watersheds. The parties do so in the unanimous belief that restoring these assets to their full potential will provide significant aesthetic, recreational, economic and environmental benefits to the area for years to come.

BACKGROUND

The Kalamazoo River is a major feature of southwest Michigan, and has played a crucial role in the exploration, settlement, and economic growth of our region. It remains among our most valuable resources. Presenting unparalleled cultural, recreational, aesthetic, and ecological benefits, the land and water resources within the watershed contribute immeasurably to the quality of life for all Michigan citizens and visitors, present and future.

The watershed has had a history of pollution problems, many of which still linger today. Working with and for, local communities, business and industry, state and federal agencies, educational institutions and non-profit organizations, local citizens have shown great commitment and significant success in enhancing the quality of the watershed's resources. Recent efforts to address water quality concerns of the Kalamazoo River system are nationally recognized for their watershed-wide, community based approach stressing voluntary, cooperative strategies.

While there are numerous organizations working on a particular watershed issue, or a portion of the watershed, there really is no single organization that attempts to deal with all issues throughout the watershed, or that speaks on behalf of the entire watershed. Through a series of public forums, workshops and other discussions in recent years, there is strong support for an overall, watershed wide "umbrella" organization. After many meetings of a wide variety of concerned citizens, the following outlines what this organization should, and should not, be:

It should:

- Provide a common, single voice for the entire watershed and its citizens;
- Serve as an information clearing house on all watershed related issues, including action alerts when appropriate;
- In certain circumstances, serve as the fiduciary agent for those organizations without that capability;
- Coordinate overall educational and watershed planning efforts; and,
- Provide overall watershed leadership.

It should not:

- Attempt to be a “super” or “supervisory” organization;
- Hinder, conflict or interfere with other organizations working on behalf of the watershed; or,
- Attempt to speak for another organization, unless requested by that organization and/or part of an overall agreed upon watershed strategy.
- This partnership agreement is intended to provide structure to this coordinated effort to provide long-term, sustainable protection and enhancement to the environmental, economic, aesthetic, recreational and environmental values of the Kalamazoo River Watershed.

PRINCIPAL ENTITIES AND THEIR ROLES

Umbrella organization

The Kalamazoo River Watershed Council (Council) has agreed to serve as the overall “umbrella” organization. The Kalamazoo River Watershed Council* is a public, non-profit 501(c)3 organization whose mission is to work collaboratively with the community, government agencies, local officials and businesses to improve and protect the health of the Kalamazoo River, its tributaries, and its watershed. The goals of the Kalamazoo River Watershed Council are to: 1) Promote wise stewardship and use of the natural resources of the Kalamazoo River and its watershed through education about its environmental, social, and economic issues; 2) Promote and celebrate the river as a recreational, aesthetic, and economic resource; 3) Facilitate, support, and provide technical assistance to partners addressing river and watershed issues, management planning, and funding; 4) Develop and implement resource protection and ecological enhancement projects; and, 5) Continue to function as the Public Advisory Council for all matters related to the problem of contaminated sediments in the Kalamazoo River system, advocating long-term solutions that will help produce a cleaner and safer river environment.

* The Kalamazoo River Watershed Council is the assumed name of this organization, which was incorporated under the name of the Kalamazoo River Public Advisory Council.

Stephen K. Hamilton, President

Kalamazoo River Watershed Council

PARTNER ORGANIZATIONS

What follows is a description, in their own words, of each of the partner organizations:

Who they are, what they do and how they do it; and
How they envision interacting with, serving and being served by the Watershed Council acting as the "umbrella" organization.

1) Kalamazoo River/Lake Allegan Total Maximum Daily Load (TMDL) Implementation Committee (Committee)

The Committee is an informal, voluntary, stakeholder based gathering of citizens, coming together to reduce phosphorus within the watershed. Its purpose is to provide watershed wide leadership in the implementation of the Phosphorus TMDL Implementation Plan developed in 2002. This includes: overall coordination and communication; convening and facilitation of stakeholders; assist in reporting and tracking; encourage and support appropriate regulatory activities; identify watershed needs and sources of funding; nurture and support existing community organizations; and examine and analyze other successful watershed protection efforts for possible use within this watershed.

The Committee and the Council agree to the following: 1) jointly participate in governance and participation in activities of both groups; 2) assist the Council in serving as the center for watershed communications; 3) develop a long-term repository for watershed information and data, and serve as an information clearing house; and 4) provide assistance in promotion and support of activities, issues and areas of mutual interest.

Thomas Dunn, Chair Date

Attachment 2. Crosswalk table of subwatersheds as defined by project, agency, and management unit.

SUB	*HUC - NRCS 14 digit*	*HUC - NRCS 12 digit and 303d*	DRAIN_TO	WCOURSE	OUTLET	SEC	TN	RNG	CO	AREA_MI	TDA_MI	Sub-WMP	SWWMP	Phosphorus TMDL
1	*30100 10*	*201*	2	S Br Kalamazoo River	at Mosherville Road	3	05S	02W	30	14.3	14.3			TMDL
2	*30100 20*	*201*	3	S Br Kalamazoo River	at Unnamed Trib	31	04S	02W	30	24.7	39.1			TMDL
3	*30100 30*	*202*	4	S Br Kalamazoo River	at Unnamed Trib	11	05S	03W	30	22.0	61.1			TMDL
4	*30100 40*	*203*	5	S Br Kalamazoo River	at Beaver Creek	30	04S	03W	38	29.2	90.3			TMDL
5	*30100 50*	*204*	7	S Br Kalamazoo River	at Swains Lake Drain	12	04S	04W	13	17.3	107.6			TMDL
6	*30100 60*	*205*	7	Lampson Run Drain	at Mouth	8	04S	04W	13	21.7	21.7			TMDL
7	*30100 70*	*206*	8	S Br Kalamazoo River	at Gage #04102850	20	03S	04W	13	18.4	147.7			TMDL
8	*30100 80*	*206*	12	S Br Kalamazoo River	at Mouth	35	03S	04W	13	5.5	153.2			TMDL

SUB	*HUC - NRCS 14 digit*	*HUC - NRCS 12 digit and 303d*	DRAIN_TO	WCOURSE	OUTLET	SEC	TN	RNG	CO	AREA_MI	TDA_MI	Sub-WMP	SWWMP	Phosphorus TMDL
9	*3010090*	*101*	11	North Kalamazoo River	at Cross Lake	32	03S	02W	38	33.3	33.3			TMDL
10	*3010100*	*102*	11	Spring Arbor and Concord	at Mouth	9	03S	03W	38	20.9	20.9			TMDL
11	*3010110*	*103*	12	N Br Kalamazoo River	at Spring Arbor and Concord Drain	9	03S	03W	38	25.2	79.3			TMDL
12	*3010120*	*104 & 406*	20	Kalamazoo River	at Gage #04103010	26	02S	05W	13	37.1	269.6			TMDL
13	*3020010*	*404*	14	Wilder Creek	at Huckleberrry Drain	15	03S	05W	13	15.1	15.1			TMDL
14	*3020020*	*404*	20	Wilder Creek	at Mouth	33	02S	05W	13	14.8	29.9			TMDL
15	*3020030*	*401*	16	S Br Rice Creek	at State Route 99	18	02S	03W	38	16.9	16.9	Rice Creek		TMDL
16	*3020040*	*402*	19	S Br Rice Creek	at Mouth	14	02S	05W	13	22.5	39.4	Rice Creek		TMDL
17	*3020050*	*403*	18	N Br Rice Creek	at Gordon Lake	26	01S	04W	13	21.6	21.6	Rice Creek		TMDL
18	*3020060*	*403*	19	N Br Rice Creek	at Mouth	14	02S	05W	13	14.5	36.1	Rice Creek		TMDL
19	*3020070*	*405*	20	Rice Creek	at Mouth	25	02S	06W	13	21.0	96.5	Rice Creek		TMDL
20	*3020080*	*406*	21	Kalamazoo River	at Gage #04103500	25	02S	06W	13	15.4	411.5			TMDL

SUB	*HUC - NRCS 14 digit*	*HUC - NRCS 12 digit and 303d*	DRAIN_TO	WCOURSE	OUTLET	SEC	TN	RNG	CO	AREA_MI	TDA_MI	Sub-WMP	SWWMP	Phosphorus TMDL
21	*3020090*	*407*	22	Kalamazoo River	at Squaw Lake Drain	33	02S	06W	13	24.6	436.1			TMDL
22	*3020100*	*408*	23	Kalamazoo River	at Pigeon Creek	25	02S	07W	13	21.5	457.6			TMDL
23	*3020110*	*411*	42	Kalamazoo River	at Dickinson Creek	15	02S	07W	13	14.6	472.2			TMDL
24	*3020120*	*409*	25	Harper Creek	at Mouth	19	02S	07W	13	26.6	26.6			TMDL
25	*3020130*	*410*	42	Minges Brook	at Mouth	18	02S	07W	13	27.6	54.2			TMDL
26	*3030010*	*301*	28	Battle Creek	Above Hogle and Miller Drain	20	01N	04W	23	20.6	20.6	Battle Creek		TMDL
27	*3030020*	*301*	28	Hogle and Miller Drain	at Mouth	20	01N	04W	23	6.6	6.6	Battle Creek		TMDL
28	*3030030*	*302*	30	Battle Creek	at Unnamed Trib	28	02N	04W	23	15.9	43.0	Battle Creek		TMDL
29	*3030050*	*303*	30	Big Creek	at Mouth	15	01N	05W	23	18.0	18.0	Battle Creek		TMDL
30	*3030040*	*306*	33	Battle Creek	at Big Creek	15	01N	05W	23	27.4	88.5	Battle Creek		TMDL
31	*3030060*	*304*	32	Indian Creek	at State and Indian Creek	13	01S	05W	13	33.1	33.1	Battle Creek		TMDL
32	*3030070*	*305*	33	Indian Creek	at Mouth	18	01N	05W	23	16.7	49.7	Battle Creek		TMDL
33	*3030080*	*306*	34	Battle Creek	at Indian Creek	18	01N	05W	23	9.7	147.9	Battle Creek		TMDL

SUB	*HUC - NRCS 14 digit*	*HUC - NRCS 12 digit and 303d*	DRAIN_TO	WCOURSE	OUTLET	SEC	TN	RNG	CO	AREA_MI	TDA_MI	Sub-WMP	SWWMP	Phosphorus TMDL
34	*3030090*	*307*	35	Battle Creek	at Gage #04104500	29	01N	06W	23	23.7	171.6	Battle Creek		TMDL
35	*3030100*	*308*	36	Battle Creek	at Ackley Creek	6	01S	06W	13	18.7	190.3	Battle Creek		TMDL
36	*3030110*	*309*	40	Battle Creek	at Unnamed Trib	13	01S	07W	13	16.8	207.0	Battle Creek		TMDL
37	*3030120*	*310*	38	Wanadoga Creek	at Ellis Creek	23	01N	07W	8	26.0	26.0	Battle Creek		TMDL
38	*3030130*	*311*	39	Wanadoga Creek	at Gage #04104945	9	01S	07W	13	22.3	48.3	Battle Creek		TMDL
39	*3030140*	*311*	40	Wanadoga Creek	at Mouth	21	01S	07W	13	5.9	54.3	Battle Creek		TMDL
40	*3030150*	*312*	41	Battle Creek	at Gage #04105000	5	02S	07W	13	12.8	274.0	Battle Creek		TMDL
41	*3030160*	*312*	42	Battle Creek	at Mouth	1	02S	08W	13	6.4	280.4	Battle Creek		TMDL
42	*3030170*	*411*	45	Kalamazoo River	at Gage #04105500	1	02S	08W	13	12.5	819.3			TMDL
43	*3040010*	*501*	44	Wabascon Creek	at Luce Road	36	01N	08W	8	27.4	27.4			TMDL
44	*3040020*	*502*	45	Wabascon Creek	at Mouth	29	01S	08W	13	19.5	46.9			TMDL
45	*3040030*	*503*	52	Kalamazoo River	at Wabascon Creek	29	01S	08W	13	24.5	890.8			TMDL
46	*3040040*	*504*	52	Sevenmile Creek	at Mouth	25	01S	09W	39	16.3	16.3			TMDL
47	*3040050*	*505*	48	Augusta Creek	at Unnamed Trib	3	01S	09W	39	19.1	19.1	Four Townships		TMDL

SUB	HUC - NRCS 14 digit	HUC - NRCS 12 digit and 303d	DRAIN_TO	WCOURSE	OUTLET	SEC	TN	RNG	CO	AREA_MI	TDA_MI	Sub-WMP	SWWMP	Phosphorus TMDL
48	*3040060*	*506*	49	Augusta Creek	at Gage #04105700	27	01S	09W	39	17.7	36.8	Four Townships		TMDL
49	*3040070*	*506*	52	Augusta Creek	at Mouth	34	01S	09W	39	1.0	37.8	Four Townships		TMDL
50	*3040080*	*507*	51	Gull Creek	at Gage #04105800	7	02S	09W	39	35.7	35.7	Four Townships		TMDL
51	*3040090*	*507*	52	Gull Creek	at Mouth	17	02S	09W	39	1.8	37.5	Four Townships		TMDL
52	*3040100*	*508*	53	Kalamazoo River	at Gull Creek	17	02S	09W	39	30.6	1012.9		Mainstem 3	TMDL
53	*3040110*	*509*	55	Kalamazoo River	at Morrow Lake Dam	21	02S	10W	39	23.9	1036.8		Mainstem 3	TMDL
54	*3040120*	*601*	55	Comstock Creek	at Mouth	20	02S	10W	39	18.3	18.3	Four Townships		TMDL
55	*3040130*	*604*	63	Kalamazoo River	at Gage #04106000	20	02S	10W	39	4.4	1059.5		Mainstem 3	TMDL
56	*3050010*	*604*	63	Davis Creek	at Mouth	24	02S	11W	39	14.5	14.5	Davis Creek	Mainstem 3 overlap	TMDL
57	*3050020*	*603*	58	Portage Creek	at Gage #04106180	16	03S	11W	39	14.9	14.9	Portage/Arcadia		TMDL
58	*3050030*	*603*	61	Portage Creek	at Gage #04106300	34	02S	11W	39	5.4	20.3	Portage/Arcadia		TMDL
59	*3050040*	*602*	60	W Fork Portage Creek	at Gage #04106320	6	03S	11W	39	14.5	14.5	Portage/Arcadia		TMDL
60	*3050050*	*602*	61	W Fork Portage Creek	at Gage #04106400	6	03S	11W	39	6.7	21.2	Portage/Arcadia		TMDL
61	*30500*	*603*	62	Portage	at Gage	27	02S	11W	39	6.2	47.7	Portage/Arc		TMDL

SUB	*HUC - NRCS 14 digit*	*HUC - NRCS 12 digit and 303d*	DRAIN_TO	WCOURSE	OUTLET	SEC	TN	RNG	CO	AREA_MI	TDA_MI	Sub-WMP	SWWMP	Phosphorus TMDL
	60			Creek	#04106500							adia		
62	*3050070*	*603*	63	Portage Creek	at Mouth	15	02S	11W	39	4.0	51.7	Portage/Arcadia		TMDL
63	*3050080*	*604*	65	Kalamazoo River	at Portage Creek	15	02S	11W	39	6.0	1131.7		Mainstem 3	TMDL
64	*3050090*	*605*	65	Spring Brook	at Mouth	27	01S	11W	39	38.6	38.6	Four Townships		TMDL
65	*3050100*	*606*	66	Kalamazoo River	at Spring Brook	27	01S	11W	39	40.5	1210.7	Portage/Arcadia portion	Mainstem 3 portion	TMDL
66	*3050110*	*607*	67	Kalamazoo River	at Silver Creek	4	01S	11W	39	36.8	1247.6	Four Townships		TMDL
67	*3050120*	*607*	74	Kalamazoo River	at Plainwell Dam	24	01N	12W	3	17.5	1265.1			TMDL
68	*3060010*	*701*	69	Gun River	at Gun Lake Outlet	6	02N	10W	8	34.2	34.2	Gun River		TMDL
69	*3060020*	*702*	70	Gun River	at Culver Drain	26	02N	11W	3	46.2	80.5	Gun River		TMDL
70	*3060030*	*703*	74	Gun River	at Mouth	24	01N	11W	3	34.0	114.5	Gun River		TMDL
71	*3060040*	*901*	73	Sand Creek	at Mouth	30	01S	12W	39	21.2	21.2			TMDL
72	*3060050*	*902*	73	Base Line Creek	at Mouth	31	01N	12W	3	36.6	36.6			TMDL
73	*3060060*	*903*	74	Pine Creek	at Mouth	21	01N	12W	3	33.3	91.0			TMDL
74	*3060070*	*905*	76	Kalamazoo River	at Otsego Dam	17	01N	12W	13	17.8	1488.4			TMDL
75	*3060080*	*904*	76	Schnable Brook	at Mouth	7	01N	12W	3	36.2	36.2			TMDL

SUB	*HUC - NRCS 14 digit*	*HUC - NRCS 12 digit and 303d*	DRAIN_TO	WCOURSE	OUTLET	SEC	TN	RNG	CO	AREA_MI	TDA_MI	Sub-WMP	SWWMP	Phosphorus TMDL
76	*3060090*	*905*	77	Kalamazoo River	at Trowbridge Dam	12	01N	13W	3	7.3	1531.9			TMDL
77	*3060100*	*906*	78	Kalamazoo River	at Unnamed Dam	28	02N	13W	3	19.5	1551.4			TMDL
78	*3060110*	*907*	80	Kalamazoo River	at Unnamed Dam	28	02N	13W	3	44.8	1596.2			TMDL
79	*3060120*	*908*	80	Swan Creek	at Mouth	9	02N	14W	3	49.1	49.1			
80	*3060130*	*909*	93	Kalamazoo River	at Gage #04108500	32	03N	14W	3	8.1	1653.4			
81	*3070010*	*806*	82	Little Rabbit River	at Dorr and Nichols Drain	17	04N	12W	3	25.6	25.6	Rabbit River		
82	*3070020*	*807*	89	Little Rabbit River	at Mouth	29	04N	13W	3	23.5	49.0	Rabbit River		
83	*3070030*	*804*	88	Bear Creek	at Mouth	17	03N	12W	3	20.1	20.1	Rabbit River		
84	*3070040*	*801*	85	Green Lake Creek	at Mouth	31	04N	11W	3	28.2	28.2	Rabbit River		
85	*3070050*	*802*	86	Rabbit River	at Green Lake Creek	31	04N	11W	3	21.4	49.6	Rabbit River		
86	*3070060*	*805*	88	Rabbit River	at Gage #04108600	16	03N	12W	3	15.5	65.1	Rabbit River		
87	*3070070*	*803*	88	Miller Creek	at Mouth	20	03N	12W	3	30.3	30.3	Rabbit River		
88	*3070080*	*805*	89	Rabbit River	at Bear Creek	17	03N	12W	3	2.7	118.3	Rabbit River		

SUB	*HUC - NRCS 14 digit*	*HUC - NRCS 12 digit and 303d*	DRAIN_TO	WCOURSE	OUTLET	SEC	TN	RNG	CO	AREA_MI	TDA_MI	Sub-WMP	SWWMP	Phosphorus TMDL
89	*3070090*	*808*	91	Rabbit River	at Little Rabbit River	29	04N	13W	3	32.5	199.9	Rabbit River		
90	*3070100*	*809*	91	Black Creek	at Mouth	25	04N	14W	3	35.1	35.1	Rabbit River		
91	*3070110*	*810*	92	Rabbit River	at Silver Creek	35	04N	14W	3	20.4	255.4	Rabbit River		
92	*3070120*	*811*	93	Rabbit River	at Mouth	16	03N	15W	3	37.2	292.6	Rabbit River		
93	*3070130*	*909*	95	Kalamazoo River	at Rabbit River	16	03N	15W	3	26.9	1972.9			
94	*3070140*	*910*	95	Mann Creek	at Mouth	17	03N	15W	3	17.4	17.4			
95	*3070150*	*911*	96	Kalamazoo River	at Peach Orchid Creek	22	03N	16W	3	23.5	2013.8			
96	*3070160*	*912*	0	Kalamazoo River	at Mouth	5	03N	16W	3	17.3	2031.1			

SUB – Subwatershed number from Michigan Geospatial Data Library watershed dataset
HUC - Hydrologic Unit Code, NRCS – Natural Resource Conservation Service
DRAIN_TO – Subwatershed drains to, WCOURSE – Watercourse
SEC – Section, TN – Township, RNG – Range, CO – County
AREA_MI – Area in square miles, TDA_MI – Total drainage area in square miles
Sub-WMP – Subwatershed management planning area
SWWMP – Stormwater watershed management planning area
TMDL – Total Maximum Daily Load, for Lake Allegan

Attachment 3. Build-out analysis and urban cost scenarios (63 pages).

BUILD-OUT ANALYSIS AND URBAN COST SCENARIOS

FOR THE KALAMAZOO RIVER WATERSHED MANAGEMENT PLAN

Prepared for:
Kalamazoo River Watershed Council
408 E. Michigan Avenue
Kalamazoo, Michigan 49007

Prepared by:
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Kalamazoo, Michigan 49007

September 30, 2010

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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

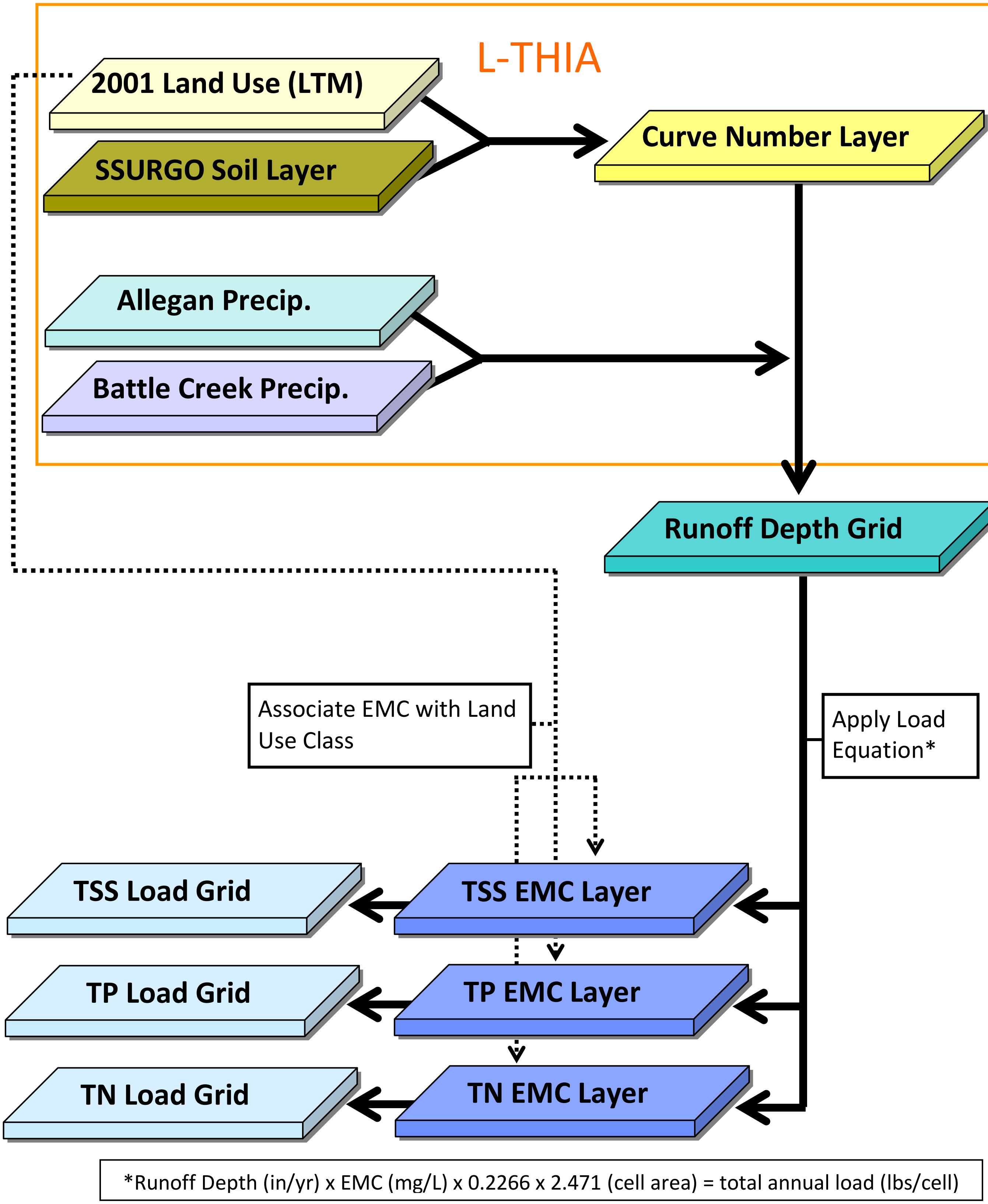

Figure 1. Conceptual flow chart of L-THIA nonpoint source modeling used to calculate runoff depth grids and additional datasets used to calculate annual nutrient and sediment loads in the watershed (where TP is total phosphorus, TN is total nitrogen and TSS is total suspended solids).

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.

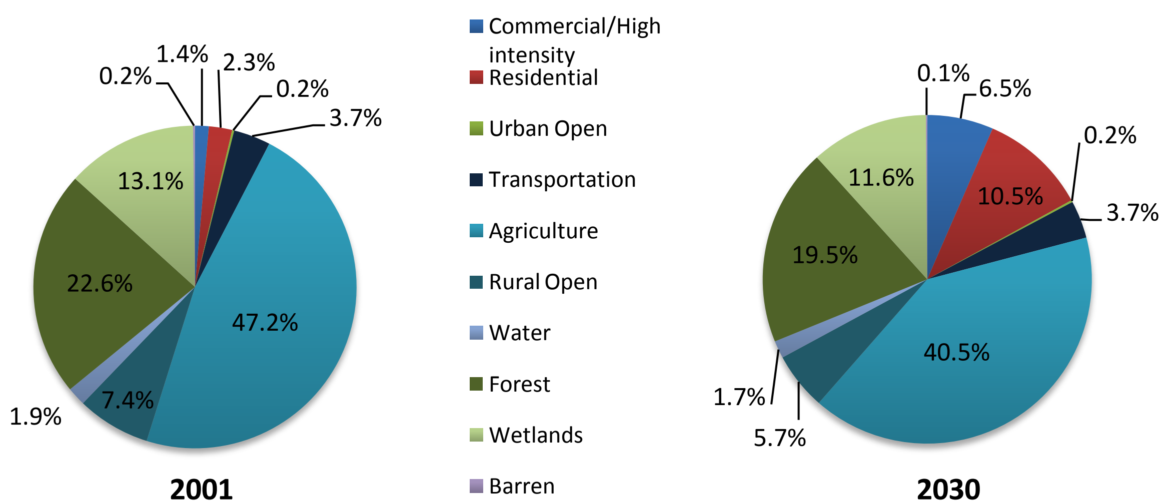

Figure 2. Comparison of land use breakdowns for the Kalamazoo River watershed in 2001 and 2030 (as predicted by the Land Transformation Model).

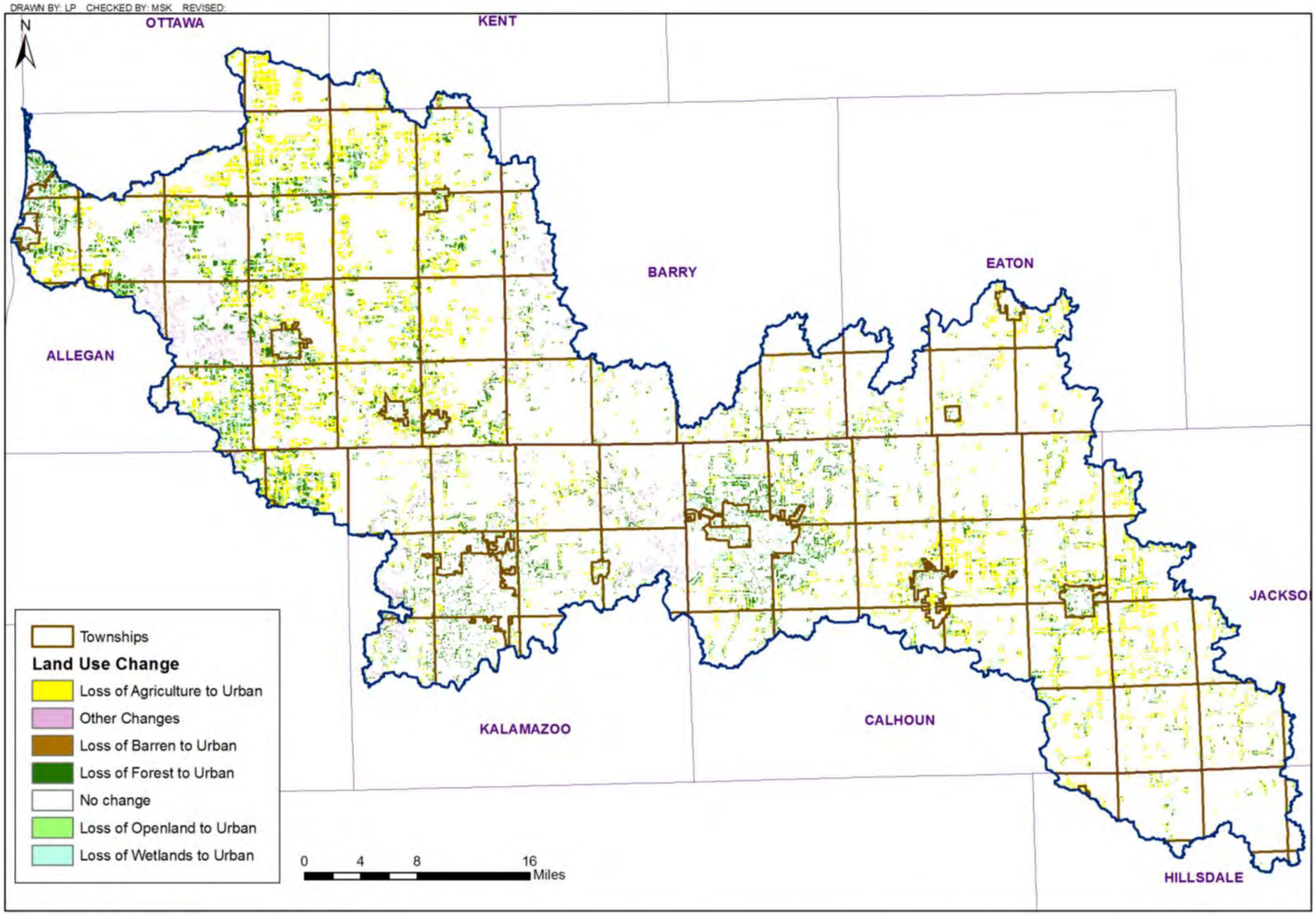

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Figure 3. Land use change from 2001 to 2030 in the Kalamazoo River watershed as predicted by the Land Transformation Model.

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.

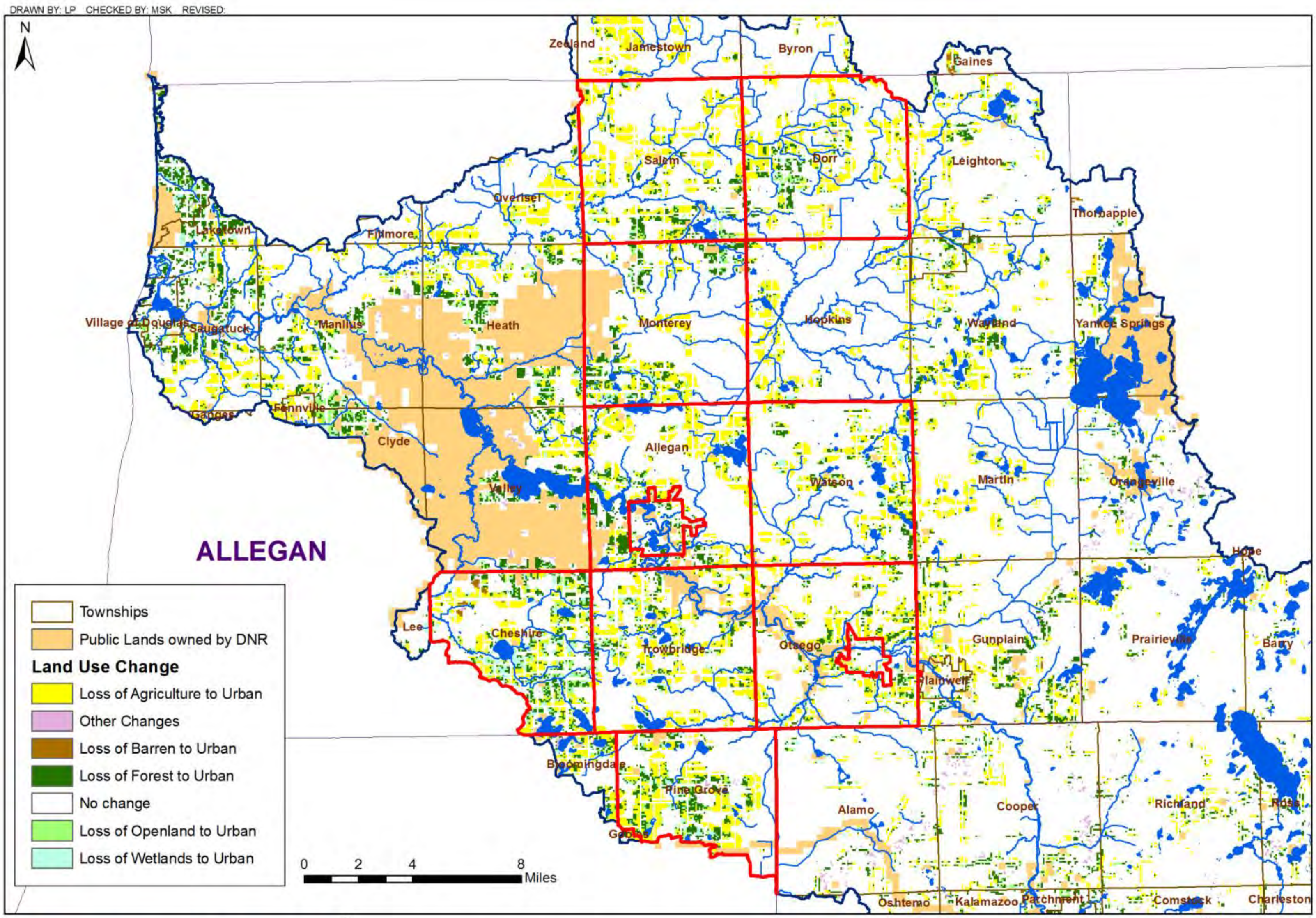

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Figure 4. Townships outlined in red located in the western section of the Kalamazoo River watershed have the largest predicted increase in urban area from the Land Transformation Model.

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.

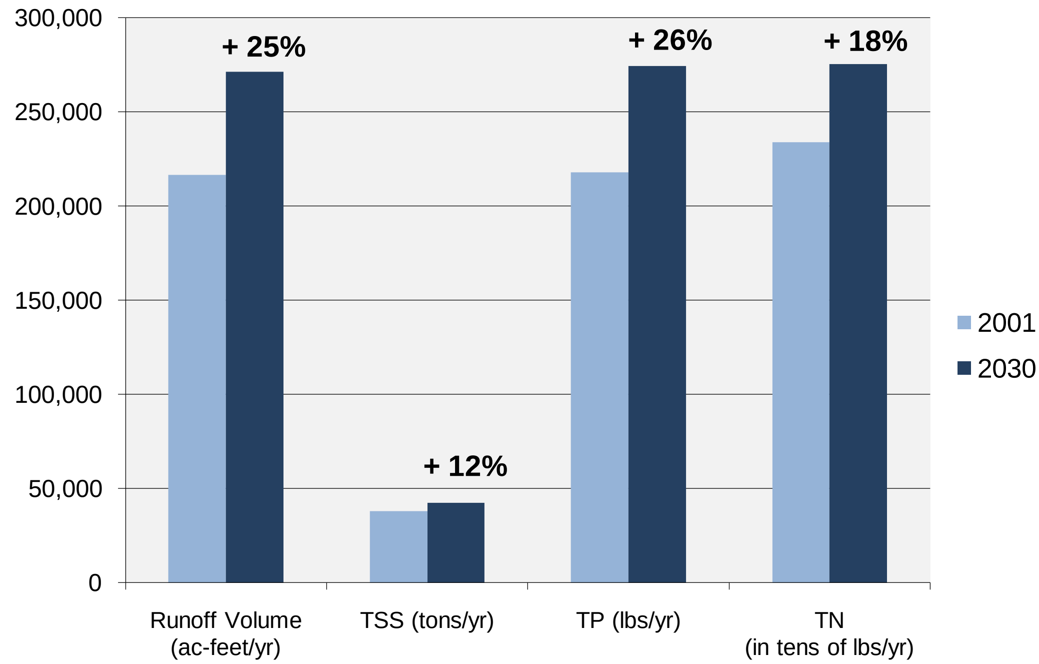

Figure 5. Nutrient load, sediment load and runoff volume comparisons between 2001 and 2030 for the Kalamazoo River watershed.

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.

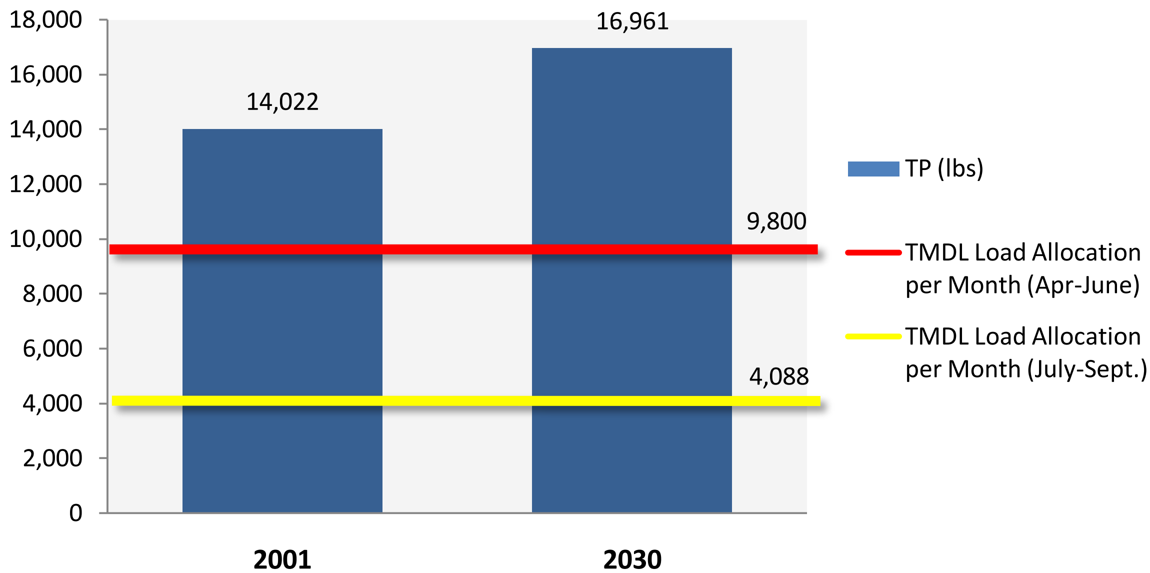

Figure 6. Comparison of NPS TP load (per month) in 2001 and 2030 with TMDL load allocation for the Lake Allegan/ Kalamazoo River TMDL area.

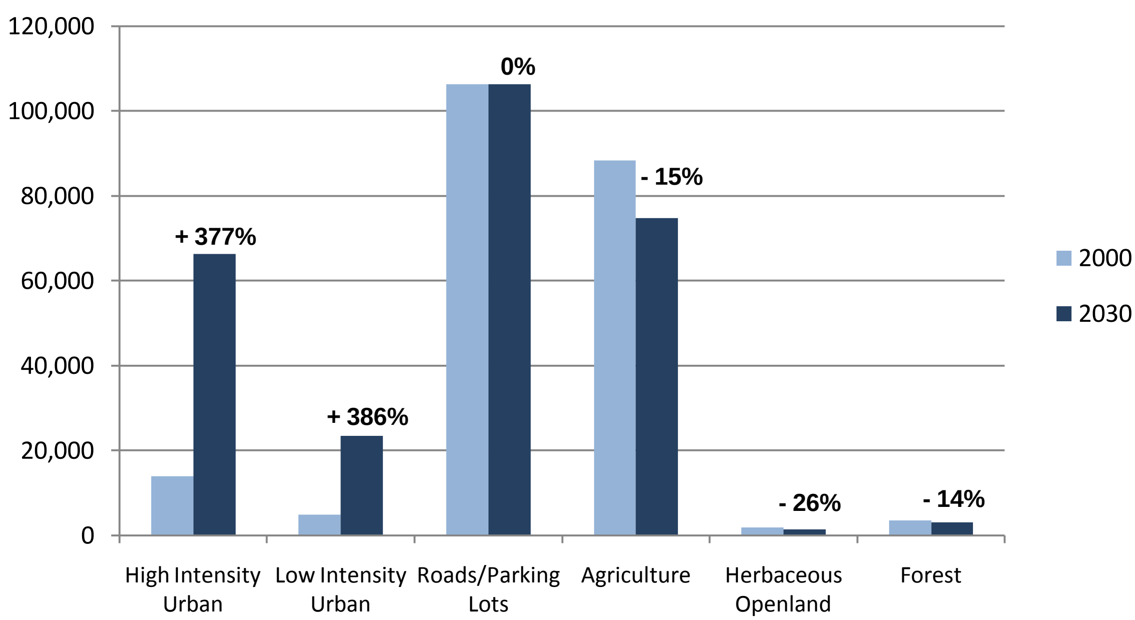

Figure 7. Total phosphorus load (in lbs/year) per land use in the Kalamazoo River watershed.

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.

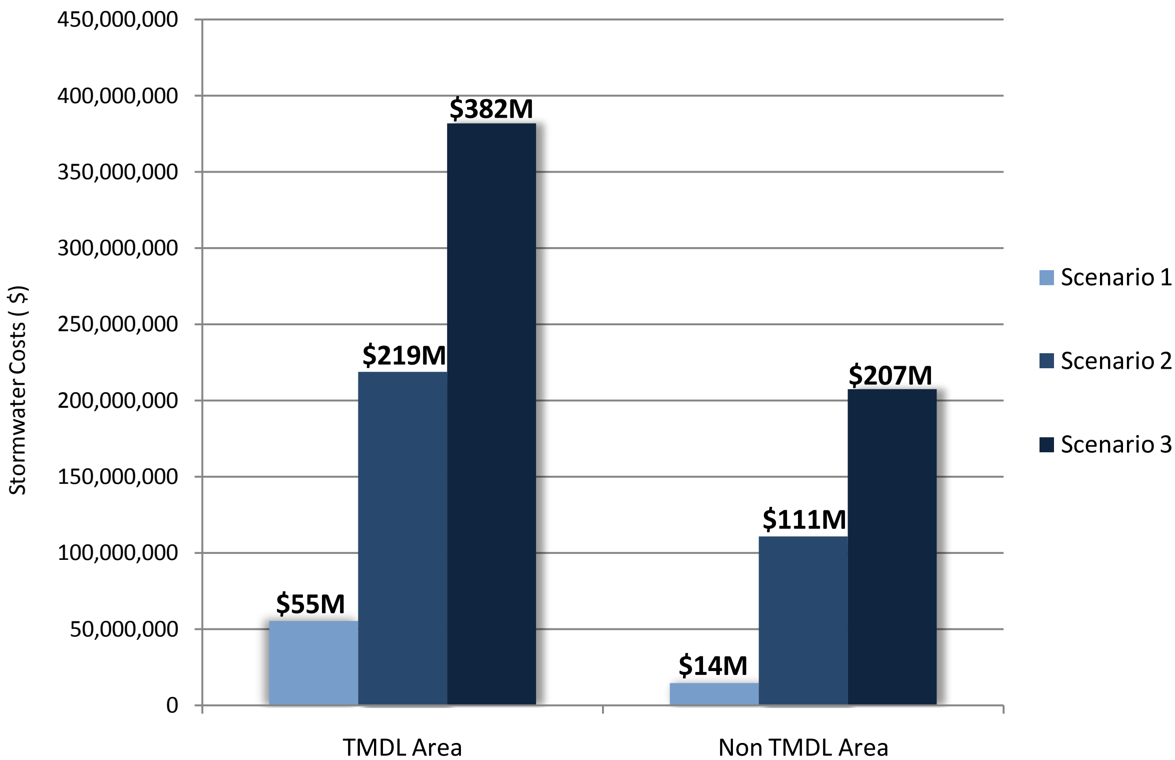

Figure 8. Increasing costs for stormwater controls to treat increasing urban phosphorus loads from 2001 to 2030 in both the TMDL area and the non TMDL area of the watershed.

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**

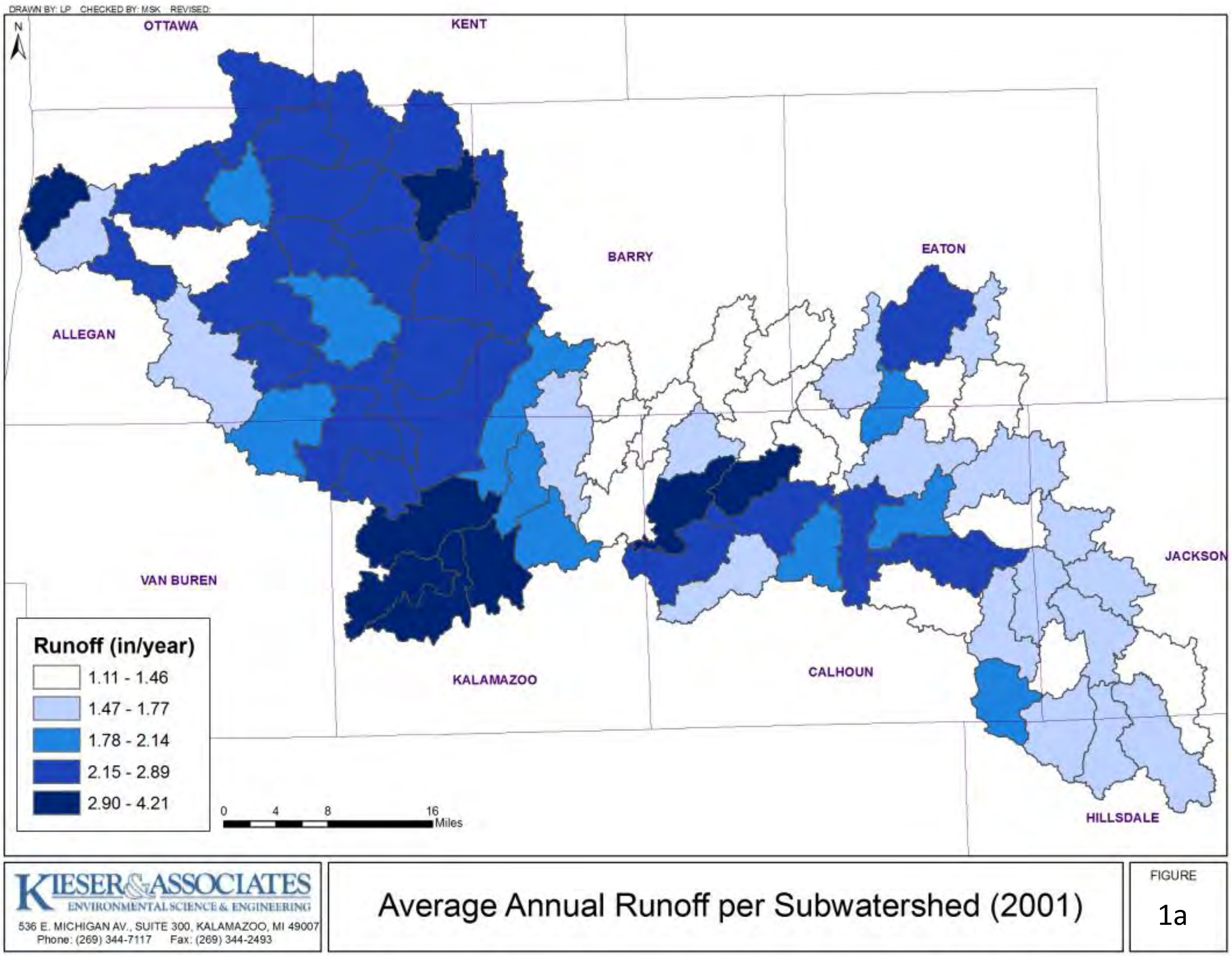
Note: The category "Urban Open" was removed for the table for practical reasons. It represents a small portion of the watershed and does not change during build-out.

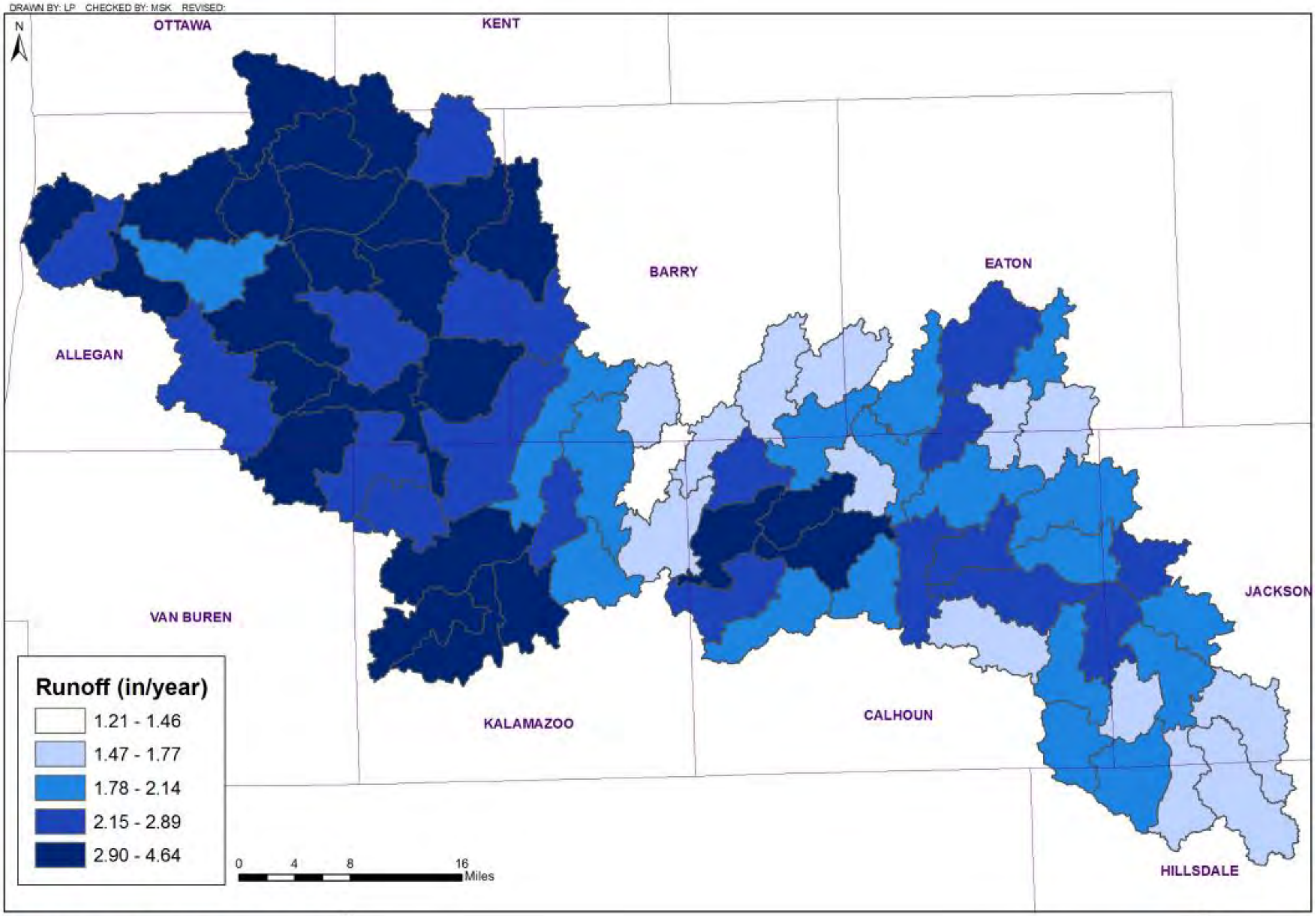
Appendix B

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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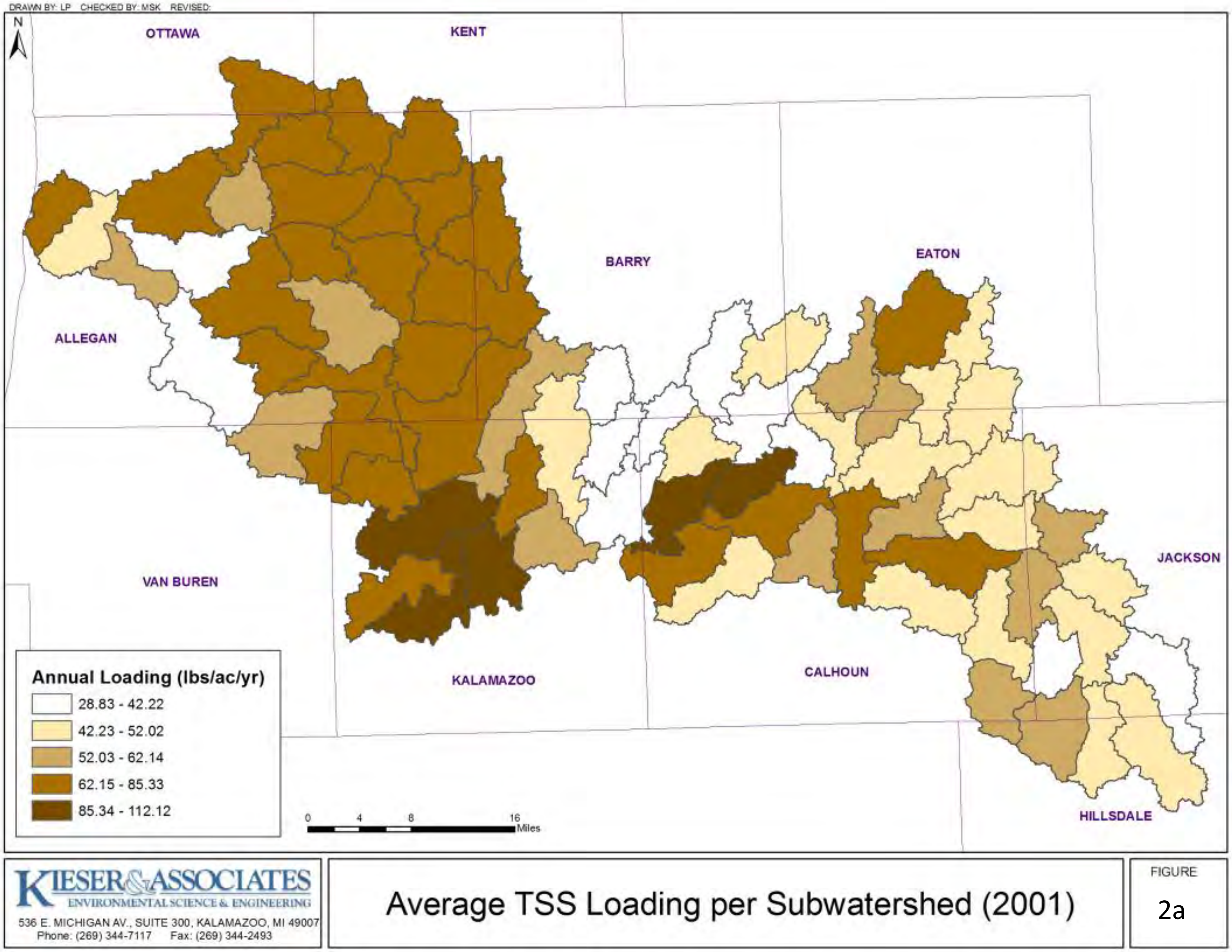
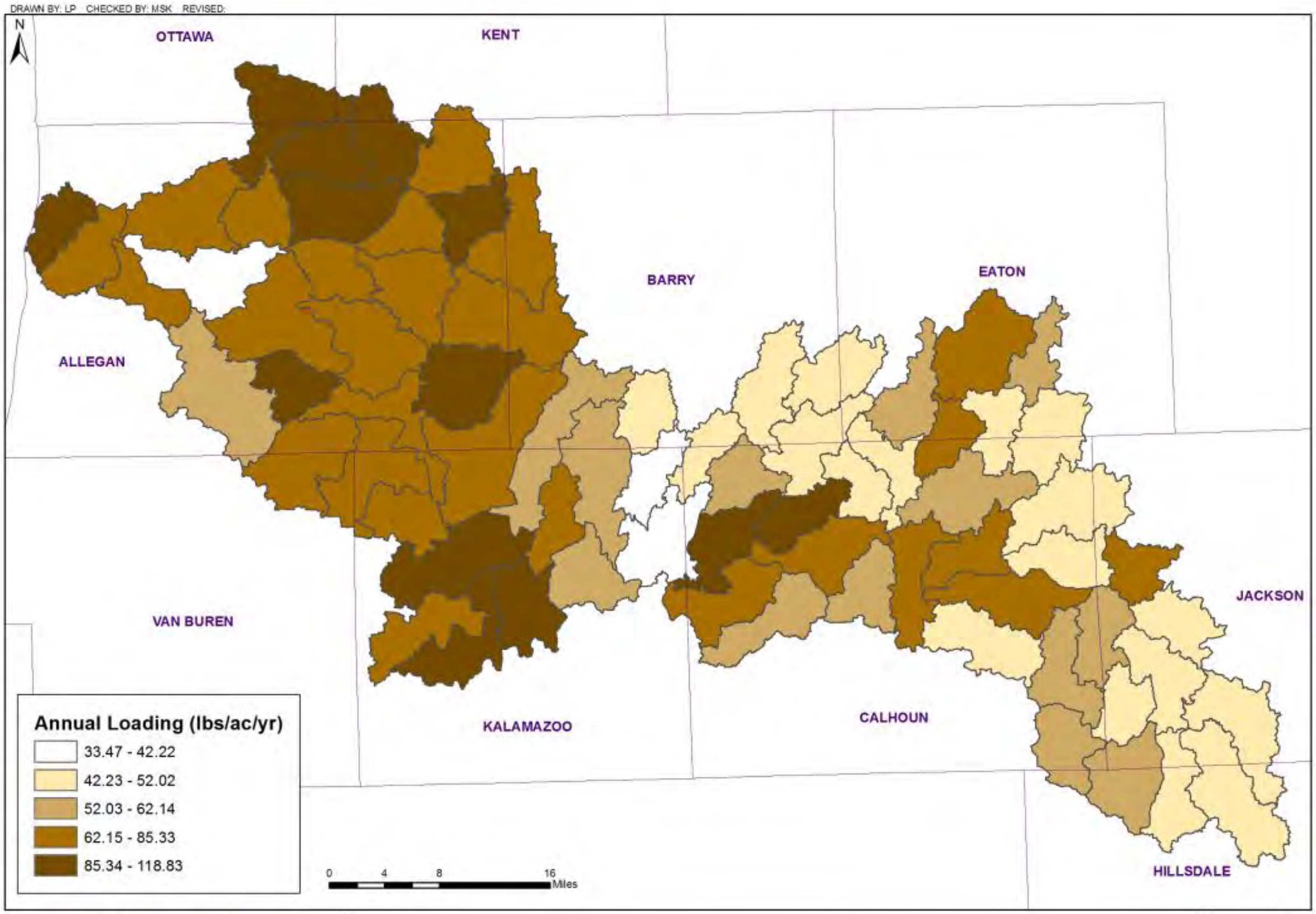
Average Annual Runoff per Subwatershed (2030)

FIGURE
1b

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





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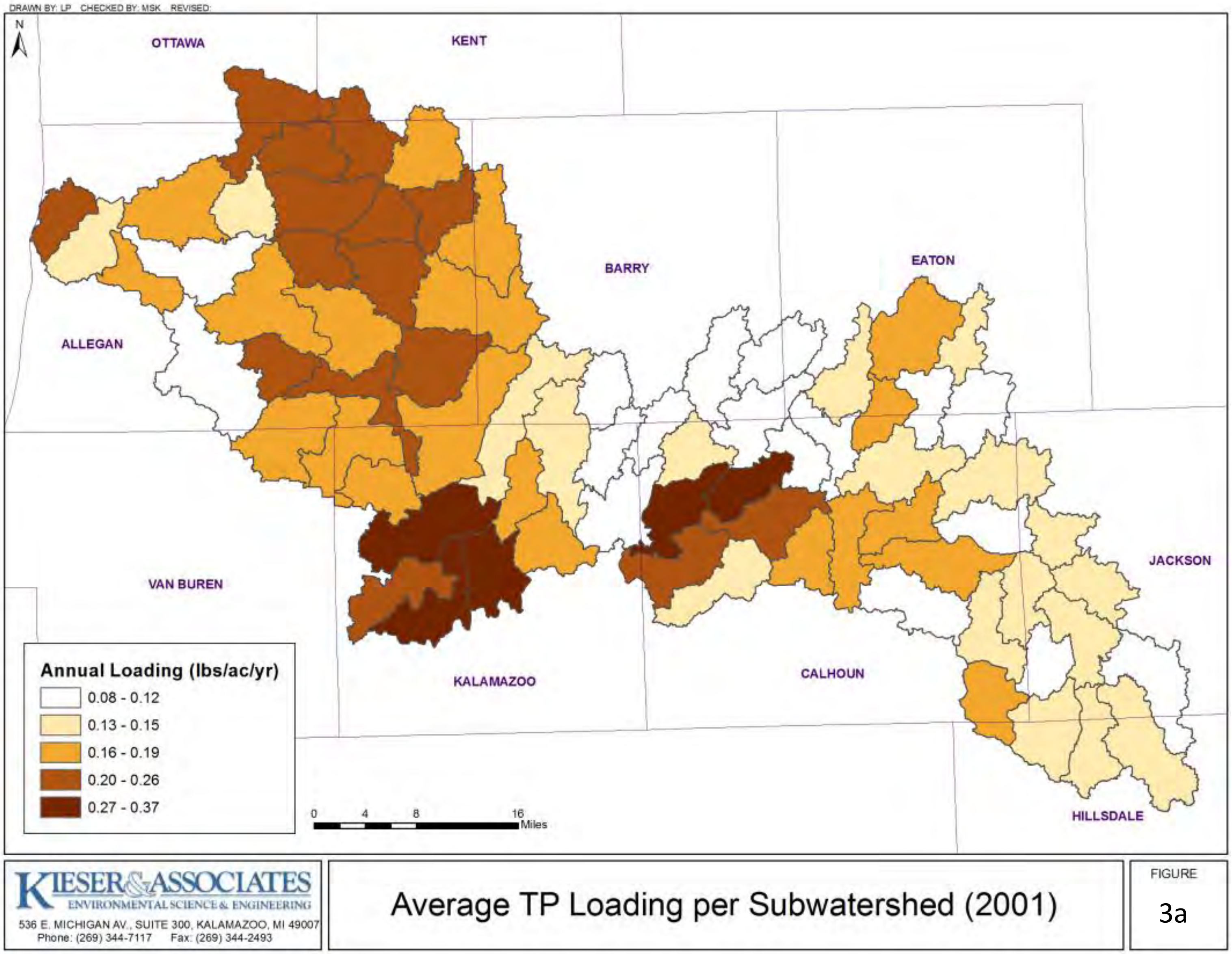
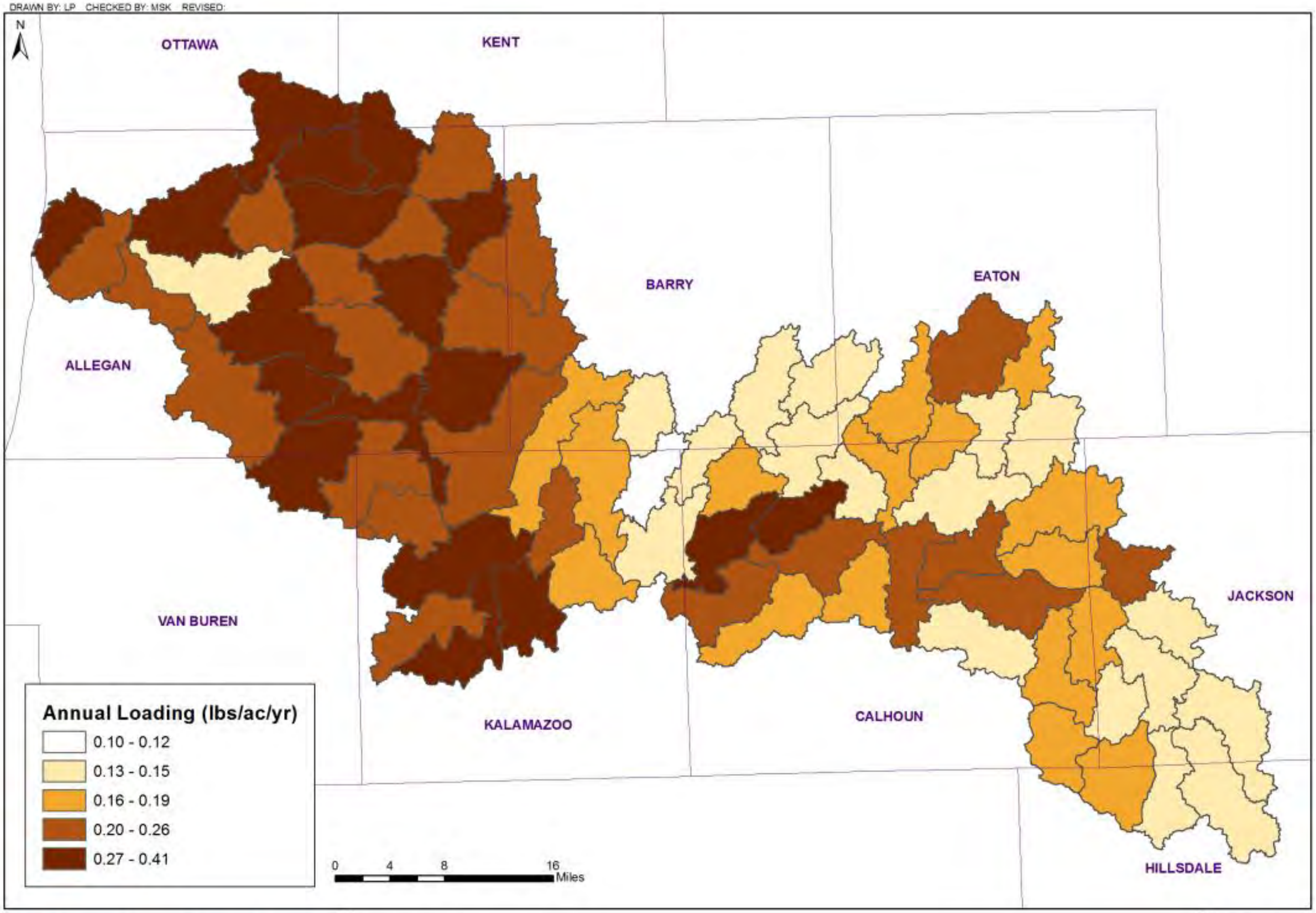
Average TSS Loading per Subwatershed (2030)

FIGURE 2b

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



DRAWN BY: LP CHECKED BY: MSK REVISED:



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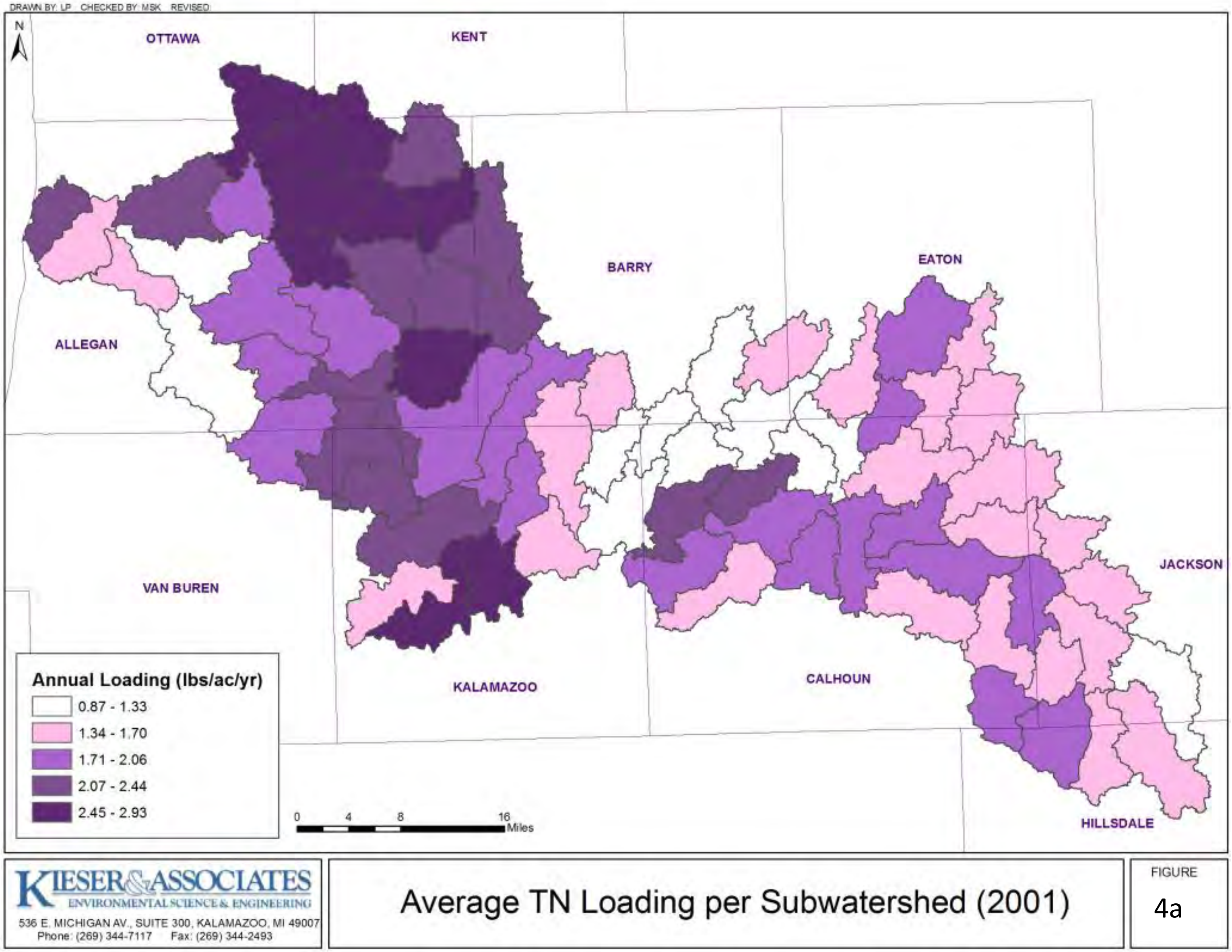
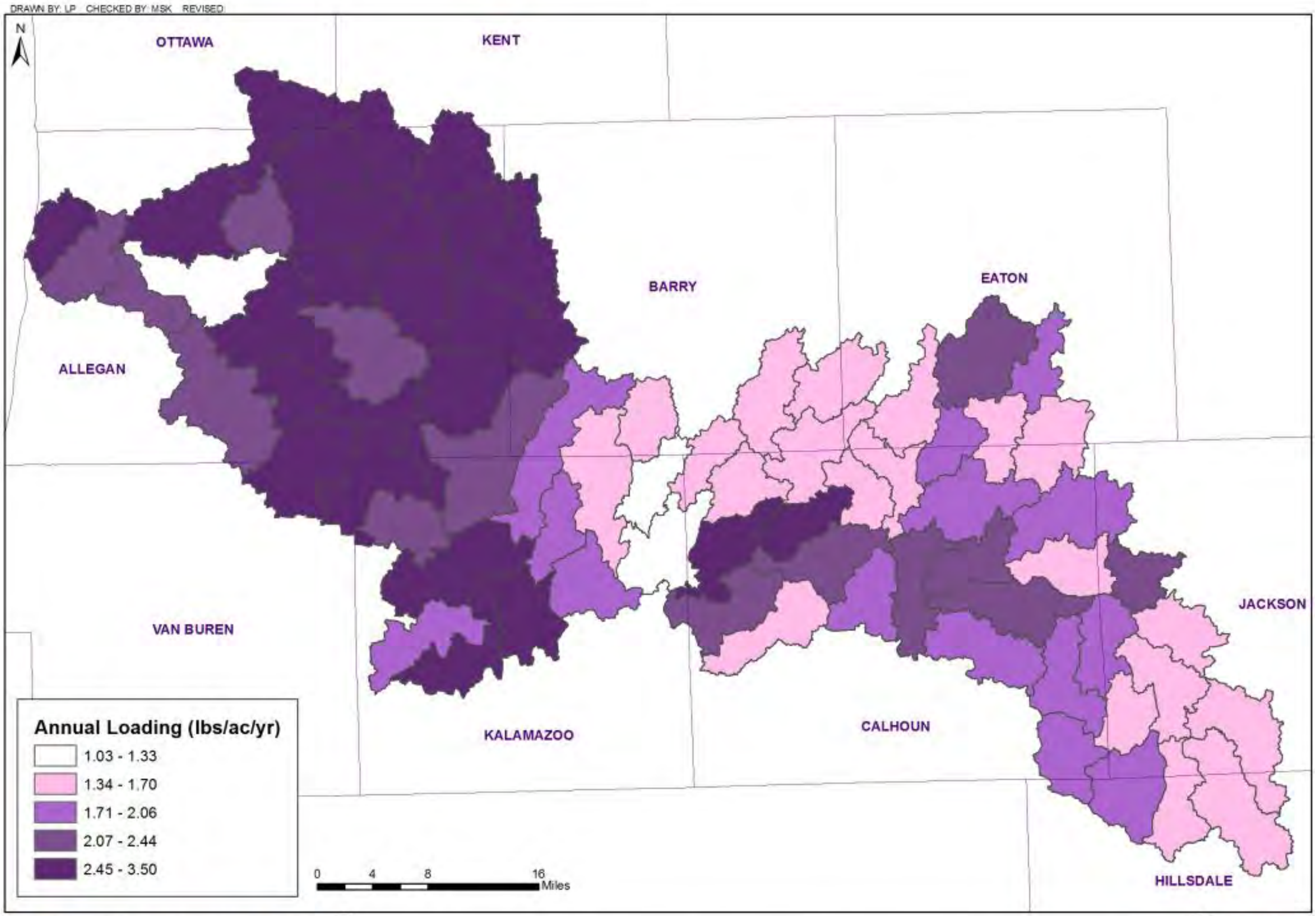
Average TP Loading per Subwatershed (2030)

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

		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
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

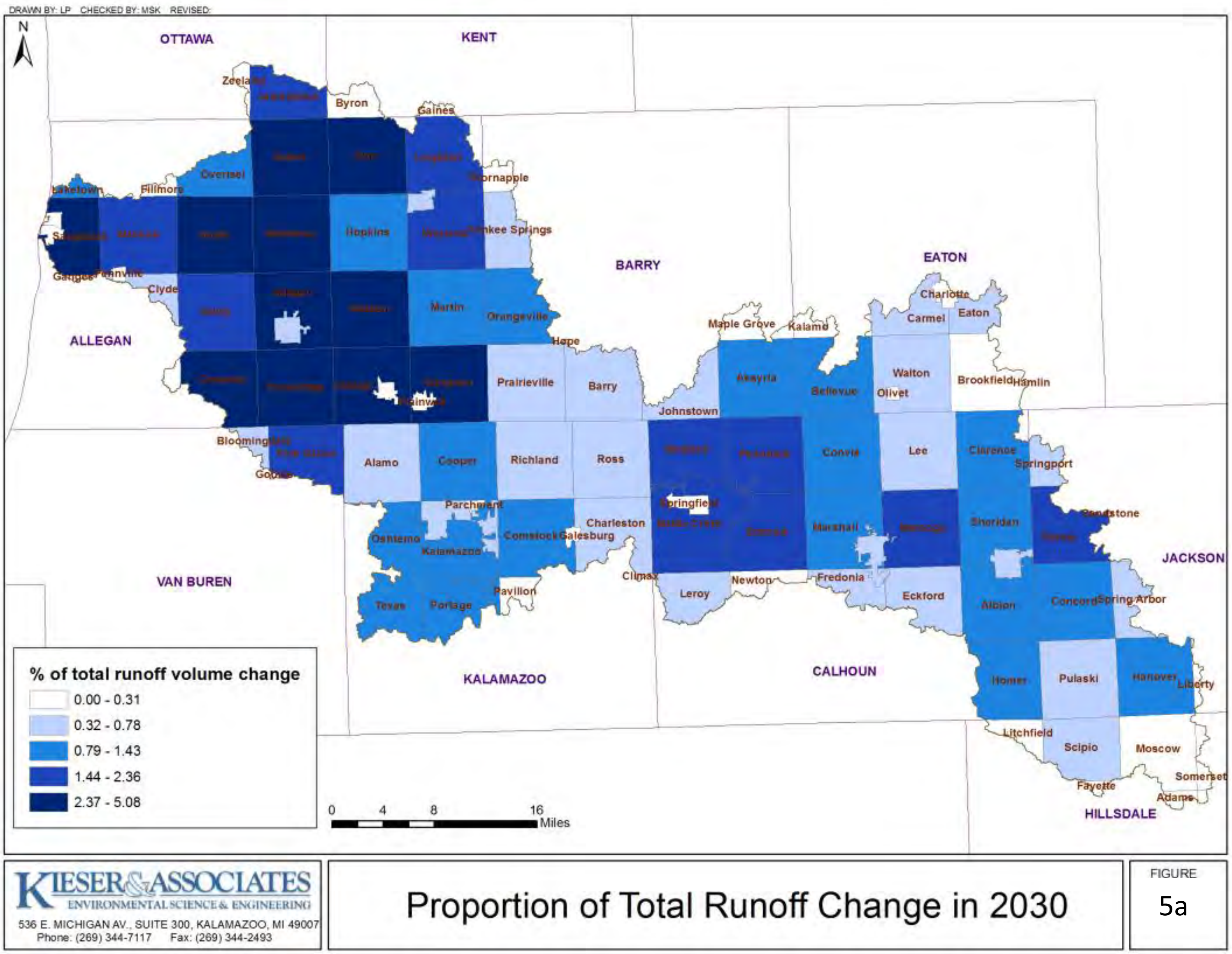
		Runoff Volume (acre-feet/yr)				TSS (tons/yr)				TP (lbs/yr)				TN (lbs/yr)			
Stream	**HUC**	**2001**	**2030**	**Change**	**% of total change**	**2001**	**2030**	**Change**	**% of total change**	**2001**	**2030**	**Change**	**% of total change**	**2001**	**2030**	**Change**	**% of total change**
Davis 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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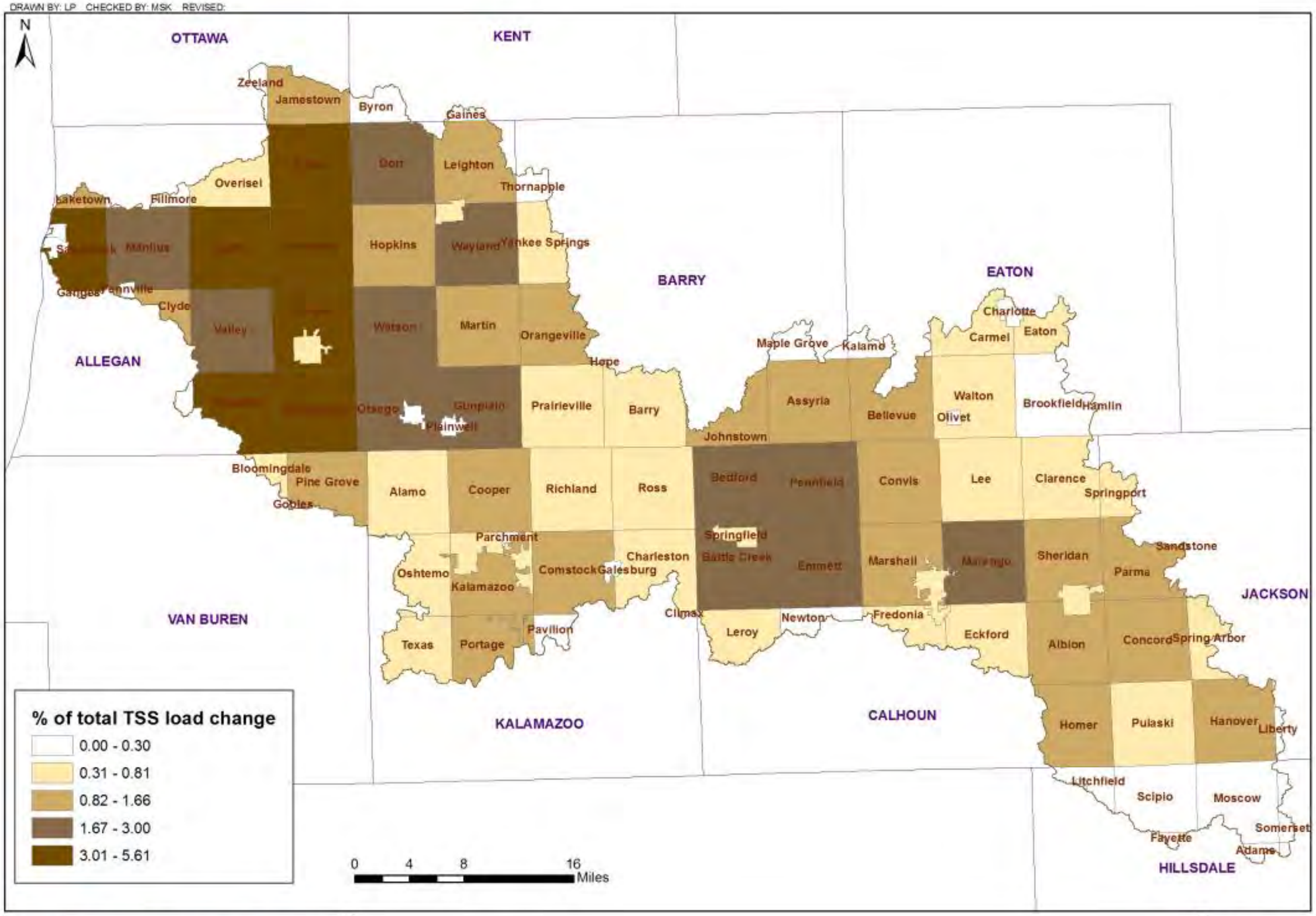

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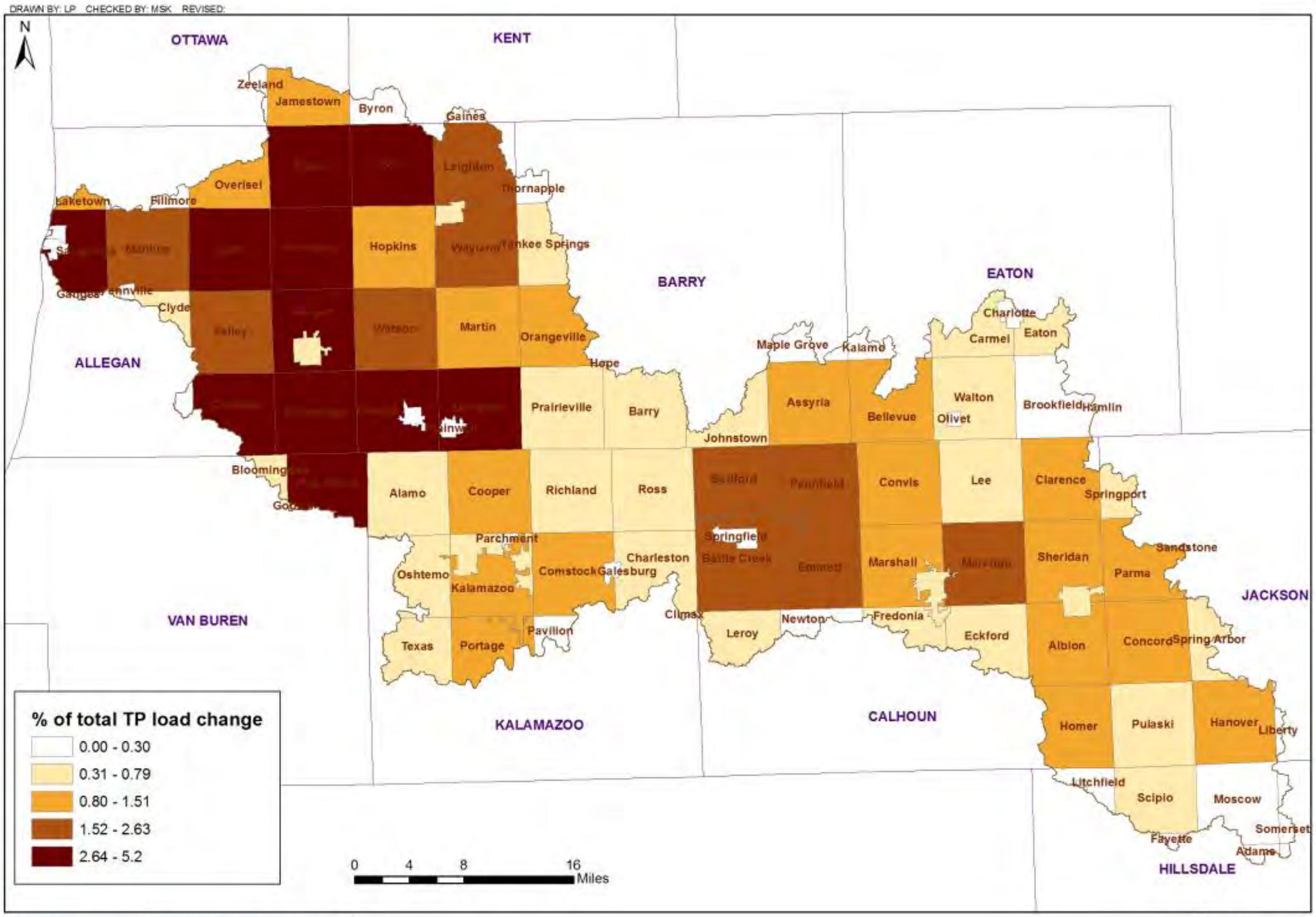
Proportion of Total TSS Change in 2030

FIGURE

5b



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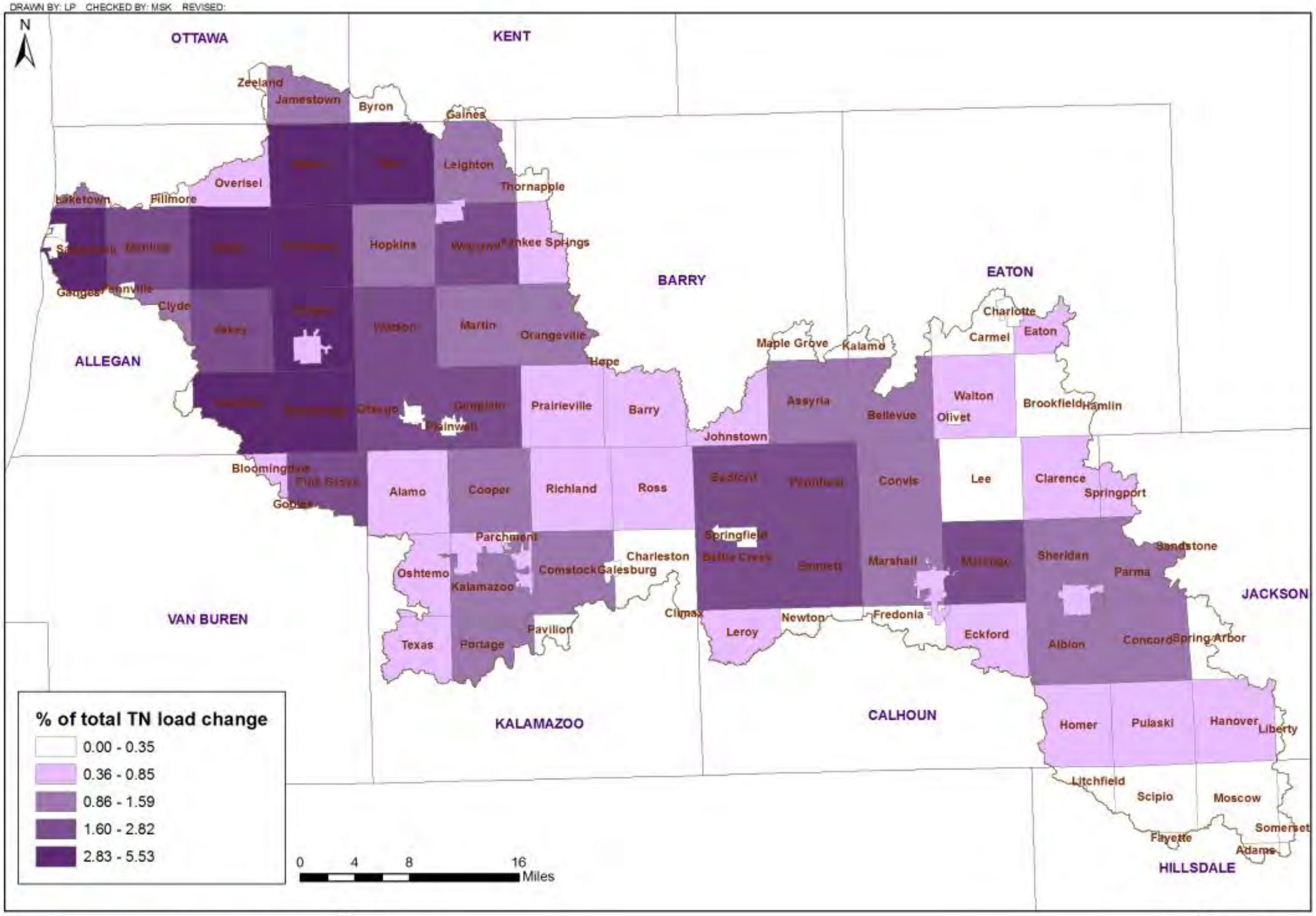
Proportion of Total TP Change in 2030

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

		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
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

NAME	TP LOAD (LBS/YR)				COSTS OF STORMWATER CONTROLS (S)		
	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

Attachment 4. Road stream crossing data for the Kalamazoo River Watershed & streambank erosion sites

The Michigan Department of Environmental Quality (MDEQ) conducted road-stream crossing (RSX) surveys from 2000-2003 on approximately 80% of the crossings within the Kalamazoo River watershed (Kirkwood email, 2007). Approximately 500 road stream crossing sites were surveyed using the MDEQ Road Stream Crossing Survey Form, although not all data fields were completed. The following information summarizes the RSX surveys performed.

Survey Year(s)	2000-2003
Approximate Number of Sites	500
Sub-watersheds without RSX Surveys	Rice Creek Greater Battle Creek Area Kalamazoo Zone B
Concentrated Poor Scores	Mainstem 3 Corridor Mainstem Zone A Rabbit River

Table 1 provides a summary for the scores of RSXs by rating and percent. Table 2 provides information on the approximate subwatershed location of each RSX. MDEQ ranked each site as either poor, fair, or good. Thirty seven RSXs were not given scores or missing location data.

Table1. Rating and associated percent of road-stream crossings

Rating of Road-Stream Crossings in the Kalamazoo River Watershed

Rating	RSX	Percent
Poor	30	6
Fair	191	38
Good	242	49
None	34	7

Table 2. Location of road-stream crossings and number of crossings with poor ratings

Road-Stream Crossings and Poor Ratings in the Kalamazoo River Watershed Per Subwatershed

Subwatershed	RSX	Poor Rating	Percent
Rabbit River	163	4	2
Lower Kalamazoo (Zone A)	109	12	11
Mainstem 3	47	6	13
North Branch Kalamazoo	46	0	0
South Branch Kalamazoo	45	0	0
Battle Creek	14	5	36
Gun River	9	0	0
Portage Creek	9	4	44
Davis Creek	0	0	0
Four Townships Area	0	0	0
Rice Creek	0	0	0

Sites with poor ratings occur in the lower portion of the watershed with no poor ratings appearing in the upper reaches. All of the RSXs in the North and South Branches of the Kalamazoo River have a good or fair rating and no poor ratings. Overall, the MDEQ data appears to have few surveys on RSXs in the middle portion of the watershed.

Attachment 5. 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.

Attachment 6. Individual water body assessment.

Several subwatersheds of the Kalamazoo River watershed have undergone watershed planning exercises, typically funded by Clean Water Act Section 319 grants. In most cases, the following subwatersheds have complete, or nearly completed, USEPA approved watershed plans, making these areas eligible for implementation project funding through the 319 program.

MDEQ Surface Water Quality Division has conducted biosurveys of a number of streams in the Kalamazoo River watershed over the years. See most recent subwatershed management plans for more details linked at www.kalamazooriver.net.

Portage and Arcadia creeks

Portage Creek is a first- to third-order coldwater stream that flows into the Kalamazoo River in the city of Kalamazoo. A survey conducted in 1993 indicated that macroinvertebrate communities were moderately impaired, with the majority of taxa being those that are relatively tolerant of poor water quality and habitat. Designated uses for a coldwater fishery were being met, as indicated by a fish community containing greater than 1% salmonids, however, the physical habitat was rated as severely to moderately impaired. Arsenic concentrations in water samples at two of four locations exceeded those typically found in streams in this ecoregion.

The Portage-Arcadia Creek Watershed is composed of four subwatersheds: Arcadia Creek, Axtell Creek, Portage Creek and the West Fork of Portage Creek. Axtell Creek and the West Fork of Portage Creek flow into Portage Creek, which meets the Kalamazoo River in the City of Kalamazoo.

Arcadia Creek also discharges into the Kalamazoo River in Kalamazoo, just north of the Portage Creek outlet. The dominant soils are Urban Complex and Oshtemo Sandy Loam. Urban lands are those areas that are so obscured by urban work and structures that identification of the soil is not possible. Though the lower reaches of the watershed are largely urban, 44% of the whole watershed is composed of forested land cover. The Arcadia Creek Subwatershed lies within portions of Oshtemo Township and the City of Kalamazoo. This subwatershed flows mostly in an easterly direction, with the headwaters of Arcadia Creek starting west of 11th Street, in the southeastern portion of Oshtemo Township. The watercourse then flows through the western portion of the City of Kalamazoo, roughly parallel with Stadium Drive and on through to the downtown area before finally discharging to the Kalamazoo River. Within the City of Kalamazoo portion of the subwatershed, curb and gutter systems direct storm water from 1,862 acres to storm sewers that collect, transport and discharge approximately 2,362 acre-feet per of storm water into the creek annually. Virtually all 5.5 miles of the creek receive storm water contributions from lightly to heavily urbanized areas within the City of Kalamazoo.

The Axtell Creek Subwatershed lies entirely inside of the City of Kalamazoo. There are 1,519 acres in this subwatershed, located within the west-southwest portion of the city. Greater than half of these acres, including the areas surrounding Pikes Pond, Kleinstuck Marsh, Whites Lake and Woods Lake, contribute no surface water flow to the creek. The land uses of the drainage area are approximately 48% urban, 45% open space and forest, 4% water/wetlands and 3% agriculture. The artesian headwaters of Axtell Creek are found within the City of Kalamazoo Well Field #4, at the intersection of Maple Street and Crosstown Parkway. Pressure relief overflow from active wells provides a significant contribution to the base flow of the creek. The stream flows 1.24 miles from the well field through a channel along Crosstown Parkway to a series of large, shallow storm water detention ponds before discharging to Portage Creek. Over portions of its length, small sections of the creek are piped underground, especially under roadways. Much of the watershed is commercial with several mowed parks surrounding the ponds. Storm water drainage units contribute an approximate 815 acre-feet of runoff annually to the creek.

The Portage Creek Subwatershed lies within the Cities of Portage and Kalamazoo and in Texas Township, with the majority flowing through the City of Portage. This 12.5-mile creek begins to flow west of US-131 in Texas Township to Hampton Lake. After exiting this lake the creek then curves, flowing generally in a northeast direction, through most of the City of Portage before coursing sinuously almost due north through the City of Kalamazoo, and into the Kalamazoo River. Both the West Branch of Portage Creek and Axtell Creek (each considered as separate sub-watersheds in this project) flow into Portage Creek within the City of Kalamazoo. The drainage area includes land uses of approximately 21.3% urban, 52.4% open space and forest, 3.1% water/wetlands and 23.2% agriculture. In the City of Kalamazoo, storm sewers directly drain 2,215 acres into the creek and contribute 3,346 acre-feet of runoff annually.

Battle Creek River

The Battle Creek River Watershed covers 196,750 acres (307 square miles) in northern Calhoun, southeastern Barry, and southern Eaton counties. Land use consists primarily of agriculture followed with forestland, wetland, and urban/rural/non-farm. The headwaters of the Battle Creek River begin at the Duck Lake/Narrow Lake areas as the Battle Creek Drain. As it leaves Narrow Lake, it heads north through the City of Charlotte, southwest through the Village of Bellevue, and finally south towards the City of Battle Creek to where it empties into the Kalamazoo River.

The MDEQ has identified the Battle Creek River as one of the leading tributaries contributing sediment and phosphorus to the Kalamazoo River. It is also one of the flashiest gauged tributaries in the Kalamazoo River Watershed. Through a rigorous inventory of the watershed, the main source of sediment was found to be stream bank erosion resulting from historic dredging.

The dredged channel sediments are often deposited as “berms” along the drainage ditches and may be reintroduced to the drainage system over time through bank erosion. Bank erosion has been suggested as being the largest portion of the sediment budget for the Battle Creek River, but there has not been enough data collected to properly estimate the contribution of sediment from bank erosion, though efforts are ongoing at the Calhoun Conservation District. These sources may represent large components of sediment budgets at the local and watershed scale.

Davis Creek

Davis Creek, also sometimes referred to in whole or in part as Allen Creek or the Olmsted-Davis Drain, is a highly modified, predominately urban drainage corridor in the urban and urbanizing core of Kalamazoo County. Recent water quality tests and biological assessments have shown that the creek is stressed from development and land use impacts associated with continued urbanization of the watershed.

Davis Creek originates at East Lake in Pavilion Township of Kalamazoo County, Michigan. The creek and its watershed are located entirely in Kalamazoo County. The creek joins the Kalamazoo River at a point upstream of the City of Kalamazoo. Davis Creek flows northwest from its origin at East Lake, through agricultural areas of Pavilion Township, and into the City of Portage. The creek then flows north through a densely populated mobile home park, and into eastern parts of the City of Kalamazoo and Kalamazoo Township.

Based on a 1994 MDNR aquatic habitat quality varied widely in the Davis Creek watershed.In an unnamed tributary near Lexington Green Park habitat conditions were rated as severely impaired because of the regular dredging maintenance and industrial storm water discharges. Silt deposition was more than three feet deep, and a petroleum sheen was discharging from a storm sewer outfall. The aquatic macroinvertebrate community was rated as moderately impaired.

At Sprinkle Road habitat quality was rated as unimpaired and the macroinvertebrate community was slightly impaired. However, from Kilgore Road to the confluence of Davis Creek with the Kalamazoo River, habitat and macroinvertebrate communities were rated as moderately impaired. Fish community structure throughout the Davis Creek basin was rated as slightly impaired. The results of this survey suggest that there have been no improvements in water quality and the biological health of Davis Creek as compared to previous surveys in 1977, 1979 and 1985.

The creek suffers from the following known types of pollution:

Suspended Solids and Sediments- The creek contains high concentrations of muck, dirt, sand and other grit which are washed in from roads, streambanks, bare urban lots and agricultural fields. Often other pollutants find their way to the creek by attaching to eroding soil. Sediments can also cause a stream to become wide and shallow which increases flooding problems.

Bacteria- Fecal coliform bacteria have been found in unhealthy amounts in the creek waters. Fecal coliform bacteria are associated with human and animal waste and probably come from septic tank leakage, runoff from manure-fertilized fields, and/or pet wastes, but can also come from warm-blooded wild animals including deer, ducks and geese.

Chemicals- Water samples have shown that Davis Creek contains high levels of phosphate and nitrogen compounds, both of which are found in most lawn fertilizers. Oil and grease remain a localized problem despite past attempts at remediation.

Trash- The creek contains a great deal of garbage in the form of glass bottles, tires, metal drums, plastic, styrofoam and cans.

Unstable hydrology- Large portions of the Davis Creek corridor have been modified by dredging and straightening. It is assumed these changes were made to (1) improve drainage of lands within the watershed, (2) to control seasonal flooding, and (3) to claim additional land for other uses by removing the natural creek meander and reducing the width of the natural drainage corridor. Historically, Davis Creek was known as a trout stream and cold water fishery.

The Kalamazoo County Drain Commission has a current American Recovery and Reinvestment Act grant to study hydrology and devise an engineering plan for stabilizing streambanks and culverts (February 2010 – September 2011).

Rice Creek

The Rice Creek Watershed covers 58,200 acres (90.9 square miles) in western Jackson and eastern Calhoun Counties. Rice Creek includes a North and South Branch and main stem. Flowing from east to west, its headwaters are a network of small, vegetated channels located in western Jackson County. Flowing west into Calhoun County, these smaller tributary channels merge to form the North and South Branches of Rice Creek, which then combine to form the main stem in Marengo Township. Rice Creek then joins with the Kalamazoo River in Marshall. The North Branch of Rice Creek is approximately nineteen miles long. The character of the North Branch is marked by several popular lakes, including Prairie Lake and the Gang Lakes, some of which are impacted by seasonal nuisance algal and weed growth stemming from excess nutrients. These lakes act as a sediment trap, often to the point of needing to be dredged in order to maintain their recreational and habitat functions. The amount of sediment in the lakes is a direct result of streambank erosion and the lack of floodplain or wetland depositories for those sediments. The lakes in the North Branch increase the amount of surface water exposed to sun, thereby heating the waters.

The South Branch of Rice Creek is approximately seventeen miles long. It has fewer lakes than the North Branch and also high groundwater contribution to the creek. The South Branch is a designated trout stream. Sediment and nutrient problems, as well as a lack of cover for shade and temperature control, are prevalent issues. From the main stem of Rice Creek, the point where the North and South Branches merge, to the outlet at the Kalamazoo River, the Creek is approximately another six miles long.

Rice Creek suffers from impairments to designated water uses. Generally, though, water quality is acceptable and much of the Creek retains rural charm. Those factors that occasionally and locally rise above or near regulatory levels of concern are poor macroinvertebrate communities, excess fecal coliforms, and suspended solids and turbidity. The probable root causes for these impairments include livestock in the stream and instability of sediments caused by a long history of drain work. Variable daily cycles in turbidity demonstrate the abundance of easily mobilized sediments in the Creek.

Gull Lake, Augusta Creek, and nearby watersheds

This area is denoted as the "Four Townships Watershed Area" and has been the topic of a parallel watershed planning process (FTWRC, 2010). The Augusta Creek and Gull Lake watersheds include a number of high quality streams and lakes as well as abundant wetlands, and are important sites from a biodiversity standpoint. The focus of watershed management in these subwatersheds 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. To maintain and enhance the presently good water quality in area lakes and streams, priority is given to riparian buffers of 1000-foot width along all significant streams as well as 8 lakes with the most residential development.

Augusta Creek and other area streams tend to carry low concentrations of phosphorus and ammonium, but many do have high concentrations of nitrate, reflecting the elevated concentrations in local groundwater. The stream waters are usually clear and low in suspended sediments, although they may carry considerable amounts of sediment as sand that moves along the stream bottom. Most of these streams originate in or pass through lakes and wetlands, which effectively remove sediment and nutrients and thereby improve the downstream water quality.

Augusta Creek 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 (managed by the MDNR). Fly fishing is popular in the stream, which is annually stocked with trout. The outflows from Gilkey and Fair Lakes supply water to the headwaters of the Augusta Creek system, and several smaller lakes also drain into the creek system. The 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.

Spring Brook is a cold water tributary to the Kalamazoo River immediately downstream of the city of Kalamazoo. A 1991 MDEQ biological survey conducted on Spring Brook indicated that this stream had the highest habitat quality for fish and other aquatic life of any cold water 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.

Gull Creek, a second order warmwater stream that originates at the Gull Lake outflow, was sampled in MDEQ biosurveys in 1986 and 1994. Both surveys indicated the stream to be high quality. Fish and macroinvertebrate communities were rated "acceptable". Habitat conditions were slightly impaired to non-impaired. Most water quality parameters were within the normal ranges for streams in this ecoregion. Nitrite (0.014 mg/L), nitrate-nitrite (0.142 mg/L), and ammonium (0.132 mg/L) were elevated on one sampling date in 1994 compared with a second sampling date and with other sites in the watershed.

Gull Lake is one of the largest inland lakes in Michigan, with an area of 2040 acres 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 lake. After the early 1970’s, lakeside homes were put on a sewer system to reduce septic inputs and residents were urged to apply fertilizers sparingly if at all, and these measures apparently led to reductions in summer algal blooms and improvements in water clarity in later years (Tessier and Lauff 1992).

Gun River

The Gun River Watershed encompasses an area of 73,272 acres in Allegan and Barry Counties, The Gun River flows from Gun Lake through agricultural land into the urbanizing area of Otsego Township, Allegan County, where it joins the Kalamazoo River. The watershed has been significantly altered from its presettlement conditions, primarily due to agricultural development including extensive tile drainage of muck soils. Sedimentation and excessive nutrient inputs have resulted in areas of the watershed exhibiting degraded aquatic habitat, decline of biodiversity, and reduced fish populations.

The MDEQ has focused on restoration of two Gun River subwatersheds that have identified impairments: Fenner Creek, and an upstream stretch of the Gun River between Gun Lake and Orangeville Creek.

The Gun River and its tributaries are impaired by nonpoint source pollution. Previous studies have identified pathogens, phosphorus, polychlorinated biphenyls (PCBs), mercury, nutrients, and poor macroinvertebrate communities as degrading the water quality in certain waterbodies within its watershed. Other significant water quality impairments include degraded indigenous aquatic habitat, a decline of biotic diversity, and reduced fish populations caused by sedimentation.

Best Management Practices (BMPs) to address non-point source pollution have been identified to accomplish goals listed in the Watershed Plan. Land use planning is recognized as critical to improve water quality through conservation easements, farmland preservation, model ordinances, and low impact development techniques such as reducing impervious surfaces to increase infiltration. Currently, no townships in the Gun River Watershed have a comprehensive ordinance designed to protect water quality. Township ordinances have the greatest potential for future protection of resources in the Watershed.

Rabbit River

The Rabbit River is a tributary of the Kalamazoo River located primarily in Allegan County with a watershed that encompasses 187,200 acres. Land use in the watershed is primarily agricultural, but forested and urban areas are also represented. The Rabbit River originates east of Wayland, MI, in Leighton Township, and flows westerly to join the Kalamazoo River at New Richmond, which then flows on to Lake Michigan. The Rabbit River is a State Designated Trout Stream, as are several of its tributaries.

The Rabbit River Watershed is ranked third out of twenty-eight in the state of Michigan as a Conservation Priority Area for the USDA's Environmental Quality Incentive Program (EQIP) to reduce non-point source pollution. Significant water quality impairments include degraded indigenous aquatic habitat and biotic diversity, reduced fish populations and flooding. Major NPS pollutants include sediment, excessive nutrients, and high flow. Occasional spikes in fecal coliform bacteria have also been noted, raising concerns about water-body contact. Development is steadily increasing in the watershed as open space and agricultural land is re-zoned to residential and industrial. The Rabbit River Watershed Management Plan states that water quality threats and impairments are caused by sedimentation, nutrient inputs, and high-flow occurrences. The sources of sediment include stream banks, cropland, construction sites, and road crossings/road ditches.

In 1989 an agricultural pesticide spray (endosulfan) contaminated the Rabbit River west of 2nd Street near Wayland and resulted in fish and macroinvertebrate kills. Brown trout and other fish were severely impacted for more than 3 miles downstream. Macroinvertebrate communities were severely impacted for more than 10 miles downstream. Biosurveys conducted in 1989 and 1990 to assess impacts and recovery from the pesticide discharge indicated that macroinvertebrate communities had substantially recovered by the following year. Brown trout populations were still depleted but recovering. These biosurveys also indicated that habitat and biological communities in the Rabbit River were significantly degraded because of agricultural activities apart from the pesticide incident, primarily due to erosion and sedimentation from runoff and cattle access, and river channelization. River quality did not appear to be affected by permitted point source discharges from Dean Foods and Northbrook Mobile Home Park Estates.

In 1993 another biosurvey of this reach of the Rabbit River indicated further recovery of stream communities from the pesticide incident. However, overall biological and habitat integrity of the upper Rabbit River was still considered poor. Fish communities of Green Lake outlet and Miller Creek were evaluated as slightly impaired. Community structure in both tributaries was considered typical of first to second order warm water systems.

The Red Run Drain system forms the headwaters of the Little Rabbit River. Based on a 1991 survey, the overall biological quality in the Red Run Drain, Dorr/Byron Drain and near the confluence of the Red Run Drain with the Little Rabbit River was assessed as moderately to severely impaired. Impairments appeared to result from farming practices. Little or no buffer areas existed between active fields and stream banks, and significant sedimentation has resulted in degraded habitat quality. Total phosphorus concentrations were higher than normal for streams in this area of Allegan County, ranging from 127 to 430 ppb in the Red Run Drain and Byron/Dorr Drain.

Nutrients enter the stream from agricultural production and residential area runoff. Damaging high flows result from uncontrolled storm water runoff due to development and past drainage practices. The MDEQ staff effort focuses on restoration of three Rabbit River subwatersheds that have identified impairments: Green Lake Creek (Tollenbar Drain), Headwaters Little Rabbit River (Red Run Drain), and Black Creek.

The Upper Rabbit River Watershed, located in rural Allegan, Barry, and Ottawa Counties encompasses 91,210 acres of agricultural, urban and forested land. The Upper Rabbit River Watershed is approximately 60 percent agricultural land. Streams in the Upper Rabbit River Watershed have suffered impairments due to human derived land based activities.

The Rabbit River has a Watershed Management Plan that seeks to improve water quality and reduce non-point source pollution through implementation of land-use planning, zoning, ordinance review strategies and by increasing awareness of water quality and watershed issues through information and education. Land use planning needs are similar to the Gun River. Recent projects have enjoyed some success in this area:

- Updated master plans to reflect water quality protection in all seven municipalities
- Riparian Overlay District Ordinance adopted by all seven municipalities within the Watershed
- Funnel Ordinance for water quality protection adopted by three municipalities
- Water Quality Zoning in Review Document
- The Watershed Project partnered with Monterey Township to disseminate a Land Use Planning Survey for Water Quality. Results were in full support of preserving water quality and in full support of land preservation.

Other notable water quality issues in tributaries

Comstock Creek, also sampled in 1994, is a second order warmwater stream and the outlet of Campbell Lake. The area is still largely wetland, which has buffered the creek from impacts. The City of Kalamazoo operates a well field along the stream below Campbell Lake as part of its water supply network. The fish and macroinvertebrate communities were rated as non-impaired, and had a very diverse community of molluscs. The habitat was rated as slightly impaired. Ammonium concentrations were elevated (96 ppb) compared to other sampling stations in the tributaries of the lower Kalamazoo River watershed. All other water quality parameters were within normal ranges for streams in this ecoregion.

Allen Creek is a small coldwater stream originating west of Parchment and flowing for approximately one mile to the Kalamazoo River. Four fish surveys conducted in the 1980s documented impacts of dewatering and dredging in the headwaters from Westnedge Avenue to Allen Street by Kalamazoo Township in 1981, 1982 and 1984. These operations resulted in a reduction of the native Brook trout population by 97% from 1981 to 1984, and impacts to the macroinvertebrate communities because of heavy siltation. In 1984 MDNR Fisheries Division initiated a three year restocking program of brook trout; a 1987 survey indicated slow recovery.

A 1994 biosurvey indicated moderate impairment of the macroinvertebrate community, and habitat conditions were degraded. Allen Creek was not meeting the designated uses for coldwater fishery. No brook trout were collected, and heavy siltation was still very prevalent. All water quality parameters were within the normal ranges for streams in this ecoregion.

Cooper Creek (Collier Creek, Coopers Glen Creek, Trout Run).   Cooper Creek, a first order coldwater stream, originates north of Parchment and flows along a very steep gradient in the Kalamazoo Nature Center to the Kalamazoo River. In a 1994 survey, biological quality was non-impaired based on the aquatic macroinvertebrate community. The creek was meeting the designated uses for coldwater fishery. Ninety-eight percent of the fish collected were salmonids, primarily brook trout. All water quality parameters were within the normal ranges for streams in this ecoregion.

Dumont Creek. Dumont Creek is a first order warmwater stream originating at Dumont Lake, flowing approximately 4 miles along a fairly steep gradient, to the Kalamazoo River. In a 1994 the macroinvertebrate community and habitat were rated as non-impaired. All water quality parameters were within the normal ranges for streams in this ecoregion.

Swan Creek. This is a third order warmwater stream from the outlet of Swan Lake to 109th Avenue. The stream then becomes a largely groundwater fed coldwater stream within the Kalamazoo State Game Area to the Kalamazoo River. A 1989 fish survey indicated recent declines in the trout fishery because of increasing sedimentation. A 1994 survey rated biological quality of Swan Creek severely impaired based on fish and macroinvertebrate communities. The designated uses for coldwater fishery were being met in the coldwater portion of Swan Creek (2.9% salmonids). Habitat conditions ranged from moderately impaired to slightly impaired. Many of the pool and riffle areas were affected by significant amounts of shifting sand. The loss of habitat appears to be attributable to the extensive sand bedload from eroding road crossings and forested areas.

Chart Creek. The overall biological quality of the East Branch, West Branch and main branch of Chart Creek was rated as severely impaired to slightly impaired based on the assessment of the macroinvertebrate community and habitat conditions in 1993. Impairments were attributed to nutrient enrichment from nonpoint sources and groundwater discharges from Murco, Inc. Improvements in treatment have occurred and natural attenuation is currently being used as an approved interim remedial action plan. Lack of suitable substrate was attributed to drain maintenance projects.

Species diversity in the West Branch and mainstem were good, and indicative of a cold water system. The fish community on the East Branch was severely degraded because of low oxygen, elevated ammonia and poor habitat.

Attachment 7. Buffer analysis memo (16 pages)

To: Jeff Spoelstra, KRWC **Date:** September 20, 2010

From: Kieser & Associates, LLC **cc:** Project files

Re: Buffer Analysis for the Kalamazoo Watershed Management Plan

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Introduction

Riparian buffers play an important role in preserving water quality in rivers and streams. The functions of riparian buffers are well established and include filtering pollutants from stormwater and agricultural runoff, stabilizing streambanks to prevent erosion, moderating the microclimate of a stream or waterbody, and protecting fish and wildlife habitat (Johnson and Ryba, 1992). Because of these beneficial functions, the area along a river corridor can be considered a critical area for water resource protection and restoration. As part of the Kalamazoo River watershed management planning project, the project team determined that a simple analysis of the buffer area around tributaries and lakes in the Kalamazoo River watershed would illustrate potential water quality impacts associated with land cover and land use changes in the riparian corridor. Since land use influences the quality and quantity of runoff in a watershed, this analysis provides information that can be used in: a) recommendations for future land use planning decisions; b) prioritizing best management practices (BMPs); and, c) informing watershed stakeholders on future loading that would adversely impact the Kalamazoo River in the context of the phosphorus Total Maximum Daily Load (TMDL).

As part of this buffer analysis, Kieser & Associates, LLC (K&A) used model output data to estimate pollutant loading for areas within the 100-meter buffer that are predicted to change to urban land use in the future (i.e., future build-out). K&A used model results from the Land Transformation Model[1], which is a Geographic Information System (GIS) and neural network-based model that predicts future land change in the year 2030. This buffer analysis provides stakeholders with a simplistic model of the potential increase in pollutant loading to the river if a portion of the land use in the river corridor becomes developed. To further support decision-making and BMP recommendations, agricultural management scenarios were also applied within the 100-meter buffer boundary. The agricultural scenarios included modeling runoff and pollutant loading to the river under scenarios where 25%, 50% and 75% of the agricultural land in the 100-meter buffer was permanently planted in grass or hay buffers. These scenarios were applied to riparian areas that are currently defined as agriculture in the 2001 land cover. These loading results can then be compared with the predicted loading increases due to future build-out.

The results from the buffer analysis and agricultural buffer scenarios are summarized in table format in this memorandum. These results, along with information obtained from the Kalamazoo River watershed

[1] *More information about the Land Transformation Model and data for download are available at:* *http://ltm.agriculture.purdue.edu/ltm.htm*

build-out analysis report by K&A, will be used by the project team in developing recommendations for BMPs included as part of the watershed management plan.

GIS Buffer Methodology

Geographic information system (GIS) software allows for the definition of a distance buffer around geographic features. For this analysis, the Kalamazoo River stream network (available from the Michigan Geographic Data Library) was used as the baseline feature for defining the buffer. Using the "Buffer" function within ArcGIS Spatial Analyst, a 100-meter buffer (i.e. 50-meter on each side of a stream line) was created around the entire stream network in the Kalamazoo River watershed. Lakes in the available stream network data layer are not modeled as polygons but are defined by a line around the shoreline. Because of this fact, buffers around lakes also included a 50-meter portion on the water inside of the lake. This buffer area on surface water was deleted from the analysis for practical purposes since surface water land cover cannot be converted to vegetated buffer. This deleted surface water area did not affect the agricultural buffer analysis since only agricultural land use in the 2001 data layer was used to calculate runoff and pollutant loading. Therefore, any LTM considerations for land conversion from water are excluded from results. Figure 1 presents the overall view of the buffer in the entire Kalamazoo River watershed. At this large scale, it is not possible to view the land area within the buffer area, which only appears as a line in the image. Figures 2 and 3 show a semi-transparent close-up view of the buffer overlaid on an aerial photograph within an agricultural and an urban location, respectively.

The decision to use a 100-meter buffer was based on the land use data resolution used in the build-out analysis (100x100 meter). A 100-meter resolution is the minimum scale for the land use change and loading analysis used in GIS. The 2001 and 2030 predicted land use areas within the 100-m buffer were calculated using the "Tabulate Area" function[2] and compared. Pollutant loads were calculated using the "Raster Calculator" function with raster[3] layers for runoff (calculated using the Long-Term Hydrologic Impact Assessment or L-THIA tool[4]) and coupled with event mean concentrations. To evaluate the affects of these buffers on adjacent, upland areas, a 300-meter buffer was delineated around the stream network in the Kalamazoo River watershed in the same way the 100-meter buffer was created. This buffer represents a theoretical area treated by the 50-meter riparian buffer and extends 100-meters beyond each riparian buffer on either side of the river.

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[2] *This GIS function internally converts the buffer from a vector to a raster format in order to match the land use format and cell resolution.*

[3] *Raster data model is a regular "grid cell" approach to defining space. Usually square cells are arranged in rows and columns (as defined in Bolstad, 2005).*

[4] *The L-THIA GIS extension is available for download at: http://www.ecn.purdue.edu/runoff/lthianew/Index.html*

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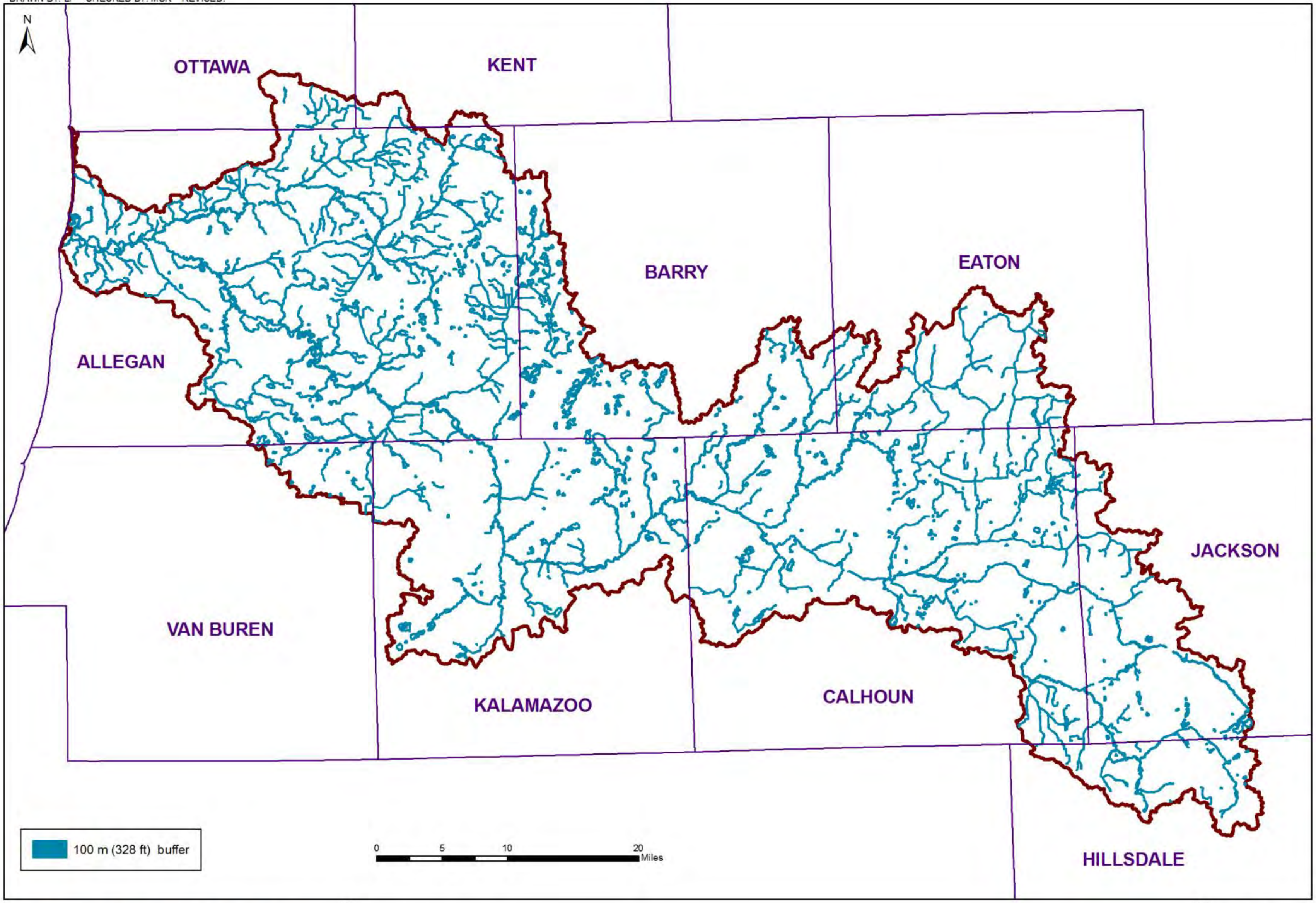

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Delineated 100-meter riparian buffer in the Kalamazoo River Watershed (hydrographic network downloaded from the Michigan Geographic Data Library).

FIGURE 1

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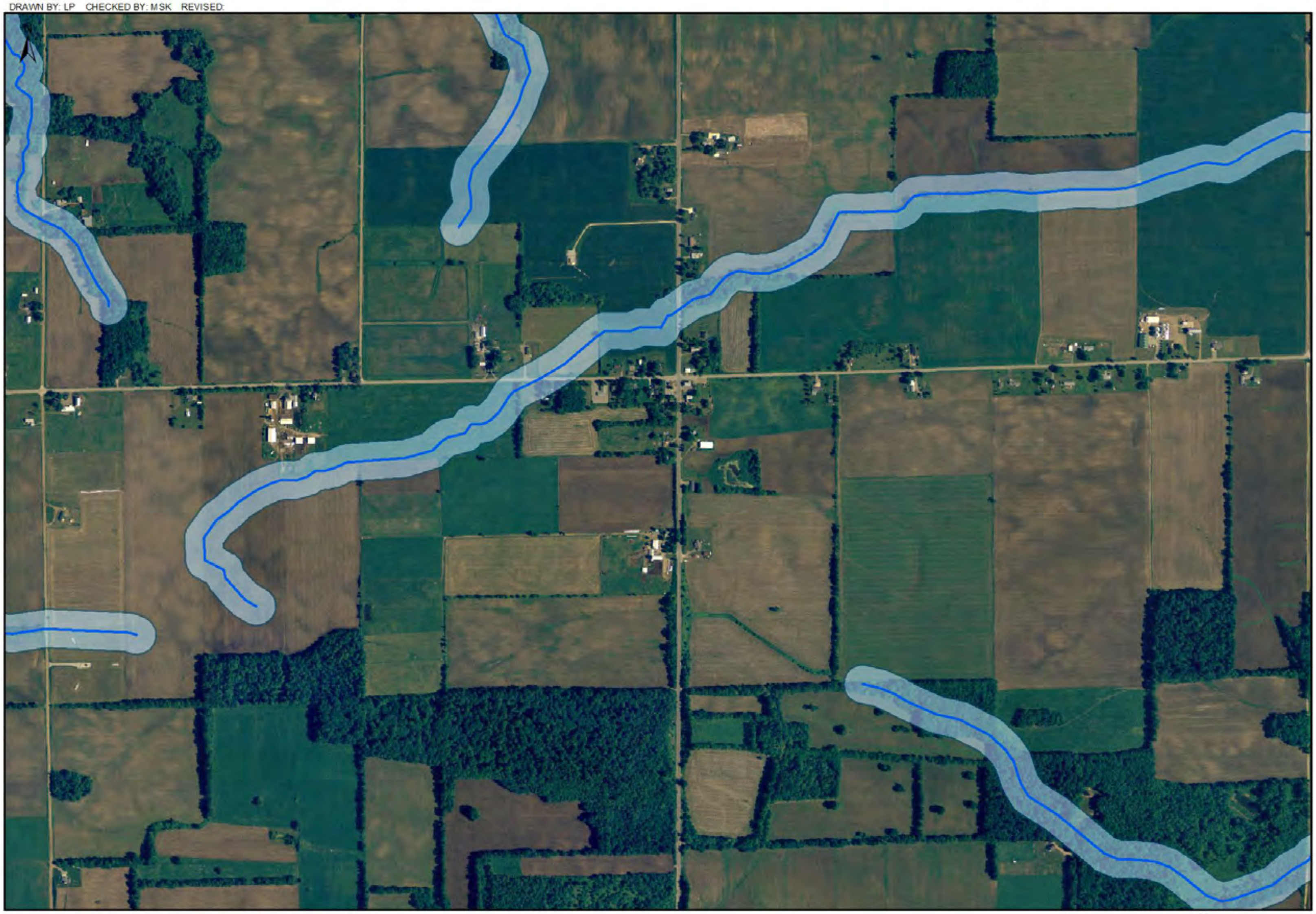

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Small scale image of 100-meter buffer in a non-urban setting within the Rabbit River subwatershed (dark blue represents the stream network and lighter blue represents the 100 meter buffer).

FIGURE 2

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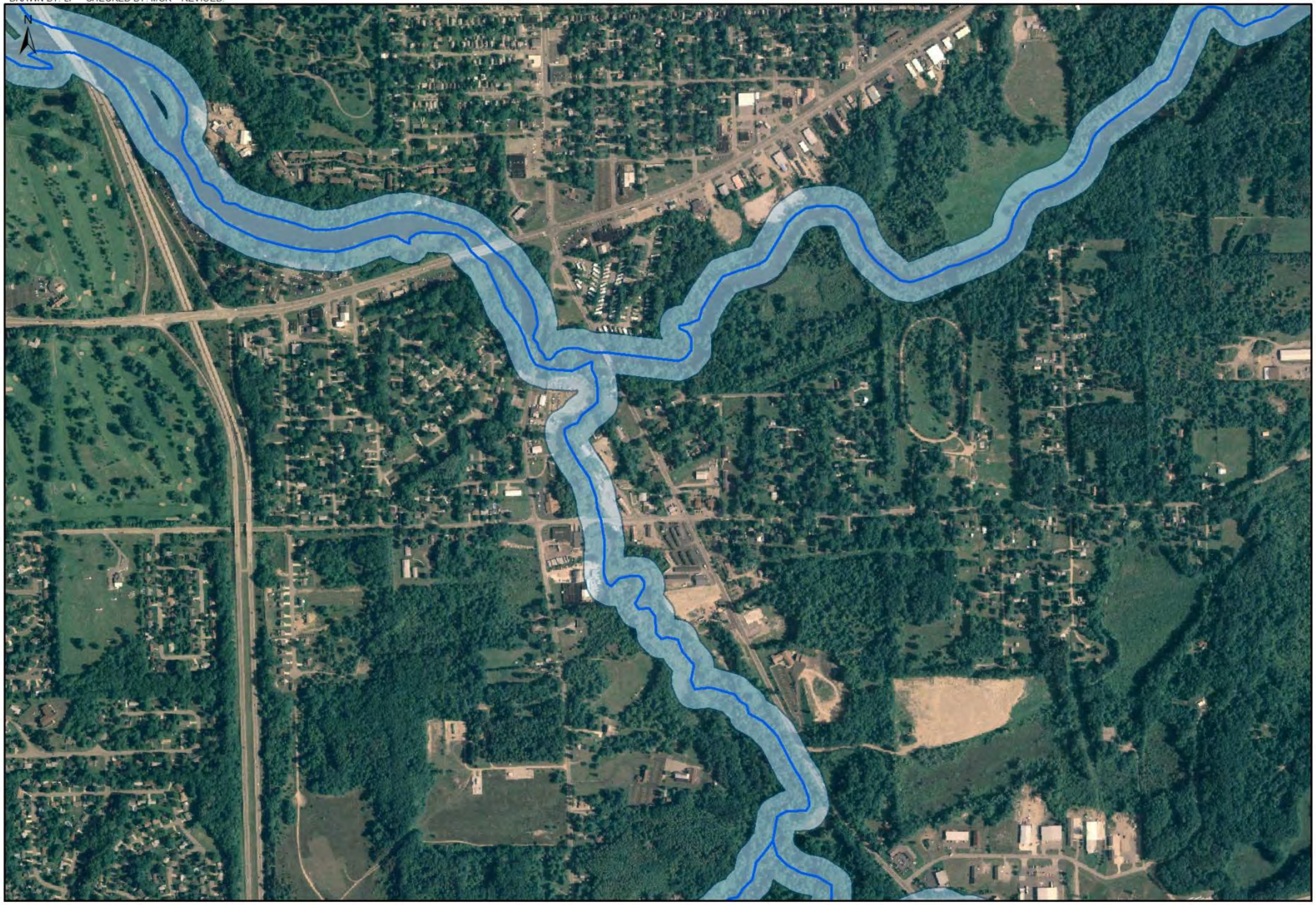

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Small scale image of 100-meter buffer in an urban setting within the Battle Creek River subwatershed (dark blue represents the stream network and lighter blue represents the 100-meter buffer).

FIGURE 3

Buffer Land Use Change

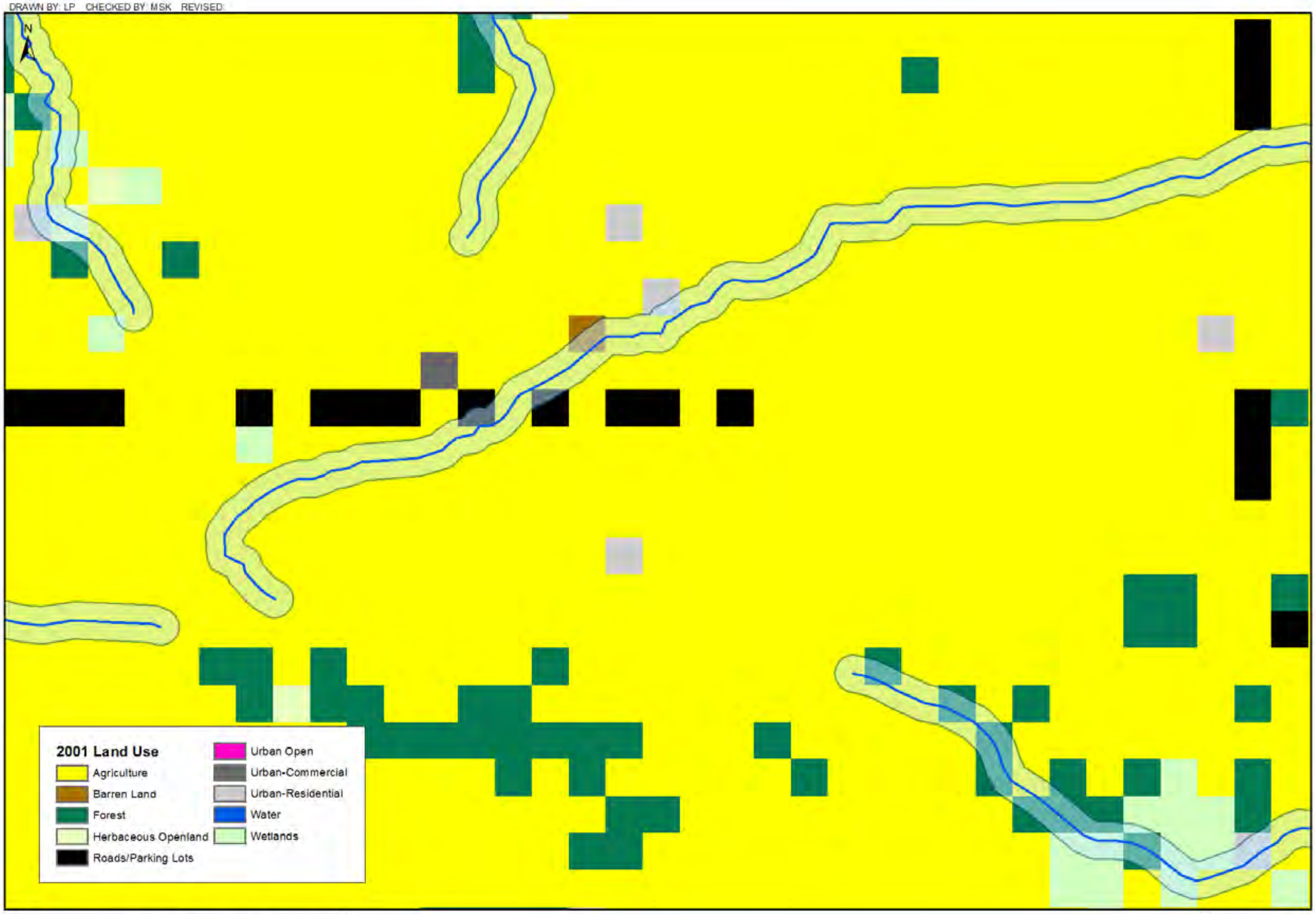
Between 2001 and 2030, commercial and residential land uses within the riparian buffer are expected to increase by over 250%, as predicted by the Land Transformation Model or LTM (Pijanowski *et al*., 2002). The LTM is a GIS-based model that predicts land use changes by combining spatial rules with artificial 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. As a part of the Kalamazoo River buffer analysis, K&A used the 2030 LTM layer created for the Kalamazoo River watershed and compared it to the current (2001) land use in the watershed to determine overall land use change within the 100-meter buffer area between 2001 and 2030. Figures 4 and 5 illustrate the land use in 2001 and 2030 within the smaller scale section of the buffer example area in the Rabbit River subwatershed. A comparison of the two layers reveals that much of the agricultural land use along the river corridor and to the east in 2001 is predicted to change to urban land use by 2030 (both commercial and resident urban land use).

Predicted land use change from 2001 to 2030 within the 100-meter buffer area is provided in Table 1. Land use for commercial and residential urban use is predicted to have the greatest increase in change between 2001 and 2030 within the riparian corridor. As a result of this increase, the watershed is predicted to lose nearly 12% of rural open areas, 10% of forested areas, and 8% of wetland areas within the 100-meter buffer area along the river corridor. This increase in urban areas, together with the loss of rural, open forest and wetlands could have a substantial impact on runoff and pollutants delivered to the river in the future, as well as an increase in future channel erosion. In order to better gauge how this land use change might affect nutrient and sediment loading to the river, K&A used an empirical calculation to estimate the new load resulting from the 2030 land use breakdown as described below.

Table 1: Land use change within 100-meter buffer from 2001 to 2030 in the Kalamazoo River watershed.

	Area (acres)			
Land use category	**2001**	**2030**	**Change in Value**	**Percent Change**
Urban-Commercial	991	3,610	2,619	264.3
Urban-Residential	1,426	5,550	4,124	289.3
Urban Open	54	54	0	0.0
Transportation	1,858	1,858	0	0.0
Agriculture	18,916	17,631	-1,285	-6.8
Rural Open	4,665	4,094	-571	-12.2
Forest	13,242	11,955	-1,287	-9.7
Wetlands	31,950	29,296	-2,654	-8.3
Barren	40	27	-12	-31.3
Total	*81,017*	*81,017*		

Note: The 2030 LTM land use layer contains an error where 934 acres of surface water in the buffer area (1.2% of total buffer area) were changed to “other urban” and “non-urban” land uses. However, this error does not impact the loading analysis. No load was calculated for those erroneous cells because the SSURGO soil layer used in the build-out analysis does not include data for lake areas and consequently, runoff and load cannot be calculated.



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2001 land use within 100-meter buffer example area located in the Rabbit River subwatershed.

FIGURE 4

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Predicted 2030 land use within the 100-meter buffer example area located in the Rabbit River subwatershed.

FIGURE 5

Buffer Loading Analysis

As a component of the Kalamazoo River watershed buffer analysis, runoff volume and pollutant loads were calculated using the same methodology presented in the Kalamazoo River Watershed Build-out Analysis Report (K&A, 2010). Using EMC values for each land use category, runoff volume and loading for total suspended solids (TSS), total phosphorus (TP), and total nitrogen (TN) were calculated for 2001 and predicted 2030 land use. Table 2 provides the difference between 2001 and 2030 loading values due to watershed build-out (using LTM-predicted land use change).

From this analysis, runoff volume and the TP load are predicted to increase by more than 20% between 2001 and 2030 in the 100-meter buffer area; this increase is directly correlated to the increase in impervious land use (Table 2). This predicted increase in TP would add an additional 2,200 pounds of TP to the watershed annually, above and beyond the current TP loading already in exceedence of the TMDL load allocation. In addition, the 2030 predicted loading from the buffer area could contribute almost 19,000 additional pounds of TN and 200 tons of TSS per year.

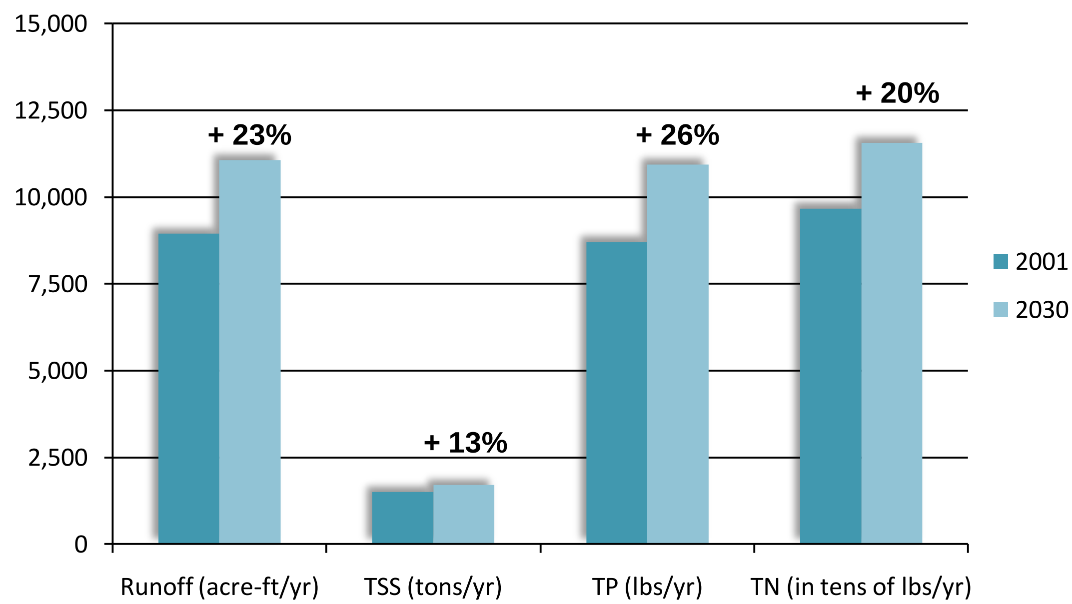
Table 2: Pollutant load comparison between 2001 and 2030 land uses within 100-m buffer area in the Kalamazoo River watershed.

Loading	2001	2030	Change in Value	Percent Change
Runoff (acre-feet/yr)	8,945	11,066	2,121	23.7
TSS (tons/yr)	1,508	1,705	197	13.1
TP (lbs/yr)	8,713	10,950	2,237	25.7
TN (lbs/yr)	96,813	115,717	18,904	19.5

When comparing the buffer area to the entire watershed, runoff volume and loading changes predicted between 2001 and 2030 are very similar. Figure 1 provides a comparison of increases in runoff and pollutant loading for the buffer area and entire watershed. Runoff for the entire watershed is predicted to increase by approximately 25%, TSS by 12%, TP by 26%, and TN by 18% (Figure 1b). It is important to note a distinction, however, between loads associated with riparian areas and loads associated with lands more distant from surface waters. Areas within the 100-meter buffer will have a much greater delivery rate than those areas located further from surface water. For this reason, the potential impact of changing land use within the 100-meter buffer may have a greater overall impact on water quality than is captured by this analysis. This should be noted in watershed management plan recommendations for protecting and managing future land uses.

One major land use category impacting water quality in the 100-meter buffer area is agriculture. The loading analysis revealed that approximately 40% of the TP load generated within the watershed-wide 100-meter buffer comes from agricultural land use. Due to this large load, recommending agricultural BMPs that include buffer protections or new buffers should be considered in the watershed management plan. Buffers or filter strips are one of the agricultural BMPs promoted by the Natural Resources Conservation Service (NRCS) conservation programs. NRCS's electronic Field Office Technical Guide (eFOTG) for the state of Michigan describes filter strips as vegetated areas used to treat runoff

1a: Predicted Change in Loading from 2001 to 2030 within the Riparian Buffer Area



1b: Predicted Change in Loading from 2001 to 2030 within the Entire Kalamazoo River Watershed

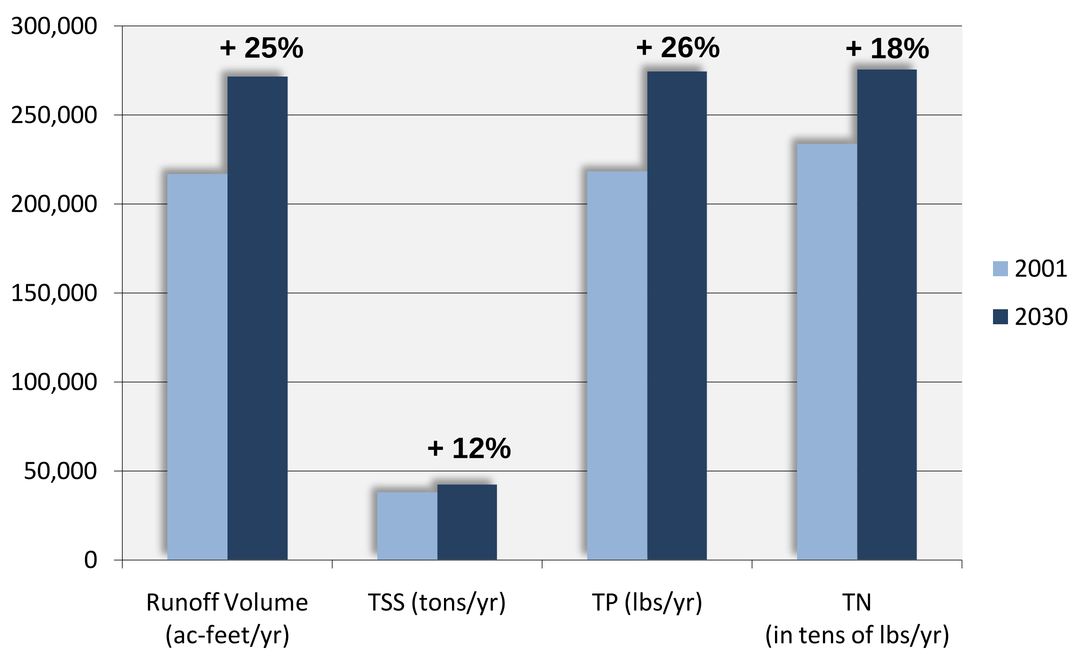


Figure 1a-b: Percent change in runoff and loading values for the Kalamazoo River buffer area (1a) and entire Kalamazoo River watershed (1b) are predicted to increase at similar rates as urban land use increases from 2001 to 2030. It is important to note that modeling in this analysis does not factor in delivery; therefore, loading from the buffer area will have a higher rate of delivery than loading from areas in the watershed not directly adjacent to surface water.

that is not part of the adjacent cropland rotation. The filter strips must be established to permanent herbaceous vegetation consisting of a single species or a mixture of grasses, legumes, and/or other forbs adapted to the soil, climate, nutrients, chemicals, and practices used in the current management system. Filter strips must be managed to maximize vegetation density and can be mowed under an approved management plan (which functions to remove nutrients and increase plant growth).

Buffer Cost Analysis

As part of the cost calculation component of the watershed management plan, K&A performed a limited analysis of agricultural filter strips on a portion of the 100-meter buffer area[5]. This limited analysis involved changing a portion of land use within the 100-meter buffer area that was agricultural land in 2001 to herbaceous open land. This change represents the resulting load change that might be expected from farmers installing buffer strips as part of the Farm Bill or other incentive program. The higher percentages of land converted from agriculture to filter strip (50%-75%) is likely too ambitious for any conservation incentive programs, but provides watershed planners with an estimate of the potential benefits of applying other BMPs with similar benefits to the riparian buffer area. The following simple scenarios were run to quantify the impact of restoring agricultural areas to filter strips (i.e., herbaceous open land):

Scenario 1: 25% of 2001 agricultural land in the buffer area is converted to grass filter strip

Scenario 2: 50% of 2001 agricultural land in the buffer area is converted to grass filter strip

Scenario 3: 75% of 2001 agricultural land in the buffer area is converted to grass filter strip

In order to calculate the TP load change from typical agricultural land use to filter strips, an annual unit area load was calculated for each land use. The unit area loads are shown in Table 3 and were derived from GIS analysis of the total area in the 100-meter buffer and the resulting total TP load using empirical calculations and event mean concentrations (MI-ORR, 2002). On an annual per acre basis, the average load is 0.19 pounds of TP/acre/year for agriculture and only 0.03 pounds of TP/acre/year for open land (open land category was used because it most closely represents the vegetation of a grass or hay filter strip used in agricultural conservation practices). The unit area loads were applied to the land conversion in the 100-meter buffer for the three scenarios. Results from these calculations are presented in Table 4 and show that conversion of land in the 100-meter buffer from agriculture to filter strips would yield a TP reduction of approximately 795 lbs TP/year in Scenario 1, 1,591 lbs TP/year in Scenario 2, and 2,836 lbs TP/year in Scenario 3.

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[5] *It must be stated that this analysis is strictly limited to buffer strip considerations using relatively simplistic empirical loading calculations. No other modeling has been conducted for other agricultural or urban areas which might otherwise suggest a host of other BMPs necessary to control and/or reduce associated runoff. Mechanistic modeling using the Soil Water & Assessment Tool (SWAT) would yield a more detailed analysis of effective BMPs for subwatershed agricultural practices. The Hydrological Simulation Program - FORTRAN (HSPF) is a similarly sophisticated water quality model that would be suitable for detailed assessment of urban BMP selection. This level of sophisticated modeling is expensive and beyond the current K&A scope and budget.*

Table 3: Total phosphorus loads and unit area loads for land use categories within 100-meter buffer.

	Total area within 100-m buffer area (in acres)	Total TP load (in lbs/year)	Average TP load (in lbs/acre/year)
Agricultural	18,916	3,364	0.19
Open land, non-forested (i.e., filter strip)	4,665	119	0.03

In addition, it was assumed that the riparian filter strip filters runoff and nutrients from an upstream area about twice the size of vegetated area (i.e., the filter strip treats runoff from an additional 100 meters of agricultural land above the filter strip on each side of the stream). The 1999 Michigan Department of Environmental Quality's Pollutants Controlled Manual estimates that filter strips reduce TP loads from agricultural land by 85% (MDEQ, 1999). To better estimate the full load reduction potential of the filter strip, the TP load from the 300-meter buffer in each scenario (by percentage) was reduced by 85%. This simulates the treatment affect of the riparian filter strip. By quantifying this additional load reduction, a better estimate of the efficiency of the scenarios could be calculated. The total estimated TP loading reduction potential when accounting for additional treatment above the filter strip is summarized in Table 4. In total, conversion of agricultural land adjacent to streams to vegetated filter strips could potentially reduce TP loading by 2,471 lbs TP/year in Scenario 1, 4,943 lbs TP/year in Scenario 2, and 7,865 lbs TP/year in Scenario 3.

A cost analysis was also conducted to provide an estimate for the watershed management plan. Using NRCS filter strip implementation costs for 2009 provided by the Allegan County Conservation District, installing filter strips on 25% of agricultural land within the 100-meter buffer would cost approximately $2.1 million. If filter strips were installed on 50% or 75% of agricultural land in the 100-meter buffer, the resulting cost would be $4.3 and $6.4 million, respectively. In terms of the cost per benefit, or cost per pound of TP reduction, the total load reduction from both the land use change and the runoff treated in the 600-meter buffer beyond the filter strip were added together and the costs divided over the total TP load reduction. The resulting cost per pound for TP reductions in the riparian buffer using filter strips is approximately $392.

One factor not included in the cost analysis for the TP load reduction from filter strips is the potential income from a commodity grown in the filter strip, such as hay. The potential gross income that would result from producers haying the filter strip following NRCS standards was calculated using 2009 NRCS payment values. These dollar values represent some of the benefits from installing filter strips for producers. Using the average commodity prices for 2009 from the Allegan Conservation District and assuming all of the filter strips installed would be planted in hay, the potential income from hay sales from $1.9-8.5 million depending on the scenario applied.

Table 4: Buffer scenarios and cost analysis for agricultural land conversion to grass plantings/filter strips.

Conversion Scenarios							Cost Analysis	
	Agricultural Area Converted to Grass (acres)	TP Load from Grass (lbs/year) (1)	Original TP Load(1) from Agriculture (lbs/year)	TP Load Reduction from Land Conversion (in 100-m buffer) (lbs/year)	TP Load Reduction from Treated Area Above Buffer (lbs/year)	Total Load Reduction (lbs/year)	Implementation Costs (in 2009 $) (NRCS) (2)	Estimated Cost per Pound of Load Reduction (in 2009 $)
Scenario 1 25%	4,729	121	916	795	1,676	2,471	$2,137,508	$865
Scenario 2 50%	9,458	241	1,832	1,591	3,352	4,943	$4,275,016	$865
Scenario 3 75%	14,187	362	2,748	2,836	5,029	7,865	$6,412,524	$865

Note:

(1) TP loads in the table above were calculated using average annual loading values (see Table 3).

(2) Cost calculations were done using a value of $452/acre for buffer strip installation (Communication with Allegan Conservation District).

Conclusions

From the information provided by this buffer analysis, it appears that land use change within the 100-meter buffer area over the next 20 years will be similar to predictions throughout the Kalamazoo River and its tributaries. Generally, urban land use will increase while forest, wetland and rural open area will decrease. The resulting watershed impacts will be increased runoff and pollutant loading to the Kalamazoo River. Due to the geographic nature of the buffer area, delivery of pollutants will be greater in this area than in other areas throughout the watershed. In the context of the phosphorus TMDL, this predicted load increase will need to be addressed in order to meet water quality goals, on top of existing load reductions that are required under the TMDL. For this reason, a number of BMPs and land use planning will need to be included as part of the watershed management plan.

Overall, implementing agricultural BMPs in the 100-meter buffer area, such as restoring grass buffers on agricultural lands within the riparian zone, could provide a significant phosphorus load reduction depending on the extent of the BMP implementation. Added incentives for producers may involve allowing cutting of hay in order to generate some income from the property. While the cost per pound of TP reduction for riparian filter strips appears relatively high for an agricultural practice, it provides a great cost savings when compared to urban BMP costs (which can be greater than $10,000 per pound of TP reduction[6]). For this reason, stakeholders should seek out the lowest cost reductions in order to maximize TP reductions and reach TMDL goals. Other agricultural BMPs should be examined and recommended as part of the watershed management plan.

From this analysis, the 100-meter buffer is one critical area in the watershed that should be prioritized due to the high delivery rate of runoff and pollutants to the river. In particular, agricultural BMP recommendations and implementation will be particularly important as agriculture comprises almost one-quarter of the total acreage within the 100-meter buffer area. A second important priority within the critical area will be protection of undeveloped areas, including forests, wetlands and rural open areas. Much of the acreage in these land use categories is predicted to be developed in the next 20 years. As urban land use increases, runoff and pollutant loading to the Kalamazoo River will also likely increase if best management practices and other protective measures are not applied to this critical area.

Implementing agricultural BMPs, retrofitting urban areas within the 100-meter buffer, and strategic land use planning are all important factors in reducing the predicted increase in runoff and pollutant loading to the Kalamazoo River. Invariably, these actions will require robust funding to increase implementation and efficacy. The information generated in this analysis, while limited in scope, should inform the Kalamazoo River watershed management planning project on the general impact and range of cost estimates for various levels of agricultural BMP application. In addition, results from this memorandum highlight the future conditions that are predicted through various modeling efforts that all conclude the

[6] *See Kalamazoo River Build-out Report, 2010 in the Kalamazoo River Watershed Management Plan for more information.*

current trajectory of land use change will have an overall negative impact on water quality if left on course.

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Attachment 8. Kalamazoo River BMP screening tool (8 pages)

Six Ways to Use the Kalamazoo River BMP Screening Tool

1. To calculate general stormwater treatment costs in your township:
    - Tab A: Select your township or city, enter entire township or city acreage per land use (refer to LOOKUP Tables)
    - Tab B: Select appropriate BMPs for all areas/acres generating urban stormwater in your township or city
    - Tab C: Review & print summary of BMP cost estimates

2. To selectively calculate TP loading from specific portions of your township and estimate BMP implementation costs:
    - Tab A: Select your township or city, enter acreage per land use for the specific area in your township or city you are interested in treating stormwater
    - Tab B: Select BMPs you are interested in implementing to treat stormwater in that specific area
    - Tab C: Review & print summary of site-specific BMP cost estimates*

3. To compare and select the most cost effective reductions by selecting different BMPs:
    - Tab A: Select your township or city, enter acreage per land use for the area of interest
    - Tab B: Select one set of BMPs to determine cost estimates and reduction efficiency
    - Open and save a second workbook, under Tab B select a different set of BMPs to compare cost estimates and reduction efficiencies
    - Tab C: Review & print summary of estimated costs for each workbook/set of BMPs

4. To track progress toward TMDL NPS load allocation goals using installed BMPs in your township:
    - Open and save two separate workbooks
    - Tab A: For both workbooks, select your township and city, enter entire township or city acreage per land use (refer to LOOKUP Table)
    - Tab B: In workbook one, enter the BMPs (or equivalent stormwater treatment by area) that were present in your township or city in 1998; in workbook two, enter all current BMPs that are presently implemented in your township or city
    - Tab C: Review & print both summary sheets to compare "future load with BMP application" for workbook one and "future load with BMP application" for workbook two (these figures will show 1998 "baseline" TP load in lbs/yr and 2010 "current" TP load in lbs/yr**)

5. To calculate BMP costs to reduce current TP load in order to comply with TMDL NPS load allocation:
    - Using workbook one created in Step #4, divide the "future load with BMP application" TP value in half to get your TMDL goal allocation
    - Subtract this TP load value from the 2010 "future load with BMP application" TP value in workbook two created in #4, this is the remaining TP load that must be offset to comply with the TMDL

- Open and save a third workbook, under Tab A enter the area of all untreated acreage generating urban stormwater (you can use information from workbook two, Tab B, column J "Area Not Treated by BMPs")
- Tab B: Enter a variety of appropriate BMPs for areas that generate stormwater until the "total load reduction" cell (L32) equals the number of pounds of TP required for TMDL compliance calculated above

6. To estimate the potential pollutant loading "prevention" from areas in the township that are permanently protected from development:

- Open and save a new workbook, under Tab A/Step 1 select the appropriate township or municipality
- Enter in the appropriate acreage for each land use in the area of interest (or area where permanent protection is being considered) and record the current loading in row 34
- Open and save a second workbook, under Tab A/Step 1 select the appropriate township or municipality
- Enter the identical number of acres from the first workbook, but place these under the low density, medium density or high density residential land use categories instead of the current land use
- Record the current load from this new land use category and compare to the loading calculated in the first workbook (where the current existing land use category was used)

*The BMP Screening Tool should be used for screening purposes only. For more accurate BMP design and cost estimates, a user should consult an environmental engineering firm.

**These figures are gross estimates of 1998 baseline loading and 2010 current loading to provide a general trend of whether TP loading is increasing, decreasing or remaining the same over time, depending on land use changes over time and stormwater BMPs employed for new or existing development. Variability is introduced by accuracy of acreages associated with each land use, location to surface waters, efficiencies of BMPs, annual average rainfall, and other general assumptions used in the BMP Screening Tool.

READ ME

INSTRUCTIONS AND REFERENCES FOR THE KALAMAZOO RIVER URBAN STORMWATER BMP SCREENING TOOL

Version 1.0- October 2009

This workbook contains the Urban Stormwater BMP Screening Tool developed by Kieser & Associates, LLC for the Kalamazoo River Watershed Council as part of the Kalamazoo River Watershed Management Plan. It is constructed only for applications in the Kalamazoo River Watershed.

The BMP Tool is designed to provide an estimate of current Total Phosphorus (TP) and Total Suspended Solids (TSS) loads and runoff volume using regional event mean concentrations (MDEQ, 2002) and average annual precipitation. It can also be used to estimate cost-effectiveness of common urban best management practices using national construction cost averages and efficiency values. It should not be used for site design, or for calculating site-specific BMP costs or pollutant loads.

The empirical model requires the following inputs to be provided by the user:

- land use breakdown of the area of interest,
- appropriate BMP(s) for the area,
- area of each land use category draining to the selected BMP(s).

Cells requiring user's input are in yellow. All other cells are automatically calculated.

The BMP Tool workbook is divided into 3 worksheets:

A- Calculate current pollutant load

Pollutant loads and stormwater volume are calculated for current land use footprints using equations and event mean concentrations provided in the Michigan Trading Rules (Rule 323.3013) (see LOOKUP TABLE 3).

Average annual precipitation values were calculated using long-term average precipitation data from cooperative stations in Allegan, Gull Lake, Battle Creek and Hillsdale. Look-up tables with land use breakdowns (by township or city only) and average annual precipitation for that area are provided to facilitate user input.

Please note that this simple tool was designed to be used to support TMDL implementation and watershed management in the Kalamazoo River Basin. By default, the tool will only model land use conditions without including the impact of previously installed urban or agricultural BMPs. New BMPs are only applicable to urban stormwater applications.

B- Apply stormwater best management practice(s)

This worksheet allows a user to select urban stormwater treatment BMPs. The BMPs selected represent general applications of BMP systems and do not necessarily represent a site-specific BMP. The selection process should be guided by best professional judgment and treatment efficiency. It should also be noted that this tool does not model the combined efficiency of multiple BMPs. Each BMP is modeled individually and may not reflect actual site conditions when multiple BMPs are installed together.

Related costs are for general comparison purposes; they should not to be used for site-specific applications.

C- Print results

All results are compiled in this worksheet to allow the user to print one summary page for a scenario.

These results can be used as a screening tool to assess loading issues from urban stormwater and generalized options (costs and benefits) to address these issues.

This document should be used as a template. Users can save this worksheet using a separate file name for each modeled scenario.

References:

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Available for download at: http://www.werf.org/AM/Template.cfm?Section=Research_Profile&Template=/CustomSource/Research/PublicationProfile.cfm&id=SW2R08

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October 2009

KALAMAZOO RIVER URBAN STORMWATER BMP SCREENING TOOL
Version 1.0 - October 2009

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A- Calculate Current Pollutant Load

Step 1 Select municipality or township of modeled catchment (for default rainfall data).

Richland Twp

Only enter values in yellow cells:

Step 2 Enter land use area (in acres) of catchment to be modeled in Table A below (yellow cells, column C).
(For reference, the 2001 land use breakdown per township is provided in the LOOKUP TABLES worksheet)

Step 3 OPTIONAL: The load calculations use default imperviousness values for each land use (see LOOKUP TABLE 3).
Users have the option of entering a more specific land use imperviousness value (LOOKUP TABLE 3/Column U) based on their local knowledge of the area modeled.

TABLE A

Land Cover of Modeled Area	Area (acres)	Average Annual Precipitation (in/yr)	Current Load		
	2		TP (lbs/yr)	TSS (lbs/yr)	Runoff Volume (acre-feet/yr)
Low Density Residential		37.63	0.0	0	0.0
Medium Density Residential		37.63	0.0	0	0.0
High Density Residential		37.63	0.0	0	0.0
Industrial		37.63	0.0	0	0.0
Commercial		37.63	0.0	0	0.0
Roads/Parking Lots		37.63	0.0	0	0.0
Airport		37.63	0.0	0	0.0
Parks/Golf Courses		37.63	0.0	0	0.0
Agriculture (Row Crops, Orchards, Forage crops)		37.63	0.0	0	0.0
Herbaceous Openland		37.63	0.0	0	0.0
Forest		37.63	0.0	0	0.0
Water		37.63	0.0	0	0.0
Wetlands		37.63	0.0	0	0.0
Other (Sand, Rock, Bare soil)		37.63	0.0	0	0.0
TOTAL	**0.00**		**0.0**	**0**	**0.0**

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B- Apply Stormwater Best Management Practices

Step 4 Enter the area for each land use that will be treated by selected BMP(s).
Note: The total area entered in the BMP columns should be less or equal to the total land use area entered in Table A (The current land use area from Table A automatically populates Column C).

Total loads after BMP application are presented in Columns L & M.
BMP cost estimates are presented below Table B. Please note that land costs are not included in the BMP cost calculations.

BMP definitions are provided in the LOOKUP TABLES worksheet.

Note: Professional judgment should be used when selecting BMPs for the area selected. For instance, rain gardens and constructed wetlands are more appropriate for residential neighborhoods, retention and detention ponds are more appropriate for commercial or transportation areas.

This tool does not model the combined efficiency of multiple BMPs. Each BMP is modeled individually and may not reflect actual site conditions when multiple BMPs are installed.

TABLE B

Land Use (Zoning) of Modeled Area	Total Area (acres)	Average Annual Precipitation (in/yr)	BMP Coverage Projections					
			Area Treated by Grass Swale	Area Treated by Extended Dry Detention Basin	Area Treated by Wet Detention Pond	Area Treated by Rain Garden	Area Treated by Constructed Wetlands	Area Not Treated by BMPs
Low Density Residential	0.00	37.63						0.0
Medium Density Residential	0.00	37.63						0.0
High Density Residential	0.00	37.63						0.0
Industrial	0.00	37.63						0.0
Commercial	0.00	37.63						0.0
Roads/Parking Lots	0.00	37.63						0.0
Airport		37.63						0.0
Parks/Golf Courses	0.00	37.63						0.0
Agriculture (Row Crops, Orchards, Forage crops)	0.00	37.63						0.0
Herbaceous Openland	0.00	37.63						0.0
Forest	0.00	37.63						0.0
Water	0.00	37.63						0.0
Wetlands	0.00	37.63						0.0
Other (Sand, Rock, Bare soil)	0.00	37.63						0.0
Total area treated by BMP type (in acres)			**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0**

Land Use (Zoning) of Modeled Area	Future Load (lbs/yr) with BMP		
	Total Load TP	Total Load TSS	Runoff Volume (acre-feet/yr)
Low Density Residential	0.0	0	0.0
Medium Density Residential	0.0	0	0.0
High Density Residential	0.0	0	0.0
Industrial	0.0	0	0.0
Commercial	0.0	0	0.0
Roads/Parking Lots	0.0	0	0.0
Airport	0.0	0	0.0
Parks/Golf Courses	0.0	0	0.0
Agriculture (Row Crops, Orchards, Forage crops)	0.0	0	0.0
Herbaceous Openland	0.0	0	0.0
Forest	0.0	0	0.0
Water	0.0	0	0.0
Wetlands	0.0	0	0.0
Other (Sand, Rock, Bare soil)	0.0	0	0.0
Total Load/Volume with BMP application	**0.0**	**0.0**	**0.0**
Total Load/Volume with BMP no application	**0.0**	**0.0**	**0.0**
Load reduction from BMP application	**0.0**	**0.0**	**0.0**
Average cost per lb (or acre-feet) of reduction			

BMP Cost Estimate		Grass Swale	Extended Dry Detention Basin	Wet Detention Pond	Rain Garden	Constructed Wetlands
BMP Cost Estimate	**Base BMP Cost**	**$0**	**$0**	**$0**	**$0**	**$0**
	Engineering & Planning / Landscaping Cost *(25% of base cost for retention/detention/swales/wetlands, 3% of base cost for rain gardens)*	**$0**	**$0**	**$0**	**$0**	**$0**
	Total BMP Cost	**$0**	**$0**	**$0**	**$0**	**$0**

KALAMAZOO RIVER URBAN STORMWATER BMP SCREENING TOOI
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Summary

Date:	1/6/2011 8:41	
Name of area/project (optional):		
Total area modeled	0.00	acres

TOTAL POLLUTANT LOADS

	Runoff Volume *(acre-feet/yr)*	**TP** *(lbs/yr)*	**TSS** *(lbs/yr)*
Current Load/Volume	0.0	0.0	0
Future Load/Volume with BMP Application	0.0	0.0	0
Load/Volume Reduction from BMP Application	0.0	0.0	0

BMP APPLICATION

	Total Area Treated *(acres)*	**Base BMP Cost** *($)*	**Engineering & Planning Cost** *($)*	**Total Cost** *($)*
Grass Swales	0.00	0	0	0
Extended Dry Detention Basins	0.00	0	0	0
Wet Detention Ponds	0.00	0	0	0
Rain Gardens	0.00	0	0	0
Construction Wetlands	0.00	0	0	0
Total	0.00	0	0	0

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TABLE 1- BMP DATA

BMP	% Efficiency [1]			Base Cost[2]	
	TP	TSS	Runoff	($ per acre treated)	Cost Adjustment for Small Project [2]
Grass Swale	40%	80%	15%	3,000	3.00
Extended Dry Detention	30%	90%	15%	3,000	2.10
Wet Detention Pond	90%	90%	0%	3,000	2.10
Rain Garden (Neighborhood)	50%	90%	50%	69,914	n/a
Constructed Wetlands	49%	76%	0%	42,254	n/a

(1) Efficiency values (for TP and TSS) for extended detention basin, wet de/retention pond and grass swale are taken from the Michigan Trading Rules. Efficiency values (for TP and TSS) for constructed wetlands were taken from EPA (2005), rain garden efficiencies were taken CSN Technical Bulletin No. 4 and MA DEP Stormwater Drainage Report (2009).

Runoff volume efficiency values were taken from the Chesapeake Bay Stormwater Network (Schueler, 2008). Level 1 runoff reductions (baseline BMP design) are used here to provide conservative estimates. Level 2 design (i.e. more innovative) would provide a greater runoff reduction (see reference for more information).

(2) Base cost and cost adjustment values are provided in WERF's BMP and LID Whole Life Cost Worksheets (2009b). The medium value of $3,000 per acre is used for retention, detention and swale.

For rain gardens, the cost per area treated is $16.05 (cost per sq. ft of rain garden) x 20% (rain garden area ratio to drainage area) =$3.21 per sq. foot treated (or $139,828 per acre treated). The assumption used in this tool is that rain gardens will be installed at a neighborhood scale, therefore providing economies of scale. The WERF neighborhood discount factor (50%) was applied to give a value per acre treated of $69,914.

The base BMP cost of $42,254 per acre (effective drainage area) for curb-contained bioretention is used for constructed wetlands.

See full references in READ ME worksheet

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BMP DEFINITIONS

Extended Dry Detention: Dry detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, 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 Pond: Wet ponds (a.k.a. stormwater ponds, wet retention 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, and 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.

Swales: The term swale (a.k.a. grassed channel, dry swale, wet swale, biofilter, or bioswale) refers to a 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 sedimentation, filtering through a subsoil matrix, 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.

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 within the practice. 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 2- PRECIPITATION AND LAND USE DATA PER TOWNSHIP

Note: Only land use area located within the Kalamazoo River Watershed is provided in the table below.

Township	Average Annual Precipitation (in/yr)	2001 Land Use (in acres) [1]									
		Low Density Residential	Commercial	Airport	Road/parking lot	Agriculture	Herbaceous Open land	Parks/Golf Course	Forest	Water	Wetlands	Sand/Bare Soil
Adams Twp	36.50	10.5	2.4	0.0	40.0	1,164.9	116.3	0.0	149.7	0.0	117.0	0.7
Alamo Twp	39.16	246.0	80.3	0.0	702.5	10,176.1	2,091.4	71.2	5,505.0	184.4	4,151.8	4.7
Albion	36.50	401.4	206.8	0.0	496.6	595.8	536.2	0.0	789.9	11.1	259.3	6.7
Albion Twp	36.50	166.1	34.0	0.0	505.7	13,809.1	1,356.4	0.0	3,448.8	20.7	1,680.6	10.5
Allegan, City of	39.16	159.0	447.7	96.7	339.4	265.5	340.3	0.0	557.1	277.1	296.2	34.2
Allegan Twp	39.16	271.8	430.3	18.9	660.5	10,740.5	1,832.3	0.0	3,638.5	875.8	1,790.2	36.5
Assyria Twp	34.44	129.0	73.4	0.0	543.1	9,571.4	1,948.1	0.0	5,450.6	189.7	5,233.1	9.6
Barry Twp	37.63	164.6	109.4	0.0	607.8	10,267.3	1,518.7	0.0	3,610.3	803.7	3,968.3	9.3
Battle Creek	34.44	2,791.7	1,763.6	332.0	3,411.9	4,176.9	3,558.7	249.1	7,650.9	515.7	3,291.1	196.4
Bedford Twp	34.44	620.5	145.4	0.0	714.5	3,403.7	2,668.7	133.0	7,706.7	229.3	3,343.2	5.3
Bellevue Twp	34.44	152.1	127.7	0.0	720.1	10,173.5	1,478.2	0.0	3,302.9	75.6	3,679.2	32.2
Bloomingdale Twp	39.16	65.6	4.2	0.0	113.9	1,318.3	421.4	0.0	690.7	205.5	554.4	0.4
Brookfield Twp	34.44	57.2	28.9	0.0	527.3	12,102.5	787.7	0.0	1,728.4	143.9	2,436.9	41.8
Byron Twp	39.16	107.4	67.4	0.0	193.3	4,054.6	346.0	0.0	678.1	13.1	232.4	25.1
Carmel Twp	34.44	62.3	50.0	0.0	326.5	7,610.4	504.8	0.4	1,143.5	24.2	1,025.2	4.0
Charleston Twp	37.63	147.9	119.0	0.0	601.3	4,557.0	1,922.1	0.0	8,405.9	375.8	2,291.5	32.9
Charlotte	34.44	183.0	248.0	0.0	285.5	362.7	246.9	10.9	279.5	13.1	90.1	23.4
Cheshire Twp	39.16	250.4	47.4	0.0	538.6	6,397.9	2,466.1	0.0	3,556.2	562.6	3,590.0	182.6
Clarence Twp	34.44	85.0	44.0	0.0	498.2	11,138.2	1,179.1	0.0	2,690.7	811.3	4,010.1	8.7
Climax Twp	34.44	0.0	0.0	0.0	1.3	215.7	5.6	0.0	7.6	0.0	2.4	0.0
Clyde Twp	39.16	79.8	33.8	0.0	120.5	198.8	1,431.5	0.0	2,917.1	2.2	337.1	0.7
Comstock Twp	37.63	1,157.1	732.3	0.0	1,094.4	7,808.6	1,959.3	6.9	5,512.6	1,176.9	1,674.4	91.2
Concord Twp	36.50	164.3	57.4	0.0	628.9	13,886.5	1,799.4	0.0	3,531.8	43.1	3,044.3	14.9
Convis Twp	34.44	139.7	118.1	0.0	763.7	8,395.9	1,862.7	0.0	5,188.4	351.6	6,161.5	367.4
Cooper Twp	39.16	509.3	86.1	0.0	661.8	9,298.3	2,884.6	106.3	7,454.7	177.7	2,187.4	70.5
Dorr Twp	39.16	664.5	360.0	0.0	811.3	15,500.1	1,460.2	0.0	2,589.3	11.8	1,232.7	41.8
Eaton Twp	34.44	42.7	42.0	0.0	310.0	4,139.6	429.9	0.0	1,046.6	8.0	977.2	116.8
Eckford Twp	34.44	62.5	12.2	0.0	405.2	11,246.3	785.5	0.0	1,728.2	99.9	1,966.4	2.7
Emmett Twp	34.44	747.5	431.7	0.0	1,225.6	8,331.2	1,857.0	2.2	5,408.1	272.0	2,530.8	42.3
Fayette Twp	36.50	7.1	3.6	0.0	16.7	389.8	76.7	0.0	180.1	9.6	161.2	2.4
Fennville	39.16	115.6	78.9	0.0	61.8	261.5	78.5	0.0	74.1	22.2	33.1	2.4
Fillmore Twp	39.16	35.8	30.9	0.0	65.4	1,746.0	58.9	0.0	82.3	1.1	25.8	14.0
Fredonia Twp	34.44	34.7	9.1	0.0	203.7	3,390.6	525.3	0.0	1,107.9	208.8	1,966.6	1.1
Gaines Twp	39.16	7.8	7.6	0.0	48.0	881.1	81.8	0.0	210.2	5.6	222.6	113.2
Galesburg	37.63	59.8	25.8	0.0	95.4	263.5	104.1	0.0	219.7	33.8	124.8	2.7
Ganges Twp	39.16	5.1	0.9	0.0	19.6	241.3	32.0	0.0	27.6	0.2	4.0	0.0
Gobles	39.16	8.9	0.7	0.0	7.8	88.5	17.3	0.0	40.3	0.0	0.7	0.0
Gunplain Twp	39.16	276.4	213.7	0.0	771.2	11,343.9	1,837.2	76.7	5,095.2	186.8	2,102.3	62.9
Hamlin Twp	34.44	0.2	0.0	0.0	1.8	3.6	0.4	0.0	0.0	0.0	0.0	0.0
Hanover Twp	36.50	230.8	41.6	0.0	548.0	10,235.7	2,618.9	0.0	5,171.0	257.8	3,132.4	5.1
Heath Twp	39.16	368.1	250.2	0.0	587.1	4,205.4	3,918.1	0.0	9,868.8	167.7	3,570.7	44.7
Homer Twp	36.50	110.5	41.1	0.0	531.1	13,492.6	1,086.6	0.0	1,742.6	12.2	2,588.6	8.7
Hope Twp	37.63	0.4	0.7	0.0	0.0	3.3	9.1	0.0	42.5	0.0	2.0	0.0
Hopkins Twp	39.16	187.7	168.6	0.0	676.1	17,331.1	928.7	0.0	1,903.7	109.4	1,719.7	21.8
Jamestown Twp	39.16	130.5	65.8	0.0	394.5	10,656.9	331.4	0.0	742.8	14.9	354.0	18.7

TABLE 3- LAND USE CATEGORIES AND ASSOCIATED COEFFICIENTS FROM MICHIGAN TRADING RULES

2001 IFMAP Land use categories [1]	Equivalent Land Use - MI trading [1]	User-defined fractional imperviousness [2]	Defaullt Coefficients from MI Trading Rules			Event Mean concentrations (mg/L)	
			IMP_L	C_I	C_P	TSS	TP
Low intensity urban	Low density residential		0.1	0.95	0.2	70	0.52
High density urban	Commercial		0.9	0.95	0.2	77	0.33
Not applicable	Medium Density Residential		0.3	0.95	0.2	70	0.52
Not applicable	High Density Residential		0.85	0.95	0.2	97	0.24
Not applicable	Industrial		0.8	0.95	0.2	149	0.32
Airports	Highways		0.9	0.95	0.2	141	0.43
Road/Parking Lots	Highways		0.9	0.95	0.2	141	0.43
Agriculture (Non-vegetated farmland, row crops, forage crops, orchards/vineyards)	Agricultural		0.05	0.95	0.2	51	0.37
Herbaceous Openland/Shrub-scrub	Forest/rural open		0.05	0.95	0.2	51	0.11
Parks/Golf courses	Urban open		0.05	0.95	0.2	51	0.11
Forest	Forest/rural open		0.05	0.95	0.2	51	0.11
Water	Water/Wetlands		1	0.95	0.2	6	0.08
Wetlands (Lowland forest, emergent wetlands, non-forest wetlands)	Water/Wetlands		1	0.95	0.2	6	0.08
Sand/Bare soil	Forest/rural open		0.05	0.95	0.2	51	0.11

(1) Land use categories used in this Tool are a combination of IFMAP categories and MI Trading Rules categories. The most representative terms v used to give users a better understanding of each land use category.

(2) Users have the option of defining a land use imperviousness value (as a ratio) based on their local knowledge of the area modeled. If no value is entered, calculations will use the default imperviousness coefficient (IMP_L)

Definitions:

IMP_L Fractional imperviousness of land use L

C_I Impervious area runoff coefficient

C_P Pervious area runoff coefficient

Equations used in the Tool

R_L x A_L x 0.0833 = R_{Vol}

EMC_L x R_L x A_L x 0.2266 = L_L

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 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

Johnstown Twp	37.63	75.4	39.4	0.0	307.8	4,887.0	937.6	0.0	2,454.1	62.5	2,119.6	9.1
Kalamazoo, City of	37.63	3,459.9	2,167.0	307.1	2,673.6	597.3	1,661.7	271.3	3,725.5	282.2	768.8	109.9
Kalamazoo Twp	37.63	1,361.7	714.5	0.0	926.7	940.9	949.6	0.0	2,103.8	68.5	407.6	99.0
Kalamo Twp	34.44	11.3	5.1	0.0	89.4	2,413.4	181.0	0.0	298.7	4.2	556.2	2.2
Laketown Twp	39.16	152.6	99.4	0.0	144.1	390.7	333.6	0.2	853.3	18.0	256.2	215.9
Lee Twp-Allegan	39.16	5.6	1.1	0.0	34.7	362.7	171.5	0.0	532.6	0.0	347.2	0.7
Lee Twp-Calhoun	34.44	65.8	73.4	0.0	584.4	14,768.5	1,366.6	0.0	2,922.0	180.6	3,309.4	9.8
Leighton Twp	39.16	232.4	318.7	0.0	656.7	12,282.2	1,178.4	0.0	2,300.2	416.1	2,026.0	215.3
Leroy Twp	34.44	140.8	10.5	0.0	306.7	5,517.9	883.6	0.0	1,976.2	281.5	2,643.1	2.4
Liberty Twp	36.50	20.5	7.3	0.0	55.4	612.7	78.7	0.0	127.9	139.7	167.0	0.2
Litchfield	36.50	2.9	1.6	0.0	8.9	161.7	3.6	0.0	4.2	0.0	0.4	0.0
Litchfield Twp	36.50	15.3	13.1	0.0	145.7	3,939.6	123.6	0.0	248.4	0.0	295.8	2.7
Manlius Twp	39.16	368.1	176.1	0.0	468.8	6,669.3	3,027.0	0.0	6,487.1	427.4	5,053.8	94.5
Maple Grove Twp	34.44	26.0	18.0	0.0	115.0	3,581.1	373.6	0.0	633.6	10.0	703.9	3.8
Marengo Twp	34.44	124.8	32.7	0.0	673.6	14,415.3	1,329.4	0.0	2,988.7	80.9	3,206.0	2.4
Marshall	34.44	423.4	172.6	0.0	373.6	1,107.9	379.2	0.0	943.8	49.4	560.2	37.8
Marshall Twp	34.44	198.1	81.4	0.0	956.3	11,741.5	1,330.3	0.0	2,916.2	129.2	2,877.1	15.8
Martin Twp	39.16	154.3	175.0	0.0	669.8	17,955.8	956.5	0.0	1,653.0	102.5	1,273.0	70.9
Monterey Twp	39.16	311.1	179.0	0.0	569.3	12,636.6	2,225.2	0.0	4,996.2	138.5	1,932.6	36.0
Moscow Twp	36.50	92.5	36.5	0.0	544.0	12,213.2	1,520.9	0.0	3,235.6	5.8	1,981.7	7.8
Newton Twp	34.44	43.1	8.2	0.0	113.6	2,031.3	478.4	123.0	1,101.1	5.3	1,175.3	142.1
Olivet	34.44	39.6	37.1	0.0	70.3	92.1	91.2	0.0	211.5	0.2	110.3	2.4
Orangeville Twp	39.16	342.5	201.5	0.0	397.2	4,154.0	1,977.3	0.0	6,597.2	1,006.5	2,700.9	4.7
Oshtemo Twp	39.16	682.5	413.4	0.0	690.1	4,113.3	1,691.9	163.9	4,588.1	45.4	363.8	47.1
Otsego	39.16	178.8	167.7	0.0	252.4	233.3	151.4	0.0	219.9	44.7	96.7	12.2
Otsego Twp	39.16	322.0	221.1	0.0	775.3	11,499.6	2,013.3	0.0	3,950.8	373.6	2,477.9	45.8
Overisel Twp	39.16	228.2	49.4	0.0	319.6	8,649.2	372.5	0.0	595.8	0.7	1,017.4	7.1
Parchment	37.63	155.9	80.1	0.0	105.6	13.1	64.7	0.0	122.1	18.5	35.6	3.8
Parma Twp	36.50	152.1	43.4	0.0	528.0	9,507.8	1,227.6	0.9	2,150.3	0.7	2,423.6	9.1
Pavilion Twp	37.63	41.1	21.8	0.0	110.8	2,335.1	203.7	0.0	433.0	49.1	630.0	9.1
Pennfield Twp	34.44	556.6	173.7	0.0	868.7	6,247.6	2,628.6	100.5	8,357.9	180.1	3,280.5	59.2
Pine Grove Twp	39.16	144.8	21.3	0.0	432.1	7,902.4	1,737.5	0.0	3,742.8	64.0	2,303.1	7.8
Plainwell	39.16	168.8	141.4	0.0	236.2	288.0	150.6	0.0	233.5	46.5	42.5	18.0
Portage	37.63	3,359.6	1,203.6	41.8	1,321.7	1,133.5	1,392.8	85.6	3,642.3	17.6	1,341.7	69.2
Prairieville Twp	37.63	202.8	113.9	0.0	549.3	12,145.6	1,793.4	0.0	4,949.1	1,565.8	2,006.2	12.2
Pulaski Twp	36.50	121.4	17.8	0.0	519.3	13,560.2	2,167.0	80.5	3,626.5	113.4	3,268.0	1.6
Richland Twp	37.63	357.8	99.6	0.0	698.3	12,271.0	1,742.2	255.1	5,315.1	931.8	1,446.6	29.4
Ross Twp	37.63	324.9	118.5	0.0	604.7	5,891.8	1,889.6	432.8	8,565.4	1,470.2	3,717.9	6.4
Salem Twp	39.16	344.0	333.8	0.0	698.7	14,158.9	1,670.4	36.5	3,195.1	169.0	2,337.1	58.0
Sandstone Twp	36.50	0.0	0.0	0.0	1.1	67.6	10.7	0.0	22.7	0.4	4.2	0.0
Saugatuck	39.16	94.7	51.4	0.0	91.0	0.0	89.4	0.4	230.2	162.1	51.6	24.2
Saugatuck Twp	39.16	508.6	167.5	0.0	516.6	4,398.7	1,642.8	218.6	3,358.1	651.4	2,021.7	210.4
Scipio Twp	36.50	94.3	38.5	0.0	502.6	10,231.9	1,416.6	0.0	2,517.0	74.9	2,531.9	10.5
Sheridan Twp	34.44	166.6	76.9	0.0	650.3	9,473.8	1,573.0	91.2	3,757.3	66.9	4,055.5	6.4
Somerset Twp	36.50	12.5	25.6	0.0	68.9	1,272.7	215.3	0.0	373.4	0.2	244.2	0.4
Spring Arbor Twp	36.50	164.3	35.6	0.0	203.0	4,149.6	824.4	0.0	1,274.1	19.6	1,173.3	2.9
Springfield	34.44	303.8	302.0	40.5	452.3	15.6	508.6	0.0	555.8	9.8	191.7	8.5
Springport Twp	34.44	29.1	32.5	0.0	143.7	3,959.0	261.3	0.0	457.2	5.3	490.8	8.2
Texas Twp	37.63	497.0	167.0	0.0	463.9	4,136.7	1,440.0	0.0	4,876.6	524.0	783.3	21.1
Thornapple Twp	39.16	29.6	20.9	0.0	85.6	2,188.1	175.2	0.0	379.6	34.7	145.7	239.3
Trowbridge Twp	39.16	211.9	120.1	0.0	661.8	12,602.2	1,927.2	0.0	3,654.8	570.9	3,131.3	16.9
Valley Twp	39.16	252.0	107.2	0.0	477.7	1,359.2	4,157.8	0.0	11,770.2	1,612.1	2,913.3	26.0
Village of Douglas	39.16	155.5	92.5	0.0	152.1	8.0	270.2	103.6	248.0	86.5	72.3	9.6
Walton Twp	34.44	96.3	96.3	0.0	985.9	13,832.4	1,259.4	0.0	2,706.3	134.3	3,582.0	12.0
Watson Twp	39.16	173.2	165.7	0.0	604.9	12,972.9	1,832.5	0.0	3,907.4	334.0	3,051.4	44.0
Wayland	39.16	164.3	254.0	0.0	174.4	602.5	247.1	0.0	268.9	35.8	156.6	18.5
Wayland Twp	39.16	188.6	198.8	0.0	714.5	11,586.1	1,575.6	0.0	3,717.5	353.4	3,025.4	43.6
Wheatland Twp	36.50	0.9	0.0	0.0	5.3	227.7	52.9	0.0	68.5	0.0	93.8	0.0
Yankee Springs Twp	39.16	178.6	178.6	0.0	363.8	1,777.8	953.6	0.0	3,876.7	2,564.2	1,846.5	34.5
Zeeland Twp	39.16	19.3	9.3	0.0	64.5	1,541.6	12.2	0.0	26.5	0.7	6.9	2.7

(1) The land use categories used here correspond to the equivalent Michigan Trading Rules categories, and not to the original IFMAP categories.

Attachment 9. 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 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 watershed. 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 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 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

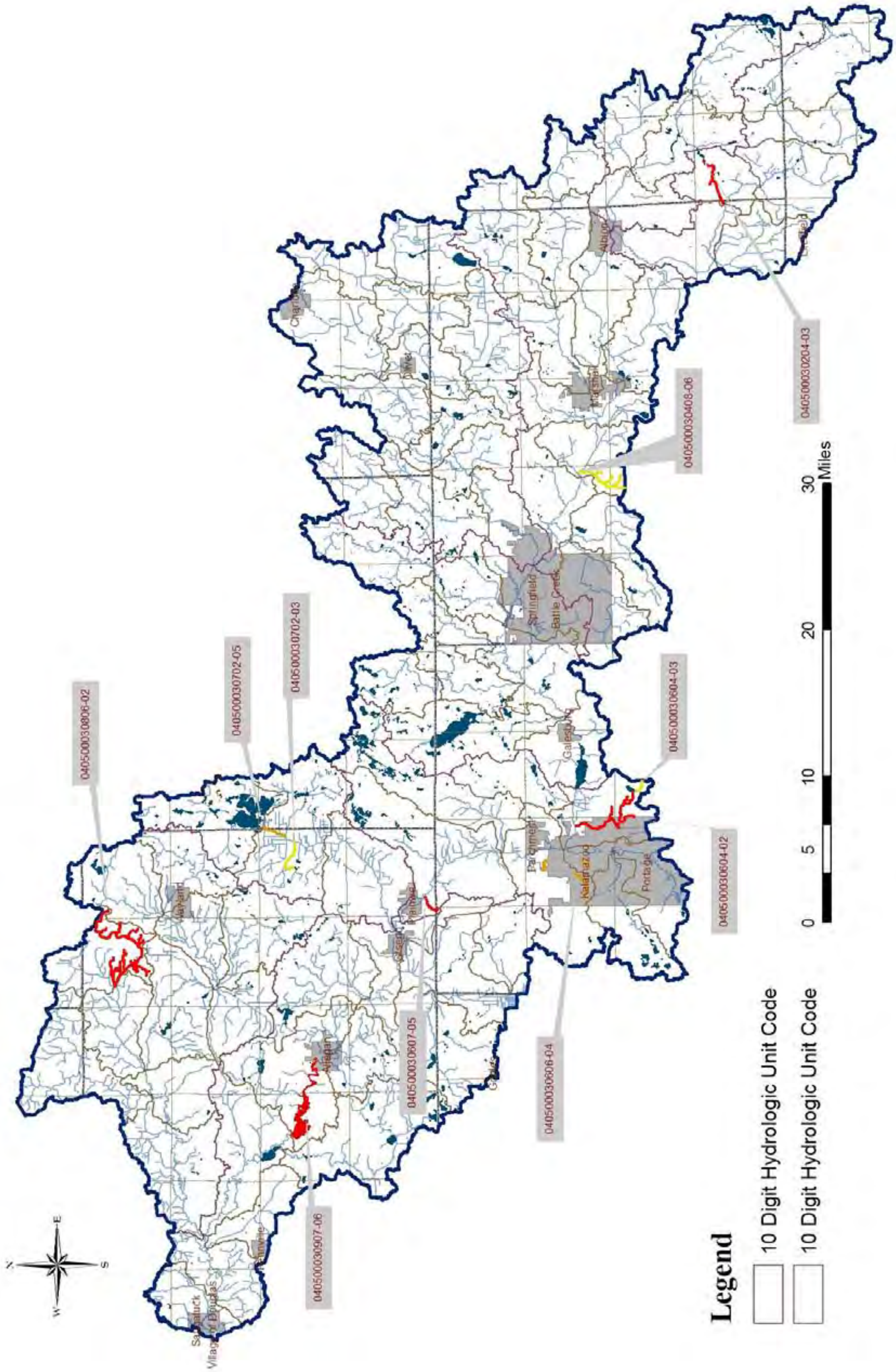
Attachment 10. Public comment.

1) The Southwest Michigan Land Conservancy (SWMLC) offered clarification in Section 4 regarding preserved lands in the watershed as well as SWMLC functions. A new figure was provided by SWMLC for Figure 10. An implementation task was added to Table 28 calling for the development of a watershed wide conservation plan.

2) Watershed Council Board members offered editorial comments throughout the text.

3) The Michigan Department of Environmental Quality offered numerous comments that have been incorporated throughout the text. Key items included a reorganization of Section 8 including adding more information from attachments, a calculation of phosphorus loading reduction goals from agricultural and urban lands now described in Section 10 and documented in Attachment 12, and a request for a map of impaired waterbodies now included as Attachment 11.

Attachment 11. Impaired waterbodies.



Attachment 12. Watershed and TMDL phosphorus load reduction goal calculations.

Land Use	Acres of Land Use	Goal of 10% of Total area for BMP	Goal 30% of Area Total area for BMP	BMP Efficiency Min Value Table 34- pg 157	Load reductions for 10%	Load Reduction for 30%
	Numbers based on table 3			extended detention tp-lbs/acre/yr		
Low Density Urban	29,786	2,978.60	8,935.80	0.3	893.58	2,680.74
High Density Urban	16,800	1,680.00	5,040.00	0.8	1,344.00	4,032.00
Transportation	49,803	4,980.30	14,940.90	2.3	11,454.69	34,364.07
					13,692.27	**41,076.81**
Agriculture	100 meter buffer	area above 100 meter buffer	Total Reduction			
Based on Table 25						
25%	795	1,676	**2,471.00**			
50%	1,591	3,352	**4,943.00**			
75%	2,836	5,029	**7,865.00**			

Total Load Reduction from 75% Ag & 30% LDU, HDU & Transportation	**48,941.81**					
TMDL Load	**Present Load**	**Goal**	**Reduction per month**	**Total Reduction**		
April/June	17,218	9,800	7,418	22,254		
July/Sept	8,135	4,088	4,047	12,141		
total reduction needed to meet TMDL	**34,395**					
Lake Allegan WS sq miles	1551.4					
Whole WS sq miles	2031.1					
% of WS under TMDL	0.763822559					
Total Load Reduction from 75% Ag & 30% LDU, HDU & Transportation in TMDL portion of watershed	**37,382.86**					